Manure application on forages

Barry M. Olson and Lawrence W. Papworth

July, 2002

Alberta
Agriculture, Food and
Rural Development

Agtech
CENTRE

Irrigation
Branch

Manure application on forages

Barry M. Olson[1] and Lawrence W. Papworth[2,3]

[1] Irrigation Branch, Alberta Agriculture, Food and Rural Development, Lethbridge, Alberta, Canada
[2] Agriculture Technology Centre, Alberta Agriculture, Food and Rural Development, Lethbridge, Alberta, Canada
[3] Project manager

Prepared for

Canada-Alberta Beef Industry Development Fund
Project number 97AB117

and

Canada-Alberta Hog Industry Development Fund
Project number 60

July, 2002

Citation format:
Olson, B.M. and Papworth, L.W. 2002. Manure application on forages. Alberta Agriculture, Food and Rural Development, Lethbridge, Alberta, Canada. Final report for the Canada-Alberta Beef Industry Development Fund and the Canada-Alberta Hog Industry Development Fund. 257 pp.

SUMMARY

The livestock sector is a significant part of Alberta's agricultural industry. The livestock industry in general, and the beef feedlot sector in particular, has grown significantly during the past several years. Global market opportunities may support continued expansion of Alberta's livestock sector. A large livestock industry generates a considerable amount of manure, which must be managed in a responsible manner. The application of manure on agricultural land is the most effective method of using manure. Generally, manure is applied on cultivated land. However, in areas where suitable cultivated land is not available or because of convenience, the use of forage land is an alternative for manure application. However, research in Alberta on the effects of manure on soil quality, water quality, and crop production has mainly focused on cultivated land. There has been limited research on the effects of manure application on forage crops in Alberta in terms of soil properties, forage yield, and forage quality. The objective of our 5-yr (1996 to 2001) study was to determine the effects of repeated, annual applications of beef and hog manure on soil quality, forage yield, and forage quality.

The 5-yr field study was carried out in southern Alberta. One site was started in 1996 near Lethbridge under irrigated alfalfa (*Medicago sativa* L.), and a second site was started in 1997 near Airdrie under rainfed timothy (*Phleum pratense* L.). The experimental design at both sites included two manure application times (spring and fall), two manure types and application methods [surface-applied, solid, cattle (*Bos taurus*) manure and injected, liquid, hog (*Sus scrofa*) manure], and five application rates. Annual (spring and fall) manure rates were 0, 31, 61, 92, and 122 Mg ha^{-1} (wet-weight basis) for the solid manure, and 0, 42, 84, 126, and 168 Mg ha^{-1} (wet-weight basis) for the liquid manure. Because of the differences in the amounts applied between the two manure types, the manure application rates are referred to as rate 0, rate 1, rate 2, rate 3, and rate 4. Soil samples were collected to 1.5 m depth at the start of the study at both sites and in the spring of each year during the study. Soil samples were analysed for extractable nitrate-N, ammonium-N, phosphate-P, sodium, potassium, and sulphate-S, pH, electrical conductivity, and organic matter. Forage-yield data were collected from 1996 to 2000 at the Lethbridge site and from 1997 to 2000 at the Airdrie site. Tissue samples from both sites from 1997 to 2000 were analysed for protein, acid detergent fiber, nitrate, phosphorus, calcium, magnesium, sodium, potassium, copper, selenium, sulphur, zinc, manganese, aluminum, boron, and iron. Because of the way the study was started at the two sites, the application time factor (spring versus fall) could not be statistically compared. The data were analysed by site and by application time. The main factors were manure type and manure rate, and year was treated as a split treatment in the statistical analysis of the data.

The application of beef or hog manure on irrigated alfalfa and rainfed timothy significantly affected soil chemistry. Soil extractable nitrate-N increased in the soil with evidence of nitrate leaching down the soil profile at both sites. The differences between beef and hog manure at the two sites could be explained, in part, by differences in total nitrogen applied between the manure types and by the potentially greater loss of volatile nitrogen from the surface-applied, non-incorporated, beef manure. Extractable phosphate-P in the soil generally increased, but higher levels of phosphate-P remained in the top 15 cm of soil. Extractable potassium was also increased, but only for beef-manure application. About four to eight times more potassium was added from beef-manure applications compared to hog-manure applications. Extractable sodium

content was increased at both sites. Beef manure had a larger affect than hog manure at the Lethbridge site, and this was probably because a little more than eight times more sodium was added from beef manure at this site. Manure application did not affect sulphate-S content at the Lethbridge site, whereas sulphate-S content was significantly increased in the 0- to 30-cm depth at the Airdrie site. Spring-applied manure essentially did not affect soil electrical conductivity at the Lethbridge site. However, the fall-applied manure significantly increased soil electrical conductivity. Similar results were observed at the Airdrie site. Soil organic matter was not affected by manure application at the Airdrie site, whereas soil organic matter was increased in the 0- to15-cm depth at the Lethbridge site. Beef manure had a greater effect than hog manure, and this is probably because three times more organic matter was added to the beef-manure plots.

The application of manure had no significant effect on alfalfa yield at the Lethbridge site in 1996 to 1998, regardless of the manure type and the time of application. In 1999, most manure treatments yielded significantly higher than the control, and in 2000 all manure treatments yielded higher than the control. After four or five annual applications of manure, there was no nutrient advantage of applying more than the lowest rate used on alfalfa. There were significant treatment-by-year interactions for the fall- and spring-applied treatments. There were no significant differences among the four rates for each manure type and no differences between the two manure types, regardless of the application time and year. Timothy yield was not significantly different from the control for the spring-applied treatments in 1997 at the Airdrie site. In 1998 to 2000, manure treatments often had significantly higher yield than the control. The spring-applied treatments showed no differences between the two manure types. Generally, yield increased as the spring-applied manure rate increased from rates 1 to 3. Rate 4 was not significantly different than rates 2 and 3, and there was a tendency for yield from the rate 4 treatment to be less than rate 3. This may be an indication that a yield depression occurred with the high application rate.

The effects of manure application on tissue quality varied according to measured parameter, site location, year, manure type, and manure rate. There were manure-by-rate, manure-by-year, and rate-by-year interactions. Sixteen crop-tissue parameters were measured, and of these, protein, acid detergent fiber, nitrate, phosphorus, calcium, magnesium, sodium, potassium, copper, selenium, sulphur, zinc, and manganese were significantly affected by manure application. Only boron, iron, and aluminum were not significantly affected by beef or hog manure application. The concentration of most parameters that were significantly affected increased when manure was applied. The exception was selenium, which was the only parameter that decreased in concentration with the application of manure. The cumulative effect of annual manure applications was apparent, because the effect became more pronounced for many of the increases in successive years. Concentration of the parameters that increased with added manure tended to be more pronounced for timothy than for alfalfa under the conditions of the study.

The overall conclusions of our study is that surface-applied solid beef manure and injected liquid hog manure can be effectively applied to forage land. This is particularly good for liquid manures, because injection methods are considered good practices to reduce odours, reduce nitrogen losses, and help prevent nutrient losses by surface runoff. Our results also showed that manure application significantly affected soil quality, forage yield, and forage quality. In terms of soil quality, several nutrients of environmental concern accumulated in the soil, such as

nitrate-N and phosphate-P, and an increase in soil salinity was observed. Based on electrical conductivity alone, as a measure of salinity, the annual application of manure at the higher rates is not sustainable with time under the conditions of the study. Annual applications should not exceed the lowest rates used in the study. The cumulative effect of 4 to 5 yr of manure application generally did not show differences among manure application rates (other than the control) in terms of yield increase. Long-term manure application above the lowest rates used in this study will not add any significant benefit to increase yield. There was some indication that the highest manure rates may have suppressed yield relative to the second highest manure rates for timothy at the Airdrie site. For the most part, the application of manure on forages did not have any negative effect on alfalfa and timothy forage quality. The comparison between beef and hog manure was variable and one type was not found to be better than the other. The physical action of injecting hog manure into forage land did not have a deleterious effect on crop yield. Many differences among beef and hog manure treatments, in terms of soil chemistry and tissue quality, could be explained by the differences in the nutrient load in the two types of manure. Statistically, the spring- and fall-application treatments could not be compared; however, a qualitative comparison indicated there were minimal differences between spring and fall applications.

ACKNOWLEDGEMENTS

We greatly appreciate the assistance from Ryan Anderson, Craig Assenheimer, Nathan Eshpeter, Murray Green, Edward Griffiths, Robert Maze, Gary McGregor, Michelle McKinnon, Blaine Metzger, Vince Murray, Troy Ormann, George Ragan, Rich Smith, and Brian West. We are also grateful to the land owners, Robyn Jones and Herman Schimanski, and for the manure donations from Doug Hall, Dan McKinnon, Thiessen Feedlot, and Sunbutte Management and Feeders Ltd.

Soil, manure, and plant-tissue analyses were carried out by the Agri-Food Laboratories Branch, Soil and Crop Unit, Alberta Agriculture, Food and Rural Development, Edmonton, Alberta.

Advice on statistical analysis of the data was provided by Toby Entz of Agriculture and Agri-Food Canada, Lethbridge Research Centre.

We appreciate the time that Rod Bennett and Frank Larney took to review the report.

We gratefully acknowledge the funding received from the Canada-Alberta Beef Industry Development Fund, Canada-Alberta Hog Industry Development Fund, County of Lethbridge No. 26, Foothills Forage Co-op Association, and the Municipal District of Rocky View No. 44.

TABLE OF CONETENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

INTRODUCTION

The livestock sector is a significant part of Alberta's agricultural industry. The number of cattle in Alberta has more than doubled during the past 50 yr with about 5.7 million head in 2000 (Jaipaul 2001a). This represents about 40 percent of the Canadian herd. There are about 4,500 feedlots in Alberta with a one-time feeding capacity of one-million head (Dey 1998). The hog population increased steadily from 960,000 head in 1978 to more than two-million head in 1995, followed by a decrease to 1.78 million head in 2000 (Jaipaul 2001b). The livestock industry in general, and the beef feedlot sector in particular, has grown significantly due to a number of factors, including a large supply of feeder cattle, favorable market locations, large supply of feed grains, water availability, favorable climate, good transportation infrastructure, and management expertise (Dey 1998). Global market opportunities may support continued expansion of Alberta's livestock sector.

A large livestock industry generates a considerable amount of manure, which must be managed in a responsible manner. In certain regions of Alberta where high densities of intensive livestock operations exist, such as the County of Lethbridge (Bennett and McCarley 1995), the land base may be inadequate to accommodate the manure produced based on sound nutrient management practices. The application of manure on agricultural land is the most effective method of using manure. Generally, manure is applied on cultivated land. However, in areas where suitable cultivated land is not available or because of convenience, the use of forage land is an alternative for manure application. In many parts of the province, forage crops occupy a significant portion of the land potentially available for manure application. About 2.23 million hectares of land produced tame hay in 1999 (Hansen 2000). This was about 22% of Alberta's total land area used to grow principal field crops. However, research in Alberta on the effects of manure on soil quality, water quality, and crop yield has mainly focused on cultivated land (Riddell and Rodvang 1992; Chang and Entz 1996; Olson et al. 1998 and 2001).

Preliminary research in Saskatchewan has shown that shallow injection of liquid hog manure in crested wheat grass (*Agropyron cristatum* L.), Russian wildrye grass (*Psathyrostachys juncea* Fisch. Nevski), and smooth brome grass (*Bromus inermis* Leyss)-alfalfa (*Medicago sativa* L.) stands increased yield by 1.5 to 4.4 fold in the first year of a 3-yr study (Pastl et al. 1999). Other researchers have also shown the positive influence manure application can have on forage yield (Schmitt et al. 1993; Liu et al. 1997; Ma et al. 1998; Bittman et al. 1999; Sullivan et al. 2000). Manure application can also affect the quality and nutrient composition of forages. Bomke and Lowe (1991) reported an increase in copper and zinc concentrations in forages that had received poultry manure. Liu et al. (1997) found that hog lagoon effluent generally increased nitrogen and phosphorus concentrations in forage. Results from a study in Minnesota showed preplant application of dairy manure did not affect phosphorus content of alfalfa, but the potassium content increased in direct proportion to manure application rate (Schmitt et al. 1993). A 3-yr study in Manitoba showed that liquid hog manure increased nitrogen, phosphorus, and potassium concentrations in a grass-alfalfa crop (Bailey et al. 1999).

Method of manure application on forage crops has also been studied by some researchers. Common methods include broadcasting, banding on the surface, and subsurface injection. Thompson et al. (1987) compared broadcasted and injected manure into stands of perennial

ryegrass (*Lolium perenne* L.). They found larger nitrogen losses, through ammonia volatilization, from the broadcasted manure. They also found that the injection method significantly improved apparent nitrogen recovery by the crop. Bittman et al. (1999) reported that dairy liquid manure that was surface banded with a drag shoe resulted in better nitrogen uptake by tall fescue grass (*Festuca arundinacea* Schreb.), as compared to broadcasted manure. Another aspect of comparing methods of application on forages is the concern about nutrient content in runoff water. When manure is applied to forages and not incorporated, particularly for solid manure, there is a greater risk of nutrient loss by runoff (Edwards and Daniel 1993; Sauer et al. 1999; Sauer et al. 2000).

There has been limited research on the effects of manure application on forage crops in Alberta in terms of soil properties, forage production, and forage quality. The objective of our 5-yr (1996 to 2001) study was to determine the effects of repeated, annual applications of beef and hog manure on soil quality, forage yield, and forage quality.

MATERIALS AND METHODS

Two sites were established in southern Alberta on established forage land. One site was established in 1996 about 14 km northeast of Lethbridge (SE-29-9-20-W4), and the other site was established in 1997 about 5.9 km east-northeast of Airdrie (NW-17-27-28-W4). The Lethbridge site was managed under irrigated alfalfa (*Medicago sativa* L.). The site was seeded to alfalfa in 1994. The surface (0-15 cm) was a clay-textured soil (20% sand; 51% clay), with an organic matter content of 4.3% , a pH of 7.8, and a electrical conductivity of 0.7 dS m^{-1}. The Airdrie site was managed under rainfed timothy (*Phleum pratense* L.). The site was seeded to timothy in 1993. The surface (0-15 cm) was a loam-textured soil (36% sand; 21% clay), with an organic matter content of 11.6 %, a pH of 7.3, and a electrical conductivity of 0.5 dS m^{-1}.

The Lethbridge site was in the Dark Brown soil zone in the Mixed Grass ecoregion. The AGRASID (CAESA-Soil Inventory Project Working Group 1998) map unit name for the area is CLD1/U1l. This has a dominant Coaldale (CLD) soil series, which is a Orthic Dark Brown Chernozemic soil. The land form is undulating with low relief (U1l). It is moderately calcareous on fine-textured, glaciolacustrine parent material (F1).

The Airdrie site was in the Thin Black soil zone in the Fescue Grass, Mixed Grass, and Aspen Parkland ecoregion. The AGRASID (CAESA-Soil Inventory Project Working Group 1998) map unit name for the area is ADRK14/U1h. This has two co-dominate soil series: Rockyview (RKV) and Academy (ADY). Both soil series are Black Chernozemic soils and are strongly calcareous. Rockyview has medium-textured glaciolacustrine and moderately-fine textured till parent materials (L3). Academy has moderately-fine textured till parent material (M4). There are also three significant soil series in the area: Beddington (Black Solonetz), Kathyrn (Gleyed Black Chernozem), and a miscellaneous Gleysolic (ZGW; Orthic Humic Gleysol). The landform is undulating with high relief.

The experimental design at both sites included two manure application times (spring and fall), two manure types and application methods (surface-applied solid-beef manure and injected, liquid-hog manure), and five manure application rates. The treatments were arranged in a two-by-two-by-five factorial in a randomized complete block design. The treatments were replicated four times to give a total of 80 plots (Appendix 1). The plots were 7.5 m by 15 m, with 5 m borders between plots. Beef manure was spread with a tractor-pulled box-type spreader. Hog manure was applied using a sub-soil injector, which consisted of five K-Hart coulter assemblies mounted on a three-point-hitch toolbar.

Annual (spring and fall) manure rates were 0, 31, 61, 92, and 123 Mg ha^{-1} (wet-weight basis) for the beef manure, and 0, 42, 84, 126, and 168 Mg ha^{-1} (wet-weight basis) for the hog manure. These rates were originally based on assumed available nitrogen and moisture contents, with the intent of applying 67, 134, 201, and 268 kg ha^{-1} of available nitrogen for both manure types. The assumed values used were 2.2 kg Mg^{-1} of available nitrogen and 50 percent moisture content for the beef manure, and 1.6 kg Mg^{-1} of available nitrogen and 96 percent moisture content for the hog manure (ILOC 1995). Because of the differences in the amounts (total mass) applied between the two manure types, and the variability in the actual available nitrogen, we refer to the manure application rates as rate 0, rate 1, rate 2, rate 3, and rate 4.

Manure samples (one to six samples) were collected for chemical analyses prior to each application. Manure samples were analysed for following parameters:

Water content ……..	oven dried at 105 ^{o}C
Total nitrogen (N) …….	Kjeldahl digestion method
Total phosphorus (P) …….	Kjeldahl digestion method
Extractable ammonium-nitrogen (ammonium-N) ..	potassium chloride extraction method for the beef manure samples; hog manure samples were centrifuged, filtered, and analysed directly
Extractable nitrate-nitrogen (nitrate-N) ……..	Miller-Axley extraction method
Orthophosphate-phosphorus (phosphate-P) ……..	Miller-Axley extraction method
Organic matter ……..……..	loss-on-ignition method
Electrical conductivity and pH …….…….	direct measurement for hog manure samples and a water paste for the beef manure samples
Exchangeable cations (calcium, magnesium, potassium, and sodium) ……..……	ammonium acetate method
Total elemental analysis (sulphur, zinc, boron, manganese, iron, magnesium, aluminum, calcium, copper, sodium, and potassium …….…….	nitric-prechloric acid digest and analysed by inductively coupled plasma spectroscopy (ICPS)

The water content, total nitrogen, total phosphorus, and extractable ammonium-N analyses where carried out on wet samples as received by the laboratory. For the other analyses, the hog and beef manure samples were first dried at 105 ^{o}C. However, for some liquid manure samples, drying would have resulted in very little solid material. For the analysis of extractable nitrate-N, phosphate-P, sodium, potassium, calcium, and magnesium, subsamples were centrifuged, filtered, and analysed directly.

Baseline soil samples were taken in six incremental depths (0 to 15, 15 to 30, 30 to 60, 60 to 90, 90 to 120, and 120 to 150 cm) prior to the application of the treatments. Two soil cores were taken from each plot using a truck-mounted, hydraulic soil sampler. Composite samples were prepared for each incremental depth. A total of 480 soil samples were collected per site. Annual soil samples were also collected each spring during the study using the same protocol as described for the baseline soil sampling. Soil samples were air dried and ground through a 2 mm sieve. Soil samples were analysed for the following parameters:

Extractable ammonium-N…….……	potassium chloride extraction method
Extractable nitrate-N……..……..	Miller-Axley extraction method
Extractable phosphate-P …..……	Miller-Axley extraction method
Electrical conductivity …….	2:1 water mixture
pH ……	2:1 water mixture

Extractable potassium ……..	ammonium acetate extraction method
Extractable sodium ……..	ammonium acetate extraction method
Extractable sulphate-sulphur (sulphate-S)	calcium chloride extraction method
Organic matter……..	loss-on-ignition method

Soil samples from 16 selected plots at the Lethbridge site and 33 selected plots at the Airdrie site were analysed for sand, silt, and clay content (hydrometer method) in 1998 (i.e. 1998 soil samples) for the purpose of soil characterization.

Soil samples were collected on September 13, 2000 (Lethbridge site) and September 14, 2000 (Airdrie site) to determine bulk density. A truck-mounted hydraulic soil sampler was used to collect soil samples from 12 locations within the border area at each site. Soil cores were taken to a depth of 150 cm. The cores were divided into six incremental depths: 0-15, 15-30, 30-60, 60-90, 90-120, 120-150 cm. From each incremental core depth, a 5.08-cm long, intact soil core section was placed into metal cans. The diameter of the soil cores was 3.81 cm. The samples were oven dried at 105 ^{o}C for 24 hours and weighed.

Irrigated alfalfa yield samples were collected twice each year at the Lethbridge site (June and August), and rainfed timothy yield samples were collected in July at the Airdrie site. Two harvest machines were used for of the study. One was a walk-behind flail mower, which harvested a 60.96-cm wide path. The harvested and chopped plant material was dumped into a weighing container and weighed. The other machine used was a small-plot, self-propelled forage harvester, which cut a 149.35 cm wide path, and also used a flail-mower type cutting head. The forage harvester had load cells and weighed the harvested material onboard. One harvest strip was taken from each plot, through the long dimension (15 m) and was either 60.96 cm or 149.35 cm wide. Therefore, either about 8% or 20% of the area of each plot was harvested for yield. Subsamples were collected from the plant material cut and chopped by the harvest machines. The subsamples were weighed, dried (by microwave), and re-weighed to determine moisture content. The subsamples were then finely ground, and the ground plant samples were analysed for the following parameters. Of the two annual sample sets from the Lethbridge site, only samples from the second harvest (i.e. August) were chemically analysed.

Moisture content ……	oven dried at 105 ^{o}C
Protein ……	near infrared reflection
Calcium ……..	near infrared reflection
Phosphorus ……	near infrared reflection
Acid detergent fiber (ADF)……..…….	near infrared reflection
Nitrate-N ……	water extractable
Total elemental analysis (selenium, sulphur, zinc, boron, manganese, iron, magnesium, aluminum, copper, sodium, and potassium) ……..	nitric-perchloric acid and analysis by ICPS, except for selenium, which was analysed by graphitic furnace

The alfalfa crop at the Lethbridge site was irrigated as required by the landowner. A wheel-line sprinkler system was used to irrigate the crop.

A chronological listing of the main field activities is shown in Appendix 2.

As already indicated, the experiment was a factorial design with two manure types, five application rates, and two application times. Because of the method used to establish the two sites, the application-time factor, with two levels (spring and fall), could not be included in the statistical analysis. Spring soil sampling was preceded by spring and fall manure application in the previous year. Relative to annual soil sampling, the spring-manure treatments were subjected to a growing season, whereas the fall-manure treatments had not yet gone through a growing season. This would make interpretation of results difficult. Relative to the crop-yield and tissue-analysis data, spring-applied treatments had one more year of manure application than the fall-applied treatments. The end result is the spring-applied and fall-applied treatments could not be statistically compared.

In the statistical analysis, manure-type and manure rate were treated as the main effects and year was used as a split-plot factor. The data sets were analyzed by site and by application time. The original study design was a complete factorial experiment. For each manure-type and application-time combinations there was a zero rate, or control. Since there were four manure-type and application-time combinations, there were four controls per replicate (Appendix 1). Rather than keeping these four controls separate, it was decided to average the four controls per replicate so that only one control value was used in the statistical analysis.

The soil and crop data were analysed using the PROC MIX procedure in the Statistical Analysis System (SAS Institute 2000). The PROC MIX procedure ensures the correct error terms are used with each comparison for the split-plot design. Two SAS programs were used in the data analysis. One SAS program was used to test for significant main treatment effects (at nine levels), year, and possible treatment-by-year interactions. The nine levels for the treatment effect were: control; beef-manure rate 1; beef-manure rate 2 beef-manure rate 3 beef-manure rate 4; hog-manure rate 1; hog-manure rate 2; hog-manure rate 3; and hog-manure rate 4. The main comparison was to determine if manure application at the various rates were significantly different from the control. Significant differences were determined at $p<0.05$ using ESTIMATE (control-beef; control-hog) and LSMEANS. The other SAS program was used, without the control, to test for significant main treatment effects of manure type (beef versus hog), manure rate (rates 1, 2, 3, 4), year, and their possible interactions. Significant differences were determined at $p<0.05$ using LSMEANS.

RESULTS AND DISCUSSION

Climatic Conditions

The nearest climatic stations to the research sites was the Agriculture and Agri-Food Canada Research Centre at Lethbridge, located 10 km southwest of the Lethbridge site, and the Calgary International Airport, located 23 km south-southwest of the Airdrie site. Mean monthly temperature and monthly precipitation are shown in Appendix 3.

Mean monthly temperature tended to be above the 30-yr normals in 1998, 1999, and 2000, and to a lesser extent in 1997 near the Lethbridge site (Figure 1a). Annual precipitation at the Lethbridge site was below normal from 1996 to 2000, except for 1998 (Figure 1b). The March to July period in 1998 received most of the above normal precipitation. Precipitation received in May and June, 1999 was also well above normal. Precipitation in 2000 was 29 percent below normal, with the May to December period being particularly dry.

Mean monthly temperature near the Airdrie site was generally similar to the 30-yr normals (Figure 2a). Annual precipitation during the 1997 to 2000 period ranged from 3 to 35 percent higher than the 30-yr normals (Figure 2b). The wettest year was 1998 and the driest year was 2000. The May-June period in 1997, the March-July period in 1998, and the April-August period in 1999 were particularly wet, relative to the 30-yr normals.

Precipitation was recorded at the sites during the growing seasons (April to September), and these values are shown in Appendix 4. Precipitation during the growing season was above the 30-yr normals in 1998 at the Lethbridge site and in 1998 and 1999 at the Airdrie site. The 2000 growing season received 52 percent of the 30-yr normal precipitation at the Lethbridge site, and 83 percent of the 30-yr normal precipitation at the Airdrie site.

Manure Chemical Analysis

Mean values of selected parameters are shown in Table 1. More detailed results of the manure analyses are shown in Appendix 5.

The moisture content of the beef manure was similar for both sites. This was also true for the hog manure. There was only a slight tendency for drier manure used at the Lethbridge site (Table 1). Nutrient content varied greatly in the manures. For example, maximum ammonium-N concentration in the Airdrie hog manure was 2.6-fold greater than the minimum value, and as high as 261-fold for the Airdrie beef manure. Total phosphorus varied less than total nitrogen. Ammonium-N accounted, on average, for 11 to 16 percent of the total nitrogen in the beef manure, and for 44 to 63 percent in the hog manure (Table 1). Nitrate-N content was about 1.5 percent of the total nitrogen in the beef manure, and accounted for a negligible amount of total nitrogen (i.e. about 0.002 percent on average) in the hog manure (Appendix 5). On average, total nitrogen content was 2.2 to 4.4 times greater than total phosphorus content. The greatest variability in the nitrogen-to-phosphorus ratio occurred in the hog manure (Table 1). Extractable phosphate-P generally accounted for 6 to 65 percent of the total phosphorus content (Appendix 5). However, essentially all of the phosphorus was in the phosphate-P form in the hog manure

Table 1. Mean, range, and standard deviation values of selected parameters measured on the beef and hog manure used at the two research sites.

Parameter [z]	Mean	Minimum	Maximum	Stand. Dev.	n
		Lethbridge site beef manure			
moisture (%)	49.4	33.4	71.1	10.1	29
ammonium-N (mg kg^{-1})	1616	96	4329	1179	29
total nitrogen (mg kg^{-1})	10003	3000	18400	4200	29
total phosphorus (mg kg^{-1})	3483	800	7700	1815	29
total potassium (mg kg^{-1})	10916	5930	18878	3325	29
		Lethbridge site hog manure			
moisture (%)	93.0	86.9	99.8	4.7	27
ammonium-N (mg kg^{-1})	1481	248	2930	770	27
total nitrogen (mg kg^{-1})	3370	500	4900	1256	27
total phosphorus (mg kg^{-1})	1504	100	3100	966	27
total potassium (mg kg^{-1})	1012	233	1680	375	25
		Airdrie site beef manure			
moisture (%)	56.9	36.6	74.5	13.1	22
ammonium-N (mg kg^{-1})	701	12	3128	739	22
total nitrogen (mg kg^{-1})	6145	3500	9400	1659	22
total phosphorus (mg kg^{-1})	2195	1200	3800	775	22
total potassium (mg kg^{-1})	7417	2220	13196	3255	22
		Airdrie site hog manure			
moisture (%)	96.1	94.6	98.3	1.0	17
ammonium-N (mg kg^{-1})	3071	1670	4350	967	17
total nitrogen (mg kg^{-1})	4882	2800	6500	1001	17
total phosphorus (mg kg^{-1})	1112	500	1600	252	17
Total potassium (mg kg^{-1})	1402	714	2178	497	15

[z] Values are expressed on a wet-weighted basis. To convert to a dry-weight basis, multiply by 100 and then divide by (100 - percent moisture).

used at the Lethbridge site in spring, 1998 (Appendix 5, Table 5.2). This was consistent for the three subsamples that were analysed.

The manure application rates were originally based on assumed available nitrogen and moisture contents, with the intent of applying 67, 134, 201, and 268 kg ha^{-1} of available nitrogen for both manure types. The assumed values used were 2.2 kg Mg^{-1} (2200 mg kg^{-1}) of available nitrogen and 50 percent moisture content for the beef manure, and 1.6 kg Mg^{-1} (1600 mg kg^{-1}) of available nitrogen and 96 percent moisture content for the hog manure (ILOC 1995). The Code of Practice (ILOC 1995) defines available nitrogen as the portion of the total nitrogen that is in

the mineral (usually ammonium-N), plant-available form at the time of application. The actual available nitrogen in the manure varied widely as stated above.

The Code of Practice also uses a term called "crop nitrogen", which is defined as an estimate of available nitrogen plus the portion of the organic nitrogen that is mineralized during the growing season, less the amount of nitrogen lost by volatilization (ILOC 1995). Crop nitrogen should be used as a manure's fertilizer effectiveness, rather than available nitrogen. Crop nitrogen is largely a result of biological processes, which are influenced by a variety of factors that can be influenced by the quality of the manure and method of application and incorporation. As a result, it is essentially impossible to measure crop nitrogen directly. However, total nitrogen and ammonium-N (i.e. available nitrogen) analyses can be used to estimate crop nitrogen, based on a few assumptions. Many manure application calculators follow a similar approach and use similar assumptions. The Manure Application Rate Calculator 1998 (MARC98) program assumes that 25 percent of the organic nitrogen (total N less ammonium-N) will become available to plants through the process of mineralization, and that a portion of the ammonium-N will be lost through volatilization depending on method of application and climatic conditions (Manitoba Agriculture 1999). Appendix 6 shows the ammonium-N (i.e. available nitrogen) and total nitrogen that was actually applied for the lowest manure application rate (i.e. 31 Mg ha^{-1} beef manure and 42 Mg ha^{-1} hog manure), and the estimated crop nitrogen, using the MARC98 assumptions. Similar calculations were carried out for the other three manure application rates and the results are summarized in Table 2.

The average application rate of total nitrogen from beef manure was nearly twice that from hog manure at the Lethbridge site (Table 2). However, the amount of ammonium-N applied was similar for the two manure types, and was about 15 percent less than the original target application rates. In contrast, total nitrogen applied at the Airdrie site was similar between the two manure types, whereas the amount of ammonium-N was more than four-fold larger for the hog manure compared to the beef manure. Beef manure supplied about 42 percent of the target ammonium-N application rate on average, and hog manure supplied about 1.75 times the target rate at the Airdrie site. On average, the beef-manure plots at the Lethbridge site received the most total nitrogen, followed by the hog-manure plots at the Airdrie site, beef-manure plots at the Airdrie site, and hog-manure plots at the Lethbridge site. Crop nitrogen estimates were largest for Airdrie site hog-manure plots. The two manure types at the Lethbridge site provided similar amounts of crop nitrogen, and the Airdrie site beef-manure plots had the smallest amount of crop nitrogen. The reason why the hog-manure plots at the Airdrie site had more crop nitrogen than the beef-manure plots at the Lethbridge site, even though more total nitrogen was applied at the latter site, is a much higher proportion of the nitrogen was in ammonium-N form and it was assumed very little of this was lost through volatilization because the hog manure was injected into the soil.

Based on the above results and discussion, care needs to be taken when making comparisons between the two manure types for a given site and year, and for comparison between sites and among years. Table 3 shows the average annual application of various elements from the manure rates at the two sites.

Table 2. Average application rates of total nitrogen, and ammonium-N, and estimated crop nitrogen at the Lethbridge and Airdrie field sites.

Rate no.	Manure application rate (Mg ha^{-1})	Target rate of available N (kg ha^{-1})	Actual total N applied (kg ha^{-1})	Actual available N[z] applied (kg ha^{-1})	Estimated crop N[y] (kg ha^{-1})
		Lethbridge site beef manure			
1	31	67	299	55	77
2	61	134	598	110	154
3	92	201	897	165	231
4	123	268	1196	220	308
		Lethbridge site hog manure			
1	42	67	148	59	81
2	84	134	296	118	162
3	126	201	444	177	243
4	168	268	592	236	324
		Airdrie site beef manure			
1	31	67	192	28	55
2	61	134	384	56	110
3	92	201	576	84	165
4	123	268	768	112	220
		Airdrie site hog manure			
1	42	67	205	117	139
2	84	134	410	234	278
3	126	201	615	351	417
4	168	268	820	468	556

[z] Measured as ammonium-N.

[y] Crop nitrogen was calculated by assuming that 25 percent of the organic nitrogen was mineralized during the first year after application, and 50 percent of the available N was lost from the surface-applied beef manure and zero loss of available N from the injected hog manure under cool, dry conditions (Appendix 6).

Soil Chemical Analysis

All soil chemical data are shown in Appendix 7, including the individual replicate values and means. Results of the statistical analysis are shown in Appendix 8.

Soil texture. Selected soil samples collected in 1998 were analysed to determine soil texture. Sand and silt content decreased with depth, whereas clay content increased with depth at the

Table 3. Average annual application rates of total phosphorus, sulphur, sodium, potassium, calcium, magnesium, iron, aluminum, copper, manganese, boron, and zinc from applied manure at the Lethbridge and Airdrie sites.

Rate no.	Manure rate applied (Mg ha^{-1})	Total elemental application (kg ha^{-1})											
		P	S	Na	K	Ca	Mg	Fe	Al	Cu	Mn	B	Zn
Lethbridge site beef manure													
1	31	105	64	78	324	571	165	182	164	0.8	4.7	0.3	6
2	61	206	125	153	637	1124	324	359	323	1.6	9.3	0.6	12
3	92	311	189	230	961	1696	489	541	487	2.4	14	0.9	18
4	123	416	253	308	1284	2267	654	723	651	3.2	19	1.2	24
Lethbridge site hog manure													
1	42	66	18	9	41	88	30	14	10	0.8	1.4	0.1	2.6
2	84	132	36	19	83	176	60	27	19	1.7	2.8	0.1	5.3
3	126	198	54	28	124	265	90	41	29	2.5	4.2	0.2	7.9
4	168	263	72	38	166	353	119	55	39	3.4	5.5	0.3	11
Airdrie site beef manure													
1	31	66	36	31	206	362	92	110	91	0.4	3.7	0.2	2.0
2	61	131	70	62	405	713	182	217	179	0.7	7.3	0.3	4.0
3	92	197	106	93	610	1075	274	327	270	1.0	11	0.5	6.0
4	123	263	142	125	816	1437	367	438	361	1.4	15	0.7	8.0
Airdrie site hog manure													
1	42	47	20	34	58	53	18	3.4	1.0	0.5	0.7	0.1	2.2
2	84	94	40	68	116	105	35	6.8	2.0	0.9	1.4	0.1	4.3
3	126	140	60	103	174	158	53	10	3.0	1.4	2.2	0.2	6.5
4	168	187	79	137	232	210	71	14	4.0	1.8	2.9	0.2	8.7

Lethbridge site (Table 4). The textural class was dominantly clay at the Lethbridge site. Soil at the Airdrie site contained more sand and less clay than the Lethbridge site. Clay loam was the dominate soil-texture class at the Airdrie site (Table 4).

Extractable nitrate-N. Baseline (1996) mean nitrate-N content in the soil ranged from 3.0 to 36.8 kg ha^{-1} throughout the site and with depth at the Lethbridge site (Fig. 3a, c, e, g). Nitrate-N content was relatively uniform down the soil profile, with slightly higher amounts in the 60- to 90-cm depth. Five annual applications of beef and hog manure significantly increased nitrate-N content in the soil profile relative to the control (Fig. 3b, d, f, h). Manure rates were significant to the 60- to 90-cm depth for the fall-application treatment, and to the 60- to 120-cm depth for the spring application treatments. Generally, there were few differences between beef and hog manure at the Lethbridge site. Hog manure had significantly higher nitrate-N content in the 15- to 30-cm and 30- to 60-cm depths for the fall-application treatments, whereas beef manure had higher nitrate-N content in the 0- to 15-cm and 30- to 60-cm depths for the spring applied

Table 4. Soil texture analysis of selected 1998 samples from the two study sites.

Soil depth (cm)	Sand Mean (%)	Sand s.d.[z]	Silt Mean (%)	Silt s.d.[z]	Clay Mean (%)	Clay s.d.[z]	Texture class[y]
			Lethbridge site				
0-15	19.9	2.4	29.0	1.8	51.1	2.0	C
15-30	17.9	3.1	30.4	2.3	51.7	2.5	C
30-60	15.3	4.9	30.9	6.4	53.9	6.0	C
60-90	14.1	5.1	29.0	5.1	56.9	6.8	C
90-120	13.6	7.2	26.4	4.5	60.1	8.5	C
120-150	15.7	9.3	22.4	7.1	61.9	13.3	HC
			Airdrie site				
0-15	35.7	8.3	43.5	8.1	20.8	3.3	L
15-30	31.6	5.9	40.6	5.0	27.7	3.8	CL
30-60	30.8	6.6	37.8	4.6	31.4	3.7	CL
60-90	33.2	8.7	36.4	4.8	30.3	5.3	CL
90-120	33.9	10.5	36.2	6.5	29.9	7.1	CL
120-150	32.3	9.7	36.8	6.2	30.9	9.4	CL

[z] standard deviation.
[y] C = clay, HC = heavy clay, L = loam, CL = clay loam

treatments. There were no manure type-by-application rate interactions at the Lethbridge site (Appendix 8, Table 8.1).

The baseline (1997) mean nitrate-N content at the Airdrie site was also generally low (2.9 to 30.3 kg ha^{-1}) and uniform (Fig. 4a, c, e, g). There were a few exceptions where nitrate-N increased with depth in three plots (plots 12, 41, and 78; Appendix 1). These plots were associated with treatments spring-hog-rate 3 in rep 1, fall-hog-rate 3 in rep 3, and spring-hog-rate 1 in rep 4 (Fig. 2c and g). These three plots were distributed throughout the site (Appendix 1) and it is unknown why they had higher nitrate-N content than the rest of the site. There was a significant difference between the two manure types at the Airdrie site. In fact, the beef treatments were not significantly different from the control (Appendix 8, Table 8.1; Fig. 2b and f). However, the highest rate of spring-applied beef treatment tended to have the highest nitrate-N content throughout the soil profile, but the differences were not statistically significant (Fig. 4b). As a result there was a significant manure type-by-year interaction at the Airdrie site (Appendix 8, Table 8.1). Hog manure applications significantly increased soil nitrate-N in the soil profile (Fig. 4d and h). It appeared that more nitrate-N accumulated with the spring application of hog manure than with the fall application, however application time could not be statistically compared. Similar to the Lethbridge site, most of the increase in soil nitrate-N was restricted to the 0- to 90-cm depth. This suggests that nitrate-N derived from the manure had leached into the soil profile. High manure application rates can cause nitrate-N accumulation

and leaching in soil, and this can pose a threat to groundwater quality (Chang and Entz 1996; Olson et al. 2001).

The change in nitrate-N with time in the 0- to 90-cm depth is shown in Fig. 5 for the Lethbridge site and in Fig. 6 for the Airdrie site. There was a highly significant treatment-by-year interaction (Appendix 8, Table 8.1). Except for the beef-manure treatments at the Airdrie site, nitrate-N content generally increased with rate and with year. However, there were manure-by-year interactions at both sites. At the Lethbridge site for fall applications, hog-manure treatments had significantly higher levels of nitrate-N than beef manure in 1999, whereas there were no significant differences between beef and hog manure in the other years. At the Lethbridge site for spring applications, beef-manure treatments had significantly higher levels of nitrate-N than hog manure in 2000, whereas there were no significant differences between beef and hog manure in the other years. At the Airdrie site, there were no differences between beef and hog manure in 1997 and 1998 for the fall applications, and in 1997 to 1999 for the spring applications, whereas soil nitrate-N content in the 0- to 90-cm depth was significantly higher for hog manure in the other years for both application times. There were also rate-by-year interactions except for the fall applications of hog manure at the Airdrie site (Appendix 8, Table 8.1). Though soil nitrate-N content generally increased with manure application rate, there were some years this was not true, such as the fall application of hog manure in 1998 at the Lethbridge site (Fig. 5d) and the hog-spring application in 1999 at the Airdrie site (Fig. 6b). Also, at the Airdrie site there was a significant manure-by-rate interaction, which reflects the difference between the two manure types at this site (Fig. 6).

The most striking observation in the nitrate-N data is the differences in nitrate-N accumulation between the two sites. More nitrate-N accumulated from hog manure at the Airdrie site (Fig. 4), whereas nitrate-N accumulated to similar amounts for both manure types at the Lethbridge site (Fig. 3). This difference between the two sites may be due to a number of factors. A significant portion of nitrogen in manure can be lost by ammonia volatilization during storage and land application (Lockyer et al. 1989). However, ammonia loss can continue to occur after land application. Researchers have shown that non-incorporated manure caused the highest loss of ammonia, and that incorporated manure greatly reduced volatile-nitrogen loss (McGinn and Pradhan 1997). Reduced nitrogen loss by incorporation into soil has been attributed to greater contact between soil and manure, and this can enhance the sorption of ammonium on soil particles (Coffee and Bartholomew 1964). In our study, beef manure was surface applied and not incorporated, whereas the hog manure was injected directly into the soil. We would, therefore, expect more volatile-nitrogen loss from the solid beef manure. This explains the Airdrie data, but not the Lethbridge data. In fact, the nitrate-N content in the surface soil was slightly higher for the beef-manure treatments at the Lethbridge site (Fig. 3). The lack of difference between the beef and hog manure treatments at the Lethbridge sites can be explained by the manure chemical analysis (Table 2), which showed that on average about twice as much total nitrogen was added in the beef manure treatments compared to the hog-manure treatments. In contrast, about the same amount of total nitrogen was applied in the beef- and hog-manure treatments at the Airdrie site. This may have compensated, to a large extent, for the greater volatile-N loss from the surface-applied beef manure at the Lethbridge site. McGinn and Pradhan (1997) showed that a light irrigation (6 mm) immediately after the surface application of cattle manure (non-incorporated) can significantly reduce volatile ammonia loss. Even though

the Lethbridge site was irrigated, we suspect this factor only had a minor effect because the sites were not irrigated immediately after manure application.

Extractable ammonium-N. Baseline ammonium-N content throughout the soil profile was on average less than 50 kg ha^{-1} at the Lethbridge site in 1996 (Fig. 7) and less than 20 kg ha^{-1} at the Airdrie site in 1997 (Fig. 8). Extractable ammonium-N content was not affected by manure type or manure rate from 1997 to 2000 at the Lethbridge site (Fig. 9) and from 1998 to 2000 at the Airdrie site (Fig. 10). However, there were significant accumulations of ammonium-N in 2001, particularly at the Lethbridge site. Most of the ammonium-N accumulation was restricted to the 0- to 60-cm depth. Ammonium-N content in 2001 increased as manure rate increased at the Lethbridge site. There was no significant difference between the two manure types. The increase in ammonium-N at the Lethbridge site in 2001 was not expected. It is assumed that nitrification is not a limiting process in arable, tillage systems, and it is unusual to observe an accumulation of ammonium-N (Jarvis et al. 1996). However, Jarvis and Barraclough (1991) suggested that significant accumulation of ammonium-N may occur in grassland soils that are grazed or receive fertilizer or farm waste. It may have been by chance that when we soil sampled in the April, 2001, that we managed to detect an accumulation of ammonium-N. We suspect that with time (i.e., several weeks) that this ammonium-N would have nitrified to nitrate-N. This may also be reflected in the nitrate-N data. The soil nitrate-N content in 2001 was generally less than what was observed in 2000 at the Lethbridge site (Fig. 5). Possibly a lot more ammonium-N had not yet nitrified to nitrate-N by the time soil samples were collected in April 2001.

Even though some increases in ammonium-N was observed at the Airdrie site in 2001, the increases were not significant. There were no consistent trend among the manure rates at the Airdrie site. For example, the apparent large increase in ammonium-N for the spring-hog-rate 3 treatment in 2001 (Figs. 8d and 10b) was caused by unusually high values found in one of the rep 4 plots (plot number 77; Appendix 1). If this replicate is removed from the data, the mean for this treatment becomes similar to the other treatments. This is also true for the spring-beef-rate 4 treatment in the 0- to 15-cm depth (Fig. 8b).

Extractable phosphate-P. Extractable phosphate-P increased in the soil with added manure at both sites. Most of the increase in phosphate-P occurred in the 0- to 15-cm soil layer. However, there were inconsistencies among manure application rates and among years. There were significant treatment-by-year interactions and rate-by-year interactions at both sites (Appendix 8, Table 8.3). Phosphate-P content in soil is expected to increase as manure is applied with time, particularly if application rates are in excess of crop requirements (Sharpley et al. 1994; Breeuwsma et al. 1995; Graetz et al. 1999). However, this was not always the case each year, particularly at the Lethbridge site (Fig. 11a and d). Whalen and Chang (2001) reported large increases in soil phosphorus after 16 yr of annual beef manure application on continuous cereal plots in southern Alberta. Vervoort et al. (1998) observed phosphorus accumulation in soil after poultry manure was applied to hayfields. At the Lethbridge site, phosphate-P generally increased until 1998, and then decreased in 1999, followed by a relatively large increase in 2000, with a decrease in 2001 (Fig. 11). There was a more consistent increase in phosphate-P with time at the Airdrie site (Fig. 12). However, there were some discrepancies from this trend, such as for the fall-applied hog-manure treatments (Fig. 12d). The inconsistent nature of the phosphorus-P data may be due to the soil extraction method that was used in the study. The Miller-Axley extraction

method is similar to the Bray extraction method. Both methods use ammonium fluoride (NH_4F) and hydrochloric acid (HCl). The Bray and other extraction methods are often not considered suitable for calcareous soil (Kleinman et al. 2001). Perhaps this may have been a factor for the calcareous soils at the two study sites.

Extractable sodium. Prior to the start of the study at the Lethbridge, mean sodium content was 53 kg ha^{-1} in the 0- to 15-cm depth, and increased with depth to about 640 kg ha^{-1} (Fig 13). Variability was generally greater with depth. Hog manure had no effect on sodium content (Fig. 13d and h; Appendix 8, Table 8.4), whereas beef manure caused significant increases in sodium content in the 0- to 60-cm depth (Fig. 13b and f; Appendix 8, Table 8.4) at the Lethbridge site. There was a significant treatment-by-year interaction (Appendix 8, Table 8.4). After 1998, sodium content increased as manure rate increased (Fig. 14a and c). Beef manure had no effect in 1997 and 1998 for the spring-applied treatments and no effect in 1997 for the fall-applied treatments. For the fall-beef treatments, the rate 3 was significantly higher than the control in 1998. In 1999, rates 3 and 4 were significantly higher than the control. All four rates were significantly higher than the control in 2000 and 2001. For the spring-beef treatments, all four rates were significantly higher than the control in 1999 to 2001. The difference between beef and hog manure may be due to the difference in the amount of sodium added to the soil from the two manure types. On average, a range of 78 to 308 kg ha^{-1} (rates 1 to 4) of sodium was added from beef manure, whereas only 9 to 38 kg ha^{-1} (rates 1 to 4) was added from hog manure (Table 3).

The application of manure also increased sodium content for the fall-applied treatments at the Airdrie site, whereas the spring-applied treatments had no significant effect. Even though there were no significant effects for the spring-applied treatment, there was a trend for sodium content to increase with manure rate and to increase with time for annual applications of manure (Fig. 15a and b). The fall-applied treatments caused significant increases in sodium content (Fig. 15c and d). In 1998 the two highest hog manure rates were significantly higher than the control. In 1999, all four hog-manure rates and the beef-manure rates 2 to 4 treatments had significantly more sodium then the control. All four rates of both manure types contained more sodium than the control in 2000 and 2001.

Clearly, manure application increased sodium content in soil, but the extent of increase depended on manure quality. The accumulation of sodium in soil from long-term manure application may degrade soil quality by adversary affecting soil structure (Miller et al. 1999). However, Miller et al. (1999) found that beef manure applied annually for 24 yr on rainfed and irrigated cereal plots either had a positive or neutral effect on soil physical properties.

Extractable potassium. Soil potassium was not significantly affected by the application of hog manure at either site (Appendix 8, Table 8.5). Potassium levels were significantly increased by beef manure, but were restricted to the 0- to 30-cm depth (Figs. 16b, 16f, 17b, and 17f). Potassium content generally increased as manure rate increased. However, there were treatment-by-year interactions (Appendix 8, Table 8.5) and these can be seen in Figs. 18a, 18c, 19a, and 19c. For example, Fig. 18c shows no differences among the five manure rates for the fall-applied beef manure in 1997, 1998, and 1999, whereas the four manure-rate treatments had significantly higher potassium content than the control in 2000 and 2001. Because of these treatment

interactions there were manure-by-rate, manure-by-year, and manure-by-rate-by-year interactions (Appendix 8, Table 8.5).

The difference in potassium accumulation between the two manure types can be attributed to the different amounts of added potassium from the manure treatments. On a wet-weight basis, the average potassium content in beef manure was 11 times greater at the Lethbridge site and five times greater at the Airdrie site than in hog manure (Appendix 5). After taking into account the different application rates for the two manure types, the average amount of potassium applied from beef manure was nearly eight times greater than from hog manure at the Lethbridge site and nearly four times greater than hog manure at the Airdrie site (Table 3).

Extractable sulphate-S. Manure application had no effect on sulphate-S in the soil at the Lethbridge site, regardless of manure type and time of application (Appendix 8, Table 8.6). Manure application at the Airdrie site increased sulphate-S in the 0- to 30-cm depth (Fig. 20). There were no significant differences in 1998 and 1999 for the spring-applied treatments and in 1998 for the fall-applied treatments. The highest rates of beef and hog manure for the spring-applied treatments had significantly more sulphate-S than the control in 2000 and 2001. The beef-rate 3 treatment in 2000 and the hog-rate 3 in 2001 had significantly higher sulphate-S than the control (Fig. 20a and b). The other beef and hog application rates were not significantly different from the control in 2000 and 2001. For the fall-applied beef treatments, only the highest application rate treatment had significantly higher sulphate-S than the control in 1999 to 2001 (Fig. 20c). Rates 2, 3, 4 of fall-applied hog manure were significantly higher than the control in 1999 to 2001 (Fig. 20d). Other researchers have reported minimal effects of manure on soil extractable sulphate-S. Chang et al. (1991) concluded that the effect of annual beef manure for 11 yr on soluble sulphate-S in soil was smaller than for other measured soil parameters. Chang et al. (1990) used regression analysis to determine the rate of accumulation of various soluble salts and nutrients from manure application, and they found that changes in soluble sulphate-S in soil were poorly correlated with time. Warman and Cooper (2000b) applied fresh and composted chicken manure to a mixed forage crop and found few significant differences among treatments for Mehlich 3-extractable sulphate-S.

pH. Surface mean pH (0 to 15 cm) prior to treatments application was 7.83 ± 0.02 (standard error) at the Lethbridge site. Soil pH increased slightly with depth, with an average value of 8.08 ± 0.03 at the 120- to 150-cm depth. Soil pH also increased with soil depth at the Airdrie site with a mean range of 7.32 ± 0.04 (0 to 15 cm) to of 8.65 ± 0.03 (120 to 150 cm).

Manure application had no effect on soil pH at the Airdrie site (Appendix 8, Table 8.7). However, the application of beef and hog manure had a significant effect at the Lethbridge site. The effect was only observed in the 0- to 15-cm depth (Appendix 8, Table 8.7). There was a treatment-by-year interaction for the Lethbridge spring-application. The general trend was the application of manure reduced soil pH (Table 5). The decreases compared to the controls were relatively small, with the largest difference of 0.4 pH units. Significant decreases were generally only associated with the two higher application rates for both manure types and these mainly occurred in 2000 and 2001.

Table 5. Soil pH values for the 0- to 15-cm depth at the Lethbridge site.

Year[z]	Control	Spring-applied treatments				Fall-applied treatments			
		Rate 1	Rate 2	Rate 3	Rate 4	Rate 1	Rate 2	Rate 3	Rate 4
					Beef manure [y]				
1996	7.8	7.9	7.9	7.8	7.8	7.8	7.8	7.9	7.8
1997	7.9	7.9	7.8	7.8	7.8	7.8	7.8	7.8	7.9
1998	8.1	8.1	8.0	**7.9 ***	**7.9 ***	8.0	8.0	8.0	8.0
1999	8.0	8.0	8.0	8.1	8.1	7.9	7.9	8.0	7.9
2000	8.0	7.9	**7.9 ***	**7.8 ***	**7.8 ***	7.9	7.9	**7.8 ***	**7.8 ***
2001	7.8	7.7	7.7	7.7	**7.5 ***	7.7	7.7	7.8	**7.6 ***
					Hog manure [y]				
1996	7.8	7.7	7.8	7.8	7.8	8.0	8.0	7.9	7.7
1997	7.9	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8
1998	8.1	8.1	8.1	8.0	**7.9 ***	8.0	7.9	7.9	8.0
1999	8.0	8.0	7.9	8.1	7.9	8.1	7.8	7.9	7.9
2000	8.0	7.9	7.9	**7.7 ***	**7.7 ***	8.0	7.8	**7.7 ***	**7.6 ***
2001	7.8	7.8	7.8	7.7	**7.4 ***	7.7	7.7	**7.6 ***	**7.5 ***

[z] 1996 baseline values are for soil samples collected prior to treatment application.
[y] Means followed with an asterisk (*) are significantly different ($P < 0.05$) from the control for a given year.

Chang et al. (1991) reported a 0.3- to 0.7-unit decrease in soil pH after 11 yr of annual manure application during a field experiment carried out in southern Alberta. They attributed the decrease in pH to nitrification of ammonium-N and organic acid production during manure decomposition. Others have found that manure application can increase soil pH (Smith et al. 1980; Whalen et al. 2000). Whalen et al. (2000) reported a 0.8 to 1.2 unit increase in acid soils amended with beef manure in a laboratory study. Manure application can either increase or decrease soil pH depending on manure and soil characteristics (Whalen et al. 2000).

Electrical conductivity. The surface (0-15 cm) mean electrical conductivity for the Lethbridge site in 1996 (baseline) was 0.70 ± 0.03 dS m^{-1}. Electrical conductivity generally remained constant to the 60- to 90-cm depth, but increased to 1.41 ± 0.14 dS m^{-1} in the 90- to 120-cm depth and to 2.42 ± 0.19 dS m^{-1} in the 120- to 150-cm depth. There were essentially no treatment effects for the spring-applied manure treatments (Appendix 8, Table 8.8). The exception was in the 30- to 60-cm depth, where the rate 4 beef treatment was significantly higher than the control in 2000 and 2001 (Table 6). There were essentially no treatment effects for fall-applied manure from 1997 to 1999. There were significant differences in the upper three soil depths (0-15, 15-30, and 30-60 cm) in 2000 and 2001 (Appendix 8, Table 8.8). Most of the differences were associated with beef manure, whereas only the highest hog manure rate had significantly higher electrical conductivity values than the control (Table 6).

Table 6. Soil electrical conductivity values (dS m^{-1}) at the Lethbridge site.

Year[z]	Control	Spring-applied treatments				Fall-applied treatments			
		Rate 1	Rate 2	Rate 3	Rate 4	Rate 1	Rate 2	Rate 3	Rate 4
					0- to 15-cm depth; Beef manure [y]				
1996	0.7	0.6	0.5	0.7	0.7	1.2	0.5	0.6	0.6
1997	0.6	0.7	0.6	0.7	0.7	0.8	0.6	0.8	0.7
1998	0.8	0.7	0.7	1.2	0.9	1.1	0.9	0.8	**1.4 ***
1999	0.6	0.7	0.8	0.8	0.8	1.0	0.8	0.9	0.9
2000	0.8	1.0	0.9	**1.1 ***	**1.4 ***	**1.3 ***	**1.5 ***	**2.1 ***	**2.2 ***
2001	1.2	1.3	1.1	1.2	**1.9 ***	1.5	**1.7 ***	**2.0 ***	**3.0 ***
					0- to 15-cm depth; Hog manure [y]				
1996	0.7	0.9	0.6	0.6	0.7	0.6	0.6	0.7	0.6
1997	0.6	0.6	0.7	0.6	0.6	0.6	0.6	0.5	0.6
1998	0.8	0.6	0.7	1.0	0.9	0.8	0.8	1.0	0.7
1999	0.6	0.6	0.6	0.6	0.8	0.7	0.8	1.1	1.1
2000	0.8	0.8	0.8	1.1	0.9	0.8	0.9	1.2	1.3
2001	1.2	**0.8 ***	1.0	1.0	1.1	1.1	1.2	1.3	**1.7 ***
					15- to 30-cm depth; Beef manure [y]				
1996	0.9	1.2	0.7	0.7	0.8	1.3	0.6	0.8	0.8
1997	0.6	0.5	0.5	0.7	0.6	0.7	0.6	0.5	0.7
1998	0.7	0.7	0.6	0.7	0.7	0.7	0.8	0.7	0.9
1999	0.6	0.6	0.7	0.6	0.9	0.6	0.7	0.6	0.8
2000	0.6	0.7	0.6	0.9	0.9	0.9	**1.0 ***	**1.3 ***	**1.9 ***
2001	0.8	0.9	1.0	1.0	1.3	1.1	1.1	**1.5 ***	**1.7 ***
					15- to 30-cm depth; Hog manure [y]				
1996	0.9	1.1	1.0	0.8	1.0	0.8	0.6	0.7	0.6
1997	0.6	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.7
1998	0.7	0.6	0.7	0.8	0.8	0.7	0.6	0.8	0.7
1999	0.6	0.5	0.5	0.6	0.6	0.7	0.6	0.6	0.7
2000	0.6	0.6	0.6	0.7	0.8	0.7	0.8	0.9	**1.1 ***
2001	0.8	0.8	1.0	0.9	1.1	0.9	1.0	1.1	**1.2 ***
					30- to 60-cm depth; Beef manure [y]				
1996	0.8	1.0	0.6	0.7	0.8	0.8	0.6	0.7	0.8
1997	0.5	0.5	0.5	0.6	0.6	0.8	0.5	0.6	0.7
1998	0.6	0.6	0.6	0.7	0.8	0.8	0.6	0.6	0.7
1999	0.6	0.6	0.7	0.8	0.9	0.6	0.6	0.7	0.8
2000	0.5	0.6	0.7	0.8	**0.9 ***	0.6	0.8	**0.9 ***	**1.2 ***
2001	0.6	0.8	0.8	0.9	**1.3 ***	**0.9 ***	**0.9 ***	**1.1 ***	**1.4 ***
					30- to 60-cm depth; Hog manure [y]				
1996	0.8	0.9	0.8	0.6	0.8	1.0	0.6	0.6	0.8
1997	0.5	0.6	0.6	0.5	0.6	0.6	0.6	0.5	0.7
1998	0.6	0.5	0.7	0.6	0.6	0.7	0.5	0.6	0.6
1999	0.6	0.5	0.6	0.6	0.6	0.6	0.5	0.5	0.7
2000	0.5	0.5	0.6	0.7	0.5	0.6	0.6	0.6	**0.8 ***
2001	0.6	0.7	0.8	0.8	0.9	0.8	0.7	0.8	0.8

[z] 1996 baseline values are for soil samples collected prior to treatment application.

[y] Means followed with an asterisk (*) are significantly different ($P < 0.05$) from the control within a given soil depth, manure type, and year.

Electrical conductivity at the Airdrie site in 1997 (baseline) was relatively low and similar throughout the soil profile. The site averages for the six incremental soil depths ranged from 0.41 to 0.48 dS m^{-1} (Fig. 21). There was a clear increase in soil electrical conductivity for both manure types and for both application times (Fig. 21). Electrical conductivity increased with manure rate and with time for repeated manure applications (Fig. 22). Treatment effects were observed in the top three soil depths (Table 7). Significant differences were observed in each year after manure application started. In 1998, only the two highest rates of fall-applied beef and hog manure were significantly different in the 0- to 15-cm depth. Overall, hog manure had a greater effect on soil electrical conductivity than beef manure at the Airdrie site.

Some of the manure treatments increased soil electrical conductivity to near or above 2 dS m^{-1} in the top 15 cm, changing the soil from a non-saline status to a weakly saline status. Soil salinity increased by manure application has regulatory implication in Alberta. The Agricultural Operation Practices Act (Province of Alberta 2001) states that, "A person must not apply manure in an amount that would increase the soil salinity after the manure is applied by more than 1 dS m^{-1} … in the top 15 cm". The Act also states that, "A person must not apply manure to a soil if the soil salinity is more than 4 dS m^{-1} … in the top 15 cm".

Electrical conductivity of the manures used at the two sites varied with time (Appendix 5). The average electrical conductivity at the Lethbridge site was 12.4 dS m^{-1} for beef manure and 11.4 dS m^{-1} for hog manure. The average electrical conductivity of manure used at the Airdrie site was 7.6 dS m^{-1} for beef manure and 32.4 dS m^{-1} for hog manure. The hog manure used at the Airdrie site contain a higher salt load than beef manure based on electrical conductivity measurements. This is probably why hog manure had a larger effect on soil electrical conductivity than beef manure at the Airdrie site. Charles (1999) applied beef and hog manure on canola plots in Saskatchewan and found no significant differences in soil electrical conductivity among treatments. The lack of any difference was attributed to the low salt loads from only one application of manure. Our results showed that at least two or more years of manure application are required before significant differences can be detected. Other workers have shown that several years of manure application, often at high rates, will significantly increase soil electrical conductivity (Liebhardt and Shortall 1974; Pratt 1984; Chang et al. 1991; Olson et al. 2001). Chang et al. (1991) compared adjacent rainfed and irrigated plots regarding the effects of repeated beef manure application on soil chemical properties. They reported that soil electrical conductivity increased as manure rate increased, and that the effects were observed to a depth of 90 cm in the rainfed plots and down to 150 cm in the irrigated plots. They found that irrigation reduced the buildup of salts at the soil surface and that electrical conductivity of subsoil was higher under irrigation than under nonirrigation. Pratt (1984) reported that higher irrigation rates can reduce the buildup of salts from manure application. In our study, the irrigated site and the dryland site can not be compared because of the distance between sites (> 200 km), different soil types, and cropping practices. We suspect that without irrigation at the Lethbridge site, the accumulation of salts would have been more concentrated near the soil surface.

Organic matter. Manure application at the Airdrie site had no significant effect on soil organic matter. However, at the Lethbridge site treatment effects and treatment-by-year interactions were observed, but these were restricted to the 0- to 15-cm depth in 1998 for spring-applied beef

Table 7. Soil electrical conductivity values (dS m^{-1}) at the Airdrie site.

Year[z]	Control	Spring-applied treatments				Fall-applied treatments			
		Rate 1	Rate 2	Rate 3	Rate 4	Rate 1	Rate 2	Rate 3	Rate 4
					0- to 15-cm depth; Beef manure [y]				
1997	0.5	0.5	0.4	0.6	0.4	0.5	0.4	0.4	0.5
1998	0.5	0.5	0.6	0.6	0.5	0.6	0.5	0.6	**0.7** *
1999	0.5	0.6	0.6	0.6	**0.7** *	0.7	0.8	0.8	**1.7** *
2000	0.5	0.6	0.7	**0.9** *	**1.2** *	0.7	0.8	**1.0** *	**1.5** *
2001	0.6	0.6	0.8	**1.0** *	**1.7** *	0.7	0.8	**1.5** *	**2.0** *
					0- to 15-cm depth; Hog manure [y]				
1997	0.5	0.4	0.5	0.5	0.5	0.4	0.4	0.4	0.5
1998	0.5	0.5	0.6	0.7	0.8	0.7	0.6	0.8	**1.2** *
1999	0.5	0.5	0.7	0.8	**1.0** *	0.9	0.9	1.1	**1.7** *
2000	0.5	0.5	**0.8** *	**0.8** *	**1.4** *	0.9	1.1	**1.5** *	**1.8** *
2001	0.6	0.7	**1.0** *	**1.0** *	**1.8** *	1.1	1.4	**1.6** *	**2.0** *
					15- to 30-cm depth; Beef manure [y]				
1997	0.4	0.4	0.3	0.4	0.5	0.4	0.5	0.4	0.4
1998	0.5	0.5	0.5	0.5	0.4	0.4	0.5	0.6	0.6
1999	0.5	0.4	0.5	0.5	0.6	0.5	0.6	0.5	**0.7** *
2000	0.5	0.6	0.5	0.7	**0.8** *	0.6	0.6	0.7	**0.9** *
2001	0.5	0.6	0.6	**0.8** *	**1.2** *	0.6	0.7	**1.0** *	**1.3** *
					15- to 30-cm depth; Hog manure [y]				
1997	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.3
1998	0.5	0.5	0.5	0.6	0.5	0.6	0.5	0.5	0.7
1999	0.5	0.4	0.6	0.7	**1.0** *	0.6	0.6	**0.9** *	**0.8** *
2000	0.5	0.5	0.6	**0.8** *	**1.1** *	0.5	0.7	**0.8** *	**1.1** *
2001	0.5	0.5	**1.2** *	**1.7** *	**2.0** *	0.7	**1.1** *	**1.1** *	**1.2** *
					30- to 60-cm depth; Beef manure [y]				
1997	0.5	0.5	0.4	0.5	0.4	0.4	0.6	0.4	0.4
1998	0.4	0.4	0.5	0.5	0.5	0.4	0.7	0.5	0.5
1999	0.5	0.4	0.5	0.5	0.5	0.5	0.6	0.5	0.5
2000	0.5	0.7	0.6	0.5	0.7	0.6	**0.7** *	**0.7** *	**0.8** *
2001	0.6	0.6	0.6	0.6	**1.0** *	0.5	0.6	**0.9** *	**1.1** *
					30- to 60-cm depth; Hog manure [y]				
1997	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5
1998	0.4	0.4	0.4	0.5	0.7	0.4	0.4	0.5	0.5
1999	0.5	0.4	0.5	0.7	0.8	0.5	0.4	0.5	0.7
2000	0.5	0.5	0.6	0.8	**1.1** *	0.6	0.6	**0.7** *	**0.7** *
2001	0.6	0.6	0.8	**1.6** *	**1.6** *	0.6	0.6	**1.0** *	**0.9** *

[z] 1996 baseline values are for soil samples collected prior to treatment application.

[y] Means followed with an asterisk (*) are significantly different ($P < 0.05$) from the control within a given soil depth, manure type, and year.

manure and in 2000 and 2001 for both manure types and both application times (Table 8). There were significant manure type-by-year interactions. In the years that manure application had a significant effect, there were no differences between the two manure types for the spring-applied treatments in 1998 and for the fall-applied treatments in 2000. Beef manure plots had significantly higher organic matter content than hog manure plots for spring-applied treatments in 2000 and 2001 and for fall-applied treatments in 2001. Taking the spring-applied and fall-applied treatments together, by 2001 the plots that received the highest beef-manure rate had 1.78 times more organic matter than the control in the top 15-cm soil depth, whereas the plots that received the highest hog-manure rate had 1.37 times the organic matter than the control. The difference between the two manure types may be due to the total amount of organic matter that was applied. For a given manure rate (e.g. rate 2) about three times more organic matter was applied from beef manure compared to hog manure at the Lethbridge site (Table 9).

Table 8. Soil organic matter content (Mg ha^{-1}) in the 0- to 15-cm depth at the Lethbridge site.

		Spring-applied treatments				Fall-applied treatments			
Year[z]	Control	Rate 1	Rate 2	Rate 3	Rate 4	Rate 1	Rate 2	Rate 3	Rate 4
					Beef manure [y]				
1996	99	97	94	99	101	96	100	100	100
1997	103	107	108	125	118	115	106	122	122
1998	103	116	111	**135 ***	**138 ***	119	120	115	122
1999	89	106	98	97	83	101	97	92	101
2000	105	117	125	**132 ***	**139 ***	123	119	**130 ***	**142 ***
2001	109	**147 ***	**151 ***	**177 ***	**187 ***	**145 ***	**140 ***	**148 ***	**200 ***
					Hog manure [y]				
1996	99	105	100	104	101	104	102	100	98
1997	103	104	107	105	98	106	105	109	97
1998	103	110	109	114	124	110	122	124	104
1999	89	92	101	93	93	91	94	93	90
2000	105	110	113	120	121	114	111	**124 ***	123
2001	109	117	124	123	**160 ***	122	**130 ***	**133 ***	**138 ***

[z] 1996 baseline values are for soil samples collected prior to treatment application.
[y] Means followed with an asterisk (*) are significantly different ($P < 0.05$) from the control for a given manure type and year.

Table 9. Average amount of organic matter added per year from manure application at the two sites.

	Organic matter applied (kg ha^{-1})			
Manure rate no.	Lethbridge site beef manure	Lethbridge site hog manure	Airdrie site beef manure	Airdrie site hog manure
1	7663	2614	5279	1288
2	15326	5228	10558	2576
3	22989	7842	15837	3864
4	30652	10456	21116	5152

The lack of significant effects at the Airdrie site may have been caused by the higher initial soil organic matter content, which may have made it difficult to detect any changes in only four years of manure application. Baseline organic matter content in the top 15 cm of soil was 195 Mg ha^{-1} at the Airdrie site and 100 Mg ha^{-1}at the Lethbridge site. Paré et al. (1999) could not measure any significant difference in soil carbon content after a single application of cattle manure. Many other researchers have shown that soil organic matter content can be increased with repeated manure application (Sommerfeldt et al. 1988; Chang et al. 1991; Schulten and Leinweber 1991; Barkle et al. 2000; Grant et al. 2001; Kanchikerimath and Singh 2001).

Forage Yield

The application of manure had no significant effect on alfalfa yield at the Lethbridge site in 1996 to 1998, regardless of the manure type and the time of application (Fig. 23). Yield differences for the fall treatments in 1996 were not expected since these plots had not yet received manure applications. In 1999, most manure treatments yielded significantly higher than the control, except for spring-beef-rate 1 and fall-beef-rates 1 and 2 (Fig. 24a). All manure treatments yielded higher than the control in 2000 (Fig. 24b). There were significant treatment-by-year interactions for the fall- and spring-applied treatments (Appendix 8, Table 8.10). There were no significant differences among the four rates for each manure type and no differences between the two manure types, regardless of the application time and year (Appendix 8, Table 8.10).

Timothy yield was not significantly different from the control for the spring-applied treatments in 1997 at the Airdrie site (Fig. 25a). The fall-applied plots also showed no differences from the control, but this was expected since the fall-applied manure treatments had not yet been applied. In 1998 to 2000, manure treatments often had significantly higher yield than the control (Figs. 25b and 26). The spring-applied treatments had a significant rate and year effect, whereas the fall-applied treatments had significant manure, year, and manure-by-year interaction effects (Appendix 8, Table 8.10). The spring-applied treatments showed no differences between the two manure types. Generally, yield increased as the spring-applied manure rate increased from rates 1 to 3. Rate 4 was not significantly different than rates 2 and 3, and there was a tendency for yield from the rate 4 treatment to be less than rate 3. This may be an indication that a yield depression occurred with the high application rate, though the yield from the rate-4 treatment remained significantly higher than the control and rate 1. There were significant manure, year, and manure-by-year interaction effects for the fall-applied manure treatments (Appendix 8, Table 8.10). Fall-applied hog manure significantly yielded more than fall-applied beef manure in 1998 and 1999. On average for the four rates, beef manure yielded 17 percent less than hog manure in 1998 and 25 percent less than hog manure in 2000. Hog manure plots yielded slightly higher in 1999, but the difference was not significant. Though the spring-applied and fall-applied treatments could not be statistically compared because of the experimental design, there appeared to be a tendency for the yields of the spring-applied treatments to be higher than the yields from the fall-applied treatments. This trend was not consistent among years. Yields from spring-applied manure was about 17 to 18 percent greater than fall-applied manure on average in 1998 and 2000, whereas yields for the two application times were nearly the same in 1999. This tendency many be caused by the different number of manure applications relative to a given growing season. For example, in 1998 the spring-applied-

manure plots had two annual manure applications (i.e. applied in the springs of 1997 and 1998), whereas the fall-applied-manure plots had only one annual manure application (i.e. fall 1997).

Daliparthy et al. (1995) applied liquid dairy manure to established alfalfa for 2 yr at two sites in western Massachusetts, United States. They observed a positive yield response at one site and no significant yield response at the other site. The difference between the two sites was attributed to the age of the alfalfa crops. The site that showed a yield response to manure had a 2-yr-old alfalfa crop, whereas the other site had a 1-yr-alfalfa crop. Preliminary research in Saskatchewan has shown that shallow injection of liquid hog manure in crested wheat, Russian wildrye, and smooth brome-alfalfa stands increased yield by 1.5 to 4.4 fold in the first year of a 3-yr study (Pastl et al. 1999). Other researchers have also shown the positive influence manure application can have on forage yield (Schmitt et al. 1993; Liu et al. 1997; Ma et al. 1998; Bittman et al. 1999; Sullivan et al. 2000). Legumes, such as alfalfa, have the ability to fix nitrogen from the atmosphere, but they will use nitrate from the soil first (Mathers et al. 1975). The presence of nitrate can also reduce the nodulation of legumes and subsequently reduce dinitrogen fixation (Munns 1968; Paul and Clark 1989; Cherney and Duxbury 1994).

Forage Tissue Analysis

No tissue analyses were not carried out for the alfalfa crop at the Lethbridge site in 1996. All tissue chemistry data are shown in Appendix 9.

Protein. Protein content in alfalfa from the spring-applied manure plots did not differ from the control in 1997, 1998 and 2000 at the Lethbridge site. Only alfalfa from the spring-beef-rates 2 to 4, and the spring-hog-rates 1 and 4 plots had significantly higher protein content than the control in 1999 (Fig. 27c). There were more differences for the fall-applied treatments, with differences for beef and hog manure in 1998 to 2000 (Fig. 27). When significant differences occurred, the protein content for the manure treatment was always greater than the control plots. There were no significant trends among the four manure rates for either manure type regardless of the application time (Appendix 8, Table 8.10). However, manure type was significant for spring- and fall-applied treatments. There were no significant interactions with manure type. Beef-manure treatments had significantly higher protein content than hog-manure treatments at the Lethbridge site. The average protein content for spring-applied-beef manure was 25.4 percent and for spring-applied-hog manure was 24.3 percent ($p > 0.0043$). The average protein content for fall-applied-beef manure was 24.9 percent and for fall-applied-hog manure was 24.2 percent ($p > 0.0173$). The difference between the two manure types may be caused by the larger amount of total nitrogen added from beef manure (Table 2).

There was no treatment effects in 1997 for the fall-applied treatments at the Airdrie site because the fall-manure treatments had not been applied (Fig. 28a). Treatment, year, and treatment-by-year interaction were significant for the spring-applied and fall-applied treatments (Appendix 8, Table 8.10). Where treatment values were different than the control, the former was always significantly higher than the latter, and in some cases the manure treatment more than doubled the protein content relative to the control (Fig. 28). Among the four application rates, manure type, rate, manure-by-rate interaction (fall-applied only), year, manure-by-year interaction, rate-by-year interaction, and manure-by-rate-by-year interaction were significant at

the Airdrie site (Appendix 8, Table 8.10). The spring-applied treatments showed a strong positive relationship with protein content in timothy. For the fall-applied treatments, this trend was not as consistent. In 1998 for beef and hog manure, in 1999 for hog manure, and in 2000 for beef manure this trend seems to hold. But for beef manure in 1999 and hog manure in 2000, protein content in timothy peaked at a lower manure rate (i.e. rate 3 and 2, respectively) and then decreased thereafter for higher application rates (Fig 28c and d). In contrast to the Lethbridge site, hog manure generally caused higher protein content than beef manure at the Airdrie site. The average protein content for spring-applied-beef manure was 7.91 percent and for spring-applied-hog manure was 10.6 percent ($p = 0.0001$). The average protein content for fall-applied-beef manure was 6.57 percent and for fall-applied-hog manure was 7.97 percent ($p = 0.0001$). These differences may be due to the difference in the amount of total nitrogen applied from the two manure types. More total nitrogen was applied to the hog manure plots than to the beef manure plots at the Airdrie site (Table 2). As already indicated, there were manure-by-rate and manure-by-year interactions. There were no significant differences between beef and hog manure at the lowest rate for both application times, and there was no difference between the two manure types in 1998 for the fall-applied treatments.

The above results show that addition of nitrogen from manure application can increase protein content in alfalfa and timothy. The response was more pronounced for timothy than for alfalfa. Other workers have shown that application of nitrogen fertilizer to soil can increase protein content in timothy (Guertin et al. 1979; Belanger et al. 1989). The response of protein content in alfalfa to added nitrogen is less clear. Cherney and Duxbury (1994) reported that added nitrogen increased nitrogen concentration in young alfalfa plants grown in vermiculite. In contrast, Schmitt et al. (1994) found in a field study that preplant application of hog manure did not result in consistently more nitrogen in alfalfa. Even though we observed protein content increases in alfalfa with the addition of manure, these increases were relatively small and not consistent.

Acid detergent fiber. There was no effect of manure application on acid detergent fiber (ADF) content in alfalfa at the Lethbridge site (Appendix 8, Table 8.10). However, there was a year effect for the two application times. All year comparisons for the spring plots were significantly different, except for the comparison between the 1999 (31.4 percent) and 2000 (31.9 percent) ADF mean values. All year comparisons for the fall plots were significantly different, except for the comparison between the 1997 (36.0 percent) and 1998 (37.2 percent) ADF mean values.

There were significant treatment, year, and treatment-by-year interaction effects at the Airdrie site for ADF content in timothy. There were no treatment effects in 1997 for the spring- and fall-applied treatments (Fig. 29a). This was expected for the fall-applied plots because the manure treatments had not yet been applied. In 1998 and 1999, all manure treatments had higher ADF content than the control (Fig. 29b and c). In 2000, only the spring-beef-rates 2 and 3, fall-hog-rates 1 and 2, and the fall-hog-rate 1 treatments were significantly higher than the control (Fig. 29d). All the other treatments did not differ from the control in 2000. There was a slight significant ($p = 0.0351$) manure-type effect only for the fall-applied treatments, and there was no differences among the four manure rates for either manure type or application time (Appendix 8, Table 8.10). The average ADF content was 39.7 percent for the fall-applied-beef and 40.7 percent for the fall-applied-hog manure.

We could not find any references in the literature that examined the effects of manure application on acid detergent fiber content of forages. However, a few workers have reported the effects of inorganic fertilizers, usually nitrogen fertilizer, on acid detergent fiber content. Stringer et al. (1996) found that the addition of nitrogen fertilizer to a mixture of bermudagrass [*Cynodon dactylon* (L.) Pers.] and alfalfa slightly decreased acid detergent fiber content in the grass, but had no effect on fiber content in alfalfa. Mooso et al. (1996) also reported a small decrease in acid detergent fiber with the addition of nitrogen fertilizer to bermudagrass. Jefferson et al. (2001) grew timothy with 100 and 150 kg ha^{-1} nitrogen fertilizer and reported that the higher fertilizer rate caused a slight decrease in fiber content compared to the lower fertilizer rate. O'Leary and Rehm (1990) found that nitrogen and sulphur fertilizers had no consistent effect on acid detergent fiber content in corn (*Zea mays* L.)silage. However, Cox et al. (1993) found that acid detergent fiber content in corn responded linearly to nitrogen fertilizer rates. A single application of nitrogen fertilizer on a forage mixture planted on lodgepole pine (*Pinus contorta* Dougl. ex Loud.) clear-cut sites caused an increase in acid detergent fiber content in year one and a decrease in fiber content in years two and three relative to the control (Wikeem et al. 1993). Collins et al. (1990) applied nitrogen fertilizer to nine oat (*Avena sativa* L.) cultivars at two sites in Wisconsin, United States. They found that nitrogen generally had a tendency to slightly reduce acid detergent fiber, but at one site during one crop year, fiber content increased rapidly with nitrogen fertilizer.

Nitrate. Manure application significantly increased nitrate content of alfalfa at the Lethbridge site. However, there was a treatment-by-year interaction for the spring- and fall-applied treatments (Appendix 8, Table 8.10). For the spring applications, nitrate content generally increased as beef- and hog-manure rates increased (Fig. 30). However, some of the manure-rate treatments, particularly rates 1 and 2 for both manure types, were not significantly higher than the control each year. Fall-applied treatments did not differ from the control in 1997 and 1998, whereas alfalfa, for most manure rates, had significantly higher nitrate content than the control (Fig. 30). There was a significant rate effect for the spring-applied manure rates (Appendix 8, Table 8.10). There were no significant manure-type effects for either application time, and there was no significant rate effect for the fall-applied manure rates.

Beef manure had no significant effect on the nitrate content in timothy for either manure type or application time at the Airdrie site (Appendix 8, Table 8.10). Hog manure significantly increased nitrate content (Appendix 8, Table 8.10), and this was particularly evident for the spring-applied treatments (Fig. 31). There was a manure-by-rate interaction for the spring-applied manure treatments because beef manure did not affect nitrate content. Generally, as hog manure rate increased, nitrate content increased (e.g. 1997 to 1999). However, this trend was not as evident in 2000, though the three highest application rates were significantly greater than the control (Fig. 31d). The two highest fall rates of hog manure in 1998 and 2000, and the fall-hog-rate 3 in 1999 were the only treatments that caused an increase in nitrate content in timothy. The increases caused by the fall applications were considerably less than the increases observed for the spring-applied treatments (Fig. 31). Statistically, there were no manure type, rate, year, or interaction effects for the fall-applied manure treatments (Appendix 8, Table 8.10).

Phosphorus. Spring-applied beef and hog manure significantly increased phosphorus content of alfalfa at the Lethbridge site. There was a significant year effect, but there was no treatment-by-

year interaction (Appendix 8, Table 8.10). Spring-applied-beef manure treatments had significantly higher phosphorus content (3297 mg kg^{-1}) than spring-applied-hog manure treatments (3069 mg kg^{-1}). Beef and hog manure applied in the fall had no effect on alfalfa phosphorus content in 1997 (Fig. 32). In 1998 to 2000, all four fall-beef rates and most of the hog-manure rates significantly increased phosphorus content (Fig. 32b, c, and d). Fall-applied-beef manure treatments had significantly higher phosphorus content (3173 mg kg^{-1}) than fall-applied-hog manure treatments (3041 mg kg^{-1}). There were also significant rate, year, manure-by-year interaction, and rate-by-year interaction effects for the fall-applied treatments (Appendix 8, Table 8.10). Beef- and hog-manure fall-applied treatments did not differ in 1997 and 1998, but they were significantly different in 1999 and 2000. Other researchers have shown that phosphorus content in alfalfa can be increased with the addition of manure or phosphorus inorganic fertilizer (Goss and Stewart 1979), whereas Schmitt et al. (1993) found no effect from manure application.

Spring-applied manure in 1997 to 2000 and fall-applied manure in 1998 to 2000 increased phosphorus content in timothy at the Airdrie site (Fig. 33). There were treatment-by-year interactions for the fall-applied treatment, and this was caused by the lack of treatment effect in 1997 because the fall-manure treatments had not yet been applied. There was a manure-type effect for both application times (Appendix 8, Table 8.10). Spring-applied-hog manure treatments had significantly higher phosphorus content (2158 mg kg^{-1}) than spring-applied-beef manure treatments (1886 mg kg^{-1}). Fall-applied-hog manure treatments had significantly higher phosphorus content (1677 mg kg^{-1}) than fall-applied-beef manure (1539 mg kg^{-1}). This was the opposite to what was observed for alfalfa at the Lethbridge site, even though more total phosphorus was applied by beef manure than by hog manure at both sites (Table 3). There was also a manure-by-year interaction for both application times (Appendix 8, Table 8.10). Hog manure was significantly higher than beef manure only in 1997 (2481 vs. 2069 mg kg^{-1}) and 1998 (2331 vs. 1925 mg kg^{-1}) for the spring-applied treatments, and only in 2000 (1769 vs. 1400 mg kg^{-1}) for the fall-applied treatments. Liu et al. (1997) found that the application of hog manure generally increased phosphorus content in bermudagrass and annual ryegrass (*Lolium multiflorum* Lam.), but varied with date of harvest. Warman (1986) obtained mixed results from a 2-yr study where they applied inorganic fertilizer, hog manure, and sewage sludge on timothy. They found that phosphorus content in timothy was higher with the addition of hog manure relative to the control in the first year, but in the second year there were no differences between the hog manure treatments and the control. In another study by Warman and Cooper (2000a) they applied fresh and composted chicken manure to a mixed-forage sward of grasses and legumes. They observed an increase of phosphorus content in the mixed-forage tissue.

Calcium. None of the manure treatments significantly affected calcium content in alfalfa at the Lethbridge site. However, there was a significant year effect (Appendix 8, Table 8.11). Yearly means for the two application times ranged from 2.07 to 2.39 percent. All year comparisons for the spring plots were significantly different, except for the comparison between the 1998 (2.12 percent) and 1999 (2.09 percent) calcium mean values. All year comparisons for the fall plots were significantly different, except for the comparison between the 1998 (2.07 percent) and 1999 (2.10 percent) calcium mean values. Razmjoo and Henderlong (1997) reported that the application of fertilizer to alfalfa had little effect on calcium content of alfalfa.

Calcium content in timothy was not significant affected by spring-applied manure in 1997, and only the spring-beef-rate 1 and spring-hog-rate 4 treatments significantly affected calcium content in 1998 (Fig. 34a and b). Fall-applied manure had no effect in 1998 (Fig. 34b). In 1999, rates 2, 3, and 4 of spring-applied and fall-applied manure caused significantly higher calcium content relative to the control (Fig. 34c). The only time beef manure caused a significant difference was for the spring-applied treatments in 2000 (Fig. 34d). The effect of hog manure on calcium content was not as prominent in 2000 compared to 1999. Overall, there was a tendency for manure to cause an increase in calcium content in timothy at the Airdrie site, but the effect was not consistent with manure type, rate, or from year to year. Warman and Cooper (2000b) also observed inconsistencies in the effect of applied manure, compost, and inorganic fertilizer on the calcium content in a mixed-forage crop.

Magnesium. None of the manure treatments significantly affected magnesium content in alfalfa at the Lethbridge site. However, there was a significant year effect (Appendix 8, Table 8.11). Yearly means for the two application times ranged from 4377 to 6003 mg kg^{-1}. All year comparisons for the spring plots were significantly different, except for the comparison between the 1998 (4377 mg kg^{-1}) and 1999 (4633 mg kg^{-1}) magnesium mean values. Only three year comparisons for the fall plots were significantly different: 1997 (4805 mg kg^{-1}) and 2000 (5837 mg kg^{-1}); 1998 (4446 mg kg^{-1}) and 2000; and 1999 (4586 mg kg^{-1}) and 2000.

There were few significant differences relative to the control at the Airdrie site in 1997, 1998, and 1999 (Fig. 35a, b, and c). There was a tendency for the higher rates of hog manure to increase the magnesium content in timothy. In 2000, the higher rates of spring- and fall-applied hog manure and fall-applied beef manure treatments had significantly greater magnesium content in timothy compared to the control (Fig. 35d). Even though the spring-applied beef manure had higher magnesium content than the control, the values were not statistically different ($p > 0.0557$). As with calcium at the Airdrie site, there was a tendency for manure to cause an increase in magnesium content in timothy, but the effect was not consistent with manure type, rate, or from year to year. Warman and Cooper (2000b) found that the application of manure or inorganic fertilizer on a mixed-forage crop either decreased magnesium content in plant tissue or had no significant effect.

Sodium. Spring-applied beef and hog manure had no effect on sodium content in alfalfa at the Lethbridge site in 1997 and 1998 (Fig. 36a and b). However, in 1999 and 2000, sodium content in spring-applied manure treatments were significantly greater than the control, except for the lowest rate of hog manure in 1999 (Fig. 36c and d). Fall-applied manure treatments were not significantly different from the control (Appendix 8, Table 8.11). This seems to be evident from Fig. 36a and b for 1997 and 1998, but in 1999 and 2000, the fall-applied manure treatments consistently had higher sodium content than the control, but with the high variability, the differences were not statistically significant.

There were treatment, year, and treatment-by-year interaction effects for the spring-applied and fall-applied treatments at the Airdrie site (Appendix 8, Table 8.11). None of the treatments were significantly different from the control in 1997 to 1999. All significant differences occurred in 2000 (Fig. 37). Sodium content in timothy increased as manure rate increased. All rates were significantly greater than the control for spring-applied beef manure treatment. However, only

the highest application rates were significantly different from the control for the spring-applied hog manure and fall-applied manure. Manure types were significantly different for spring-applied treatments, but not for the fall-applied treatments (Appendix 8, Table 8.11). Averaged for the four application rates in 2000, timothy on spring-applied beef-manure plots contained 184 mg kg^{-1} sodium, whereas spring-applied hog-manure plots contained 63 mg kg^{-1} sodium. Manure type was not significantly different for fall-applied manure in 2000 (Appendix 8, Table 8.11), though sodium content in timothy in the beef-manure plots tended to be greater than in the hog-manure plots (Fig. 37d).

Potassium. For the most part, manure application had little effect on potassium content in alfalfa at the Lethbridge site. In 2000, all manure treatments had greater potassium content than the control, however, only three out of four fall-applied beef-manure rates and the fall-applied hog-rate 3 treatment were significantly different (Fig. 38d). In part contrast, Schmitt et al. (1993) reported that manure application consistently increased potassium content in alfalfa compared with the control treatment. They went on to suggest that the lack of crop yield response to the increase in potassium content infers that luxury consumption of potassium may have occurred. Warman and Cooper (2000a) observed a positively linear response in tissue potassium content of a mixed-forage crop with application rates of fresh and composted chicken manure. Manure type was significant for the spring-applied treatments (Appendix 8, Table 8.11). In 2000, alfalfa contained an average of 3.04 percent potassium for spring-applied beef manure, whereas alfalfa contained an average of 2.80 percent potassium for fall-applied hog manure. Fall-applied beef treatments tended to have greater potassium content (3.06 percent) than fall-applied hog treatments (2.90 percent), but the difference was not significant. This difference in manure type seems to follow the soil data, which showed much higher potassium accumulation from beef manure than from hog manure (Fig. 16).

Manure application caused a significant increase in potassium content in timothy at the Airdrie site. This was true for most rates of spring-applied beef and hog manure from 1997 to 2000, and for fall-applied beef and hog manure from 1998 to 2000 (Fig. 39). The effect of the lowest manure application rates were inconsistent from year to year. Rate effect, year effect, and rate-by-year interaction were significant for both application times (Appendix 8, Table 8.11). Manure-type effect was significant for spring-applied manure ($p = 0.0046$), but not for fall-applied manure. Timothy contained, on average, 1.76 percent potassium for the spring-applied hog-manure treatments, whereas average potassium content was 1.63 percent for spring-applied beef-manure treatments. This manure-type effect was opposite to what was observed at the Lethbridge site, even though soil potassium accumulated more from beef manure than from hog manure at the Airdrie site (Fig. 17).

Copper. Manure application at the Lethbridge site had little effect on copper content in alfalfa. The only significant differences that occurred were in 1999 for spring-applied hog manure when copper content of alfalfa for all four hog manure rates was less than the control (Fig. 40c). Manure type was a significant effect for both application times, with no interactions (Appendix 8, Table 8.11). On average, alfalfa copper content was 10 percent less on spring-applied hog manure treatments compared to spring-applied beef-manure treatments. On average, alfalfa copper content was six percent less on fall-applied hog manure treatments compared to fall-applied beef-manure treatments.

Manure application had no effect on copper content in timothy in 1997 to 1999 at the Airdrie site. In 2000, copper content in timothy increased as beef and hog manure rates increased for both application times (Fig. 41d). All of the applications rates caused significantly higher copper content in timothy except for the rate 1 and the spring-hog-rate 2. Manure type was a significant effect for the fall-applied treatments, but not for the spring-applied treatments. On average, timothy copper content was 17 percent less on fall-applied hog manure treatments compared to fall-applied beef-manure treatments.

Warman and Cooper (2000b) found that the application of fresh and composted chicken manure had little effect on copper content in a mixed forage crop. In contrast, other workers have reported that the application of animal manure increased copper concentration in test crops (Chang et al. 1994; van der Watt et al. 1994; Arnesen and Singh 1998). Payne et al. (1988) found that eight annual applications of hog manure increased copper content in corn ear-leaf tissue but did not affect copper content in corn grain. However, in a subsequent paper on the same study, but after 11 yr of manure application, Anderson et al. (1991) concluded that long-term application of pig manure did not affect copper concentration in corn.

Selenium. There was a slight treatment effect and a highly significant year effect for the spring-applied treatments at the Lethbridge site (Appendix 8, Table 8.12). The application of manure had a tendency to reduce selenium content in alfalfa (Fig. 42). There were a few significant differences in 1997, 1998, and 1999, and these differences were associated with the two higher rates of manure. In 2000, it was clear that as manure rate increased, selenium content decreased for the spring-applied treatments (Fig. 42d). There was no treatment effect, but there was a year effect for fall-applied manure on selenium content of alfalfa at the Lethbridge site (Appendix 8, Table 8.12). The annual mean selenium content for the fall-applied manure and control plots ranged from 0.44 mg kg^{-1} (1999) to 0.74 mg kg^{-1} (1997). There was also a significant manure-type effect for the fall-applied treatments (Appendix 8, Table 8.12). Hog-manure treatments had significantly higher selenium content (0.64 mg kg^{-1}) than beef-manure treatments (0.48 mg kg^{-1}).

As with the Lethbridge site, none of the fall-applied manure treatments were significantly different than the control (Appendix 8, Table 8.12). However, the trend was that selenium content values were less than the control for most plots that received manure. This was also true for the spring-applied manure treatments, with significant differences in each year (Fig 43). The reduction in selenium content was particularly evident in 1999. There was no significant rate effect at the Airdrie site (Appendix 8, Table 8.12). In 2000, there was a tendency for selenium content to increase as spring-applied beef manure rate increased, but none of the spring-applied beef-manure treatments were significantly different from the control (Fig. 43d). There was no difference between manure type for either application time at the Airdrie site.

In a pot study, Ajwa et al. (1998) showed that addition of soluble, inorganic selenium increased the selenium concentration in canola and tall fescue. They also observed that when cattle manure was applied with inorganic selenium, the amount of selenium accumulation in plant tissue was reduced. They suggested that the bioavailability (i.e. to the crop) of added selenium was reduced by the addition of organic materials, which can stimulate microbial

assimilatory reduction of selenium. Our results seem to support this concept, or at least the ability of added organic matter to reduce crop uptake of selenium.

Sulphur. Manure application had very little effect on sulphur content in alfalfa at the Lethbridge site. There was no treatment effect for the spring-applied treatments (Appendix 8, Table 8.12). However, there was a significant year effect. Annual mean sulphur content ranged from 3659 mg kg^{-1} (1998) to 4085 mg kg^{-1} (2000). Only a few of the fall-applied manure treatments were significantly different from the control (Fig. 44). In all cases that were significant, the manure sulphur content was greater for the manure treatments than for the control. Significant differences only occurred in 1997 and 1999. At the most, manure only had a minor effect of sulphur content in alfalfa at the Lethbridge site, with no consistent trend with manure type, rate, or year. Our results are in agreement with other workers who have found minimal effect of manure application on sulphur concentration in crop tissue (Chang et al. 1994; Warman and Cooper 2000b). However, others have found that cattle manure can increase sulphur concentration in canola (*Brassica napus* L.) (Eriksen and Mortensen 1999) and African millet (*Eleusine coracana* Gaertn.)(Chowdhury et al. 2000).

The application of manure had a greater effect on sulphur content in timothy at the Airdrie site. Spring-applied hog manure caused a significant increase in sulphur content each year (Fig. 45). Even though spring-applied beef manure had a tendency to increase sulphur content, particularly in 1999 and 2000, none of the beef manure treatments were statistically different from the control (Appendix 8, Table 8.12). The different response caused by the two manure types caused a significant manure-by-year interaction for the spring-applied manure treatments. Hog manure treatments had significantly higher sulphur content from 1997 to 1999, whereas there was no difference between the two manure types in 2000. There were no significant difference for the fall-applied treatments in 1997. This was expected since the fall-applied manure had not yet been applied. Figure 45b shows that as hog manure rate increased sulphur content increased, however, only the highest manure rate was significantly different from the control. The effect of annual hog manure application became more evident in 1999 and 2000 (Fig. 45c and d). Sulphur content in timothy on fall-applied beef manure plots was not significantly different from the control in 1998 and 1999 (Fig. 45). In 2000, beef manure rates 2, 3, and 4 significantly increased sulphur content. There was no significant difference between the two manure types for the fall-applied treatments, though there was a significant manure-by-year interaction.

Zinc. Manure application had no effect on zinc content in alfalfa from 1997 to 1999 at the Lethbridge site regardless of manure type and application time (Fig. 46a-c). In 2000, beef manure caused zinc content to increase as manure rate increased. Spring-applied beef manure rates 2, 3, and 4, and the two highest rates of fall-applied beef manure caused significantly higher zinc content in alfalfa than the control (Fig. 46d). Hog manure had very little effect, except for the spring-hog-rate-4 treatment. On average, more than two times the total zinc was applied in the beef-manure plots than in the hog-manure plots at the Lethbridge site (Table 3).

There was a strong tendency for zinc content in timothy to increase as manure rate increased. There were only a few significant differences for spring-applied hog manure in 1997, 1998, and 1999, and for fall-applied beef and hog manure in the same years (Fig. 47a-c). Most of the

differences were associated with the two highest application rates for both manure types. The effect of manure on zinc content was most evident in 2000 (Fig. 47d). All four application rates of spring- and fall-applied beef manure significantly increased zinc content relative to the control. Only the two highest application rates of hog manure caused significant increases. Manure type was not significant for the spring-applied treatments, whereas manure type and manure-by-year interactions were significant for the fall-applied manure treatments (Appendix 8, Table 8.12). There was no difference between the two manure types in 1999, but in 1998 and 2000, zinc content in timothy was greater for fall-applied beef manure compared to the fall-applied hog manure. On average, similar amount of total zinc were applied in the beef- and hog-manure plots at the Airdrie site (Table 3).

Chang et al. (1994) found that long-term application of cattle manure increased zinc concentration in barley (*Hordeum vulgare* L.). Arnsen and Singh (1998) reported that dairy and hog manures increased zinc concentration in grain and straw. In a greenhouse pot experiment, van der Watt et al. (1994) measured an increase in the zinc content in sorghum [*Sorghum bicolor* (L.) Moench)] caused by the application of chicken manure. In contrast, Warman and Cooper (2000b) reported that fresh and composted chicken manure caused few differences in mixed forage concentration of zinc. At the other end of spectrum of results, Pierzynski and Schwab (1993) found that cattle and poultry manures significantly decreased soybean [*Glycine max* (L.) Merr.] tissue zinc concentrations.

Manganese. The manganese content in alfalfa for hog-manure treatments was not significantly different from the control for either application times at the Lethbridge site (Appendix 8, Table 8.12). This was also true for beef manure in 1997, 1998, and 1999 (Fig. 48a-c). However, in 2000 spring- and fall-applied beef manure increased manganese content (Fig. 48d). Manure type was a significant factor for the spring-applied treatments. Manganese content in alfalfa was greater for beef-manure treatments (43.0 mg kg^{-1}) compared to hog-manure treatments (39.5 mg kg^{-1}). There was no manure-by-year interaction for the spring-applied treatments (Appendix 8, Table 8.12). Manure type and manure-by-year interactions were significant for the fall-applied treatments (Appendix 8, Table 8.12). There were no differences between beef and hog manure in 1998 and 1999, but in 2000 manganese content in alfalfa was greater for beef-manure treatments (63.3 mg kg^{-1}) compared to hog-manure treatments (47.5 mg kg^{-1}). On average, about 3.4 times more total manganese was added to the beef-manure plots than to the hog-manure plots (Table 3).

In contrast to alfalfa at the Lethbridge site, manganese content in timothy for beef-manure treatments was not significantly different from the control for either application times at the Airdrie site (Appendix 8, Table 8.12). There were few significant differences caused by hog-manure treatments in 1997 (spring applied), 1998, and 1999. The two highest spring-applied hog-manure rates and the three highest fall-applied hog-manure rates caused significantly higher manganese content compared to the control in 2000 (Fig. 49d). Manganese content in timothy was greater for hog-manure treatments (87.3 mg kg^{-1}) compared to beef-manure treatments (63.9 mg kg^{-1}). This is in contrast to the fact that about five times more total manganese was added to the beef-manure plots than to the hog-manure plots (Table 3). There was no manure-by-year interaction for the spring-applied treatments (Appendix 8, Table 8.12). Manure type and manure-by-year interactions were not significant for the fall-applied treatments (Appendix 8, Table 8.12).

Chang et al. (1994) found that cattle manure had no effect on manganese concentration in barley, whereas Warman and Cooper (2000b) reported a decrease in manganese concentration in a mixed forage crop with the addition of fresh and composted chicken manure. In contrast, van der Watt et al. (1994) found that chicken manure increased manganese concentration in sorghum tissue.

Aluminum, boron, and iron. None of the manure application treatments significantly affected aluminum, boron, and iron content, regardless of application time and site location (Appendix 8, Tables 8.11 and 8.12). However, there were significant year effects for all three parameters for each application time per site. Mean and range values are summarized in Table 10.

Table 10. Aluminum, boron, and iron content in alfalfa at the Lethbridge site and in timothy at the Airdrie site.

		Aluminum (mg kg^{-1})		Boron (mg kg^{-1})		Iron (mg kg^{-1})	
		Mean	SE [z]	Mean	SE	Mean	SE
				1997			
Lethbridge	alfalfa	162	6	53	1	239	8
Airdrie	timothy	88	4	6.8	0.1	131	6
				1998			
Lethbridge	alfalfa	121	3	45	1	155	3
Airdrie	timothy	330	47	6.5	0.1	236	16
				1999			
Lethbridge	alfalfa	116	4	45	1	180	11
Airdrie	timothy	306	39	4.6	0.1	298	27
				2000			
Lethbridge	alfalfa	704	37	55	1	536	27
Airdrie	timothy	1815	175	8.2	0.2	1833	189

[z] Standard error.

General discussion of crop-tissue results. The effects of manure application on tissue quality varied according to measured parameter, site location, year, manure type, and manure rate. There were manure-by-rate, manure-by-year, and rate-by-year interactions. Sixteen crop-tissue parameters were measured, and of these, 13 were significantly affected by manure application to some extent. Only boron, iron, and aluminum were not affected by beef or hog manure application. Most significant effects resulted in an increase of the concentrations in plant tissue of the measured parameters. The exception was selenium, which was the only parameter that

decreased in concentration with the application of manure. The cumulative effect of annual manure applications was apparent, because for many of the increases the effect became more pronounced in successive years.

The tissue quality results for alfalfa and timothy measured during the study are summarized in Tables 11 and 12 along with average values for Alberta (Corbett 1996) and values published by the National Research Council (2001). The values given by the National Research Council (NRC) are not specific for alfalfa and timothy, but rather are more general for legumes and grasses. The study results are summarized in two columns. The values in the first data column are from the control plots, and the results in the second data column are from the manured plots. The means in these two columns are for all plots (control or manured) for all study years.

Many of the parameters measured in alfalfa tissue from the control plots were generally higher than the Alberta 10-yr means and the NRC means (Table 11). The only exceptions were iron and manganese. The means for the manured plots tended to be higher than the control means for most parameters. Most of the manured-plot means were within 1 to 22 percent of the control

Table 11. Overall means of alfalfa tissue analysis from the Lethbridge site for the control and manured plots compared to 10-yr mean values for Alberta and mean values for feedstuff published by the National Research Council.

Parameter	Control plots from study [z] (alfalfa)	Manured plots from study [y] (alfalfa)	Alberta 10-yr means [x] (alfalfa)	NRC means [w] (legumes, forages) (hay, all samples)
Protein (%)	22.8 (2.3) [v]	24.7 (3.0)	18.1 (3.9)	20.2 (2.6)
Calcium (%)	2.24 (0.16)	2.21 (0.20)	1.80 (0.58)	1.52 (0.27)
Phosphorus (%)	0.27 (0.02)	0.31 (0.04)	0.23 (0.70)	0.26 (0.05)
Selenium (mg kg^{-1})	0.65 (0.19)	0.51 (0.25)	0.33 (0.80)	0.20 (0.18)
Sulphur (mg kg^{-1})	3616 (346)	3917 (535)	3100 (1100)	2500 (500)
Iron (mg kg^{-1})	255 (152)	286 (215)	213 (347)	286 (270)
Copper (mg kg^{-1})	10.7 (1.6)	10.0 (2.3)	6.3 (3.6)	9 (4)
Manganese (mg kg^{-1})	37 (8)	41 (14)	48 (74)	35 (13)
Zinc (mg kg^{-1})	33 (4)	36 (15)	27 (18)	24 (19)
Magnesium (mg kg^{-1})	4559 (621)	5053 (1089)	3100 (1400)	3000 (600)
Potassium (%)	2.73 (0.35)	2.95 (0.55)	1.80 (0.80)	2.53 (0.49)
Sodium (mg kg^{-1})	172 (59)	310 (143)	151 (256)	100 (1200)
Acid deter. fiber (%)	33.8 (3.6)	34.5 (3.8)	31.9 (8.9)	31.2 (4.6)
Nitrate (%)	0.03 (0.02)	0.25 (0.20)	na	na
Aluminum (mg kg^{-1})	264 (261)	282 (311)	na	na
Boron (mg kg^{-1})	53 (9)	49 (8)	na	na

[z] Means of all control plots from the study (n=64).
[y] Means of all manured plots from the study (number of samples ranged from 250 to 256).
[x] Corbett (1996).
[w] National Research Council (2001, Tables 15-1 and 15-3).
[v] Mean values followed by standard deviation in parentheses.

Table 12. Overall means of timothy tissue analysis from the Airdrie site for the control and manured plots compared to 10-yr mean values for Alberta and mean values for feedstuff published by the National Research Council.

Parameter	Control plots from study [z] (timothy)	Manured plots from study [y] (timothy)	Alberta 10-yr means [x] (timothy)	NRC means [w] (grasses, cool season) (hay, all samples)
Protein (%)	5.2 (0.99) [v]	8.25 (2.77)	8.2 (3.3)	10.6 (3.1)
Calcium (%)	0.41 (0.06)	0.51 (0.20)	0.54 (0.30)	0.58 (0.23)
Phosphorus (%)	0.11 (0.03)	0.18 (0.05)	0.15 (0.07)	0.23 (0.06)
Selenium (mg kg^{-1})	0.14 (0.05)	0.10 (0.07)	0.10 (0.14)	0.06 (0.06)
Sulphur (mg kg^{-1})	1114 (195)	1402 (431)	1400 (0.07)	2100 (600)
Iron (mg kg^{-1})	525 (669)	666 (1208)	173 (391)	156 (157)
Copper (mg kg^{-1})	3.1 (0.9)	4.5 (2.7)	5.6 (7.4)	9 (6)
Manganese (mg kg^{-1})	52 (22)	66 (46)	68 (82)	72 (52)
Zinc (mg kg^{-1})	23 (4)	34 (17)	26 (16)	31 (30)
Magnesium (mg kg^{-1})	1375 (310)	1690 (655)	1400 (0.05)	2000 (500)
Potassium (%)	1.19 (0.16)	1.60 (0.31)	1.25 (0.37)	2.01 (0.53)
Sodium (mg kg^{-1})	20 (10)	41 (56)	42 (54)	400 (800)
Acid deter. fiber (%)	36.8 (2.5)	40.4 (3.5)	37.3 (6.0)	39.5 (4.0)
Nitrate (%)	0.006 (0.001)	0.03 (0.06)	na	na
Aluminum (mg kg^{-1})	514 (660)	668 (1161)	na	na
Boron (mg kg^{-1})	6.8 (1.3)	6.5 (1.9)	na	na

[z] Means of all control plots from the study (n=64).
[y] Means of all manured plots from the study (number of samples ranged from 250 to 256).
[x] Corbett (1996).
[w] National Research Council (2001, Tables 15-1 and 15-3).
[v] Mean values followed by standard deviation in parentheses.

means, excluding nitrate. Only the sodium mean value for the manured plots was greater than 22 percent of the control plots. The means for the control plots and the manured plots generally fell within one standard deviation of the Alberta 10-yr means and the NRC means.

In contrast to alfalfa at the Lethbridge site, the means for timothy from the control plots at the Airdrie site tended to be lower than the Alberta 10-yr means and the NRC means (Table 12). The means for the manured plots tended to be higher than the control means for most parameters. The manured-plot means were within 9 to 105 percent of the control means, excluding nitrate. The simple comparison between the control-plot means and manured-plot means in Tables 11 and 12 indicates that timothy tissue quality was affected more by manure application than alfalfa under the conditions of the study. For the most part, the mean values for the manured plots are very similar to the Alberta 10-yr means and the NRC means. The notable exception is for iron, which is about four times higher for the manured plots (and three times higher for the control plots) compared to the Alberta 10-yr and NRC means. The sodium mean value for the manured plots is very similar to the Alberta 10-yr mean (41 versus 42 mg kg^{-1}), whereas both these values are

about one-tenth the NRC value of 400 mg kg^{-1}. It is unknown why there is such a large discrepancy between the Alberta 10-yr mean and the NRC mean for sodium content.

The balance between potassium and calcium plus magnesium in forage tissue can be a dietary problem for ruminants because grass tetany can result if the potassium-to-(calcium plus magnesium) ratio [K:(Ca+Mg) ratio] in forages exceeds 2.2:1 (Grunes et al. 1970). The K:(Ca+Mg) ratios for alfalfa at the Lethbridge site were well below this critical value through out the study with or without manure application (Table 13). However, at the Airdrie site K:(Ca+Mg) ratios for timothy were higher than alfalfa with several mean values above the critical level of 2.2. The highest ratio mean was 3.8 for the fall-applied beef-manure rate 3 treatment. The controls also had higher ratios ranging from 1.8 to 2.6. None of the manure treatments at either site were statistically different from the controls (Table 13).

Table 13. Potassium:(calcium + magnesium) ratios for alfalfa tissue at the Lethbridge site and for timothy tissue at the Airdrie site.

		Spring-applied treatments				Fall-applied treatments			
Year[z]	Control	Rate 1	Rate 2	Rate 3	Rate 4	Rate 1	Rate 2	Rate 3	Rate 4
					Lethbridge site - beef manure [z]				
1997	0.9	0.8	0.9	0.9	0.9	0.9	1.0	0.9	1.0
1998	1.1	1.2	1.3	1.2	1.3	1.2	1.1	1.2	1.2
1999	1.1	1.3	1.2	1.1	1.3	1.3	1.3	1.2	1.1
2000	0.9	1.2	1.1	1.1	1.4	1.3	1.0	1.3	1.2
					Lethbridge site - hog manure [z]				
1997	0.9	1.0	1.0	1.0	0.9	1.0	1.0	1.0	0.8
1998	1.1	1.1	1.1	1.2	1.0	1.2	1.1	1.2	1.1
1999	1.1	1.1	1.1	1.1	1.3	1.1	1.0	1.3	1.2
2000	0.9	1.1	1.0	0.9	1.0	1.1	1.0	1.1	1.0
					Airdrie site - beef manure [z]				
1997	2.6	2.7	3.0	3.0	3.1	2.6	2.3	2.3	2.3
1998	2.4	2.0	2.9	3.6	3.0	2.5	3.0	3.8	3.5
1999	1.8	2.8	2.6	2.6	2.8	4.6	3.1	2.3	3.4
2000	2.4	1.6	1.4	1.8	1.5	2.0	1.6	1.9	1.6
					Airdrie site - hog manure [z]				
1997	2.6	3.7	3.4	2.7	2.7	2.5	2.3	2.6	2.3
1998	2.4	3.0	2.9	2.9	2.7	3.1	3.2	3.5	3.5
1999	1.8	2.9	1.6	1.6	1.8	2.9	1.9	2.1	1.4
2000	2.4	2.4	2.5	1.8	1.9	2.6	2.0	2.2	2.7

[z] Means followed with an asterisk (*) are significantly different ($P < 0.05$) from the control for a given site, manure type, and year. There were no significant differences.

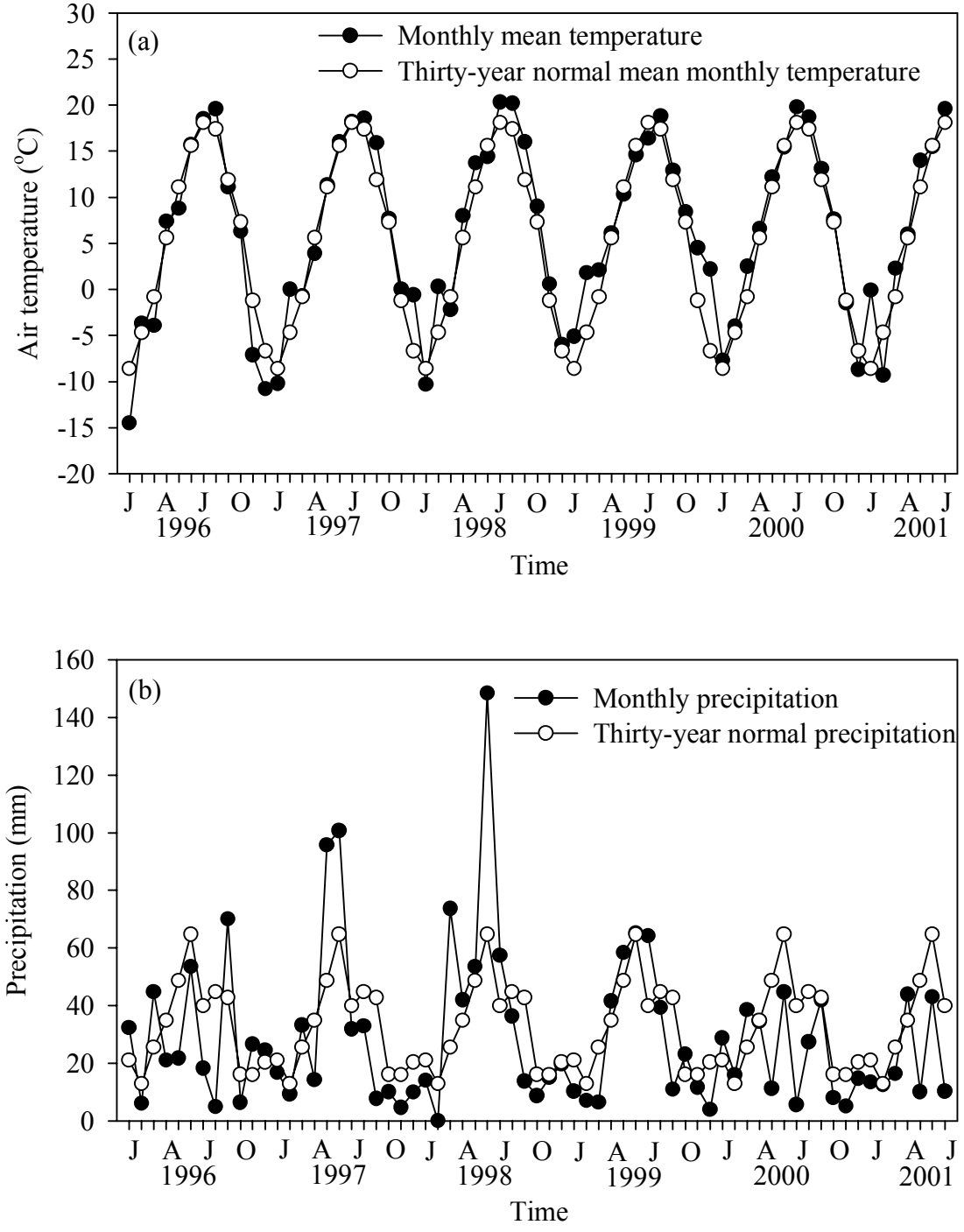


Fig. 1. Mean monthly temperature and monthly precipitation from 1996 to 2001 at the Agriculture and Agri-Food Canada Research Centre at Lethbridge.

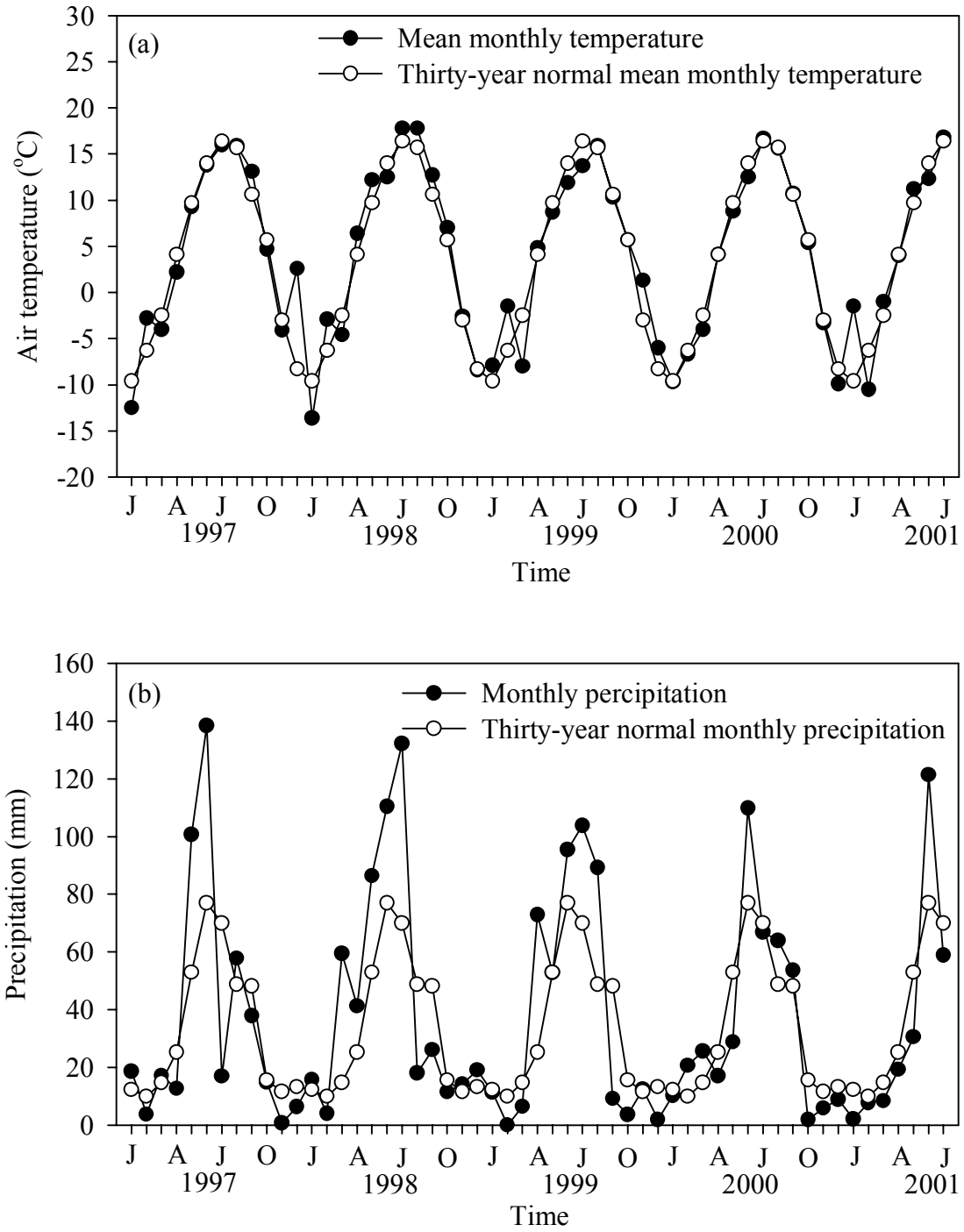


Fig. 2. Mean monthly temperature and monthly precipitation from 1997 to 2001 at the Calgary International Airport.

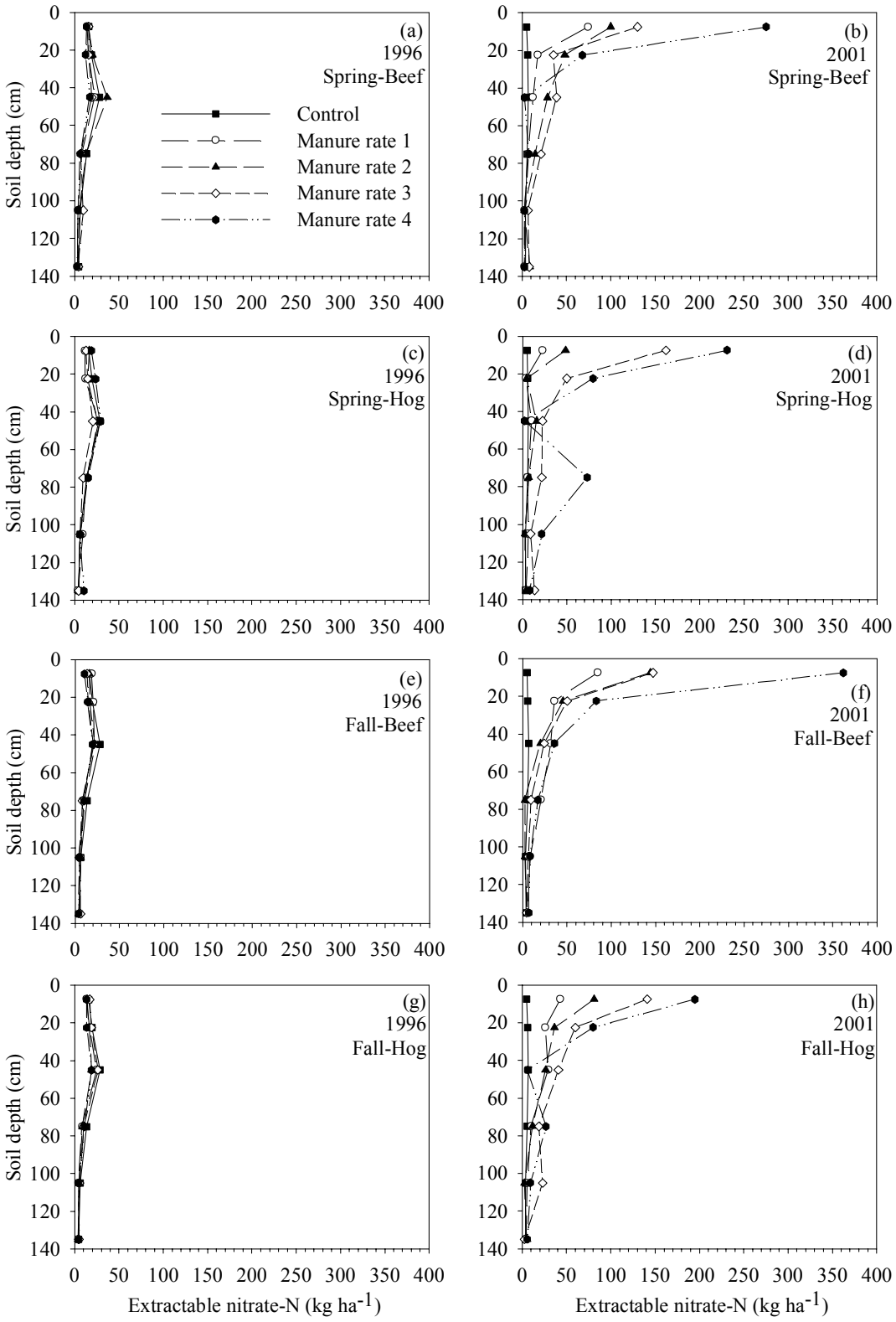


Fig. 3. Soil extractable nitrate-N content in 1996 (baseline) prior to manure application and in 2001 after five annual manure applications at the Lethbridge site.

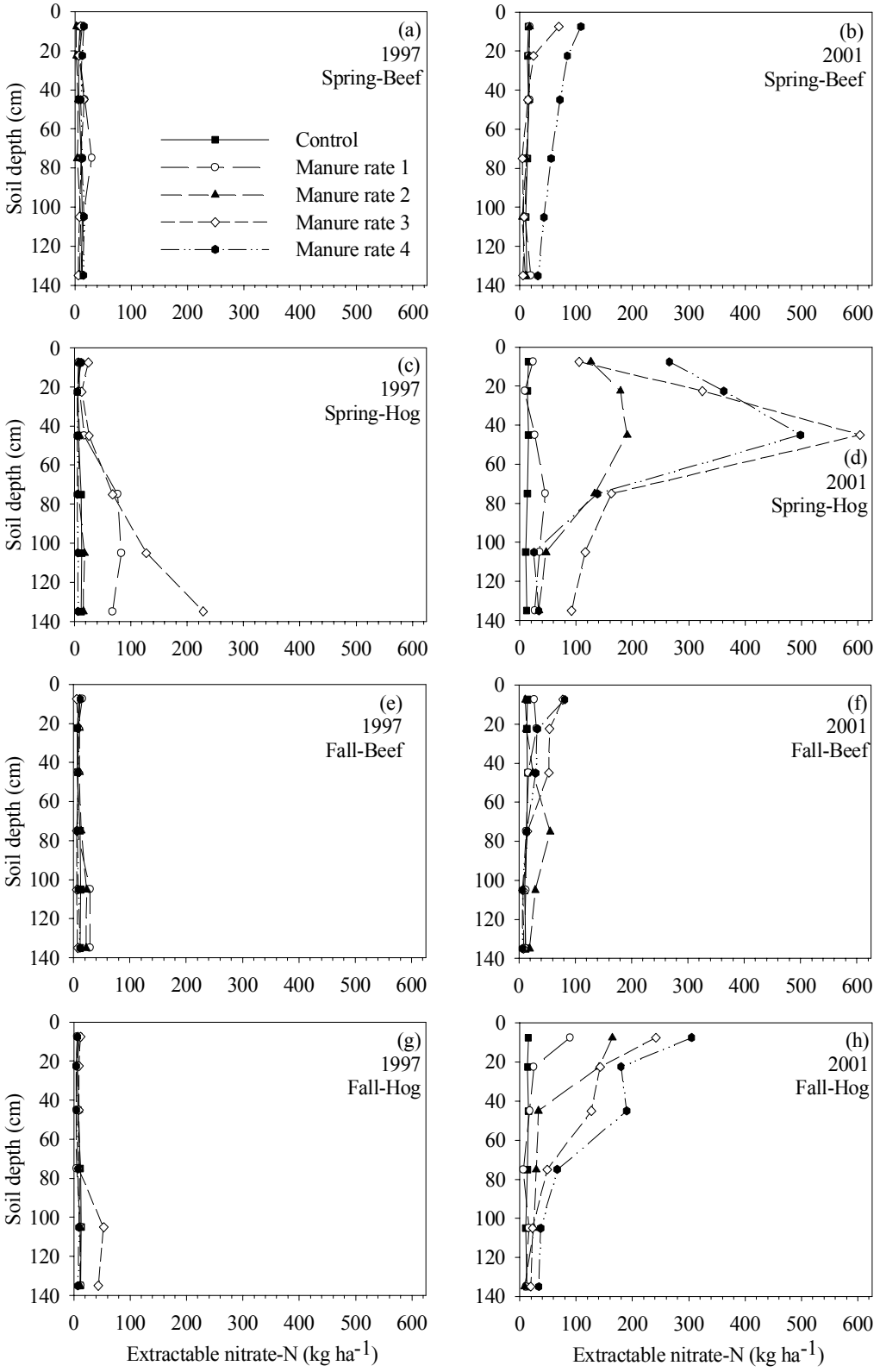


Fig. 4. Soil extractable nitrate-N content in 1997 (baseline) prior to manure application and in 2001 after four annual manure applications at the Airdrie site.

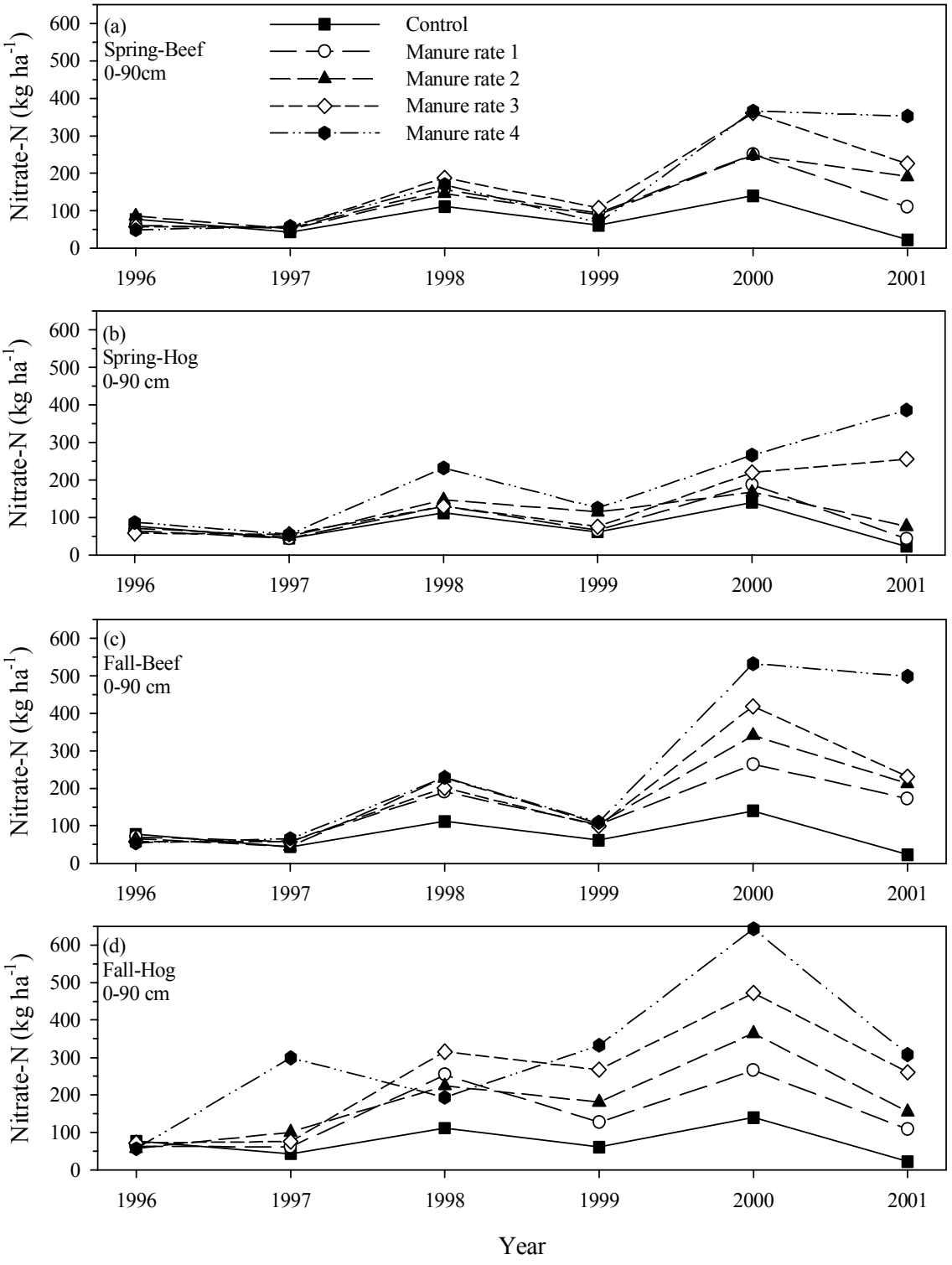


Fig 5. Soil extractable nitrate-N content in the 0- to 90-cm depth at the Lethbridge site from 1996 to 2001.

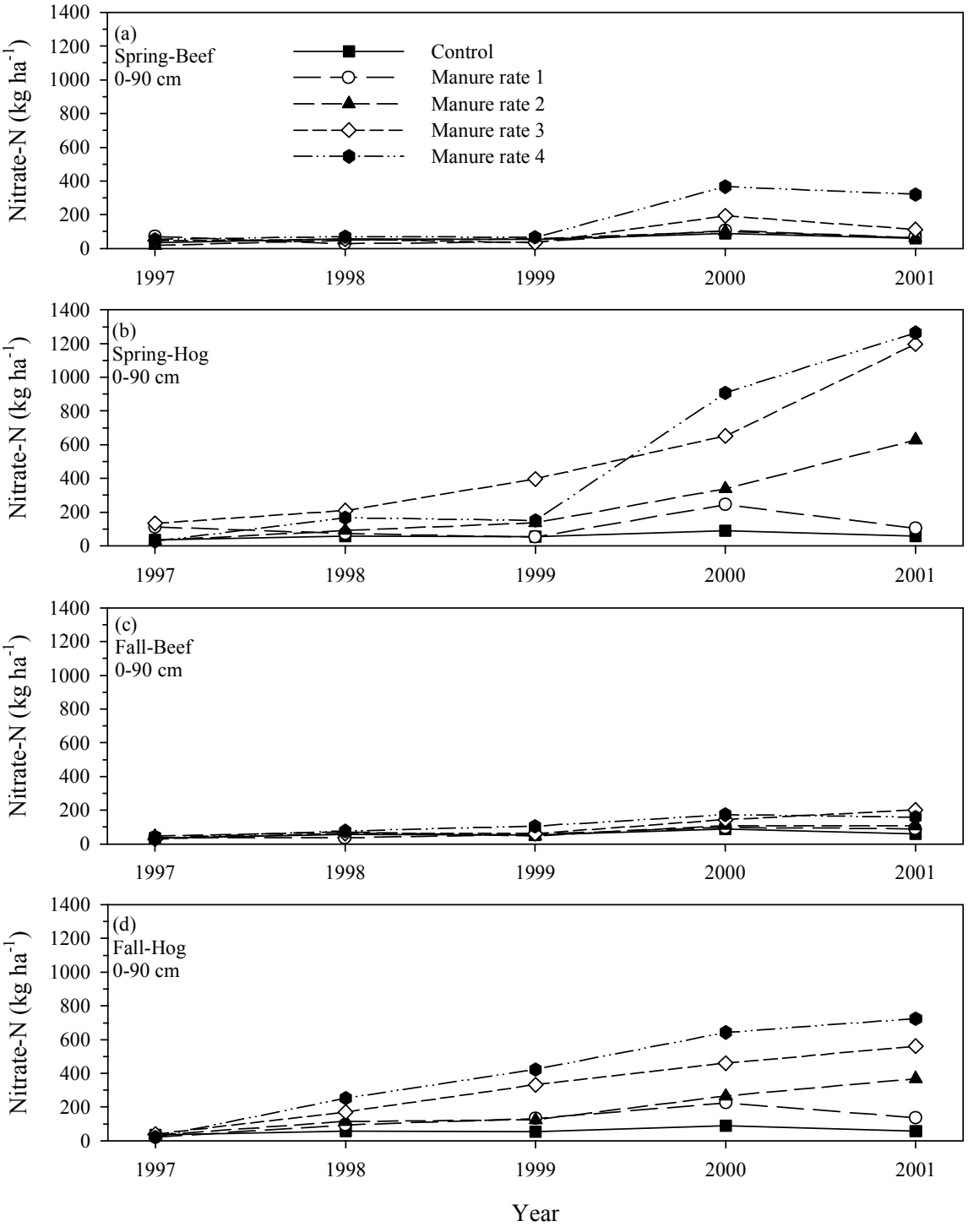


Fig 6. Soil extractable nitrate-N content in the 0- to 90-cm depth at the Airdrie site from 1997 to 2001.

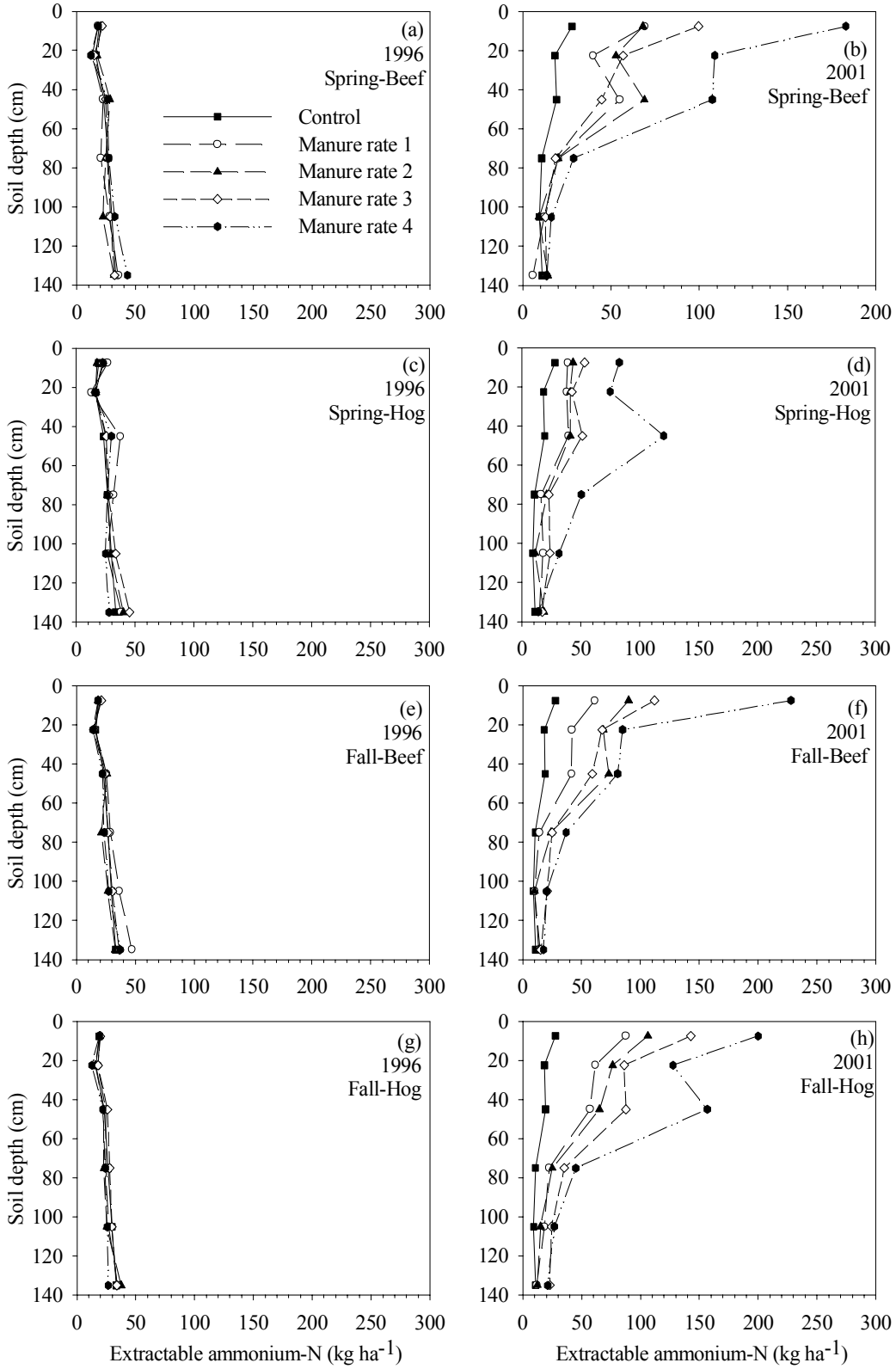


Fig. 7. Soil extractable ammonium-N content in 1996 (baseline) prior to manure application and in 2001 after five annual manure applications at the Lethbridge site.

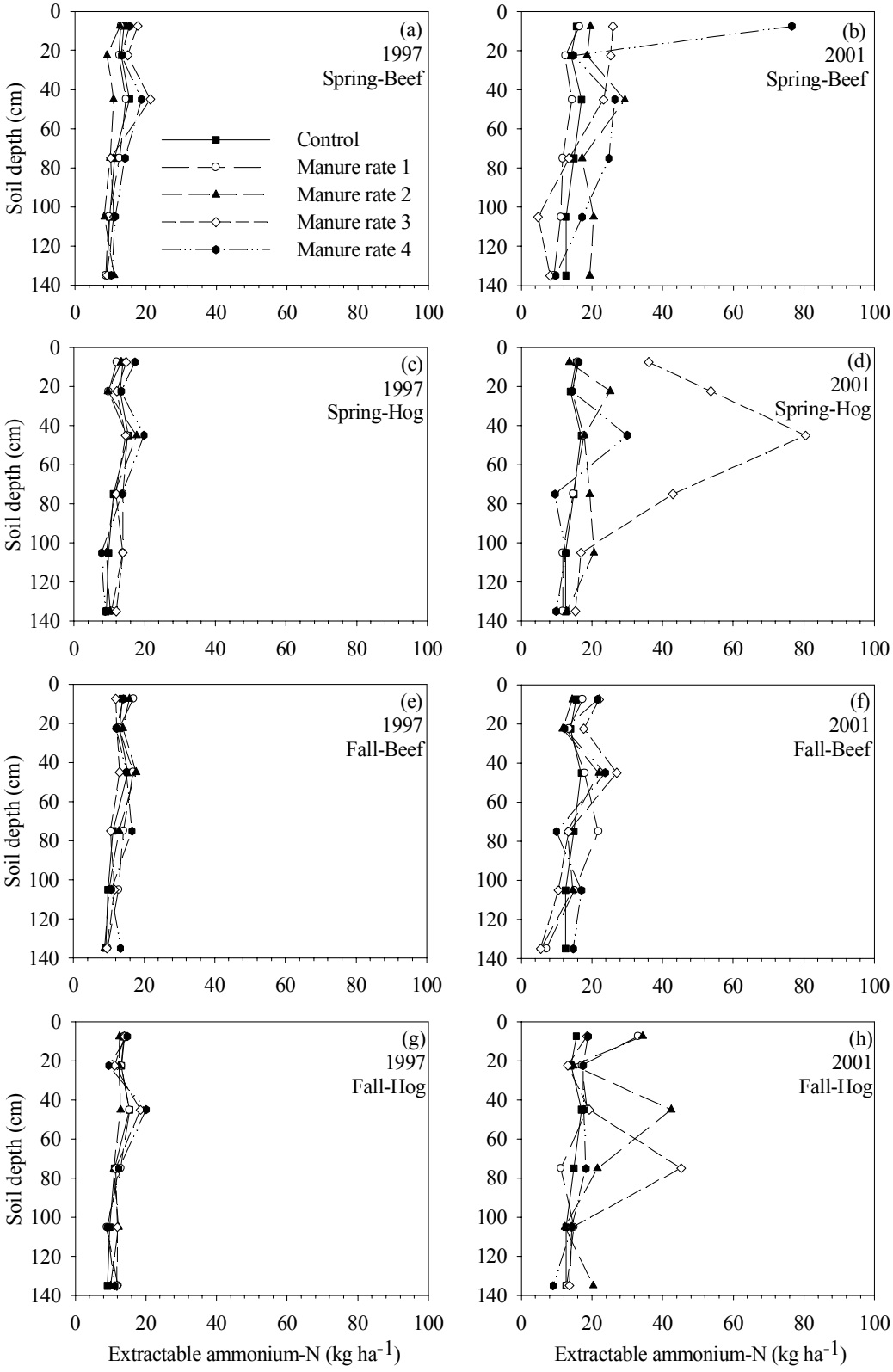


Fig. 8. Soil extractable ammonium-N content in 1996 (baseline) prior to manure application and in 2001 after four annual manure applications at the Airdrie site.

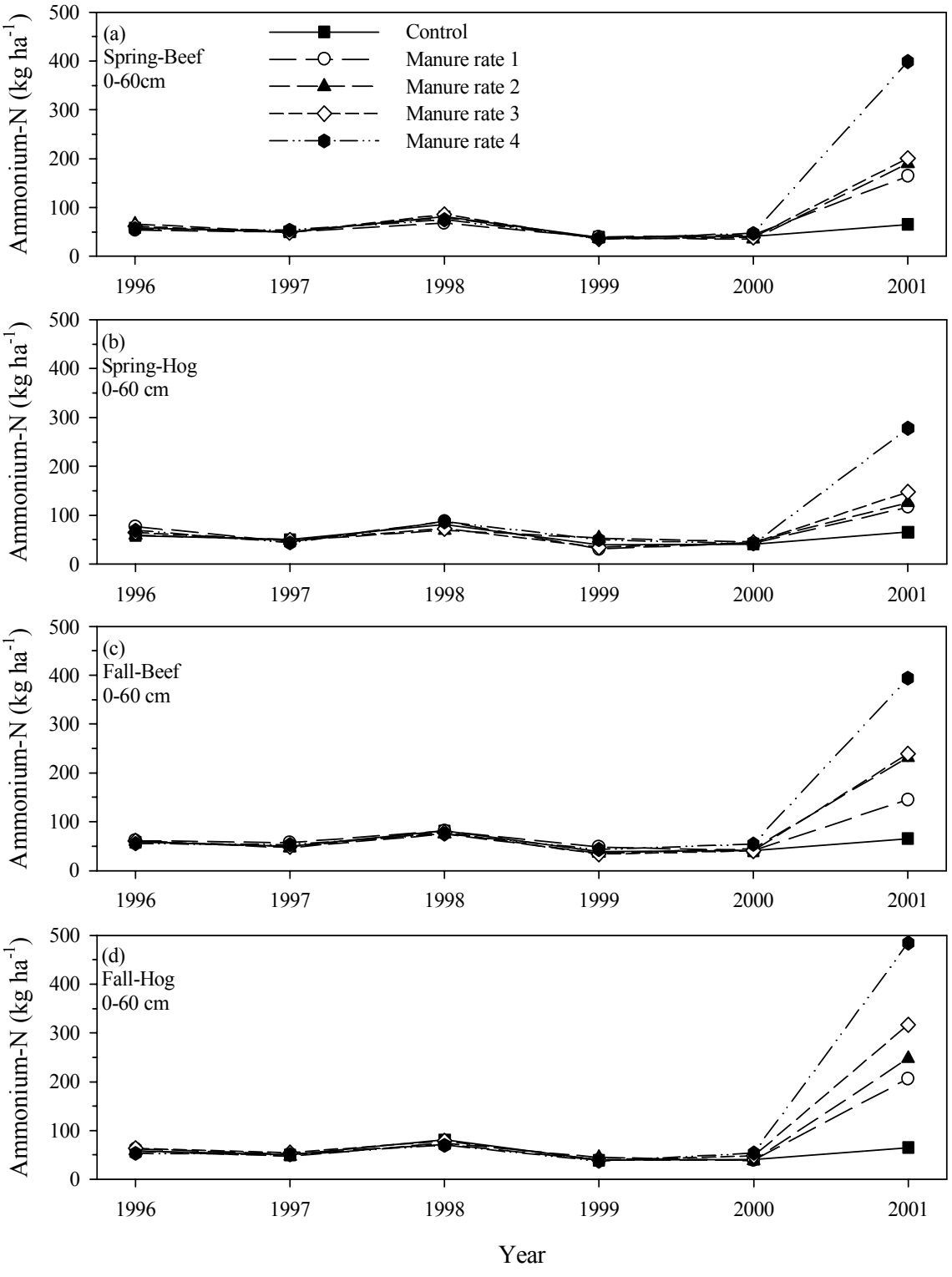


Fig 9. Soil extractable ammonium-N content in the 0- to 60-cm depth at the Lethbridge site from 1996 to 2001.

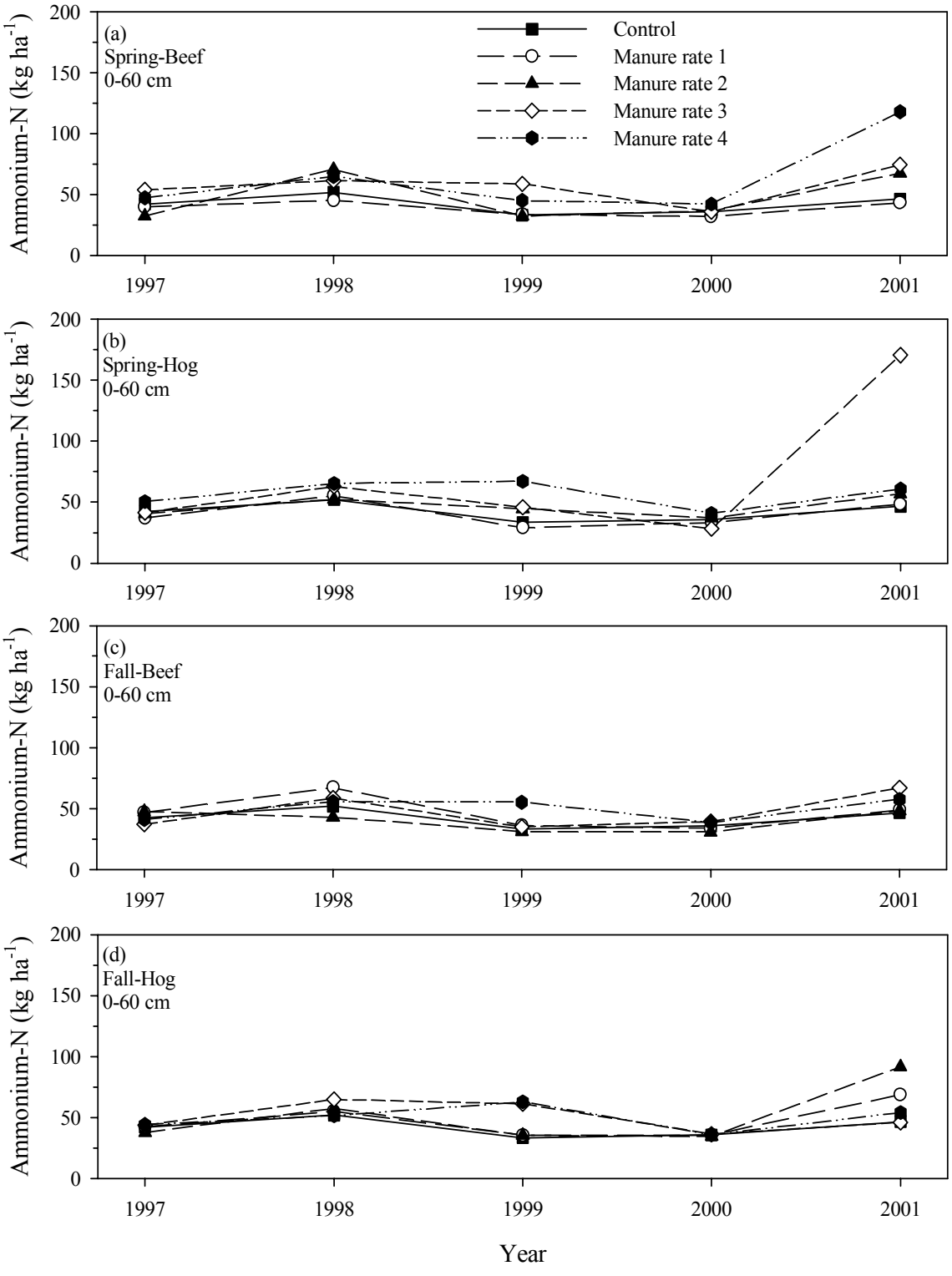


Fig 10. Soil extractable ammonium-N content in the 0- to 60-cm depth at the Airdrie site from 1997 to 2001.

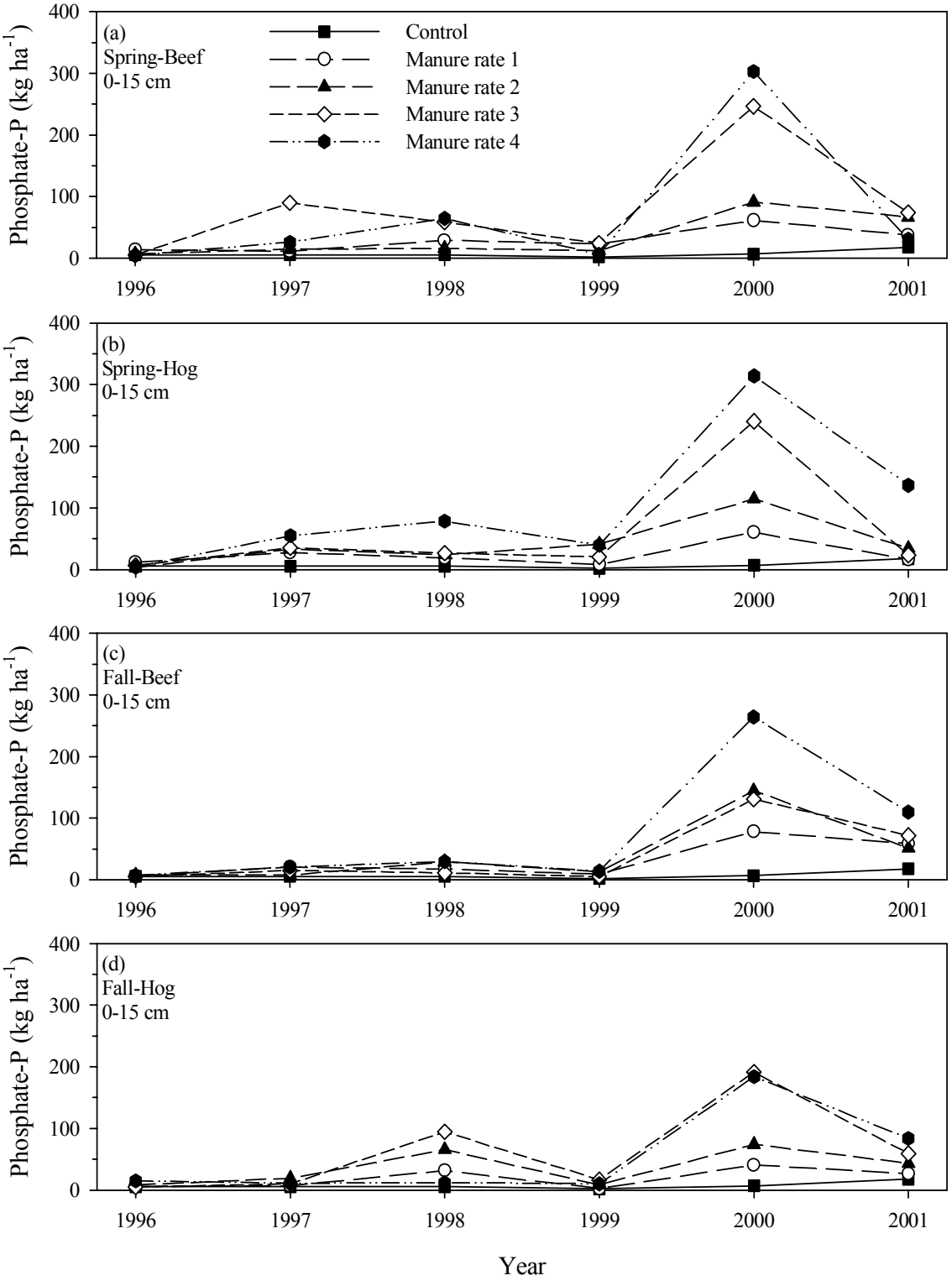


Fig 11. Soil extractable phosphate-P content in the 0- to 15-cm depth at the Lethbridge site from 1996 to 2001.

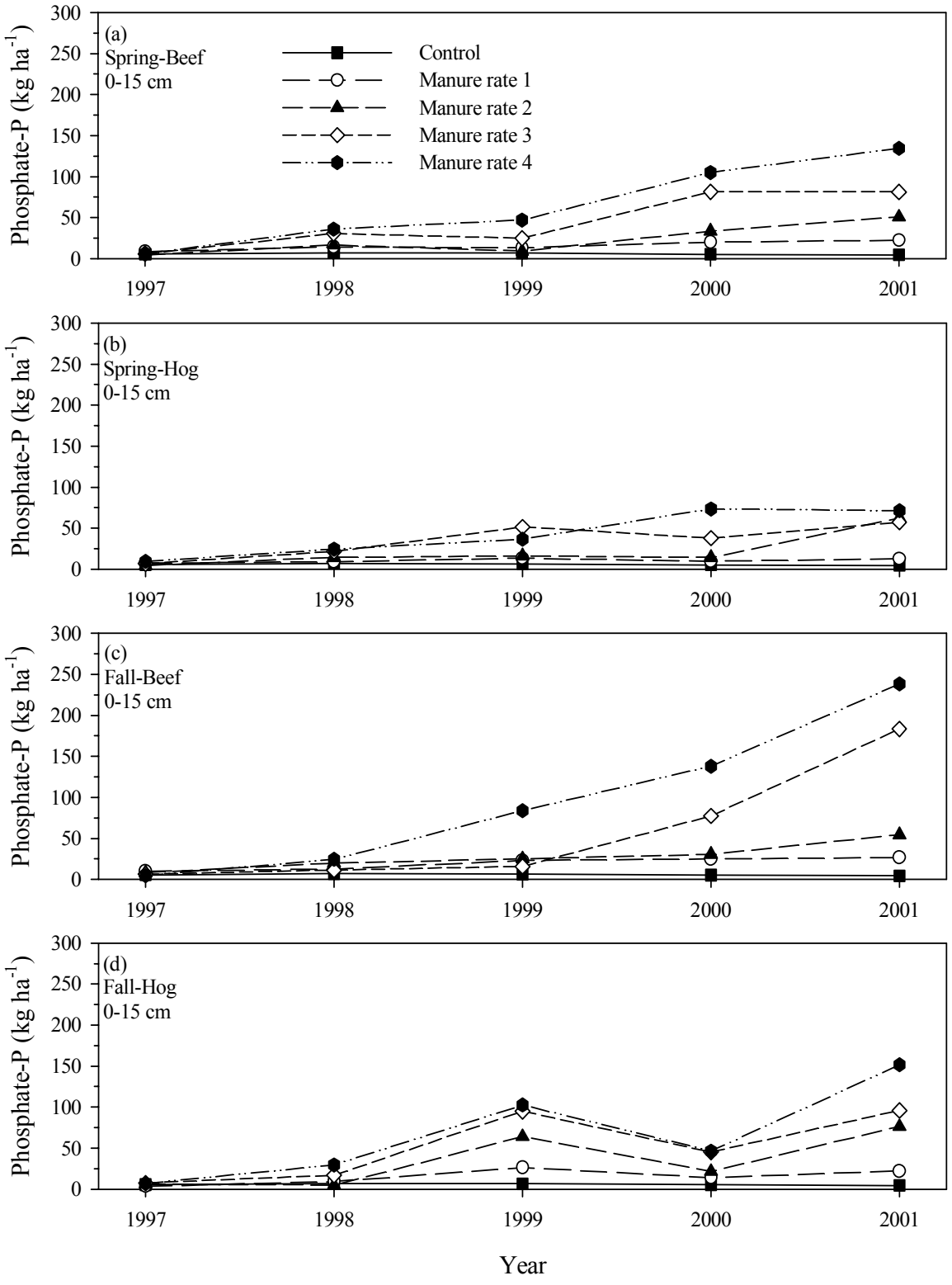


Fig 12. Soil extractable phosphate-P content in the 0- to 15-cm depth at the Airdrie site from 1997 to 2001.

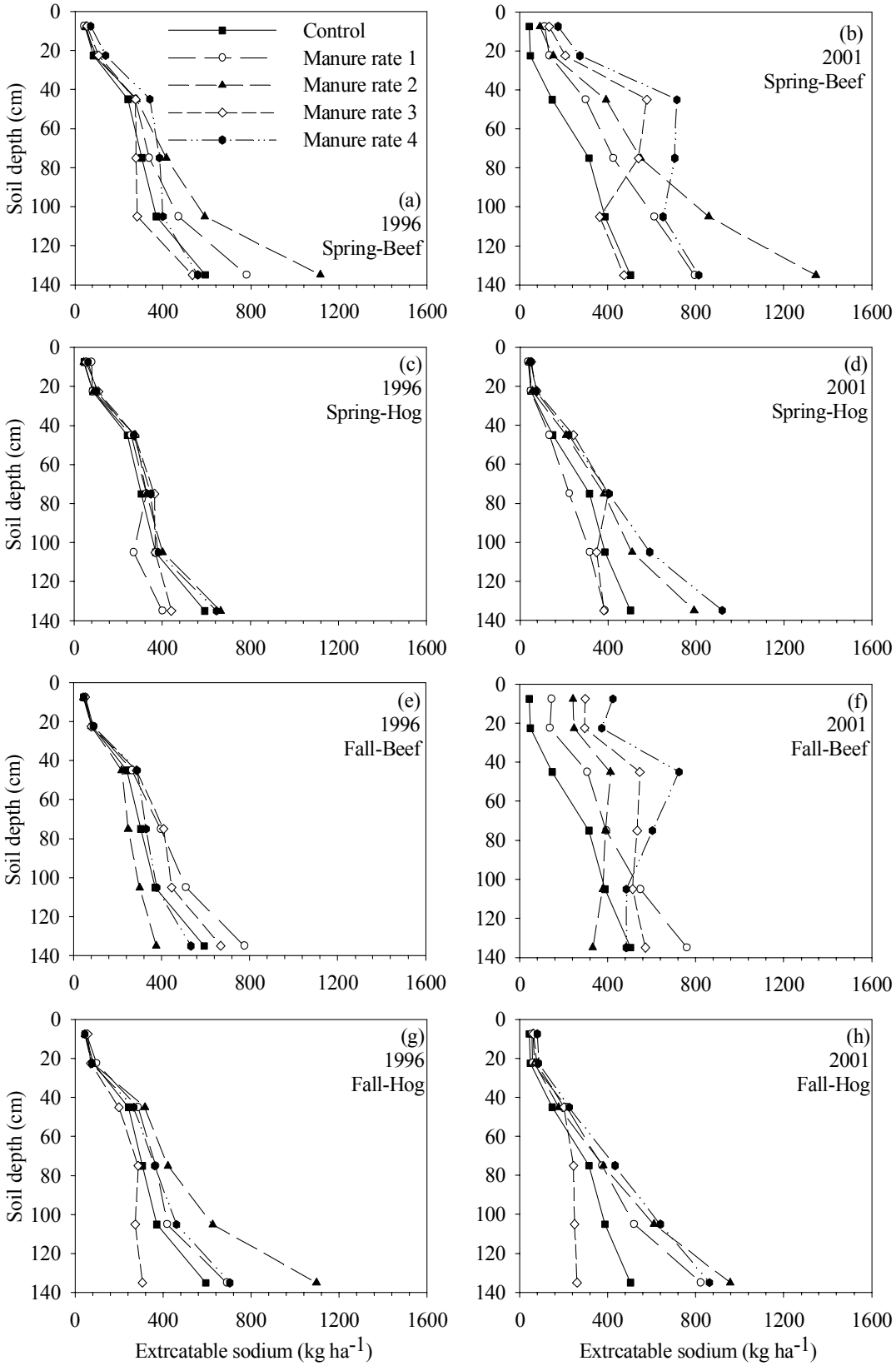


Fig. 13. Soil extractable sodium content in 1996 (baseline) prior to manure application and in 2001 after five annual manure applications at the Lethbridge site.

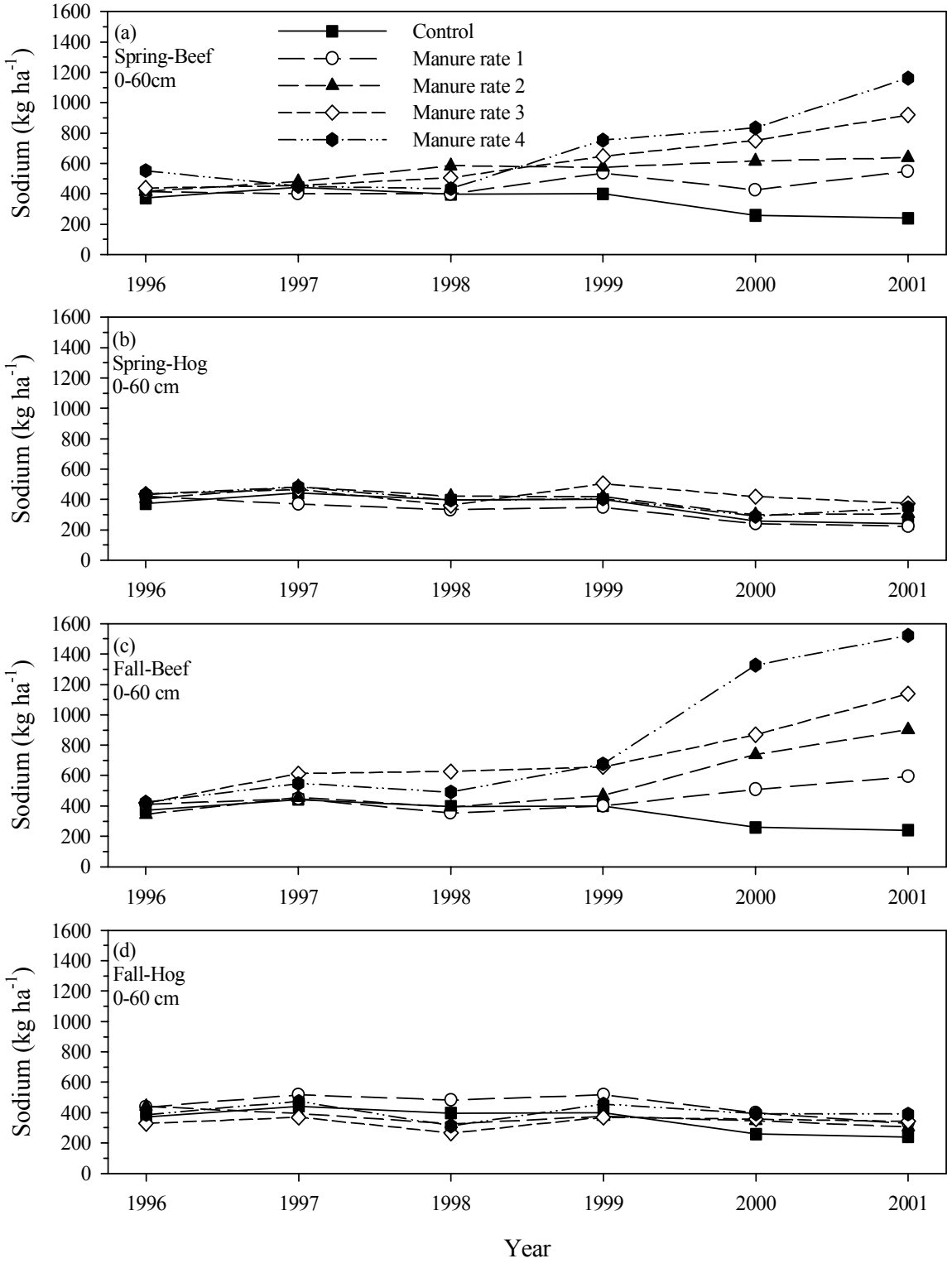


Fig 14. Soil extractable sodium content in the 0- to 60-cm depth at the Lethbridge site from 1996 to 2001.

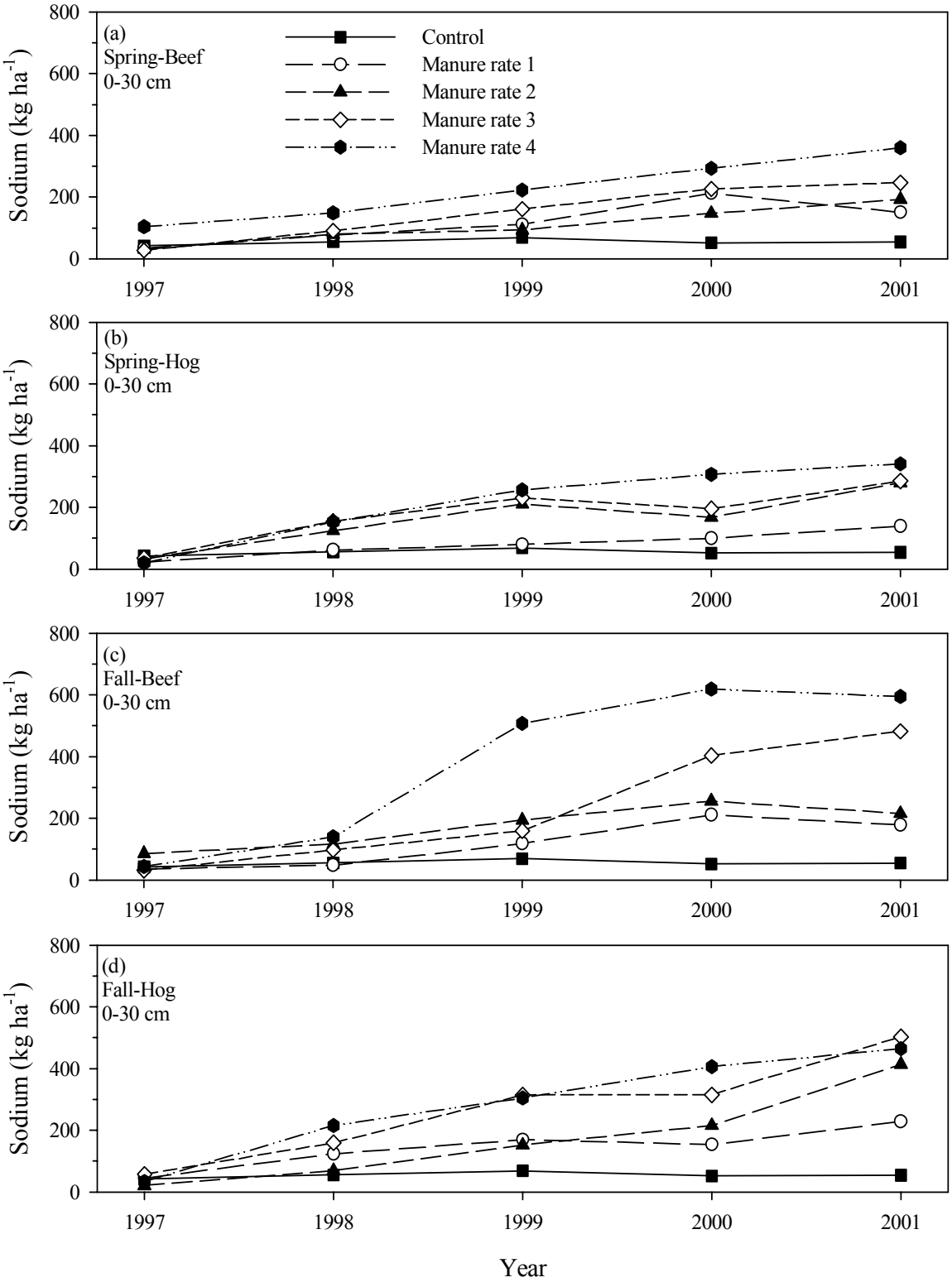


Fig 15. Soil extractable sodium content in the 0- to 30-cm depth at the Airdrie site from 1996 to 2001.

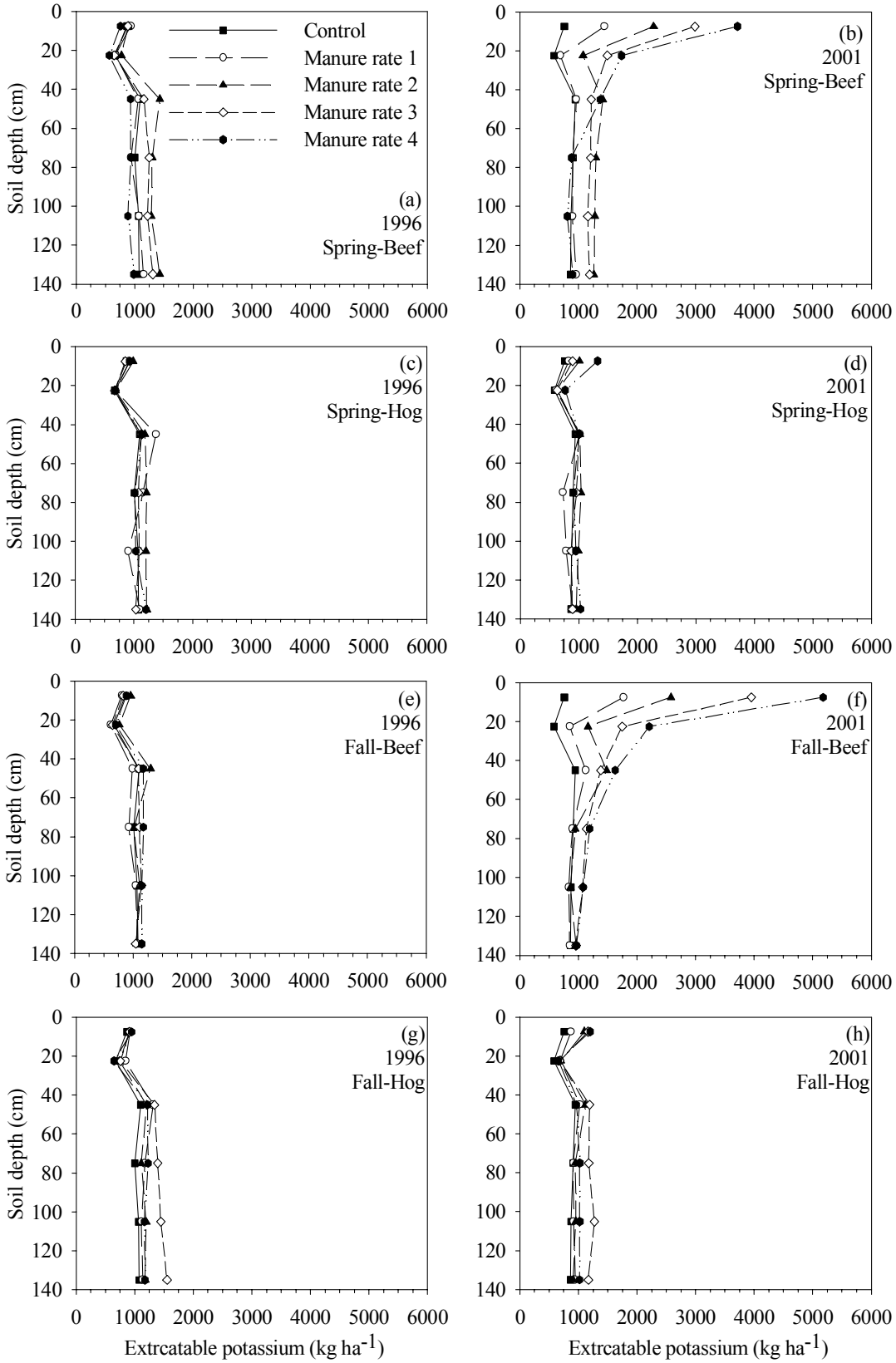


Fig. 16. Soil extractable potassium content in 1996 (baseline) prior to manure application and in 2001 after five annual manure applications at the Lethbridge site.

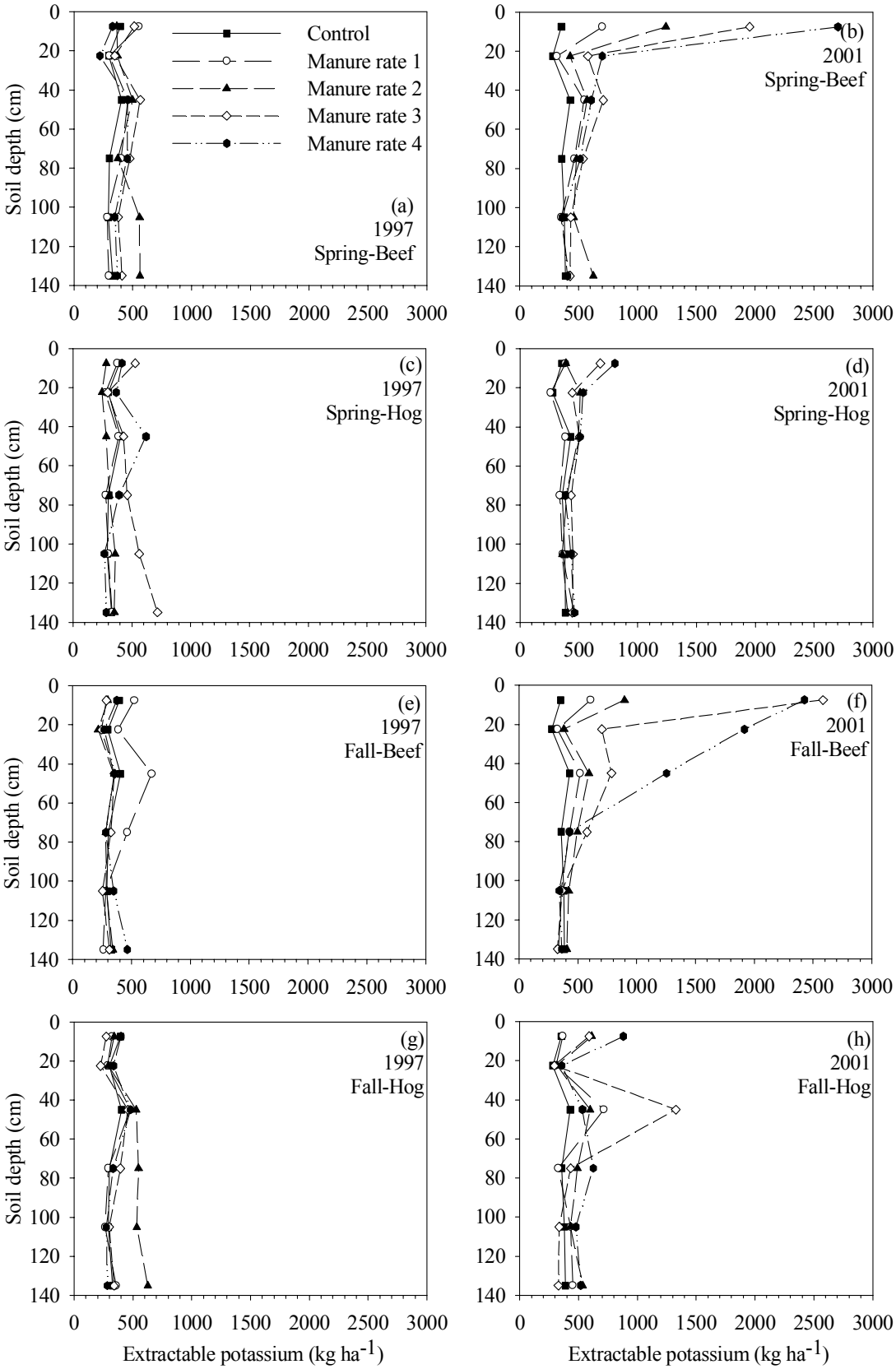


Fig. 17. Soil extractable potassium content in 1997 (baseline) prior to manure application and in 2001 after four annual manure applications at the Airdrie site.

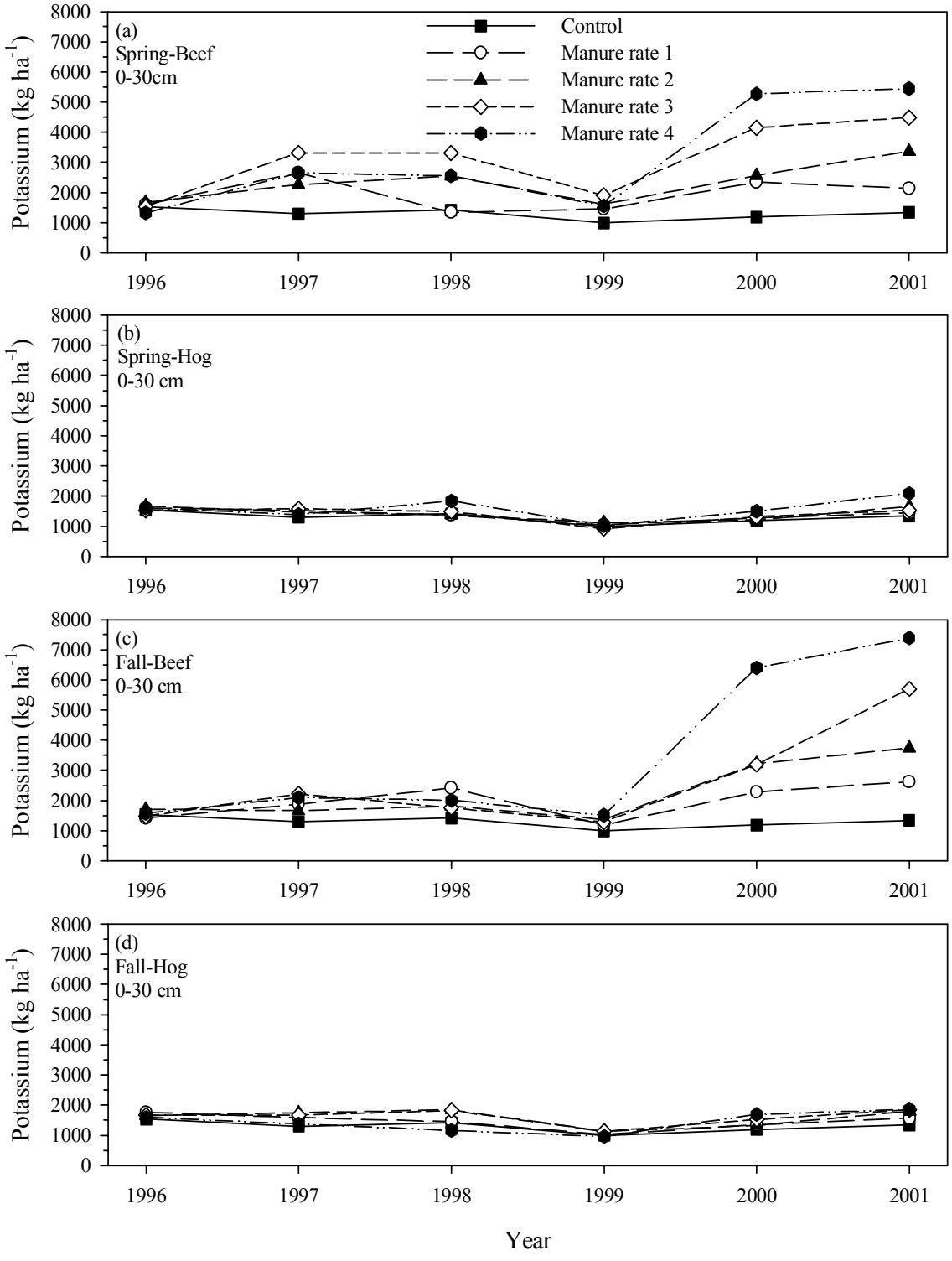


Fig 18. Soil extractable potassium content in the 0- to 30-cm depth at the Lethbridge site from 1996 to 2001.

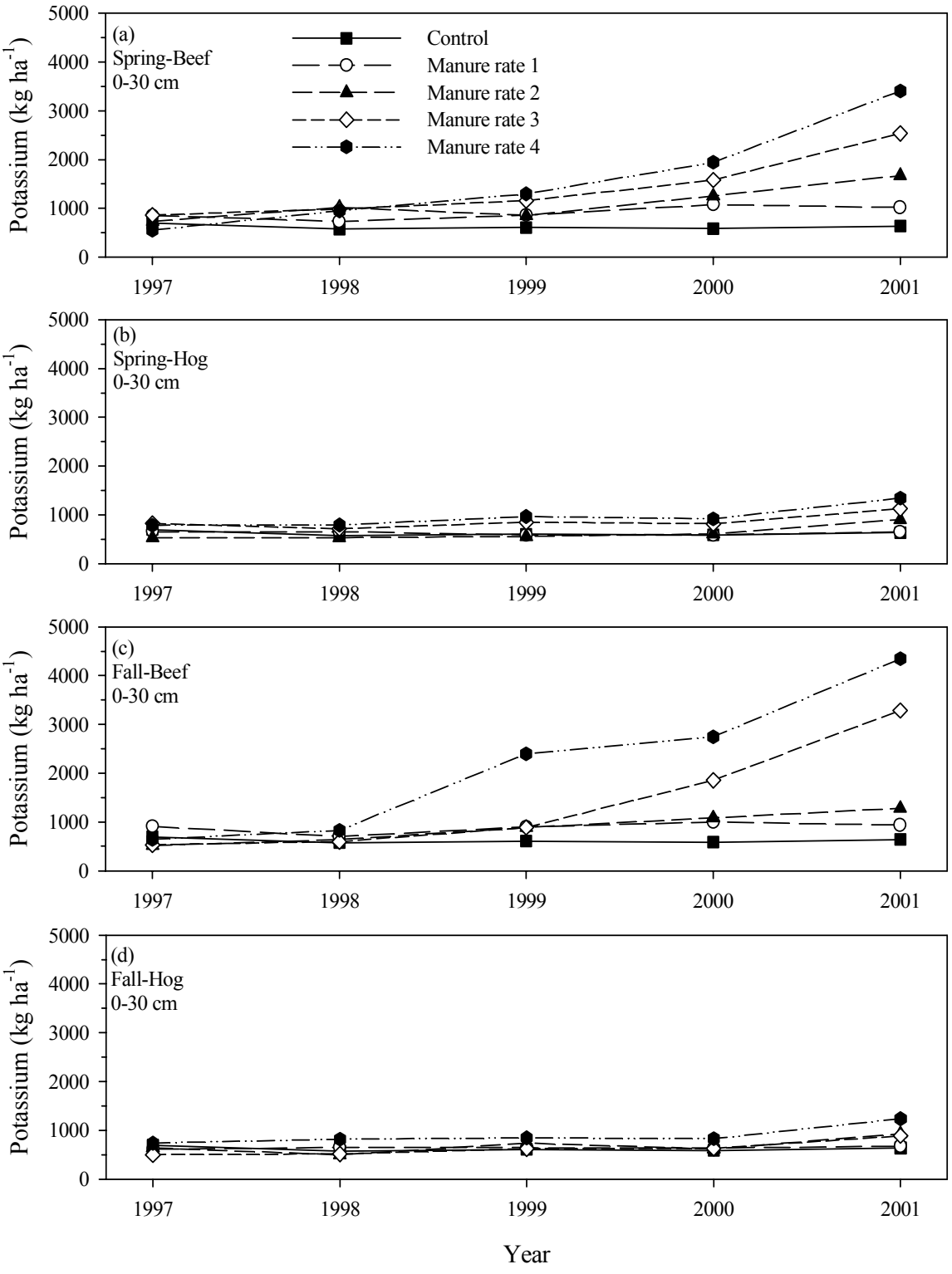


Fig 19. Soil extractable potassium content in the 0- to 30-cm depth at the Airdrie site from 1997 to 2001.

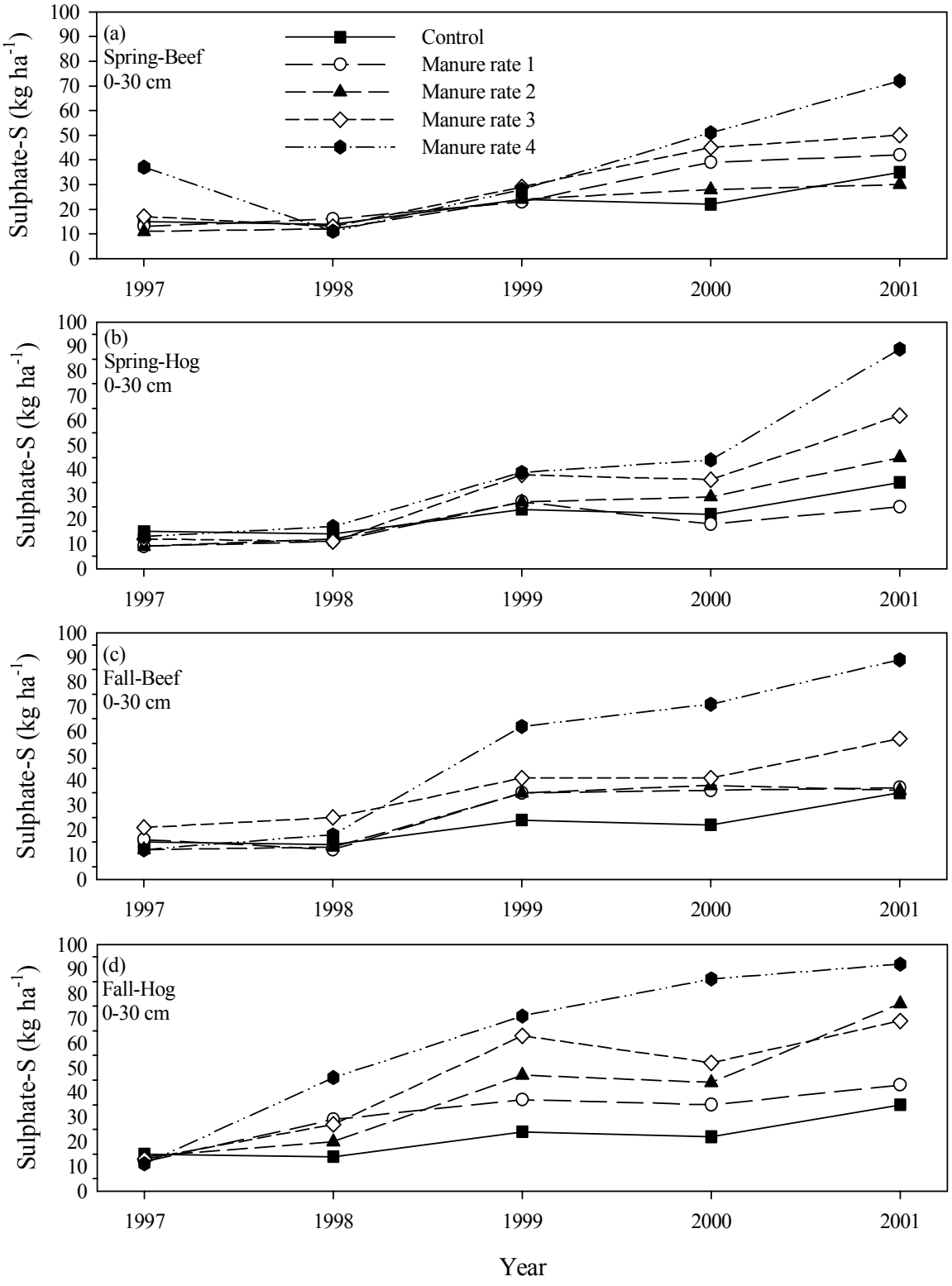


Fig 20. Soil extractable sulphate-S content in the 0- to 30-cm depth at the Airdrie site from 1997 to 2001.

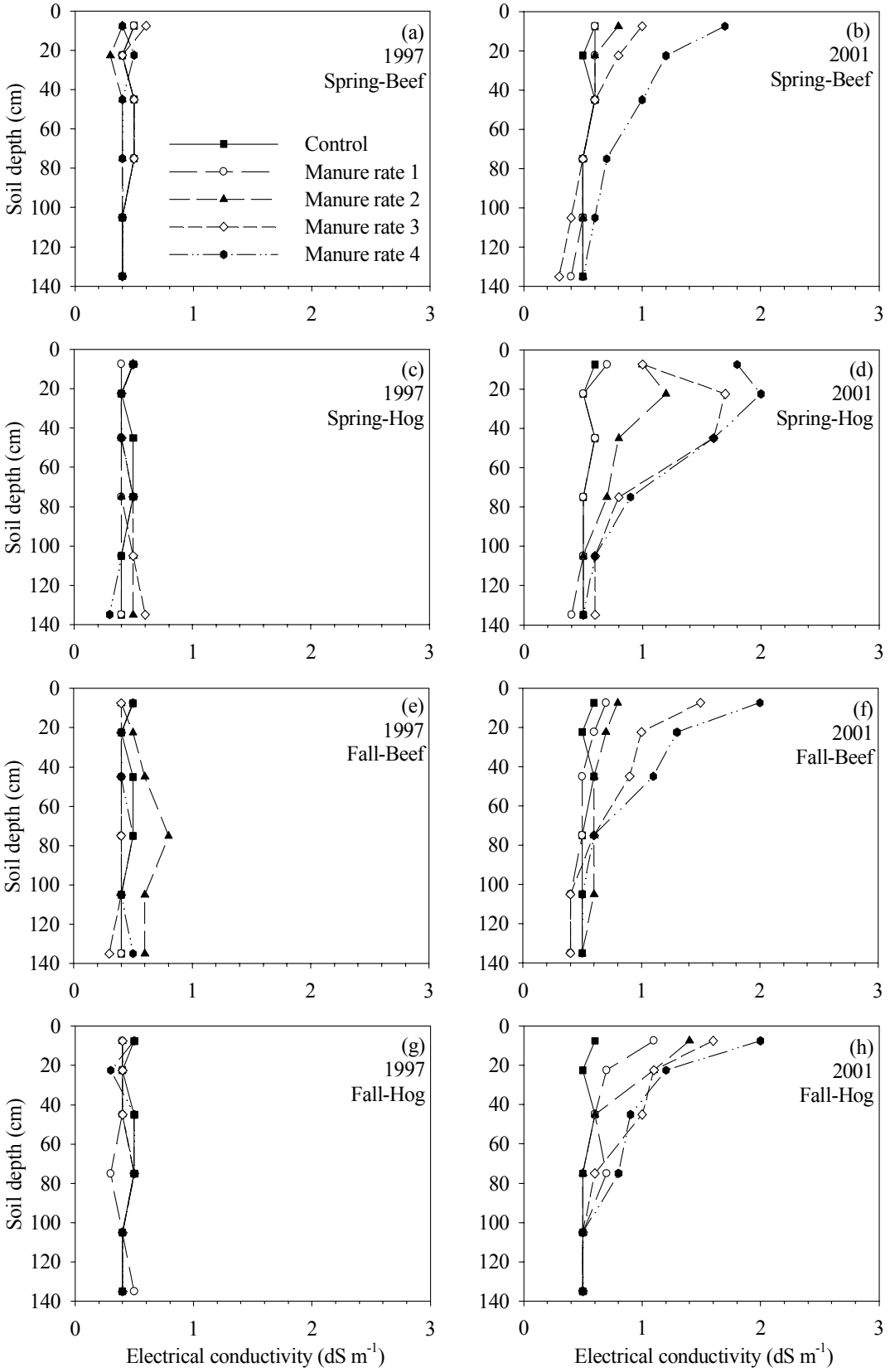


Fig. 21. Soil electrical conductivity in 1997 (baseline) prior to manure application and in 2001 after four annual manure applications at the Airdrie site.

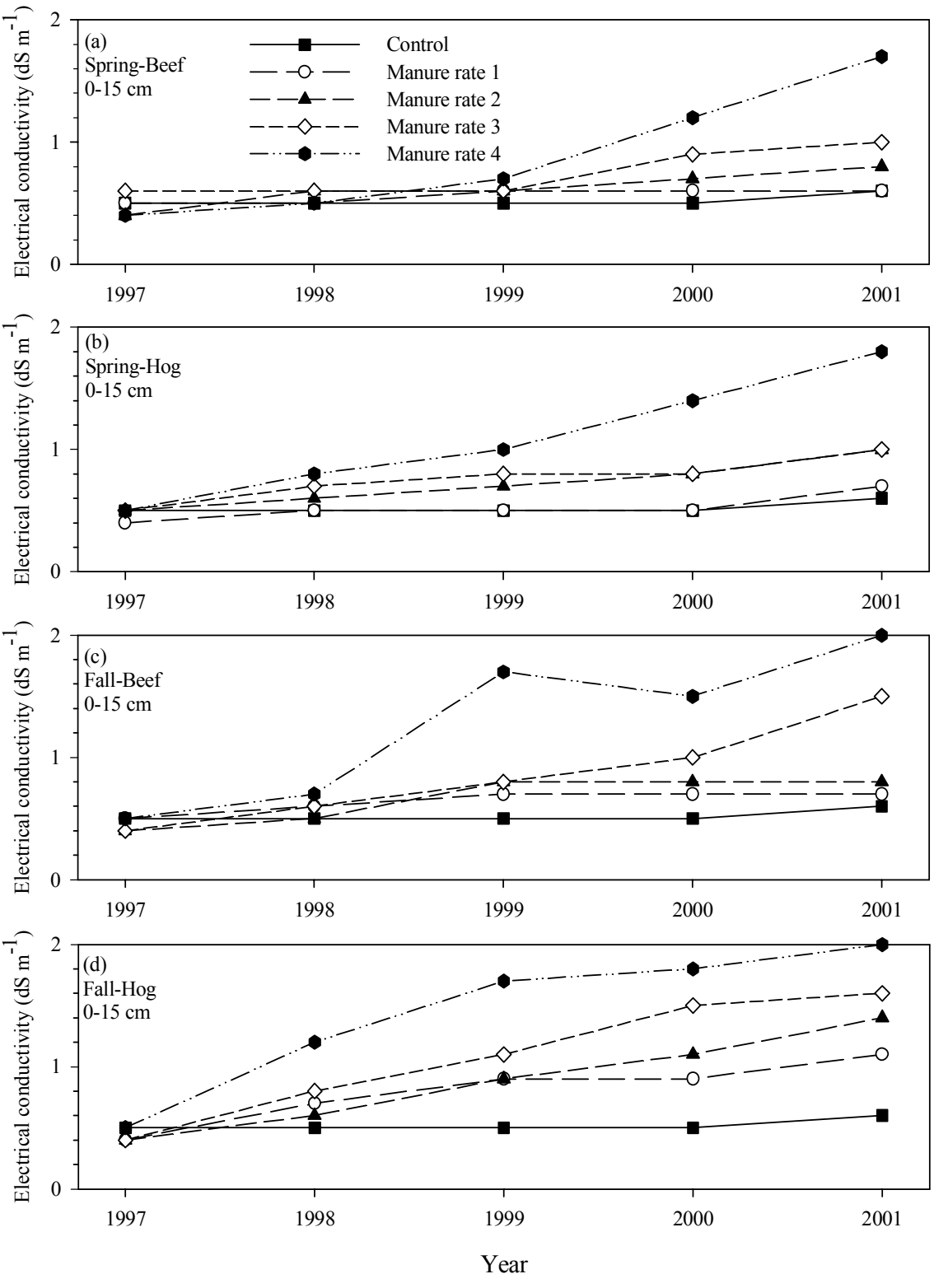


Fig 22. Soil electrical conductivity in the 0- to 15-cm depth at the Airdrie site from 1997 to 2001.

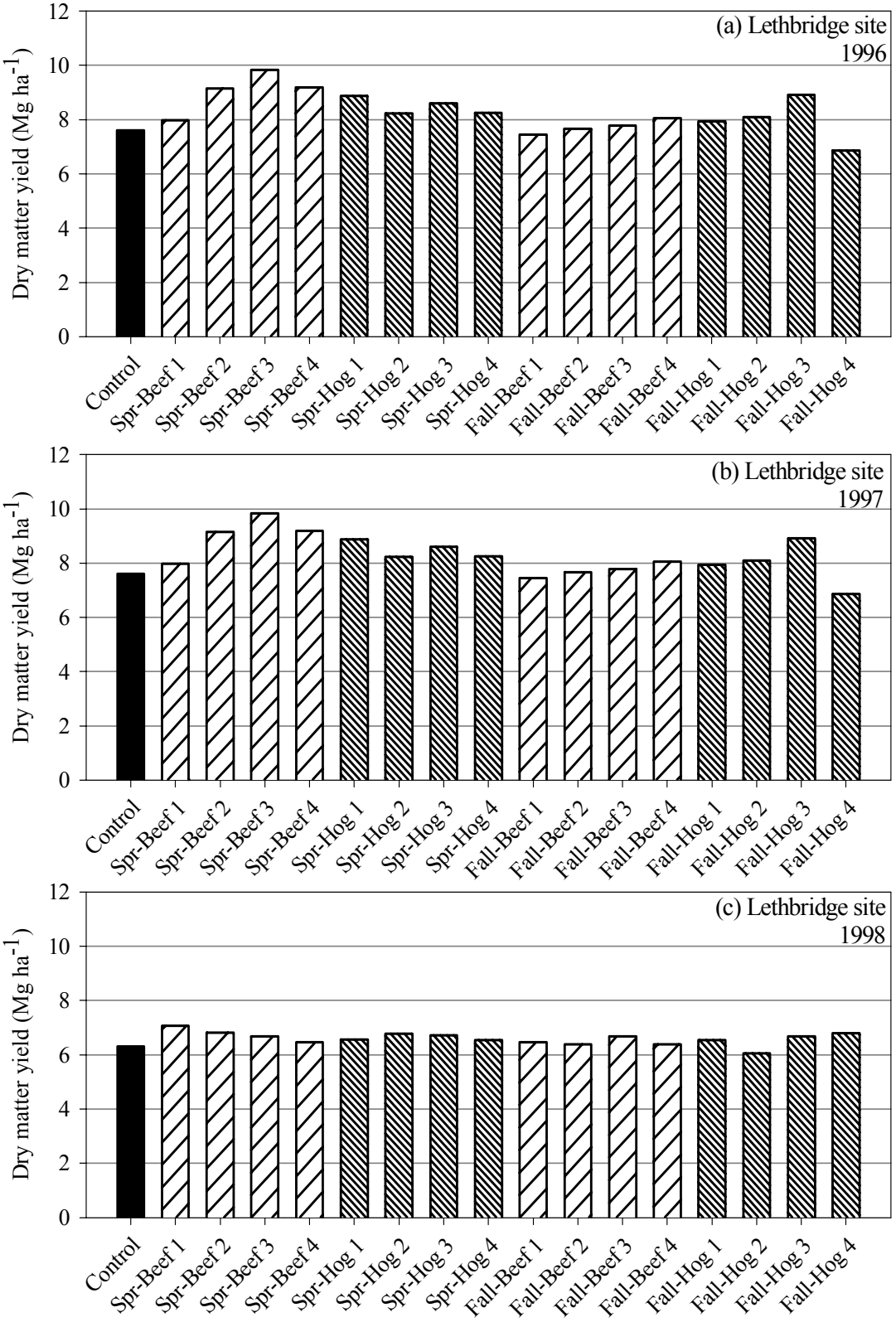


Fig. 23. Effects of manure application on alfalfa yield at the Lethbridge site in 1996, 1997, and 1998.

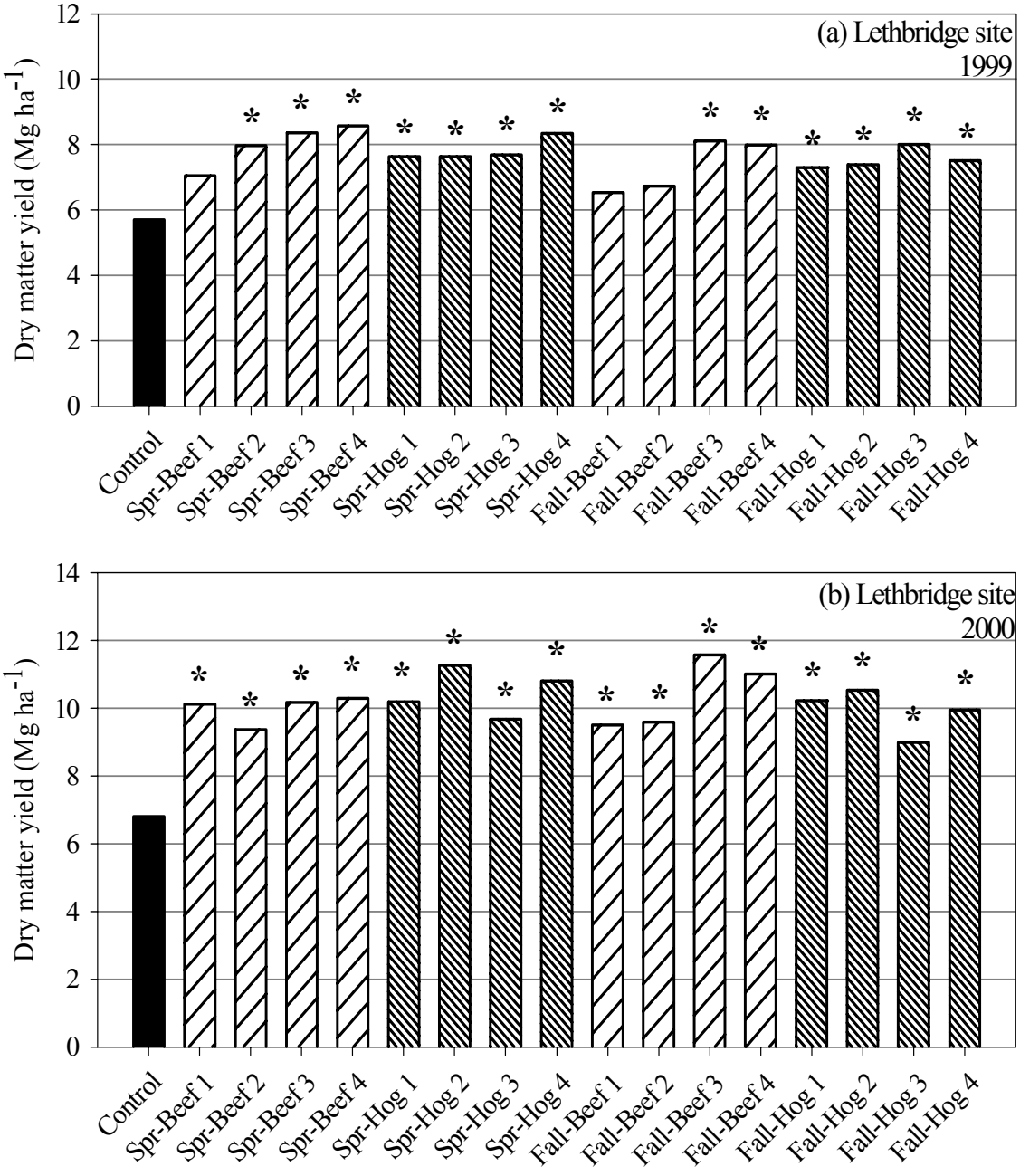


Fig. 24. Effects of manure application on alfalfa yield at the Lethbridge site in 1999 and 2000. Means that are significantly different from the control are indicated with an asterisk ($p < 0.05$).

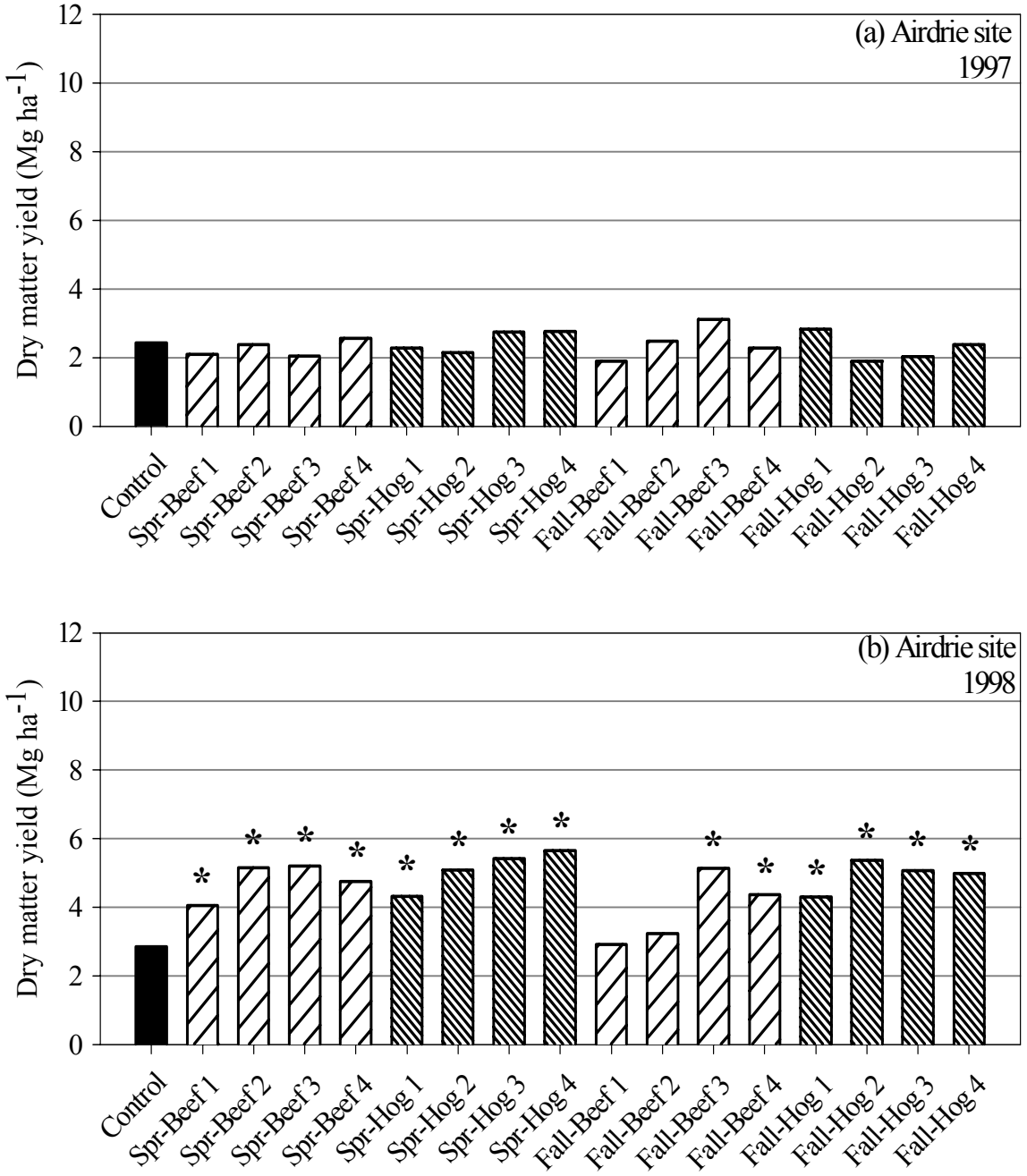


Fig. 25. Effects of manure application on timothy yield at the Airdrie site in 1997 and 1998. Means that are significantly different from the control are indicated with an asterisk ($p < 0.05$).

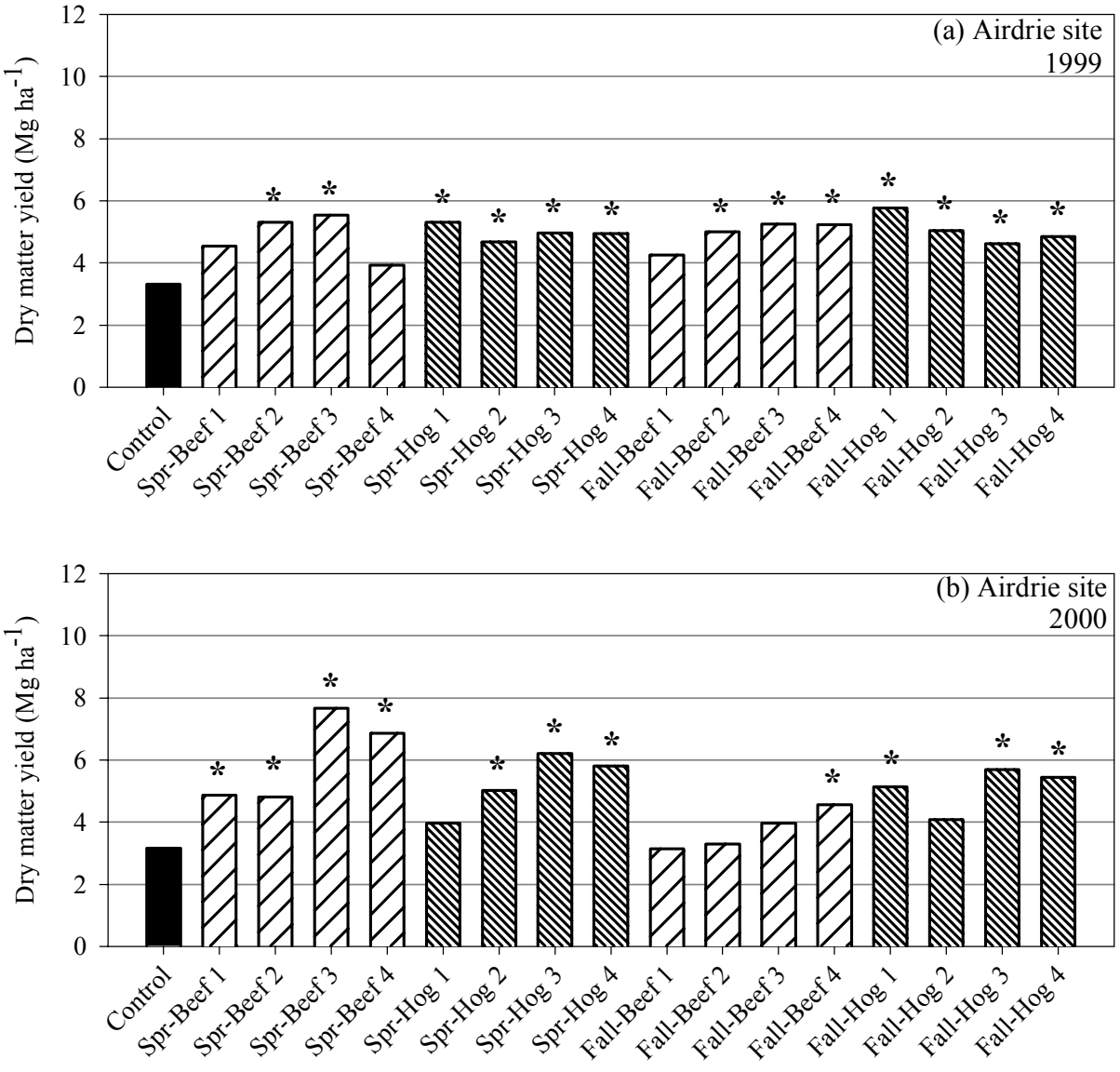


Fig. 26. Effects of manure application on Timothy grass yield at the Airdrie site in 1999 and 2000. Means that are significantly different from the control are indicated with an asterisk ($p < 0.05$).

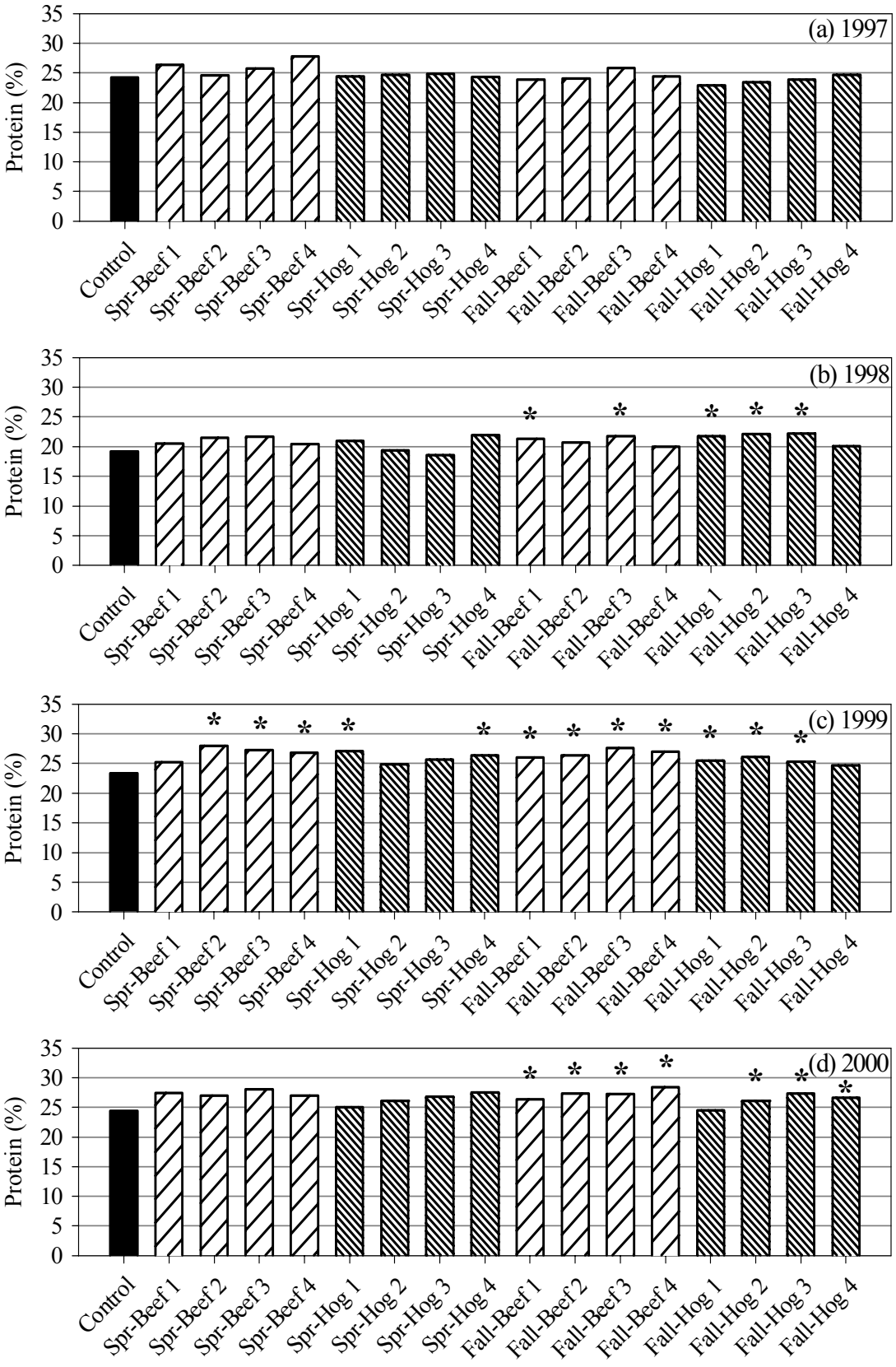


Fig. 27. Effects of manure application on protein content in alfalfa at the Lethbridge site from 1997 to 2000. Means that are significantly different from the control are indicated with an asterisk ($p < 0.05$).

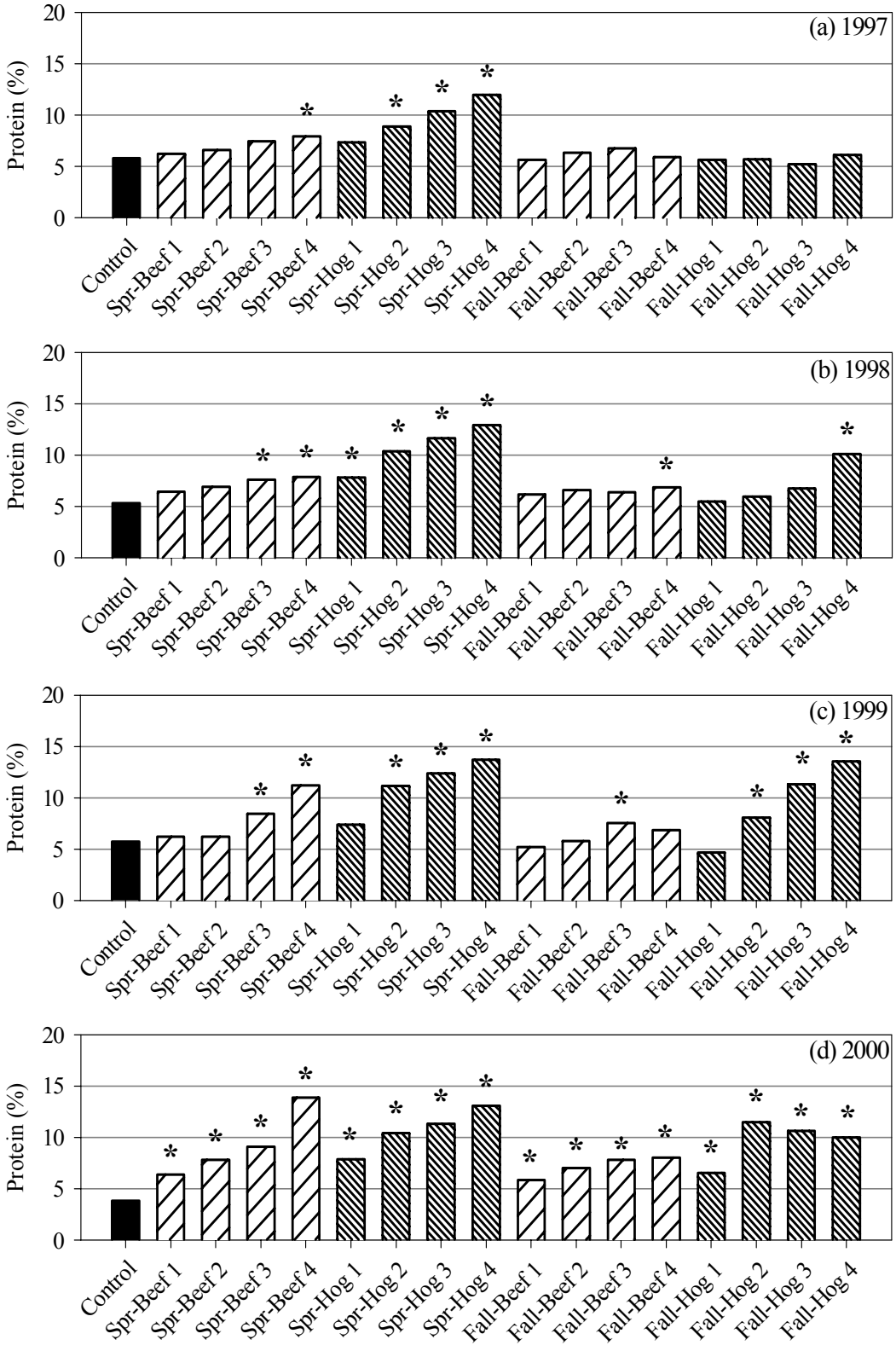


Fig. 28. Effects of manure application on protein content in timothy at the Airdrie site from 1997 to 2000. Means that are significantly different from the control are indicated with an asterisk ($p < 0.05$).

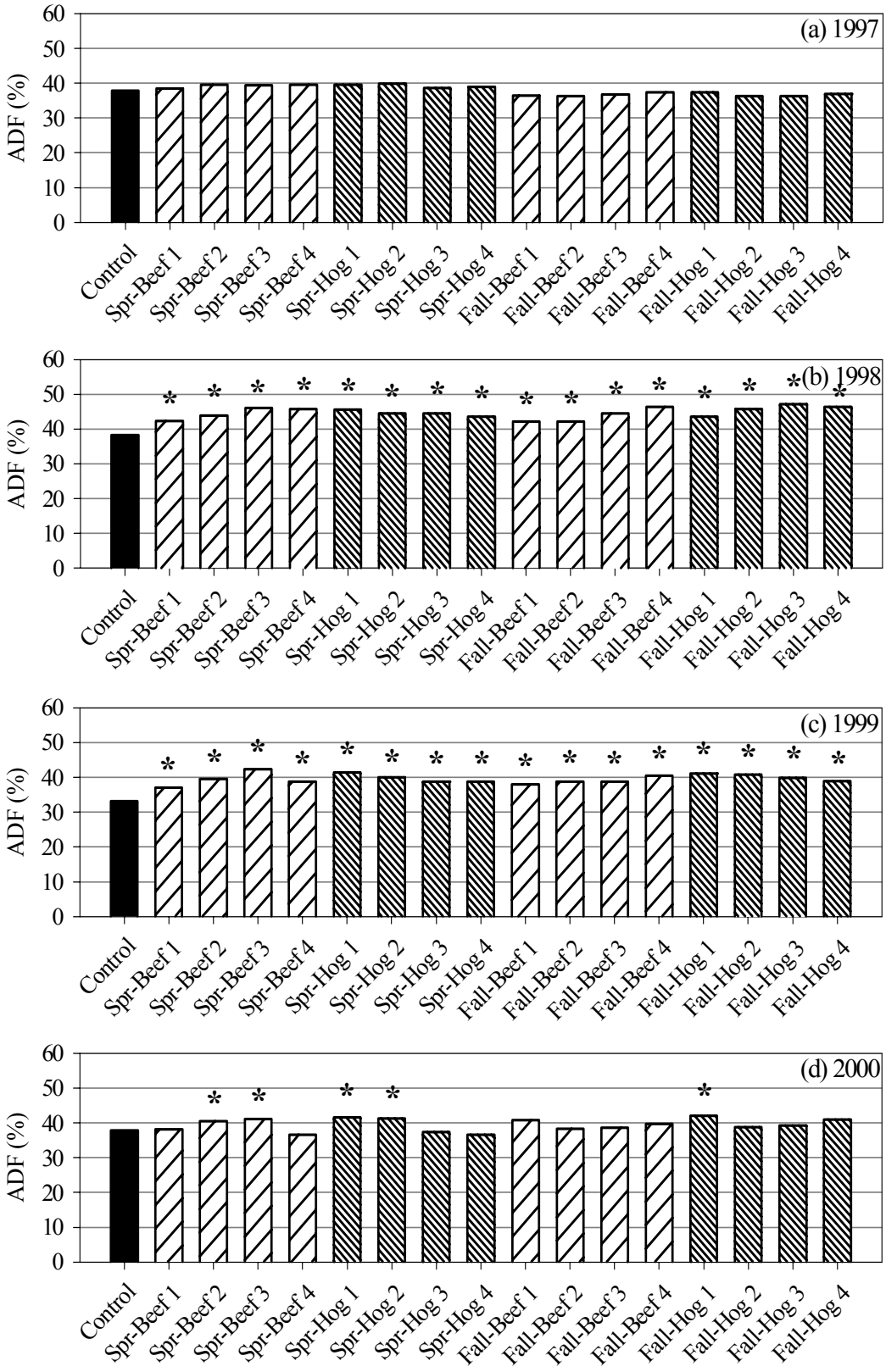


Fig. 29. Effects of manure application on ADF content in timothy at the Airdrie site from 1997 to 2000. Means that are significantly different from the control are indicated with an asterisk ($p < 0.05$).

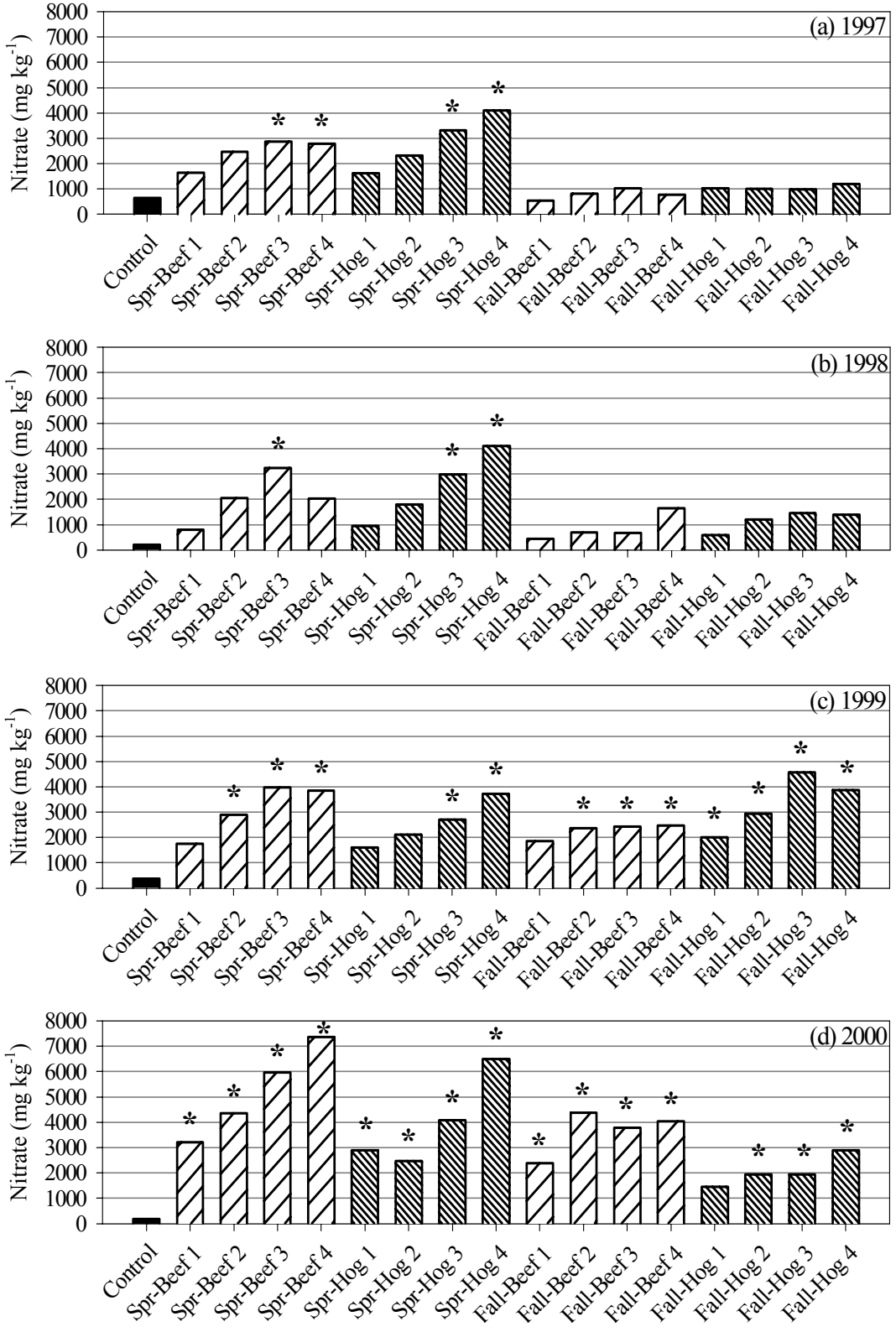


Fig. 30. Effects of manure application on nitrate content in alfalfa at the Lethbridge site from 1997 to 2000. Means that are significantly different from the control are indicated with an asterisk ($p < 0.05$).

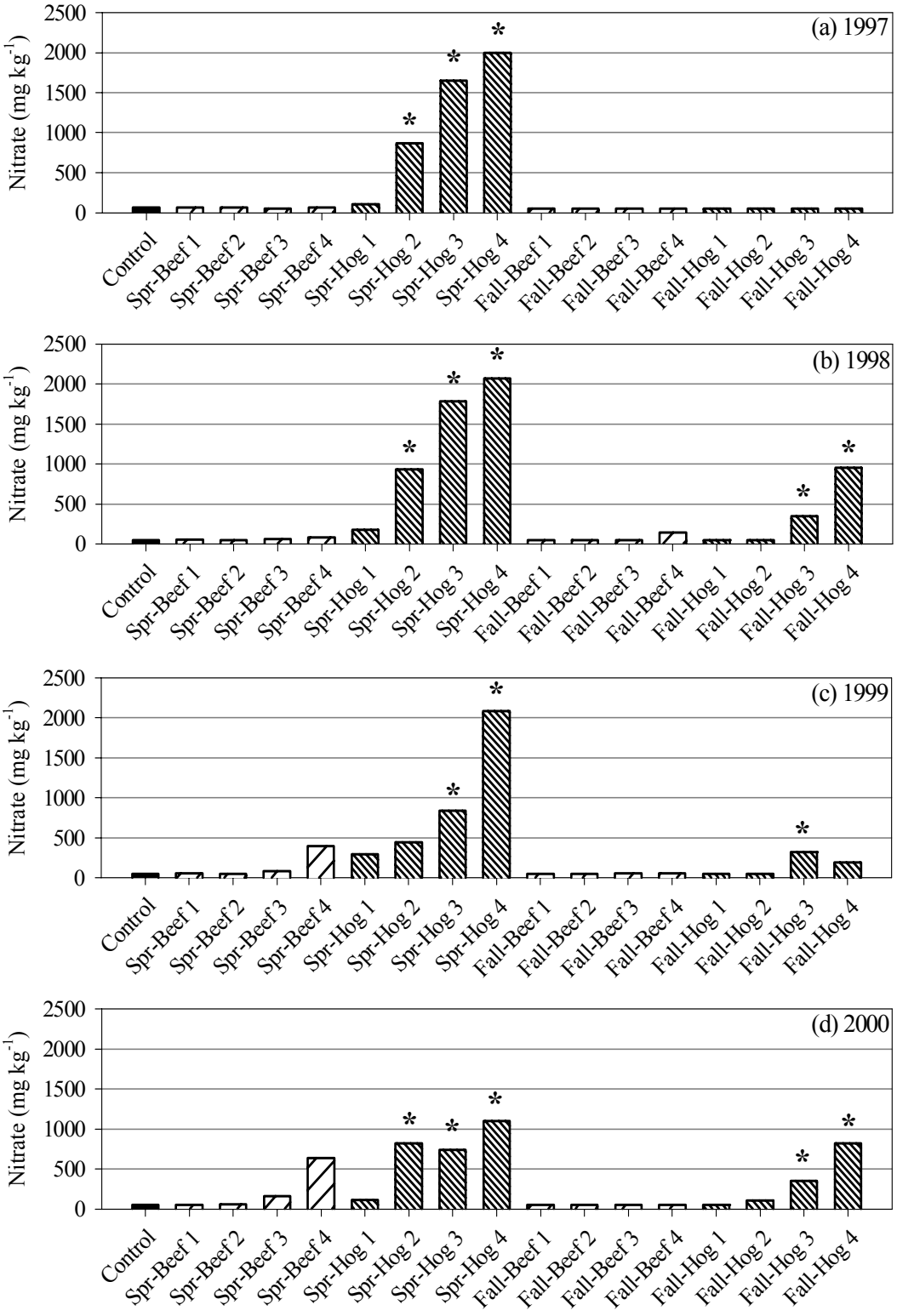


Fig. 31. Effects of manure application on nitrate content in timothy at the Airdrie site from 1997 to 2000. Means that are significantly different from the control are indicated with an asterisk ($p < 0.05$).

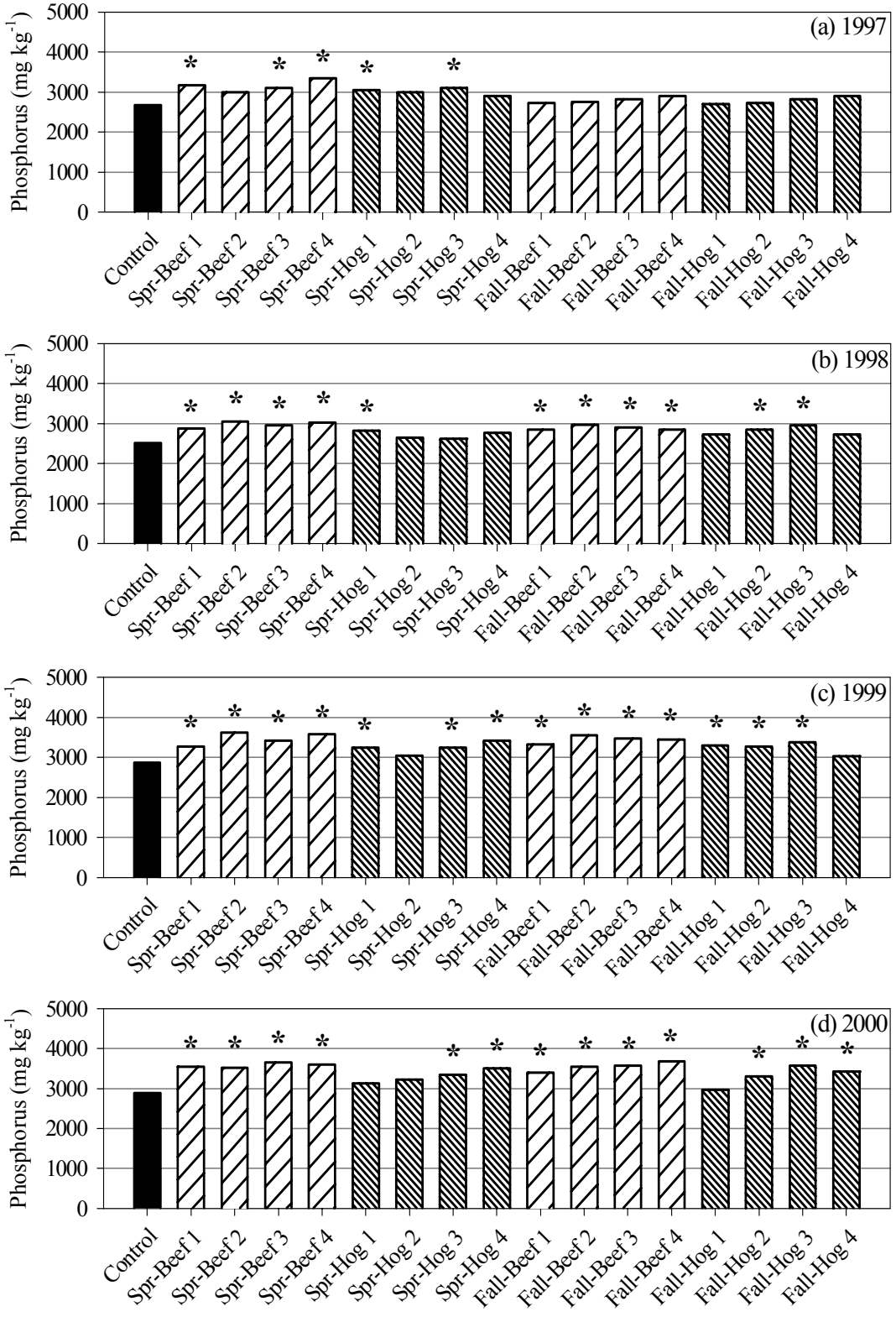


Fig. 32. Effects of manure application on phosphorus content in alfalfa at the Lethbridge site from 1997 to 2000. Means that are significantly different from the control are indicated with an asterisk ($p < 0.05$).

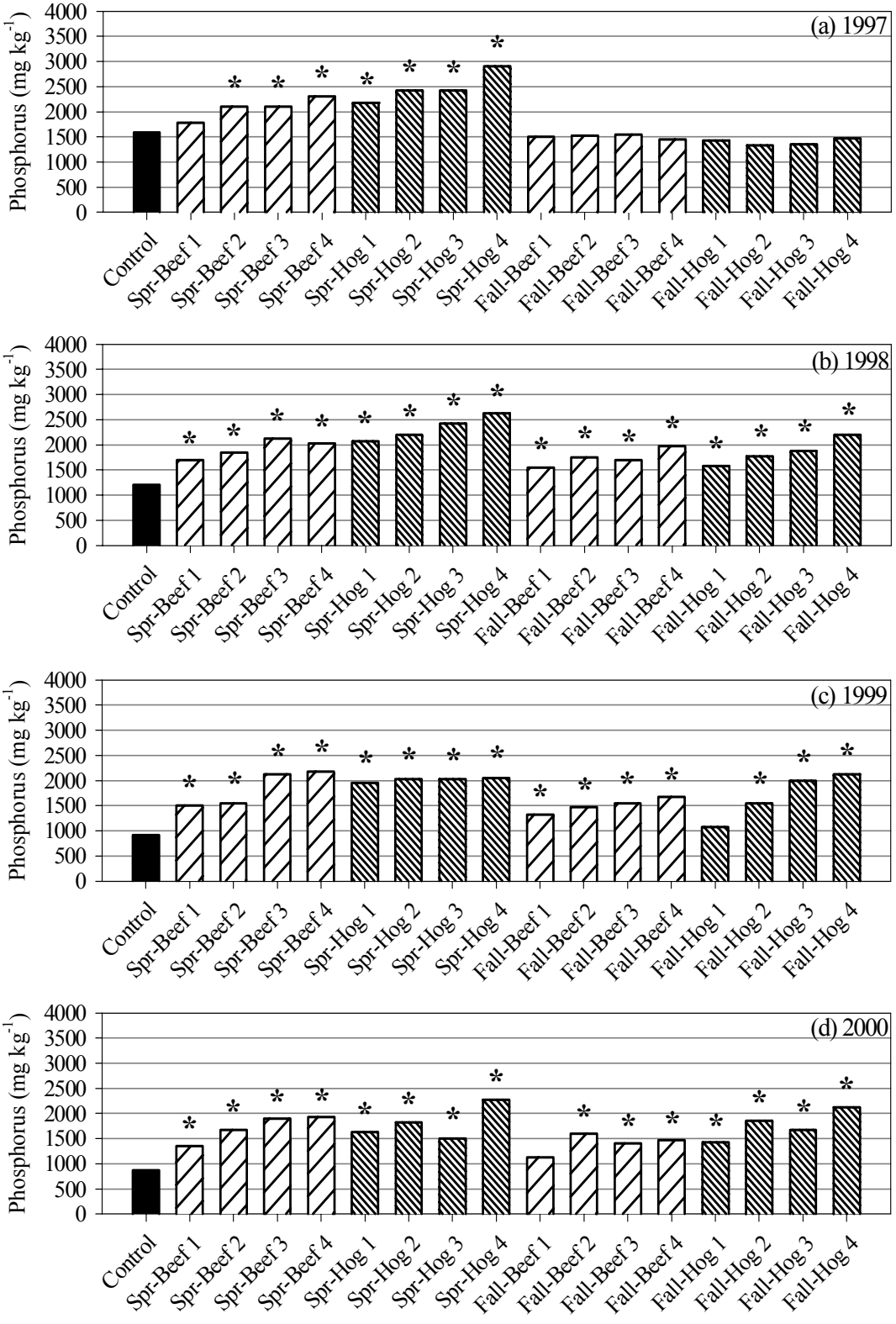


Fig. 33. Effects of manure application on phosphorus content in timothy at the Airdrie site from 1997 to 2000. Means that are significantly different from the control are indicated with an asterisk ($p < 0.05$).

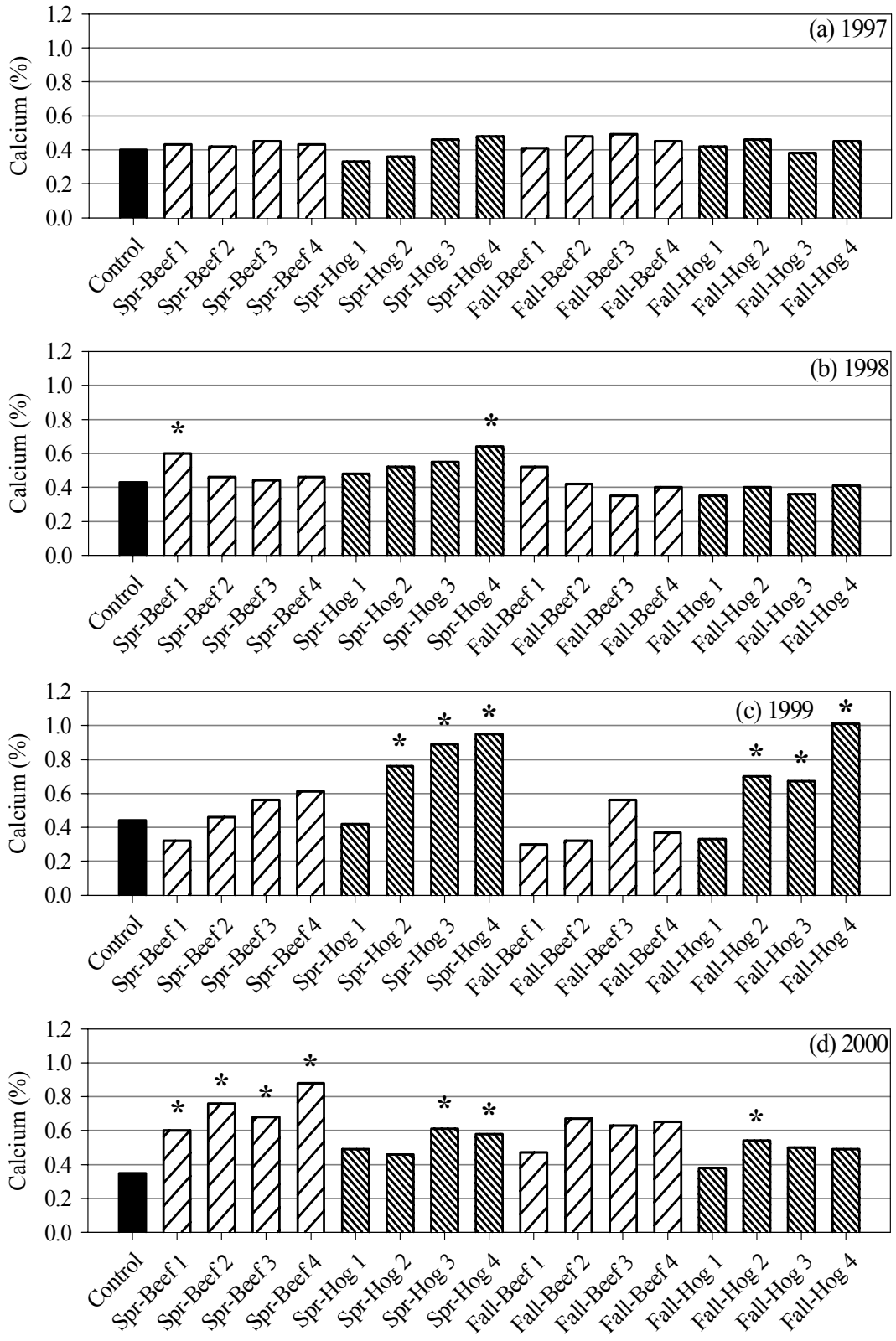


Fig. 34. Effects of manure application on calcium content in timothy at the Airdrie site from 1997 to 2000. Means that are significantly different from the control are indicated with an asterisk ($p < 0.05$).

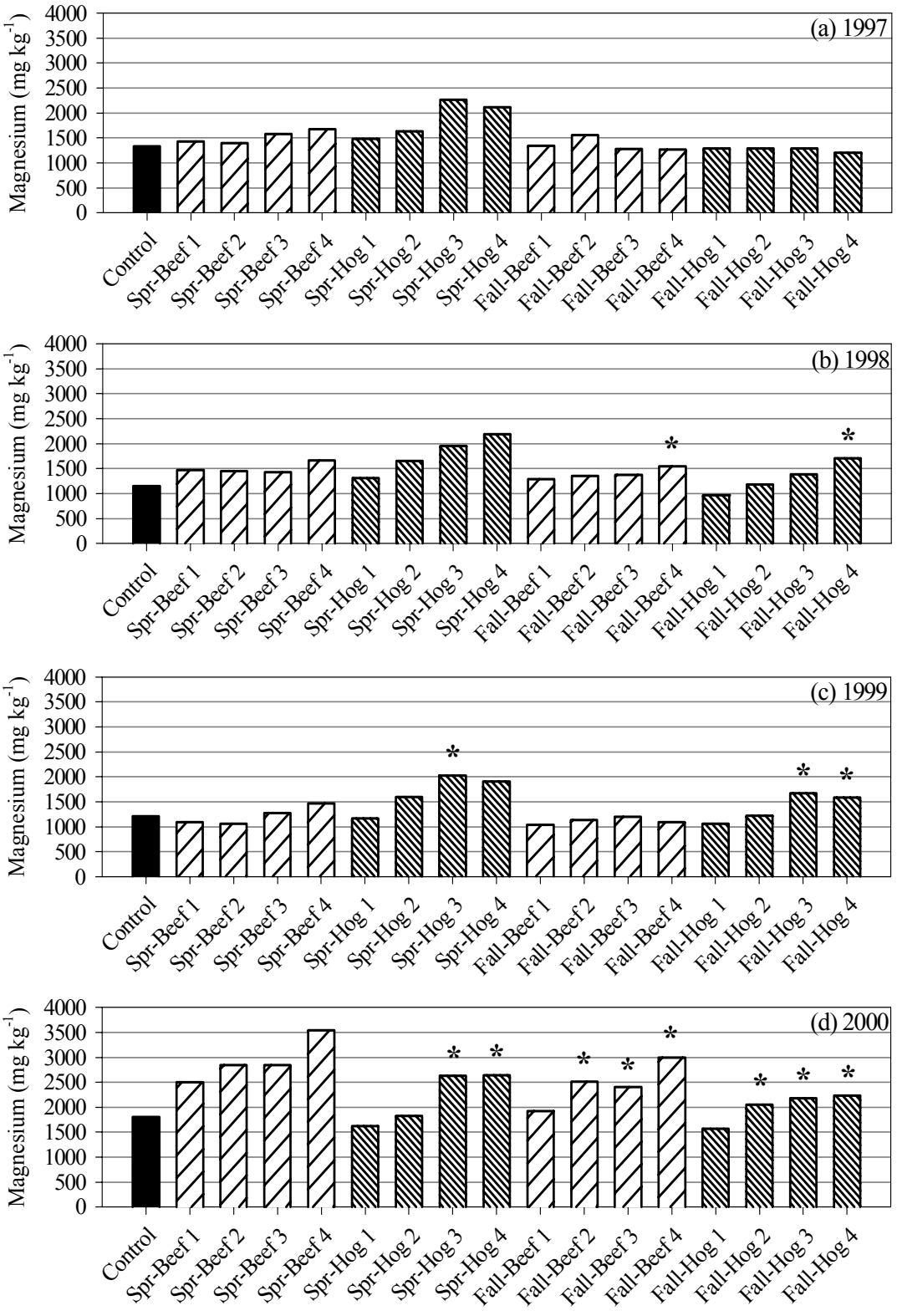


Fig. 35. Effects of manure application on magnesium content in timothy at the Airdrie site from 1997 to 2000. Means that are significantly different from the control are indicated with an asterisk ($p < 0.05$).

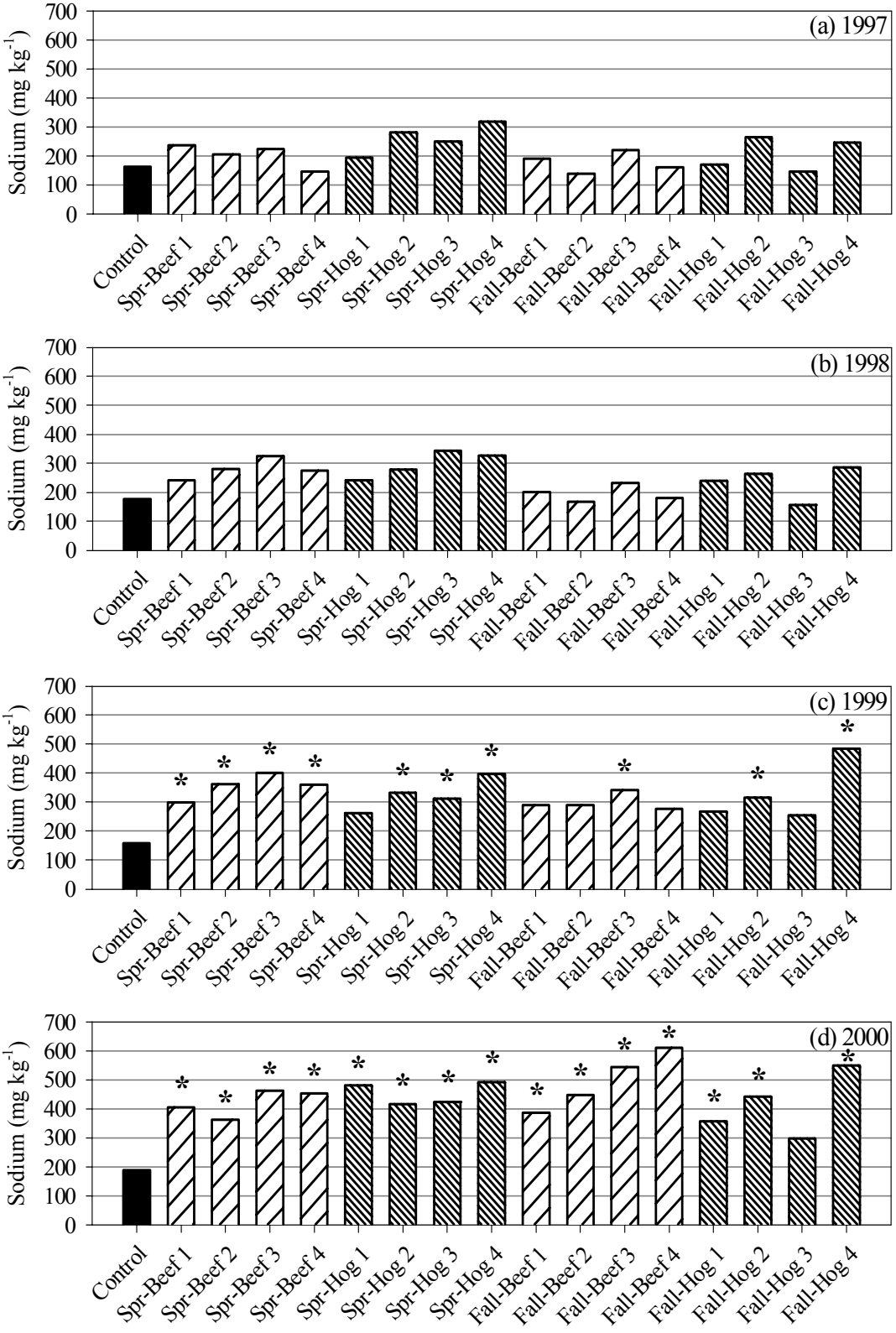


Fig. 36. Effects of manure application on sodium content in alfalfa at the Lethbridge site from 1997 to 2000. Means that are significantly different from the control are indicated with an asterisk ($p < 0.05$).

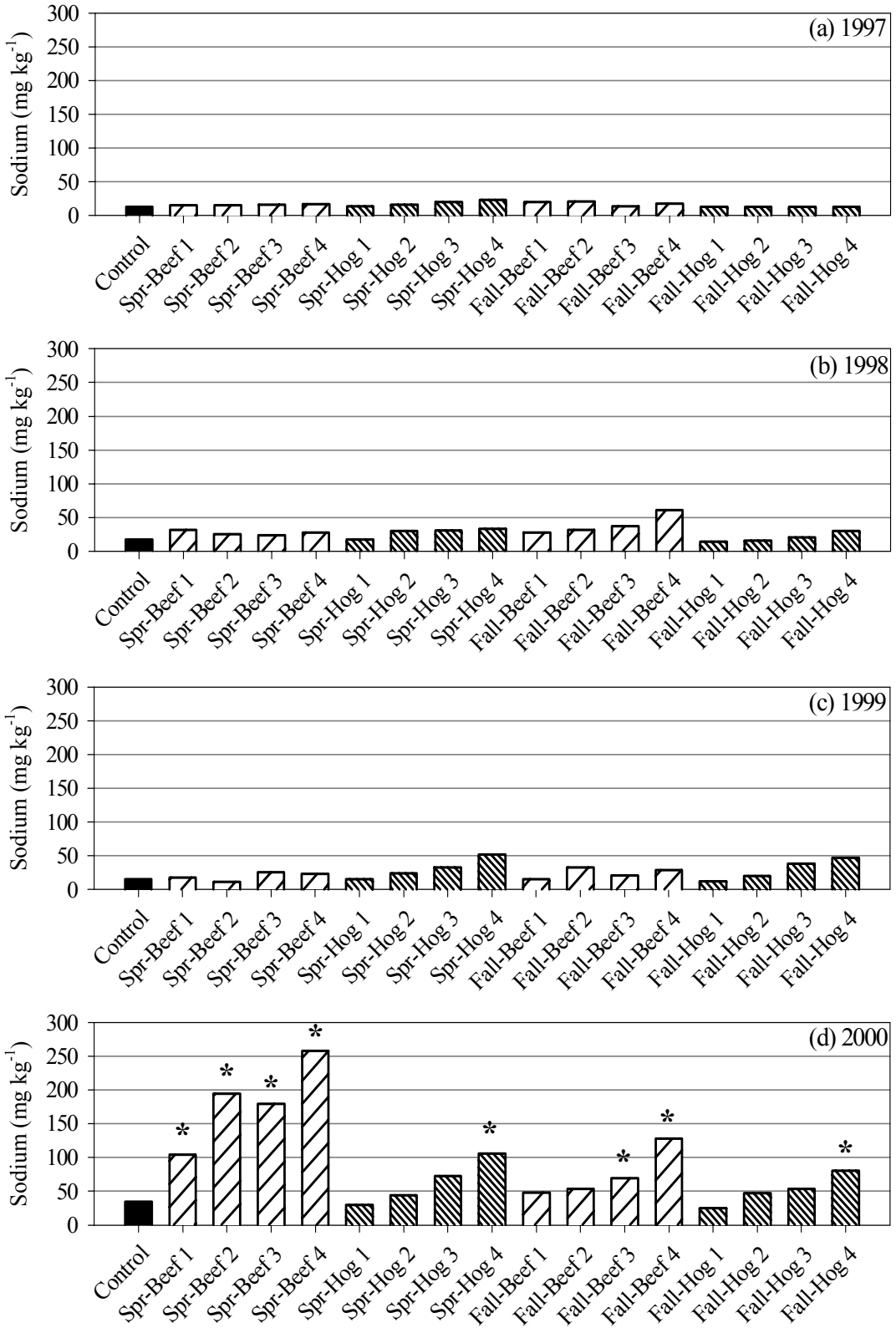


Fig. 37. Effects of manure application on sodium content in timothy at the Airdrie site from 1997 to 2000. Means that are significantly different from the control are indicated with an asterisk ($p < 0.05$).

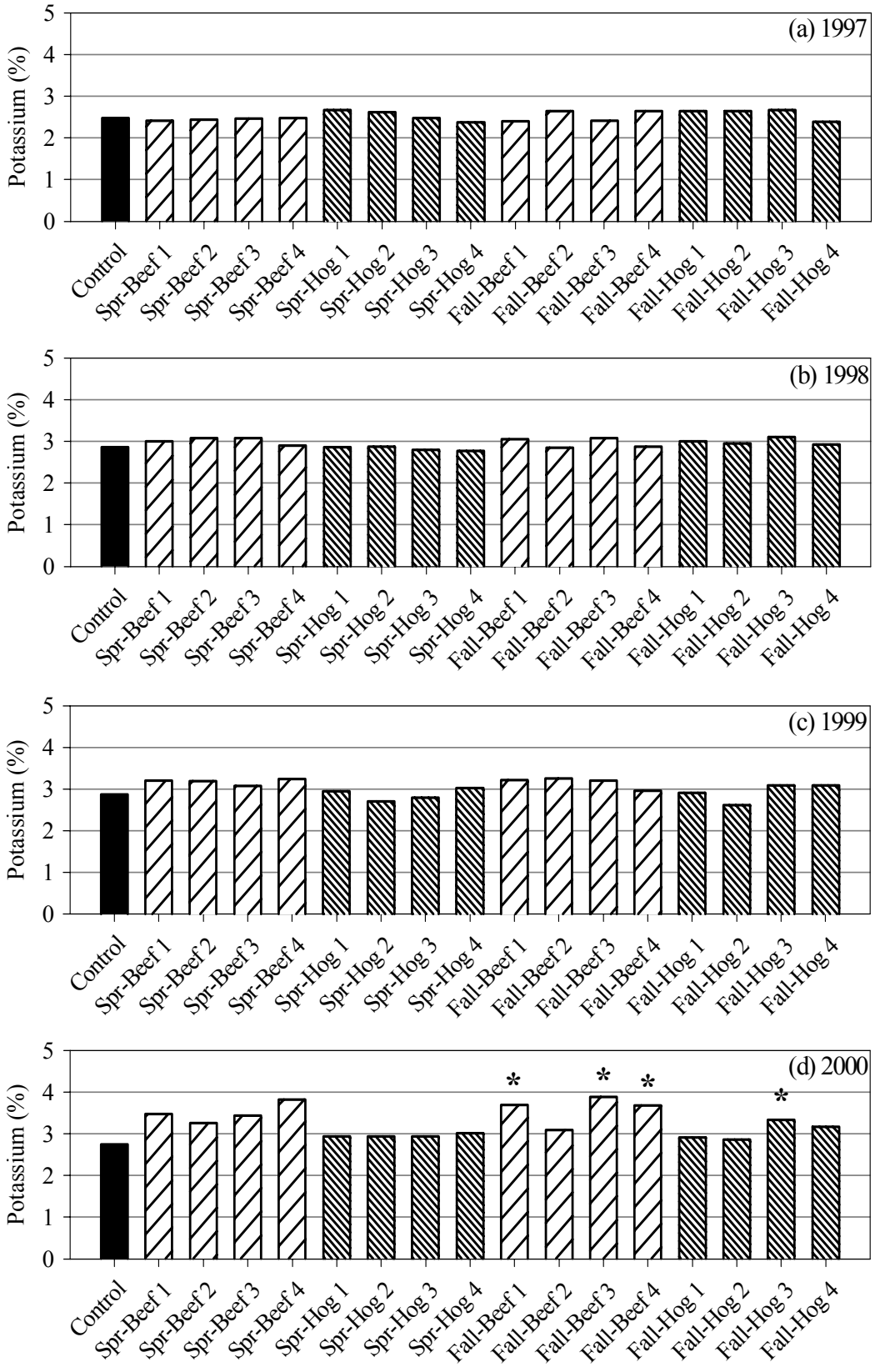


Fig. 38. Effects of manure application on potassium content in alfalfa at the Lethbridge site from 1997 to 2000. Means that are significantly different from the control are indicated with an asterisk ($p < 0.05$).

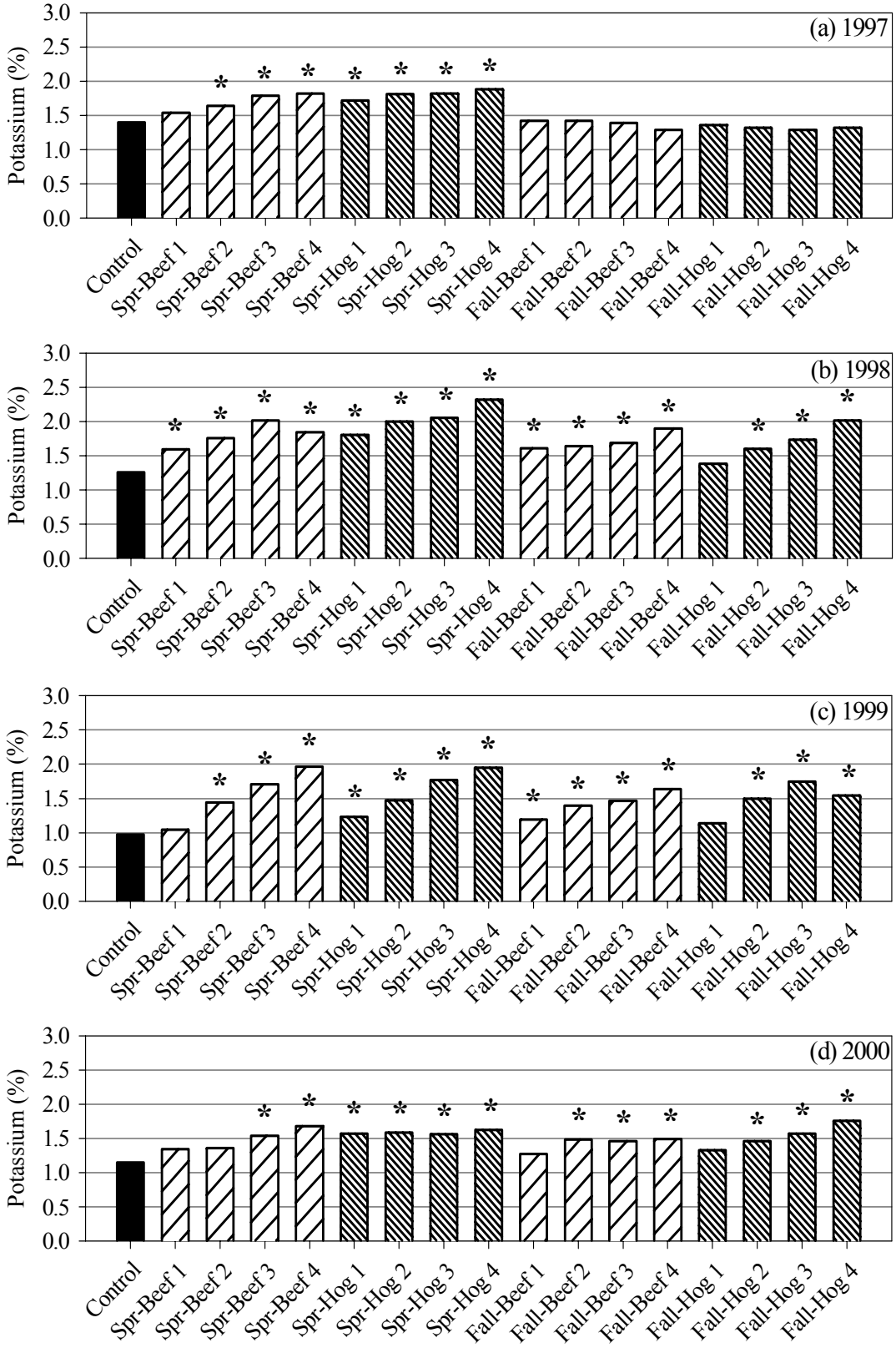


Fig. 39. Effects of manure application on potassium content in timothy at the Airdrie site from 1997 to 2000. Means that are significantly different from the control are indicated with an asterisk ($p < 0.05$).

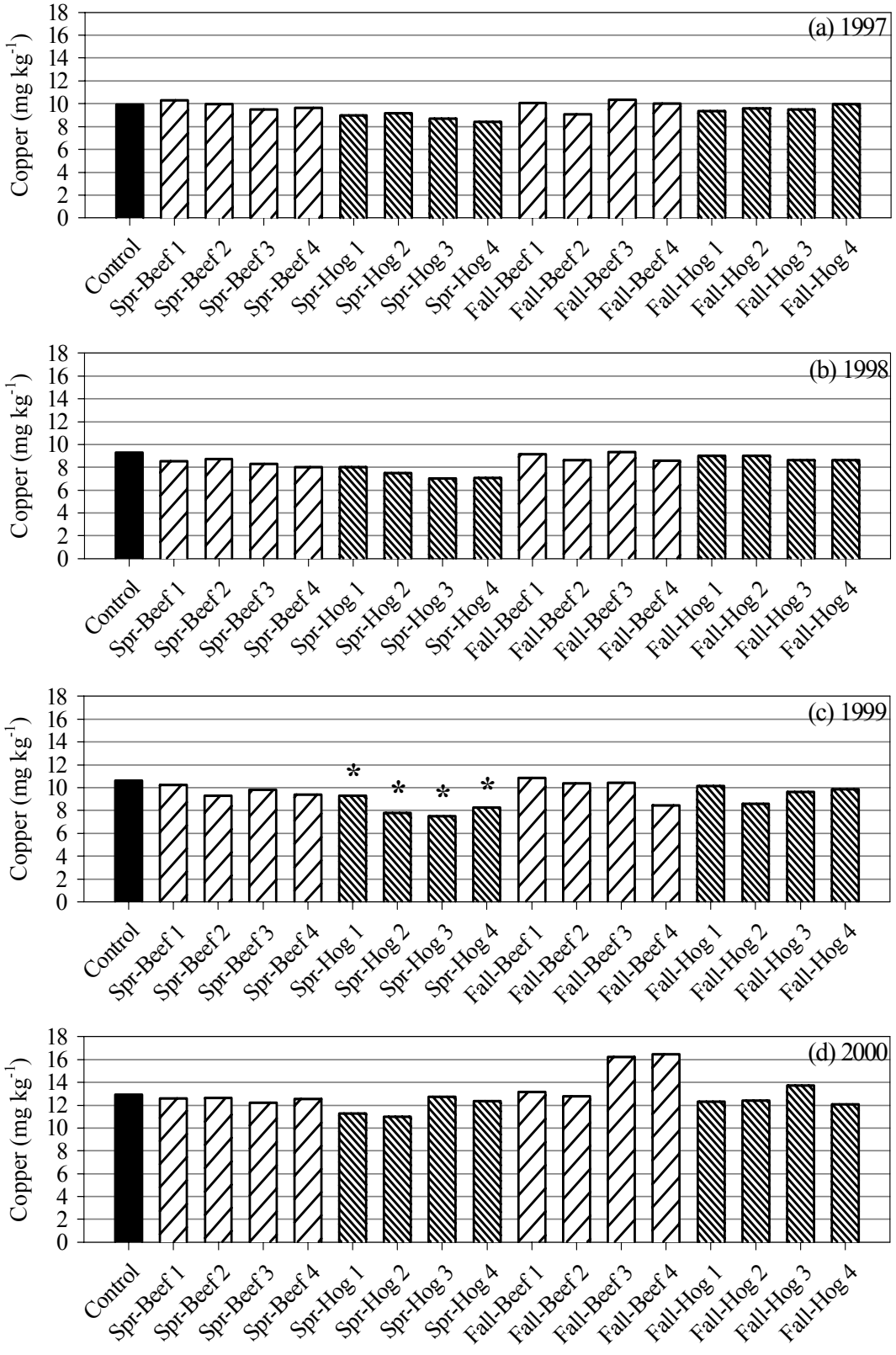


Fig. 40. Effects of manure application on copper content in alfalfa at the Lethbridge site from 1997 to 2000. Means that are significantly different from the control are indicated with an asterisk ($p < 0.05$).

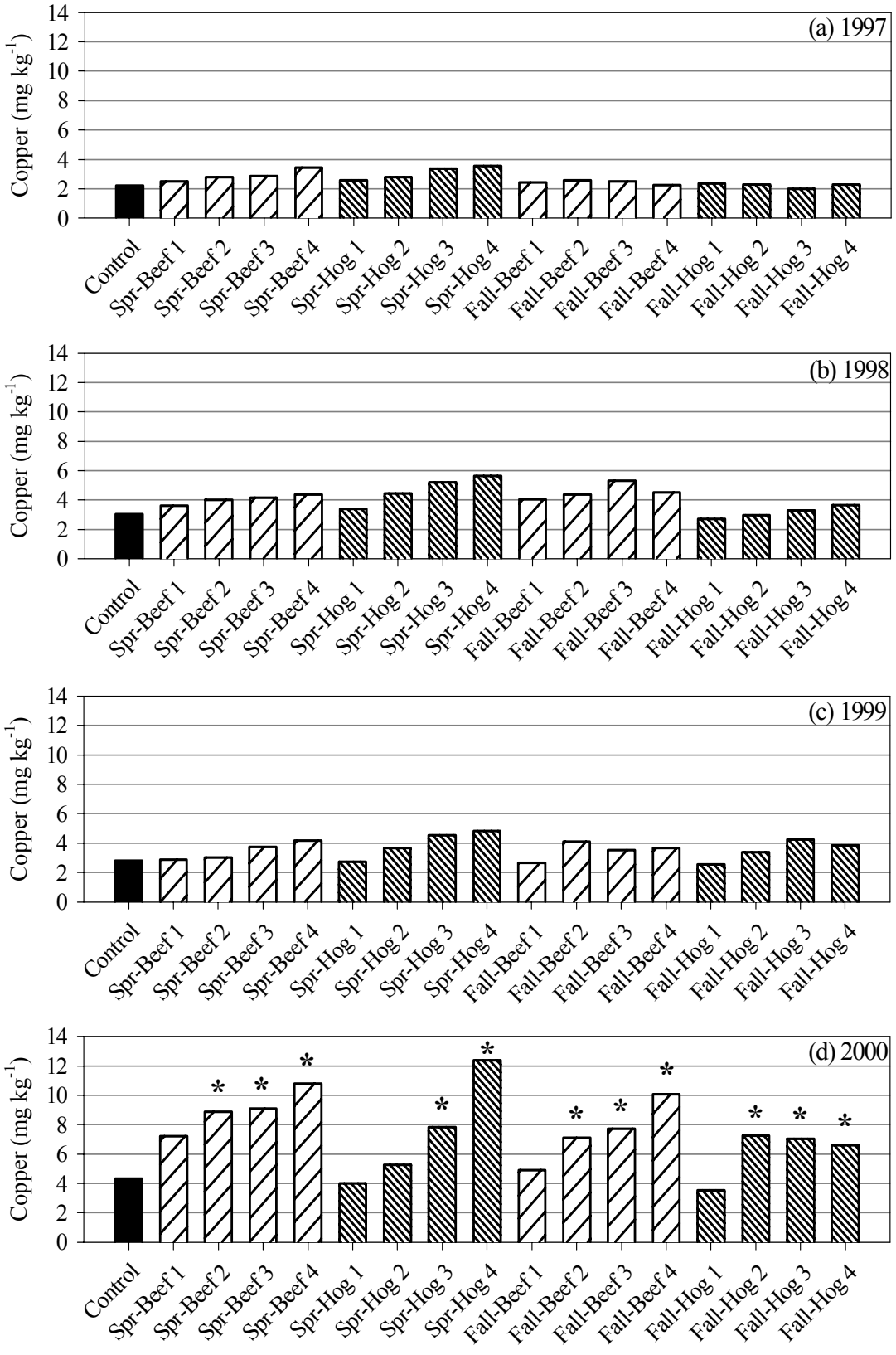


Fig. 41. Effects of manure application on copper content in timothy at the Airdrie site from 1997 to 2000. Means that are significantly different from the control are indicated with an asterisk ($p < 0.05$).

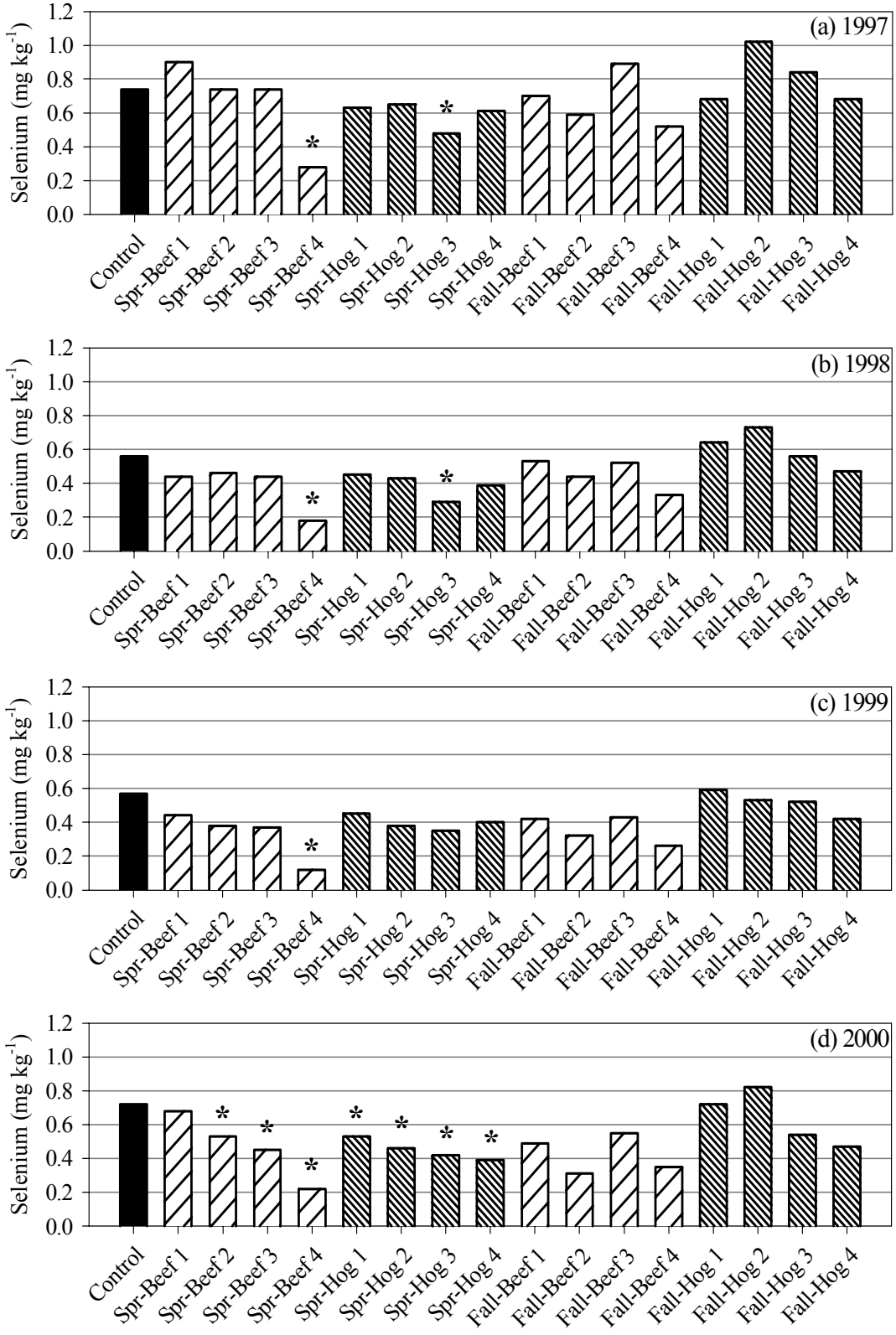


Fig. 42. Effects of manure application on selenium content in alfalfa at the Lethbridge site from 1997 to 2000. Means that are significantly different from the control are indicated with an asterisk ($p < 0.05$).

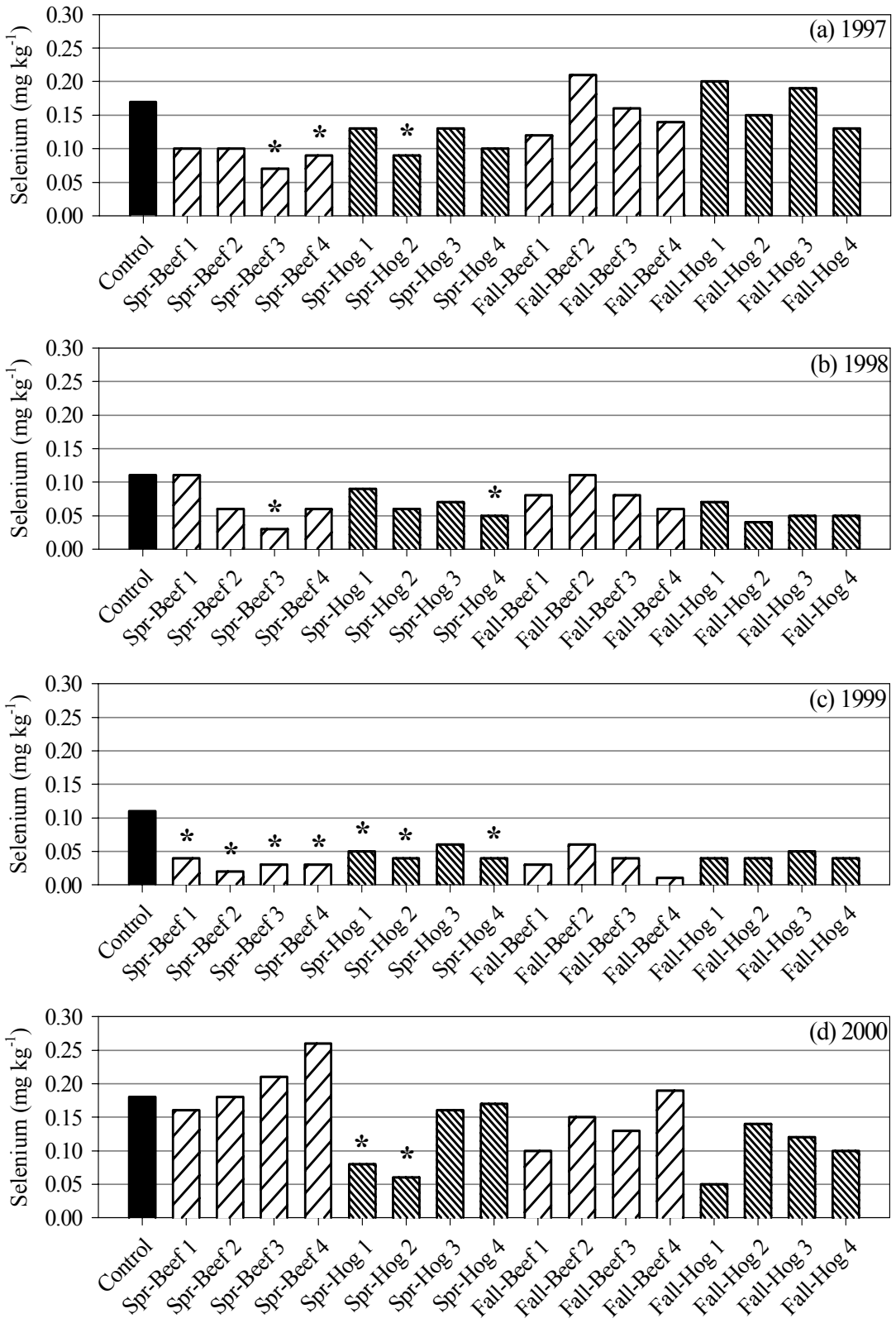


Fig. 43. Effects of manure application on selenium content in timothy at the Airdrie site from 1997 to 2000. Means that are significantly different from the control are indicated with an asterisk ($p < 0.05$).

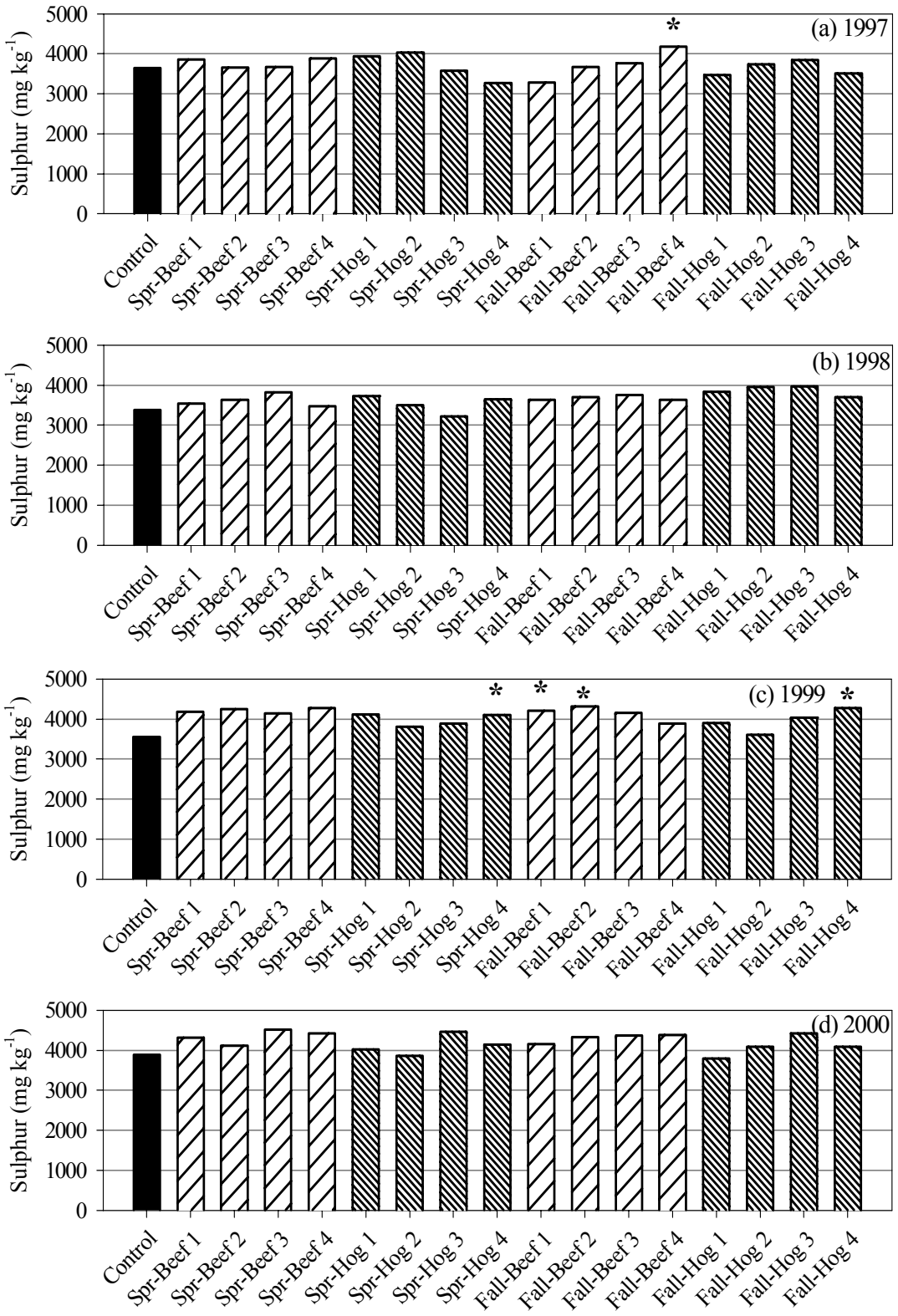


Fig. 44. Effects of manure application on sulphur content in alfalfa at the Lethbridge site from 1997 to 2000. Means that are significantly different from the control are indicated with an asterisk ($p < 0.05$).

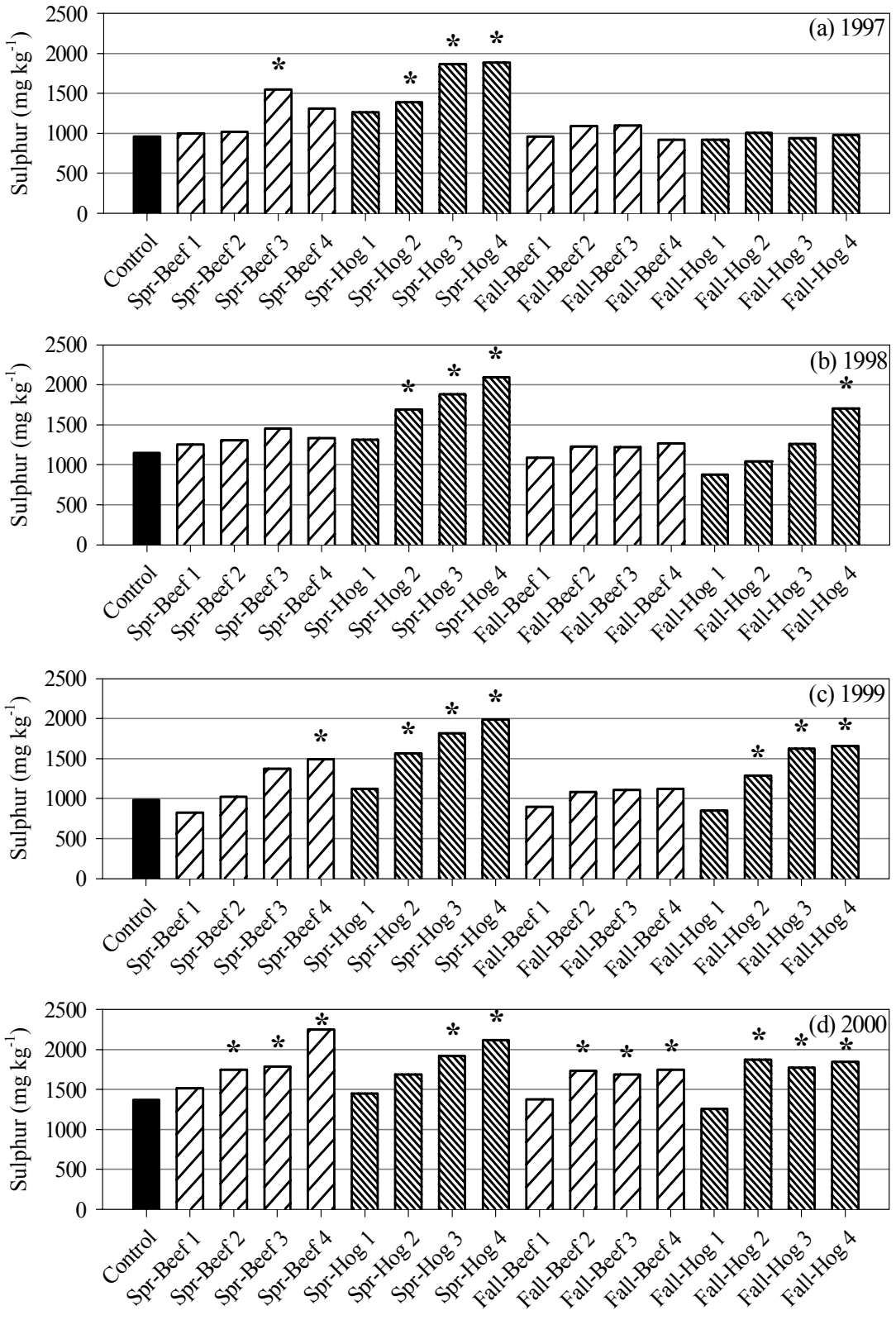


Fig. 45. Effects of manure application on sulphur content in timothy at the Airdrie site from 1997 to 2000. Means that are significantly different from the control are indicated with an asterisk ($p < 0.05$).

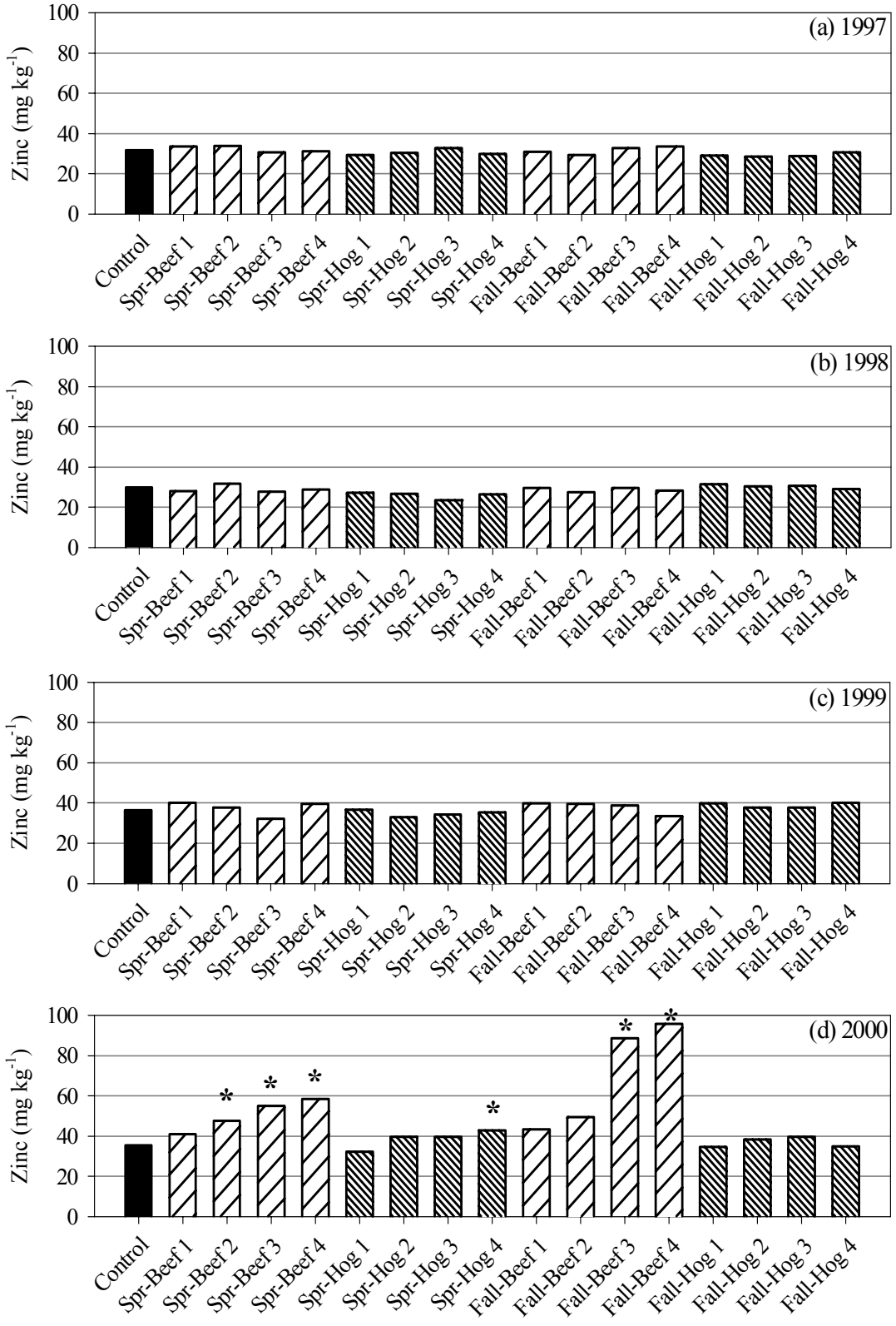


Fig. 46. Effects of manure application on zinc content in alfalfa at the Lethbridge site from 1997 to 2000. Means that are significantly different from the control are indicated with an asterisk ($p < 0.05$).

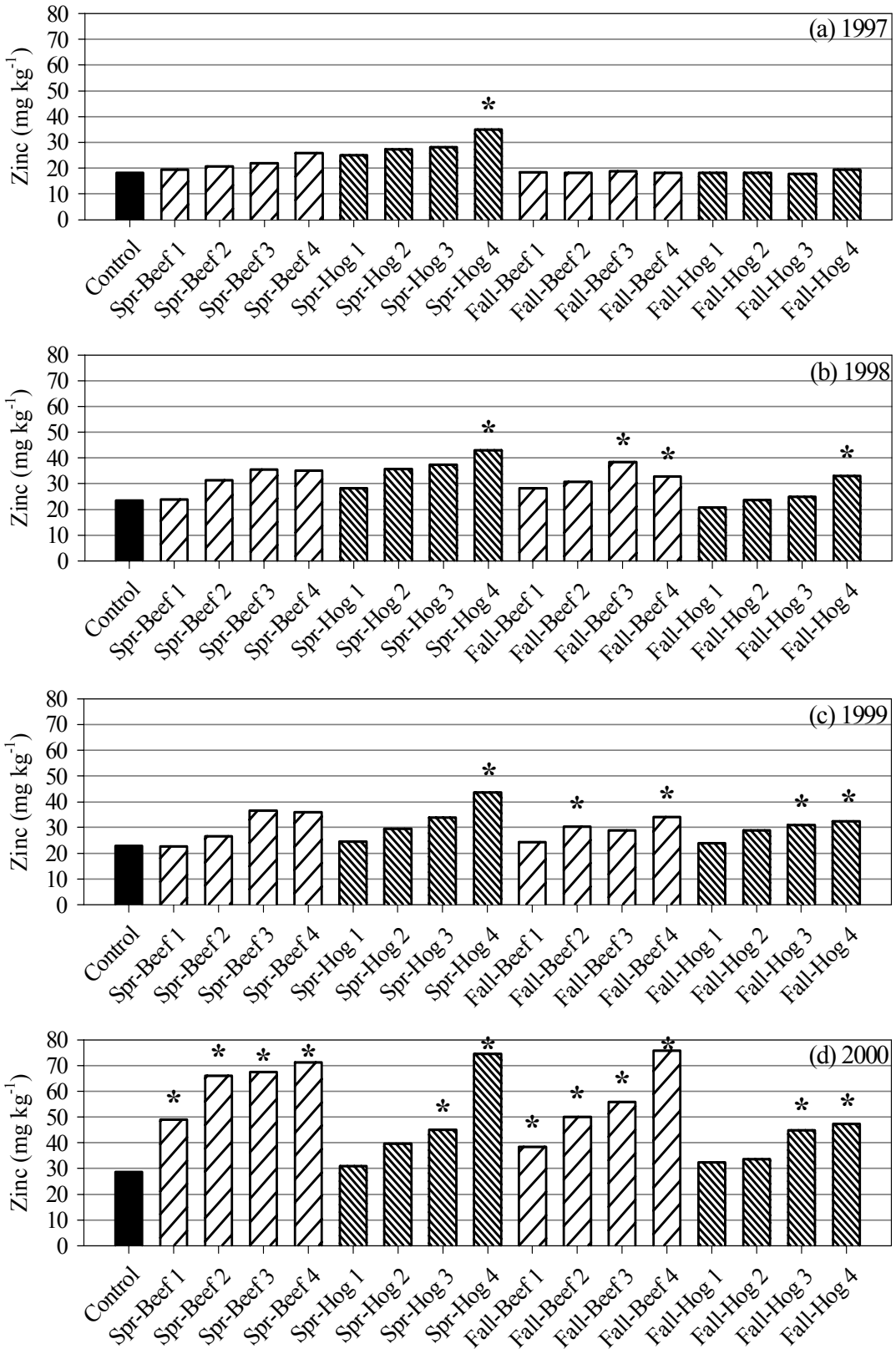


Fig. 47. Effects of manure application on zinc content in timothy at the Airdrie site from 1997 to 2000. Means that are significantly different from the control are indicated with an asterisk ($p < 0.05$).

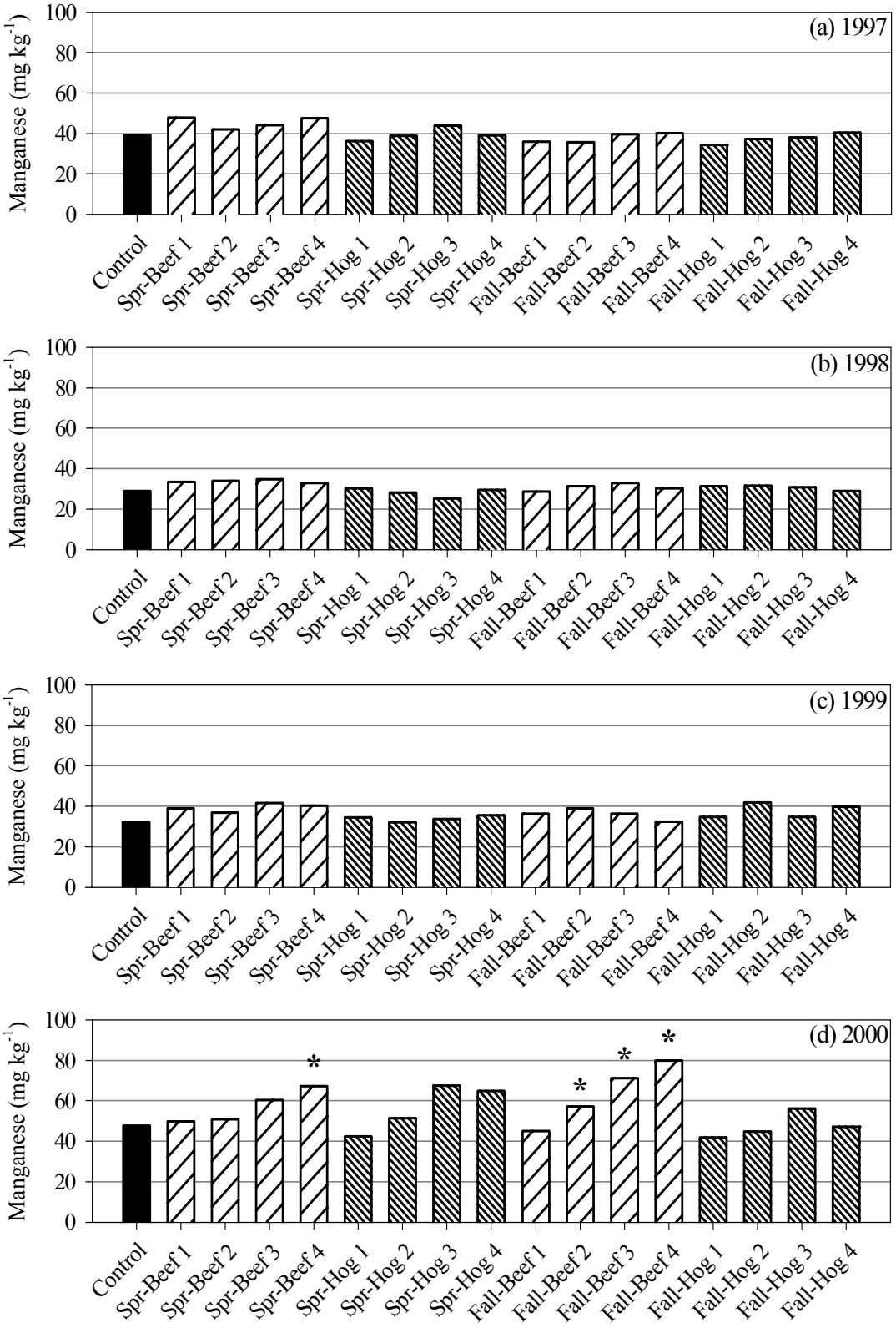


Fig. 48. Effects of manure application on manganese content in alfalfa at the Lethbridge site from 1997 to 2000. Means that are significantly different from the control are indicated with an asterisk ($p < 0.05$).

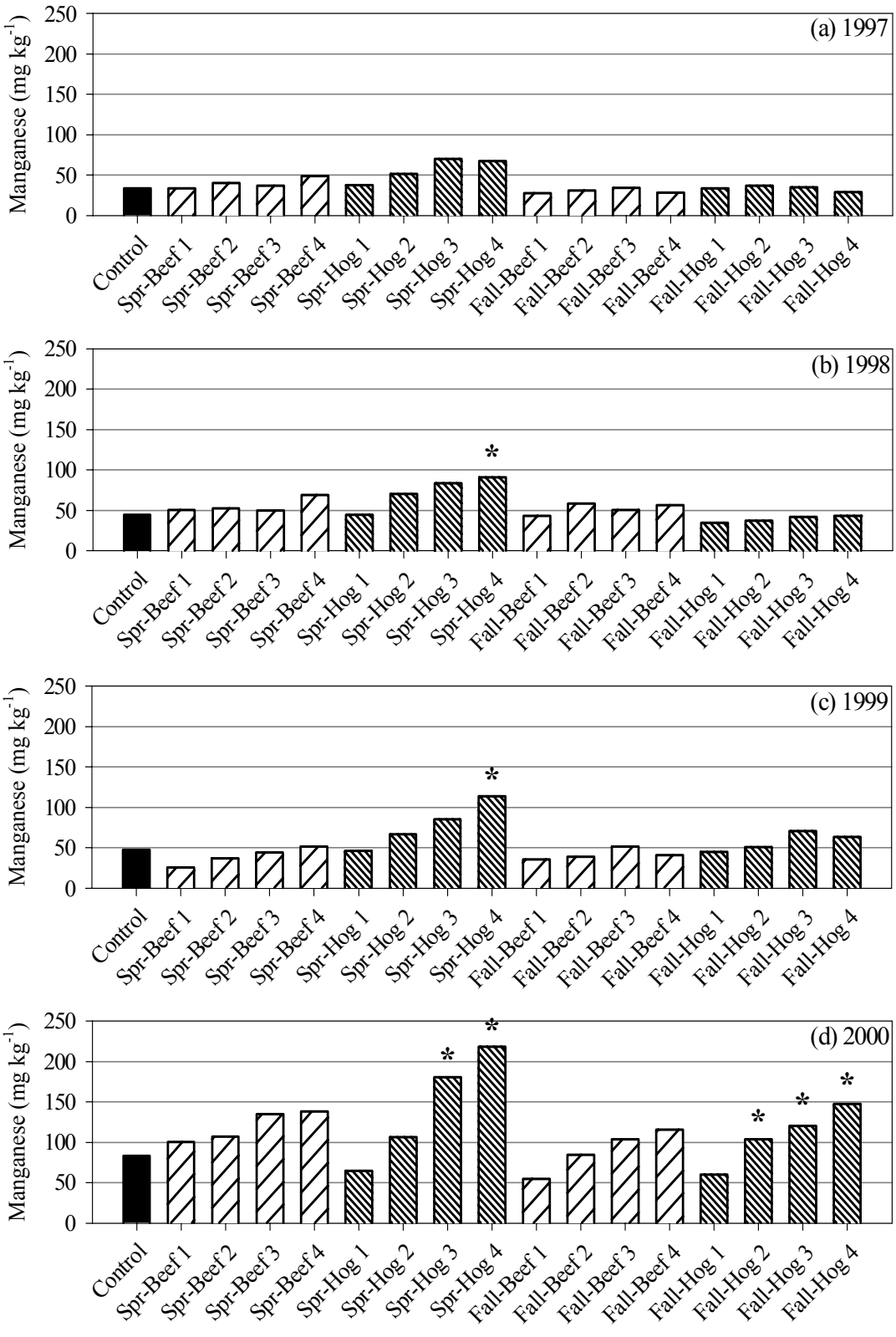


Fig. 49. Effects of manure application on manganese content in timothy at the Airdrie site from 1997 to 2000. Means that are significantly different from the control are indicated with an asterisk ($p < 0.05$).

CONCLUSIONS

Soil Quality Results

- Manure application increased extractable nitrate-N in the soil, with evidence of nitrate leaching down the soil profile at both sites. The differences between beef and hog manure at the two sites could be explained, in part, by differences in total nitrogen applied between the manure types and by the potentially greater loss of volatile nitrogen from the surface-applied, non-incorporated, beef manure.
- Extractable phosphate-P in the soil generally increased, but higher levels of phosphate-P remained in the top 15 cm of soil, reflecting the less mobile nature of phosphate-P compared to nitrate-N. There were some inconsistencies with the phosphate-P data and these were attributed to the extraction method, which may not have been suitable for calcareous soils.
- Extractable potassium was also increased, but only for beef-manure application. The difference in manure-type can be attributed to manure quality. About four to eight times more potassium was added from beef-manure applications compared to hog-manure applications.
- Extractable sodium content was increased at both sites. Beef manure had a greater effect than hog manure at the Lethbridge site, and this was probably because a little more than eight times more sodium was added from beef manure at this site.
- Manure application did not affect sulphate-S content at the Lethbridge site, whereas sulphate-S content was significantly increased in the 0- to 30-cm depth at the Airdrie site.
- Soil pH was not affected by manure application at the Airdrie site, and soil pH was slightly decreased at the Lethbridge site. The largest decrease was only 0.4 units, and the significant differences were generally associated with the two higher application rates for both manure types and these mainly occurred in 2000 and 2001.
- Spring-applied manure essentially did not affect soil electrical conductivity at the Lethbridge site. However, the fall-applied manure significantly increased soil electrical conductivity. The differences occurred mainly in 2000 and 2001, and beef manure had a greater effect than hog manure. In fact, the two high rates of beef manure increased the 0- to 15-cm depth from a non-saline status (< 2 dS m^{-1}) to a weakly saline status (2 to 4 dS m^{-1} range) at the Lethbridge site. Similar results were observed at the Airdrie site. The adverse effects of manure on soil salinity have regulatory implications in Alberta. The Agricultural Operation Practices Act in Alberta states that manure must not be applied if soil salinity is more than 4 dS m^{-1}.
- Soil organic matter was not affected by manure application at the Airdrie site, whereas soil organic matter was increased in the 0- to15-cm depth at the Lethbridge site. Beef manure had a greater effect than hog manure, and this was probably because three times more organic matter was added to the beef-manure plots. The lack of significant effects at the Airdrie site may have been caused by the higher initial soil organic matter content, which may have made it difficult to detect any changes in only 4 yr of manure application. The surface soil at the Airdrie site contained about twice as much organic matter as the Lethbridge site.

Crop Yield Results

- The application of manure had no significant effect on alfalfa yield at the Lethbridge site in 1996 to 1998, regardless of the manure type and the time of application. In 1999, most

manure treatments yielded significantly higher than the control, and in 2000 all manure treatments yielded higher than the control. After four or five annual applications of manure, there was no nutrient advantage of applying more than the lowest rate used on alfalfa. There were significant treatment-by-year interactions for the fall- and spring-applied treatments. There were no yield responses from 1996 to 1998, whereas nearly all manure treatments yielded more than the control in 1999 and 2000. There were no significant differences among the four rates for each manure type and no differences between the two manure types, regardless of the application time and year.

- Timothy yield was not significantly different from the control for the spring-applied treatments in 1997 at the Airdrie site. In 1998 to 2000, manure treatments often had significantly higher yield than the control. The spring-applied treatments showed no differences between the two manure types. Generally, yield increased as the spring-applied manure rate increased from rates 1 to 3. Rate 4 was not significantly different than rates 2 and 3, and there was a tendency for yield from the rate 4 treatment to be less than rate 3. This may be an indication that yield depression occurred with the high application rate, though the yield from the rate-4 treatment remained significantly higher than the control and rate 1. Fall-applied hog manure significantly yielded more than fall-applied beef manure in 1998 and 1999. There was no significant manure-rate effect for the fall-applied manure at the Airdrie site.

Crop Quality Results

- The effects of manure application on tissue quality varied according to measured parameter, site location, year, manure type, and manure rate. There were significant manure-by-rate, manure-by-year, and rate-by-year interactions.
- Sixteen crop-tissue parameters were measured, and of these, protein, acid detergent fiber, nitrate, phosphorus, calcium, magnesium, sodium, potassium, copper, selenium, sulphur, zinc, and manganese were significantly affected by manure application. Only boron, iron, and aluminum were not affected by beef or hog manure application.
- The concentration of most parameters that were significant affected increased when manure was applied. The exception was selenium, which was the only parameter that decreased in concentration with the application of manure.
- The cumulative effect of annual manure applications was apparent, because the effect became more pronounced for many of the increases in successive years. Nitrate concentration increased the most with the addition of manure compared to the other parameters.
- Concentration of the parameters that increased with added manure tended to be more pronounced for timothy than for alfalfa under the conditions of the study. Even with the effects of manure on crop-tissue quality, the means of the parameters generally stayed within published ranges for alfalfa and timothy.
- The K:(Ca+Mg) ratios for alfalfa at the Lethbridge site were well below the critical value of 2.2, above which grass tetany may occur in ruminants, throughout the study, with or without manure application. However, at the Airdrie site K:(Ca+Mg) ratios for timothy were higher than alfalfa, with many mean values above the critical level. This applied to the control and manured plots. None of the manure treatments at either site were statistically different from the controls.

The overall conclusion of our study is that surface-applied solid beef manure and injected liquid hog manure can be effectively applied to forage land. This is particularly beneficial for liquid manures, because injection methods are considered good practices to reduce odours, reduce nitrogen losses, and help prevent nutrient losses by surface runoff. Even though surface-applied beef manure cannot be incorporated in forage crops, our results showed a nutrient benefit. However, with surface-applied, non-incorporated manure, special care needs to be taken to prevent runoff losses and possible contamination of surface water bodies.

Our results also showed that manure application significantly affected soil quality, forage yield, and forage quality. In terms of soil quality, several nutrients of environmental concern accumulated in the soil, such as nitrate-N and phosphate-P, and an increase in soil salinity was observed. Based on electrical conductivity alone, as a measure of salinity, the annual application of manure at the higher rates is not sustainable with time under the conditions of the study. Annual applications should not exceed the lowest rates used in the study (31 Mg ha^{-1} for beef manure and 42 Mg ha^{-1} for hog manure).

The cumulative effect of 4 to 5 yr of manure application generally did not show differences among manure application rates (other than the control) in terms of yield increase. Long-term application above the lowest rates used in this study will not add any significant benefit to increase yield, but repeated applications of high rates of manure may lead to environmental problems. There was some indication that the highest manure rates may have suppressed yield relative to the second highest manure rates for timothy at the Airdrie site.

For the most part, the application of manure on forages did not have any negative effect on alfalfa and timothy forage quality.

The comparison between beef and hog manure was variable and one type was not found to be better than the other. The physical action of injecting hog manure into forage land did not have a deleterious effect on crop yield. Many differences among beef and hog manure treatments, in terms of soil chemistry and tissue quality, could be explained by the differences in the nutrient load in the two types of manure. Nutrient load at the time of application depends on nutrient concentration and application rate. Nutrient content of manure must be known and application equipment should be properly calibrated.

Statistically, the spring- and fall-application treatments could not be compared; however, a qualitative comparison indicated there were minimal differences between spring and fall applications. Factors such as available time, convenience, labour, equipment availability, and management style may be more important in determining the timing of manure application.

REFERENCES

Ajwa, H.A., Bañuelos, G.S., and Mayland, H.F. 1998. Selenium uptake by plants from soils amended with inorganic and organic materials. J. Environ. Qual. **27**: 1218-1227.

Anderson, M.A., McKenna, J.R., Martens, D.C., Donohue, S.J., Kornegay, E.T., and Lindemann, M.D. 1991. Long-term effects of copper rich swine manure application on continuous corn production. Commun. Soil Sci. Plant Anal. **22**: 993-1002.

Arnesen, A.K.M. and Singh, B.R. 1998. Plant uptake and DTPA-extractability of Cd, Cu, Ni, and Zn in a Norwegian alum shale soil as affected by previous addition of dairy and pig manures and peat. Can. J. Soil Sci. **78**: 531-539.

Bailey, L., Grant, C., and Choudhary, M. 1999. Use of lagoon stored swine manure for pasture production. Page 111-115 *in* Manure management '99: Proceedings of a tri-provincial conference on manure management. Saskatoon, Saskatchewan, Canada. June 22-25, 1999.

Barkle, G.F., Stenger, R., Singleton, P.L., and Painter, D.J. 2000. Effect of regular irrigation with dairy farm effluent on soil organic matter and soil microbial biomass. Aust. J. Soil Res. **38**: 1087-1097.

Belanger, G., Richards, J.E., and Walton, R.B. 1989. Effects of 25 years of N, P, and K fertilization on yield, persistence and nutritive value of a timothy sward. Can. J. Plant Sci. **69**: 501-512.

Bennett, D.R. and McCarley, E.L. 1995. Land availability for manure disposal in the LNID portion of the County of Lethbridge. Irrigation Branch, Alberta Agriculture, Food and Rural Development, Lethbridge, Alberta, Canada. 19 pp.

Bittman, S., Kowalenko, C.G., Hunt, D.E., and Schmidt, O. 1999. Surface-banded and broadcast dairy manure effects on tall fescue yield and nitrogen uptake. Agron. J. **91**: 826-833.

Bomke, A.A. and Lowe, L.E. 1991. Trace element uptake by two British Columbia forages as affected by poultry manure application. Can. J. Soil. **71**: 305-312.

Breeuwsma, A., Reijerink, J.G.A., and Schoumans, O.F. 1995. Impacts of manure on accumulation and leaching of phosphate in areas of intensive livestock farming. Pages 239-249 *in* K. Steele (ed.) Animal waste and the land-water interface. Lewis Publishers, Boca Raton, Florida, United States.

Canada-Alberta Environmental Sustainable Agriculture (CAESA)-Soil Inventory Project Working Group. 1998. AGRASID: Agricultural Region of Alberta Soil Inventory Database (Version 1.0). [CD-ROM computer file] J.A. Brierley, B.D. Walker, P.E. Smith, and W.L. Nikiforuk (eds.). Agriculture and Agri-Food Canada, Alberta Research Council, and Alberta Agriculture, Food and Rural Development.

Chang, C. and Entz, T. 1996. Nitrate leaching losses under repeated cattle feedlot manure applications in southern Alberta. J. Environ. Qual. **25**: 145-153.

Chang, C., Janzen, H.H., and Entz, T. 1994. Long-term manure application effects on nutrient uptake by barley. Can. J. Plant Sci. **74**: 327-330.

Chang, C., Sommerfeldt, T.G., and Entz, T. 1990. Rates of soil chemical changes with eleven annual applications of cattle feedlot manure. Can. J. Soil Sci. **70**: 673-681.

Chang, C., Sommerfeldt, T.G., and Entz, T. 1991. Soil chemistry after eleven annual applications of cattle feedlot manure. J. Environ. Qual. **20**: 475-480.

Charles, J.L. 1999. Soil and crop response to hog and cattle manure additions in east central Saskatchewan. Master of Science Thesis. College of Graduate Studies and Research, University of Saskatchewan, Saskatoon, Saskatchewan, Canada. 151 pp.

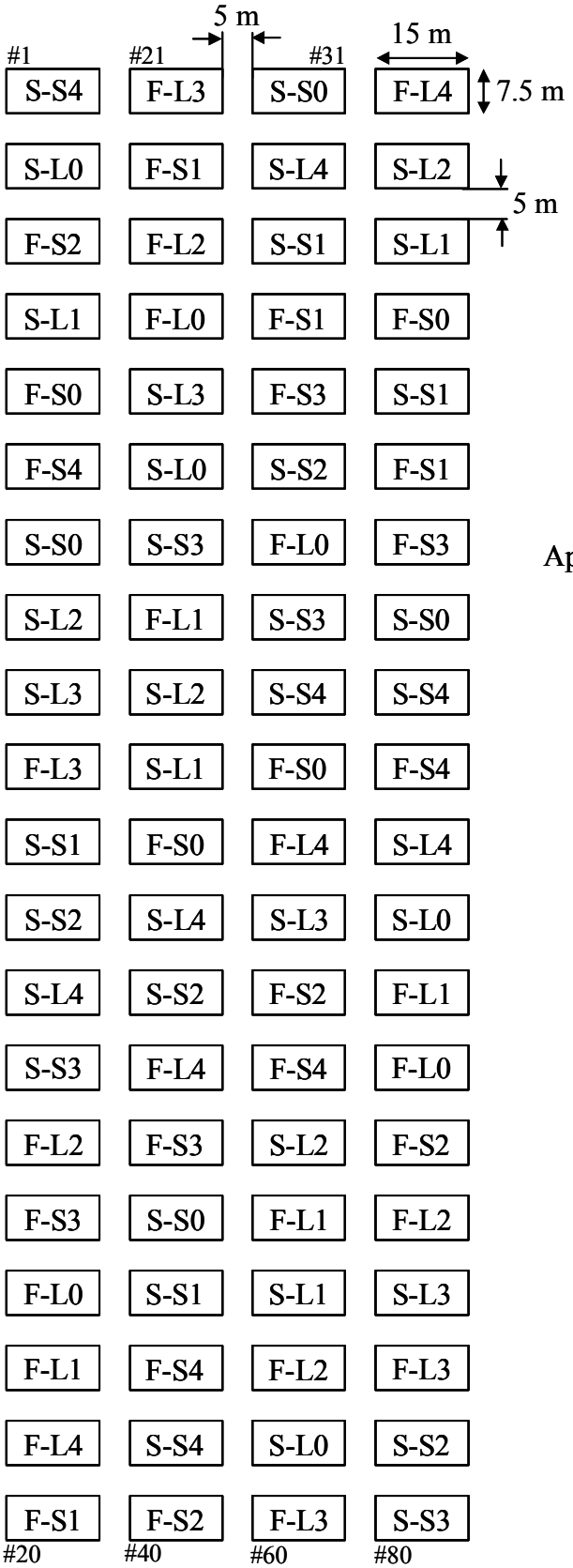
Cherney, J.H. and Duxbury, J.M. 1994. Inorganic nitrogen supply and symbiotic dinitrogen fixation in alfalfa. J. Plant. Nutr. **17**: 2053-2067.
Chowdbury, M.A.H., Kouno, K., Ando, T., and Nagaoka, T. 2000. Microbial biomass, S mineralization, and S uptake by African millet from soil amended with various composts. Soil Biol. Biochem. **32**: 845-852.
Coffee, R.C, and Bartholomew, W.V. 1964. Some aspects of ammonia sorption by soil surfaces. Soil Sci. Soc. Am. Proc. **28**: 485-490.
Collins, M., Brinkman, M.A., and Salman, A.A. 1990. Forage yield and quality of oat cultivars with increasing rates of nitrogen fertilization. Agron. J. **82**: 724-728.
Corbett, R. 1996. Ten year average analysis of Alberta Feeds 1984-1994. [Online]. Alberta Agriculture Food and Rural Development. Available at http://www.agric.gov.ab.ca/livestock/feed/index.html (posted April 26, 1996; accessed April 24, 2002).
Cox, W.J., Kalonge, S., Cherney, D.J.R., and Reid, W.S. 1993. Growth, yield, and quality of forage maize under different nitrogen management practices. Agron. J. **85**: 341-347.
Daliparthy, J., Herbert, S.J., Moffitt, L.J., and Veneman, P.L.M. 1995. Herbage production, weed occurrence, and economic risk from dairy manure applications to alfalfa. J. Prod. Agric. **8**: 495-501.
Dey, D. 1998. Commercial cattle feeding industry. AG-Ventures: Agriculture business profiles. Alberta Agriculture, Food and Rural Development Agdex 420/830-2. 24 pp.
Edwards, D.R., and Daniel, T.C. 1993. Effects of poultry litter application rate and rainfall intensity on quality of runoff from fescuegrass plots. J. Environ. Qual. **22**: 361-365.
Environment Canada. 2001a. Canadian climate normals: Lethbridge CDA. [Online]. Environment Canada. Available at http://www.mscsmc.ec.gc.ca/climate/climate_normals/show_normals_e.cfm?station_id=437&prov=AB&start_row=1&end_row=13 (posted April 14, 2001; accessed August 12, 2001).
Environment Canada. 2001b. Canadian climate normals: Calgary Int'l A. [Online]. Environment Canada. Available at http://www.msc-smc.ec.gc.ca/climate/climate_normals/show_normals_e.cfm?station_id=320&prov=AB&start_row=1&end_row=13 (posted April 19, 2001; accessed August 12, 2001).
Eriksen, J. and Mortensen, J.V. 1999. Soil sulphur status following long-term annual application of animal manure and mineral fertilizers. Biol. Fertil. Soils. **28**: 416-421.
Goss, D.W. and Stewart, B.A. 1979. Efficiency of phosphorus utilization by alfalfa from manure and superphosphate. Soil Sci. Soc. Am. J. **43**: 523-528.
Graetz, D.A., Nair, V.D., Portier, K.M., and Voss, R.L. 1999. Phosphorus accumulation in manure-impacted Spodosols of Florida. Agric. Ecosyst. Environ. **75**: 31-40.
Grant, R.F., Juma, N.G., Robertson, J.A., Izaurralde, R.C., and McGill, W.B. 2001. Long-term changes in soil carbon under different fertilizer, manure, and rotation: Testing the mathematical model *ecosys* with data from the Breton plots. Soil Sci. Soc. Am. J. **65**: 205-214.
Grunes, D.L., Stout, P.R., and Brownell, J.R. 1970. Grass tetany in ruminants. Adv. Agron. **22**: 331-374.
Guertin, S.P., St-Pierre, J.C., and Gervais, P. 1979. Influence de la fertilization azotée sur le rendement, la valeur nutritive et la teneur en diverses fractions azotées de trois cultivars de la fléole des prés. Can. J. Plant Sci. **59**: 839-846.
Hansen, D. 2000. Agriculture statistics yearbook: Crops. [Online]. Alberta Agriculture, Food and Rural Development. Available at http://www.agric.gov.ab.ca/economic/yearbook/crops.html (in Table 72 pdf file) (posted May 26, 2000; accessed July 28, 2001).

Intensive Livestock Operations Committee (ILOC). 1995. Code of practice for the safe and economic handling of animal manures. Agdex 400/27-2. Alberta Agriculture, Food and Rural Development, Edmonton, Alberta. 38 pp.
Jaipaul, R. 2001a. Agriculture statistics yearbook: Alberta livestock industry. [Online]. Alberta Agriculture, Food and Rural Development. Available at http://www.agric.gov.ab.ca/economic /yearbook/livestock.html (in Table 45 pdf file) (posted July 24, 2001; accessed July 28, 2001).
Jaipaul, R. 2001b. Agriculture statistics yearbook: Alberta livestock industry. [Online]. Alberta Agriculture, Food and Rural Development. Available at http://www.agric.gov.ab.ca/economic /yearbook/livestock.html (in Table 46 pdf file) (posted July 24, 2001; accessed July 28, 2001).
Jarvis, S.C. and Barraclough D. 1991. Variation in mineral nitrogen under grazed grassland swards. Plant and Soil **138**: 177-188.
Jarvis, S.C., Stockdale, E.A., Sheperd, M.A., and Powlson D.S. 1996. Nitrogen mineralization in temperate agricultural soils: Processes and measurement. Adv. Agron. **57**: 187-235.
Jefferson, P.G., Coulman, B.E., and Kielly, G.A. 2001. Production and quality of irrigated timothy hay in Saskatchewan for export hay markets. Agron. J. **93**: 910-917.
Kanchikerimath, M. and Singh, D. 2001. Soil organic matter and biological properties after 26 years of maize-wheat-cowpea cropping as affected by manure and fertilization in a Cambisol in semiarid region of India. Agric. Ecosys. Environ. **86**: 155-162.
Kleinman, P.J.A., Sharpley, A.N., Gartley, K., Jarrell, W.M., Kuo, S., Menon, R.G., Myers, R., Reddy, K.R., and Skogley, E.O. 2001. Interlaboratory comparison of soil phosphorus extracted by various soil test methods. Comm. Soil Sci. Plant Anal. **32**: 2325-2345.
Liebhardt, W.C. and Shotall, J.G. 1974. Potassium is responsible for salinity in soils amended with poultry manure. Comm. Soil Sci. Plant Anal. **5**: 385-398.
Liu, F., Mitchell, C.C., Odom, J.W., Hill, D.T., and Rochester, E.W. 1997. Swine lagoon effluent disposal by overland flow: Effects on forage production and uptake of nitrogen and phosphorus. Agron. J. **89**: 900-904.
Lockyer, D.R., Pain, B.F., and Klarenbeek, J.V. 1989. Ammonia emissions from cattle, pig and poultry wastes applied to pasture. Environ. Pollut. **56**: 19-30.
Ma, L., Scott, H.D., Shaffer, M.J., and Ahuja, L.R. 1998. RZWQM simulations of water and nitrate movement in a manured tall fescue field. Soil Sci. **163**: 259-270.
Manitoba Agriculture. 1999. Manure application rate calculator: MARC98 user manual, version 1.01. S. Tessier (ed.). [Available as a CD-ROM computer file] Manitoba Agriculture, Winnipeg, Manitoba, Canada, 59 pp.
Mathers, A.C., Stewart, B.A., Blair, B. 1975. Nitrate-nitrogen removal from soil profiles by alfalfa. J. Environ. Qual. **4**: 403-405.
McGinn, S.M. and Pradhan, R. 1997. Reducing ammonia loss from manure-amended soils. Pages 217- 223 *in* 34th Annual Alberta soil science workshop proceedings. Calgary, Alberta, February 18-20, 1997.
Miller, J.J., Sweetland, N.J., and Chang, C. 1999. Impact of long-term manure applications on soil physical properties. Agriculture and Agri-Food Canada, Lethbridge, Alberta, Canada. Farming for the Future Research Program final technical report. Project no. 970793. 99 pp.
Mooso, G.D., Cuomo, G.J., Blouin, D.C., and Pitman, W.D. 1996. Fertilizer effect on common bermudagrass on a southwest Louisiana coastal plain soil. J. Plant Nutr. **19**: 817-826.
Munns, D.N. 1968. Nodulation of *Medicago sativa* in solution culture. II. Compensating effects of nitrate and of prior nodulation. Plant Soil **28**: 246-257.

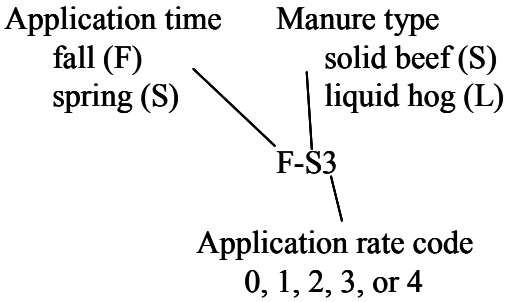
National Research Council. 2001. Nutrient requirements of dairy cattle. Seventh revised edition. Subcommittee on Dairy Nutrition, National Research Council. National Academy Press, Washington, D.C., United States. 381 pp.
O'Leary, M.J. and Rehm, G.W. 1990. Nitrogen and sulfur effects on yield and quality of corn grown for grain and silage. J. Prod. Agric. **3**: 135-140.
Olson, B.M., Bennett, D.R., McKenzie, R.H., Ormann, T, and Atkins, R.P. 1998. Manure nutrient management to sustain groundwater quality near feedlots. Alberta Agriculture, Food and Rural Development, Lethbridge, Alberta. CAESA Research Report RES-028-93. 214 pp.
Olson, B.M., McKenzie, R.H., Ormann, T, and Atkins, R.P. 2001. Effects of manure over application. Pages 19-26 *in* Agronomy update 2001 conference. Lethbridge, Alberta, Canada, January 17-18, 2001.
Paré, T., Dinel, H., Moulin, A.P., and Townley-Smith, L. 1999. Organic matter quality and structural stability of a Black Chenozemic soil under different manure and tillage practices. Geoderma **91**: 311-326.
Pastl, R., Michie, M., and Schoenau J. 1999. Shallow injection of hog manure into grassland. Pages 86-92 *in* Manure management '99: Proceedings of a tri-provincial conference on manure management. Saskatoon, Saskatchewan, Canada. June 22-25, 1999.
Paul, E.A. and Clark, F.E. 1989. Soil microbiology and biochemistry. Academic Press, Inc., San Diego, California, United States. p. 175.
Payne, G.G., Martens, D.C., Kornegay, E.T., and Lindemann, M.D. 1988. Availability and form of copper in three soils following eight annual applications of copper-enriched swine manure. J. Environ. Qual. **17**: 740-746.
Pierzynski, G.M. and Schwab, A.P. 1993. Bioavailability of zinc, cadmium, and lead in a metal-contaminated alluvial soil. J. Environ. Qual. **22**: 247-254.
Pratt, P.F. 1984. Salinity, sodium, and potassium in an irrigated soil treated with bovine manure. Soil Sci. Soc. Am. J. **48**: 823-828.
Province of Alberta. 2001. Alberta Regulation 267/2001. Agricultural Operation Practices Act. Standards and Administration Regulations, Soil protection: 25(1) and 25(2).
Razmjoo, K. and Henderlong, P.R. 1997. Effect of potassium, sulfur, boron, and molybdenum fertilization on alfalfa production and herbage macronutrient contents. J. Plant. Nutr. **20**: 1681-1696.
Riddell, K.M. and Rodvang, S.J. 1992. Soil and groundwater chemistry beneath irrigated land receiving manure applications in southern Alberta. Pages 69-109 *in* Impact of agricultural management practices on water quality. Agriculture Canada and Alberta Agriculture, Lethbridge, Alberta, Canada.
SAS Institute. 2000. SAS/STAT software. The SAS System for Windows®, v8. SAS Institute Inc., Cary, North Carolina, United States.
Sauer, T.J., Daniel, T.C., Moore, Jr., P.A., Coffey, K.P., Nichols, D.J., and West, C.P. 1999. Poultry litter and grazing animal waste effects on runoff water quality. J. Environ. Qual. **28**: 860-865.
Sauer, T.J., Daniel, T.C., Nichols, D.J., West, C.P., Moore, Jr., P.A., and Wheeler, G.L. 2000. Runoff water quality from poultry litter-treated pasture and forest sites. J. Environ. Qual. **29**: 515-521.
Schmitt, M.A., Sheaffer, C.C., and Randall, G.W. 1993. Preplant manure and commercial P and K fertilizer effects on alfalfa production. J. Prod. Agric. **6**: 385-390.

Schmitt, M.A., Sheaffer, C.C., and Randall, G.W. 1994. Manure and fertilizer effects on alfalfa plant nitrogen and soil nitrogen. J. Prod. Agric. **7**: 104-109.
Schulten, H.-R. and Leinweber, P. 1991. Influence of long-term fertilization with farmyard manure on soil organic matter: Characteristics of particle-size fractions. Biol Fertil Soils **12**: 81-88.
Sharpley, A.N., Chapra, S.C., Wedepohl, R., Sims, J.T., Daniel, T.C., and Reddy, K.R. 1994. Managing agricultural phosphorus for protection of surface waters: Issues and options. J. Environ. Qual. **23**: 437-451.
Smith, S.J., Mathers, A.C., and Stewart, B.A. 1980. Distribution of nitrogen forms in soil receiving cattle feedlot waste. J. Environ. Qual. **9**: 215-218.
Sommerfeldt, T.G., Chang, C., and Entz, T. 1988. Long-term annual manure applications increase soil organic matter and nitrogen, and decrease carbon to nitrogen ratio. Soil Sci Soc. Am. J. **52**: 1668-1672.
Stringer, W.C., Morton, B.C., and Pinkerton, B.W. 1996. Row spacing and nitrogen: Effect on alfalfa-bermudagrass quality components. Agron. J. **88**: 573-577.
Sullivan D.M., Cogger C.G., Bary A.I., and Fransen S.C. 2000. Timing of dairy manure applications to perennial grass on well drained and poorly drained soils. J. Soil Water Cons. **55**: 147-152.
Thompson R.B., Ryden J.C., and Lockyer D.R. 1987. Fate of nitrogen in cattle slurry following surface application or injection to grassland. J. Soil Sci. **38**: 689-700.
van der Watt, H.v.H., Summer, M.E., and Cabrera, M.L. 1994. Bioavailability of copper, manganese, and zinc in poultry litter. J. Environ. Qual. **23**: 43-49.
Vervoort, R.W., Radcliffe, D.E., Cabrera, M.L., and Latimore, Jr., M. 1998. Field-scale nitrogen and phosphorus losses from hayfields receiving fresh and composted broiler litter. J. Environ. Qual. **27**: 1246-1254.
Warman, P.R. 1986. Effects of fertilizer, pig manure, and sewage sludge on timothy and soils. J. Environ. Qual **15**: 95-100.
Warman, P.R. and Cooper, J.M. 2000a. Fertilization of a mixed forage crop with fresh and composted chicken manure and NPK fertilizer: Effects on dry matter yield and soil and tissue N, P, and K. Can. J. Soil Sci. **80**: 337-344.
Warman, P.R. and Cooper, J.M. 2000b. Fertilization of a mixed forage crop with fresh and composted chicken manure and NPK fertilizer: Effects on soil and tissue Ca, Mg, S, B, Cu, Fe, Mn, and Zn. Can. J. Soil Sci. **80**: 345-352.
Whalen, J.K. and Chang, C. 2001. Phosphorus accumulation in cultivated soils from long-term annual applications of cattle feedlot manure. J. Environ. Qual. **30**: 229-237.
Whalen, J.K., Chang, C., Clayton, G.W., and Carefoot, J.P. 2000. Cattle manure amendments can increase the pH of acid soils. Soil Sci. Soc. Am. J. **64**: 962-966.
Wikeem, B.M., Newman, R.F., and Van-Ryswyk, A.L. 1993. Forage response to N, P, and S fertilization on clearcut lodgepole pine sites. J. Range Manage. **46**: 262-270.

Appendix 1. Plot layout and treatment randomization at the Lethbridge and Airdrie field sites.



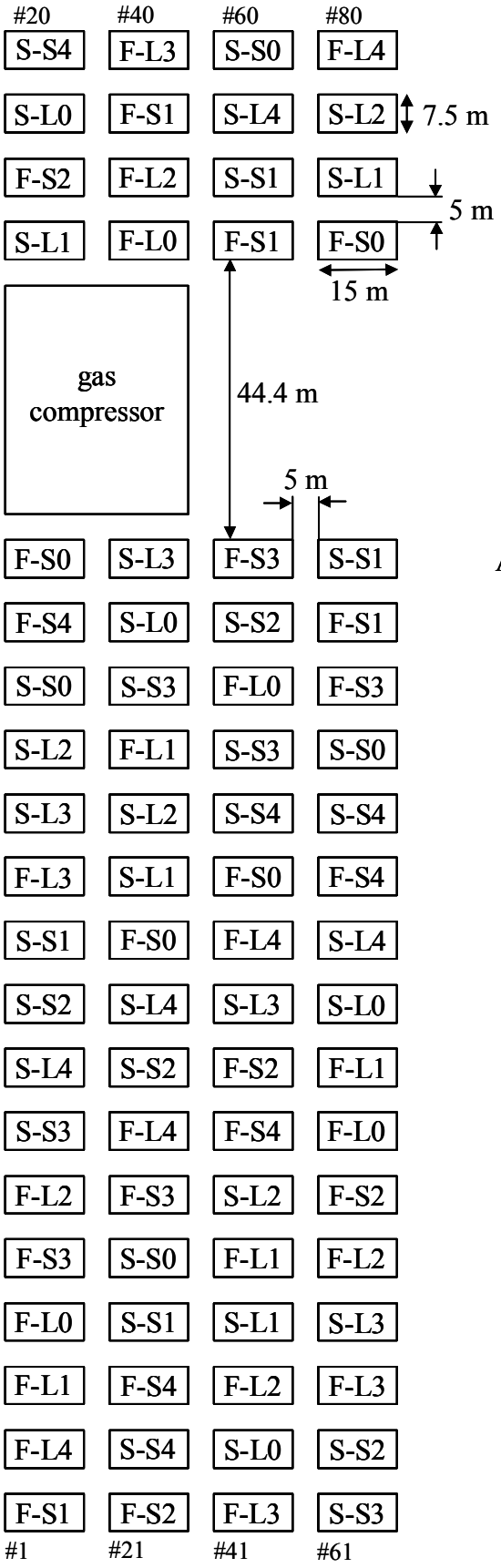
Lethbridge site
SE-29-9-20-W4



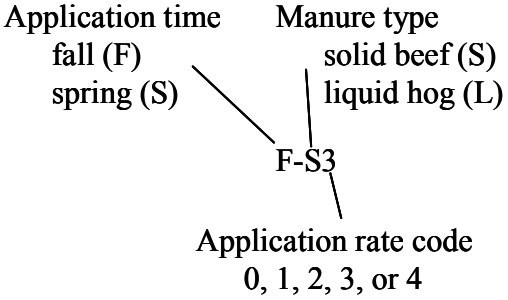
Rep 1: Plots 1-20
Rep 2: Plots 21-40
Rep 3: Plots 41-60
Rep 4: Plots 61-80

Manure rates (solid beef)
0 = control
1 = 31 Mg ha^{-1}
2 = 61 Mg ha^{-1}
3 = 92 Mg ha^{-1}
4 = 122 Mg ha^{-1}

Manure rates (liquid hog)
0 = control
1 = 42 Mg ha^{-1}
2 = 84 Mg ha^{-1}
3 = 126 Mg ha^{-1}
4 = 168 Mg ha^{-1}



Airdrie site
NW-17-27-28-W4



Rep 1: Plots 1-20
Rep 2: Plots 21-40
Rep 3: Plots 41-60
Rep 4: Plots 61-80

Manure rates (solid beef)
0 = control
1 = 31 Mg ha^{-1}
2 = 61 Mg ha^{-1}
3 = 92 Mg ha^{-1}
4 = 122 Mg ha^{-1}

Manure rates (liquid hog)
0 = control
1 = 42 Mg ha^{-1}
2 = 84 Mg ha^{-1}
3 = 126 Mg ha^{-1}
4 = 168 Mg ha^{-1}

Appendix 2. Dates of main field activities carried out at the Lethbridge and Airdrie sites from 1996 to 2001.

Activity	Lethbridge site	Airdrie site
	1996	n/a
soil sampling	May 1, 2	n/a
spring manure application	May 6	n/a
first harvest	July 2	n/a
second harvest	Aug 15	n/a
fall manure application	Aug 29, 30	n/a
	1997	
soil sampling	April 21, 22	April 23, 24
spring manure application	April 24, 25	April 30
first harvest	June 18	July 24
second harvest	August 21	n/a
fall manure application	Sept. 25, 26	Sept 22, 23
	1998	
soil sampling	April 15, 16	April 20, 21
spring manure application	April 16, 17	April 22, 23
first harvest	June 24	July 27, 28
second harvest	August 11	n/a
fall manure application	Sept 8, 9	Sept 22, 23
	1999	
soil sampling	April 6, 7	April 12, 13
spring manure application	April 9, 12	April 19, 20
first harvest	June 25	Aug 16
second harvest	Aug 20	n/a
fall manure application	Oct 5, 6	Oct 7, 8
	2000	
soil sampling	April 25, 26	April 27, 28
spring manure application	April 28, May 1	May 1, 2
first harvest	June 27	Aug 2
second harvest	August 4	n/a
Soil bulk density sampling	Sept 13	Sept. 14
fall manure application	Oct 11, 24	Sept 28, Oct 11
	2001	
soil sampling	April 23, 24	April 25, 26

n/a = not applicable

Appendix 3. Mean monthly temperature and monthly precipitation at the Agriculture and Agri-Food Canada Research Centre at Lethbridge and at the Calgary International Airport.

Table 3.1. Mean monthly temperature and monthly precipitation from 1996 to 2001 at the Agriculture and Agri-Food Canada Research Centre (49° 42' N, 112° 47' W, 899 m elevation) at Lethbridge, which is near the Lethbridge site.

	Mean temperature (°C)[z]							Monthly precipitation (mm)[z]						
	1996	1997	1998	1999	2000	2001	Norm.[y]	1996	1997	1998	1999	2000	2001	Norm.[y]
January	-14.5	-10.2	-10.3	-5.1	-7.7	-0.1	-8.6	32.3	16.7	14.0	10.2	28.6	13.4	21
February	-3.7	0.0	0.3	1.8	-4.0	-9.3	-4.7	6.0	9.2	0.0	7.0	15.8	12.5	12.8
March	-3.9	-0.7	-2.2	2.1	2.5	2.3	-0.8	44.7	33.1	73.6	6.4	38.5	16.3	25.4
April	7.4	3.9	8.0	6.1	6.6	6.0	5.6	21.0	14.2	41.9	41.5	34.5	43.8	34.8
May	8.8	11.3	13.7	10.3	12.2	14.0	11.1	21.7	95.7	53.4	58.3	11.2	10.0	48.6
June	15.7	16.0	14.4	14.6	15.4	15.5	15.6	53.5	100.6	148.4	65.1	44.6	42.9	64.6
July	18.5	18.2	20.3	16.4	19.8	19.6	18.1	18.1	31.8	57.4	64.2	5.5	10.2	39.8
August	19.6	18.6	20.2	18.8	18.7	n/a[x]	17.4	4.8	32.8	36.2	39.3	27.3	n/a	44.7
September	11.1	15.9	16.0	12.9	13.1	n/a	11.9	70.0	7.6	13.7	10.8	41.9	n/a	42.7
October	6.3	7.7	9.0	8.4	7.6	n/a	7.3	6.3	10.0	8.6	23.0	7.9	n/a	16
November	-7.1	0.0	0.6	4.5	-1.5	n/a	-1.2	26.5	4.6	14.9	11.6	5.0	n/a	15.9
December	-10.8	-0.6	-6.0	2.2	-8.7	n/a	-6.7	24.4	9.9	19.6	3.9	14.7	n/a	20.3
Year	4.0	6.7	7.0	7.8	6.2	n/a	5.4	329.3	366.2	481.7	341.3	275.5	n/a	386.5

[z] Monthly data from January, 1996 to May, 2001 were obtained from the Agriculture and Agri-Food Canada Research Centre in Lethbridge.
[y] Thirty-year normal values from 1961 to 1990 (Environment Canada 2001a).
[x] Not available.

Table 3.2. Mean monthly temperature and monthly precipitation from 1997 to 2001 at the Calgary International Airport (51° 7' N, 114° 7' W, 1077 m elevation), which is near the Airdrie site.

	Mean temperature (°C)[z]						Monthly precipitation (mm)[z]					
	1997	1998	1999	2000	2001	Norm.[y]	1997	1998	1999	2000	2001	Norm.[y]
January	-12.5	-13.6	-7.9	-9.7	-1.5	-9.6	18.5	15.6	11.3	10.2	2.0	12.2
February	-2.8	-2.9	-1.5	-6.7	-10.5	-6.3	3.7	4.0	trace	20.6	7.7	9.9
March	-4.0	-4.6	-8.0	-4.0	-1.0	-2.5	17.1	59.4	6.4	25.5	8.4	14.7
April	2.2	6.4	4.8	4.1	4.0	4.1	12.6	41.2	72.8	17.0	19.2	25.1
May	9.3	12.2	8.7	8.8	11.2	9.7	100.7	86.4	52.8	28.8	30.5	52.9
June	13.8	12.5	11.9	12.5	12.3	14	138.4	110.4	95.4	109.8	121.4	76.9
July	16.0	17.8	13.7	16.7	16.8	16.4	16.9	132.2	103.8	66.8	58.8	69.9
August	15.9	17.8	15.9	15.6	n/a[x]	15.7	57.8	18.0	89.2	63.9	n/a	48.7
September	13.1	12.7	10.3	10.7	n/a	10.6	37.8	26.0	9.1	53.6	n/a	48.1
October	4.7	7.0	5.7	5.4	n/a	5.7	14.8	11.4	3.6	1.8	n/a	15.5
November	-4.1	-2.6	1.3	-3.3	n/a	-3	0.6	14.1	12.4	5.8	n/a	11.6
December	2.6	-8.4	-6.0	-9.9	n/a	-8.3	6.3	19.0	1.8	8.8	n/a	13.2
Year	4.5	4.5	5.1	3.4	n/a	3.9	425.2	537.7	458.6	412.6	n/a	398.8

[z] Monthly data from January, 1996 to May, 2001 were obtained from Environment Canada, Calgary Office.
[y] Thirty-year normal values from 1961 to 1990 (Environment Canada 2001b).
[x] Not available.

Appendix 4. Precipitation recorded during the April to September growing seasons at the Lethbridge and Airdire sites, as well as 30-yr normals from nearby climatic stations.

Year	April (mm)	May (mm)	June (mm)	July (mm)	August (mm)	September (mm)	Total (mm)
			Lethbridge site				
1996	24.5	33.0	58.9	11.5	27.0	70.0	224.9
1997	29.6	66.4	89.2	22.0	28.0	6.8	242.0
1998	36.2	55.0	128.5	36.1	25.0	18.6	299.4
1999	25.0	32.6	61.0	72.5	38.5	16.5	246.1
2000	30.5	14.0	29.5	10.5	14.0	44.0	142.5
30-yr normals [z]	34.8	48.6	64.6	39.8	44.7	42.7	275.2
			Airdrie site				
1997	9.6	77.8	92.4	12.4	37.8	49.4	279.4
1998	43.6	57.2	105.2	90.0	13.0	22.6	331.6
1999	47.0	45.4	95.4	114.0	58.2	7.6	367.6
2000	3.8	28.2	64.2	70.4	62.2	39.6	268.4
30-yr normals [y]	25.1	52.9	76.9	69.9	48.7	48.1	321.6

[z] 30-yr normals (1961-1990) from the Agriculture and Agri-Food Canada Lethbridge Research Centre.

[y] 30-yr normals (1961-1990) from the Calgary International Airport.

Appendix 5. Moisture content and chemical analysis of the beef manure and hog manure used at the Lethbridge and Airdrie sites.

Table 5.1. Moisture content and chemical analysis of solid beef manure used at the Lethbridge site. [z]

	1996		1997		1998		1999		2000		Five-year means
	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	
Moisture (%)	63.2	48.4	71.1	47.6	56.0	47.0	45.8	40.5	47.8	40.7	50.8
Extractable nutrients (mg kg^{-1})											
NH_4-N	394	376	550	4329	1192	3037	2185	2440	852	2249	1760
NO_3-N	163	0.0	394	980	0.0	4.94	0.54	27.0	0.52	2.12	157
PO_4-P	299	91.0	331	557	1201	1608	1792	2978	1639	1482	1198
Na	214	969	119	335	2821	3520	2435	3401	2586	3178	1958
K	7583	6525	3624	9048	9282	9892	7713	13385	6478	6048	7958
Ca	809	2473	992	1693	1594	1421	1677	1766	1744	2169	1634
Mg	382	862	480	1248	1615	1047	1363	1737	1662	1963	1236
Total elemental analysis (mg kg^{-1})											
N	6633	3300	6100	6600	9750	10533	12400	17033	11133	13000	9648
P	1567	900	3200	1700	3250	3800	3900	6767	3500	5225	3381
S	1122	3083	879	1359	1895	2369	1896	2856	2091	3021	2057
Na	263	1977	197	392	2746	3937	3361	4685	3175	4295	2503
K	8448	10373	5930	8765	7510	11898	11764	15924	9029	14791	10443
Ca	11603	34308	n/a [y]	13199	13041	18763	18096	19994	17000	19887	18432
Mg	3141	11154	2800	3933	3797	5915	4756	6170	5316	6168	5315
Fe	3683	12519	7271	10054	2153	5318	5922	2928	4009	4924	5878
Al	1558	6903	1603	18321	1984	6242	7780	3600	3414	1552	5296
Cu	9.26	18.0	7.46	13.2	25.2	34.4	31.5	40.4	35.3	47.3	26.2
Mn	101	269	108	160	103	160	148	160	142	176	153
B	6.06	22.0	9.25	16.5	5.77	8.80	10.1	6.48	5.94	8.72	9.96
Zn	30.9	54.0	32.4	57.7	234	308	241	370	286	306	192
Organic matter (%)	11.1	18.8	7.69	14.6	29.7	29.2	29.9	38.1	31.7	36.4	24.7
pH	8.80	8.85	7.30	6.90	6.91	7.27	6.53	6.60	7.27	6.95	7.34
EC (dS m^{-1})	19.4	3.08	8.50	16.5	20.2	9.13	12.1	13.0	9.43	12.4	12.4
No. of samples	3	4	1	1	4	3	3	3	3	4	

[z] Values are expressed on a wet-weight basis. To convert to a dry-weight basis, multiply by 100 and then divide by (100 - % moisture). To convert mg kg^{-1} to percent, divide by 10,000.

[y] Not analysed.

Table 5.2. Moisture content and chemical analysis of liquid hog manure used at the Lethbridge site. [z]

	1996		1997		1998		1999		2000		Five-year means
	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	
Moisture (%)	95.5	99.4	91.3	91.4	87.8	94.6	87.0	(96.0)	89.9	90.6	92.4
Extractable nutrients (mg kg^{-1})											
NH_4-N	1033	729	1130	590	2200	299	1526	(1852)	2887	1795	1404
NO_3-N	0.01	0.0	0.09	0.09	0.0	0.11	0.13	0.05	0.10	0.09	0.07
PO_4-P	361	73.0	184	395	990	161	972	268	1360	797	556
Na	233	152	194	51.6	259	392	149	101	264	287	208
K	1138	674	722	352	1415	1115	783	430	1069	245	794
Ca	274	99.5	188	265	502	74.8	234	74.4	225	312	225
Mg	155	9.67	300	244	764	172	332	87.3	399	364	283
Total elemental analysis (mg kg^{-1})											
N	3600	1450	3600	3500	3333	2900	4700	(3867)	4600	3650	3520
P	1167	267	1200	1600	967	1200	3025	(1900)	2100	2250	1568
S	319	77.3	463	581	571	302	782	75.7	510	630	431
Na	216	179	218	95.8	214	426	238	67.7	271	313	224
K	1111	750	881	593	1096	1176	1031	310	1251	1675	987
Ca	1047	205	n/a [y]	2762	2686	830	4286	374	2605	4115	2101
Mg	463	107	752	567	1082	422	1347	185	1036	1151	711
Fe	172	13.8	419	777	437	117	667	75.0	205	385	327
Al	153	6.83	247	693	311	94.8	436	80.5	103	183	231
Cu	13.1	2.67	20.1	35.5	23.1	11.4	56.3	4.00	18.0	18.1	20.2
Mn	17.6	2.33	34.3	44.5	44.0	14.3	71.4	6.32	39.0	56.4	33.0
B	0.88	0.82	1.58	1.77	2.38	1.00	2.85	0.24	1.76	2.46	1.57
Zn	25.1	3.67	56.3	72.4	75.5	35.7	196	14.1	72.8	76.6	62.8
Organic matter (%)	3.18	n/a	6.75	5.64	9.55	4.44	9.52	2.05	8.02	6.86	6.22
pH	5.80	7.78	6.10	5.70	6.33	6.30	6.33	6.50	6.40	6.65	6.39
EC (dS m^{-1})	38.8	6.85	12.0	9.90	9.07	9.20	5.20	8.70	6.37	7.90	11.4
No. of samples	3	6	1	1	3	1	4	1 or (3)	3	2	

[z] Values are expressed on a wet-weight basis. To convert to a dry-weight basis, multiply by 100 and then divide by (100 - % moisture). To convert mg kg^{-1} to percent, divide by 10,000.

[y] Not analysed.

Table 5.3. Moisture content and chemical analysis of solid beef manure used at the Airdrie site. [z]

	1997		1998		1999		2000		Four-year means
	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	
Moisture (%)	70.4	71.8	53.3	38.7	70.7	54.2	72.6	49.4	60.1
Extractable nutrients (mg kg^{-1})									
NH_4-N	282	3128	224	433	1128	431	1322	246	899
NO_3-N	0.30	13.0	0.0	171	0.78	61.6	0.36	33.2	35.0
PO_4-P	168	429	355	877	773	984	687	699	622
Na	325	676	743	2437	632	543	690	799	856
K	1869	3137	4609	8773	7455	5868	5587	2851	5019
Ca	1131	647	1116	1500	955	1018	1087	1540	1124
Mg	597	583	580	539	254	628	593	1048	603
Total elemental analysis (mg kg^{-1})									
N	5800	7500	4225	8825	5533	5900	6367	5433	6198
P	1500	2300	1325	3225	2033	2900	1533	2300	2140
S	715	747	829	2282	1079	1140	868	1574	1154
Na	435	683	690	2900	1053	769	756	842	1016
K	2219	4156	4228	12531	9656	7061	7183	6020	6632
Ca	n/a [y]	4905	14070	18108	5934	13244	7190	18319	11681
Mg	1306	1858	3713	5495	1886	3454	1596	4544	2982
Fe	312	3647	5093	7306	1006	4270	1318	5520	3559
Al	350	5156	2597	6992	1081	3874	1287	2173	2939
Cu	3.40	16.4	10.3	19.3	8.46	10.4	6.25	16.0	11.3
Mn	28.4	126	125	243	66.3	134	58.6	174	119
B	1.72	4.37	7.23	12.0	3.57	4.86	2.99	6.38	5.39
Zn	21.6	69.8	59.9	108	57.1	81.4	36.2	87.1	65.1
Organic matter (%)	25.5	9.32	12.7	17.6	19.0	17.4	16.3	18.4	17.0
pH	7.60	6.90	8.45	7.95	8.87	8.37	8.07	8.20	8.05
EC (dS m^{-1})	3.70	13.6	7.70	10.2	8.73	5.03	7.27	4.20	7.55
No. of samples	1	1	4	4	3	3	3	3	

[z] Values are expressed on a wet-weight basis. To convert to a dry-weight basis, multiply by 100 and then divide by (100 - % moisture). To convert mg kg^{-1} to percent, divide by 10,000.

[y] Not analysed.

Table 5.4. Moisture content and chemical analysis of liquid hog manure used at the Airdrie site. [z]

	1997		1998		1999		2000		Four-year means
	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	
Moisture (%)	95.3	94.8	96.7	94.6	96.6	(95.4)	96.4	97.0	95.9
Extractable nutrients (mg kg^{-1})									
NH_4-N	1700	1882	3080	2312	2950	(4093)	4193	2103	2789
NO_3-N	0.05	0.16	0.0	0.0	0.05	0.19	0.08	0.13	0.08
PO_4-P	59.0	120	173	281	198	267	254	78.3	179
Na	744	1013	707	700	594	863	266	835	715
K	1294	1441	1624	1297	231	1981	1868	1093	1354
Ca	69.8	291	85.2	125	168	235	190	181	168
Mg	101	225	147	144	143	245	162	152	165
Total elemental analysis (mg kg^{-1})									
N	5200	5100	4767	4500	4800	(5433)	5767	3567	4892
P	1000	1100	1167	1300	1050	(1233)	1100	967	1115
S	369	515	316	494	468	590	511	520	473
Na	600	892	672	798	733	974	845	997	814
K	786	888	886	1429	1590	2158	1959	1351	1381
Ca	n/a [y]	1535	1010	1690	769	1589	1087	1070	1250
Mg	398	405	375	585	310	510	374	414	421
Fe	108	92.1	69.3	142	52.4	79.3	55.9	49.1	81.0
Al	23.3	15.5	22.8	34.4	18.1	28.2	15.7	32.0	23.8
Cu	8.61	9.68	23.9	18.5	4.81	6.74	8.37	6.24	10.9
Mn	15.0	18.2	23.8	20.5	9.42	15.4	17.8	16.5	17.1
B	0.91	0.92	2.36	1.51	1.14	1.42	0.95	0.94	1.27
Zn	48.5	56.8	101	75.3	25.4	44.1	31.9	29.1	51.5
Organic matter (%)	3.59	3.91	2.14	4.16	2.51	3.30	2.39	(2.54)	3.07
pH	6.80	6.00	7.62	6.70	6.20	5.90	6.43	(7.10)	6.59
EC (dS m^{-1})	33.0	45.8	43.4	13.2	25.5	28.8	36.0	(33.8)	32.4
No. of samples	1	1	3	1	2	1 or (3)	3	(2) or 3	

[z] Values are expressed on a wet-weight basis. To convert to a dry-weight basis, multiply by 100 and then divide by (100 - % moisture). To convert mg kg^{-1} to percent, divide by 10,000.

[y] Not analysed.

Appendix 6. Total nitrogen and ammonium nitrogen actually applied and estimates of crop nitrogen for the lowest manure application rates at the two field sites.

Table 6.1. Lethbridge field site.

Application time	Target rate of available N [z] (kg ha^{-1})	Manure application rate [y] (Mg ha^{-1})	Actual total N applied [x] (kg ha^{-1})	Actual ammonium-N applied [x] (kg ha^{-1})	Estimated crop N [w] (kg ha^{-1})
		Surface-applied, solid, beef manure			
1996 spring	67	31	206	12	54
1996 fall	67	31	102	12	28
1997 spring	67	31	189	17	51
1997 fall	67	31	205	134	85
1998 spring	67	31	302	37	85
1998 fall	67	31	327	94	105
1999 spring	67	31	384	68	113
1999 fall	67	31	528	76	151
2000 spring	67	31	345	26	93
2000 fall	67	31	403	70	118
average			299	55	77
		Injected, liquid, hog manure			
1996 spring	67	42	151	43	70
1996 fall	67	42	61	31	38
1997 spring	67	42	151	47	73
1997 fall	67	42	147	25	55
1998 spring	67	42	140	92	104
1998 fall	67	42	122	13	40
1999 spring	67	42	197	64	97
1999 fall	67	42	162	78	99
2000 spring	67	42	193	121	139
2000 fall	67	42	153	75	95
average			148	59	81

[z] Assumed an available N (i.e. ammonium-N) content of 2.2 kg Mg^{-1} and 50 percent moisture content for the beef manure and 1.6 kg Mg^{-1} and 96 percent moisture content for the hog manure (ILOC 1995).

[y] Wet weight of the lowest application rate per manure type. Multiply all the numbers in the table by 2, 3, and 4 to determine the values for the three higher manure application rates used at the field sites.

[x] Based on mean values from laboratory analysis (Appendix 5).

[w] Assumed that 25 percent of the organic nitrogen was mineralized during the first year after application, and 50 percent of the ammonium-N was lost from the surface applied beef manure and zero loss of ammonium-N from the injected hog manure under cool, dry conditions (Manitoba Agriculture 1999). Example:

$$((206 - 12) \times 0.25) + (12 \times 0.5) = 54.5 \text{ kg ha}^{-1} \text{ crop nitrogen}$$

Table 6.2. Airdrie field site.

Application time	Target rate of Available N [z] (kg ha^{-1})	Manure application rate [y] (Mg ha^{-1})	Actual total N applied [x] (kg ha^{-1})	Actual ammonium-N applied [x] (kg ha^{-1})	Estimated crop N [w] (kg ha^{-1})
		Surface-applied, solid, beef manure			
1997 spring	67	31	180	9	47
1997 fall	67	31	233	97	82
1998 spring	67	31	131	7	34
1998 fall	67	31	274	13	72
1999 spring	67	31	172	35	52
1999 fall	67	31	183	13	49
2000 spring	67	31	197	41	60
2000 fall	67	31	168	8	44
average			192	28	55
		Injected, liquid, hog manure			
1997 spring	67	42	218	71	108
1997 fall	67	42	214	79	113
1998 spring	67	42	200	129	147
1998 fall	67	42	189	97	120
1999 spring	67	42	202	124	143
1999 fall	67	42	228	172	186
2000 spring	67	42	242	176	193
2000 fall	67	42	150	88	104
average			205	117	139

[z] Assumed an available N (i.e. ammonium-N) content of 2.2 kg Mg^{-1} and 50 percent moisture content for the beef manure and 1.6 kg Mg^{-1} and 96 percent moisture content for the hog manure (ILOC 1995).

[y] Wet weight of the lowest application rate per manure type. Multiply all the numbers in the table by 2, 3, and 4 to determine the values for the three higher manure application rates used at the field sites.

[x] Based on mean values from laboratory analysis (Appendix 5).

[w] Assumed that 25 percent of the organic nitrogen was mineralized during the first year after application, and 50 percent of the ammonium-N was lost from the surface applied beef manure and zero loss of ammonium-N from the injected hog manure under cool, dry conditions (Manitoba Agriculture 1999). Example:

$$((180 - 9) \times 0.25) + (9 \times 0.5) = 47 \text{ kg ha}^{-1} \text{ crop nitrogen}$$

Appendix 7. Soil chemical analysis results for the Lethbridge and Airdrie sites.

Tables 7.1 to 7.6	nitrate-N	Lethbridge site	1996 to 2001
Tables 7.7 to 7.11	nitrate-N	Airdrie site	1997 to 2001
Tables 7.12 to 7.17	ammonium-N	Lethbridge site	1996 to 2001
Tables 7.18 to 7.22	ammonium-N	Airdrie site	1997 to 2001
Tables 7.23 to 7.28	phosphate-P	Lethbridge site	1996 to 2001
Tables 7.29 to 7.33	phosphate-P	Airdrie site	1997 to 2001
Tables 7.34 to 7.39	sodium	Lethbridge site	1996 to 2001
Tables 7.40 to 744	sodium	Airdrie site	1997 to 2001
Tables 7.45 to 7.50	potassium	Lethbridge site	1996 to 2001
Tables 7.51 to 7.55	potassium	Airdrie site	1997 to 2001
Tables 7.56 to 7.61	sulphate-S	Lethbridge site	1996 to 2001
Tables 7.62 to 7.66	sulphate-S	Airdrie site	1997 to 2001
Tables 7.67 to 7.72	pH	Lethbridge site	1996 to 2001
Tables 7.73 to 7.77	pH	Airdrie site	1997 to 2001
Tables 7.78 to 7.83	electrical conductivity	Lethbridge site	1996 to 2001
Tables 7.84 to 7.88	electrical conductivity	Airdrie site	1997 to 2001
Tables 7.89 to 7.94	organic matter	Lethbridge site	1996 to 2001
Tables 7.95 to 7.99	organic matter	Airdrie site	1997 to 2001

Table 7.1. Soil extractable nitrate-N (kg ha^{-1}) at the Lethbridge site in 1996.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	18.5	11.6	15.5	7.0	16.2	22.5	18.7	14.2	12.7	10.9	17.5	12.6	11.2	10.0	16.6	12.2	7.8
2	14.3	11.6	18.6	26.6	12.8	24.0	12.8	9.7	9.3	11.4	18.6	18.3	8.5	16.6	12.5	26.1	11.6
3	17.6	13.3	13.0	16.6	10.0	17.5	10.7	21.4	10.4	9.2	15.2	10.5	37.2	9.8	11.4	15.8	15.2
4	13.6	21.2	13.9	13.9	16.8	10.9	21.6	8.9	9.2	15.2	13.2	9.4	18.4	17.0	16.3	13.1	18.9
Mean	16.0	14.4	15.2	16.0	13.9	18.7	16.0	13.5	10.4	11.7	16.1	12.7	18.8	13.4	14.2	16.8	13.3
								15-30 cm soil depth									
1	21.7	9.2	15.2	11.4	6.9	23.0	17.7	17.3	13.7	15.2	19.5	13.7	20.7	13.7	11.7	21.7	18.2
2	18.3	18.8	25.9	19.4	17.2	20.5	16.1	8.3	12.9	12.2	16.6	17.4	10.6	17.8	15.2	21.3	9.2
3	19.1	16.4	17.6	19.0	13.4	17.6	14.6	19.9	19.5	9.2	12.2	14.7	46.7	20.3	17.2	12.9	17.8
4	18.2	18.4	22.8	13.9	11.3	21.6	17.3	13.1	11.6	11.0	11.2	13.0	17.3	16.3	20.7	20.1	9.4
Mean	19.3	15.7	20.4	15.9	12.2	20.7	16.4	14.7	14.4	11.9	14.9	14.7	23.8	17.0	16.2	19.0	13.6
								30-60 cm soil depth									
1	33.4	14.6	33.2	23.4	4.9	13.0	32.5	15.7	21.4	33.4	27.0	19.0	32.4	24.5	13.9	33.2	34.2
2	29.9	30.2	47.3	20.3	21.6	23.0	17.4	20.0	18.1	22.7	23.0	31.9	44.2	26.3	25.0	22.8	14.6
3	27.6	22.6	38.4	14.4	23.1	30.2	18.9	34.0	28.6	19.4	21.7	20.2	29.0	25.4	18.2	24.5	18.2
4	22.4	23.6	28.4	19.4	17.9	19.1	20.9	12.8	9.7	32.0	31.7	10.4	10.0	22.6	19.5	24.6	9.7
Mean	28.3	22.7	36.8	19.4	16.9	21.3	22.4	20.6	19.5	26.9	25.9	20.4	28.9	24.7	19.2	26.3	19.1
								60-90 cm soil depth									
1	19.3	5.2	14.2	9.0	2.6	8.5	16.6	6.5	11.0	17.0	11.7	7.1	16.8	8.5	6.1	11.0	15.5
2	11.8	17.4	9.0	7.7	7.9	10.8	10.6	5.8	7.9	7.7	10.7	13.0	15.1	11.7	10.9	9.9	15.5
3	13.4	4.6	18.6	5.2	9.3	11.0	8.4	17.1	14.9	5.2	10.9	10.6	25.4	7.2	7.7	9.0	6.6
4	9.8	5.3	9.9	5.2	5.6	5.4	6.6	4.4	5.2	23.1	23.2	7.6	2.6	5.3	8.6	11.6	6.0
Mean	13.6	8.1	12.9	6.8	6.3	8.9	10.6	8.4	9.8	13.2	14.1	9.5	15.0	8.2	8.3	10.4	10.9
								90-120 cm soil depth									
1	8.7	2.5	7.3	5.6	2.5	4.5	12.0	5.1	4.7	10.2	9.0	5.8	9.7	4.8	4.2	8.9	7.0
2	6.2	4.7	2.5	25.2	6.0	7.2	4.6	2.5	4.8	3.0	5.7	7.2	4.5	6.0	8.9	4.4	2.5
3	6.3	4.2	5.5	3.3	3.4	9.9	4.1	7.6	6.2	5.0	4.7	7.6	7.9	3.3	3.7	2.5	3.6
4	3.8	4.7	5.8	5.0	3.3	2.5	4.5	2.7	2.5	18.5	5.0	3.2	2.7	3.1	3.5	6.5	4.0
Mean	6.2	4.0	5.3	9.8	3.8	6.0	6.3	4.5	4.6	9.2	6.1	6.0	6.2	4.3	5.1	5.6	4.3
								120-150 cm soil depth									
1	6.1	2.5	4.2	5.1	2.5	2.8	6.9	4.3	6.6	6.5	5.3	5.1	3.6	3.8	3.2	3.6	10.0
2	5.7	3.0	2.5	6.4	4.0	5.3	4.4	4.8	3.7	2.5	5.6	7.9	2.5	8.9	5.3	10.3	2.5
3	3.2	3.8	6.5	3.2	2.5	11.8	2.5	11.4	2.5	2.5	2.5	2.5	23.0	2.5	2.5	2.5	2.5
4	2.9	2.7	2.6	2.5	2.5	2.5	2.5	3.8	2.5	3.6	2.5	2.6	12.0	2.6	3.3	2.8	2.5
Mean	4.5	3.0	3.9	4.3	2.9	5.6	4.1	6.1	3.8	3.8	4.0	4.5	10.3	4.4	3.6	4.8	4.4

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.2. Soil extractable nitrate-N (kg ha^{-1}) at the Lethbridge site in 1997.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	17.2	33.7	42.0	55.7	53.8	40.9	18.4	56.4	29.1	28.9	28.4	40.4	29.3	48.5	32.3	23.6	28.6
2	7.9	9.8	7.5	13.8	19.2	31.9	17.9	24.5	17.7	16.7	22.7	15.4	13.8	13.1	18.1	10.7	38.1
3	17.6	18.1	27.7	11.9	33.5	11.7	6.7	16.7	28.4	23.8	18.7	27.0	14.8	27.0	35.1	31.4	28.2
4	18.2	29.6	19.5	24.3	1.2	29.1	22.0	6.8	18.2	10.1	16.9	14.6	16.4	21.3	28.2	19.8	63.8
Mean	15.2	22.8	24.2	26.4	26.9	28.4	16.2	26.1	23.4	19.9	21.7	24.3	18.6	27.5	28.4	21.4	39.7
								15-30 cm soil depth									
1	8.5	15.9	8.0	10.8	15.7	7.3	8.4	19.9	8.8	9.6	8.2	10.0	9.8	10.6	12.3	12.2	37.0
2	4.9	5.3	4.6	7.3	13.6	9.4	6.6	8.0	7.6	5.3	6.5	7.0	10.6	8.9	3.3	9.5	62.6
3	8.7	6.2	11.8	5.4	12.5	10.9	4.8	13.7	27.3	12.3	10.6	14.2	6.1	25.6	52.4	7.0	22.9
4	13.4	15.5	10.3	8.9	4.8	29.6	10.9	5.6	11.9	6.1	12.2	11.4	10.0	6.5	13.0	39.7	116.0
Mean	8.9	10.7	8.7	8.1	11.6	14.3	7.6	11.8	13.9	8.3	9.4	10.6	9.1	12.9	20.2	17.1	59.6
								30-60 cm soil depth									
1	9.8	13.1	5.3	27.2	12.4	11.5	15.8	23.8	20.8	9.4	11.3	12.8	8.4	12.6	26.9	17.9	131.7
2	4.1	13.2	14.6	6.9	15.4	5.0	6.7	8.8	15.6	2.4	5.8	2.4	17.7	2.4	5.3	18.7	88.0
3	14.3	10.7	6.7	7.7	11.3	12.2	7.8	14.2	27.1	10.7	12.4	12.3	11.1	17.8	88.9	10.6	41.7
4	15.0	13.6	22.9	15.9	9.7	9.5	18.5	8.6	14.4	9.7	15.5	8.6	11.3	9.7	12.9	45.2	322.2
Mean	10.8	12.6	12.4	14.4	12.2	9.5	12.2	13.9	19.5	8.1	11.3	9.1	12.1	10.6	33.5	23.1	145.9
								60-90 cm soil depth									
1	9.8	6.3	2.6	8.8	9.6	7.5	8.6	8.4	7.5	6.8	5.2	10.5	7.5	9.3	8.9	12.7	21.5
2	3.7	10.5	10.8	2.6	8.8	2.6	2.6	2.6	8.9	5.3	2.6	11.9	38.2	7.2	2.6	12.1	35.2
3	9.6	5.8	2.6	5.7	6.6	7.6	9.9	7.8	6.4	10.7	13.3	13.1	6.5	15.5	51.3	12.7	25.0
4	11.6	7.2	8.1	12.2	6.1	6.0	12.2	5.3	11.4	7.4	6.1	7.9	7.7	7.2	11.7	20.0	133.6
Mean	8.7	7.5	6.0	7.3	7.8	5.9	8.3	6.0	8.6	7.6	6.8	10.8	15.0	9.8	18.6	14.4	53.8
								90-120 cm soil depth									
1	6.3	2.5	2.5	2.5	6.9	5.6	2.5	5.8	11.7	5.9	2.5	6.8	6.0	6.0	8.5	10.0	2.5
2	2.5	2.5	2.5	5.1	8.1	2.5	2.5	2.5	6.0	2.5	2.5	2.5	2.5	2.5	2.5	5.7	5.6
3	5.7	2.5	2.5	2.5	2.5	5.4	7.5	2.5	2.5	2.5	5.3	9.5	5.6	9.4	12.3	10.3	7.9
4	22.1	6.0	7.2	7.9	6.4	2.5	9.5	2.5	6.0	2.5	5.2	6.5	5.6	6.0	8.7	10.7	46.2
Mean	9.2	3.4	3.7	4.5	6.0	4.0	5.5	3.4	6.6	3.4	3.9	6.3	5.0	6.0	8.0	9.2	15.6
								120-150 cm soil depth									
1	4.8	2.5	2.5	2.5	6.5	2.5	2.5	6.5	2.5	2.5	2.5	2.5	2.5	5.4	7.1	7.9	2.5
2	3.4	5.2	5.2	2.5	2.5	2.5	2.5	2.5	5.9	2.5	2.5	2.5	2.5	2.5	2.5	7.6	5.8
3	5.1	2.5	2.5	2.5	2.5	2.5	5.5	2.5	2.5	5.8	5.0	8.5	5.1	7.6	13.4	2.5	9.9
4	19.8	9.1	6.3	8.6	5.7	2.5	7.3	6.0	8.1	2.5	2.5	6.2	6.0	6.6	9.2	7.5	21.5
Mean	8.3	4.8	4.1	4.0	4.3	2.5	4.4	4.4	4.8	3.3	3.1	4.9	4.0	5.5	8.0	6.4	9.9

[z] Control: No manure application; each replicate value is a mean of four control plots.
[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).
[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.3. Soil extractable nitrate-N (kg ha^{-1}) at the Lethbridge site in 1998.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	36.6	46.7	28.0	109.5	39.5	158.5	64.4	95.9	109.7	34.0	40.7	2.3	78.8	99.1	111.6	43.9	88.5
2	47.0	93.3	66.8	45.5	100.3	67.7	130.3	105.8	90.3	38.8	53.6	55.7	168.6	92.9	50.4	56.6	82.5
3	39.6	48.7	45.7	54.3	103.5	31.0	44.1	61.0	43.7	42.7	108.3	50.8	67.2	129.4	93.6	156.8	39.7
4	33.3	39.7	66.5	127.1	58.9	46.2	128.4	70.0	143.2	42.5	37.7	65.1	98.9	66.8	138.6	150.2	86.2
Mean	39.1	57.1	51.7	84.1	75.5	75.8	91.8	83.2	96.7	39.5	60.1	43.5	103.4	97.0	98.5	101.9	74.2
								15-30 cm soil depth									
1	28.6	28.9	1.2	28.6	25.9	67.9	28.6	38.1	2.3	25.9	12.9	29.3	69.3	66.1	44.8	28.6	40.7
2	27.4	42.7	52.4	33.7	43.9	26.8	89.6	58.7	89.9	28.0	34.9	46.2	60.5	61.0	33.3	46.4	60.3
3	24.5	23.3	33.3	36.3	35.3	22.5	23.1	52.0	27.7	20.0	45.0	27.3	32.8	65.4	38.3	131.2	27.7
4	18.2	79.2	40.9	63.1	21.9	35.1	53.4	43.7	68.8	50.1	39.0	48.7	25.6	61.4	80.4	135.4	40.0
Mean	24.7	43.5	31.9	40.4	31.7	38.1	48.7	48.1	47.2	31.0	33.0	37.9	47.1	63.5	49.2	85.4	42.2
								30-60 cm soil depth									
1	29.1	22.2	25.8	38.3	48.6	108.4	45.4	52.5	76.8	25.7	12.3	12.4	31.8	49.1	55.9	29.8	48.6
2	43.8	60.8	50.1	37.9	60.3	35.4	87.5	55.4	86.0	42.5	45.8	32.2	86.5	68.5	35.8	54.4	71.9
3	29.7	30.0	52.5	42.7	40.9	49.1	38.7	47.1	40.8	31.2	49.6	47.0	36.3	107.9	48.6	156.0	29.5
4	27.8	39.8	47.4	54.9	35.2	37.9	95.3	38.9	42.6	60.3	32.4	44.8	36.3	33.6	68.0	106.4	78.7
Mean	32.6	38.2	43.9	43.4	46.2	57.7	66.7	48.5	61.6	39.9	35.0	34.1	47.7	64.8	52.1	86.7	57.2
								60-90 cm soil depth									
1	16.7	6.8	18.0	19.9	21.5	36.1	20.3	34.0	22.5	13.8	6.5	6.6	22.6	17.1	26.8	23.2	19.1
2	13.8	35.1	10.5	12.0	25.9	13.4	17.5	23.5	30.5	19.7	14.4	11.8	85.1	31.0	12.8	24.8	15.3
3	20.4	15.2	12.6	16.7	10.0	12.7	17.5	17.3	26.4	24.9	32.6	17.3	17.4	58.3	34.1	68.1	19.2
4	11.1	9.7	31.8	28.8	7.5	10.3	25.4	10.1	12.4	21.1	19.2	22.3	9.7	8.5	24.3	49.9	26.3
Mean	15.5	16.7	18.2	19.3	16.2	18.1	20.2	21.2	23.0	19.9	18.2	14.5	33.7	28.7	24.5	41.5	20.0
								90-120 cm soil depth									
1	8.3	6.2	7.3	10.4	14.7	9.7	7.0	7.8	2.5	5.5	5.2	2.5	12.4	7.1	9.3	8.9	13.4
2	6.5	18.9	14.9	6.0	5.9	2.5	7.3	5.3	15.1	9.1	11.3	2.5	47.4	8.6	2.5	8.3	7.3
3	8.5	2.5	8.5	2.5	9.1	2.5	8.2	2.5	8.6	2.5	8.1	8.3	9.6	10.0	10.7	13.2	6.5
4	7.1	2.5	8.2	9.4	2.5	10.6	2.5	2.5	2.5	5.2	7.1	2.5	6.9	11.7	8.1	7.6	9.8
Mean	7.6	7.5	9.7	7.1	8.1	6.3	6.2	4.5	7.2	5.6	8.0	4.0	19.1	9.3	7.6	9.5	9.3
								120-150 cm soil depth									
1	3.4		2.5	2.5	15.5	6.9	2.5	2.5		2.5			5.7	5.2	6.4		7.9
2	2.5	2.5	2.5	2.5	2.5	2.5	6.0	2.5	2.5	2.5	10.2	2.5	48.5	2.5	2.5	2.5	7.7
3	5.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	5.2	2.5	5.6	2.5	2.5	2.5	2.5	6.2	6.8
4	2.5	2.5	5.5	2.5	2.5	2.5	2.5	2.5	2.5	7.4	5.4	2.5	5.8	2.5	2.5	2.5	2.5
Mean	3.5	2.5	3.3	2.5	5.8	3.6	3.4	2.5	3.4	3.7	7.1	2.5	15.6	3.2	3.5	3.7	6.2

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.4. Soil extractable nitrate-N (kg ha^{-1}) at the Lethbridge site in 1999.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	38.8	103.7	74.4	93.6	7.4	98.2	112.0	71.8	80.9	55.2	111.1	85.5	86.4	134.4	43.4	49.2	115.5
2	32.1	30.7	30.0	58.4	26.8	35.3	28.0	23.6	45.3	41.6	58.2	21.1	37.9	42.3	91.2	366.1	81.1
3	22.4	47.1	61.2	27.0	54.5	44.1	25.6	79.2	35.1	5.8	26.1	27.3	57.5	13.0	138.4	137.7	120.1
4	25.4	50.6	21.0	23.3	41.1	37.7	27.0	28.2	42.0	40.0	44.4	17.6	50.4	53.8	246.0	175.1	383.5
Mean	29.7	58.0	46.7	50.6	32.5	53.8	48.2	50.7	50.8	35.6	59.9	37.9	58.0	60.9	129.8	182.0	175.0
								15-30 cm soil depth									
1	20.4	26.6	19.0	46.9	9.3	32.3	42.3	23.8	45.3	11.7	39.5	15.4	49.0	65.4	18.2	25.2	26.8
2	9.3	10.9	13.0	17.5	7.9	16.4	10.9	10.1	13.4	19.7	15.8	7.3	12.4	77.4	23.1	105.3	69.3
3	10.6	13.8	23.6	13.9	22.1	18.9	10.7	32.6	23.8	5.2	10.5	10.1	29.1	8.4	28.2	19.6	21.6
4	10.3	17.3	9.4	11.3	13.5	8.7	10.0	7.3	15.6	8.2	21.0	10.3	23.1	8.8	30.3	25.2	152.9
Mean	12.7	17.2	16.2	22.4	13.2	19.1	18.5	18.5	24.5	11.2	21.7	10.7	28.4	40.0	24.9	43.8	67.7
								30-60 cm soil depth									
1	16.5	12.4	22.0	62.2	18.3	40.2	44.5	29.7	32.4	9.8	44.8	12.9		34.7	12.7	16.1	21.1
2	9.5	15.2	20.5	9.1	10.5	17.8	7.9	20.3	19.1	20.5	15.7	28.5	13.8	10.4	17.9	51.5	47.6
3	13.3	11.0	11.4	12.4	12.9	10.0	13.8	13.0	20.9	9.4	15.0	15.9	24.0	11.3	21.6	17.1	26.5
4	8.9	7.2	11.1	12.5	11.6	13.2	13.9	8.1	16.4	9.5	12.2	14.0	18.3	13.0	15.2	20.1	152.1
Mean	12.0	11.4	16.2	24.1	13.3	20.3	20.0	17.8	22.2	12.3	21.9	17.8	18.7	17.4	16.8	26.2	61.8
								60-90 cm soil depth									
1	8.4	9.6	15.9	15.9	21.3	20.8	42.3	23.2	13.0	4.8	16.6	12.7	42.0	14.0	8.5	11.5	13.3
2	5.5	9.2	12.9	4.9	5.7	8.6	18.5	11.7	14.2	7.8	7.8	7.4	9.3	5.7	7.9	20.0	40.7
3	7.2	7.6	4.3	6.0	5.9	3.9	0.0	8.7	12.2	7.2	11.9	10.3	30.2	7.9	12.5	13.9	12.6
4	6.7	3.7	9.0	15.9	4.8	6.0	13.7	6.0	8.1	5.7	6.3	5.3	15.4	7.5	9.0	15.2	44.6
Mean	7.0	7.6	10.5	10.7	9.4	9.8	18.6	12.4	11.9	6.4	10.7	8.9	24.2	8.8	9.5	15.1	27.8
								90-120 cm soil depth									
1	9.9	6.7	6.0	9.2	17.3	14.9	26.9	13.1	11.5	4.9	9.0	7.7	18.4	13.0	9.6	8.2	10.1
2	4.9	4.0	4.2	3.8	3.1	4.1	9.6	6.6	8.0	7.5	5.1	3.6	5.3	8.0	4.8	16.8	14.2
3	3.5	12.3	3.8	3.6	7.7	4.1	0.0	5.4	5.5	5.4	6.0	6.2	14.0	5.9	7.8	18.2	12.6
4	4.7	6.9	5.4	7.9	4.2	5.3	5.5	5.3	4.6	3.7	6.4	4.3	8.2	8.4	6.8	9.5	10.0
Mean	5.8	7.5	4.8	6.1	8.1	7.1	10.5	7.6	7.4	5.4	6.6	5.4	11.5	8.8	7.2	13.2	11.7
								120-150 cm soil depth									
1	8.3	6.2	5.2	8.5	10.0	9.4	15.3	6.7	18.6	4.2	6.2	6.9	12.9	11.7	6.9	9.1	7.1
2	3.3	6.4	10.3	4.2	9.4	3.4	4.0	4.5	4.5	5.9	6.9	8.8	6.3	5.0	4.6	11.9	12.0
3	3.5	4.4	9.5	3.4	3.5	0.0	4.3	7.9	5.2	4.3	5.6	5.3	7.5	5.1	15.1	11.6	12.2
4	5.7	3.8	6.6	5.2	4.6	5.1	5.3	4.4	4.0	3.6	5.0	3.2	5.0	7.8	6.5	18.7	26.6
Mean	5.2	5.2	7.9	5.3	6.9	4.4	7.2	5.8	8.1	4.5	5.9	6.0	7.9	7.4	8.3	12.8	14.5

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.5. Soil extractable nitrate-N (kg ha^{-1}) at the Lethbridge site in 2000.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	98.9	192.9	184.8	98.2	197.5	173.3	190.6	272.6	158.2	140.4	99.8	88.7	79.9	102.6	109.3	300.3	325.7
2	55.7	136.3	150.2	233.3	139.8	107.9	130.1	265.7	214.8	52.0	122.4	157.1	108.3	151.3	127.3	197.5	291.1
3	52.8	70.0	156.6	136.8	198.7	157.5	170.5	187.1	225.2	40.7	46.7	109.7	220.6	67.7	94.2	100.0	184.8
4	62.9	119.4	92.6	172.1	140.0	133.5	161.2	176.7	257.6	121.7	74.2	105.1	41.3	123.4	234.5	289.9	249.5
Mean	67.6	129.6	146.0	160.1	169.0	143.0	163.1	225.5	214.0	88.7	85.8	115.2	112.6	111.2	141.3	221.9	262.8
								15-30 cm soil depth									
1	45.1	52.4	98.4	75.5	59.6	44.4	47.6	57.5	192.9	48.0	34.4	26.6	91.7	55.4	99.3	125.9	201.0
2	26.7	49.4	28.9	84.8	66.1	45.0	58.7	137.4	183.6	17.4	40.7	63.5	38.6	161.7	140.9	115.3	142.1
3	33.6	57.1	46.2	100.0	112.3	50.8	91.9	145.1	114.6	19.3	22.7	49.2	165.2	64.4	69.3	96.6	205.6
4	29.7	34.2	26.6	65.1	66.5	117.1	70.0	46.4	84.8	107.4	29.3	47.4	24.5	60.8	136.3	87.1	141.8
Mean	33.8	48.3	50.0	81.4	76.1	64.3	67.0	96.6	144.0	48.0	31.8	46.7	80.0	85.6	111.5	106.2	172.6
								30-60 cm soil depth									
1	41.7	32.1	37.9	87.0	95.3	24.3	28.8	31.5	152.1	42.6	30.2	28.6	46.6	24.3	63.2	218.2	221.1
2	24.5	52.0	24.9	78.7	64.6	28.5	63.2	69.0	127.3	21.6	29.6	37.0	26.5	47.6	95.3	64.2	86.0
3	24.4	56.4	44.7	48.2	92.8	30.4	119.1	134.1	187.1	29.2	34.0	43.3	65.6	66.1	98.2	95.7	175.9
4	19.9	51.5	33.2	104.5	42.9	68.5	67.6	25.2	69.0	36.2	28.3	41.3	34.7	39.0	71.9	60.8	132.2
Mean	27.6	48.0	35.2	79.6	73.9	37.9	69.6	65.0	133.9	32.4	30.5	37.5	43.4	44.2	82.1	109.7	153.8
								60-90 cm soil depth									
1	14.8	19.5	17.8	69.7	60.9	11.6	27.1	22.0	81.5	19.0	23.5	14.9	30.3	14.6	20.8	42.7	27.2
2	9.8	32.5	15.3	28.1	52.6	22.9	43.2	40.5		13.7	15.7	19.0	18.3	44.9	24.4	35.0	23.8
3	9.3	33.0	17.8	21.6	50.8	18.5	56.2	48.8	54.2	22.1	22.1	17.4	50.6	19.9	38.2	33.9	39.7
4	10.0	12.4	16.7	37.4	22.4	21.6	35.8	15.6	25.2	15.7	15.4	27.7	21.7	18.2	34.1	25.1	123.8
Mean	11.0	24.4	16.9	39.2	46.7	18.6	40.6	31.7	53.6	17.6	19.2	19.8	30.2	24.4	29.4	34.2	53.6
								90-120 cm soil depth									
1	14.9	13.6	11.9	83.2	63.0	12.0	16.0	19.3	22.9	12.5	13.4	21.3	26.3	8.8	15.6	20.2	24.7
2	6.4	17.6	11.5	9.3	19.4	8.8	22.9	19.8	24.9	10.4	12.7	12.0	17.0	44.0	10.6	12.5	14.5
3	4.9	19.0	10.7	9.8	32.7	9.6	41.7	14.5	29.0	11.5	15.6	12.8	46.0	16.8	24.9	22.5	24.0
4	6.5	10.9	12.2	24.9	10.3	9.0	13.1	8.2	14.6	8.2	14.0	29.0	16.3	12.1	14.9	13.6	113.4
Mean	8.1	15.3	11.6	31.8	31.3	9.9	23.4	15.4	22.9	10.6	13.9	18.8	26.4	20.4	16.5	17.2	44.2
								120-150 cm soil depth									
1	11.4	12.8	8.8	48.8	49.3	5.2	11.9	14.2	19.4	14.1	12.5	10.2	27.3	24.2	12.5	11.7	18.7
2	6.3	32.1	8.5	11.1	11.7	6.2	16.9	9.9	10.7	6.8	10.2	8.9	8.7	22.4	9.9	11.5	17.4
3	5.0	29.1	12.8	8.4	16.2	9.5	39.9	19.3	11.9	13.5	11.9	15.7	35.4	12.4	13.5	13.3	21.2
4	5.4	10.8	9.7	12.8	7.4	2.9	13.1	5.3	10.9	11.2	10.5	12.4	15.3	8.4	10.9	12.0	77.7
Mean	7.0	21.2	9.9	20.3	21.2	5.9	20.4	12.2	13.2	11.4	11.3	11.8	21.7	16.9	11.7	12.1	33.7

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.6. Soil extractable nitrate-N (kg ha^{-1}) at the Lethbridge site in 2001.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	16.5	78.1	145.1	106.0	430.8	123.4	183.6	139.1	169.8	27.3	52.4	45.3	93.6	118.0	108.8	156.2	395.0
2	1.2	160.3	158.7	124.5	306.8	98.6	113.4	328.0	594.8	31.4	76.9	100.3	432.0	10.4	41.3	94.7	283.0
3	1.2	57.1	30.7	194.7	263.8	109.3	86.4	70.2	570.6	17.1	63.1	193.6	188.7	23.1	68.6	149.9	11.5
4	1.2	1.2	64.9	95.4	99.3	6.9	193.1	50.8	113.0	14.7	1.2	307.7	209.5	20.8	104.9	163.5	90.6
Mean	5.0	74.2	99.8	130.2	275.2	84.5	144.1	147.0	362.0	22.6	48.4	161.7	230.9	43.1	80.9	141.1	195.0
								15-30 cm soil depth									
1	19.9	40.2	97.3	91.0	171.9	85.9	33.0	76.2	93.6	12.8	1.2	32.3	184.6	88.5	83.4	110.4	268.0
2	1.2	17.7	32.3	13.9	63.5	17.4	93.6	104.4	134.4	1.2	1.2	33.7	74.6	1.2	8.8	10.6	42.7
3	1.2	11.3	7.0	15.9	22.5	38.3	14.0	10.9	91.2	1.2	14.1	19.7	13.0	12.3	24.0	34.7	1.2
4	1.2	1.2	55.7	20.9	13.4	1.2	40.9	8.9	13.3	1.2	1.2	113.0	45.3	1.2	30.0	83.4	7.8
Mean	5.8	17.6	48.1	35.4	67.8	35.7	45.4	50.1	83.1	4.1	4.4	49.7	79.4	25.8	36.6	59.8	79.9
								30-60 cm soil depth									
1	18.8	41.3	68.0	96.2	2.4	118.6	2.4	73.4	105.9	34.1	45.3	42.7	2.4	110.3	86.5	73.4	2.4
2	2.4	2.4	2.4	2.4	2.4	2.4	57.3	19.0	2.4	2.4	2.4	2.4	2.4	2.4	2.4	13.8	16.2
3	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	32.7	2.4	13.3	2.4	2.4	2.4	14.5	73.4	2.4
4	2.4	2.4	40.9	54.4	2.4	2.4	17.9	2.4	2.4	2.4	2.4	42.5	2.4	2.4	2.4	2.4	2.4
Mean	6.5	12.1	28.4	38.9	2.4	31.5	20.0	24.3	35.9	10.3	15.9	22.5	2.4	29.4	26.5	40.8	5.9
								60-90 cm soil depth									
1	11.4	18.0	24.1	45.4	2.6	75.3	2.6	29.9	41.2	15.6	20.8	26.2	142.4	32.4	37.5	21.4	99.6
2	5.5	2.6	2.6	2.6	21.2	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6
3	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	22.2	2.6	2.6	2.6	145.0	2.6	2.6	2.6	2.6
4	2.6	2.6	29.9	34.1	2.6	2.6	2.6	2.6	2.6	2.6	2.6	55.7	2.6	2.6	2.6	47.8	2.6
Mean	5.5	6.4	14.8	21.2	7.2	20.8	2.6	9.4	17.1	5.8	7.1	21.8	73.1	10.0	11.3	18.6	26.8
								90-120 cm soil depth									
1	5.9	2.5	2.5	2.5	2.5	25.9	2.5	11.2	24.4	11.9	2.5	20.2	67.5	14.8	2.5	71.6	30.0
2	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	11.0	2.5	2.5	2.5	15.0	2.5
3	2.5	2.5	2.5	2.5	2.5	2.5	2.5	8.8	2.5	9.1	2.5	2.5	2.5	2.5	2.5	2.5	2.5
4	2.5	2.5	2.5	18.2	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	13.8	2.5	2.5	2.5	2.5
Mean	3.4	2.5	2.5	6.5	2.5	8.4	2.5	6.3	8.0	6.5	2.5	9.0	21.6	5.6	2.5	22.9	9.4
								120-150 cm soil depth									
1	6.3	2.5	10.6	16.7	2.5	15.9	12.1	10.3	18.5	9.4	8.5	29.6	24.9	9.9	13.8	2.5	15.0
2	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
3	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
4	2.5	2.5	17.4	9.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	18.6	2.5	2.5	2.5	2.5	2.5
Mean	3.5	2.5	8.3	7.8	2.5	5.9	4.9	4.5	6.5	4.2	4.0	13.3	8.1	4.4	5.3	2.5	5.6

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.7. Soil extractable nitrate-N (kg ha^{-1}) at the Aridrie site in 1997.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	11.9	4.2	3.0	3.4	9.5	5.5	5.5	4.9	2.2	4.4	9.3	3.8	1.9	6.6	3.6	5.0	6.1
2	8.0	6.1	3.0	14.2	27.1	26.0	19.1	7.9	12.6	3.4	2.0	75.6	20.3	2.0	5.9	23.6	11.2
3	3.5	36.5	0.8	4.9	7.1	15.3	6.8	6.3	21.3	9.2	11.6	8.0	7.2	11.2	2.5	14.9	3.2
4	14.9	6.4	5.5	18.8	20.8	14.8	13.0	5.4	12.3	14.8	7.3	12.4	18.6	5.7	18.3	5.1	4.4
Mean	9.6	13.3	3.1	10.3	16.1	15.4	11.1	6.1	12.1	8.0	7.5	24.9	12.0	6.4	7.6	12.2	6.2
								15-30 cm soil depth									
1	9.1	16.0	3.6	4.9	5.1	5.1	6.5	15.7	5.3	8.9	6.1	10.9	2.2	6.8	8.7	4.0	7.4
2	5.3	4.6	2.7	6.6	19.5	9.7	9.4	5.8	8.1	8.5	2.4	23.5	2.6	2.6	1.0	9.1	5.7
3	4.5	6.1	2.2	7.0	7.4	8.2	15.9	5.3	7.3	4.0	4.0	12.2	4.7	6.7	3.9	10.6	2.9
4	6.8	7.4	3.2	11.7	20.5	11.4	10.0	7.1	8.8	17.5	12.9	6.7	11.6	3.4	12.0	11.8	2.2
Mean	6.4	8.5	2.9	7.6	13.1	8.6	10.4	8.5	7.4	9.7	6.4	13.3	5.3	4.9	6.4	8.9	4.6
								30-60 cm soil depth									
1	8.7	50.0	6.7	9.8	16.3	6.8	7.4	18.2	7.0	11.1	16.0	47.5	5.7	2.1	11.1	7.1	
2	5.6	4.8	4.6	15.3	12.2	4.8	13.7	5.0	6.1	6.5	5.4	33.8	5.0	2.1	2.1	17.8	
3	6.0	2.1	4.3	10.6	7.5	6.8	8.6	5.2	6.5	13.4	2.1	8.8	2.1	11.9	7.4	9.1	
4	8.5	13.5	7.2	30.3	6.8	12.0	12.4	5.7	12.9	37.7	12.7	14.7	6.6	2.1	17.0	2.1	
Mean	7.2	17.6	5.7	16.5	10.7	7.6	10.5	8.5	8.1	17.1	9.0	26.2	4.8	4.5	9.4	9.0	
								60-90 cm soil depth									
1	21.0	106.4	5.2	6.9	29.4	7.5	20.1	9.5	9.4	11.4	12.2	218.5	2.4	2.4	7.0	10.5	12.3
2	3.9	6.2	5.9	2.4	6.8	7.9	13.6	7.0	6.5	6.9	5.7	28.1	5.6	5.2	8.9	8.7	5.5
3	5.0	2.4	2.4	2.4	11.1	5.1	9.3	4.9	2.4	2.4	2.4	2.4	5.1	6.8	7.1	7.3	6.4
4	17.0	6.3	6.1	33.1	5.2	8.0	11.9	2.4	6.9	286.8	9.4	24.1	7.6	7.1	16.7	6.9	6.8
Mean	11.7	30.3	4.9	11.2	13.1	7.1	13.7	5.9	6.3	76.9	7.4	68.3	5.2	5.4	9.9	8.3	7.7
								90-120 cm soil depth									
1	25.7	38.8	5.3	2.6	29.0	55.5	26.5	5.3	9.2	14.6	46.2	477.5	2.6	19.4	5.6	2.6	13.8
2	4.4	7.7	5.2	2.6	11.7	43.8	24.9	8.0	6.7	5.9	8.6	7.5	5.6	5.3	11.8	197.2	5.9
3	7.2	2.6	17.6	5.7	17.5	6.9	6.8	7.2	10.0	11.3	6.4	2.6	9.9	9.8	9.3	2.6	7.9
4	13.3	11.0	12.4	23.3	7.8	10.0	35.4	2.6	9.5	302.1	11.2	24.8	6.9	12.4	18.4	9.5	10.6
Mean	12.7	15.0	10.2	8.5	16.5	29.1	23.4	5.8	8.8	83.5	18.1	128.1	6.2	11.7	11.3	53.0	9.5
								120-150 cm soil depth									
1	22.2	30.7	2.7	2.7	19.1	46.7	16.2	5.7	11.7	13.2	32.9	881.8	2.7	9.6	2.7	6.2	6.4
2	6.3	7.7	5.5	2.7	18.2	57.3	18.3	7.8	7.0	5.8	7.5	6.2	6.0	6.7	9.0	142.0	5.7
3	8.8	2.7	14.1	2.7	17.6	2.7	6.9	9.8	16.2	12.1	13.0	2.7	10.9	15.2	8.6	17.0	9.3
4	10.4	9.6	11.6	16.5	6.6	10.4	46.5	5.8	9.8	239.7	9.3	24.7	6.5	15.9	25.0	10.5	8.3
Mean	11.9	12.7	8.5	6.2	15.4	29.3	22.0	7.3	11.2	67.7	15.7	228.8	6.5	11.9	11.3	43.9	7.4

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.8. Soil extractable nitrate-N (kg ha^{-1}) at the Aridrie site in 1998.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
							0-15 cm soil depth										
1	15.1	5.5	9.0	6.9	9.9		21.5	28.1	21.0	31.0	51.6	31.3	31.5	18.8	42.8	90.7	31.3
2	23.0		22.6	14.2	15.0	22.6	9.9	21.8	28.8	30.5	42.0	83.9	106.2	44.6	32.8	43.1	64.1
3	5.9	14.8	13.1	31.3	13.6	22.0	31.6	14.4	20.8	9.7	37.8	85.4	61.8	24.8	44.0	151.0	201.5
4	11.2	2.9	17.3	12.3	24.8	4.8	10.6	25.3	24.6	13.6	8.7	79.1	71.8	74.9	61.8	86.1	379.6
Mean	13.8	7.7	15.5	16.2	15.8	16.5	18.4	22.4	23.8	21.2	35.0	69.9	67.8	40.8	45.3	92.7	169.1
							15-30 cm soil depth										
1	11.4	4.8	9.5	8.2	14.1	1.0	10.2	18.6	11.5	23.1	32.3	22.3	12.0	9.8	12.0	37.5	23.7
2	19.1	11.2	14.6	21.5	13.4	15.8	12.1	10.6	29.9	10.9	14.4	77.8	77.4	28.7	17.6	22.5	58.5
3	11.7	7.9	18.0	17.2	20.0	4.1	16.4	16.3	23.1	6.6	23.3	32.9	17.5	19.7	30.5	39.9	23.9
4	8.5	10.1	16.7	10.7	27.7	11.0	12.0	15.0	11.0	13.4	12.8	30.1	37.7	28.7	53.7	20.3	59.9
Mean	12.7	8.5	14.7	14.4	18.8	8.0	12.7	15.1	18.9	13.5	20.7	40.8	36.1	21.8	28.4	30.1	41.5
							30-60 cm soil depth										
1	15.9	5.1	14.4	11.5	21.4	4.8	27.0		10.9	17.0	26.4	31.1	19.3	11.6	14.9	49.6	43.0
2	15.0	10.3	8.9	27.5	12.8	9.6	21.7	19.1	37.4	11.1	16.8	61.7	80.5	20.6	9.8	9.5	32.3
3	16.8	2.1	13.5	14.0	29.0	6.8	21.4	12.1	27.6	14.2	17.9	36.0	14.2	31.5	26.9	79.6	22.1
4	16.6	11.1	15.6	20.0	19.5	16.2	10.0	21.3	14.6	21.5	12.7	19.7	45.0	22.6	44.2	14.5	9.2
Mean	16.1	7.2	13.1	18.2	20.7	9.4	20.0	17.5	22.6	16.0	18.4	37.2	39.8	21.6	24.0	38.3	26.6
							60-90 cm soil depth										
1	14.6	6.2			21.1	10.2	25.1	19.6	8.9	2.4	35.9	191.7	6.3	2.4	8.8	15.3	28.4
2	16.2	7.2	6.8	2.4	19.3	2.4	30.2		21.6	2.4	14.6	21.5	52.8	10.0	17.0	7.0	8.6
3	9.3	7.2	4.9	6.7	11.2	5.1	14.2	19.1	11.1	10.8	6.5	17.1	13.9	13.6	19.2	10.8	19.1
4	11.7	7.8	6.3	11.1	7.1	9.3	9.2	8.1	4.8	71.1	9.7	11.2	17.0	10.6	20.8	5.1	6.5
Mean	13.0	7.1	6.0	6.7	14.7	6.7	19.7	15.6	11.6	21.7	16.6	60.4	22.5	9.2	16.4	9.6	15.6
							90-120 cm soil depth										
1	10.6	5.6	8.7	2.6	25.4	12.8	15.9	24.5	5.9	11.5	38.1	420.4	6.2	2.6	2.6		17.7
2	9.5	6.3	2.6	2.6	29.0	15.2	19.3	2.6		2.6	9.2	5.9	47.1	67.5	18.0	20.6	2.6
3	8.5	2.6	7.0	9.2	41.3	2.6	9.1	12.5	20.0	11.1	8.1	21.0	18.8	17.5	35.3	11.5	11.2
4	10.8	5.2	7.3	11.0	2.6	11.5	9.6	2.6	5.7	113.1	10.1	10.2	13.1	7.7	35.1	7.2	6.7
Mean	9.8	4.9	6.4	6.3	24.6	10.5	13.5	10.5	10.5	34.6	16.4	114.4	21.3	23.8	22.8	13.1	9.6
							120-150 cm soil depth										
1	9.3	2.7	6.0	2.7	19.1	7.8	17.5	14.2	2.7	5.6	31.2	420.4	2.7	2.7	6.7	2.7	14.4
2	7.9	9.7	5.8	2.7	11.6	33.3	14.4	2.7	7.4	2.7	6.9	6.6	16.1	16.3	8.5	27.3	6.1
3	6.4	2.7	8.3	8.0	57.3	2.7	7.2	12.1	11.6	11.1	8.5	17.4	15.1	13.4	18.3	21.5	8.7
4	11.0	8.4	2.7	8.7	2.7	14.5	9.8	2.7	10.7	98.8	10.3	12.8	11.1	11.0	44.9	10.2	6.7
Mean	8.7	5.9	5.7	5.5	22.7	14.6	12.2	7.9	8.1	29.6	14.3	114.3	11.2	10.9	19.6	15.4	9.0

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.9. Soil extractable nitrate-N (kg ha^{-1}) at the Airdrie site in 1999.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	5.1	4.0	2.6	10.9	28.0	5.0	15.6	10.9	84.1	20.3	32.0	73.1	83.3	36.6	91.7	116.6	152.5
2	8.1	2.7	4.8	3.5	13.2	11.1	10.9	46.6	37.0	33.1	146.9	101.7	182.3	5.2	95.9	289.7	474.5
3	9.2	19.3	37.0	4.2	22.8	17.1	7.4	15.6	70.8	12.4	23.0	103.6	17.1	146.5	82.1	125.2	356.3
4	16.2	9.3	12.9	14.9	11.7	7.5	13.1	8.4	22.3	7.4	20.6	12.0	11.7	26.1	13.8	14.7	10.2
Mean	9.7	8.8	14.3	8.4	18.9	10.2	11.7	20.4	53.5	18.3	55.6	72.6	73.6	53.6	70.9	136.5	248.4
								15-30 cm soil depth									
1	7.2	10.7	5.1	6.3	15.9	20.5	8.6	6.3	28.7	5.3	25.9	116.9	25.1	25.3	14.3	64.8	98.6
2	12.2	8.6	4.5	12.0	21.9	16.3	13.6	23.5	18.8	16.2	74.8	75.8	83.0	6.2	23.3	186.5	28.3
3	12.8	11.1	12.5	7.5	23.1	11.7	22.5	8.9	46.3	36.5	42.7	156.6	14.2	122.9	11.4	175.6	169.6
4	10.7	5.7	14.7	13.0	9.8	32.7	10.8	17.6	6.1	5.3	7.4	11.3	7.8	6.9	13.7	10.3	8.0
Mean	10.7	9.0	9.2	9.7	17.7	20.3	13.9	14.1	25.0	15.8	37.7	90.1	32.5	40.3	15.7	109.3	76.1
								30-60 cm soil depth									
1	16.5	12.6	13.9	3.3	13.7	27.0	11.8	8.5	22.0	8.2	14.0	193.1	50.0	20.2	9.7	67.6	88.4
2	16.7	10.3	7.8	8.0	10.7	14.1	8.1	28.2	19.0	18.1	34.5	78.8	49.6	24.9	19.3	44.2	43.4
3	39.6	21.9	16.8	13.1	25.4	24.2	14.8	14.3	12.6	6.8	17.1	301.1	15.9	56.7	9.3	68.8	70.1
4	16.9	4.3	22.3	13.3	9.8	11.0	9.7	13.3	10.4	6.8	8.3	12.6	8.4	5.2	52.5	18.5	18.0
Mean	22.4	12.3	15.2	9.4	14.9	19.1	11.1	16.1	16.0	10.0	18.5	146.4	31.0	26.7	22.7	49.8	55.0
								60-90 cm soil depth									
1	10.6	7.8	8.1	2.4	16.2	9.7	5.0	6.0	9.7	8.2	33.3	116.8	10.1	13.1	3.4	13.7	36.4
2	10.2	10.5	6.1	6.9	12.4	7.2	8.3	13.9	11.5	9.7	50.4	16.5	22.0	8.8	15.0	110.2	96.1
3	15.5	9.1	25.2	6.9	18.1	9.3	13.9	15.5	11.2	6.1	7.9	202.5	10.5	10.5	26.0	16.5	30.8
4	7.9	5.0	29.8	7.5	9.2	8.0	13.7	6.7	11.7	7.9	6.5	13.7	7.0	9.6	13.1	8.7	8.7
Mean	11.0	8.1	17.3	5.9	14.0	8.5	10.2	10.5	11.1	7.9	24.5	87.4	12.4	10.5	14.4	37.3	43.0
								90-120 cm soil depth									
1	8.9	4.1	5.9	2.6	20.8	6.7	12.9	9.4	6.4	8.9	34.0	122.0	7.6	9.4	5.6	6.9	29.6
2	7.4	6.6	4.9	4.9	13.9	15.7	7.0	27.4	18.2	20.0	26.1	16.8	23.5	8.4	21.2	102.8	76.8
3	13.2	7.3	9.5	3.7	24.8	5.2	9.7	7.2	27.7	10.4	5.3	134.9	20.3	11.6	76.3	58.6	10.6
4	7.7	4.6	8.4	5.1	16.3	7.6	15.8	6.9	20.1	4.6	5.7	12.7	7.2	7.1	15.8	4.3	7.7
Mean	9.3	5.6	7.2	4.1	18.9	8.8	11.3	12.7	18.1	11.0	17.8	71.6	14.7	9.1	29.7	43.1	31.2
								120-150 cm soil depth									
1	6.8	7.0	5.2	6.4	15.2	9.3	10.4	6.6	6.8	7.3	21.9	89.0	7.3	6.1	3.2	7.8	25.1
2	8.2	6.1	5.0	5.8	9.0	13.2	10.4	10.5	12.1	10.3	14.6	16.9	18.8	7.8	18.9	60.6	8.6
3	11.7	6.2	13.1	4.5	21.3	6.6	7.2	6.0	11.2	12.3	8.7	182.4	5.4	9.9	70.4	74.3	11.6
4	10.5	6.5	9.2	6.9	9.7	9.6	13.6	8.3	19.1	6.1	9.8	6.8	6.7	19.5	13.5	21.7	7.3
Mean	9.3	6.5	8.1	5.9	13.8	9.7	10.4	7.8	12.3	9.0	13.8	73.8	9.5	10.8	26.5	41.1	13.1

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.10. Soil extractable nitrate-N (kg ha^{-1}) at the Aridrie site in 2000.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	23.7	6.7	5.8	64.1	115.7	16.3	16.6	74.4	65.1	45.3	228.1	156.5	158.2	118.2	73.4	230.6	80.1
2	18.5	21.0	44.1	121.5	164.8	58.1	19.5	52.9	78.4	31.6	20.8	87.9	228.1	144.9	147.4	376.3	307.2
3	18.1	65.6	12.8	43.6	165.7	41.0	36.1	54.4	47.1	19.8	110.9	120.7	150.7	66.6	143.2	123.2	288.9
4	31.7	60.4	50.9	83.1	187.3	18.1	31.1	42.1	75.8	42.8	78.9	92.1	295.5	108.9	170.7	188.1	546.1
Mean	23.0	38.4	28.4	78.1	158.4	33.4	25.8	56.0	66.6	34.9	109.7	114.3	208.1	109.6	133.7	229.6	305.6
								15-30 cm soil depth									
1	18.9	8.4	25.3	40.5	64.6	16.9	30.7	37.9	33.7	44.7	99.8	172.6	86.4	36.9	32.9	77.6	59.5
2	17.7	16.3	20.0	57.3	57.9	30.9	26.9	28.5	41.3		40.7	98.2	236.4	45.1	61.2	193.5	139.7
3	21.3	30.1	19.4	23.5	53.5	20.7	19.9	25.1	36.5	9.6	33.1	72.2	212.5	30.9	35.7	66.8	167.6
4	17.3	34.3	30.5	74.2	125.7	31.1	32.7	21.5	31.5	29.1	74.2	113.5	321.2	26.7	63.0	63.6	247.4
Mean	18.8	22.3	23.8	48.9	75.4	24.9	27.6	28.3	35.8	27.8	61.9	114.1	214.1	34.9	48.2	100.4	153.5
								30-60 cm soil depth									
1	34.1	21.5	25.2	33.2	91.3	17.7	42.1	42.1	31.4	92.6	178.1	392.0	103.0	62.6	44.6	57.1	53.0
2	20.8	24.2	21.6	50.0	40.4	32.3	29.0	30.9	58.0	25.6	79.6	234.8	316.9	38.9	43.4	113.4	113.4
3	31.1	24.1	32.7	28.7	71.7	17.0	32.8	42.1	35.5	18.5	44.2	348.2	458.7	50.9	49.6	62.1	189.3
4	28.7	45.9	35.9	59.2	91.3	33.9	24.7	47.5	49.2	71.7	86.7	144.3	400.3	29.4	65.9	43.8	162.2
Mean	28.7	28.9	28.8	42.8	73.7	25.2	32.2	40.7	43.5	52.1	97.2	279.8	319.7	45.4	50.9	69.1	129.5
								60-90 cm soil depth									
1	14.9	15.1	19.4	20.8	73.5	6.3	23.6	26.5	24.8	34.5	174.3	168.1	37.0	33.9	27.5	46.4	33.7
2	15.8	16.8	11.0	29.0	41.7	16.2	25.2	19.8	29.6	16.7	25.7	46.7	160.1	34.8	32.6	111.2	44.9
3	20.1	16.8	11.9	19.3	89.0	13.5	26.1	14.1	26.0	24.8	29.7	268.5	334.4	42.8	30.5	41.0	85.7
4	18.8	16.4	36.2	23.4	33.3	21.6	17.6	14.4	30.1	466.3	47.1	90.0	131.4	23.9	37.9	44.4	49.0
Mean	17.4	16.3	19.6	23.1	59.4	14.4	23.1	18.7	27.6	135.6	69.2	143.3	165.7	33.8	32.1	60.7	53.3
								90-120 cm soil depth									
1	14.8	6.5	11.6	17.9	34.3	8.5	10.7	22.3	17.9	15.5	147.4	180.1	34.8	19.6	17.6	21.2	28.1
2	17.3	16.1	8.9	22.4	40.8	31.6	19.8	16.5	17.6	7.2	28.4	22.2	56.6	28.5	18.7	171.3	14.5
3	11.6	11.4	11.9	11.2	94.5	7.1	14.6	12.3	17.2	26.3	15.2	125.1	135.5	32.7	22.0	45.2	68.5
4	14.3	10.1	21.2	24.8	32.9	15.5	12.7	5.5	10.8	498.2	26.1	62.8	49.7	17.5	52.4	40.8	14.2
Mean	14.5	11.0	13.4	19.0	50.6	15.7	14.5	14.1	15.9	136.8	54.3	97.5	69.1	24.6	27.7	69.6	31.3
								120-150 cm soil depth									
1	19.9	10.3	14.0	19.7	48.4	19.5	11.8	21.7	14.0	14.7	109.2	183.5	16.8	32.6	29.3	26.3	40.2
2	18.6	23.0	15.2	39.7	46.5	41.6	15.6	24.2	25.4	11.0	14.8	95.0	62.2	27.6	29.1	179.1	58.4
3	22.0	12.8	14.4	14.6	80.8	8.4	12.3	23.5	19.4	28.9	22.6	152.3	157.8	32.2	43.1	67.7	50.5
4	16.1	15.0	27.5	69.3	74.3	25.4	16.9	9.3	10.3	344.0	14.9	90.6	80.8	32.2	60.6	32.8	13.8
Mean	19.1	15.3	17.8	35.8	62.5	23.7	14.1	19.7	17.3	99.7	40.4	130.4	79.4	31.1	40.5	76.5	40.7

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.11. Soil extractable nitrate-N (kg ha^{-1}) at the Aridrie site in 2001.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	20.3	18.1	12.2	67.1	83.9	12.4	14.4	61.6	40.6	37.1	146.5	122.2	179.8	88.4	31.8	557.8	166.3
2	9.5	10.5	20.3	62.1	73.9	50.4	12.3	41.8	108.2	11.6	209.8	183.2	464.5	178.2	399.6	142.9	452.9
3	14.8	31.8	16.5	34.5	64.6	24.3	10.1	176.5	143.2	15.5	108.2	50.9	248.1	60.8	129.9	145.7	203.1
4	15.8	8.3	21.5	112.9	213.1	21.5	10.4	33.6	33.5	30.8	39.8	64.1	169.8	29.1	95.6	120.7	397.9
Mean	15.1	17.2	17.6	69.1	108.9	27.2	11.8	78.4	81.4	23.7	126.1	105.1	265.6	89.1	164.2	241.8	305.1
								15-30 cm soil depth									
1	15.7	9.0	25.5	26.5	37.5	66.0	13.7	27.7	11.4	13.0	229.4	728.2	718.2	25.9	33.3	346.1	128.9
2	16.7	22.3	19.2	40.9	75.0	28.7	15.3	4.0	46.3	9.6	373.1	403.0	357.1	55.5	381.0	74.4	132.1
3	10.7	21.7	10.8	17.3	56.1	21.5	9.4	172.6	41.5	12.1	110.7	157.6	236.4	5.9	61.2	46.1	263.3
4	13.2	12.7	10.3	12.4	169.6	10.8	15.8	14.3	31.9	1.0	1.0	9.0	137.7	12.2	86.8	103.3	195.1
Mean	14.1	16.5	16.5	24.3	84.5	31.8	13.5	54.7	32.8	8.9	178.6	324.5	362.3	24.9	140.6	142.5	179.8
								30-60 cm soil depth									
1	12.5	14.8	31.6	9.2	48.4	19.6	57.5	10.5	48.4	15.1	531.7	1430.3	959.1	22.3	10.2	408.7	28.3
2	18.3	20.3	20.3	30.0	72.1	21.9	15.4	75.5	32.0	23.4	29.2	542.1	467.0	19.9	86.7	17.1	40.9
3	18.5	21.9	7.3	8.7	65.9	20.0	14.8	118.4	28.5	12.6	89.2	442.0	381.6	9.7	34.7	2.1	517.1
4	13.2	12.1	7.1	9.9	99.2	6.3	13.4	8.7	11.4	55.9	112.6	2.1	185.1	19.5	2.1	81.3	173.5
Mean	15.7	17.3	16.6	14.4	71.4	17.0	25.3	53.3	30.1	26.7	190.7	604.1	498.2	17.9	33.4	127.3	190.0
								60-90 cm soil depth									
1	14.1	8.5	30.5	2.4	25.2	11.5	178.5	8.8	17.0	13.0	341.0	316.5	113.0	2.4	8.2	146.5	37.7
2	12.0	13.0	13.0	11.2	88.5	7.4	11.0	25.2	12.5	16.5	101.3	130.9	223.3		32.7	11.3	
3	12.2	16.4	2.4	2.4	106.9	12.2	25.4	26.3	18.8	16.2	66.4	202.1	154.0	2.4	46.7	14.0	92.8
4	16.9	10.5	2.4	2.4	2.4	21.3	7.9	2.4	6.6	136.1	22.2	2.4	62.2	15.0	31.0	23.9	69.2
Mean	13.8	12.1	12.1	4.6	55.8	13.1	55.7	15.6	13.8	45.5	132.7	163.0	138.1	6.6	29.7	48.9	66.6
								90-120 cm soil depth									
1	12.3	2.6		2.6	21.8	2.6	94.5	10.8	7.9	10.8	111.1	213.8	2.6	8.6	8.0	63.8	2.6
2	8.4	9.1	2.6	12.6	45.5	2.6	2.6	2.6	2.6	11.9	31.0	49.4	31.9	24.3	35.9	2.6	71.6
3	6.6	19.1	2.6	11.6	76.3	31.1	10.5	14.4	10.8	19.4	23.0	124.6	36.9	12.2		2.6	50.7
4	15.4	7.6	9.0	2.6	28.5	12.8	9.8	2.6	2.6	99.1	21.1	76.3	29.8	20.5	30.9	22.0	23.5
Mean	10.7	9.6	4.7	7.3	43.0	12.3	29.3	7.6	6.0	35.3	46.6	116.0	25.3	16.4	24.9	22.8	37.1
								120-150 cm soil depth									
1	15.8	10.4		2.7	15.5	8.1	55.1	14.3	2.7	11.2	75.3	154.5	22.4	2.7	2.7	13.2	14.1
2	4.5	38.3	14.7	2.7	22.2	14.0	9.3	2.7	9.0	2.7	16.2	45.5	21.3	11.2	21.0	8.8	66.6
3	13.1	19.7	2.7	8.7	69.3	20.8	2.7	12.9	2.7	11.8	23.5	124.5	61.7	8.8		40.9	35.8
4	15.4	10.2	14.5	10.3	22.3	2.7	10.5	2.7	11.3	79.7	21.2	43.4	30.1	21.2	2.7	16.6	19.1
Mean	12.2	19.6	10.6	6.1	32.3	11.4	19.4	8.2	6.4	26.4	34.1	92.0	33.9	11.0	8.8	19.9	33.9

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.12. Soil extractable ammonium-N (kg ha^{-1}) at the Lethbridge site in 1996.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	21.0	13.9	22.1	17.3	16.2	19.0	19.1	17.0	18.8	48.3	18.5	24.0	23.3	16.6	24.0	17.8	19.0
2	17.5	21.7	19.8	27.5	16.1	19.6	20.9	21.2	17.6	21.4	16.5	23.1	18.2	24.0	17.1	19.6	13.9
3	20.2	18.9	23.3	23.6	23.6	20.6	20.5	29.3	19.3	13.9	15.1	19.7	26.3	20.5	17.9	25.4	23.1
4	17.0	16.9	16.7	18.5	16.9	21.6	14.0	17.2	18.5	22.2	20.1	22.3	24.5	17.2	18.1	17.0	19.6
Mean	18.9	17.9	20.5	21.7	18.2	20.2	18.6	21.2	18.5	26.4	17.5	22.3	23.1	19.6	19.3	19.9	18.9
								15-30 cm soil depth									
1	15.3	9.2	20.4	14.9	9.2	14.2	16.9	11.5	10.9	17.0	24.3	13.5	16.1	13.4	12.5	19.0	18.0
2	15.0	16.1	17.4	12.7	12.8	14.7	17.7	20.2	12.8	13.4	18.4	19.6	12.3	20.5	15.3	17.0	9.2
3	16.0	14.1	14.9	20.4	12.5	13.0	13.6	15.3	19.1	6.9	11.4	10.9	16.5	21.4	16.0	16.0	14.1
4	19.1	14.5	17.0	11.6	14.0	19.9	14.3	11.1	13.9	14.1	12.6	21.1	19.3	16.6	18.7	19.1	9.3
Mean	16.3	13.5	17.4	14.9	12.1	15.5	15.6	14.5	14.2	12.8	16.7	16.3	16.1	18.0	15.6	17.8	12.7
								30-60 cm soil depth									
1	22.4	19.4	28.1	23.2	19.4	19.9	23.4	21.0	17.4	77.3	24.7	29.7	29.0	20.1	16.7	24.6	24.5
2	24.1	28.8	28.5	31.8	23.0	22.3	36.5	27.0	23.5	20.8	23.8	26.1	38.3	29.2	21.8	24.7	24.3
3	23.3	22.0	22.9	20.1	35.6	29.7	23.2	25.6	23.4	14.6	18.4	15.2	28.2	26.7	23.1	24.8	18.4
4	22.2	19.2	33.3	24.3	27.1	30.5	20.0	24.0	24.3	36.8	33.2	31.5	23.7	21.7	29.9	29.7	20.8
Mean	23.0	22.4	28.2	24.8	26.3	25.6	25.8	24.4	22.1	37.4	25.0	25.6	29.8	24.4	22.9	26.0	22.0
								60-90 cm soil depth									
1	21.2	15.5	22.2	17.8	31.0	27.4	25.6	18.9	18.2	56.2	32.9	31.7	19.2	22.2	16.2	31.2	23.3
2	26.2	25.6	24.1	26.5	18.2	27.0	22.3	22.2	25.0	21.6	32.7	26.9	24.6	26.1	23.0	32.4	25.8
3	32.1	16.8	23.6	39.3	26.5	23.6	14.2	32.4	19.6	20.6	16.6	20.9	16.8	27.4	29.4	23.2	20.8
4	26.7	24.4	28.8	20.6	33.4	37.8	23.0	33.8	31.0	27.5	23.7	30.3	44.5	23.0	22.9	25.4	26.3
Mean	26.6	20.6	24.7	26.0	27.3	28.9	21.3	26.8	23.5	31.5	26.5	27.5	26.3	24.7	22.9	28.0	24.0
								90-120 cm soil depth									
1	24.7	20.2	23.6	20.8	25.2	45.6	31.6	28.9	31.0	24.2	38.3	40.7	22.8	35.0	16.6	41.1	29.1
2	29.1	26.3	23.2	29.9	22.6	33.9	29.1	24.0	24.4	26.3	37.2	35.7	24.5	29.9	33.8	37.0	15.1
3	31.5	30.6	19.8	38.7	41.4	19.9	18.1	35.0	19.5	20.2	13.1	23.5	19.0	16.3	19.5	17.2	21.3
4	33.2	34.0	22.1	25.2	40.2	46.4	28.3	34.1	35.3	36.0	27.7	34.3	33.1	26.7	32.2	23.9	37.6
Mean	29.6	27.8	22.2	28.6	32.4	36.4	26.8	30.5	27.5	26.6	29.1	33.5	24.8	27.0	25.5	29.8	25.8
								120-150 cm soil depth									
1	33.6	30.1	42.4	24.1	40.1	44.3	30.7	33.8	42.1	40.1	58.1	55.6	24.3	41.2	19.0	54.1	35.1
2	32.1	27.3	29.3	29.9	30.6	47.7	43.8	27.2	45.5	40.5	49.9	54.1	26.7	38.5	40.8	43.0	15.0
3	30.3	36.6	34.3	54.1	53.1	40.7	24.3	51.1	26.2	20.0	13.4	36.8	32.3	24.2	44.2	15.8	26.6
4	37.7	47.7	21.3	20.0	48.8	55.6	33.2	33.9	35.1	51.6	38.9	35.1	28.0	34.8	46.5	22.7	30.2
Mean	33.4	35.4	31.8	32.0	43.2	47.1	33.0	36.5	37.2	38.1	40.1	45.4	27.8	34.7	37.7	33.9	26.7

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.13. Soil extractable ammonium-N (kg ha^{-1}) at the Lethbridge site in 1997.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	21.7	26.1	18.4	21.6	20.7	24.7	18.1	21.8	28.6	15.8	17.1	24.9	15.3	15.4	11.9	17.0	22.9
2	12.9	15.9	16.4	10.3	17.1	21.6	11.3	13.8	13.9	11.6	22.5	9.2	12.0	15.3	16.8	16.1	13.3
3	18.0	15.6	13.2	12.2	15.3	17.0	17.0	18.1	10.6	16.7	13.3	22.2	13.0	16.5	19.2	16.8	14.4
4	18.4	17.8	13.5	20.4	12.2	13.8	16.3	14.8	13.1	13.0	16.2	14.8	20.5	15.0	18.8	15.6	17.0
Mean	17.7	18.9	15.4	16.1	16.3	19.3	15.7	17.1	16.6	14.3	17.3	17.8	15.2	15.6	16.7	16.4	16.9
								15-30 cm soil depth									
1	13.4	12.3	7.5	13.1	12.0	11.1	11.4	18.0	16.1	14.0	10.9	14.5	8.8	14.4	10.3	16.8	17.2
2	9.9	8.8	11.6	9.7	9.7	16.1	13.4	15.7	7.8	8.9	13.2	10.3	11.6	14.4	13.3	17.4	9.6
3	13.7	12.0	12.3	14.3	10.7	11.7	8.0	12.1	12.4	13.9	13.7	10.8	11.4	18.0	16.7	12.4	8.6
4	12.6	10.6	16.9	14.5	9.9	10.0	12.4	10.1	16.1	10.6	12.9	18.4	10.5	7.6	12.9	11.8	19.1
Mean	12.4	10.9	12.1	12.9	10.6	12.2	11.3	14.0	13.1	11.9	12.7	13.5	10.6	13.6	13.3	14.6	13.6
								30-60 cm soil depth									
1	21.6	22.2	12.2	23.1	26.9	36.5	23.3	20.2	33.1	27.3	20.9	22.8	15.6	23.2	14.8	33.5	19.1
2	14.8	17.1	24.3	15.7	34.7	23.9	20.0	19.8	19.6	15.5	13.4	13.0	12.2	20.4	12.3	19.4	16.0
3	22.6	24.5	23.6	15.2	28.7	24.6	16.1	12.4	17.6	19.6	19.3	14.4	21.4	23.9	20.5	20.3	20.2
4	21.0	15.7	29.6	23.7	17.6	17.5	20.6	17.7	23.2	12.8	17.9	18.4	20.8	21.7	21.0	20.1	24.4
Mean	20.0	19.9	22.5	19.4	27.0	25.6	20.0	17.5	23.4	18.8	17.9	17.2	17.5	22.3	17.2	23.3	19.9
								60-90 cm soil depth									
1	21.3	20.7	16.8	22.4	35.7	30.4	24.6	18.8	29.6	25.5	24.9	27.7	21.4	20.4	16.3	30.5	24.4
2	18.5	14.6	21.6	20.3	20.5	24.1	18.4	15.3	14.3	15.1	23.4	15.4	21.2	17.9	15.7	37.1	21.6
3	23.6	19.0	13.3	36.0	18.3	15.6	17.0	24.3	20.8	24.7	18.8	17.3	31.7	23.0	23.7	26.4	29.7
4	19.7	16.7	19.1	20.9	32.1	21.7	21.3	33.3	25.5	18.0	17.6	26.6	23.6	25.1	21.1	28.2	23.7
Mean	20.8	17.7	17.7	24.9	26.6	23.0	20.3	22.9	22.6	20.8	21.2	21.7	24.5	21.6	19.2	30.6	24.9
								90-120 cm soil depth									
1	23.8	18.2	19.3	22.2	33.6	22.1	32.5	28.9	29.7	17.6	25.1	33.6	18.8	26.9	14.9	36.3	29.4
2	22.2	22.9	19.7	20.7	19.4	31.9	34.8	16.5	33.6	22.9	25.8	23.3	16.0	25.8	20.4	32.7	16.1
3	26.6	32.0	16.8	36.7	24.8	31.7	22.1	19.6	23.2	27.0	27.2	19.6	31.3	19.6	28.0	19.8	25.5
4	28.0	27.8	22.0	27.4	46.0	40.9	25.5	27.1	46.0	22.0	29.7	28.7	27.9	22.4	35.4	26.6	17.4
Mean	25.1	25.2	19.4	26.7	31.0	31.6	28.7	23.0	33.1	22.4	27.0	26.3	23.5	23.7	24.7	28.9	22.1
								120-150 cm soil depth									
1	31.3	26.2	29.7	20.5	38.1	37.5	37.4	35.6	37.9	24.4	30.9	39.0	21.4	35.5	31.8	36.4	34.4
2	24.1	24.5	19.8	19.1	32.1	31.7	36.4	19.7	34.9	34.7	35.3	37.1	23.0	35.5	27.7	40.1	18.3
3	31.0	26.7	19.2	32.4	35.6	27.4	37.1	25.3	19.5	18.4	24.1	39.4	39.6	27.6	30.2	25.1	31.4
4	32.3	35.6	19.8	22.4	36.8	28.8	34.7	34.5	38.3	38.8	36.6	34.5	32.5	41.1	49.9	22.1	24.3
Mean	29.7	28.2	22.1	23.6	35.7	31.4	36.4	28.8	32.6	29.1	31.7	37.5	29.1	34.9	34.9	30.9	27.1

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.14. Soil extractable ammonium-N (kg ha^{-1}) at the Lethbridge site in 1998.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	24.8	20.0	15.6	27.5	17.6	18.8	14.9	21.1	30.3	19.6	16.5	19.3	33.3	27.0	28.4	17.4	15.8
2	22.5	26.3	21.9	26.3	23.8	21.7	25.4	29.3	22.3	28.4	25.2	23.3	22.7	23.6	24.0	30.5	24.7
3	27.5	22.7	25.6	28.9	18.8	25.4	22.5	21.2	16.8	26.1	20.5	22.5	29.1	20.7	27.0	26.8	13.0
4	30.4	19.6	27.5	32.1	23.3	26.6	26.3	23.0	23.6	36.3	18.4	26.1	32.8	18.9	20.8	32.6	19.1
Mean	26.3	22.2	22.7	28.7	20.9	23.1	22.3	23.7	23.2	27.6	20.2	22.8	29.5	22.5	25.1	26.8	18.2
								15-30 cm soil depth									
1	19.4	13.3	1.2	25.9	15.9	21.6	17.4	22.5	22.8	29.6	12.7	15.8	31.6	33.0	24.5	12.2	25.6
2	27.6	30.0	23.8	14.6	23.8	24.7	27.7	31.0	28.2	23.1	23.8	32.8	24.7	22.2	25.2	25.4	23.1
3	23.7	22.1	19.9	22.8	20.6	21.9	19.2	20.0	20.4	20.9	18.2	17.9	26.3	20.0	21.3	21.0	17.4
4	24.0	18.5	30.0	29.6	22.2	29.8	19.3	15.2	22.0	30.3	19.5	21.2	21.7	23.8	23.3	26.3	20.1
Mean	23.7	21.0	18.7	23.2	20.6	24.5	20.9	22.2	23.3	26.0	18.6	21.9	26.1	24.7	23.6	21.2	21.6
								30-60 cm soil depth									
1	34.4	20.3	31.3	37.2	33.9	39.0	32.4	40.2	22.8	25.0	27.8	32.6	45.1	29.5	15.0	24.2	16.4
2	33.1	43.6	29.3	20.1	40.7	23.9	51.0	43.3	44.3	35.6	35.5	17.9	39.0	20.7	10.8	23.6	56.9
3	27.6	19.5	21.1	30.9	29.2	40.2	17.3	21.5	17.0	49.6	30.6	22.8	13.4	24.9	43.0	38.3	19.1
4	28.5	15.9	70.5	48.4	29.5	31.2	24.4	23.8	30.1	23.4	26.7	36.9	27.1	22.2	33.4	37.6	28.0
Mean	30.9	24.8	38.0	34.2	33.3	33.6	31.3	32.2	28.6	33.4	30.2	27.6	31.1	24.3	25.6	30.9	30.1
								60-90 cm soil depth									
1	30.5	24.7	30.8	19.8	36.3	18.2	36.2	20.9	31.6	24.9	37.0	7.9	24.5	14.3	12.5	32.1	16.6
2	21.6	29.8	36.9	19.0	13.7	41.7	28.8	24.5	26.0	31.0	41.8	35.8	40.6	37.3	16.6	29.8	46.4
3	45.2	17.9	13.5	30.2	19.3	18.8	17.5	18.1	20.0	20.1	21.4	15.2	12.8	29.0	22.3	31.1	19.9
4	23.2	19.0	26.4	36.7	21.6	33.9	23.2	29.8	49.3	21.1	20.2	25.4	15.4	16.1	24.4	29.8	27.0
Mean	30.1	22.8	26.9	26.4	22.7	28.1	26.4	23.3	31.7	24.3	30.1	21.1	23.3	24.2	19.0	30.7	27.5
								90-120 cm soil depth									
1	26.3	71.6	53.9	21.9	35.8	33.4	33.6	11.5	54.4	24.6	65.0	53.4	14.4	36.9	11.5	93.2	23.7
2	62.7	19.3	40.4	20.9	12.4	38.8	19.2	16.6	46.5	37.7	102.8	95.8	40.4	40.5	23.6	36.9	24.7
3	57.7	20.8	22.4	44.8	177.9	25.4	35.8	17.9	23.9	16.3	20.4	27.0	26.8	23.5	34.5	20.0	19.3
4	31.0	22.7	13.0	14.2	60.5	97.3	20.9	59.0	143.6	120.5	43.5	21.1	26.4	43.2	34.0	15.8	35.5
Mean	44.4	33.6	32.4	25.5	71.7	48.7	27.4	26.2	67.1	49.8	57.9	49.3	27.0	36.0	25.9	41.5	25.8
								120-150 cm soil depth									
1	61.6	57.1	178.4	10.8	52.1	155.3	33.0	20.6	41.2	32.7	63.6	46.6	18.3	140.3	19.4	34.8	44.2
2	59.3	17.3	46.8	24.3	22.7	92.7	153.8	17.9	154.8	81.7	132.8	119.7	39.8	122.7	59.6	32.1	19.2
3	67.3	49.5	22.8	112.2	191.4	27.2	185.9	132.8	24.6	21.2	28.3	125.8	24.9	18.0	29.3	20.1	198.9
4	67.9	126.3	17.3	15.4	110.2	74.6	18.2	62.1	114.2	201.4	140.3	21.5	45.5	109.7	23.4	20.5	28.0
Mean	64.0	62.5	66.3	40.7	94.1	87.5	97.7	58.4	83.7	84.2	91.2	78.4	32.1	97.7	32.9	26.9	72.6

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.15. Soil extractable ammonium-N (kg ha^{-1}) at the Lethbridge site in 1999.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	14.2	17.5	18.5	11.4	11.4	15.4	20.9	9.9	13.0	10.1	15.2	15.8	15.0	17.1	10.0	8.0	30.3
2	10.3	16.9	9.7	9.8	8.8	24.3	7.2	7.8	17.7	15.8	12.4	9.1	12.8	12.8	10.3	31.4	9.4
3	10.9	13.2	11.1	5.4	13.3	18.2	9.3	10.7	19.5	4.7	11.8	8.8	12.8	10.5	10.0	8.2	7.9
4	9.8	9.7	7.4	5.4	7.3	11.2	5.7	5.2	10.9	10.1	31.4	5.4	12.3	7.7	10.0	9.0	11.4
Mean	11.3	14.3	11.7	8.0	10.2	17.3	10.8	8.4	15.3	10.2	17.7	9.8	13.2	12.0	10.1	14.1	14.7
								15-30 cm soil depth									
1	17.2	12.8	8.9	13.2	13.9	9.0	16.1	6.9	8.5	6.8	12.0	10.4	40.2	14.5	33.7	7.5	8.0
2	7.9	8.3	7.5	13.5	6.1	8.9	6.2	7.9	6.5	9.5	20.9	7.4	10.8	14.6	8.6	13.7	9.0
3	7.1	7.1	8.0	7.3	11.5	10.2	6.6	16.4	11.1	6.7	10.1	9.2	8.1	5.9	14.5	4.8	6.4
4	11.5	11.2	6.9	4.8	5.8	9.3	4.3	5.4	8.1	4.5	12.4	7.5	8.1	7.0	13.8	5.9	6.9
Mean	10.9	9.9	7.8	9.7	9.3	9.3	8.3	9.2	8.5	6.9	13.8	8.6	16.8	10.5	17.7	8.0	7.6
								30-60 cm soil depth									
1	19.8	20.3	14.8	20.3	29.1	21.4	31.4	13.8	13.1	12.5	22.1	18.1	17.0	19.3	15.0	15.9	14.2
2	15.8	13.3	29.5	12.2	10.8	16.5	14.5	18.7	13.6	16.9	31.4	16.7	18.0	22.9	33.7	25.7	16.2
3	15.8	13.1	11.1	27.8	12.8	16.1	11.0	13.0	33.3	14.0	15.8	20.8	14.8	11.2	9.7	17.2	16.8
4	16.6	12.7	12.3	10.3	16.9	31.8	9.3	17.7	16.4	11.4	16.2	8.3	29.0	14.0	9.4	11.4	13.4
Mean	17.0	14.8	16.9	17.7	17.4	21.5	16.5	15.8	19.1	13.7	21.4	16.0	19.7	16.9	16.9	17.5	15.2
								60-90 cm soil depth									
1	16.1	24.5	19.0	18.1	24.6	19.8	18.6	19.3	33.7	10.6	14.9	20.2	20.1	21.2	15.9	17.6	20.5
2	15.6	16.7	15.5	10.2	10.5	21.1	25.5	15.7	14.3	22.0	21.5	15.2	24.0	25.5	18.9	30.2	28.5
3	24.5	17.2	11.9	21.4	19.5	11.2	0.0	15.4	21.5	14.4	18.5	15.2	25.3	8.5	8.6	14.9	19.5
4	21.4	18.9	12.8	27.5	31.7	22.3	27.1	26.3	23.1	14.5	13.9	12.7	40.1	15.6	10.1	12.7	19.6
Mean	19.4	19.3	14.8	19.3	21.6	18.6	17.8	19.2	23.2	15.4	17.2	15.8	27.4	17.7	13.4	18.9	22.0
								90-120 cm soil depth									
1	24.4	38.5	21.6	20.2	22.1	30.8	16.1	37.2	40.1	16.5	22.4	26.9	22.5	32.2	22.0	21.5	28.5
2	23.7	21.5	20.3	13.1	14.1	26.0	31.9	20.8	27.7	34.2	33.0	23.3	22.6	30.1	22.4	25.6	16.8
3	20.3	35.9	17.5	30.9	41.6	16.6	0.0	23.4	21.7	16.4	18.6	20.9	20.4	12.7	18.1	11.6	22.5
4	24.3	24.7	10.9	14.5	34.3	27.7	16.8	31.4	32.4	18.9	26.3	17.1	42.1	26.7	22.7	14.6	24.1
Mean	23.2	30.2	17.6	19.7	28.0	25.3	16.2	28.2	30.5	21.5	25.1	22.0	26.9	25.4	21.3	18.3	23.0
								120-150 cm soil depth									
1	31.5	33.3	34.0	21.1	29.1	45.6	16.8	35.3	26.2	23.3	28.0	39.9	24.2	33.4	15.7	47.4	29.5
2	20.7	19.4	30.1	13.0	54.6	34.9	33.7	20.7	39.7	34.2	32.8	47.2	25.3	33.5	24.7	31.4	23.7
3	23.1	30.7	35.7	30.6	28.5	19.0	33.7	26.6	20.1	14.0	19.2	30.0	26.5	18.5	22.8	14.9	20.5
4	28.9	30.8	18.8	12.0	38.4	40.6	23.4	31.5	29.6	23.8	32.3	20.9	34.0	34.1	24.8	15.7	45.5
Mean	26.0	28.6	29.6	19.2	37.7	35.0	26.9	28.5	28.9	23.8	28.1	34.5	27.5	29.9	22.0	27.4	29.8

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.16. Soil extractable ammonium-N (kg ha^{-1}) at the Lethbridge site in 2000.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	14.0	12.1	14.7	8.5	17.0	9.7	14.3	13.5	13.2	18.6	18.0	14.9	18.2	10.7	7.8	19.0	12.2
2	10.2	10.7	9.1	11.3	14.1	10.2	10.9	17.9	11.0	11.2	12.5	13.6	11.5	13.7	13.1	23.3	9.5
3	14.0	9.6	11.0	13.1	16.3	11.6	16.1	14.3	13.7	11.0	14.6	16.1	16.3	10.7	12.9	11.3	18.9
4	10.7	18.6	12.5	16.9	13.9	17.5	14.2	12.0	30.5	16.9	13.5	13.1	11.1	10.4	13.4	19.9	16.1
Mean	12.2	12.8	11.8	12.5	15.3	12.2	13.9	14.4	17.1	14.4	14.7	14.4	14.3	11.4	11.8	18.4	14.2
								15-30 cm soil depth									
1	11.2	9.2	11.2	5.1	11.6	6.5	11.1	5.3	31.9	11.4	11.6	11.0	16.0	7.7	7.9	9.6	10.8
2	8.9	10.8	7.1	6.4	10.7	8.0	9.5	12.9	16.1	7.2	9.4	7.6	8.9	14.6	11.9	10.2	11.4
3	10.5	12.2	7.8	16.7	13.9	9.1	10.8	8.8	7.8	9.7	8.1	13.5	11.6	11.2	10.3	9.9	19.4
4	9.4	16.2	9.0	16.4	9.4	21.7	8.5	9.4	10.0	13.6	12.2	12.6	8.7	10.7	9.9	12.0	12.4
Mean	10.0	12.1	8.8	11.1	11.4	11.3	10.0	9.1	16.4	10.5	10.3	11.2	11.3	11.1	10.0	10.4	13.5
								30-60 cm soil depth									
1	17.2	20.2	15.1	11.0	20.1	10.3	20.4	8.9	15.5	17.8	19.8	22.6	22.6	11.2	15.5	16.2	24.4
2	18.7	19.0	11.9	10.5	20.8	12.8	15.9	26.7	14.4	12.7	16.6	14.5	10.1	19.9	14.7	14.5	15.5
3	20.7	13.3	12.6	17.9	22.0	13.1	28.0	11.6	35.0	18.4	17.9	15.6	14.7	18.0	18.3	22.6	32.9
4	17.3	23.7	19.9	20.8	17.8	32.4	18.3	20.2	17.6	23.0	26.7	19.4	14.4	20.8	17.4	22.4	31.1
Mean	18.5	19.0	14.9	15.0	20.2	17.1	20.7	16.8	20.6	18.0	20.3	18.0	15.5	17.5	16.5	18.9	26.0
								60-90 cm soil depth									
1	17.8	24.1	23.8	10.8	30.1	19.8	26.0	12.0	23.5	15.1	21.2	26.0	14.4	11.9	9.1	22.2	14.8
2	19.5	17.1	14.0	10.0	11.8	23.1	17.5	19.1		13.8	24.1	21.9	15.4	27.1	18.2	20.7	18.0
3	23.0	16.1	13.8	24.7	23.3	11.2	20.9	15.6	24.4	20.1	20.8	18.2	13.1	19.1	22.2	18.3	34.9
4	20.5	56.2	24.5	26.0	28.2	47.2	22.4	27.5	23.8	27.0	31.3	21.9	19.4	18.4	24.0	18.7	22.8
Mean	20.2	28.4	19.0	17.9	23.3	25.3	21.7	18.6	23.9	19.0	24.3	22.0	15.6	19.2	18.4	20.0	22.6
								90-120 cm soil depth									
1	20.9	29.8	29.8	14.6	27.3	18.6	25.9	18.5	30.1	22.9	31.3	36.0	15.4	21.6	18.1	28.3	20.0
2	21.3	21.7	16.9	13.0	16.4	23.9	21.0	24.0	25.1	22.1	29.2	25.5	17.2	21.1	28.7	23.8	18.0
3	29.4	22.4	25.1	39.8	35.7	16.2	25.8	21.4	24.3	16.5	20.7	22.1	17.6	17.9	21.7	17.1	25.6
4	27.5	38.1	22.4	25.0	25.9	42.9	28.0	30.1	32.6	27.4	35.6	24.5	22.6	22.9	30.2	17.8	34.4
Mean	24.8	28.0	23.5	23.1	26.3	25.4	25.1	23.5	28.0	22.3	29.2	27.0	18.2	20.9	24.7	21.8	24.5
								120-150 cm soil depth									
1	30.6	35.5	34.6	14.1	36.4	25.2	30.9	28.1	37.5	31.5	37.6	36.3	22.2	16.3	24.2	33.7	28.8
2	20.9	23.8	18.6	21.6	25.1	33.3	35.7	24.2	33.0	25.2	32.2	31.5	17.4	23.5	28.6	35.1	25.1
3	28.3	25.0	17.2	36.6	47.1	26.4	33.4	27.4	42.5	23.2	18.0	32.3	27.7	21.0	29.7	15.7	34.0
4	27.7	42.4	25.4	25.8	30.0	39.8	43.0	29.9	29.5	33.2	38.7	26.7	25.5	33.4	36.3	18.8	23.8
Mean	26.9	31.7	23.9	24.5	34.7	31.2	35.7	27.4	35.6	28.3	31.6	31.7	23.2	23.6	29.7	25.8	27.9

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.17. Soil extractable ammonium-N (kg ha^{-1}) at the Lethbridge site in 2001.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	22.3	19.2	34.4	17.7	239.1	16.2	20.6	28.2	31.6	32.3	15.8	18.3	21.6	19.1	21.6	23.8	26.3
2	33.6	122.7	95.4	142.8	181.6	76.0	116.4	166.3	384.6	46.0	64.2	95.4	129.4	105.6	131.4	209.1	322.2
3	25.5	67.2	125.7	130.7	186.6	78.3	91.2	124.5	363.8	37.9	65.4	43.2	79.9	119.7	114.6	134.4	103.7
4	29.9	67.5	16.3	106.7	124.7	74.2	132.1	129.8	131.9	39.0	27.3	56.8	99.3	105.6	157.1	204.4	347.7
Mean	27.8	69.1	68.0	99.5	183.0	61.2	90.1	112.2	228.0	38.8	43.2	53.4	82.5	87.5	106.2	142.9	200.0
								15-30 cm soil depth									
1	13.5	10.9	19.1	13.6	129.8	14.9	73.9	16.7	15.1	32.6	48.5	10.4	67.2	14.0	12.8	20.8	19.4
2	25.8	64.9	71.1	94.5	92.2	48.7	90.8	94.7	152.0	42.0	46.9	79.5	101.2	81.3	90.3	131.7	187.1
3	15.3	40.0	107.0	58.0	128.0	57.8	48.0	76.5	122.0	40.9	36.7	30.0	49.9	73.7	86.4	172.1	71.1
4	18.5	43.4	13.7	61.4	85.2	46.2	61.2	82.2	51.1	36.5	32.6	50.1	80.9	76.9	116.9	19.5	233.3
Mean	18.3	39.8	52.7	56.9	108.8	41.9	68.5	67.5	85.0	38.0	41.2	42.5	74.8	61.5	76.6	86.0	127.7
								30-60 cm soil depth									
1	16.5	20.5	27.3	20.6	174.0	25.3	81.2	30.0	22.4	13.7	22.5	17.2	97.2	24.5	20.8	27.0	192.5
2	26.3	94.8	80.2	65.1	96.7	43.2	87.0	64.2	122.5	51.0	54.4	69.0	159.9	67.6	68.5	112.3	174.0
3	13.9	54.9	111.8	27.9	88.9	57.3	46.3	41.5	131.2	43.5	43.7	36.4	105.0	61.7	81.2	140.0	63.2
4	20.0	49.6	56.4	65.1	69.5	40.9	78.7	101.6	47.1	50.1	43.4	83.1	119.1	74.8	89.9	71.9	197.3
Mean	19.2	54.9	68.9	44.7	107.3	41.7	73.3	59.3	80.8	39.6	41.0	51.4	120.3	57.2	65.1	87.8	156.7
								60-90 cm soil depth									
1	15.9	22.5	24.3	22.1	56.2	23.1	39.6	25.4	22.2	15.1	35.7	25.0	19.5	23.1	22.7	22.1	29.6
2	14.8	27.8	25.7	13.8	15.9	10.6	20.1	27.1	51.6	18.2	16.7	15.2	76.9	19.6	13.2	33.8	49.8
3	4.3	15.4	7.4	8.7	20.8	2.6	19.1	8.6	56.2	15.9	17.9	21.9	20.4	25.1	34.4	53.7	29.8
4	7.9	14.5	23.2	29.9	21.9	20.5	18.6	38.5	17.5	15.2	13.9	28.9	85.1	21.8	30.7	31.4	70.2
Mean	10.7	20.0	20.2	18.6	28.7	14.2	24.3	24.9	36.9	16.1	21.1	22.8	50.5	22.4	25.2	35.3	44.9
								90-120 cm soil depth									
1	24.1	9.0	13.6	23.8	28.6	28.7	19.4	31.4	32.2	21.0	17.0	49.8	25.4	31.3	28.3	28.5	24.9
2	3.8	17.3	8.7	2.5	13.3	2.5	8.5	17.3	15.0	14.8	10.0	22.8	35.0	11.7	11.5	17.4	21.6
3	4.1	14.6	2.5	2.5	11.4	2.5	2.5	21.9	25.3	24.5	9.5	8.8	40.7	14.9	10.5	32.5	14.3
4	5.1	7.8	11.9	22.3	11.4	7.6	9.9	12.8	9.9	11.1	8.0	13.9	24.8	15.8	10.3	19.4	46.8
Mean	9.3	12.2	9.2	12.8	16.2	10.3	10.1	20.9	20.6	17.9	11.1	23.8	31.5	18.4	15.1	24.5	26.9
								120-150 cm soil depth									
1	35.3	8.7	42.9	24.3	19.3	39.2	37.2	29.8	34.6	33.7	50.6	35.5	32.6	27.6	27.3	18.2	31.2
2	2.5	2.5	2.5	9.8	22.4	2.5	7.5	19.7	15.8	11.6	13.1	2.5	13.3	10.2	2.5	35.5	13.5
3	3.9	9.3	2.5	2.5	2.5	15.1	2.5	2.5	18.5	11.0	7.8	8.5	2.5	7.2	9.5	24.7	12.6
4	2.5	2.5	8.7	17.6	10.2	2.5	7.5	10.0	2.5	2.5	2.5	21.1	7.3	2.5	9.4	14.0	27.2
Mean	11.0	5.7	14.2	13.5	13.6	14.8	13.7	15.5	17.8	14.7	18.5	16.9	13.9	11.9	12.2	23.1	21.1

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.18. Soil extractable ammonium-N (kg ha^{-1}) at the Airdrie site in 1997.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	15.0	13.7	9.3	9.7	7.7	11.8	13.6	13.9	16.7	19.5	13.9	16.2	10.1	13.0	12.7	9.6	11.7
2	13.5	12.1	14.4	30.8	16.7	14.6	18.3	12.4	14.5	9.6	9.9	16.3	17.6	10.6	17.1	13.3	18.6
3	10.7	12.1	12.2	16.0	13.1	25.1	14.2	13.5	13.9	8.2	17.0	9.2	20.3	16.1	9.1	14.0	11.1
4	16.1	14.3	14.9	14.5	24.0	16.6	17.3	7.8	11.6	11.3	12.2	17.3	21.3	16.0	11.5	19.1	17.3
Mean	13.8	13.0	12.7	17.7	15.4	17.0	15.8	11.9	14.2	12.1	13.3	14.7	17.3	13.9	12.6	14.0	14.7
								15-30 cm soil depth									
1	15.2	13.1	9.4	11.4	8.7	10.2	14.9	12.9	22.9	15.7	10.9	12.7	8.9	11.4	13.4	7.5	8.5
2	12.4	7.0	7.9	21.5	13.8	14.7	18.4	11.7	7.4	5.8	10.3	18.7	15.1	17.6	15.2	13.6	11.0
3	11.9	19.4	8.7	12.0	11.0	14.4	14.8	15.6	8.5	6.7	7.4	7.6	16.2	10.1	9.2	8.7	9.6
4	12.9	10.6	10.3	14.5	19.4	12.7	7.9	9.2	9.5	11.0	10.0	9.4	13.2	13.2	11.6	14.8	8.8
Mean	13.1	12.5	9.1	14.9	13.2	13.0	14.0	12.3	12.1	9.8	9.6	12.1	13.3	13.1	12.4	11.2	9.5
								30-60 cm soil depth									
1	13.8	14.4	10.0	18.8	10.3	11.9	22.0	12.8	20.3	24.1	18.4	21.1	17.2	17.9	11.1	15.9	8.4
2	12.9	8.0	13.8	38.4	21.9	19.8	18.4	15.4	10.3	6.9	22.1	14.5	15.2	12.4	16.2	17.7	18.1
3	19.3	21.5	7.9	14.3	18.8	17.6	19.1	9.7	12.7	8.9	13.3	11.2	24.9	13.8	9.8	22.1	34.4
4	15.8	13.8	11.8	13.6	24.0	18.1	11.4	14.3	16.6	20.3	17.4	11.8	21.9	17.6	14.1	18.1	19.6
Mean	15.4	14.4	10.9	21.3	18.8	16.9	17.7	13.1	15.0	15.1	17.8	14.6	19.8	15.4	12.8	18.5	20.1
								60-90 cm soil depth									
1	12.5	15.8	11.4	6.5	8.4	8.3	18.8	10.0	26.3	26.3	13.3	19.6	9.1	18.2	4.9	9.5	14.4
2	11.6	5.1	13.6	15.7	17.1	17.2	7.5	11.9	17.6	5.7	6.6	11.5	8.1	10.2	13.4	10.0	13.2
3	9.9	15.4	8.4	6.9	8.5	13.3	9.7	8.0	8.3	9.5	11.1	6.9	22.3	12.5	11.1	12.5	7.4
4	10.9	14.1	6.6	11.3	22.9	18.0	15.7	12.2	14.0	14.3	14.5	9.6	14.7	10.6	14.8	13.9	14.3
Mean	11.2	12.6	10.0	10.1	14.2	14.2	12.9	10.5	16.6	13.9	11.4	11.9	13.6	12.9	11.0	11.5	12.3
								90-120 cm soil depth									
1	10.5	6.7	5.9	6.4	9.9	8.7	9.8	6.2	10.8	10.5	11.1	26.9	5.3	8.4	8.9	11.3	
2	9.1	3.2	12.7	24.4	12.8	9.3	16.6	8.1	7.3	4.3	4.6	9.3	4.9	7.3	11.7	15.4	6.9
3	10.0	19.3	9.0	4.6	7.1	18.5	6.0	16.5	7.5	16.6	5.5	8.5	11.2	9.4	14.4	12.8	8.0
4	9.6	9.2	5.6	8.6	15.8	14.5	8.2	16.0	17.4	23.7	15.6	11.1	9.8	10.5	14.2	8.7	12.3
Mean	9.8	9.6	8.3	11.0	11.4	12.8	10.1	11.7	10.7	13.8	9.2	13.9	7.8	8.9	12.3	12.0	9.1
								120-150 cm soil depth									
1	8.8	8.6	5.1	7.2	8.1	4.5	6.7	6.0	11.2	9.6	12.6	11.7	6.1	12.9	4.6	11.9	21.6
2	7.2	4.1	12.8	8.5	13.8	11.6	11.8	8.8	5.9	4.8	5.3	12.9	5.5	7.9	8.8	13.7	5.7
3	9.2	12.0	14.8	5.8	5.4	10.4	8.4	8.8	7.8	8.5	5.1	8.8	12.2	13.1	15.8	10.5	6.8
4	11.1	10.2	11.5	14.7	13.9	12.0	8.3	14.0	28.4	19.6	17.9	14.3	11.3	14.4	10.6	11.2	10.5
Mean	9.1	8.7	11.1	9.1	10.3	9.6	8.8	9.4	13.3	10.6	10.2	11.9	8.8	12.1	10.0	11.8	11.2

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.19. Soil extractable ammonium-N (kg ha^{-1}) at the Airdrie site in 1998.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
							0-15 cm soil depth										
1	19.3	26.8	24.0	27.3	18.5		18.0	16.3	25.6	16.4	19.5	21.1	22.0	12.8	20.3	21.1	16.1
2	16.1		22.0	25.6	23.1	24.5	23.1	21.1	19.0	23.5	22.0	21.6	18.6	21.6	18.8	19.1	9.7
3	22.2	25.3	21.8	22.5	17.3	26.0	20.3	30.0	28.8	21.1	23.6	19.3	21.8	21.6	21.5	29.0	22.3
4	20.8	21.0	24.8	19.6	34.0	30.3	11.7	22.0	19.6	16.6	17.8	21.5	30.0	21.6	17.3	23.5	45.1
Mean	19.6	24.4	23.1	23.8	23.2	26.9	18.3	22.3	23.3	19.4	20.7	20.9	23.1	19.4	19.5	23.2	23.3
							15-30 cm soil depth										
1	14.9	13.5	65.6	11.1	14.2	9.7	14.5	16.9	13.3	16.8	20.9	13.3	16.8	4.8	13.0	18.5	17.0
2	14.0	5.1	10.3	22.9	18.9	28.3	19.7	21.3	20.0	17.6	16.0	22.5	16.1	18.6	17.2	14.4	12.2
3	16.2	18.9	19.7	27.3	20.5	19.6	19.2	19.4	25.7	19.1	18.9	15.6	14.4	24.7	16.1	23.1	8.3
4	17.6	14.0	23.5	17.0	25.1	25.7	5.7	20.5	14.4	13.9	16.2	22.7	10.0	21.7	14.6	22.1	16.8
Mean	15.7	12.9	29.8	19.6	19.7	20.9	14.8	19.5	18.4	16.9	18.0	18.5	14.3	17.5	15.2	19.5	13.6
							30-60 cm soil depth										
1	16.5	23.3	14.3	19.2	13.5	15.4	7.0		8.8	10.3	7.5	10.3	37.6	5.8	8.9	17.8	6.9
2	20.7	3.4	10.0	34.4	9.2	29.9	9.5	28.2	6.7	14.7	18.4	10.4	27.4	27.3	20.2	7.3	10.3
3	10.5	24.1	8.6	9.3	15.8	26.8	14.6	8.9	28.0	32.7	14.6	25.3	30.7	19.5	41.4	26.6	8.4
4	19.3	6.0	37.9	9.7	49.2	32.7	8.7	29.8	12.6	18.0	13.4	47.5	15.5	20.2	21.0	36.7	33.6
Mean	16.8	14.2	17.7	18.1	21.9	26.2	9.9	22.3	14.0	18.9	13.5	23.4	27.8	18.2	22.9	22.1	14.8
							60-90 cm soil depth										
1	9.6	8.0			12.5	3.0	7.3	6.8	7.1	7.0	7.3	11.7	9.7	3.8	10.6	10.9	3.4
2	8.0	2.6	17.1	12.4	6.9	15.6	10.1		5.7	10.8	12.2	8.3	21.6	8.5	8.3	8.8	5.4
3	8.9	14.8	5.9	9.2	9.6	10.1	9.2	8.2	12.7	11.1	9.5	12.0	9.7	13.5	12.2	10.9	8.0
4	14.3	7.0	23.3	10.9	21.2	26.1	13.3	26.4	13.8	14.7	12.2	17.0	14.3	22.2	10.1	16.8	16.7
Mean	10.2	8.1	15.4	10.8	12.6	13.7	10.0	13.8	9.8	10.9	10.3	12.2	13.8	12.0	10.3	11.8	8.4
							90-120 cm soil depth										
1	8.1	9.4	11.1	15.3	17.4	2.7	5.5	11.7	5.3	11.6	13.6	11.8	11.1	3.7	9.5		3.8
2	7.4	4.0	34.9	7.2	6.2	9.7	11.1	4.5		12.9	6.2	4.8	15.7	19.6	7.4	11.4	4.5
3	10.4	8.1	12.1	8.5	17.5	13.9	8.5	8.7	9.5	15.1	23.3	25.8	7.6	14.4	14.2	9.4	6.7
4	14.4	7.4	10.2	10.3	17.5	27.1	13.9	27.1	19.6	11.7	10.4	12.6	8.8	11.1	13.6	10.2	14.3
Mean	10.1	7.2	17.1	10.3	14.6	13.4	9.7	13.0	11.5	12.8	13.4	13.8	10.8	12.2	11.2	10.3	7.3
							120-150 cm soil depth										
1	14.0	5.5	7.6	20.7	8.2	3.5	9.1	19.7	6.2	6.0	5.7	11.4	8.2	4.9	12.5	8.4	4.0
2	9.0	10.6	37.3	6.6	9.9	11.3	13.3	13.5	4.1	20.6	6.3	6.3	13.8	14.5	8.8	8.7	7.3
3	10.4	6.3	17.8	14.2	10.2	8.9	8.3	13.9	10.5	17.1	15.8	15.5	8.1	16.4	15.8	9.0	14.6
4	16.6	9.6	11.4	11.1	17.4	22.9	9.4	27.6	45.0	11.5	12.3	9.0	16.4	25.2	15.7	14.4	13.8
Mean	12.5	8.0	18.5	13.2	11.4	11.6	10.0	18.7	16.4	13.8	10.0	10.6	11.6	15.3	13.2	10.1	9.9

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.20. Soil extractable ammonium-N (kg ha^{-1}) at the Airdrie site in 1999.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	12.4	10.2	11.1	17.0	9.6	14.9	9.2	5.8	26.0	13.7	11.0	12.1	13.2	17.1	20.3	19.3	14.4
2	12.2	10.2	8.4	16.3	8.1	18.1	10.1	12.5	12.9	11.3	9.1	12.0	11.0	14.0	18.0	18.8	55.3
3	19.3	16.5	20.5	15.9	14.9	6.3	21.3	46.3	40.1	13.1	14.7	9.7	103.9	17.3	13.2	16.2	19.6
4	2.4	0.0	22.1	69.4	42.5	10.9	7.1	22.0	27.5	0.0	8.2	41.0	0.0	8.2	23.3	31.0	11.9
Mean	11.6	9.2	15.5	29.6	18.8	12.6	11.9	21.6	26.6	9.5	10.8	18.7	32.0	14.2	18.7	21.3	25.3
								15-30 cm soil depth									
1	12.1	27.1	8.7	5.3	7.9	13.4	19.0	8.1	30.3	7.3	12.6	10.8	12.6	16.7	10.0	22.7	12.4
2	13.4	4.9	5.7	13.3	10.6	13.1	12.6	11.4	5.6	14.4	56.1	5.0	7.2	7.7	10.8	16.1	11.3
3	14.4	5.6	6.3	13.2	9.7	4.6	13.3	12.2	14.0	18.6	18.8	17.2	28.5	17.5	7.4	20.1	13.5
4	2.8	0.0	21.7	26.5	19.9	3.7	0.0	4.2	0.0	0.0	0.0	10.2	0.0	0.0	1.0	12.5	1.9
Mean	10.7	9.4	10.6	14.6	12.0	8.7	11.2	9.0	12.5	10.1	21.9	10.8	12.1	10.5	7.3	17.9	9.7
								30-60 cm soil depth									
1	20.4	48.0	10.1	4.7	18.1	31.8	15.9	9.3	47.5	13.7	18.2	13.8	51.7	12.3	12.7	32.7	60.0
2	11.3	4.0	6.1	17.5	11.4	19.7	2.1	6.8	5.0	7.5	12.9	7.0	28.6	20.4	15.6	28.5	13.2
3	11.7	8.4	0.0	32.9	17.3	8.0	14.1	2.2	12.2	16.1	16.5	43.8	11.5	11.1	9.3	16.0	38.1
4	1.0	0.0	9.3	3.3	10.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.2	0.0
Mean	11.1	15.1	6.4	14.6	14.4	14.9	8.0	4.6	16.2	9.3	11.9	16.1	22.9	11.0	9.4	22.1	27.8
								60-90 cm soil depth									
1	7.8	9.9	4.9	4.8	7.3	4.5	3.1	7.5	8.1	8.4	24.5	15.8	9.1	6.5	4.9	13.0	9.8
2	8.8	11.8	5.6	15.9	7.0	15.2	5.3	4.1	2.6	6.5	8.6	7.7	7.3	9.5	11.0	13.6	4.8
3	5.9	5.9	0.0	8.9	9.9	3.1	15.3	2.8	16.4	14.2	11.9	9.1	3.9	7.8	8.5	26.0	18.6
4	0.0	0.0	3.8	2.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8	0.0
Mean	5.6	6.9	3.6	8.1	6.0	5.7	5.9	3.6	6.8	7.3	11.2	8.2	5.1	5.9	6.1	13.9	8.3
								90-120 cm soil depth									
1	4.8	3.4	6.4	3.4	2.9	2.6	3.8	6.2	6.4	12.0	6.2	2.6	6.6	4.7	12.6	3.9	22.7
2	6.5	2.6	6.3	9.9	12.9	15.6	2.6	19.8	11.4	12.7	8.4	8.7	21.0	9.2	7.5	12.4	4.0
3	6.0	3.5	0.0	6.7	24.4	3.1	23.0	2.8	8.1	9.7	20.1	9.4	4.8	15.0	8.9	9.7	17.9
4	0.0	0.0	3.6	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	0.0
Mean	4.3	2.4	4.1	5.8	10.0	5.3	7.4	7.2	6.5	8.6	8.7	5.2	8.1	7.2	7.2	7.7	11.2
								120-150 cm soil depth									
1	4.3	12.3	6.9	21.8	2.7	5.1	3.2	33.1	6.9	4.6	3.0	2.7	3.8	2.7	6.4	4.5	6.6
2	8.2	2.8	6.7	9.9	10.0	13.2	2.7	5.4	12.7	12.0	11.8	9.8	7.4	12.7	15.8	11.5	3.3
3	7.2	3.6	0.0	12.9	11.2	3.4	15.2	3.3	9.2	10.6	20.4	14.9	3.5	10.6	12.6	13.4	18.0
4	0.0	0.0	4.2	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mean	4.9	4.7	4.5	12.2	6.0	5.4	5.3	10.4	7.2	6.8	8.8	6.9	3.7	6.5	8.7	7.4	7.0

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.21. Soil extractable ammonium-N (kg ha^{-1}) at the Airdrie site in 2000.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	12.0	9.8	9.3	10.7	14.0	10.9	9.3	13.1	16.1	10.4	12.5	7.4	10.2	13.2	11.6	13.3	7.7
2	11.5	10.8	17.1	13.3	17.3	11.1	12.7	12.3	12.5	9.7	8.2	11.5	12.9	16.2	13.1	10.0	17.0
3	13.8	15.3	12.4	11.9	10.4	14.2	8.8	16.1	12.0	9.8	13.5	10.0	13.0	13.7	12.3	11.3	10.7
4	12.2	9.9	11.9	11.6	15.6	11.4	8.6	12.9	18.6	11.0	14.5	9.0	17.6	10.4	11.0	12.0	16.7
Mean	12.4	11.4	12.7	11.9	14.3	11.9	9.9	13.6	14.8	10.2	12.2	9.5	13.4	13.4	12.0	11.7	13.0
								15-30 cm soil depth									
1	8.8	8.2	8.8	8.5	9.5	10.5	7.9	9.2	12.5	8.1	10.6	8.3	10.5	7.4	7.2	10.2	5.7
2	10.4	9.4	10.3	8.4	11.4	12.1	9.9	12.5	9.7		7.6	6.9	8.9	11.2	10.4	7.7	11.2
3	10.5	8.8	8.6	8.7	8.8	9.2	6.8	7.5	7.2	9.0	8.1	7.7	7.4	9.0	7.5	8.3	6.4
4	8.9	7.6	10.2	15.3	11.0	8.1	5.0	8.9	6.7	7.9	14.1	8.0	11.5	10.3	7.3	8.2	15.0
Mean	9.6	8.5	9.5	10.2	10.2	10.0	7.4	9.5	9.0	8.3	10.1	7.7	9.6	9.5	8.1	8.6	9.6
								30-60 cm soil depth									
1	12.6	9.5	12.9	10.8	14.8	8.0	17.6	13.8	17.6	33.9	14.7	9.5	21.3	12.6	12.6	14.1	7.7
2	15.0	17.2	18.9	12.3	15.4	17.2	14.6	19.4	14.8	9.7	7.0	12.8	18.3	16.1	17.8	11.8	13.2
3	13.1	13.1	14.1	16.8	15.3	11.6	16.4	13.6	12.7	12.1	11.8	11.7	11.9	14.2	15.5	16.3	9.3
4	14.9	8.9	12.5	15.7	25.8	11.0	5.9	18.1	14.2	11.6	26.0	9.5	19.5	8.8	12.1	22.9	23.1
Mean	13.9	12.2	14.6	13.9	17.8	12.0	13.6	16.2	14.8	16.8	14.9	10.9	17.8	12.9	14.5	16.3	13.3
								60-90 cm soil depth									
1	9.9	8.0	11.9	14.3	13.3	7.1	10.8	14.5	11.9	12.5	14.2	7.3	10.2	10.1	9.5	14.7	6.4
2	9.2	17.4	9.7	17.9	14.0	15.2	16.2	13.6	14.8	9.5	8.9	8.0	10.0	17.4	11.3	9.0	9.9
3	12.8	9.2	13.8	12.2	12.6	10.7	9.6	8.4	9.0	14.2	16.5	9.7	11.8	13.8	21.4	15.0	11.5
4	9.6	8.8	11.2	8.1	23.6	7.8	8.6	10.4	14.0	7.6	18.6	7.7	15.4	8.4	8.1	12.2	16.0
Mean	10.4	10.9	11.6	13.1	15.9	10.2	11.3	11.7	12.4	10.9	14.6	8.2	11.8	12.4	12.6	12.7	11.0
								90-120 cm soil depth									
1	9.1	8.5	7.3	18.9	14.7	16.4	10.0	23.1	12.5	9.9	11.8	12.7	9.2	10.2	11.4	13.1	7.3
2	11.4	13.2	10.9	8.3	15.8	23.6	23.6	11.8	19.5	7.8	12.7	11.2	6.8	19.4	8.0	11.1	11.1
3	9.0	11.3	13.4	19.4	14.5	6.5	8.8	10.5	9.4	12.0	11.9	9.3	10.9	14.2	21.0	21.2	15.6
4	14.4	26.5	7.5	6.2	19.2	7.8	7.2	9.8	12.1	21.0	15.3	8.1	19.3	11.5	11.6	8.7	15.7
Mean	11.0	14.9	9.8	13.2	16.0	13.6	12.4	13.8	13.4	12.7	12.9	10.3	11.5	13.8	13.0	13.5	12.4
								120-150 cm soil depth									
1	12.0	9.0	8.8	8.7	18.1	10.9	10.9	16.3	14.5	10.3	9.3	11.8	9.6	11.1	11.1	8.6	10.7
2	13.3	18.8	13.2	15.2	18.2	8.7	21.4	15.3	22.3	9.6	15.3	10.5	9.4	15.5	11.5	13.2	14.7
3	12.1	9.1	18.1	22.3	17.9	6.1	12.9	11.4	9.6	12.6	8.0	13.0	15.0	15.2	21.2	11.5	14.9
4	12.2	7.8	12.7	11.8	28.4	10.2	7.3	25.6	12.2	18.8	17.4	9.1	15.1	16.4	11.1	12.7	21.8
Mean	12.4	11.2	13.2	14.5	20.7	9.0	13.1	17.2	14.7	12.8	12.5	11.1	12.2	14.6	13.7	11.5	15.5

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.22. Soil extractable ammonium-N (kg ha^{-1}) at the Airdrie site in 2001.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	18.6	22.0	16.8	28.5	19.8	12.4	15.1	18.3	23.8	16.1	12.8	16.3	25.1	30.5	86.4	24.8	17.5
2	17.3	12.6	23.8	21.5	24.0	22.0	17.0	23.3	21.6	21.3	14.0	17.0	19.8	72.4	25.8	23.8	26.1
3	13.8	18.8	23.1	14.7	18.8	20.0	14.9	32.1	23.8	14.6	16.4	14.4	13.7	18.0	13.8	13.2	19.8
4	12.5	12.8	14.7	39.1	243.9	15.4	11.0	14.3	17.0	11.9	11.3	96.9	6.5	11.7	11.4	12.4	12.3
Mean	15.6	16.5	19.6	25.9	76.6	17.4	14.5	22.0	21.6	16.0	13.6	36.1	16.3	33.1	34.4	18.6	18.9
								15-30 cm soil depth									
1	15.4	14.4	17.2	46.1	11.2	6.7	10.2	12.6	16.4	9.9	7.6	16.0	25.1	12.4	20.3	17.9	9.3
2	15.7	9.9	18.4	15.4	10.3	12.2	10.1	8.0	9.9	20.7	11.1	13.9	15.1	30.7	16.4	12.8	35.9
3	12.7	14.4	25.5	20.7	17.0	15.1	21.9	20.5	10.9	9.9	11.5	13.4	12.8	19.3	10.0	11.6	9.3
4	12.0	10.8	13.3	19.0	20.3	19.8	4.9	30.1	11.9	17.6	70.4	171.6	4.8	6.1	12.1	10.3	15.4
Mean	14.0	12.4	18.6	25.3	14.7	13.5	11.8	17.8	12.3	14.5	25.2	53.7	14.4	17.1	14.7	13.1	17.5
								30-60 cm soil depth									
1	20.7	16.1	50.5	34.8	15.3	16.0	37.7	16.6	43.4	15.9	21.2	23.0	58.0	23.1	42.1	22.5	26.5
2	18.2	2.1	15.2	28.5	14.0	17.9	12.7	24.9	20.2	26.8	15.1	22.5	39.0	24.7	32.4	17.1	2.1
3	18.8	19.1	31.9	15.4	50.5	21.1	35.6	38.7	13.8	15.6	14.2	22.4	13.7	17.0	12.2	18.0	20.9
4	10.4	20.2	19.5	14.5	26.3	16.8	2.1	28.4	17.8	12.8	21.0	254.4	9.5	9.5	83.4		21.4
Mean	17.0	14.4	29.3	23.3	26.5	18.0	22.0	27.1	23.8	17.8	17.9	80.6	30.0	18.6	42.5	19.2	17.7
								60-90 cm soil depth									
1	15.3	21.1	25.7	21.2	10.2	14.2	18.2	17.4	11.4	14.5	37.6	15.1	10.9	14.6	19.5	14.8	11.1
2	15.4	2.4	2.4	19.2	19.4	13.8	12.2	20.1	12.2	11.9	12.1	15.2	2.4	20.4	13.8	24.1	30.9
3	15.0	12.8	25.7	2.4	14.1	34.5	19.7	13.8	2.4	12.3	12.2	20.8	12.7	7.4	27.6	15.8	18.3
4	13.8	10.5	15.2	11.2	55.6	25.2	2.4	2.4	14.0	20.3	16.2	120.6	12.6	2.4	25.7	126.2	12.8
Mean	14.9	11.7	17.2	13.5	24.8	21.9	13.1	13.4	10.0	14.7	19.5	42.9	9.6	11.2	21.6	45.2	18.3
								90-120 cm soil depth									
1	14.2	17.5	33.0	2.6	2.6	8.5	17.6	12.6	25.9	2.6	24.8	15.0	34.3	21.1	26.5	2.6	14.1
2	14.6	2.6	17.2	2.6	12.7	11.0	12.7	2.6	13.6	18.8	11.0	14.0	2.6	13.0	2.6	2.6	2.6
3	16.1	11.1	14.5	2.6	23.4	22.2	25.7	15.4	18.6	2.6	30.2	21.9	11.1	22.7	17.9	17.5	27.7
4	5.4	13.9	17.3	11.5	30.3	18.8	2.6	11.9	10.3	23.0	16.6	17.0	2.6	2.6	2.6	34.4	12.7
Mean	12.6	11.2	20.5	4.8	17.2	15.1	14.6	10.6	17.1	11.8	20.6	17.0	12.6	14.9	12.4	14.3	14.3
								120-150 cm soil depth									
1	15.8	2.7	40.6	2.7	2.7	20.4	2.7	13.9	15.5	18.1	13.1	12.7	2.7	2.7	20.3	2.7	16.5
2	13.4	11.9	18.3	2.7	13.8	2.7	14.3	2.7	12.3	2.7	15.1	15.7	2.7	12.7	2.7	2.7	2.7
3	12.0	2.7	15.8	2.7	2.7	2.7	2.7	2.7	15.8	11.6	2.7	15.8	22.3	12.9	26.6	14.1	14.1
4	9.2	19.3	2.7	24.7	20.0	2.7	2.7	2.7	15.2	14.6	20.5	17.5	12.0	23.5	32.1	35.2	2.7
Mean	12.6	9.2	19.4	8.2	9.8	7.2	5.6	5.5	14.7	11.8	12.9	15.4	9.9	12.9	20.4	13.7	9.0

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.23. Soil extractable phosphate-P (kg ha^{-1}) at the Lethbridge site in 1996.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	6.9	2.3	12.9	7.6	4.6	6.5	9.4	3.4	11.5	28.4	2.7	3.4	7.0	5.0	13.6	2.4	7.6
2	4.3	46.2	6.3	7.3	5.2	1.6	15.3	10.2	13.8	3.2	3.7	13.5	4.3	5.7	4.9	3.8	48.5
3	7.5	5.1	2.0	3.5	5.4	13.9	2.1	4.9	1.5	13.9	5.0	1.2	1.6	7.1	4.7	5.0	1.2
4	2.7	1.2	7.3	2.3	3.6	1.2	4.8	2.2	1.2	1.9	1.2	7.0	3.6	3.4	9.1	9.4	2.2
Mean	5.4	13.7	7.1	5.2	4.7	5.8	7.9	5.2	7.0	11.8	3.1	6.3	4.1	5.3	8.1	5.1	14.8
								15-30 cm soil depth									
1	3.3	1.2	3.6	6.9	1.2	1.8	9.4	2.8	1.2	1.5	3.0	1.5	5.3	1.8	4.1	2.4	1.8
2	2.4	6.6	5.5	2.5	1.4	1.3	4.7	7.0	1.2	1.2	3.3	4.7	1.2	2.9	3.6	1.4	4.6
3	1.2	4.3	3.7	3.6	1.2	2.6	3.8	2.3	2.1	1.2	1.3	1.2	1.2	3.4	2.7	2.9	2.1
4	3.0	1.2	6.7	2.3	2.0	1.2	4.6	5.1	1.2	1.5	1.2	5.7	1.2	3.2	6.5	8.8	1.2
Mean	2.5	3.3	4.9	3.8	1.4	1.7	5.6	4.3	1.4	1.3	2.2	3.3	2.2	2.8	4.2	3.9	2.4
								30-60 cm soil depth									
1	4.5	2.4	5.2	5.5	2.4	3.9	8.0	4.0	5.8	20.2	6.7	2.4	4.6	3.2	2.8	5.0	3.3
2	3.9	2.4	3.8	3.8	2.4	4.5	2.4	6.6	2.4	2.4	2.4	3.5	2.4	2.5	5.8	3.2	9.7
3	2.4	8.3	9.7	6.2	2.4	6.0	4.4	8.8	2.4	2.4	2.4	4.4	2.4	2.4	2.4	7.2	4.4
4	3.6	3.3	10.9	2.4	2.4	3.4	8.1	8.4	2.4	2.4	2.4	8.2	4.6	3.2	6.6	12.7	2.4
Mean	3.6	4.1	7.4	4.5	2.4	4.4	5.7	6.9	3.3	6.9	3.5	4.6	3.5	2.8	4.4	7.0	5.0
								60-90 cm soil depth									
1	4.7	2.6	3.9	5.3	2.6	4.4	7.0	3.5	4.9	7.3	4.6	7.1	3.3	2.6	4.4	6.4	2.6
2	3.3	5.2	2.6	5.6	2.6	5.9	2.6	2.6	2.6	3.3	2.6	6.0	2.6	2.6	5.4	3.1	2.6
3	2.6	2.9	6.9	5.9	2.6	7.2	2.6	9.0	2.6	2.6	2.6	2.6	4.6	2.6	2.6	2.6	2.6
4	5.2	2.6	6.3	2.6	4.3	2.6	6.8	9.6	2.6	2.6	4.9	6.3	7.7	2.6	7.2	8.2	2.6
Mean	3.9	3.3	4.9	4.9	3.0	5.0	4.7	6.2	3.2	3.9	3.7	5.5	4.6	2.6	4.9	5.1	2.6
								90-120 cm soil depth									
1	5.4	2.5	2.5	4.5	2.5	2.5	5.6	2.5	5.7	7.6	2.7	6.7	6.7	6.3	3.8	6.1	2.5
2	3.5	2.5	2.5	6.1	2.5	5.3	2.5	2.5	3.0	2.5	2.5	5.2	4.8	4.2	4.7	6.1	2.5
3	2.6	2.5	7.6	5.3	2.5	8.8	2.5	7.1	2.5	2.5	2.5	2.5	6.4	2.5	2.5	5.7	4.5
4	5.2	5.4	5.4	2.5	3.5	2.5	8.7	5.7	2.5	2.5	2.5	10.3	7.1	2.5	6.2	5.4	4.7
Mean	4.2	3.3	4.5	4.6	2.8	4.8	4.8	4.4	3.4	3.8	2.6	6.2	6.3	3.9	4.3	5.8	3.6
								120-150 cm soil depth									
1	4.9	2.5	7.7	2.5	2.5	5.1	2.5	4.1	7.2	6.8	3.7	6.9	8.2	2.5	2.5	5.2	2.5
2	5.4	2.5	2.5	6.7	2.5	6.8	2.5	3.6	2.5	2.8	5.3	3.2	2.5	4.6	5.4	5.5	2.5
3	2.6	9.9	6.0	5.6	2.5	7.5	2.5	5.5	2.5	2.5	3.4	2.5	4.1	2.5	2.5	5.7	4.5
4	5.9	2.9	8.7	5.0	8.5	2.5	6.2	10.1	2.5	4.7	4.7	7.3	4.0	4.0	7.9	7.1	3.3
Mean	4.7	4.4	6.2	4.9	4.0	5.5	3.4	5.8	3.7	4.2	4.3	5.0	4.7	3.4	4.6	5.8	3.2

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.24. Soil extractable phosphate-P (kg ha^{-1}) at the Lethbridge site in 1997.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	8.8	25.2	17.2	282.3	78.8	60.3	15.1	45.0	71.4	100.3	124.0	108.1	212.8	9.5	22.8	11.0	20.4
2	8.6	16.3	17.0	59.1	6.3	19.2	3.5	8.7	4.7	1.2	2.4	27.5	4.5	2.5	17.4	1.2	20.5
3	1.7	2.9	3.6	1.2	17.3	1.2	1.2	5.2	4.5	6.4	4.6	1.2	1.2	14.2	21.3	7.2	1.2
4	2.1	1.2	20.2	15.4	1.2	1.2	9.3	1.2	1.2	1.2	1.2	3.3	1.2	1.2	14.2	19.6	1.2
Mean	5.3	11.4	14.5	89.5	25.9	20.4	7.3	15.0	20.4	27.2	33.0	35.0	54.9	6.8	18.9	9.7	10.8
								15-30 cm soil depth									
1	3.9	1.2	1.2	3.8	1.2	2.9	3.7	2.7	3.9	7.0	6.6	6.5	12.5	2.9	5.5	6.4	6.8
2	3.6	1.2	4.6	1.2	2.7	10.2	5.4	2.6	1.2	1.2	5.4	6.8	5.3	3.9	1.2	1.2	6.3
3	1.5	1.2	1.2	1.2	1.2	1.2	1.2	1.2	4.4	4.1	1.2	1.2	1.2	8.7	5.8	2.7	1.2
4	1.2	1.2	12.2	2.5	1.2	1.2	1.2	1.2	9.1	1.2	1.2	7.3	1.2	1.2	1.2	2.4	1.2
Mean	2.5	1.2	4.8	2.1	1.5	3.9	2.9	1.9	4.6	3.4	3.6	5.4	5.0	4.2	3.4	3.2	3.9
								30-60 cm soil depth									
1	7.3	2.4	2.4	9.4	2.4	2.4	8.0	2.4	6.6	9.3	9.8	12.4	2.4	2.4	2.4	11.5	2.4
2	2.4	2.4	24.3	2.4	10.1	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
3	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	5.6	2.4	2.4	2.4	5.6	5.3	2.4	2.4
4	2.4	2.4	16.7	5.3	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	6.7	2.4
Mean	3.6	2.4	11.5	4.9	4.3	2.4	3.8	2.4	3.5	4.9	4.3	4.9	2.4	3.2	3.2	5.8	2.4
								60-90 cm soil depth									
1	7.2	2.6	2.6	2.6	2.6	2.6	8.5	2.6	12.5	6.6	11.3	12.7	2.6	2.6	2.6	11.6	2.6
2	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	6.0	2.6	2.6	2.6	2.6	2.6	2.6	2.6
3	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6
4	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	5.4	2.6
Mean	3.7	2.6	2.6	2.6	2.6	2.6	4.1	2.6	5.1	4.4	4.8	5.1	2.6	2.6	2.6	5.5	2.6
								90-120 cm soil depth									
1	6.6	2.5	2.5	2.5	6.9	2.5	7.5	7.7	10.8	2.5	9.1	12.0	2.5	2.5	2.5	10.6	5.3
2	2.5	2.5	2.5	2.5	2.5	8.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
3	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
4	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	5.2	2.5	2.5	2.5	2.5	2.5
Mean	3.5	2.5	2.5	2.5	3.6	4.0	3.8	3.8	4.6	2.5	4.2	5.6	2.5	2.5	2.5	4.5	3.2
								120-150 cm soil depth									
1	7.1	2.5	2.5	2.5	5.8	2.5	6.5	5.3	12.3	8.1	12.7	12.8	2.5	2.5	2.5	9.8	5.9
2	6.2	2.5	2.5	2.5	2.5	16.1	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
3	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
4	2.5	2.5	7.7	8.3	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	5.3	2.5	2.5	8.2	2.5
Mean	4.6	2.5	3.8	3.9	3.3	5.9	3.5	3.2	5.0	3.9	5.0	5.1	3.2	2.5	2.5	5.7	3.4

[z] Control: No manure application; each replicate value is a mean of four control plots.
[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).
[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.25. Soil extractable phosphate-P (kg ha^{-1}) at the Lethbridge site in 1998.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	8.6	4.0	5.2	140.2	15.2	45.9	20.9	10.4	19.4	16.4	5.7	5.3	121.0	32.3	136.5	1.2	10.7
2	4.2	93.9	19.8	15.7	137.5	7.9	22.4	20.0	37.3	1.2	26.6	49.5	53.9	11.4	11.7	6.2	16.8
3	5.1	12.7	3.8	19.7	94.8	7.5	16.0	5.8	10.4	24.9	51.6	17.8	74.2	78.9	17.5	92.6	5.6
4	4.8	4.9	34.7	58.5	11.0	7.8	57.3	7.9	51.3	32.3	11.7	33.7	64.7	3.2	96.8	277.0	14.1
Mean	5.7	28.9	15.9	58.5	64.6	17.3	29.1	11.0	29.6	18.7	23.9	26.6	78.5	31.5	65.6	94.2	11.8
								15-30 cm soil depth									
1	5.1	3.6	4.3	11.6	2.5	6.2	5.1	3.5	6.2	4.4	4.4	3.5	85.4	1.2	9.5	1.2	6.8
2	3.0	10.3	10.7	5.8	27.8	4.9	17.3	4.6	23.6	1.2	1.2	12.4	7.1	4.6	10.0	4.3	11.0
3	4.8	1.2	2.7	3.4	6.5	5.7	8.9	1.2	7.6	9.4	9.8	8.0	5.9	9.0	9.6	36.5	6.1
4	3.0	4.6	23.9	25.7	4.7	4.9	10.8	3.8	4.6	6.1	6.4	14.5	6.0	1.2	10.2	33.7	4.8
Mean	4.0	4.9	10.4	11.6	10.4	5.4	10.5	3.2	10.5	5.3	5.5	9.6	26.1	4.0	9.8	18.9	7.2
								30-60 cm soil depth									
1	9.5	5.1	9.8	12.0	5.8	2.4	2.4	2.4	11.8	12.9	2.4	2.4	30.8	2.4	10.8	2.4	10.1
2	6.9	10.4	7.2	8.4	12.0	10.8	12.4	2.4	2.4	6.6	2.4	2.4	9.3	2.4	7.8	2.4	5.2
3	7.8	7.9	2.4	8.5	6.9	2.4	13.7	2.4	14.1	13.5	15.5	13.9	8.7	7.8	11.9	29.0	2.4
4	5.6	7.9	17.9	14.1	8.2	8.7	2.4	8.5	9.7	9.4	9.9	7.4	9.7	2.4	2.4	6.2	10.2
Mean	7.4	7.8	9.3	10.8	8.2	6.1	7.8	3.9	9.5	10.6	7.6	6.5	14.6	3.8	8.2	10.0	7.0
								60-90 cm soil depth									
1	6.5	8.2	10.1	2.6	7.3	2.6	2.6	2.6	11.6	12.3	10.5	2.6	12.0	2.6	10.7	2.6	2.6
2	4.3	10.3	6.0	2.6	6.0	2.6	10.4	2.6	10.0	6.7	8.0	9.1	7.9	8.6	9.3	7.0	5.9
3	8.9	9.6	9.0	2.6	10.0	2.6	14.2	2.6	16.0	11.8	15.5	12.2	10.4	15.6	11.7	14.0	11.2
4	6.1	9.2	2.6	16.3	9.2	8.8	8.7	8.5	2.6	2.6	2.6	8.4	2.6	5.2	8.2	10.3	10.3
Mean	6.4	9.3	6.9	6.0	8.1	4.1	9.0	4.1	10.0	8.3	9.1	8.1	8.2	8.0	10.0	8.5	7.5
								90-120 cm soil depth									
1	10.7	2.5	2.5	7.0	2.5	2.5	5.9	5.3	13.8	5.8	10.0	9.4	11.5	2.5	2.5	2.5	11.6
2	4.3	2.5	5.3	7.8	7.1	8.5	8.8	5.7	7.5	2.5	8.0	2.5	6.6	8.7	9.1	6.7	2.5
3	4.7	9.8	9.5	2.5	10.4	2.5	14.5	2.5	11.5	11.7	14.9	13.5	10.2	8.4	2.5	11.1	13.3
4	5.9	9.2	14.1	13.8	9.2	8.4	9.5	2.5	2.5	2.5	2.5	2.5	9.4	8.5	2.5	11.6	2.5
Mean	6.4	6.0	7.8	7.8	7.3	5.5	9.7	4.0	8.8	5.6	8.8	7.0	9.4	7.0	4.2	8.0	7.5
								120-150 cm soil depth									
1	29.8	32.2	2.5	2.5	5.4	6.4	7.8	2.5	13.8	12.8	71.5	13.7	5.4	5.3	2.5	2.5	8.5
2	7.4	6.9	2.5	8.8	9.6	6.4	8.9	10.0	8.4	5.2	5.7	14.3	2.5	7.2	10.5	5.9	11.6
3	9.8	8.6	2.5	10.8	10.7	2.5	8.1	7.5	15.6	2.5	9.1	12.9	9.6	12.1	11.5	13.9	13.7
4	9.0	2.5	18.1	22.4	2.5	2.5	9.4	9.4	9.0	9.9	10.2	6.9	6.9	9.7	8.9	9.3	2.5
Mean	14.0	12.6	6.4	11.1	7.0	4.4	8.5	7.3	11.7	7.6	24.1	11.9	6.1	8.6	8.3	7.9	9.1

[z] Control: No manure application; each replicate value is a mean of four control plots.
[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).
[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.26. Soil extractable phosphate-P (kg ha^{-1}) at the Lethbridge site in 1999.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	3.7	79.2	26.6	77.8	0.0	27.7	39.3	11.0	40.0	29.6	150.4	37.2	120.1	9.3	3.0	0.0	29.8
2	1.6	5.5	4.3	0.0	15.2	2.7	3.2	4.6	5.3	0.0	0.0	9.7	18.2	0.0	2.4	37.9	6.7
3	1.1	6.9	2.7	1.3	6.8	5.7	1.7	4.5	8.6	0.0	9.1	7.3	11.8	0.0	8.8	13.4	0.0
4	0.7	0.0	15.1	17.6	1.9	0.0	6.7	0.0	1.7	1.2	4.6	27.7	7.7	0.0	18.7	14.7	3.4
Mean	1.8	22.9	12.2	24.2	6.0	9.0	12.7	5.0	13.9	7.7	41.0	20.5	39.5	2.3	8.2	16.5	10.0
								15-30 cm soil depth									
1	1.0	0.0	0.0	15.1	0.0	2.3	4.5	0.0	0.0	3.4	2.5	0.0	3.2	1.5	0.0	0.0	0.0
2	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5
3	0.5	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5	0.0	0.0	0.0	2.4	3.5	0.0
4	0.0	0.0	2.6	4.9	0.0	0.0	2.1	0.0	0.0	0.0	0.0	5.9	0.0	0.0	1.5	2.1	0.0
Mean	0.5	0.6	0.6	5.0	0.0	0.6	1.6	0.0	0.0	0.8	1.3	1.5	0.8	0.4	1.0	1.4	0.6
								30-60 cm soil depth									
1	1.0	0.0	0.0	6.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.2
3	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.3	0.0
4	0.0	0.0	2.9	3.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mean	0.2	0.0	0.7	2.5	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.8	1.3
								60-90 cm soil depth									
1	0.7	0.0	0.0	0.0	3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mean	0.2	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
								90-120 cm soil depth									
1	0.7	0.0	0.0	0.0	0.0	0.0	3.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	3.6	4.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mean	0.6	0.0	0.9	1.1	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
								120-150 cm soil depth									
1	0.0	0.0	0.0	0.0	8.6	0.0	3.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	4.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.2
3	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	28.8	20.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mean	0.5	0.0	7.2	5.0	2.2	1.2	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.27. Soil extractable phosphate-P (kg ha^{-1}) at the Lethbridge site in 2000.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	11.3	60.3	167.5	285.3	367.3	149.7	166.3	265.7	194.5	152.7	216.7	179.7	489.7	70.0	39.0	123.1	274.9
2	7.1	100.7	74.6	321.1	406.6	94.7	102.6	169.1	249.5	35.3	95.4	406.6	145.3	49.9	110.2	218.8	111.8
3	5.0	71.6	37.2	73.2	230.8	61.9	179.9	64.9	281.8	17.0	32.6	157.5	596.0	33.3	59.1	30.3	64.7
4	3.8	12.7	85.2	306.1	208.6	5.9	129.4	24.0	331.5	36.0	112.7	218.8	25.4	8.5	87.3	392.7	284.1
Mean	6.8	61.3	91.1	246.4	303.3	78.0	144.5	130.9	264.3	60.3	114.3	240.6	314.1	40.4	73.9	191.2	183.9
								15-30 cm soil depth									
1	6.8	7.7	75.1	65.6	62.8	12.1	20.0	22.2	354.6	69.1	3.0	1.2	204.0	4.9	21.7	2.9	25.2
2	1.9	24.0	7.6	9.1	84.5	2.6	21.4	59.4	240.2	2.2	5.2	10.3	12.3	30.0	11.9	10.3	29.3
3	2.8	47.8	2.8	10.9	80.6	15.5	49.9	2.6	56.4	7.2	1.3	25.6	304.9	7.4	14.5	12.5	25.9
4	1.7	1.8	18.5	81.1	37.2	1.2	18.0	1.2	25.9	2.9	2.1	128.4	1.2	1.2	14.1	24.7	46.4
Mean	3.3	20.3	26.0	41.7	66.3	7.8	27.3	21.3	169.3	20.3	2.9	41.4	130.6	10.9	15.5	12.6	31.7
								30-60 cm soil depth									
1	1.5	5.2	5.5	47.2	0.0	0.0	7.6	0.0	5.5	19.2	3.6	4.2	21.7	0.0	0.0	4.7	0.0
2	0.0	3.9	2.7	0.0	4.7	0.0	11.8	5.2	13.4	2.9	4.1	0.0	0.0	0.0	0.0	0.0	5.8
3	4.4	2.4	2.4	2.4	4.2	2.4	23.3	2.4	101.6	16.4	2.4	6.8	2.4	5.7	5.7	20.7	7.4
4	2.4	2.7	40.0	60.8	2.4	2.4	2.4	2.4	2.4	2.4	2.4	11.2	2.4	2.4	2.4	32.6	6.5
Mean	2.1	3.6	12.7	27.6	2.8	1.2	11.3	2.5	30.7	10.2	3.2	5.5	6.6	2.0	2.0	14.5	4.9
								60-90 cm soil depth									
1	1.4	5.1	0.0	23.0	0.0	0.0	0.0	0.0	0.0	2.6	3.5	4.2	0.0	0.0	0.0	5.0	0.0
2	0.0	2.8	0.0	0.0	0.0	0.0	0.0	5.7		2.8	4.0	0.0	0.0	3.7	0.0	0.0	2.6
3	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	9.3	6.6
4	3.4	2.6	11.2	21.6	2.6	2.6	2.6	4.4	2.6	2.6	2.6	3.9	2.6	2.6	2.6	4.9	2.6
Mean	1.8	3.3	3.4	11.8	1.3	1.3	1.3	3.2	1.7	2.6	3.1	2.7	1.3	2.2	1.3	4.8	3.0
								90-120 cm soil depth									
1	1.2	0.0	0.0	147.2	0.0	0.0	0.0	0.0	6.1	0.0	3.3	4.9	0.0	0.0	0.0	4.8	0.0
2	2.9	0.0	0.0	0.0	0.0	7.5	0.0	0.0	0.0	2.9	3.8	0.0	0.0	9.9	3.9	9.0	3.0
3	3.6	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	6.1	2.5	2.5	2.5	3.1
4	3.0	2.5	16.8	20.6	2.5	2.5	2.5	3.3	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Mean	2.7	1.3	4.8	42.6	1.3	3.1	1.3	1.5	2.8	2.0	3.0	2.5	2.2	3.7	2.2	4.7	2.2
								120-150 cm soil depth									
1	1.9	0.0	0.0	65.6	7.7	0.0	4.4	7.8	9.5	0.0	3.8	4.5	0.0	5.1	0.0	4.9	0.0
2	6.4	11.6	0.0	0.0	0.0	6.2	0.0	3.9	0.0	0.0	4.3	9.8	0.0	13.3	4.7	10.0	14.6
3	5.2	2.5	2.5	6.1	2.5	3.2	19.1	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	14.3	5.4
4	2.7	2.5	50.6	45.7	7.8	2.5	2.5	4.9	2.5	2.5	2.5	4.2	2.5	2.5	5.5	2.5	3.0
Mean	4.0	4.1	13.3	29.3	4.5	3.0	6.5	4.8	3.6	1.3	3.3	5.2	1.3	5.8	3.2	7.9	5.7

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.28. Soil extractable phosphate-P (kg ha^{-1}) at the Lethbridge site in 2001.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	13.1	82.2	100.7	225.5	38.8	157.3	134.7	215.5	303.5	16.2	81.5	35.1	471.2	48.3	111.1	120.4	249.5
2	19.0	23.1	28.4	24.9	21.6	25.4	20.6	28.9	56.4	17.4	19.7	19.1	21.4	19.4	24.5	23.6	37.4
3	22.0	27.0	30.0	24.5	28.6	25.2	19.2	25.2	61.7	14.5	21.6	23.6	24.0	19.0	19.1	17.6	20.8
4	16.3	17.6	108.6	20.4	34.4	25.6	29.8	17.2	17.1	18.2	14.7	16.3	30.3	19.1	18.4	74.4	26.8
Mean	17.6	37.5	66.9	73.8	30.9	58.4	51.1	71.7	109.7	16.6	34.4	23.5	136.7	26.4	43.3	59.0	83.6
								15-30 cm soil depth									
1	4.7	9.9	36.0	72.1	18.3	62.8	15.1	57.5	105.1	14.5	12.8	7.5	14.5	12.3	30.7	21.2	93.6
2	16.0	12.4	14.2	15.5	15.1	15.7	18.8	20.3	14.6	13.6	15.8	18.4	14.8	14.4	14.7	15.9	14.9
3	13.6	14.8	16.7	14.6	16.7	15.9	11.8	28.9	16.6	11.6	20.2	13.3	17.8	12.0	15.1	26.3	10.4
4	11.9	21.4	28.4	20.5	16.6	12.2	12.3	14.6	9.8	16.8	12.1	24.3	20.3	16.7	16.2	18.7	21.0
Mean	11.6	14.6	23.8	30.7	16.7	26.7	14.5	30.3	36.5	14.1	15.2	15.9	16.8	13.9	19.2	20.5	35.0
								30-60 cm soil depth									
1	7.9	12.9	18.3	36.4	41.3	26.6	24.6	12.7	2.4	2.4	16.8	13.6	18.8	2.4	2.4	2.4	25.8
2	25.9	18.1	22.6	28.8	18.6	39.6	46.4	22.0	21.0	38.7	23.2	32.5	35.0	20.6	38.0	29.3	28.5
3	25.1	22.1	26.1	23.7	26.1	22.3	22.3	38.9	28.6	26.5	25.2	16.7	28.2	38.5	29.4	46.1	18.8
4	26.4	28.9	25.1	23.7	47.2	29.2	23.0	36.2	24.0	38.5	22.6	49.1	28.1	22.6	22.2	29.5	30.2
Mean	21.3	20.5	23.0	28.2	33.3	29.4	29.1	27.4	19.0	26.5	22.0	28.0	27.5	21.0	23.0	26.8	25.8
								60-90 cm soil depth									
1	7.0	2.6	2.6	14.5	29.3	2.6	31.6	2.6	2.6	2.6	16.3	14.1	2.6	2.6	2.6	2.6	2.6
2	11.3	16.3	34.0	27.5	2.6	27.0	22.7	19.4	17.1	27.9	21.8	36.8	25.1	29.4	23.7	27.7	27.7
3	28.0	20.5	21.7	30.5	30.4	13.1	19.2	20.0	25.9	23.1	22.6	21.5	2.6	21.2	28.0	28.3	28.3
4	26.2	24.8	2.6	2.6	33.3	30.4	25.4	36.0	24.3	25.5	25.3	2.6	27.1	19.3	23.1	2.6	29.4
Mean	18.1	16.1	15.2	18.8	23.9	18.3	24.7	19.5	17.5	19.8	21.5	18.8	14.3	18.1	19.3	15.3	22.0
								90-120 cm soil depth									
1	10.1	34.3	24.2	19.3	30.0	2.5	33.5	2.5	2.5	2.5	42.9	14.5	2.5	2.5	20.0	17.5	2.5
2	27.2	20.3	22.2	24.4	34.1	34.8	24.9	26.4	20.9	27.6	30.9	2.5	22.0	35.1	36.8	32.5	19.6
3	36.3	2.5	25.0	37.2	42.2	19.5	16.7	2.5	27.7	2.5	22.5	23.9	22.5	24.0	35.5	25.8	24.0
4	28.8	39.8	21.8	2.5	29.4	42.5	26.8	33.8	33.1	34.1	33.3	29.2	33.3	22.4	39.9	23.7	30.2
Mean	25.6	24.2	23.3	20.9	33.9	24.8	25.5	16.3	21.0	16.7	32.4	17.5	20.1	21.0	33.0	24.9	19.1
								120-150 cm soil depth									
1	5.5	51.6	2.5	2.5	35.6	2.5	2.5	2.5	2.5	2.5	14.3	2.5	2.5	2.5	2.5	33.6	2.5
2	28.5	28.1	33.5	28.6	28.6	37.4	29.5	28.2	38.0	43.8	40.1	47.3	31.1	40.4	33.8	21.4	22.2
3	36.8	22.2	45.7	44.7	38.4	2.5	30.3	32.8	25.4	18.9	43.7	57.6	29.6	26.8	41.9	45.0	36.2
4	32.0	46.2	37.7	19.8	46.7	46.5	37.4	46.8	41.4	36.2	41.6	2.5	39.1	22.5	38.5	23.4	36.5
Mean	25.7	37.0	29.8	23.9	37.3	22.2	24.9	27.6	26.8	25.4	34.9	27.5	25.6	23.1	29.2	30.9	24.4

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.29. Soil extractable phosphate-P (kg ha^{-1}) at the Airdrie site in 1997.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	6.8	8.3	5.0	5.0	3.4	8.7	14.8	9.8	11.6	17.0	7.3	5.5	8.3	5.2	13.2	5.0	5.8
2	4.9	4.0	5.9	9.3	8.7	14.3	7.5	7.3	4.0	6.4	3.0	8.5	10.4	4.5	8.0	10.2	12.7
3	4.3	16.8	2.6	0.8	2.6	12.0	8.0	8.3	3.1	0.8	5.4	0.8	11.9	3.2	0.8	7.6	2.3
4	5.9	4.0	3.3	8.3	9.4	4.9	2.6	0.8	0.8	5.2	2.1	12.0	7.1	0.8	2.0	7.6	6.3
Mean	5.5	8.3	4.2	5.8	6.0	10.0	8.2	6.5	4.9	7.4	4.4	6.7	9.4	3.4	6.0	7.6	6.8
								15-30 cm soil depth									
1	4.0	2.0	2.0	4.0	3.4	1.0	11.9	7.3	2.9	8.4	1.0	1.0	4.0	3.8	4.7	2.0	1.0
2	3.4	4.6	7.7	6.4	5.0	4.5	2.4	5.9	4.9	4.1	4.7	5.0	6.5	5.9	1.0	4.4	8.2
3	2.5	6.2	1.0	1.0	1.0	2.7	1.0	1.0	1.0	1.0	1.0	1.0	3.8	1.0	1.0	1.0	1.0
4	1.3	2.1	2.5	4.5	1.0	3.1	1.0	1.0	1.0	1.0	1.0	2.2	1.0	1.0	1.0	4.3	2.4
Mean	2.8	3.7	3.3	4.0	2.6	2.8	4.1	3.8	2.4	3.6	1.9	2.3	3.8	2.9	1.9	2.9	3.1
								30-60 cm soil depth									
1	3.3	2.1	2.1	4.2	7.3	2.1	14.8	2.1	2.1	16.6	2.1	2.1	2.1	2.1	2.1	2.1	2.1
2	5.5	9.1	14.8	6.3	5.1	2.1	6.3	10.0	8.8	8.5	10.4	2.1	11.0	10.0	2.1	2.1	
3	2.1	4.3	2.1	2.1	2.1	4.5	2.1	2.1	2.1	2.1	2.1	2.1	4.4	2.1	2.1	2.1	2.1
4	2.1	2.1	2.1	4.3	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	6.1	2.1	2.1
Mean	3.2	4.4	5.3	4.2	4.2	2.7	6.3	4.1	3.8	7.3	4.2	2.1	4.9	4.1	3.1	2.1	2.1
								60-90 cm soil depth									
1	3.8	4.7	2.4	4.7	7.3	2.4	9.3	2.4	2.4	7.3	2.4	2.4	2.4	2.4	2.4	2.4	2.4
2	6.2	11.4	12.3	8.1	5.8	2.4	7.6	11.6	11.4	5.4	8.1	2.4	10.0	8.7	2.4	2.4	11.6
3	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
4	2.4	2.4	5.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	5.4	2.4	2.4	4.9	2.4	2.4
Mean	3.7	5.2	5.6	4.4	4.5	2.4	5.4	4.7	4.6	4.3	3.8	3.1	4.3	3.9	3.0	2.4	4.7
								90-120 cm soil depth									
1	4.2	2.6	2.6	5.2	6.4	2.6	10.3	2.6	2.6	7.1	2.6	11.8	2.6	2.6	2.6	2.6	2.6
2	6.7	11.0	11.8	2.6	8.8	2.6	2.6	12.5	10.1	13.1	10.2	2.6	8.3	11.1	2.6	2.6	12.7
3	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6
4	2.6	2.6	2.6	6.3	2.6	2.6	2.6	2.6	2.6	2.6	2.6	7.6	2.6	2.6	2.6	2.6	2.6
Mean	4.0	4.7	4.9	4.2	5.1	2.6	4.5	5.1	4.5	6.3	4.5	6.1	4.0	4.7	2.6	2.6	5.1
								120-150 cm soil depth									
1	3.9	2.7	2.7	5.5	9.6	2.7	10.2	2.7	2.7	11.7	2.7	2.7	5.5	2.7	5.5	6.6	2.7
2	5.9	14.7	14.3	2.7	9.8	2.7	9.0	14.5	12.2	7.4	11.0	2.7	12.5	12.6	2.7	2.7	12.1
3	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
4	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
Mean	3.8	5.7	5.6	3.4	6.2	2.7	6.1	5.7	5.1	6.2	4.8	2.7	5.9	5.2	3.4	3.7	5.1

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.30. Soil extractable phosphate-P (kg ha^{-1}) at the Airdrie site in 1998.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
							0-15 cm soil depth										
1	7.3	13.6	14.1	29.5	38.6		13.8	2.3	56.4	9.3	11.3	5.4	12.4	6.6	0.8	25.3	4.0
2	4.1		15.3	30.7	21.6	14.8	22.5	10.6	12.8	9.5	5.9	46.3	11.8	8.3	9.1	5.8	18.8
3	8.0	21.1	14.4	33.5	25.7	14.4	42.7	10.5	21.4	12.3	36.5	13.9	24.9	9.3	7.6	23.7	28.5
4	9.1	8.4	22.4	28.4	58.2	8.9	0.8	22.7	7.5	4.7	3.9	20.1	49.0	12.4	2.5	13.1	67.0
Mean	7.1	14.3	16.5	30.5	36.0	12.7	19.9	11.5	24.5	9.0	14.4	21.4	24.5	9.2	5.0	17.0	29.6
							15-30 cm soil depth										
1	6.5	4.9	3.2	1.0	7.2	5.5	10.5	1.0	11.7	11.5	3.8	2.5	6.6	4.8	1.0	7.8	5.4
2	4.6	6.1	13.5	10.2	9.3	11.8	7.1	8.8	6.6	6.8	6.2	10.0	8.6	5.8	4.0	6.6	15.4
3	5.9	9.8	8.3	8.2	3.7	9.6	8.8	5.3	20.7	6.4	7.6	2.0	11.0	5.5	5.5	3.0	7.0
4	5.2	3.5	9.2	6.4	10.8	4.2	3.9	3.7	1.0	4.3	1.0	8.5	12.2	4.9	3.8	4.7	14.2
Mean	5.5	6.1	8.5	6.5	7.7	7.8	7.6	4.7	10.0	7.2	4.6	5.7	9.6	5.2	3.6	5.5	10.5
							30-60 cm soil depth										
1	9.0	14.1	6.6	4.7	15.3	9.7	8.7		5.5	12.4	2.1	2.1	10.4	6.9	2.1	6.6	2.1
2	11.2	11.7	30.0	18.2	9.7	13.1	9.1	7.6	9.3	14.8	2.1	8.5	21.4	2.1	6.7	6.3	34.0
3	6.4	17.4	2.1	10.8	10.1	16.4	11.3	11.5	12.2	5.1	11.5	11.4	13.2	5.7	8.8	7.8	2.1
4	7.8	7.6	6.5	6.5	11.1	7.1	7.5	7.6	6.7	8.9	9.3	9.4	9.4	7.8	7.5	13.5	15.0
Mean	8.6	12.7	11.3	10.0	11.6	11.5	9.2	8.9	8.4	10.3	6.3	7.9	13.6	5.6	6.3	8.5	13.3
							60-90 cm soil depth										
1	9.4	12.1			15.8	6.9	14.2	2.4	9.7	14.8	8.2	6.1	5.1	11.0	2.4	16.0	2.4
2	10.2	12.9	9.4	22.9	13.9	10.8	16.1		15.4	16.2	8.4	8.7	15.6	9.0	8.3	8.1	12.3
3	7.3	6.2	6.5	5.5	11.2	9.9	12.4	13.0	10.5	2.4	5.8	12.3	9.0	5.6	12.7	2.4	7.0
4	5.5	8.8	2.4	2.4	2.4	7.2	2.4	2.4	7.0	9.2	10.5	10.1	6.4	2.4	7.7	9.2	10.8
Mean	8.1	10.0	6.1	10.2	10.8	8.7	11.3	5.9	10.7	10.7	8.2	9.3	9.0	7.0	7.8	8.9	8.1
							90-120 cm soil depth										
1	11.1	16.6	5.8	5.5	16.5	13.6	9.6	2.6	13.2	14.6	8.8	6.7	6.3	13.9	2.6		8.9
2	12.7	16.1	17.9	18.7	17.1	8.2	16.8	18.3		15.6	9.4	10.3	16.6	9.4	7.3	9.1	18.3
3	8.8	15.6	14.7	2.6	12.3	15.2	12.5	15.5	13.9	13.8	2.6	12.8	2.6	6.2	14.4	9.7	12.9
4	9.4	9.4	10.7	9.4	2.6	8.5	9.4	8.2	8.9	12.3	12.6	9.8	9.0	2.6	9.2	9.3	2.6
Mean	10.5	14.4	12.3	9.1	12.1	11.4	12.1	11.2	12.0	14.1	8.4	9.9	8.6	8.0	8.4	9.4	10.7
							120-150 cm soil depth										
1	11.8	17.6	17.0	2.7	18.0	10.2	19.6	2.7	7.2	15.8	8.4	2.7	7.1	14.1	2.7	18.5	14.1
2	9.2	8.1	16.8	10.4	9.9	9.9	15.6	18.7	9.4	17.5	10.7	10.5	18.5	10.6	9.5	2.7	18.9
3	10.6	16.6	12.2	11.2	12.7	16.2	13.8	15.2	13.8	14.6	14.6	8.6	2.7	14.3	9.9	9.8	13.5
4	6.7	2.7	10.9	12.2	9.0	6.3	9.9	9.1	8.7	11.1	11.8	12.0	9.0	9.8	9.8	9.3	5.5
Mean	9.5	11.2	14.2	9.1	12.4	10.6	14.7	11.4	9.8	14.8	11.4	8.4	9.3	12.2	8.0	10.1	13.0

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.31. Soil extractable phosphate-P (kg ha^{-1}) at the Airdrie site in 1999.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	5.6	7.2	19.1	25.0	69.6	12.7	36.8	2.8	149.7	16.6	21.8	15.0	17.0	7.8	14.3	33.3	8.4
2	4.3	13.5	4.9	38.0	19.3	51.8	13.2	31.8	57.6	1.0	9.0	77.1	23.0	5.3	51.6	69.9	96.2
3	7.3	12.2	4.7	25.6	55.4	7.1	36.6	5.8	83.3	4.2	4.3	37.8	102.4	29.0	3.3	18.3	68.8
4	9.4	19.6	7.5	9.9	43.8	21.3	13.6	23.3	45.3	30.8	29.0	75.6	4.2	63.3	187.3	258.1	236.4
Mean	6.6	13.1	9.1	24.6	47.0	23.2	25.1	15.9	84.0	13.2	16.0	51.4	36.6	26.3	64.1	94.9	102.5
								15-30 cm soil depth									
1	2.7	1.6	2.9	1.0	19.2	11.9	11.2	1.1	42.7	6.5	12.8	26.3	5.9	2.0	1.0	7.0	1.0
2	1.4	1.0	1.0	11.4	22.5	13.9	13.1	4.1	9.6	1.0	1.1	1.9	3.5	4.4	10.2	66.4	8.5
3	7.2	10.6	4.0	7.2	1.0	6.2	6.2	7.6	36.5	18.7	24.5	1.2	128.7	32.9	1.0	82.0	12.6
4	10.6	8.5	9.1	11.9	18.0	5.3	13.7	4.6	16.0	12.7	14.2	56.9	5.7	33.3	128.7	96.6	30.1
Mean	5.5	5.4	4.2	7.9	15.2	9.3	11.0	4.3	26.2	9.7	13.2	21.6	35.9	18.2	35.2	63.0	13.1
								30-60 cm soil depth									
1	3.0	2.1	2.1	2.1	2.1	16.6	2.1	2.1	3.0	3.5	2.1	2.1	2.1	2.1	2.1	4.1	2.1
2	2.3	2.1	2.1	13.5	2.1	17.8	2.1	2.1	2.1	2.1	2.6	2.8	2.1	2.4	3.0	2.1	3.3
3	9.4	5.1	6.5	2.1	2.1	2.5	2.1	9.2	4.3	2.1	2.1	2.1	160.1	2.1	2.1	3.8	2.1
4	15.4	5.6	10.1	18.0	15.8	15.8	35.7	11.2	15.6	24.4	16.9	93.4	10.7	11.8	40.3	22.9	25.4
Mean	7.5	3.7	5.2	8.9	5.5	13.2	10.5	6.1	6.2	8.0	5.9	25.1	43.8	4.6	11.9	8.2	8.2
								60-90 cm soil depth									
1	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
2	2.4	2.4	2.4	9.4	2.4	4.0	2.4	2.4	2.4	2.4	2.4	2.6	2.4	2.4	3.1	2.4	2.4
3	5.6	4.3	10.0	2.4	2.4	6.0	2.4	7.9	2.4	2.4	2.4	2.4	82.0	2.4	2.4	2.4	2.4
4	21.7	5.5	15.0	9.0	16.9	11.3	21.0	6.7	12.5	87.6	18.6	91.4	56.5	9.7	27.6	27.7	27.4
Mean	8.0	3.6	7.4	5.8	6.0	5.9	7.0	4.8	4.9	23.7	6.4	24.7	35.8	4.2	8.9	8.7	8.6
								90-120 cm soil depth									
1	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6
2	2.8	2.6	2.6	5.0	2.6	3.2	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.8	2.8	2.6	2.6
3	5.2	4.3	5.6	2.6	2.6	3.2	2.6	5.3	2.6	2.6	2.6	2.6	43.1	2.6	2.6	2.6	2.6
4	11.7	7.2	8.6	6.3	15.0	13.6	18.7	5.3	11.8	150.5	18.3	92.4	24.2	10.2	54.5	15.6	14.3
Mean	5.6	4.2	4.9	4.1	5.7	5.7	6.6	3.9	4.9	39.6	6.5	25.0	18.1	4.5	15.6	5.9	5.5
								120-150 cm soil depth									
1	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
2	2.9	2.7	2.7	4.2	2.7	3.4	2.7	2.7	2.7	2.7	2.7	2.8	2.7	2.9	3.1	2.7	2.7
3	5.6	7.4	11.7	2.7	2.7	3.9	2.7	6.4	2.7	2.7	2.7	2.7	28.2	2.7	2.7	2.7	2.7
4	15.8	8.0	9.8	10.5	14.7	12.3	22.3	3.8	13.0	127.2	16.6	43.2	38.1	14.7	65.0	18.0	9.3
Mean	6.8	5.2	6.7	5.1	5.7	5.6	7.6	3.9	5.3	33.9	6.2	12.9	17.9	5.8	18.4	6.6	4.4

[z] Control: No manure application; each replicate value is a mean of four control plots.
[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).
[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.32. Soil extractable phosphate-P (kg ha^{-1}) at the Airdrie site in 2000.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	7.9	16.6	35.8	133.7	92.4	7.0	63.3	117.7	238.1	26.0	13.8	35.3	54.4	21.6	29.5	53.3	1.6
2	4.9	2.1	28.3	63.8	119.5	35.1	23.3	33.6	38.3	5.5	5.6	63.8	49.6	14.2	34.8	40.3	64.9
3	4.2	45.6	42.5	23.0	48.0	31.5	33.5	86.4	86.9	4.5	26.3	19.0	48.1	8.1	1.2	75.3	50.4
4	4.1	15.3	27.8	104.7	160.0	26.5	2.0	72.1	188.8	2.6	11.5	33.0	142.4	11.9	21.0	11.9	68.3
Mean	5.3	19.9	33.6	81.3	105.0	25.0	30.5	77.5	138.0	9.6	14.3	37.8	73.6	14.0	21.6	45.2	46.3
								15-30 cm soil depth									
1	5.5	5.1	17.2	28.9	1.0	2.4	20.7	22.5	86.4	11.8	14.9	5.4	28.1	5.7	2.3	13.1	1.8
2	2.4	2.0	6.4	12.2	7.4	12.8	1.0	8.4	1.0		1.8	12.7	12.0	3.6	10.0	10.8	13.0
3	1.5	6.3	5.5	2.3	1.0	5.8	21.1	1.0	17.6	1.0	4.0	1.0	7.7	2.5	1.0	13.4	3.0
4	2.3	1.0	6.1	2.0	36.9	2.3	1.0	11.8	4.5	1.0	4.2	4.3	40.1	1.4	1.0	2.0	18.9
Mean	2.9	3.6	8.8	11.4	11.6	5.8	11.0	10.9	27.4	4.6	6.2	5.9	22.0	3.3	3.6	9.8	9.2
								30-60 cm soil depth									
1	3.1	2.1	3.7	3.3	3.5	4.4	2.1	9.2	5.4	2.1	2.1	2.1	13.4	2.7	3.2	2.5	4.1
2	4.4	2.1	11.6	16.1	2.1	9.9	2.1	2.2	2.1	2.1	3.5	4.8	22.7	2.1	2.4	3.2	7.6
3	2.1	11.3	2.1	3.3	2.1	9.9	2.1	2.1	2.9	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1
4	2.1	2.1	3.7	2.1	16.4	2.3	2.1	2.1	2.1	2.1	3.8	2.1	5.0	2.1	2.1	2.1	13.1
Mean	2.9	4.4	5.3	6.2	6.0	6.6	2.1	3.9	3.1	2.1	2.9	2.8	10.8	2.2	2.4	2.5	6.7
								60-90 cm soil depth									
1	2.4	2.4	3.2	2.4	2.4	5.9	2.4	2.7	2.7	2.4	2.4	2.4	2.4	2.7	2.5	2.4	2.6
2	3.5	2.4	4.0	2.8	2.4	2.4	2.4	2.4	2.4	2.4	3.8	2.4	7.0	2.4	2.4	2.4	2.4
3	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
4	2.8	2.4	2.4	2.4	2.9	2.4	2.4	2.4	2.4	2.4	3.2	2.4	2.4	2.4	2.4	2.4	2.4
Mean	2.8	2.4	3.0	2.5	2.5	3.2	2.4	2.4	2.4	2.4	2.9	2.4	3.5	2.4	2.4	2.4	2.4
								90-120 cm soil depth									
1	3.0	2.6	2.6	2.6	2.6	5.4	2.6	2.9	2.6	2.6	2.6	2.6	2.6	3.6	3.5	2.6	3.0
2	2.6	2.6	2.6	2.6	2.6	2.6	2.6	6.9	2.6	5.6	3.9	2.6	5.3	2.6	2.6	2.6	2.6
3	2.6	2.6	5.1	2.6	2.6	5.2	2.6	2.6	2.6	2.6	2.6	2.6	3.0	2.6	2.6	2.6	2.6
4	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	3.4	2.6	2.6	2.6	2.6	2.6	2.6
Mean	2.7	2.6	3.2	2.6	2.6	4.0	2.6	3.7	2.6	3.3	3.1	2.6	3.4	2.8	2.8	2.6	2.7
								120-150 cm soil depth									
1	3.0	2.7	2.7	2.7	2.7	5.7	2.7	2.9	2.7	2.7	2.7	2.7	2.7	6.3	2.7	2.7	2.8
2	2.7	2.7	2.7	2.7	2.7	5.3	2.7	2.7	6.6	5.6	3.1	2.7	2.7	2.7	2.7	2.7	2.7
3	2.7	2.7	2.7	2.7	2.7	3.9	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
4	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	5.6	5.0	3.8	2.7	2.7	2.7	2.7	2.7	2.7
Mean	2.8	2.7	2.7	2.7	2.7	4.4	2.7	2.8	4.4	4.0	3.1	2.7	2.7	3.6	2.7	2.7	2.8

[z] Control: No manure application; each replicate value is a mean of four control plots.
[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).
[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.33. Soil extractable phosphate-P (kg ha^{-1}) at the Airdrie site in 2001.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	4.5	25.8	44.8	110.4	259.7	28.0	85.6	202.8	149.0	19.0	25.0	78.4	73.3	13.6	14.5	130.2	158.3
2	8.2	5.6	46.5	137.4	109.9	30.8	71.3	289.7	268.1	11.0	32.6	103.1	146.7	38.0	229.8	142.4	266.4
3	3.5	57.1	50.3	60.4	143.2	23.3	50.1	181.2	409.6	19.3	163.7	35.0	54.8	22.5	51.1	49.8	145.5
4	1.8	0.8	60.9	16.2	25.1	24.6	11.1	60.6	126.9	0.8	29.1	12.9	10.1	14.2	9.8	61.8	37.1
Mean	4.5	22.3	50.6	81.1	134.5	26.7	54.5	183.6	238.4	12.5	62.6	57.3	71.2	22.1	76.3	96.0	151.8
								15-30 cm soil depth									
1	2.5	8.0	1.0	15.9	10.9	1.0	47.5	28.9	8.4	1.0	6.8	1.0	1.0	1.0	10.4	56.5	12.3
2	4.6	1.0	16.1	26.5	30.3	15.9	1.0	6.8	44.3	1.0	13.1	40.7	22.9	12.9	47.5	19.4	8.0
3	2.4	9.2	12.1	6.1	1.0	9.0	16.2	70.4	30.9	1.0	39.1	1.0	10.7	12.2	1.0	1.0	24.5
4	1.0	1.0	8.7	1.0	31.5	12.0	1.0	25.5	30.9	7.3	11.0	14.3	1.0	1.0	1.0	6.9	1.0
Mean	2.6	4.8	9.5	12.4	18.4	9.5	16.4	32.9	28.6	2.6	17.5	14.2	8.9	6.8	15.0	20.9	11.5
								30-60 cm soil depth									
1	12.0	2.1	2.1	23.9	2.1	2.1	49.6	20.2	183.5	2.1	2.1	13.3	2.1	2.1	2.1	31.9	24.8
2	4.9	2.1	2.1	18.6	2.1	18.9	2.1	105.5	2.1	2.1	2.1	2.1	2.1	2.1	25.1	2.1	2.1
3	2.1	2.1	2.1	2.1	2.1	11.4	2.1	2.1	14.7	2.1	2.1	2.1	2.1	2.1	2.1	15.6	2.1
4	6.7	2.1	2.1	2.1	28.5	2.1	2.1	2.1	2.1	2.1	2.1	14.3	2.1	2.1	14.2	64.2	2.1
Mean	6.4	2.1	2.1	11.7	8.7	8.6	14.0	32.5	50.6	2.1	2.1	7.9	2.1	2.1	10.9	28.4	7.8
								60-90 cm soil depth									
1	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	12.8	2.4	15.6	2.4	2.4	2.4
2	2.4	12.8	2.4	2.4	2.4	2.4	2.4	31.7	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	73.9
3	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	12.9	2.4	2.4	2.4
4	2.4	2.4	2.4	2.4	29.8	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
Mean	2.4	5.0	2.4	2.4	9.2	2.4	2.4	9.7	2.4	2.4	2.4	5.0	2.4	8.3	2.4	2.4	20.3
								90-120 cm soil depth									
1	6.3	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	12.9	2.6	2.6	2.6	2.6
2	2.6	13.7	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6
3	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6
4	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	24.2	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6
Mean	3.5	5.4	2.6	2.6	2.6	2.6	2.6	2.6	8.0	2.6	2.6	2.6	5.2	2.6	2.6	2.6	2.6
								120-150 cm soil depth									
1	5.0	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	16.1	2.7	2.7	2.7
2	2.7	18.2	2.7	2.7	2.7	2.7	2.7	2.7	15.4	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
3	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
4	5.4	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	12.2	2.7	2.7
Mean	4.0	6.6	2.7	2.7	2.7	2.7	2.7	2.7	5.9	2.7	2.7	2.7	2.7	6.1	5.1	2.7	2.7

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.34. Soil extractable sodium (kg ha^{-1}) at the Lethbridge site in 1996.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	57	58	40	49	69	73	28	76	33	159	27	54	99	46	38	89	40
2	46	36	52	59	84	49	53	63	41	62	40	47	53	50	54	58	51
3	40	58	33	52	43	47	52	22	62	55	58	67	45	43	34	32	42
4	43	21	73	60	92	46	46	50	46	41	44	41	51	68	52	49	47
Mean	46	43	50	55	72	54	45	53	46	79	42	52	62	52	45	57	45
								15-30 cm soil depth									
1	87	99	128	133	85	133	38	91	88	96	98	117	145	70	109	83	62
2	97	125	76	127	148	91	97	96	100	92	58	156	87	132	59	62	79
3	75	108	60	75	121	60	110	55	65	79	94	104	83	79	58	67	73
4	76	56	84	92	204	81	78	79	106	66	94	59	90	110	89	74	89
Mean	84	97	87	107	140	91	81	80	90	83	86	109	101	98	79	71	75
								30-60 cm soil depth									
1	219	360	353	220	185	354	137	352	254	415	253	337	268	200	473	216	200
2	284	310	352	362	426	310	300	353	275	276	406	283	211	397	286	154	316
3	201	239	120	269	322	141	244	171	188	175	275	308	271	235	191	209	210
4	263	189	292	253	432	258	195	265	437	170	178	168	331	313	316	217	337
Mean	242	274	279	276	341	266	219	285	289	259	278	274	270	286	317	199	266
								60-90 cm soil depth									
1	244	454	481	439	372	470	189	397	263	548	297	370	342	292	716	354	276
2	345	323	768	214	184	505	276	527	288	351	363	363	355	306	538	259	377
3	250	348	198	252	471	274	345	325	265	160	388	475	437	276	179	311	430
4	380	232	217	206	515	333	183	391	501	254	268	249	253	595	257	225	367
Mean	305	339	416	278	385	396	248	410	329	328	329	364	347	367	422	287	362
								90-120 cm soil depth									
1	298	590	560	373	237	1092	259	429	170	319	229	325	322	300	1094	372	355
2	552	370	1340	317	178	300	311	592	282	292	521	267	531	216	1022	271	403
3	238	611	209	249	515	247	428	393	375	146	454	696	413	182	174	258	661
4	397	308	252	192	671	404	200	371	685	319	401	184	256	976	211	193	426
Mean	371	470	590	283	400	511	300	446	378	269	401	368	381	419	625	273	461
								120-150 cm soil depth									
1	460	932	1354	667	185	1756	170	804	141	403	413	338	514	277	1824	532	578
2	1040	520	2386	735	275	581	332	988	285	380	809	384	1065	759	2071	222	762
3	286	1213	277	462	722	194	765	440	683	110	740	916	727	179	149	293	1014
4	587	463	444	271	1055	573	236	444	1022	709	700	127	273	1545	345	177	463
Mean	593	782	1115	534	559	776	376	669	533	400	665	441	645	690	1097	306	704

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.35. Soil extractable sodium (kg ha^{-1}) at the Lethbridge site in 1997.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	45	34	46	14	37	51	105	252	68	43	20	29	48	23	41	28	52
2	63	72	65	43	101	33	68	163	91	50	79	49	81	55	38	43	75
3	56	47	53	76	53	90	109	120	158	59	70	70	88	38	64	30	67
4	49	59	60	42	65	119	87	117	151	52	70	80	80	71	49	50	76
Mean	54	53	56	44	64	73	92	163	117	51	60	57	74	47	48	38	67
								15-30 cm soil depth									
1	90	63	128	134	64	126	79	123	101	85	157	90	104	61	63	48	85
2	116	147	104	114	74	82	89	118	137	87	135	103	93	67	90	46	156
3	85	81	85	134	101	66	141	93	160	76	100	107	167	71	94	122	85
4	89	77	100	102	217	130	94	123	92	68	85	77	100	176	79	114	87
Mean	95	92	104	121	114	101	101	114	122	79	119	94	116	94	81	83	103
								30-60 cm soil depth									
1	273	315	397	153	152	381	234	305	270	245	292	340	306	202	208	272	296
2	379	297	482	257	128	196	281	600	307	339	429	368	265	533	254	159	458
3	210	171	202	453	394	183	338	131	279	220	267	300	370	165	223	297	204
4	315	238	204	297	413	328	197	308	378	149	228	250	226	602	372	267	257
Mean	294	255	321	290	272	272	262	336	308	238	304	315	292	375	264	249	304
								60-90 cm soil depth									
1	287	509	941	411	150	449	341	539	324	285	234	369	259	314	787	393	338
2	552	371	611	756	222	377	243	578	365	327	422	449	336	561	515	238	471
3	304	389	300	487	588	298	398	248	377	198	321	394	502	275	247	339	359
4	349	313	237	393	546	349	280	416	491	282	474	296	354	778	362	288	247
Mean	373	395	523	512	376	368	316	445	389	273	363	377	363	482	478	315	354
								90-120 cm soil depth									
1	273	925	1573	519	170	488	338	425	207	303	233	340	272	335	791	348	385
2	790	277	1811	193	180	247	246	967	294	290	524	289	816	156	864	197	866
3	309	564	209	251	595	358	553	402	668	186	363	531	604	203	215	311	473
4	339	304	279	283	840	318	358	477	577	447	573	202	253	920	287	268	373
Mean	428	518	968	311	446	353	374	568	436	306	423	340	486	403	539	281	524
								120-150 cm soil depth									
1	346	1439	2186	683	307	1041	276	587	103	354	180	317	444	237	1864	424	660
2	1513	472	2359	447	284	205	303	1355	306	390	705	308	1406	550	1353	152	1478
3	331	738	191	273	904	260	808	323	858	133	460	934	957	236	180	232	597
4	573	407	484	375	986	263	344	427	894	583	945	125	169	1766	384	165	918
Mean	691	764	1305	445	620	442	433	673	540	365	573	421	744	697	946	243	913

[z] Control: No manure application; each replicate value is a mean of four control plots.
[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).
[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.36. Soil extractable sodium (kg ha^{-1}) at the Lethbridge site in 1998.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	40	35	68	49	57	74	65	66	112	56	38	20	67	48	55	57	27
2	48	61	43	65	111	33	89	92	86	57	29	44	41	48	28	25	74
3	179	86	562	177	86	79	71	652	37	48	56	32	76	50	48	56	130
4	43	40	41	54	65	62	94	78	130	51	63	42	45	45	56	47	56
Mean	78	56	178	86	80	62	80	222	91	53	46	34	57	48	47	46	72
								15-30 cm soil depth									
1	56	63	130	90	64	109	94	95	76	71	61	71	80	85	69	58	48
2	72	102	105	92	186	55	123	101	148	70	64	74	80	92	43	27	101
3	73	105	49	103	47	49	85	73	66	68	114	39	93	77	75	65	15
4	70	64	70	99	91	70	82	123	142	65	81	83	109	67	78	60	77
Mean	68	84	88	96	97	71	96	98	108	69	80	67	90	81	66	53	60
								30-60 cm soil depth									
1	192	211	501	265	146	276	197	269	217	191	296	281	232	293	191	169	175
2	326	295	415	451	365	168	300	326	330	297	323	421	203	447	183	76	319
3	229	313	134	242	180	194	198	250	178	183	329	106	276	235	235	201	28
4	260	219	222	336	339	241	172	381	444	172	232	227	279	441	241	218	202
Mean	252	260	318	323	257	220	217	306	292	211	295	259	248	354	213	166	181
								60-90 cm soil depth									
1	274	573	1164	434	173	438	342	350	280	220	329	373	393	315	365	287	275
2	429	193	338	372	441	443	277	383	209	369	312	336	442	337	617	140	239
3	357	368	213	281	225	454	313	444	360	188	386	198	390	194	245	242	13
4	303	345	243	257	328	295	233	481	462	296	358	233	399	975	207	237	361
Mean	341	370	490	336	292	407	291	415	328	268	346	285	406	455	358	226	222
								90-120 cm soil depth									
1	246	1155	2496	657	308	927	298	279	123	354	231	360	413	251	811	321	407
2	655	282	1419	269	720	306	536	608	299	313	398	227	964	271	759	162	244
3	405	595	264	260	167	499	395	455	725	146	378	185	415	176	223	208	13
4	309	456	291	263	474	238	177	728	637	428	588	164	267	1619	199	183	633
Mean	404	622	1117	362	417	493	351	517	446	310	399	234	515	579	498	218	324
								120-150 cm soil depth									
1	192	1634	2731	1197	249	1941	185	232	128	492	298	415	490	258	1514	412	690
2	970	129	2069	810	87	476	106	183	153	416	532	598	1560	889	1137	118	180
3	530	790	414	227	153	979	623	660	1233	123	564	162	533	265	155	258	13
4	527	754	500	460	643	190	163	922	1028	691	1093	90	185	1638	235	129	991
Mean	555	827	1429	674	283	897	270	500	636	431	622	317	692	762	760	229	468

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.37. Soil extractable sodium (kg ha^{-1}) at the Lethbridge site in 1999.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	47	65	83	111	83	162	143	127	169	37	28	53	69	53	58	58	53
2	58	134	118	120	189	88	106	150	143	55	72	88	67	65	60	106	83
3	50	72	162	201	180	90	97	185	118	92	67	79	65	97	76	74	97
4	53	88	134	106	196	92	116	139	169	49	60	88	90	85	72	85	134
Mean	52	90	124	135	162	108	116	150	150	58	57	77	73	75	66	81	92
								15-30 cm soil depth									
1	69	146	136	134	164	85	72	118	152	67	55	92	85	58	83	69	72
2	77	129	155	152	159	88	129	173	164	69	99	102	76	76	60	67	104
3	72	83	118	194	196	65	125	139	127	106	109	120	69	118	69	72	88
4	71	81	120	152	219	88	97	146	171	72	74	104	116	136	69	95	92
Mean	72	110	132	158	185	81	106	144	154	79	84	105	87	97	70	76	89
								30-60 cm soil depth									
1	234	476	345	311	282	141	165	311	321	199	170	306	228	185	292	209	224
2	345	413	491	384	360	272	292	462	365	180	316	423	262	423	214	151	311
3	256	224	224	428	476	160	301	345	340	233	350	340	199	316	190	248	335
4	267	233	214	292	505	267	228	335	467	233	272	224	287	452	258	243	233
Mean	276	337	318	354	406	210	247	363	373	211	277	323	244	344	238	213	276
								60-90 cm soil depth									
1	295	614	413	557	304	206	232	372	206	320	294	397	423	284	707	366	320
2	578	366	1011	279	263	402	372	588	330	310	408	356	470	320	712	222	392
3	355	464	341	289	531	330		578	470	201	480	475	392	315	227	243	531
4	430	356	253	227	408	335	346	413	562	454	433	217	356	893	258	186	335
Mean	414	450	504	338	377	319	316	488	392	321	404	361	410	453	476	254	395
								90-120 cm soil depth									
1	270	801	373	786	307	383	272	318	121	262	176	323	509	353	1633	474	444
2	1143	484	2187	312	247	318	282	902	302	343	922	252	983	328	1517	262	993
3	330	927	358	176	650	343		711	680	171	701	585	519	363	212	222	706
4	539	287	378	262	706	297	287	333	721	398	610	166	217	1386	267	151	292
Mean	570	625	824	384	478	335	281	566	456	294	602	331	557	607	907	277	609
								120-150 cm soil depth									
1	331	1102	526	1117	200	797	230	466	110	266	150	291	767	336	2575	581	661
2	1422	366	1844	721	366	666	341	1167	311	406	481	381	1463	706	1904	190	1593
3	420	1663	516	235	1092	361	952	1027	882	145	1042	797	616	561	160	321	1037
4	710	416	611	386	511	461	261	346	957	466	882	135	210	1608	346	155	296
Mean	721	887	874	615	542	571	446	752	565	321	639	401	764	803	1246	312	897

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.38. Soil extractable sodium (kg ha^{-1}) at the Lethbridge site in 2000.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	22	99	92	127	148	243	215	226	383	23	5	37	30	39	55	76	74
2	39	42	88	88	180	104	127	275	363	46	42	46	46	60	65	62	76
3	39	49	60	150	150	132	333	425	314	42	37	51	30	37	67	69	51
4	41	46	129	120	134	113	286	215	407	46	39	44	58	67	62	76	65
Mean	35	59	92	121	153	148	240	285	367	39	31	44	41	51	62	71	66
								15-30 cm soil depth									
1	30	122	146	182	185	129	185	162	716	25	28	74	60	55	65	83	85
2	60	90	173	178	249	155	127	226	416	60	58	76	69	72	69	69	97
3	49	81	106	215	180	116	233	305	266	55	67	81	46	55	76	81	62
4	52	95	171	155	210	97	201	180	256	49	65	76	76	92	72	79	83
Mean	48	97	149	182	206	124	187	218	413	47	54	77	63	69	70	78	82
								30-60 cm soil depth									
1	95	408	457	350	345	262	238	311	462	102	117	262	160	175	194	199	219
2	230	224	476	510	447	272	350	374	598	180	296	403	224	389	238	141	365
3	183	204	267	471	515	170	384	350	525	165	209	282	156	180	214	243	190
4	193	243	296	457	593	243	272	428	603	165	233	243	204	365	204	248	204
Mean	175	270	374	447	475	237	311	366	547	153	214	298	186	277	213	208	244
								60-90 cm soil depth									
1	270	748	851	304	366	490	341	423	387	217	201	408	227	299	449	320	330
2	482	351	986	490	294	480	418	501		294	402	341	418	284	733	175	593
3	289	335	325	387	562	273	433	459	444	217	366	444	341	268	248	315	418
4	375	346	243	310	624	351	382	552	578	377	433	248	320	944	289	248	402
Mean	354	445	601	373	462	399	393	484	470	276	351	360	326	449	430	264	436
								90-120 cm soil depth									
1	246	1225	1411	373	237	771	343	449	272	343	181	348	312	378	690	373	398
2	625	348	1552	398	267	323	277	559	272	403	524	282	650	302	756	277	963
3	263	680	287	192	585	272	514	398	585	176	428	570	433	212	192	237	489
4	415	398	287	227	670	312	312	494	570	504	524	171	272	1446	197	156	398
Mean	387	663	885	297	440	420	362	475	425	357	415	343	417	585	459	261	562
								120-150 cm soil depth									
1	244	1308	1929	561	351	1328	296	561	160	381	190	326	446	782	1237	426	576
2	1087	341	2029	832	316	436	256	1067	175	391	721	501	1212	726	1012	205	1408
3	309	1263	245	266	701	215	686	366	336	155	636	536	636	296	160	245	536
4	555	521	441	291	731	351	321	566	802	701	762	125	200	1764	235	135	486
Mean	549	858	1161	487	525	582	390	640	368	407	577	372	624	892	661	253	752

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.39. Soil extractable sodium (kg ha^{-1}) at the Lethbridge site in 2001.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	48	79	95	103	167	191	187	298	273	36	39	72	63	51	62	81	91
2	40	231	76	109	218	88	171	310	486	36	35	46	52	61	83	77	97
3	41	67	100	201	221	196	289	312	654	32	43	53	42	44	36	42	66
4	41	75	97	122	95	109	324	271	290	46	43	39	42	62	61	48	69
Mean	43	113	92	134	175	146	243	298	425	38	40	52	50	55	61	62	81
								15-30 cm soil depth									
1	48	129	141	163	212	199	176	256	251	49	53	99	73	47	66	82	95
2	51	203	149	199	339	79	201	363	457	53	63	49	83	78	74	68	99
3	51	89	160	269	382	166	275	308	466	43	49	79	66	51	50	69	76
4	47	122	164	201	160	113	334	254	313	57	61	76	73	64	77	92	73
Mean	49	136	153	208	273	139	247	295	372	50	56	76	74	60	67	78	86
								30-60 cm soil depth									
1	108	397	422	434	522	443	290	449	526	127	191	316	193	152	162	183	260
2	154	340	446	660	745	222	403	660	852	146	254	167	263	343	188	177	257
3	177	173	399	700	989	283	474	540	857	144	195	273	174	209	121	190	206
4	151	292	302	519	599	284	484	532	666	122	200	222	259	147	238	260	173
Mean	148	300	392	578	714	308	413	546	725	135	210	244	222	213	177	202	224
								60-90 cm soil depth									
1	231	717	596	481	345	490	289	519	465	224	283	426	317	173	369	218	377
2	413	345	836	774	515	441	386	607	570	184	396	472	498	598	562	205	506
3	295	265	488	514	997	262	453	498	688	215	407	418	411	373	208	308	556
4	319	383	278	391	960	384	435	512	690	277	443	286	393	356	381	248	294
Mean	315	427	550	540	704	394	391	534	603	225	382	401	405	375	380	244	433
								90-120 cm soil depth									
1	318	1223	859	508	327	1093	394	546	308	342	308	352	392	334	696	345	346
2	614	376	1685	466	317	409	345	705	327	285	471	303	1048	489	1087	239	861
3	284	497	601	205	662	359	478	405	719	148	640	539	588	333	231	250	951
4	333	353	289	277	1303	335	296	394	586	496	618	202	329	926	426	165	398
Mean	387	612	859	364	652	549	378	513	485	318	509	349	589	521	610	250	639
								120-150 cm soil depth									
1	344	1476	1457	726	317	2146	288	735	185	366	389	377	526	324	1413	418	485
2	1005	510	2317	606	399	340	296	958	262	358	908	326	1892	796	1744	184	1460
3	326	760	1183	201	942	238	472	346	910	139	985	644	900	652	172	292	1112
4	337	437	426	362	1597	315	271	250	579	676	887	177	363	1522	497	151	395
Mean	503	796	1346	474	814	760	332	572	484	385	792	381	920	823	957	261	863

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.40. Soil extractable sodium (kg ha^{-1}) at the Airdrie site in 1997.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	30	13	13	4	25	12	65	20	13	4	30	15	8	28	4	25	35
2	9	10	31	14	97	17	23	8	22	11	18	28	4	21	29	12	4
3	6	4	4	17	4	4	4	4	21	11	4	4	10	4	4	10	4
4	27	4	21	12	4	4	15	17	21	4	4	4		31	4	22	15
Mean	18	8	17	12	32	9	27	12	19	7	14	13	7.3	21	10	17	15
								15-30 cm soil depth									
1	31	76	30	5	172	53	184	30	22	26	38	48	14	36	14	60	44
2	23	18	5	23	84	30	34	20	48	13	27	17	5	28	20	26	5
3	13	5	5	19	15	13	11	5	15	13	5	5	20	5	5	24	16
4	29	5	12	13	15	5	5	21	10	5	5	23		27	5	49	15
Mean	24	26	13	15	71	25	58	19	24	14	19	23	13	24	11	40	20
								30-60 cm soil depth									
1	77	1038	158	10	509	104	2160	54	46	50	104	359	46	100	33	496	671
2	117	288	10	48	58	32	129	21	392	22	81	10	10	45	44	38	10
3	42	22	10	37	10	43	61	10	40	45	10	39	31	10	10	43	10
4	168	10	52	73	55	23	10	153	38	10	26	33		57	30	35	25
Mean	101	340	58	42	158	51	590	60	129	32	56	110	29	53	29	153	179
								60-90 cm soil depth									
1	290	1484	711	12	575	499	3236	141	170	94	867	716	52	89	57	1064	1178
2	317	1597	30	55	113	31	2157	38	1064	64	541	12	12	24	77	46	12
3	129	12	78	157	77	101	219	28	50	91	12	84	55	12	121	35	159
4	359	36	198	359	46	50	45	106	427	12	460	83		479	211	59	232
Mean	273	782	254	146	203	170	1414	78	428	65	470	224	40	151	116	301	395
								90-120 cm soil depth									
1	653	851	773	13	810	2076	2107	140	145	187	3052	1069	13	789	73	322	1355
2	335	1733	50	52	332	66	4842	31	1718	73	656	31	13	93	56	222	13
3	117	13	115	195	235	53	216	38	68	256	47	127	37	82	316	66	281
4	581	33	427	636	39	62	133	117	783	13	677	233		1273	372	48	318
Mean	421	658	341	224	354	564	1825	82	679	132	1108	365	21	559	204	165	492
								120-150 cm soil depth									
1	733	666	388	14	1021	1441	2331	93	207	207	2239	950	14	863	66	322	1491
2	394	1698	29	31	480	60	5253	38	2031	67	551	70	29	184	57	360	14
3	177	14	199	206	356	14	187	48	97	355	57	157	46	84	434	410	283
4	664	61	449	906	14	31	292	232	1402	14	707	349		2480	974	56	375
Mean	492	610	266	289	468	387	2016	103	934	161	888	382	30	903	382	287	540

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.41. Soil extractable sodium (kg ha^{-1}) at the Airdrie site in 1998.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
							0-15 cm soil depth										
1	32	50	55	59	82		57	54	125	47	100	54	36	47	34	85	70
2	59		12	58	123	13	104	42	95	17	82	175	109	31	43	48	34
3	13	35	36	32	60	27	99	36	140	68	102	61	137	40	37	118	178
4	16	22	88	103	117	20	18	153	44	20	56	35		114	75	128	388
Mean	30	36	48	63	96	20	69	71	101	38	85	81	94	58	47	95	167
							15-30 cm soil depth										
1	35	110	52	14	53	62	73	40	57	34	72	75	48	163	15	96	70
2	24	56	5	42	49	27	74	22	36	16	37	138	74	33	32	38	21
3	15	31	22	23	57	26	33	11	54	32	37	38	55	17	18	56	54
4	28	5	49	30	51	14	5	30	5	12	11	42		48	21	67	48
Mean	25	50	32	27	53	32	46	26	38	23	39	73	59	65	22	64	48
							30-60 cm soil depth										
1	143	519	378	10	165	281	1299		97	27	408	231	41	440	32	517	148
2	65	411	10	58	123	49	1663	62	186	45	281	417	39	53	55	85	10
3	61	52	10	10	49	91	86	10	51	30	10	59	95	26	38	76	178
4	105	10	63	95	76	10	33	47	75	37	23	54		45	34	129	31
Mean	93	248	115	44	103	108	770	40	102	35	180	190	58	141	40	202	92
							60-90 cm soil depth										
1	329	1019			422	932	1063	68	104	37	1257	794	12	537	37	731	487
2	304	1012	12	43	559	57	3608		845	42	382	847	12	68	98	186	12
3	150	65	12	53	85	73	151	54	46	107	32	100	161	52	132	62	161
4	582	52	72	249	67	12	66	53	243	53	75	159		207	33	276	57
Mean	341	537	32	115	283	268	1222	58	309	60	437	475	62	216	75	314	179
							90-120 cm soil depth										
1	453	513	521	13	616	1165	1238	119	105	63	2407	1046	52	536	13		841
2	386	1462	13	35	1264	49	3013	13		54	454	917	13	154	69	450	13
3	196	59	13	139	149	53	118	52	116	107	92	201	93	119	374	172	183
4	710	30	179	411	35	51	110	81	507	63	147	417		820	133	244	116
Mean	436	516	181	150	516	329	1119	66	243	72	775	645	53	407	147	289	288
							120-150 cm soil depth										
1	545	341	364	14	747	1785	1604	74	123	72	2251	1290	38	623	14	242	1186
2	333	1470	14	35	1867	63	4341	14	1749	69	474	908	14	93	50	672	14
3	207	55	86	238	265	56	94	234	96	219	183	464	133	265	626	352	153
4	770	54	513	468	14	55	156	112	1599	105	231	349		2933	400	283	169
Mean	464	480	244	189	723	490	1548	109	892	116	785	753	62	979	272	387	381

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.42. Soil extractable sodium (kg ha^{-1}) at the Airdrie site in 1999.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	26	53	56	60	151	64	133	69	465	31	145	104	95	57	122	131	126
2	21	126	36	106	132	138	167	144	298	29	96	98	150	42	103	199	252
3	11	52	52	63	65	19	36	111	330	46	82	92	162	147	79	179	269
4	29	25	53	113	145	45	91	131	187	50	138	65		102	124	185	171
Mean	22	64	49	85	123	67	107	114	320	39	115	90	136	87	107	173	205
								15-30 cm soil depth									
1	62	72	59	22	136	78	75	48	207	36	122	200	37	70	38	93	131
2	64	65	23	70	125	67	155	57	202	39	70	130	41	35	36	161	49
3	19	35	39	47	89	27	44	52	277	60	140	109	283	149	32	194	163
4	43	17	57	163	49	32	73	24	63	28	51	122		75	74	114	56
Mean	47	47	44	76	100	51	87	45	187	41	96	140	120	82	45	141	100
								30-60 cm soil depth									
1	312	248	110	33	237	196	353	100	139	54	146	466	75	226	47	592	673
2	241	545	35	84	114	81	2437	81	773	87	148	254	52	165	71	214	65
3	69	55	48	59	103	95	183	61	109	61	81	113	127	95	45	156	145
4	297	64	83	113	63	64	82	45	137	53	83	139		319	65	89	118
Mean	230	228	69	72	129	109	764	72	289	64	115	243	85	201	57	263	250
								60-90 cm soil depth									
1	494	876	225	31	282	1376	892	76	98	66	867	1049	45	494	57	906	791
2	276	1313	35	124	347	76	2798	126	2225	97	186	323	55	256	143	2412	92
3	171	54	95	88	87	94	252	75	111	106	163	109	146	114	140	100	300
4	635	76	142	185	67	70	119	73	505	135	178	221		1139	68	108	240
Mean	394	580	124	107	196	404	1015	87	735	101	348	425	82	501	102	881	356
								90-120 cm soil depth									
1	558	440	310	28	480	2665	1451	67	122	58	2961	1872	36	664	60	366	987
2	329	1672	47	102	924	75	3495	221	1837	103	155	387	43	299	190	3083	77
3	263	78	102	140	147	78	164	66	197	192	175	242	141	276	419	381	283
4	631	87	223	229	59	77	150	110	892	141	217	289		1992	172	127	320
Mean	446	569	171	125	403	724	1315	116	762	124	877	697	73	808	210	989	416
								120-150 cm soil depth									
1	638	447	246	31	555	2681	1510	55	151	65	2488	2412	28	625	66	165	1181
2	325	1434	45	104	1275	81	3284	165	1614	82	140	390	50	294	213	2120	44
3	314	72	134	167	221	71	135	70	180	332	208	341	133	444	628	517	318
4	744	103	363	359	55	90	193	136	927	124	252	361		3257	262	175	347
Mean	505	514	197	165	526	731	1280	106	718	151	772	876	70	1155	292	744	473

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.43. Soil extractable sodium (kg ha^{-1}) at the Airdrie site in 2000.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	33	71	73	152	112	97	155	165	257	75	60	76	82	97	100	171	273
2	21	98	49	96	149	123	247	199	334	67	62	97	129	96	161	207	197
3	15	88	99	93	89	135	132	216	410	75	90	55	182	95	115	235	229
4	20	64	107	119	160	85	109	239	461	27	49	90		88	133	111	267
Mean	22	80	82	115	127	110	161	205	365	61	65	80	131	94	127	181	242
								15-30 cm soil depth									
1	36	141	82	139	159	158	91	220	261	57	108	103	124	76	102	125	294
2	29	263	34	85	165	124	72	124	211		105	134	142	60	68	124	86
3	21	62	57	76	126	72	130	161	287	63	115	113	263	54	59	211	126
4	33	60	88	146	213	49	84	285	251	33	82	114		46	125	77	153
Mean	30	132	65	112	166	101	95	198	253	51	102	116	176	59	89	134	165
								30-60 cm soil depth									
1	258	1432	317	91	265	708	107	166	257	56	201	236	192	268	90	589	899
2	132	839	44	88	166	91	1523	98	465	107	256	142	72	156	76	319	59
3	82	72	81	77	132	126	260	77	122	73	91	207	210	125	142	109	313
4	248	68	105	271	148	58	75	183	158	107	184	120		109	88	110	136
Mean	180	603	137	132	178	246	491	131	251	86	183	176	158	164	99	282	352
								60-90 cm soil depth									
1	450	1754	585	77	255	1153	377	152	169	269	315	260	87	468	76	833	944
2	239	1061	41	81	324	82	2920	108	927	131	342	217	51	303	79	768	53
3	177	62	83	110	113	97	292	60	199	129	124	182	276	209	225	117	512
4	735	43	132	274	86	55	95	90	221	157	133	367		371	65	154	197
Mean	400	730	210	135	194	347	921	103	379	172	229	257	138	338	111	468	426
								90-120 cm soil depth									
1	622	842	641	53	300	1569	786	128	160	47	1252	612	63	575	88	414	1148
2	254	1396	30	63	585	81	3207	89	1412	117	500	208	45	297	78	1917	48
3	238	59	95	121	133	79	188	78	176	237	130	261	170	365	348	296	800
4	766	51	210	444	98	72	118	105	327	206	162	386		1431	140	167	222
Mean	470	587	244	170	279	450	1075	100	519	152	511	367	93	667	164	698	554
								120-150 cm soil depth									
1	671	724	545	50	361	1869	1041	137	193	52	1498	881	50	506	106	280	1328
2	272	1234	43	75	832	107	3375	155	1572	103	449	220	61	288	90	1996	92
3	289	72	124	153	201	78	162	106	213	323	174	399	211	332	447	327	974
4	849	66	330	520	129	91	147	140	518	281	167	358		1777	282	182	232
Mean	520	524	261	200	381	536	1181	134	624	190	572	465	107	726	231	696	656

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.44. Soil extractable sodium (kg ha^{-1}) at the Airdrie site in 2001.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	24	50	81	109	114	78	133	404	194	81	132	96	119	120	200	420	222
2	14	51	81	146	161	62	123	309	340	65	153	88	161	190	393	324	277
3	15	56	87	155	158	44	70	208	71	103	166	69	134	193	234	252	214
4	20	49	142	132	245	135	109	224	275	77	80	118		115	166	226	442
Mean	18	51	97	136	169	80	109	286	220	82	133	93	138	154	248	305	289
								15-30 cm soil depth									
1	61	73	86	83	204	210	114	385	127	37	158	265	247	77	78	281	212
2	29	218	57	185	194	74	128	32	405	95	188	171	198	75	300	221	76
3	20	80	59	65	169	43	53	240	626	60	105	182	164	51	121	85	247
4	36	24	177	110	195	64	130	125	338	38	136	152		91	161	202	169
Mean	36	99	95	111	190	98	106	196	374	57	147	193	203	74	165	197	176
								30-60 cm soil depth									
1	400	216	122	60	414	227	227	191	477	90	362	662	305	116	50	469	216
2	84	957	48	159	633	115	326	610	417	177	181	352	171	150	124	111	38
3	63	82	47	58	126	85	135	161	910	161	281	223	159	270	82	67	373
4	228	50	178	73	147	84	68	107	183	70	142	226		156	128	160	124
Mean	194	326	99	87	330	128	189	267	497	124	242	366	212	173	96	201	188
								60-90 cm soil depth									
1	473	682	125	42	414	576	355	132	116	81	1691	544	52	145	69	760	597
2	160	1377	29	145	270	81	1166	158	621	162	161	853	65	301	106	146	536
3	126	80	61	81	115	89	224	83	252	350	198	151	87	69	57	91	467
4	999	75	488	120	106	110	69	106	333	128	73	261		297	112	689	272
Mean	439	554	176	97	227	214	453	120	331	180	531	452	68	203	86	422	468
								90-120 cm soil depth									
1	530	847	285	40	719	860	695	104	128	57	2950	1252	40	220	63	482	624
2	277	1237	39	121	1260	98	2683	68	945	166	102	806	42	133	98	534	65
3	179	116	61	111	130	72	198	92	186	385	164	333	91	77	172	213	779
4	960	87	1109	275	69	134	88	143	386	179	135	455		881	185	985	421
Mean	486	572	373	137	545	291	916	102	411	196	838	711	58	328	130	553	472
								120-150 cm soil depth									
1	437	418	89	51	984	1178	966	82	170	54	2900	2072	48	481	75	177	1161
2	258	975	52	72	1510	94	3274	77	1252	153	102	946	34	124	97	965	68
3	241	104	76	130	183	86	163	101	189	579	193	558	105	213	434	573	947
4	877	153	1028	433	63	96	91	172	437	266	215	632		1459	422	574	441
Mean	453	412	311	171	685	364	1123	108	512	263	853	1052	62	569	257	573	654

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.45. Soil extractable potassium (kg ha^{-1}) at the Lethbridge site in 1996.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	955	709	1042	829	869	966	896	825	1058	1021	1132	797	899	982	1026	598	906
2	790	1428	1127	993	730	723	1060	986	966	698	809	984	936	866	707	848	1291
3	824	665	686	790	774	834	850	917	797	1192	1227	675	875	968	1067	1132	843
4	889	942	721	929	675	688	1023	587	707	778	785	952	1007	857	852	1074	742
Mean	865	936	894	885	762	803	957	829	882	922	988	852	929	918	913	913	945
								15-30 cm soil depth									
1	742	536	822	825	536	681	776	617	610	730	774	517	887	850	619	598	834
2	628	899	975	511	755	591	751	899	723	605	619	728	538	871	670	619	742
3	598	675	527	589	566	596	765	541	919	875	799	617	529	864	845	915	575
4	723	589	776	695	409	608	755	538	543	520	543	825	746	788	832	901	444
Mean	673	675	775	655	567	619	762	649	699	683	684	672	675	843	742	758	649
								30-60 cm soil depth									
1	1162	953	1371	1482	632	1025	1395	1089	948	1672	797	1001	1317	1128	977	948	1288
2	1101	1327	1682	812	1128	875	1366	1482	1225	1045	953	1001	1458	1030	967	875	1682
3	1089	1142	909	671	1132	1069	1371	851	1575	1842	1691	1186	724	1823	1696	1628	851
4	1051	821	1764	1672	836	972	1050	948	948	953	1317	1307	1011	1268	1176	1910	1064
Mean	1100	1061	1431	1159	932	985	1295	1092	1174	1378	1189	1124	1128	1312	1204	1340	1221
								60-90 cm soil depth									
1	1006	924	1269	1305	759	1094	986	1063	913	1342	815	1161	1135	846	939	769	1109
2	831	903	1424	743	779	888	1037	1300	1223	893	1099	826	1073	1011	851	1042	1677
3	1133	893	614	1151	1156	676	1202	867	1692	1357	1765	1218	686	1600	1631	1806	986
4	1045	1037	1894	1811	1063	1032	831	1187	872	1027	1187	1104	1161	1238	1037	1966	1140
Mean	1004	939	1300	1253	939	922	1014	1104	1175	1155	1216	1077	1014	1174	1115	1396	1228
								90-120 cm soil depth									
1	1011	1008	1205	1240	585	1235	1124	1068	1038	862	937	1270	1058	1109	973	958	1124
2	956	1028	1371	837	781	907	1104	1346	1089	827	1235	973	1124	847	1119	862	1401
3	1097	1013	771	1043	1159	801	1200	1079	1547	963	1527	1144	837	1225	1608	1845	1089
4	1208	1265	1809	1774	1018	1220	1013	1063	907	953	1104	968	1114	1275	1084	2127	1043
Mean	1068	1079	1289	1223	886	1041	1110	1139	1145	901	1201	1089	1033	1114	1196	1448	1164
								120-150 cm soil depth									
1	1093	1002	1172	1187	867	1112	897	982	997	1308	1308	1278	1253	1227	1112	1062	1207
2	1055	1247	1393	1017	842	1077	1172	1062	1122	1147	1052	1047	1217	1142	1122	1062	1308
3	998	1197	1077	1112	1227	902	1057	1117	1533	907	1318	1052	1117	1207	1338	1854	1247
4	1159	1172	2074	1924	1027	1192	1092	1012	927	1017	1207	752	1232	967	1142	2224	942
Mean	1076	1155	1429	1310	991	1071	1055	1043	1145	1095	1221	1032	1205	1136	1179	1551	1176

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.46. Soil extractable potassium (kg ha^{-1}) at the Lethbridge site in 1997.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	869	2973	1880	4149	2890	1790	1368	3479	2719	1261	1552	1566	1525	1169	1065	1076	1051
2	696	1042	1363	3714	959	1331	799	1033	848	915	776	912	714	677	1026	654	1176
3	654	984	1280	668	2821	691	748	1485	1529	1021	815	716	608	1185	1049	1386	566
4	872	1319	1772	2128	1522	1488	1407	688	954	638	582	804	594	852	1273	1023	534
Mean	773	1579	1574	2665	2048	1325	1081	1671	1512	959	932	1000	860	971	1103	1035	832
								15-30 cm soil depth									
1	532	2964	608	979	672	480	536	742	584	573	381	513	672	686	541	561	693
2	531	416	926	684	635	614	598	644	524	483	524	497	571	626	522	483	681
3	522	418	418	353	714	455	476	425	744	725	723	480	358	735	827	638	344
4	527	490	827	594	383	638	716	402	504	453	478	841	508	407	658	850	462
Mean	528	1072	695	653	601	547	582	553	589	558	527	583	527	613	637	633	545
								30-60 cm soil depth									
1	776	1089	846	1312	1050	923	899	919	943	812	685	646	899	851	734	491	739
2	763	1011	1196	870	1084	826	1001	957	987	661	588	433	627	593	598	831	1055
3	961	695	413	549	744	661	923	423	1614	1477	1380	991	773	1638	1677	1550	690
4	748	593	1847	1249	821	860	948	763	894	442	782	1176	773	962	880	1575	680
Mean	812	847	1075	995	925	818	943	765	1109	848	859	812	768	1011	972	1112	791
								60-90 cm soil depth									
1	756	1006	888	1269	800	697	955	815	676	702	846	691	882	795	655	588	722
2	854	501	1280	702	728	774	784	975	888	568	867	557	676	671	542	753	1146
3	942	676	490	774	676	552	1120	537	1429	1471	1471	1140	836	1275	1579	1852	929
4	844	614	1651	1749	857	913	691	1011	955	599	898	722	774	1058	872	1791	645
Mean	849	699	1077	1124	765	734	888	835	987	835	1020	778	792	949	912	1246	860
								90-120 cm soil depth									
1	872	968	751	1008	630	670	1043	811	1038	690	766	877	882	912	660	600	847
2	828	806	1048	504	564	751	811	1028	948	816	842	731	932	786	791	721	1341
3	960	776	660	877	892	711	1104	726	1285	862	1462	1074	867	1048	1462	1698	1013
4	1042	948	1643	1840	811	1053	761	897	937	741	983	645	912	1003	932	1910	620
Mean	925	874	1026	1057	725	796	930	866	1052	777	1013	832	898	937	961	1232	955
								120-150 cm soil depth									
1	834	962	782	1002	832	772	1017	802	671	897	701	892	902	1012	977	746	957
2	845	957	1127	711	726	621	807	1052	942	987	847	666	982	872	777	827	1258
3	934	852	792	706	942	726	1052	782	1373	741	1137	952	842	1127	1393	1673	1037
4	987	932	2004	1979	827	937	997	802	927	922	962	641	857	892	1112	1693	1042
Mean	900	926	1176	1100	832	764	968	859	978	887	912	788	896	976	1065	1235	1073

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.47. Soil extractable potassium (kg ha^{-1}) at the Lethbridge site in 1998.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	828	1430	1522	2393	1416	3897	1358	1386	1421	642	1000	1035	1146	700	1162	617	1053
2	561	381	2409	1786	1009	961	439	474	707	735	903	869	1638	802	1111	956	471
3	634	878	374	393	377	852	753	520	1076	959	753	601	938	1197	1065	1208	395
4	789	936	2118	2948	2654	1009	2421	1437	2763	827	656	1123	919	785	1139	1568	820
Mean	703	906	1606	1880	1364	1680	1243	954	1492	791	828	907	1160	871	1119	1087	685
								15-30 cm soil depth									
1	565	434	681	864	363	834	679	661	681	538	499	483	915	416	589	353	695
2	433	282	956	545	372	571	370	293	256	513	499	594	748	624	739	834	307
3	1390	614	1033	3234	3324	1081	478	1751	478	725	686	446	608	790	813	705	450
4	482	432	1076	1076	677	485	762	499	651	552	506	790	455	504	776	1040	462
Mean	718	441	937	1430	1184	743	572	801	517	582	547	578	681	583	729	733	479
								30-60 cm soil depth									
1	953	773	1011	1239	758	1200	1186	909	705	744	486	700	1458	787	875	486	729
2	727	710	1322	714	646	661	768	569	782	885	744	680	1176	676	666	642	481
3	1661	1171	1550	2780	2853	1638	515	1443	671	1580	1254	442	957	1477	1448	1385	734
4	706	564	1774	1594	680	826	899	875	821	462	812	1244	656	885	996	1750	666
Mean	1011	804	1414	1582	1234	1081	842	949	745	917	824	767	1062	956	996	1066	652
								60-90 cm soil depth									
1	801	815	1099	1197	624	707	1290	934	826	702	645	784	1342	867	748	537	583
2	712	650	980	604	929	789	779	676	759	666	882	820	1207	815	826	635	604
3	1227	1280	996	1192	1347	1455	542	1295	681	1321	1316	526	960	1197	1507	1605	475
4	786	743	1760	1858	779	717	650	846	888	681	836	841	630	918	759	1734	733
Mean	881	872	1209	1213	920	917	815	938	788	842	920	743	1035	949	960	1127	599
								90-120 cm soil depth									
1	857	907	968	1099	781	816	932	685	771	882	796	948	1295	786	872	675	897
2	814	801	1048	680	968	706	832	867	776	781	907	721	983	766	832	711	640
3	1207	1230	660	978	811	1154	806	1164	756	756	1164	499	867	932	1416	1542	418
4	843	852	2006	1840	796	867	595	852	786	842	948	615	721	917	751	1567	983
Mean	930	948	1171	1149	839	886	791	892	772	815	954	696	966	851	968	1124	735
								120-150 cm soil depth									
1	1050	957	917	987	772	797	661	752	767	1042	947	942	1032	952	907	887	892
2	870	3562	957	887	1443	797	1127	2234	8101	947	787	757	1022	827	802	676	2550
3	1060	1052	812	1032	686	1192	762	731	917	862	1037	571	967	857	1162	1548	411
4	855	807	2109	2014	641	746	546	666	882	902	972	601	772	706	731	1298	957
Mean	959	1594	1199	1230	886	883	774	1096	2667	938	936	718	948	835	901	1102	1202

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.48. Soil extractable potassium (kg ha^{-1}) at the Lethbridge site in 1999.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	725	2030	1943	2054	307	1381	1499	947	1451	952	1210	716	802	781	527	425	691
2	484	748	806	933	1053	568	547	665	975	485	474	397	584	418	626	878	656
3	583	878	1035	1067	1721	772	633	1238	839	638	675	499	584	557	753	631	367
4	544	633	839	1548	1451	566	802	737	836	444	485	605	580	460	742	688	497
Mean	584	1072	1156	1400	1133	822	870	897	1025	629	711	554	638	554	662	655	553
								15-30 cm soil depth									
1	483	467	434	656	409	550	654	360	515	409	490	249	335	547	310	298	404
2	363	390	464	280	416	268	409	485	441	365	222	226	413	388	351	404	617
3	418	400	291	427	464	397	467	439	628	584	573	418	374	552	693	483	277
4	381	266	647	642	409	256	464	293	370	296	342	538	402	374	504	698	328
Mean	411	381	459	501	424	368	498	394	489	413	407	358	381	465	464	471	407
								30-60 cm soil depth									
1	657	792	885	1064	860	505	1152	768	573	676	433	452	462	637	583	471	680
2	638	525	1035	452	452	520	573	967	855	588	593	413	812	530	486	603	1264
3	840	573	403	646	680	525	943	486	1186	962	1186	885	467	943	1302	1434	671
4	599	428	1453	1497	680	656	612	685	768	447	544	676	588	889	651	1487	569
Mean	683	580	944	915	668	552	820	727	846	668	689	606	582	750	756	999	796
								60-90 cm soil depth									
1	654	898	898	965	960	578	1362	872	562	630	573	722	728	578	599	583	619
2	608	681	1032	501	459	614	660	1068	918	609	691	604	939	630	578	630	1264
3	898	686	516	774	769	495		738	1187	769	1321	955	470	913	1032	1502	846
4	804	676	1708	1682	676	841	676	836	800	614	697	588	836	970	660	1703	717
Mean	741	735	1038	980	716	632	900	878	867	655	820	717	743	773	717	1104	862
								90-120 cm soil depth									
1	829	832	706	998	872	630	1159	736	585	801	822	731	862	766	822	605	837
2	706	887	892	570	585	564	746	882	882	892	801	615	932	721	690	690	1124
3	873	877	716	716	801	595		842	1174	862	1134	932	675	958	1023	1416	937
4	832	852	1799	1774	696	776	680	811	781	660	897	605	766	937	816	1567	690
Mean	810	862	1028	1014	738	641	862	818	856	804	914	721	809	845	838	1070	897
								120-150 cm soil depth									
1	897	912	827	1012	651	696	1057	792	726	952	837	877	962	847	847	671	767
2	721	842	982	686	767	686	822	746	832	832	767	686	952	777	666	731	1077
3	881	872	872	772	877	616	922	782	1062	812	1167	862	812	942	947	1403	962
4	800	746	1954	1884	706	857	762	762	752	646	827	626	777	832	827	1418	782
Mean	825	843	1159	1088	750	714	891	770	843	810	899	763	875	849	822	1056	897

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.49. Soil extractable potassium (kg ha^{-1}) at the Lethbridge site in 2000.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	861	1897	2088	3026	3192	2615	2807	2647	3153	936	1033	845	1167	871	647	938	1254
2	681	2019	1959	3169	4729	1645	1811	2541	4876	497	711	693	783	675	728	1053	993
3	542	1194	1395	1850	3248	1014	2876	2592	3846	758	695	802	906	852	635	714	908
4	640	1326	1663	3091	3077	1441	2148	1973	4243	584	557	993	658	679	843	1197	1040
Mean	681	1609	1776	2784	3561	1679	2410	2438	4030	694	749	833	878	769	713	975	1049
								15-30 cm soil depth									
1	640	924	1104	1446	1277	619	765	825	3812	758	529	379	933	575	598	425	640
2	437	878	617	1125	2190	568	700	1137	3546	400	427	397	501	631	531	504	663
3	460	707	725	746	1987	591	1137	594	1169	686	517	522	626	665	663	522	707
4	495	416	705	2155	1386	665	642	467	961	515	404	624	420	453	649	728	557
Mean	508	731	788	1368	1710	611	811	755	2372	590	470	480	620	581	610	545	642
								30-60 cm soil depth									
1	825	763	1103	1925	787	719	1030	831	1589	1074	535	608	1055	865	729	462	676
2	751	928	996	651	1021	486	1050	1094	1623	608	661	583	797	734	627	617	1196
3	815	705	481	462	953	593	1341	428	2556	1371	1244	928	646	1273	1234	1113	792
4	663	462	1565	1341	700	875	661	821	851	535	588	948	510	933	816	1497	632
Mean	764	714	1036	1095	865	668	1021	793	1655	897	757	767	752	951	852	922	824
								60-90 cm soil depth									
1	657	924	1078	1976	877	686	1063	857	738	666	583	743	846	531	630	583	630
2	655	826	1037	547	526	671	872	1104		495	769	609	851	913	660	588	1182
3	864	660	480	722	630	531	1156	557	1434	929	1238	955	526	1115	1290	1553	893
4	777	738	1744	1584	769	831	743	867	810	516	702	568	676	965	707	1574	918
Mean	738	787	1085	1207	700	680	958	846	994	651	823	719	725	881	822	1075	906
								90-120 cm soil depth									
1	770	857	963	1905	585	696	842	791	811	857	696	761	877	640	766	635	751
2	677	887	917	640	655	590	756	862	912	741	811	559	922	867	731	620	1149
3	824	857	524	575	766	640	983	665	1331	776	1149	852	595	1053	1270	1588	902
4	764	882	1875	1673	696	912	822	701	746	665	781	549	756	847	847	1250	791
Mean	759	871	1070	1198	675	709	851	755	950	760	859	680	788	852	903	1023	898
								120-150 cm soil depth									
1	830	827	857	1448	882	636	777	711	757	932	792	782	957	1263	882	671	862
2	706	1097	897	757	902	716	726	671	606	741	651	646	917	757	606	711	1167
3	799	1057	681	626	767	711	1167	716	812	907	1057	711	711	1002	902	1678	872
4	760	691	2024	1879	601	847	937	661	646	716	631	601	721	787	857	1157	686
Mean	774	918	1115	1177	788	728	902	690	705	824	783	685	827	952	812	1055	897

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.50. Soil extractable potassium (kg ha^{-1}) at the Lethbridge site in 2001.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	809	1334	2298	2258	3900	2879	1981	3366	3151	836	898	616	1196	916	1028	880	1192
2	767	2325	2613	3650	3085	1104	2847	5365	7346	863	1104	805	1966	830	955	983	1622
3	732	1146	2092	3351	5520	2061	2596	4003	7048	1042	1410	974	1066	935	1440	1441	670
4	728	972	2139	2698	2347	1050	2900	3073	3169	589	652	1185	1063	807	962	1365	1309
Mean	759	1444	2285	2989	3713	1773	2581	3952	5178	833	1016	895	1323	872	1096	1167	1198
								15-30 cm soil depth									
1	640	719	1184	1196	2118	1287	874	1756	1447	656	586	403	840	757	681	579	805
2	621	880	1052	1998	1425	681	1870	2780	3252	607	656	744	1005	652	660	593	829
3	548	673	1104	1656	2128	962	1037	1622	3123	743	840	598	583	757	782	745	356
4	525	510	967	1128	1265	471	880	836	1022	425	440	792	653	605	684	818	637
Mean	583	695	1077	1495	1734	850	1165	1748	2211	608	631	634	770	693	702	684	657
								30-60 cm soil depth									
1	857	1048	1322	1413	1670	1508	1215	1447	1110	924	865	752	1076	1148	983	724	1004
2	1009	1102	1478	1047	1258	869	1802	1948	1905	1016	899	800	1118	903	898	889	1356
3	1015	1032	962	746	1476	1230	1437	956	2534	1487	1537	1051	880	1225	1504	1420	668
4	885	679	1906	1672	1082	895	1472	1163	956	646	767	1419	935	818	1090	1719	838
Mean	942	965	1417	1219	1372	1126	1481	1379	1626	1018	1017	1006	1002	1024	1119	1188	967
								60-90 cm soil depth									
1	848	1109	1227	1410	797	1189	1010	1181	945	662	798	906	973	700	892	627	999
2	816	712	1328	658	725	778	864	1586	1196	652	866	711	1114	984	681	734	1248
3	1006	840	645	799	1058	573	1163	716	1811	1007	1572	1136	583	1203	1283	1431	940
4	949	931	1978	1954	938	1046	754	1057	810	612	929	1091	977	761	931	1911	905
Mean	905	898	1295	1205	880	896	948	1135	1191	733	1041	961	912	912	947	1176	1023
								90-120 cm soil depth									
1	848	1004	1061	1211	737	1042	1063	981	893	796	772	941	1037	849	958	1072	924
2	826	878	1183	640	818	815	884	1446	986	762	798	768	1162	902	896	760	1196
3	968	709	930	858	904	576	614	895	1549	883	1395	1007	830	1005	1018	1279	989
4	858	988	1948	1927	785	901	877	967	901	710	1015	780	787	928	940	1975	984
Mean	875	895	1281	1159	811	834	860	1072	1082	788	995	874	954	921	953	1271	1023
								120-150 cm soil depth									
1	900	1040	940	1057	770	875	862	878	745	950	772	1079	1184	893	985	721	934
2	856	994	1066	960	1042	730	953	1256	993	837	803	730	1174	881	793	760	1134
3	918	931	952	756	963	829	958	903	1316	920	1303	932	1029	1073	939	1422	1049
4	790	884	2098	1981	835	967	1057	800	817	862	942	818	750	944	905	1768	950
Mean	866	962	1264	1188	902	850	958	959	968	892	955	890	1035	948	906	1168	1017

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.51. Soil extractable potassium (kg ha^{-1}) at the Airdrie site in 1997.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	507	741	496	486	220	431	310	336	852	589	228	308	330	248	603	276	348
2	455	353	376	868	216	427	323	321	218	394	361	978	666	414	160	212	798
3	394	833	343	334	304	971	357	357	212	288	301	366	428	472	344	328	252
4	230	277	241	368	578	264	205	130	221	236	232	460	244	163	260	278	207
Mean	396	551	364	514	330	523	299	286	376	377	281	528	417	324	342	274	401
								15-30 cm soil depth									
1	356	431	337	347	94	359	253	331	591	497	219	249	309	263	471	194	263
2	288	128	694	504	186	254	249	345	124	146	297	377	536	335	222	244	660
3	360	511	279	272	244	738	247	196	211	299	300	248	403	337	288	244	242
4	192	131	175	275	370	196	116	108	148	167	173	307	219	215	192	225	178
Mean	299	300	371	349	223	387	216	245	268	277	247	295	367	288	293	227	336
								30-60 cm soil depth									
1	413	751	459	475	200	404	417	467	667	842	350	404	467	571	926	471	209
2	531	183	1119	1102	463	575	209	563	158	168	183	254	884	492	359	420	926
3	448	711	272	386	440	1492	636	229	394	302	229	578	734	448	501	429	404
4	223	194	148	292	730	214	144	160	201	236	366	484	398	405	333	511	386
Mean	404	460	500	564	458	671	351	355	355	387	282	430	621	479	530	458	481
								60-90 cm soil depth									
1	312	787	410	236	226	301	283	325	367	320	325	546	301	429	612	344	226
2	395	273	693	1128	504	398	236	509	245	162	181	197	425	272	222	473	725
3	311	345	214	189	407	969	475	281	160	325	303	742	684	321	897	413	190
4	192	204	179	347	673	187	134	187	344	309	425	361	156	138	459	344	193
Mean	303	402	374	475	453	464	282	325	279	279	309	462	392	290	548	393	333
								90-120 cm soil depth									
1	300	306	441	322	239	192	197	275	441	291	452	841	254	202	711	208	234
2	291	275	1281	530	327	215	493	218	296	151	198	365	342	278	202	353	394
3	298	298	231	216	508	504	253	304	175	359	216	787	358	331	770	400	186
4	277	247	277	435	314	210	210	217	480	398	572	258	114	244	453	236	286
Mean	291	282	558	376	347	280	288	254	348	299	360	563	267	264	534	299	275
								120-150 cm soil depth									
1	296	268	344	371	251	175	251	311	453	273	311	1278	278	186	879	268	317
2	374	284	1191	453	268	207	606	295	355	241	230	582	393	434	280	367	322
3	314	318	363	308	596	459	245	314	205	384	224	729	333	235	874	365	213
4	324	323	348	505	362	199	264	324	847	434	637	289	134	585	476	359	276
Mean	327	298	561	409	369	260	342	311	465	333	351	719	284	360	627	340	282

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.52. Soil extractable potassium (kg ha^{-1}) at the Airdrie site in 1998.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
							0-15 cm soil depth										
1	373	682	649	724	600		454	297	1115	372	339	293	454	301	327	332	249
2	237		715	829	302	417	387	324	238	248	251	591	462	514	191	173	666
3	371	882	497	417	579	828	627	352	397	444	426	551	624	342	441	336	381
4	279	278	431	569	937	237	140	308	351	479	274	431	391	254	190	314	655
Mean	315	614	573	635	604	494	402	320	525	386	323	466	483	353	287	289	488
							15-30 cm soil depth										
1	276	413	430	289	297	320	354	299	446	315	209	204	355	169	217	226	243
2	302	114	701	523	210	265	217	322	222	191	173	285	469	453	214	218	620
3	248	439	413	319	497	523	286	284	312	267	240	285	261	340	281	216	239
4	215	123	233	266	365	200	77	201	225	304	218	214	157	199	128	236	211
Mean	260	272	444	349	342	327	233	277	301	269	210	247	310	290	210	224	328
							30-60 cm soil depth										
1	417	932	576	306	256	400	308		439	241	297	387	652	220	384	414	231
2	460	155	698	1055	242	392	165	558	193	219	167	237	965	574	236	212	644
3	324	726	295	212	702	602	495	289	382	450	273	450	308	392	469	373	238
4	290	176	502	397	647	302	191	204	267	296	294	352	417	193	257	445	398
Mean	373	497	518	493	462	424	290	350	320	301	258	356	585	345	337	361	378
							60-90 cm soil depth										
1	259	715			220	164	170	315	320	146	335	471	320	142	450	290	160
2	247	175	561	616	292	272	216		238	100	165	131	445	233	152	216	392
3	300	378	322	170	208	225	277	228	145	414	158	442	159	254	545	288	132
4	270	179	312	460	394	186	268	131	285	417	323	232	187	177	287	325	207
Mean	269	362	398	415	279	212	233	225	247	270	245	319	278	202	359	280	223
							90-120 cm soil depth										
1	200	343	461	411	255	181	154	449	270	169	404	639	282	119	360		169
2	270	248	756	329	376	164	239	285		156	108	154	272	334	145	244	309
3	310	223	431	206	277	181	144	262	111	324	274	541	154	312	688	245	132
4	292	254	190	526	235	251	285	190	460	586	387	205	190	258	338	194	273
Mean	268	267	459	368	286	194	206	297	280	309	293	385	225	256	383	228	221
							120-150 cm soil depth										
1	238	278	447	425	247	207	177	426	284	189	308	942	275	138	425	167	231
2	280	336	782	292	538	163	423	287	266	242	182	158	314	344	158	230	473
3	293	227	533	450	404	200	182	430	114	413	359	858	256	468	909	239	144
4	379	407	275	534	307	271	268	216	1132	607	503	185	184	865	453	242	311
Mean	297	312	509	425	374	210	262	339	449	363	338	536	257	454	486	219	290

[z] Control: No manure application; each replicate value is a mean of four control plots.
[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).
[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.53. Soil extractable potassium (kg ha^{-1}) at the Airdrie site in 1999.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	350	539	593	796	1003	595	695	270	3049	494	337	254	413	348	476	362	544
2	335	446	473	818	403	765	420	593	1687	170	288	812	582	410	607	413	902
3	424	962	537	483	1111	617	758	1052	1427	384	299	495	1158	408	463	298	429
4	224	228	325	1193	905	281	426	597	821	272	275	526	428	238	372	263	246
Mean	333	544	482	822	856	564	575	628	1746	330	300	522	645	351	479	334	530
								15-30 cm soil depth									
1	318	413	353	139	424	366	317	285	1207	283	301	574	324	276	249	202	406
2	221	184	342	491	429	286	331	244	507	101	199	219	220	287	321	272	394
3	362	575	389	283	424	481	330	352	616	441	299	257	481	457	198	467	284
4	186	82	399	423	483	210	259	138	268	186	227	249	258	134	240	203	173
Mean	272	313	371	334	440	336	310	255	649	253	256	325	321	289	252	286	314
								30-60 cm soil depth									
1	471	790	435	245	323	1030	272	312	640	434	301	498	742	444	378	392	653
2	295	225	464	796	384	435	241	303	311	226	243	334	274	382	282	297	538
3	429	869	443	415	472	676	444	347	429	434	460	368	523	536	371	476	462
4	297	154	371	372	652	314	259	194	356	266	358	434	350	174	348	404	230
Mean	373	509	428	457	458	614	304	289	434	340	340	409	472	384	345	392	471
								60-90 cm soil depth									
1	277	803	348	288	299	248	177	272	326	252	337	409	438	284	456	273	437
2	270	241	334	731	252	309	266	353	273	249	293	298	346	302	263	260	430
3	289	492	274	218	404	267	307	312	184	249	219	406	265	412	733	238	269
4	302	209	199	428	409	191	288	171	634	329	349	338	246	227	306	261	262
Mean	285	436	289	416	341	254	259	277	354	270	299	363	324	306	440	258	349
								90-120 cm soil depth									
1	261	417	407	341	267	277	226	253	335	254	383	430	339	180	522	210	479
2	308	297	388	374	321	229	324	519	288	374	296	324	360	411	298	315	358
3	294	309	280	221	451	250	203	294	190	413	254	694	291	383	817	353	202
4	327	275	266	447	357	209	332	213	776	421	359	296	246	365	390	230	336
Mean	297	325	335	346	349	241	271	320	397	365	323	436	309	335	507	277	344
								120-150 cm soil depth									
1	277	382	443	381	323	365	241	166	333	232	264	413	292	172	620	187	490
2	364	361	442	396	269	201	346	403	355	364	339	336	407	496	320	240	474
3	325	324	353	308	456	266	204	331	205	483	334	799	277	498	905	359	245
4	402	344	335	506	462	273	339	265	799	507	373	245	293	714	410	322	339
Mean	342	353	393	398	378	276	283	291	423	396	327	448	317	470	564	277	387

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.54. Soil extractable potassium (kg ha^{-1}) at the Airdrie site in 2000.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	324	611	633	1103	1074	316	809	1566	2388	285	392	493	669	357	473	374	199
2	328	320	953	1277	1046	661	756	641	1477	277	238	684	575	458	316	564	767
3	343	1540	1025	802	1308	1280	699	1973	1551	364	331	508	509	324	351	358	430
4	263	493	559	1042	2428	424	777	1503	3188	477	373	349	559	251	418	262	700
Mean	315	741	793	1056	1464	670	760	1421	2151	351	334	508	578	347	390	389	524
								15-30 cm soil depth									
1	277	399	523	339	435	246	444	490	1331	259	282	502	463	276	290	245	210
2	281	157	708	706	339	256	170	352	268		218	294	394	347	209	285	464
3	286	534	336	270	382	581	451	428	337	299	247	246	240	309	220	203	213
4	250	248	289	775	763	215	223	470	446	382	365	190	262	216	183	221	325
Mean	273	334	464	522	480	325	322	435	595	313	278	308	340	287	225	239	303
								30-60 cm soil depth									
1	379	548	599	266	605	287	473	627	765	298	339	505	620	438	663	443	221
2	449	265	995	1314	312	453	223	441	271	216	200	514	577	346	304	312	427
3	381	913	352	281	535	655	629	427	432	429	284	363	344	426	451	368	312
4	342	322	674	879	837	308	289	401	457	404	508	327	436	185	298	452	455
Mean	388	512	655	685	572	426	403	474	481	337	333	427	494	349	429	394	354
								60-90 cm soil depth									
1	292	544	523	246	645	260	290	440	522		362	561	331	258	705	376	233
2	259	301	466	923	215	377	256	253	305	211	224	237	437	272	235	311	354
3	355	451	339	244	529	335	424	430	290	490	254	406	219	344	547	313	376
4	300	356	495	532	538	203	314	178	459	747	456	262	288	218	314	339	277
Mean	301	413	456	486	482	294	321	325	394	483	324	367	319	273	450	335	310
								90-120 cm soil depth									
1	293	352	427	272	443	262	277	375	431	196	525	617	348	189	707	272	288
2	290	347	441	586	279	250	313	196	312	200	179	228	434	413	217	472	393
3	292	270	356	211	499	227	266	432	209	480	267	515	227	475	794	305	522
4	357	297	294	620	436	253	286	197	461	1004	373	205	256	370	386	245	292
Mean	308	317	379	422	414	248	286	300	353	470	336	391	316	362	526	323	374
								120-150 cm soil depth									
1	339	372	483	344	514	413	305	461	464	229	470	619	290	222	804	278	377
2	373	404	709	714	438	272	453	362	333	256	230	360	472	481	266	456	552
3	384	412	501	325	527	311	278	405	256	592	359	634	343	531	883	331	633
4	403	290	419	697	727	331	302	254	618	927	322	263	286	565	453	314	360
Mean	375	370	528	520	552	332	335	371	418	501	345	469	348	450	602	345	480

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.55. Soil extractable potassium (kg ha^{-1}) at the Airdrie site in 2001.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	381	803	898	1653	3020	613	1142	3525	2444	421	473	669	961	447	583	761	909
2	442	487	1320	2751	1627	602	1181	3483	4784	349	555	932	1333	602	877	677	1251
3	349	1345	1057	1587	2964	822	528	2519	116	476	193	673	601	174	555	475	1082
4	246	169	1690	1835	3210	394	739	808	2369	296	336	454	331	244	433	448	283
Mean	355	701	1241	1956	2705	608	897	2584	2428	386	389	682	806	367	612	590	881
								15-30 cm soil depth									
1	282	454	371	664	998	193	752	892	458	332	233	617	730	342	477	439	354
2	375	237	560	993	447	279	339	179	935	246	386	551	516	431	327	285	450
3	243	460	416	325	642	533	275	1359	5500	288	1209	354	363	315	259	267	382
4	222	116	368	333	718	306	164	393	781	179	220	252	535	144	206	187	238
Mean	280	317	429	579	701	328	383	705	1918	261	512	444	536	308	317	294	356
								30-60 cm soil depth									
1	439	824	531	988	392	473	1275	1054	3157	491	435	582	442	714	1018	559	747
2	575	352	672	1165	559	523	399	1152	469	354	334	552	616	490	492	461	580
3	390	792	392	325	541	806	487	588	1053	329	792	400	345	1441	545	503	478
4	321	219	698	360	941	283	218	353	344	362	429	493	642	219	337	3786	332
Mean	431	547	573	710	608	521	595	787	1255	384	498	507	511	716	598	1327	534
								60-90 cm soil depth									
1	294	834	680	428	239	247	973	1101	354	287	475	567	455	312	756	497	278
2	328	363	327	964	617	385	337	649	365	321	243	444	379	372	317	295	1430
3	355	432	336	312	529	525	388	306	619	304	481	441	275	299	528	398	482
4	456	228	579	451	676	566	284	256	380	441	391	285	428	326	369	542	311
Mean	358	464	481	539	515	431	496	578	429	338	398	434	384	327	492	433	625
								90-120 cm soil depth									
1	414	473	773	359	268	330	635	680	356	269	414	655	553	280	583	312	233
2	353	308	318	486	363	265	426	239	350	325	239	394	472	375	272	323	658
3	365	323	377	431	413	447	268	290	240	334	332	487	335	643	499	390	621
4	385	299	364	458	399	400	362	260	427	521	448	263	372	438	373	319	390
Mean	379	351	458	434	361	360	423	367	343	362	358	450	433	434	432	336	476
								120-150 cm soil depth									
1	332	376	1084	474	281	314	433	400	373	296	419	567	525	382	726	198	319
2	385	544	587	353	395	284	554	256	409	370	310	418	500	400	305	339	758
3	398	284	456	365	488	413	218	328	227	544	343	578	371	381	696	492	642
4	432	484	372	524	460	337	425	328	450	622	545	215	459	638	424	282	359
Mean	387	422	625	429	406	337	408	328	365	458	404	445	464	450	537	328	520

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.56. Soil extractable sulphate-S (kg ha^{-1}) at the Lethbridge site in 1996.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
							0-15 cm soil depth										
1	307	21	13	24	30	1393	36	3	23	40	8	98	79	43	43	193	29
2	30	56	18	21	32	32	30	11	9	320	12	31	23	11	24	27	13
3	24	41	9	196	48	23	16	29	13	36	12	34	50	13	10	16	45
4	65	27	13	15	137	15	8	48	19	23	56	17	17	16	9	10	25
Mean	107	36	13	64	62	366	23	23	16	105	22	45	42	21	21	61	28
							15-30 cm soil depth										
1	399	154	45	36	42	795	23	13	384	601	977	107	977	191	9	348	50
2	58	1261	25	24	35	132	30	18	15	260	15	173	27	157	36	23	16
3	115	140	254	181	286	372	38	232	15	24	12	130	59	21	16	14	30
4	167	67	17	14	62	187	28	306	73	42	53	9	38	23	19	11	23
Mean	185	406	85	64	106	371	30	142	122	232	264	105	275	98	20	99	30
							30-60 cm soil depth										
1	623	161	39	87	101	191	43	42	607	753	148	144	125	1225	55	128	544
2	90	1740	99	57	92	31	355	24	31	340	394	51	748	347	277	19	57
3	143	249	382	352	914	287	50	333	56	58	40	52	80	37	20	30	52
4	305	85	25	44	452	365	7	217	206	31	588	7	74	30	44	43	55
Mean	291	559	136	135	390	218	114	154	225	296	292	64	257	410	99	55	177
							60-90 cm soil depth										
1	447	400	28	58	51	164	64	54	284	237	142	197	156	151	65	118	170
2	150	513	42	57	72	61	43	49	44	164	119	122	216	191	51	8	45
3	1533	58	95	246	246	99	35	405	30	52	50	61	108	31	35	37	60
4	188	247	46	67	482	324	28	189	5986	725	196	36	5341	56	41	46	106
Mean	580	304	53	107	213	162	43	174	1586	294	127	104	1455	107	48	52	95
							90-120 cm soil depth										
1	824	5191	73	58	40	7862	80	86	5695	1220	292	544	131	479	481	166	198
2	1929	120	97	106	73	5191	148	79	76	194	449	7409	200	194	481	33	48
3	2019	95	57	5645	2389	113	56	310	68	47	66	101	74	40	39	50	68
4	1623	318	45	111	6149	5998	53	104	6174	88	272	60	711	86	80	56	131
Mean	1598	1431	68	1480	2163	4791	84	145	3003	387	270	2028	279	199	271	76	111
							120-150 cm soil depth										
1	1978	6889	3983	127	56	7916	68	6363	5661	291	6663	5762	153	971	289	5762	486
2	3533	164	686	258	74	6162	276	238	5586	3231	6037	6112	163	6263	3231	77	85
3	2842	263	167	6588	6212	536	81	604	101	53	99	5461	293	65	58	81	132
4	3246	6212	64	50	5912	6313	80	300	6112	6663	6388	59	32	4334	262	72	2285
Mean	2900	3382	1225	1756	3063	5232	126	1876	4365	2560	4797	4348	160	2908	960	1498	747

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.57. Soil extractable sulphate-S (kg ha^{-1}) at the Lethbridge site in 1997.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	14	167	9	14	19	30	29	165	35	28	10	78	15	18	34	18	16
2	17	35	18	29	28	79	18	47	37	17	111	10	17	29	8	22	10
3	17	16	14	41	16	22	33	16	39	20	9	17	116	3	10	7	25
4	29	44	10	10	11	32	13	30	43	52	18	21	41	13	27	3	10
Mean	19	65	13	23	19	41	23	65	38	29	37	32	47	16	20	13	16
								15-30 cm soil depth									
1	20	29	13	27	9	29	44	28	36	12	46	122	13	9	193	73	15
2	18	12	57	289	47	148	37	27	18	12	15	21	15	9	16	21	15
3	17	12	13	68	36	23	27	20	87	15	14	18	131	22	21	13	93
4	85	8	24	13	36	55	50	32	17	34	9	18	55	32	9	36	8
Mean	35	15	27	99	32	64	40	27	40	18	21	45	53	18	60	36	33
								30-60 cm soil depth									
1	29	69	22	26	22	270	57	77	62	221	77	77	85	46	30	41	42
2	41	37	57	60	66	373	54	57	34	41	97	76	126	36	37	85	36
3	51	35	41	135	326	69	55	67	86	39	19	39	86	7	33	39	122
4	85	35	39	50	70	355	51	77	287	49	60	34	115	77	301	44	51
Mean	51	44	40	68	121	266	54	69	117	87	63	56	103	42	100	52	63
								60-90 cm soil depth									
1	139	85	84	85	29	87	55	70	62	59	148	68	67	147	40	56	80
2	117	42	91	77	117	66	41	54	51	40	390	70	69	68	45	45	48
3	50	51	36	92	188	40	103	65	119	25	77	127	418	29	49	68	284
4	61	41	50	65	181	233	111	88	117	56	171	86	109	68	61	42	37
Mean	92	55	65	80	128	107	78	69	87	45	196	88	166	78	49	53	112
								90-120 cm soil depth									
1	133	292	384	103	45	157	56	994	78	86	128	179	154	199	86	1048	184
2	1355	66	267	109	51	152	71	127	333	328	816	203	383	146	231	79	106
3	1334	118	36	5090	312	72	335	38	166	47	67	272	350	78	61	55	222
4	209	130	52	87	3654	6451	53	913	6023	253	509	50	70	98	124	54	51
Mean	758	152	185	1347	1016	1708	129	518	1650	178	380	176	239	130	126	309	141
								120-150 cm soil depth									
1	1689	7365	7465	45	58	7565	84	5987	225	95	381	721	106	5661	772	5135	1563
2	3084	76	2119	253	113	5135	5862	391	5461	5636	6338	5912	286	6939	591	354	711
3	2422	214	45	5812	6263	676	5862	216	448	37	107	5812	6313	67	53	292	6313
4	1100	6012	126	67	7014	5862	91	2931	5937	6914	6563	51	161	6814	152	82	268
Mean	2074	3417	2439	1544	3362	4810	2975	2381	3018	3171	3347	3124	1716	4870	392	1466	2214

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.58. Soil extractable sulphate-S (kg ha^{-1}) at the Lethbridge site in 1998.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	30	20	14	17	21	44	13	18	36	11	23	61	18	21	7	32	11
2	21	15	43	656	24	8	35	31	97	72	18	137	20	25	18	13	23
3	103	21	55	45	39	7	52	26	33	3	24	151	26	38	9	37	93
4	20	12	12	33	67	455	39	46	245	16	34	9	25	12	96	45	18
Mean	43	17	31	188	38	129	35	30	103	26	25	90	22	24	33	32	36
								15-30 cm soil depth									
1	11	22	17	45	26	36	45	17	32	24	17	23	16	18	12	73	9
2	66	19	35	27	21	8	34	31	69	67	21	32	180	61	21	20	19
3	98	22	16	42	25	16	36	21	38	3	26	78	16	19	8	23	111
4	14	19	31	39	39	35	26	29	118	35	27	41	42	3	40	33	16
Mean	47	21	25	38	28	24	35	25	64	32	23	43	63	25	20	37	39
								30-60 cm soil depth									
1	105	29	69	65	56	285	82	27	43	56	67	70	26	25	18	33	32
2	45	61	50	46	79	37	67	77	70	70	63	61	32	169	29	19	127
3	70	35	63	241	110	28	78	44	57	70	43	60	58	21	7	16	74
4	40	45	23	57	362	152	23	67	104	54	105	43	17	25	34	22	27
Mean	65	42	51	102	152	126	62	54	69	63	69	59	33	60	22	22	65
								60-90 cm soil depth									
1	73	161	782	46	27	86	85	280	349	41	84	575	32	74	27	67	34
2	1088	88	70	135	61	270	66	88	146	62	949	2879	312	291	111	29	77
3	1312	143	205	169	91	335	58	63	74	22	40	137	99	48	25	61	244
4	89	60	63	75	154	2012	51	205	2043	86	67	40	80	106	57	119	43
Mean	640	113	280	107	83	676	65	159	653	53	285	908	131	130	55	69	99
								90-120 cm soil depth									
1	97	241	6250	86	39	4506	72	66	5947	197	690	4178	240	183	237	111	98
2	1819	72	202	71	83	3236	122	74	1683	128	4990	5015	120	1270	451	75	180
3	2436	174	84	2616	6048	144	2616	2177	91	39	60	1814	499	42	75	69	413
4	557	315	45	110	4208	3982	37	937	4788	5342	575	148	88	2540	73	33	178
Mean	1227	200	1645	720	2595	2967	712	814	3127	1427	1579	2789	237	1009	209	72	218
								120-150 cm soil depth									
1	1837	6934	8166	702	228	7715	89	89	6363	303	6563	6563	118	5711	589	5711	322
2	3862	138	6338	276	87	5862	6112	225	4559	3682	5987	4785	416	6237	6764	59	554
3	2077	1754	81	4935	6137	556	1979	6814	153	61	591	5060	746	76	54	71	4985
4	2462	4434	168	41	4860	3758	39	3006	4659	4835	4284	52	807	4284	177	41	468
Mean	2559	3315	3688	1488	2828	4473	2055	2533	3934	2220	4356	4115	522	4077	1896	1470	1582

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.59. Soil extractable sulphate-S (kg ha^{-1}) at the Lethbridge site in 1999.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
							0-15 cm soil depth										
1	26	30	34	25	37	29	32	14	33	19	25	24	35	42	14	41	36
2	36	34	19	55	47	35	21	20	22	26	80	35	18	22	26	26	10
3	52	22	140	77	54	196	31	47	18	9	9	11	32	17	16	13	125
4	22	31	26	14	72	63	21	41	62	10	24	17	50	18	27	11	62
Mean	34	29	55	43	52	81	26	31	34	16	35	22	34	25	21	23	58
							15-30 cm soil depth										
1	17	33	88	18	266	25	17	19	32	14	13	53	56	21	9	40	19
2	21	28	14	23	24	20	125	25	139	62	25	53	35	19	18	19	9
3	51	35	50	58	83	21	171	54	14	10	16	11	14	12	30	9	67
4	23	21	25	23	38	21	18	25	57	9	27	18	49	37	14	22	28
Mean	28	29	44	30	103	22	83	31	60	24	20	34	39	22	18	23	31
							30-60 cm soil depth										
1	27	120	87	139	65	30	29	33	81	30	24	35	85	42	12	42	93
2	113	57	41	64	69	176	67	47	99	69	53	73	37	47	23	30	37
3	82	34	51	189	93	36	34	75	57	25	28	46	71	26	21	16	527
4	27	44	40	50	116	56	44	99	135	30	35	44	60	46	28	41	34
Mean	62	64	55	110	86	74	43	64	93	39	35	50	63	40	21	32	173
							60-90 cm soil depth										
1	45	136	78	47	77	54	37	58	80	53	39	60	41	42	108	78	38
2	245	82	80	87	82	155	38	84	266	49	119	405	55	11	67	78	42
3	1835	78	50	206	159	38		156	74	28	51	165	60	37	34	24	207
4	409	77	41	59	5263	1223	65	98	4567	80	62	50	73	116	45	52	48
Mean	633	93	62	100	1395	368	47	99	1247	53	68	170	57	51	63	58	84
							90-120 cm soil depth										
1	83	6318	46	37	77	99	52	129	78	58	61	186	70	97	36	123	37
2	1910	126	6149	101	73	5317	237	204	312	1986	6073	6678	127	3236	620	30	258
3	2613	117	114	2328	5393	93		6426	438	46	91	761	114	75	85	45	136
4	1259	522	55	59	5544	6854	66	145	5141	141	471	37	2747	547	105	39	85
Mean	1466	1771	1591	632	2771	3091	118	1726	1492	558	1674	1916	764	989	212	59	129
							120-150 cm soil depth										
1	194	6209	122	85	70	131	54	126	580	130	276	5320	80	133	92	5616	127
2	4273	78	307	248	97	5010	5511	286	5110	4644	5837	5912	286	5862	5711	4835	541
3	2802	706	4749	5185	5837	3788	4419	6237	326	52	149	5436	421	431	39	53	736
4	3186	5611	71	62	5135	5711	90	266	5411	4684	5762	35	5060	6488	53	46	5261
Mean	2614	3151	1312	1395	2785	3660	2518	1729	2857	2377	3006	4176	1462	3228	1474	2637	1666

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.60. Soil extractable sulphate-S (kg ha^{-1}) at the Lethbridge site in 2000.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	29	128	38	21	21	82	27	67	67	18	42	75	20	18	13	156	33
2	153	27	16	43	129	29	27	136	59	122	59	206	20	33	152	31	45
3	107	46	40	46	236	20	374	243	90	10	42	189	18	11	18	15	137
4	62	60	14	39	81	425	40	194	256	79	15	18	141	30	22	42	26
Mean	88	65	27	37	117	139	117	160	118	57	39	122	50	23	51	61	60
								15-30 cm soil depth									
1	22	65	25	19	15	26	15	12	131	9	16	18	15	41	10	111	32
2	86	13	13	42	47	52	21	30	70	29	60	74	19	26	51	89	19
3	43	162	17	65	77	18	62	28	45	7	10	38	18	8	9	9	154
4	24	18	13	15	52	104	27	50	51	79	8	9	40	12	17	18	21
Mean	44	64	17	35	48	50	31	30	74	31	24	35	23	22	22	57	56
								30-60 cm soil depth									
1	22	76	47	41	58	47	48	19	69	24	29	38	20	165	11	48	41
2	55	15	84	92	114	60	40	52	261	31	81	168	25	45	471	32	33
3	50	49	29	100	124	25	81	49	136	11	22	131	51	19	17	18	163
4	38	83	72	105	124	55	58	94	107	21	21	33	91	41	20	32	22
Mean	41	56	58	85	105	47	57	53	143	22	38	92	47	68	130	32	65
								60-90 cm soil depth									
1	34	121	86	44	72	52	63	39	64	31	34	60	23	52	15	413	36
2	776	30	87	93	118	97	60	117		32	62	6954	44	97	92	29	75
3	1639	379	67	258	111	35	105	90	98	35	46	84	61	20	43	29	136
4	62	86	61	114	232	93	65	208	132	43	62	55	57	87	39	34	56
Mean	628	154	75	127	133	69	73	113	98	35	51	1788	47	64	48	126	76
								90-120 cm soil depth									
1	63	7106	308	55	58	6124	73	77	272	63	166	277	53	71	65	766	90
2	3446	69	282	95	73	3281	81	124	143	106	4236	6540	76	305	438	1079	180
3	2699	166	87	5015	363	57	1250	260	112	39	79	338	328	52	45	46	190
4	1363	348	47	69	6048	6224	108	3629	5519	209	340	55	80	96	70	35	59
Mean	1893	1922	181	1308	1635	3921	378	1022	1511	104	1205	1803	134	131	155	481	130
								120-150 cm soil depth									
1	2853	6814	7766	80	98	7390	97	5862	5762	203	5962	4992	1263	280	282	5335	1323
2	3451	176	4170	315	89	5636	5912	137	5436	109	6488	6697	189	5942	6857	44	532
3	2958	1904	80	5636	6112	341	5511	6638	5661	42	106	5386	15331	110	47	55	7290
4	2508	6212	58	58	6037	5762	356	3968	6112	6814	6613	41	159	131	265	41	229
Mean	2942	3777	3019	1522	3084	4782	2969	4151	5743	1792	4792	4279	4235	1616	1862	1369	2343

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.61. Soil extractable sulphate-S (kg ha^{-1}) at the Lethbridge site in 2001.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	598	82	74	26	47	74	34	225	740	17	194	187	125	266	29	170	37
2	563	50	75	104	176	175	40	53	129	313	259	40	34	237	255	113	67
3	135	23	70	120	427	30	1947	40	111	13	20	134	19	20	23	18	159
4	158	459	17	22	312	413	32	176	338	39	39	21	280	19	23	19	42
Mean	364	154	59	68	240	173	513	123	330	96	128	96	114	136	82	80	76
								15-30 cm soil depth									
1	122	120	43	19	101	185	29	64	203	97	89	121	58	95	35	112	30
2	182	49	41	34	96	103	35	47	76	225	277	160	61	129	121	33	48
3	80	13	111	127	113	20	753	28	44	13	23	63	22	12	16	38	45
4	72	146	19	44	148	113	28	129	187	82	51	15	326	3	27	21	24
Mean	114	82	53	56	115	105	211	67	127	104	110	90	117	60	50	51	37
								30-60 cm soil depth									
1	90	239	110	43	62	435	190	146	174	25	167	260	325	231	61	72	83
2	430	100	56	69	248	94	64	88	199	360	242	170	64	132	161	86	126
3	55	23	86	186	459	64	117	58	99	31	32	120	126	35	25	155	63
4	73	188	61	87	186	128	63	168	141	51	40	65	156	27	24	32	111
Mean	162	137	78	96	239	180	108	115	153	117	120	154	168	106	68	86	96
								60-90 cm soil depth									
1	189	169	150	88	81	266	41	183	105	31	105	198	90	93	26	41	90
2	162	50	98	31	169	108	71	83	95	62	415	181	79	158	140	52	51
3	943	35	91	190	290	35	110	67	142	21	39	36	63	24	39	141	93
4	88	92	57	129	217	1434	79	167	148	41	79	58	180	44	34	65	96
Mean	346	86	99	110	189	461	75	125	123	39	159	118	103	80	60	75	82
								90-120 cm soil depth									
1	1140	7510	401	180	152	8074	98	2783	105	48	93	4965	99	61	78	203	105
2	194	94	335	226	72	4695	81	103	179	27	5871	5856	138	6602	569	67	115
3	2806	47	294	1763	5336	57	142	104	118	33	93	900	178	73	36	196	220
4	2631	6327	59	117	6238	6118	68	141	4380	413	440	34	4865	98	139	50	53
Mean	1693	3494	272	572	2949	4736	97	783	1196	130	1624	2939	1320	1709	205	129	123
								120-150 cm soil depth									
1	1545	7615	6884	146	70	8289	61	6937	5619	185	5927	3862	123	128	346	5585	2179
2	297	84	7886	279	235	5905	157	398	6068	582	7951	6653	585	6869	7365	93	533
3	3065	232	7147	5683	6003	100	233	351	198	36	192	232	527	353	39	77	829
4	1456	6177	82	85	6582	5850	68	427	4321	5829	5965	40	4850	264	176	53	172
Mean	1591	3527	5500	1548	3223	5036	130	2028	4051	1658	5009	2697	1521	1904	1981	1452	928

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.62. Soil extractable sulphate-S (kg ha^{-1}) at the Airdrie site in 1997.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
							0-15 cm soil depth										
1	7	7	7	7	29	2	6	5	6	6	2	2	6	7	6	5	5
2	4	2	5	10	10	12	7	2	2	6	6	10	7	9	2	7	7
3	10	12	5	11	9	7	9	8	17	2	11	7	9	7	6	6	6
4	6	7	6	7	5	7	7	6	6	2	2	6	8	2	7	9	6
Mean	7	7	6	9	13	7	7	6	8	4	6	7	8	6	5	7	6
							15-30 cm soil depth										
1	5	7	7	6	73	3	8	3	3	10	3	3	3	3	3	3	3
2	4	3	6	11	8	14	3	3	3	3	3	7	3	14	16	7	9
3	7	6	3	6	9	3	3	3	6	3	3	3	7	3	6	3	3
4	15	6	3	10	3	16	3	54	3	3	3	7	7	3	7	12	3
Mean	8	5	5	8	23	9	4	16	4	5	3	5	5	6	8	6	5
							30-60 cm soil depth										
1	28	76	60	6	112	15	213	6	6	23	6	50	49	31	36	150	309
2	35	6	6	16	19	13	18	6	68	18	43	40	14	43	34	20	6
3	40	28	6	42	23	6	23	30	51	39	18	18	23	21	14	13	23
4	165	21	51	72	46	88	41	121	29	6	29	13	72	6	60	39	21
Mean	67	33	31	34	50	31	74	41	38	21	24	30	40	25	36	56	90
							60-90 cm soil depth										
1	69	172	121	7	106	54	787	139	185	55	70	47	93	7	122	63	288
2	44	46	7	7	36	16	109	30	61	27	72	65	7	24	94	53	7
3	67	29	49	306	70	7	84	44	48	30	46	75	58	41	89	7	62
4	73	44	44	49	43	66	65	56	85	22	69	21	151	56	60	65	144
Mean	63	73	55	92	64	36	261	67	95	33	64	52	77	32	91	47	125
							90-120 cm soil depth										
1	54	145	8	24	86	58	62	61	42	24	19	92	32	65	86	21	51
2	34	47	8	8	62	35	86	28	28	17	40	8	8	24	21	54	8
3	35	8	37	75	60	26	51	36	45	61	47	40	32	62	45	24	34
4	25	23	25	20	36	66	87	33	60	32	24	32	62	69	65	18	33
Mean	37	56	19	32	61	46	71	39	43	33	33	43	33	55	54	30	31
							120-150 cm soil depth										
1	48	84	17	19	49	49	21	17	19	23	80	139	29	26	39	21	29
2	20	41	8	8	40	40	79	36	22	19	33	8	19	23	8	36	8
3	27	8	8	33	38	20	55	8	38	55	57	52	29	54	31	73	35
4	22	37	21	27	8	25	75	8	82	44	66	34	37	91	72	21	23
Mean	29	42	14	22	34	33	57	17	40	35	59	58	29	48	37	38	24

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.63. Soil extractable sulphate-S (kg ha^{-1}) at the Airdrie site in 1998.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
							0-15 cm soil depth										
1	4	8	6	6	7		7	9	15	7	5	2	2	7	12	7	10
2	5		7	7	2	2	7	23	13	6	6	8	9	9	11	15	19
3	7	5	7	9	7	8	9	7	9	2	7	7	17	11	17	9	27
4	6	8	11	11	10	8	5	17	9	7	7	7	7	7	14	29	52
Mean	6	7	8	9	6	6	7	14	12	6	6	6	9	8	13	15	27
							15-30 cm soil depth										
1	4	17	3	3	3	3	7	10	3	3	3	9	3	53	3	7	13
2	4	6	3	3	3	3	10	7	11	3	3	3	12	3	3	3	17
3	21	3	3	3	3	3	3	3	9	3	9	3	7	16	6	10	13
4	4	12	8	9	9	12	3	23	3	12	7	3	12	9	15	26	35
Mean	8	9	4	5	4	5	6	11	6	5	5	4	8	20	7	11	19
							30-60 cm soil depth										
1	38	108	76	18	54	40	243		81	44	78	41	16	70	39	78	78
2	16	15	6	6	6	6	53	45	33	64	38	103	18	6	6	55	6
3	31	20	6	27	53	6	22	21	6	6	6	43	98	24	6	15	75
4	28	29	28	50	20	19	22	45	28	73	19	6	97	6	6	24	23
Mean	28	43	29	25	33	18	85	37	37	47	35	48	57	27	14	43	46
							60-90 cm soil depth										
1	65	116			114	68	129	27	63	41	93	53	47	34	25	58	109
2	46	48	7	7	25	25	61		65	35	35	70	17	33	22	68	7
3	72	113	33	54	102	48	130	18	65	67	36	84	115	28	54	21	41
4	70	47	27	69	50	33	40	70	49	63	124	38	142	36	24	33	68
Mean	63	81	22	43	73	44	90	38	60	52	72	61	80	33	31	45	56
							90-120 cm soil depth										
1	38	40	18	8	58	39	43	16	40	8	100	66	35	8	8		64
2	30	34	8	8	20	26	26	26		8	22	31	33	27	8	33	8
3	36	59	8	41	66	64	26	48	24	43	21	76	33	23	57	22	24
4	47	26	8	49	66	58	34	65	48	60	29	54	59	67	76	17	39
Mean	38	40	10	26	53	47	32	39	38	30	43	57	40	31	37	24	34
							120-150 cm soil depth										
1	26	8	8	8	54	31	58	8	21	8	64	79	33	24	8	8	57
2	20	27	8	8	22	8	32	8	46	8	8	8	32	8	8	18	8
3	15	35	8	8	52	128	35	8	26	26	17	91	35	8	45	33	8
4	43	8	8	23	8	58	37	17	69	37	37	38	50	75	78	8	21
Mean	26	20	8	12	34	56	41	10	41	20	32	54	37	29	35	17	24

[z] Control: No manure application; each replicate value is a mean of four control plots.
[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).
[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.64. Soil extractable sulphate-S (kg ha^{-1}) at the Airdrie site in 1999.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
							0-15 cm soil depth										
1	11	12	13	16	15	30	12	23	70	13	13	11	12	24	23	28	35
2	12	12	8	16	15	18	27	22	31	9	10	28	11	11	21	43	55
3	11	12	13	11	14	12	10	18	41	13	12	7	18	26	16	24	35
4	11	8	18	17	15	8	18	15	22	13	12	13	20	18	50	48	20
Mean	11	11	13	15	15	17	17	20	41	12	12	15	16	20	27	36	36
							15-30 cm soil depth										
1	12	13	11	14	17	36	11	48	22	5	9	23	13	30	13	22	72
2	20	9	8	15	16	16	29	19	15	32	29	50	9	8	14	30	33
3	8	12	10	10	10	8	5	10	28	11	9	7	24	20	11	32	9
4	9	14	14	18	10	12	28	10	18	10	12	12	48	10	40	24	26
Mean	13	12	11	14	13	18	18	22	21	14	15	23	23	17	19	27	35
							30-60 cm soil depth										
1	65	38	94	27	53	41	52	114	45	10	28	65	73	109	30	55	163
2	60	24	19	30	30	33	198	64	48	51	60	48	28	79	42	41	40
3	29	17	17	18	27	13	149	21	21	16	14	9	38	15	27	37	69
4	62	29	25	92	25	50	54	17	29	25	50	25	242	17	29	42	75
Mean	54	27	39	42	34	34	113	54	36	26	38	37	95	55	32	43	87
							60-90 cm soil depth										
1	59	91	32	24	57	90	74	38	29	35	64	57	36	85	26	59	84
2	53	27	21	81	143	49	91	51	102	37	66	53	23	53	65	123	31
3	56	24	57	78	76	52	51	33	62	51	142	9	99	38	60	38	97
4	66	19	38	108	42	52	66	33	52	89	66	52	146	52	47	42	66
Mean	58	40	37	73	80	61	71	39	61	53	84	43	76	57	50	66	70
							90-120 cm soil depth										
1	42	58	31	25	64	71	34	28	20	20	88	63	36	51	22	51	87
2	39	17	20	51	54	51	39	37	82	43	56	34	14	47	44	67	30
3	43	57	52	22	54	47	12	26	48	33	80	78	57	33	47	75	55
4	49	21	67	57	31	57	73	31	57	62	52	36	93	78	67	26	52
Mean	44	38	43	39	51	56	40	30	52	40	69	53	50	52	45	55	56
							120-150 cm soil depth										
1	38	49	29	22	66	50	48	22	20	19	52	61	35	38	27	53	78
2	38	37	16	45	47	39	144	25	46	21	37	33	11	24	38	55	14
3	35	22	27	6	32	38	14	22	20	32	73	81	27	22	43	61	39
4	57	22	49	44	22	120	71	66	60	55	49	33	109	93	60	22	98
Mean	42	32	30	29	42	62	69	34	37	31	53	52	46	44	42	48	57

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.65. Soil extractable sulphate-S (kg ha^{-1}) at the Airdrie site in 2000.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
							0-15 cm soil depth										
1	10	12	12	23	19	35	24	21	43	13	17	22	20	44	27	29	52
2	10	17	13	20	26	7	28	17	47	9	11	17	15	21	18	58	60
3	11	14	17	19	15	12	17	26	28	7	12	14	22	10	19	21	41
4	10	10	9	15	22	13	15	25	38	9	10	11	25	14	20	17	61
Mean	10	13	13	19	21	17	21	22	39	9	13	16	21	22	21	31	54
							15-30 cm soil depth										
1	10	24	18	34	64	40	13	19	45	9	14	25	20	18	44	16	29
2	12	47	15	14	25	7	24	17	29		35	21	18	13	21	30	37
3	10	21	16	17	14	17	16	21	20	9	8	13	28	12	13	22	25
4	14	12	12	37	20	9	16	19	31	8	9	20	30	9	14	16	38
Mean	12	26	15	25	31	18	17	19	31	9	16	20	24	13	23	21	32
							30-60 cm soil depth										
1	134	254	65	61	100	78	38	108	110	30	38	51	121	100	54	139	73
2	59	90	23	21	50	46	154	66	74	52	55	59	23	117	57	76	39
3	65	49	86	43	82	23	145	40	55	65	31	36	121	76	48	48	73
4	53	35	16	78	32	24	34	42	55	54	38	43	150	34	47	30	51
Mean	78	107	47	51	66	43	93	64	74	50	40	47	104	82	51	73	59
							60-90 cm soil depth										
1	103	97	45	46	84	53	70	101	62	41	46	57	69	56	39	139	71
2	92	54	19	45	64	54	144	42	59	51	57	130	31	90	124	109	28
3	72	72	58	33	86	45	97	40	54	55	55	44	142	73	58	46	63
4	73	27	28	69	46	33	40	57	41	108	136	116	212	40	53	31	208
Mean	85	63	38	48	70	46	87	60	54	64	74	87	114	65	68	81	92
							90-120 cm soil depth										
1	68	40	32	34	82	59	60	70	47	24	61	66	45	46	34	40	66
2	50	48	12	58	48	50	70	37	42	38	56	54	16	29	57	91	20
3	50	37	29	28	83	39	45	33	44	49	65	62	54	53	36	65	40
4	66	32	27	59	45	35	63	37	46	70	63	50	69	67	49	25	89
Mean	59	39	25	45	65	46	59	44	45	45	61	58	46	49	44	55	54
							120-150 cm soil depth										
1	52	40	34	27	102	37	44	61	41	28	49	80	41	45	39	39	51
2	36	51	14	31	41	49	68	33	45	26	40	39	15	44	37	91	26
3	44	26	33	28	54	34	38	20	46	36	45	50	46	43	31	50	46
4	57	37	20	51	27	34	50	31	43	61	21	58	75	72	64	21	55
Mean	48	38	25	34	56	39	50	36	44	38	39	57	44	51	43	50	44

[z] Control: No manure application; each replicate value is a mean of four control plots.
[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).
[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.66. Soil extractable sulphate-S (kg ha^{-1}) at the Airdrie site in 2001.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
							0-15 cm soil depth										
1	13	15	16	27	25	15	17	41	30	17	27	24	26	22	42	75	26
2	12	13	14	23	29	14	21	25	48	8	27	21	38	37	69	33	74
3	22	12	16	22	32	12	15	25	93	9	21	10	25	15	30	29	29
4	11	10	13	23	72	10	14	30	33	11	9	23	40	17	20	17	83
Mean	15	12	15	24	40	13	17	30	51	11	21	20	33	23	40	39	53
							15-30 cm soil depth										
1	21	12	13	26	39	64	14	41	32	10	17	94	74	18	24	41	30
2	33	76	12	35	27	12	32	31	32	21	40	30	24	19	63	37	28
3	10	19	11	23	26	11	9	21	55	11	22	18	22	19	28	17	45
4	15	13	23	19	40	10	21	17	32	12	16	28	106	24	28	26	52
Mean	20	30	15	26	33	24	19	27	38	14	24	42	56	20	36	30	39
							30-60 cm soil depth										
1	192	29	131	33	234	70	30	68	58	104	68	125	74	44	28	67	37
2	38	108	20	65	112	24	75	59	146	118	110	122	38	193	47	36	18
3	31	30	48	44	40	22	61	52	61	136	30	38	39	20	53	40	127
4	70	26	36	40	42	58	32	59	83	118	37	43	475	53	52	91	63
Mean	83	48	59	46	107	43	50	60	87	119	61	82	156	77	45	58	61
							60-90 cm soil depth										
1	83	106	87	27	132	74	58	82	76	59	75	70	33	50	45	97	67
2	86	82	20	87	56	23	97	58	113	65	54	156	27	170	73	34	122
3	48	38	59	40	83	66	47	47	29	113	80	37	44	41	51	36	77
4	66	20	34	39	69	27	27	79	51	49	61	36	349	34	78	69	67
Mean	71	62	50	48	85	48	57	67	67	71	68	75	113	74	62	59	83
							90-120 cm soil depth										
1	73	116	50	15	92	50	39	44	43	33	79	73	20	26	30	36	40
2	54	51	17	58	67	32	64	32	61	58	39	36	17	45	35	57	25
3	40	40	35	30	50	39	26	30	53	74	66	56	34	36	39	38	58
4	49	17	46	29	28	61	33	58	44	30	58	39	151	57	81	46	52
Mean	54	56	37	33	59	46	41	41	50	49	61	51	55	41	46	44	44
							120-150 cm soil depth										
1	56	71	41	17	76	31	40	29	26	21	60	67	16	19	18	21	34
2	36	157	23	32	60	37	47	28	47	36	35	38	14	27	27	38	22
3	29	38	36	56	44	23	19	19	171	55	46	66	26	30	38	61	39
4	56	14	30	22	21	23	26	28	58	23	28	37	120	72	65	40	28
Mean	44	70	33	32	50	28	33	26	75	34	42	52	44	37	37	40	31

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.67. Soil pH at the Lethbridge site in 1996.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	7.6	7.9	7.9	7.5	7.7	7.6	7.7	7.7	7.8	7.4	7.8	7.8	7.8	7.8	7.6	7.9	7.7
2	7.9	8.0	8.1	7.9	7.7	7.8	7.7	8.0	7.6	7.9	8.1	7.9	8.0	7.9	7.9	7.8	7.9
3	7.7	7.9	7.9	7.8	7.9	7.8	7.9	7.7	7.8	7.8	7.9	7.8	7.7	8.5	8.4	7.9	7.6
4	7.8	7.9	7.9	7.9	7.8	8.0	7.9	8.1	7.9	7.7	7.6	7.9	7.6	7.9	8.0	7.9	7.8
Mean	7.8	7.9	7.9	7.8	7.8	7.8	7.8	7.9	7.8	7.7	7.8	7.8	7.8	8.0	8.0	7.9	7.7
								15-30 cm soil depth									
1	7.6	7.9	7.9	7.7	7.7	7.7	7.6	7.9	7.8	7.6	7.6	8.0	7.6	7.8	7.7	7.8	7.7
2	8.0	7.8	8.0	8.1	7.7	7.9	7.7	8.0	7.6	8.0	8.1	7.9	8.2	7.9	7.9	7.9	8.0
3	7.8	7.8	7.9	7.9	7.9	7.7	7.9	7.8	7.6	7.8	7.9	7.9	7.9	7.7	7.8	8.0	7.8
4	7.8	7.9	7.9	7.9	8.2	7.9	7.9	8.0	8.0	7.8	7.8	7.8	7.7	8.0	7.9	8.0	8.1
Mean	7.8	7.8	7.9	7.9	7.9	7.8	7.8	7.9	7.7	7.8	7.8	7.9	7.8	7.8	7.8	7.9	7.9
								30-60 cm soil depth									
1	7.8	8.1	8.1	7.7	8.1	8.1	7.7	8.1	7.9	7.5	8.1	8.1	8.0	7.8	8.0	8.0	7.8
2	8.1	7.9	8.1	8.4	8.0	8.2	7.7	8.2	7.8	8.2	8.1	8.1	8.0	8.1	8.0	8.0	8.0
3	8.0	7.9	8.0	8.2	7.9	7.9	8.0	8.0	8.0	7.8	7.9	8.1	8.2	7.8	7.9	7.7	8.1
4	8.0	8.2	7.8	7.9	8.1	8.1	8.1	8.2	8.1	8.0	7.6	8.1	7.9	8.2	8.1	7.9	8.4
Mean	8.0	8.0	8.0	8.0	8.0	8.1	7.9	8.1	7.9	7.9	7.9	8.1	8.0	8.0	8.0	7.9	8.1
								60-90 cm soil depth									
1	7.9	8.3	8.3	8.1	8.2	8.3	8.0	8.2	8.2	7.9	8.2	8.1	8.2	8.1	8.3	8.3	7.9
2	8.4	8.3	8.4	8.5	8.1	8.4	8.0	8.4	7.9	8.4	8.3	8.3	8.3	8.4	8.4	8.1	8.0
3	8.0	8.3	8.3	8.2	8.0	8.2	8.2	8.2	8.3	8.1	8.2	8.2	8.4	7.9	7.8	7.8	8.3
4	8.2	8.4	7.3	8.1	8.0	8.3	8.3	8.0	7.7	7.9	7.8	8.2	7.6	8.4	8.2	8.1	8.5
Mean	8.1	8.3	8.1	8.2	8.1	8.3	8.1	8.2	8.0	8.1	8.1	8.2	8.1	8.2	8.2	8.1	8.2
								90-120 cm soil depth									
1	8.1	8.0	8.4	8.2	8.3	7.8	8.1	8.2	7.8	8.0	8.2	8.0	7.3	8.0	8.4	8.2	8.1
2	8.2	8.6	8.6	8.4	8.2	7.8	8.2	8.6	7.9	8.3	8.2	7.9	8.5	8.4	8.4	8.3	8.3
3	8.0	8.5	8.5	7.6	7.8	8.4	8.3	8.4	8.4	8.2	8.1	8.0	8.4	8.2	8.2	8.2	8.5
4	8.1	8.3	8.1	8.2	7.6	7.8	8.3	8.1	7.7	8.2	8.1	8.2	7.9	8.5	8.3	8.2	8.5
Mean	8.1	8.3	8.4	8.1	8.0	7.9	8.2	8.3	7.9	8.2	8.1	8.0	8.0	8.3	8.3	8.2	8.3
								120-150 cm soil depth									
1	7.9	7.8	7.9	8.3	8.3	7.8	8.2	7.7	7.6	8.2	7.6	7.7	8.4	7.9	8.5	7.7	8.0
2	8.2	8.6	8.5	8.4	8.3	7.7	8.2	8.6	7.5	7.9	7.8	7.8	8.7	8.0	8.1	8.1	8.5
3	8.0	8.5	8.4	7.6	7.7	8.3	8.3	8.2	8.5	8.2	8.3	7.7	8.3	8.3	8.3	8.4	8.4
4	7.9	7.8	8.2	8.3	7.3	7.8	8.4	8.1	7.7	7.7	7.6	8.3	8.1	7.9	8.3	8.3	8.1
Mean	8.0	8.2	8.2	8.1	7.9	7.9	8.3	8.1	7.8	8.0	7.8	7.9	8.4	8.0	8.3	8.1	8.2

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.68. Soil pH at the Lethbridge site in 1997.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	7.8	7.9	7.7	7.7	7.7	7.7	7.8	8.1	7.8	7.7	7.8	7.7	7.6	7.7	7.8	7.9	7.7
2	7.8	7.8	7.9	8.0	7.9	7.8	7.9	7.8	7.9	7.9	7.7	7.9	7.9	8.0	7.7	7.9	7.7
3	7.9	7.9	7.9	7.9	8.0	7.9	7.8	7.8	7.9	7.7	7.8	7.8	7.9	7.6	7.7	7.8	7.9
4	7.8	8.0	7.8	7.8	7.8	8.0	7.9	7.7	8.0	7.9	7.9	7.9	7.9	8.0	7.9	7.6	7.8
Mean	7.9	7.9	7.8	7.8	7.8	7.8	7.8	7.8	7.9	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8
								15-30 cm soil depth									
1	8.0	8.1	7.9	8.0	7.9	8.0	7.9	7.9	8.0	7.9	8.2	7.9	7.8	7.8	7.7	8.0	7.8
2	7.9	8.1	7.9	7.9	7.9	7.8	7.8	7.8	8.1	7.9	7.9	8.0	7.9	8.0	7.8	8.0	7.8
3	7.9	7.9	8.0	8.1	8.0	8.0	8.0	7.8	7.8	7.7	7.8	7.9	8.2	7.6	7.7	7.8	8.0
4	7.9	8.0	7.7	7.9	8.3	8.0	7.9	7.9	7.3	8.0	8.0	7.9	8.1	8.2	8.0	7.6	7.8
Mean	8.0	8.0	7.9	8.0	8.0	7.9	7.9	7.8	7.8	7.9	8.0	7.9	8.0	7.9	7.8	7.8	7.8
								30-60 cm soil depth									
1	8.1	8.2	8.1	7.8	8.0	8.1	8.0	8.1	8.1	7.9	8.3	8.2	8.0	8.0	8.1	8.2	8.0
2	8.3	8.0	8.2	8.1	7.9	8.1	7.8	8.1	8.1	8.2	8.2	8.3	8.2	8.3	8.1	8.2	8.1
3	8.0	8.1	8.3	8.2	8.2	8.2	8.1	8.0	8.0	7.7	7.9	8.1	8.3	7.6	7.7	7.8	8.1
4	8.2	8.3	7.7	7.8	8.3	8.4	8.1	8.1	8.1	8.2	8.1	8.1	8.2	8.5	8.1	7.6	8.0
Mean	8.2	8.1	8.1	8.0	8.1	8.2	8.0	8.1	8.1	8.0	8.1	8.2	8.2	8.1	8.0	7.9	8.0
								60-90 cm soil depth									
1	8.2	8.4	8.3	8.1	8.1	8.3	8.2	8.3	8.3	8.2	8.3	8.2	8.3	8.2	8.6	8.3	8.3
2	8.4	8.3	8.3	8.3	8.1	8.4	8.2	8.3	8.2	8.3	8.2	8.4	8.2	8.3	8.3	8.3	8.2
3	8.2	8.4	8.6	8.3	8.3	8.3	8.1	8.2	8.1	7.9	7.9	8.1	8.3	7.9	8.0	7.9	8.2
4	8.3	8.5	8.1	7.8	8.3	8.4	8.3	8.2	8.3	8.4	8.4	8.3	8.3	8.6	8.3	8.0	8.3
Mean	8.3	8.4	8.3	8.1	8.2	8.3	8.2	8.2	8.2	8.2	8.2	8.2	8.3	8.2	8.3	8.1	8.2
								90-120 cm soil depth									
1	8.3	8.5	8.4	8.5	8.2	8.4	8.3	8.2	8.2	8.4	8.3	8.3	8.3	8.2	8.6	8.3	8.2
2	8.4	8.5	8.5	8.6	8.3	8.3	8.4	8.4	8.2	8.1	8.0	8.5	8.5	8.3	8.5	8.4	8.4
3	8.1	8.5	8.6	7.9	8.3	8.5	8.2	8.5	8.4	8.1	8.3	8.1	8.4	8.2	8.2	7.9	8.3
4	8.2	8.5	8.2	8.2	7.9	7.9	8.4	8.0	7.8	8.5	8.4	8.4	8.3	8.7	8.5	8.1	8.5
Mean	8.3	8.5	8.4	8.3	8.2	8.3	8.3	8.3	8.1	8.3	8.2	8.3	8.4	8.3	8.4	8.2	8.3
								120-150 cm soil depth									
1	8.2	7.9	7.8	8.6	8.3	7.9	8.3	7.8	8.3	8.4	8.2	8.1	8.4	7.7	8.5	7.8	7.9
2	8.3	8.5	8.2	8.6	8.4	7.8	7.9	8.3	7.7	7.7	7.7	8.0	8.6	7.8	8.5	8.3	8.3
3	8.0	8.5	8.6	7.7	7.8	8.3	7.6	8.4	8.3	8.2	8.3	7.7	7.9	8.2	8.2	8.3	7.7
4	8.1	7.9	8.2	8.2	7.8	7.8	8.6	7.8	7.8	7.8	7.8	8.4	8.2	7.9	8.4	8.2	8.3
Mean	8.1	8.2	8.2	8.3	8.1	7.9	8.1	8.1	8.0	8.0	8.0	8.0	8.3	7.9	8.4	8.1	8.0

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.69. Soil pH at the Lethbridge site in 1998.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	8.0	8.1	7.7	7.9	7.6	7.9	8.1	8.1	7.9	8.2	8.1	8.0	7.8	8.0	7.7	8.1	7.9
2	8.2	7.9	8.1	7.9	7.8	8.1	7.9	8.0	8.0	8.1	8.1	8.0	8.0	8.1	7.9	8.1	8.0
3	8.1	8.0	8.2	8.0	8.1	8.2	8.1	7.8	8.1	8.1	8.0	8.1	7.9	7.6	8.1	7.8	8.2
4	8.2	8.3	8.1	7.9	8.2	8.0	7.9	8.1	8.0	8.1	8.2	8.1	7.9	8.2	7.9	7.6	8.1
Mean	8.1	8.1	8.0	7.9	7.9	8.0	8.0	8.0	8.0	8.1	8.1	8.0	7.9	8.0	7.9	7.9	8.0
								15-30 cm soil depth									
1	8.1	8.3	8.0	8.0	7.9	8.1	8.1	7.9	8.1	8.2	8.3	8.2	7.9	8.1	8.0	8.2	8.1
2	8.1	8.0	8.1	8.3	8.0	8.1	7.9	8.0	7.9	8.3	8.2	8.1	8.0	8.2	7.9	8.1	8.0
3	8.1	8.1	8.3	8.1	8.1	8.2	8.2	8.0	8.3	8.1	8.0	8.2	8.1	7.8	8.2	8.0	8.3
4	8.2	8.2	8.0	8.1	8.3	8.3	8.0	8.3	8.2	8.2	8.2	8.1	8.3	8.3	7.9	7.8	8.0
Mean	8.2	8.1	8.1	8.1	8.1	8.2	8.0	8.0	8.1	8.2	8.2	8.1	8.1	8.1	8.0	8.0	8.1
								30-60 cm soil depth									
1	8.2	8.4	8.3	8.3	7.9	8.2	8.3	8.2	8.3	8.5	8.5	8.4	8.2	8.2	8.3	8.4	8.3
2	8.3	8.2	8.4	8.7	8.0	8.3	7.9	8.3	8.1	8.5	8.3	8.6	8.3	8.5	8.3	8.2	8.2
3	8.3	8.3	8.4	8.1	8.2	8.3	8.4	8.2	8.4	8.1	8.2	8.4	8.3	8.0	8.3	8.0	8.5
4	8.3	8.5	8.0	8.1	8.4	8.3	8.2	8.7	8.5	8.4	8.3	8.3	8.5	8.5	8.2	8.0	8.2
Mean	8.3	8.3	8.3	8.3	8.1	8.3	8.2	8.3	8.3	8.4	8.3	8.4	8.3	8.3	8.3	8.1	8.3
								60-90 cm soil depth									
1	8.5	8.7	8.2	8.5	8.2	8.6	8.4	8.2	8.3	8.6	8.6	8.3	8.4	8.2	8.5	8.6	8.7
2	8.5	8.2	8.5	8.8	8.3	8.3	8.5	8.5	8.2	8.5	8.2	8.3	8.4	8.5	8.5	8.5	8.5
3	8.3	8.6	8.6	8.3	8.4	8.5	8.5	8.4	8.5	8.4	8.2	8.5	8.7	8.2	8.3	8.3	8.6
4	8.5	8.7	8.2	8.3	8.5	8.2	8.3	8.5	8.2	8.7	8.6	8.4	8.5	8.7	8.5	8.3	8.5
Mean	8.4	8.5	8.4	8.5	8.3	8.4	8.4	8.4	8.3	8.5	8.4	8.4	8.5	8.4	8.4	8.4	8.6
								90-120 cm soil depth									
1	8.5	8.6	8.0	8.5	8.3	8.2	8.6	8.5	7.7	8.6	8.4	8.0	8.5	8.4	8.5	8.5	8.6
2	8.5	8.5	8.6	8.9	8.3	8.1	8.5	8.8	8.1	8.4	7.9	8.1	8.7	8.3	8.5	8.6	8.7
3	8.3	8.7	8.8	8.1	7.9	8.7	8.1	8.2	8.7	8.5	8.5	8.2	8.6	8.2	8.6	8.5	8.5
4	8.4	8.6	8.5	8.5	8.1	8.0	8.4	8.3	8.0	8.2	8.3	8.5	8.5	8.2	8.6	8.5	8.5
Mean	8.4	8.6	8.5	8.5	8.1	8.2	8.4	8.4	8.1	8.4	8.3	8.2	8.6	8.3	8.5	8.5	8.6
								120-150 cm soil depth									
1	8.3	8.0	7.8	8.4	8.4	8.1	8.7	8.4	7.8	8.6	8.0	7.9	8.7	7.9	8.5	8.0	8.5
2	8.3	8.6	7.9	8.6	8.5	7.9	8.0	8.7	7.9	7.8	7.9	8.0	8.6	7.9	8.0	8.6	8.5
3	8.3	8.2	8.7	7.9	7.9	8.6	8.0	8.0	8.6	8.6	8.5	8.0	8.5	8.4	8.6	8.7	8.0
4	8.1	8.0	8.5	8.6	8.0	8.0	8.5	8.0	8.0	8.1	8.0	8.6	8.2	8.0	8.6	8.5	8.4
Mean	8.3	8.2	8.2	8.4	8.2	8.1	8.3	8.3	8.1	8.3	8.1	8.1	8.5	8.0	8.4	8.4	8.3

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.70. Soil pH at the Lethbridge site in 1999.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	8.0	7.9	7.8	7.9	8.3	7.8	7.8	8.0	7.9	7.9	7.8	8.1	7.7	7.9	8.0	8.2	7.9
2	8.0	7.9	8.1	8.1	8.0	8.1	7.8	8.0	7.9	8.0	8.1	8.0	8.1	8.1	7.8	7.7	7.8
3	8.0	8.0	8.0	8.2	8.1	7.8	8.1	7.9	7.8	8.1	8.0	8.2	7.8	8.1	7.8	7.8	8.0
4	8.0	8.1	8.0	8.2	8.1	8.0	7.9	8.2	8.1	7.9	7.9	8.1	8.1	8.2	7.8	7.9	7.8
Mean	8.0	8.0	8.0	8.1	8.1	7.9	7.9	8.0	7.9	8.0	7.9	8.1	7.9	8.1	7.8	7.9	7.9
								15-30 cm soil depth									
1	8.1	8.3	8.1	7.9	8.2	8.1	8.0	8.3	8.2	8.0	8.1	8.3	8.1	8.0	8.2	8.3	8.3
2	8.1	8.1	8.3	8.3	8.0	8.3	7.8	8.2	8.1	8.2	8.2	8.2	8.3	8.1	7.9	8.1	7.9
3	7.9	8.0	8.3	8.2	8.2	8.1	8.1	8.1	8.1	8.2	8.1	8.2	8.1	8.1	7.8	7.9	8.3
4	8.2	8.3	8.0	8.0	8.3	8.4	8.1	8.5	8.4	8.2	8.0	8.1	8.3	8.5	8.1	8.1	7.8
Mean	8.1	8.2	8.2	8.1	8.2	8.2	8.0	8.3	8.2	8.1	8.1	8.2	8.2	8.2	8.0	8.1	8.1
								30-60 cm soil depth									
1	8.4	8.5	8.2	8.1	8.4	8.3	8.2	8.5	8.3	8.3	8.4	8.4	8.2	8.3	8.5	8.4	8.3
2	8.4	8.3	8.4	8.5	8.3	8.5	8.3	8.3	8.2	8.4	8.3	8.5	8.5	8.5	8.2	8.3	7.9
3	8.3	8.4	8.5	8.2	8.4	8.4	8.3	8.5	8.3	8.4	8.4	8.2	8.4	8.4	8.1	8.0	8.4
4	8.5	8.6	8.2	8.1	8.3	8.6	8.3	8.5	8.4	8.4	8.4	8.4	8.5	8.6	8.4	8.3	8.1
Mean	8.4	8.4	8.3	8.2	8.3	8.4	8.3	8.4	8.3	8.4	8.4	8.4	8.4	8.4	8.3	8.2	8.2
								60-90 cm soil depth									
1	8.5	8.6	8.3	8.4	8.4	8.5	8.2	8.5	8.5	8.6	8.6	8.5	8.5	8.5	8.7	8.5	8.4
2	8.5	8.4	8.6	8.7	8.2	8.7	8.1	8.5	8.3	8.5	8.4	8.5	8.6	8.5	8.5	8.4	8.2
3	8.2	8.6	8.5	8.3	8.3	8.7		8.6	8.5	8.4	8.5	8.3	8.6	8.5	8.3	8.2	8.6
4	8.5	8.7	8.5	8.3	7.9	8.4	8.4	8.6	7.9	8.6	8.5	8.5	8.4	8.8	8.6	8.5	8.4
Mean																	
								90-120 cm soil depth									
1	8.4	7.9	8.3	8.5	8.4	8.6	8.3	8.0	8.5	8.6	8.6	8.4	8.7	8.4	8.8	8.5	8.4
2	8.4	8.5	8.0	8.7	8.2	8.1	8.3	8.5	8.2	8.0	7.8	8.0	8.7	7.9	8.5	8.6	8.5
3	8.1	8.7	8.5	8.0	7.8	8.7		8.0	8.6	8.4	8.7	8.1	8.7	8.6	8.4	8.3	8.6
4	8.4	8.4	8.6	8.5	7.8	8.1	8.5	8.4	7.8	8.6	8.3	8.5	8.0	8.5	8.6	8.6	8.5
Mean	8.3	8.4	8.3	8.4	8.0	8.4	8.4	8.2	8.3	8.4	8.3	8.2	8.5	8.3	8.6	8.5	8.5
								120-150 cm soil depth									
1	8.3	7.9	7.7	8.5	8.5	8.0	8.4	7.8	8.2	8.6	8.4	7.8	8.7	7.9	8.7	7.8	7.8
2	8.2	8.6	8.6	8.5	8.3	7.9	7.8	8.4	7.8	7.8	7.8	7.9	8.7	7.8	7.9	8.0	8.3
3	8.2	8.5	8.0	7.8	7.8	8.2	7.8	7.9	8.6	8.4	8.7	7.7	8.4	8.5	8.4	8.5	8.1
4	8.2	8.0	8.6	8.6	7.9	7.9	8.5	8.3	7.9	8.0	7.8	8.5	7.8	8.0	8.5	8.6	7.9
Mean	8.2	8.2	8.2	8.3	8.1	8.0	8.1	8.1	8.1	8.2	8.2	8.0	8.4	8.0	8.4	8.2	8.0

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.71. Soil pH at the Lethbridge site in 2000.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	8.0	7.9	7.6	7.7	7.6	7.8	8.0	7.7	7.9	7.9	7.9	7.9	7.5	7.9	7.9	7.7	7.6
2	8.0	7.9	7.9	7.8	7.8	8.1	7.9	7.7	7.8	8.0	7.9	7.6	7.9	7.9	7.7	7.6	7.5
3	8.0	8.0	8.0	7.9	7.9	8.0	7.8	7.9	7.7	8.0	8.0	7.7	7.4	8.0	7.9	7.9	7.8
4	8.0	8.0	8.0	7.9	7.9	7.9	7.8	7.9	7.8	7.8	7.9	7.8	8.0	8.1	7.9	7.6	7.7
Mean	8.0	7.9	7.9	7.8	7.8	7.9	7.9	7.8	7.8	7.9	7.9	7.7	7.7	8.0	7.8	7.7	7.6
								15-30 cm soil depth									
1	8.0	8.2	8.0	7.9	8.0	8.0	8.1	8.0	7.8	8.0	8.2	8.3	7.7	8.0	7.8	8.1	7.6
2	8.2	8.1	8.2	8.1	8.1	8.4	7.9	7.8	7.8	8.2	8.1	8.0	7.9	7.9	7.9	7.9	7.8
3	8.0	8.0	8.2	8.1	8.0	8.1	8.0	8.0	8.0	8.0	8.2	8.1	7.7	8.0	7.9	8.1	7.8
4	8.2	8.4	8.1	8.1	8.1	8.0	8.0	8.2	8.1	8.1	8.1	7.9	8.3	8.3	7.9	7.9	8.0
Mean	8.1	8.2	8.1	8.0	8.0	8.1	8.0	8.0	7.9	8.1	8.1	8.1	7.9	8.0	7.9	8.0	7.8
								30-60 cm soil depth									
1	8.3	8.6	8.4	8.2	8.2	8.3	8.3	8.3	8.2	8.2	8.5	8.5	8.1	8.3	8.2	8.4	8.1
2	8.4	8.2	8.3	8.4	8.1	8.6	8.1	8.3	8.0	8.4	8.5	8.5	8.3	8.2	8.3	8.2	8.3
3	8.3	8.4	8.3	8.4	8.3	8.4	8.2	8.3	8.1	8.1	8.3	8.3	8.4	8.1	8.2	8.0	8.3
4	8.5	8.7	8.1	8.0	8.4	8.4	8.3	8.5	8.3	8.5	8.5	8.3	8.5	8.6	8.3	8.1	8.4
Mean	8.4	8.5	8.3	8.2	8.2	8.4	8.2	8.3	8.1	8.3	8.4	8.4	8.3	8.3	8.2	8.2	8.3
								60-90 cm soil depth									
1	8.6	8.8	8.6	8.3	8.4	8.6	8.6	8.5	8.5	8.7	8.7	8.6	8.4	8.5	8.6	8.4	8.4
2	8.5	8.6	8.5	8.6	8.2	8.7	8.4	8.4		8.5	8.5	8.1	8.6	8.4	8.7	8.4	8.6
3	8.3	8.6	8.7	8.3	8.5	8.7	8.4	8.5	8.4	8.3	8.6	8.5	8.8	8.5	8.5	8.3	8.7
4	8.6	8.7	8.3	8.2	8.4	8.6	8.5	8.5	8.4	8.8	8.7	8.5	8.5	8.8	8.4	8.4	8.6
Mean	8.5	8.7	8.5	8.3	8.4	8.6	8.5	8.5	8.4	8.6	8.6	8.4	8.6	8.5	8.5	8.4	8.6
								90-120 cm soil depth									
1	8.6	8.1	8.5	8.3	8.4	8.0	8.7	8.5	8.5	8.8	8.6	8.4	8.4	8.5	8.6	8.3	8.4
2	8.4	8.6	8.6	8.7	8.4	8.2	8.5	8.4	8.3	8.4	8.0	8.0	8.6	8.3	8.6	8.3	8.7
3	8.3	8.8	8.8	8.0	8.3	8.8	8.1	8.7	8.6	8.4	8.7	8.4	8.7	8.6	8.5	8.5	8.6
4	8.4	8.5	8.6	8.5	8.0	8.0	8.6	8.0	7.9	8.7	8.6	8.5	8.4	8.6	8.6	8.5	8.6
Mean	8.4	8.5	8.6	8.4	8.3	8.2	8.5	8.4	8.3	8.6	8.5	8.3	8.5	8.5	8.6	8.4	8.6
								120-150 cm soil depth									
1	8.2	8.0	7.9	8.4	8.4	8.0	8.7	8.0	8.0	8.7	7.9	8.0	8.3	8.4	8.6	7.9	8.2
2	8.3	8.4	8.1	8.6	8.5	7.9	8.0	8.8	7.9	7.8	8.0	8.0	8.7	7.9	8.0	8.5	8.5
3	8.0	8.4	8.7	7.9	7.9	8.6	7.8	8.1	7.9	8.4	8.7	7.9	8.1	8.6	8.5	8.5	8.0
4	8.2	7.9	8.6	8.6	7.9	7.9	8.4	7.8	7.9	8.0	8.0	8.5	8.4	7.9	8.5	8.5	8.5
Mean	8.2	8.2	8.3	8.4	8.2	8.1	8.2	8.2	7.9	8.2	8.1	8.1	8.4	8.2	8.4	8.3	8.3

[z] Control: No manure application; each replicate value is a mean of four control plots.
[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).
[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.72. Soil pH at the Lethbridge site in 2001.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	7.7	7.8	7.5	7.6	7.1	7.7	7.5	7.7	7.4	7.8	7.7	7.7	7.2	7.6	7.6	7.6	7.4
2	7.8	7.7	7.7	7.7	7.6	7.6	7.7	7.7	7.5	7.7	7.6	7.8	7.3	7.6	7.7	7.5	7.4
3	7.8	7.8	7.7	7.6	7.5	7.8	7.8	7.8	7.7	7.9	7.8	7.6	7.6	7.8	7.7	7.7	7.8
4	7.9	7.7	7.8	7.8	7.7	7.9	7.8	7.9	7.8	7.9	8.0	7.6	7.4	7.9	7.7	7.6	7.6
Mean	7.8	7.7	7.7	7.7	7.5	7.7	7.7	7.8	7.6	7.8	7.8	7.7	7.4	7.7	7.7	7.6	7.5
								15-30 cm soil depth									
1	7.8	8.1	7.7	7.7	7.5	7.8	7.8	7.8	7.7	7.8	7.9	8.0	7.5	7.9	7.7	7.8	7.6
2	7.9	7.8	7.9	8.0	7.7	7.8	7.7	7.7	7.8	7.6	7.8	7.7	7.7	7.7	7.9	7.8	7.7
3	7.9	7.9	7.8	7.9	8.0	7.8	8.0	7.8	7.9	7.8	7.8	8.0	7.9	7.8	7.8	7.8	8.0
4	8.0	7.9	7.9	7.9	7.9	8.1	7.9	8.1	8.1	8.0	8.1	7.6	7.8	8.0	7.8	7.8	7.8
Mean	7.9	7.9	7.8	7.9	7.8	7.9	7.8	7.8	7.9	7.8	7.9	7.8	7.7	7.8	7.8	7.8	7.8
								30-60 cm soil depth									
1	8.1	8.2	8.1	7.9	7.9	8.0	7.9	8.0	8.0	8.1	8.1	8.2	7.8	7.9	8.1	8.2	8.0
2	8.1	8.0	8.1	8.2	7.9	8.1	7.8	7.9	8.0	7.9	8.1	8.1	8.1	8.1	8.1	8.0	8.0
3	8.2	8.1	8.1	8.1	7.9	8.1	8.1	7.9	8.1	7.9	8.1	8.2	8.1	8.1	7.9	7.8	8.4
4	8.2	8.2	7.8	7.8	8.2	8.4	8.0	8.2	8.2	8.2	8.3	7.9	8.1	8.2	8.0	7.9	8.1
Mean	8.2	8.1	8.0	8.0	8.0	8.1	7.9	8.0	8.1	8.0	8.1	8.1	8.0	8.1	8.0	8.0	8.1
								60-90 cm soil depth									
1	8.2	8.4	8.3	8.2	8.1	8.2	8.2	8.2	8.2	8.3	8.3	8.3	8.2	8.2	8.4	8.3	8.1
2	8.4	8.3	8.3	8.4	8.1	8.5	8.1	8.2	8.1	8.3	8.2	8.4	8.4	8.3	8.5	8.3	8.4
3	8.2	8.3	8.5	8.2	8.1	8.4	8.0	8.2	8.2	8.3	8.4	8.2	8.5	8.3	8.3	7.9	8.6
4	8.5	8.5	8.1	7.9	8.2	8.2	8.2	8.4	8.3	8.5	8.5	8.1	8.2	8.5	8.4	8.2	8.4
Mean	8.3	8.4	8.3	8.2	8.1	8.3	8.1	8.2	8.2	8.3	8.3	8.2	8.3	8.3	8.4	8.2	8.4
								90-120 cm soil depth									
1	8.3	8.0	8.4	8.4	8.2	8.0	8.3	7.9	8.2	8.4	8.3	7.8	8.4	8.3	8.5	8.1	8.4
2	8.4	8.4	8.5	8.6	8.1	8.0	8.3	8.4	8.2	8.1	7.8	8.0	8.5	7.8	8.5	8.5	8.5
3	8.1	8.7	8.4	8.0	7.7	8.6	8.3	8.4	8.4	8.3	8.6	8.1	8.5	8.4	8.4	8.3	8.6
4	8.3	8.0	8.2	8.2	7.9	7.9	8.4	8.3	8.0	8.6	8.4	8.2	7.8	8.7	8.5	8.2	8.5
Mean	8.3	8.3	8.4	8.3	8.0	8.1	8.3	8.2	8.2	8.3	8.3	8.0	8.3	8.3	8.5	8.3	8.5
								120-150 cm soil depth									
1	8.2	7.8	7.9	8.5	8.2	8.0	8.4	7.8	7.8	8.4	7.8	7.9	8.4	8.2	8.5	7.8	8.0
2	8.4	8.6	7.8	8.5	8.2	7.9	8.3	8.3	7.8	7.7	7.8	7.8	8.5	7.8	8.0	8.2	8.5
3	8.1	8.5	7.8	7.8	7.8	8.5	8.3	8.3	8.3	8.4	8.7	7.8	8.4	8.4	8.4	8.5	8.2
4	8.2	7.9	8.3	8.3	7.8	7.9	8.5	8.1	7.8	8.0	7.9	8.2	7.8	8.6	8.5	8.4	8.5
Mean	8.2	8.2	7.9	8.3	8.0	8.1	8.4	8.1	7.9	8.1	8.0	7.9	8.3	8.2	8.3	8.2	8.3

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.73. Soil pH at the Airdrie site in 1997.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	7.4	7.5	7.7	7.6	7.9	7.0	7.1	7.4	7.3	7.2	7.7	7.6	7.6	7.4	7.5	7.8	7.4
2	7.1	7.6	7.0	6.6	7.7	7.7	7.4	7.3	7.8	7.3	7.2	7.3	6.1	6.9	6.3	7.6	7.1
3	7.3	6.7	7.4	7.4	7.7	6.7	7.7	7.5	7.0	7.8	7.3	7.9	6.6	7.0	7.8	7.4	7.7
4	7.2	7.4	7.3	7.4	6.6	7.4	7.7	7.6	7.5	7.6	7.6	7.6	6.9	6.2	7.8	7.2	7.0
Mean	7.3	7.3	7.3	7.2	7.5	7.2	7.5	7.4	7.4	7.5	7.4	7.6	6.8	6.9	7.3	7.5	7.3
								15-30 cm soil depth									
1	7.4	7.8	7.9	7.6	8.3	6.7	7.1	7.3	7.0	7.3	7.6	7.8	7.6	7.2	7.4	8.0	7.4
2	7.5	7.9	6.8	6.2	7.7	7.8	7.8	7.4	8.0	7.9	7.5	6.9	6.5	7.0	6.7	7.6	6.8
3	7.6	6.3	7.7	7.5	7.9	6.8	7.9	7.8	7.4	7.9	7.8	8.2	6.4	7.3	8.0	7.9	7.9
4	7.3	7.8	7.8	7.8	6.4	7.7	8.1	8.0	7.9	7.7	7.8	7.8	7.2	7.0	8.0	6.7	6.9
Mean	7.5	7.4	7.5	7.3	7.6	7.2	7.7	7.6	7.6	7.7	7.7	7.7	6.9	7.1	7.5	7.5	7.2
								30-60 cm soil depth									
1	7.9	8.6	8.3	7.9	8.6	7.8	7.7	8.0	7.5	7.2	8.0	8.3	8.0	7.4	8.1	8.3	8.2
2	7.9	8.4	6.9	6.9	7.7	7.9	8.3	7.9	8.5	8.2	8.2	7.9	6.8	7.4	7.6	7.9	6.9
3	8.1	7.0	8.0	7.9	8.1	7.0	7.9	8.1	7.8	8.3	8.1	8.6	6.8	7.5	8.2	8.1	8.2
4	8.1	8.2	8.2	8.1	7.1	8.2	8.3	8.6	8.2	8.0	8.0	8.3	7.6	7.5	8.2	6.9	7.3
Mean	8.0	8.0	7.8	7.7	7.9	7.7	8.0	8.1	8.0	7.9	8.1	8.3	7.3	7.4	8.0	7.8	7.6
								60-90 cm soil depth									
1	8.4	8.8	8.7	8.3	8.9	8.3	8.8	8.3	8.3	8.2	8.6	8.6	8.2	8.1	8.4	8.9	8.9
2	8.3	8.9	7.7	7.1	8.2	7.9	9.2	8.0	8.9	8.4	8.8	8.3	7.8	8.2	8.3	8.6	7.3
3	8.5	7.9	8.3	8.4	8.4	7.4	8.5	8.2	8.5	8.6	8.3	8.9	7.3	8.0	8.4	8.3	8.1
4	8.7	8.5	8.4	8.4	7.6	8.5	8.5	8.7	8.7	8.0	8.6	8.6	8.7	8.7	8.7	7.6	8.4
Mean	8.5	8.5	8.3	8.0	8.3	8.0	8.7	8.3	8.6	8.3	8.6	8.6	8.0	8.2	8.4	8.3	8.2
								90-120 cm soil depth									
1	8.7	9.1	8.8	8.4	9.0	9.0	9.2	8.5	8.7	8.7	9.2	8.3	8.4	8.7	8.5	8.9	9.1
2	8.6	9.0	8.0	7.9	8.5	8.2	9.2	8.4	8.9	8.5	8.8	8.4	8.2	8.4	8.5	8.6	8.1
3	8.7	8.2	8.6	8.7	8.8	8.1	8.8	8.4	8.6	8.7	8.6	8.9	8.0	8.2	8.7	8.4	8.6
4	8.8	8.7	8.5	8.6	8.3	8.6	8.7	8.7	8.8	8.1	8.7	8.7	9.3	8.8	8.8	8.3	8.7
Mean	8.7	8.7	8.5	8.4	8.6	8.5	9.0	8.5	8.7	8.5	8.8	8.6	8.5	8.5	8.6	8.5	8.6
								120-150 cm soil depth									
1	8.7	9.0	8.9	8.4	9.0	9.0	9.3	8.5	8.6	8.7	9.4	8.1	8.4	8.8	8.5	8.8	9.0
2	8.6	9.0	8.0	8.1	8.6	8.2	9.2	8.2	9.0	8.4	8.7	8.4	8.3	8.4	8.5	8.8	8.3
3	8.7	8.3	8.5	8.7	8.7	8.2	8.7	8.5	8.7	8.7	8.6	8.8	8.4	8.5	8.7	8.5	8.5
4	8.8	8.7	8.5	8.6	8.5	8.8	8.8	8.7	8.8	8.3	8.7	8.6	9.3	8.6	8.9	8.2	8.7
Mean	8.7	8.7	8.5	8.4	8.7	8.5	9.0	8.5	8.8	8.5	8.8	8.5	8.6	8.6	8.6	8.6	8.6

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.74. Soil pH at the Airdrie site in 1998.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	7.9	7.9	7.9	7.7	8.1		7.7	7.7	7.7	7.9	8.2	8.2	7.8	7.9	7.8	8.1	7.9
2	8.1		7.2	7.3	8.2	8.1	8.1	7.7	8.3	7.5	7.5	7.8	7.0	7.3	7.5	8.2	7.3
3	7.9	7.4	7.8	7.7	7.8	7.3	8.0	8.2	7.6	7.8	7.8	8.0	7.4	7.6	8.0	7.5	7.7
4	7.9	7.8	7.3	7.5	7.1	7.8	8.3	7.7	7.4	8.2	8.3	7.8	7.2	7.5	8.1	7.3	7.0
Mean	8.0	7.7	7.5	7.5	7.8	7.7	8.0	7.8	7.7	7.8	7.9	7.9	7.3	7.6	7.8	7.8	7.5
								15-30 cm soil depth									
1	8.0	8.4	8.0	8.0	8.2	7.8	7.7	7.8	7.9	7.8	8.4	8.5	7.7	8.2	8.3	8.1	8.0
2	8.1	8.8	7.5	7.5	8.3	7.9	8.3	7.9	8.4	7.9	8.0	7.9	7.0	7.8	7.7	8.3	7.5
3	8.1	7.4	8.1	8.1	8.1	7.2	8.2	8.4	7.6	8.2	8.2	8.4	7.2	7.7	8.4	8.0	8.3
4	8.1	8.3	7.1	7.9	6.9	7.8	8.6	7.9	8.0	8.4	8.4	8.1	7.5	7.8	8.2	7.2	7.2
Mean	8.1	8.2	7.7	7.9	7.9	7.7	8.2	8.0	8.0	8.1	8.2	8.2	7.3	7.9	8.1	7.9	7.7
								30-60 cm soil depth									
1	8.4	8.4	8.5	8.4	8.8	8.4	8.8		8.5	8.5	8.8	8.8	7.6	8.7	8.5	8.6	8.4
2	8.3	9.2	7.9	7.5	8.8	7.8	9.3	8.3	8.8	8.4	8.6	8.4	7.2	8.2	8.4	8.8	7.8
3	8.7	7.3	8.6	8.7	8.3	7.4	8.6	8.7	8.1	8.4	8.5	8.6	8.2	8.3	8.4	8.2	8.9
4	8.5	8.6	7.3	8.6	7.1	8.2	8.9	8.2	8.5	8.7	8.7	8.3	8.7	8.4	8.4	7.5	7.7
Mean	8.5	8.4	8.1	8.3	8.2	7.9	8.9	8.4	8.5	8.5	8.6	8.5	7.9	8.4	8.4	8.3	8.2
								60-90 cm soil depth									
1	8.9	9.0			9.1	9.1	9.5	8.2	8.9	9.0	9.3	9.2	8.3	9.1	8.7	9.2	8.7
2	8.9	9.5	8.5	7.6	9.0	8.5	9.8		9.2	8.8	8.8	9.2	8.2	8.6	8.7	9.1	8.4
3	9.0	8.3	8.9	8.9	8.7	8.6	8.9	9.1	8.8	8.6	8.8	8.9	8.7	8.7	8.7	8.6	9.2
4	9.1	8.8	8.4	9.0	8.1	8.6	9.1	8.7	8.9	8.9	8.9	8.5	9.6	8.9	8.8	8.2	8.6
Mean	9.0	8.9	8.6	8.5	8.7	8.7	9.3	8.7	8.9	8.8	8.9	8.9	8.7	8.8	8.7	8.8	8.7
								90-120 cm soil depth									
1	9.2	9.2	9.0	8.5	9.3	9.2	9.6	8.3	9.1	9.0	9.7	9.2	8.2	9.2	8.8		9.1
2	9.0	9.5	8.5	8.4	9.2	8.8	9.8	8.9		8.9	9.2	9.6	8.5	8.4	8.9	9.3	8.8
3	9.1	8.7	9.0	9.1	8.9	8.9	9.2	9.0	9.1	8.9	9.0	9.1	9.0	8.9	8.9	8.8	9.2
4	9.3	9.0	8.8	9.1	8.5	8.7	9.1	8.9	9.1	9.1	9.2	9.0	9.6	9.2	9.1	8.6	9.1
Mean	9.2	9.1	8.8	8.8	9.0	8.9	9.4	8.8	9.1	9.0	9.3	9.2	8.8	8.9	8.9	8.9	9.0
								120-150 cm soil depth									
1	9.1	9.1	9.1	8.5	9.3	9.4	9.6	8.4	9.1	9.0	9.8	9.2	8.5	9.1	8.8	9.1	9.1
2	9.1	9.5	8.6	8.6	9.3	8.9	9.6	9.0	9.7	9.0	9.2	9.5	8.7	8.3	8.9	9.5	8.7
3	9.1	8.8	8.9	9.0	9.0	8.8	9.0	9.0	9.1	8.9	8.9	9.0	9.0	8.9	9.1	8.9	9.2
4	9.2	9.0	9.0	9.1	8.7	8.9	9.1	9.2	8.9	9.2	9.1	9.0	9.5	8.9	9.2	8.6	9.1
Mean	9.2	9.1	8.9	8.8	9.1	9.0	9.3	8.9	9.2	9.0	9.2	9.2	8.9	8.8	9.0	9.0	9.0

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.75. Soil pH at the Airdrie site in 1999.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	7.8	8.0	8.0	7.8	8.1	7.4	7.5	7.8	7.5	7.5	8.0	7.9	7.7	7.6	7.9	7.7	7.6
2	7.7	8.0	7.4	7.0	8.1	7.6	7.8	7.5	7.8	7.8	7.5	7.1	7.0	6.9	7.0	7.4	6.4
3	7.6	7.4	7.5	7.8	8.0	7.0	7.8	7.8	7.2	7.4	7.6	8.0	7.0	7.0	7.8	7.2	7.5
4	7.6	7.7	7.4	7.6	8.1	7.3	7.8	7.5	7.5	8.0	7.9	7.9	7.3	7.2	7.8	7.1	7.6
Mean	7.7	7.8	7.6	7.5	8.1	7.3	7.7	7.6	7.5	7.7	7.7	7.7	7.2	7.2	7.6	7.3	7.3
								15-30 cm soil depth									
1	7.8	8.2	8.3	8.4	8.2	7.4	7.5	8.1	7.6	7.4	8.1	8.0	7.4	7.6	8.4	7.9	7.9
2	7.9	8.2	7.7	7.0	8.1	7.7	8.1	8.0	8.0	8.4	7.9	8.3	7.6	7.4	7.3	7.7	7.1
3	7.7	7.1	7.6	7.9	8.3	6.9	8.0	8.0	7.2	7.3	7.4	8.1	7.1	6.9	7.8	6.9	8.0
4	7.9	8.3	7.5	7.4	7.0	7.5	7.9	7.8	8.0	8.3	8.1	8.0	8.5	7.9	7.9	7.0	7.7
Mean	7.9	7.9	7.8	7.7	7.9	7.4	7.9	8.0	7.7	7.8	7.9	8.1	7.6	7.4	7.8	7.4	7.7
								30-60 cm soil depth									
1	8.4	8.3	8.6	8.7	8.9	7.8	8.4	8.5	8.3	7.8	8.6	8.3	7.9	8.1	8.7	8.4	8.4
2	8.4	8.8	8.1	7.2	8.4	7.7	9.3	8.3	8.4	8.6	8.5	8.7	8.2	8.3	8.1	8.3	7.9
3	8.1	7.2	8.0	8.3	8.4	7.1	8.4	8.3	7.3	7.9	8.0	8.4	7.3	7.8	8.1	7.7	8.2
4	8.3	8.4	7.7	8.0	7.7	8.1	8.4	8.3	8.4	8.4	8.3	8.2	9.2	8.7	8.0	7.2	8.2
Mean	8.3	8.2	8.1	8.0	8.3	7.7	8.6	8.3	8.1	8.2	8.3	8.4	8.1	8.2	8.2	7.9	8.2
								60-90 cm soil depth									
1	9.1	8.9	9.1	8.7	9.2	9.2	9.2	8.7	8.8	8.7	9.1	9.2	8.4	8.8	8.7	9.2	8.9
2	8.7	9.1	8.2	7.7	8.7	8.0	9.6	8.4	9.1	8.7	8.5	8.9	8.4	8.8	8.6	9.3	8.2
3	8.7	8.0	8.4	8.7	8.8	8.3	9.0	8.5	8.5	8.5	8.6	8.8	8.2	8.3	8.4	8.4	8.9
4	8.8	8.6	8.3	8.6	8.3	8.4	8.6	8.4	8.7	8.5	8.7	8.4	9.7	9.1	8.5	8.1	8.6
Mean	8.8	8.6	8.5	8.4	8.7	8.5	9.1	8.5	8.8	8.6	8.7	8.8	8.7	8.7	8.5	8.7	8.6
								90-120 cm soil depth									
1	9.2	9.0	9.1	8.8	9.3	9.5	9.6	8.7	8.9	8.9	9.7	9.7	8.7	9.1	8.8	9.1	9.0
2	8.6	8.8	8.4	8.4	9.3	8.3	9.7	8.5	9.3	8.6	8.7	9.0	8.4	8.7	8.8	9.5	8.2
3	8.9	8.5	8.7	8.9	9.1	8.5	9.1	8.7	8.8	8.7	8.8	9.0	8.5	8.7	8.6	8.5	9.1
4	8.9	8.7	8.5	8.8	8.5	8.6	8.6	8.6	8.8	8.7	8.8	8.5	9.7	9.1	8.6	8.4	8.8
Mean	8.9	8.7	8.7	8.7	9.0	8.7	9.2	8.6	8.9	8.7	9.0	9.0	8.8	8.9	8.7	8.9	8.8
								120-150 cm soil depth									
1	9.3	9.1	9.1	8.7	9.3	9.3	9.3	8.8	8.9	9.1	9.8	9.8	8.7	9.2	8.8	9.1	9.2
2	8.6	8.9	8.3	8.4	9.4	8.4	9.5	8.6	9.1	8.6	8.7	8.9	8.4	8.7	8.8	9.5	8.4
3	8.9	8.6	8.7	9.0	9.1	8.5	9.0	8.7	8.9	8.8	8.8	8.9	8.5	8.8	8.7	8.5	9.0
4	8.9	8.6	8.5	8.8	8.5	8.6	8.8	8.7	8.8	8.8	8.9	8.8	9.5	8.8	8.6	8.5	8.7
Mean	8.9	8.8	8.6	8.7	9.1	8.7	9.1	8.7	8.9	8.8	9.0	9.1	8.8	8.9	8.7	8.9	8.8

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.76. Soil pH at the Airdrie site in 2000.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	7.7	8.0	7.9	7.6	7.7	7.9	7.6	7.7	7.6	7.5	7.8	7.8	7.6	7.6	7.9	7.6	8.1
2	7.6	8.1	7.1	7.3	7.7	7.9	7.9	7.8	7.8	7.8	7.9	7.5	6.4	7.5	7.1	7.6	6.8
3	7.6	7.3	7.5	7.7	7.7	7.2	7.9	7.8	7.4	7.3	7.3	7.9	8.1	7.6	7.6	7.3	7.6
4	7.6	7.8	7.4	7.5	7.0	7.6	8.0	7.8	7.7	7.9	7.8	7.7	6.8	7.3	7.7	7.4	7.0
Mean	7.6	7.8	7.5	7.5	7.5	7.6	7.8	7.8	7.6	7.6	7.7	7.7	7.2	7.5	7.6	7.5	7.4
								15-30 cm soil depth									
1	7.8	8.2	8.0	7.8	8.0	8.3	7.6	7.9	7.5	7.4	8.0	8.0	7.6	7.8	8.2	7.9	8.3
2	7.6	8.5	7.4	6.7	8.4	7.8	8.3	7.9	8.0		8.1	7.5	6.5	7.7	7.3	7.9	6.9
3	7.9	6.9	7.8	8.0	7.3	6.8	7.9	8.1	7.4	7.6	7.7	8.2	7.0	7.7	8.1	7.8	8.0
4	7.8	8.0	6.9	7.9	6.5	7.9	8.2	7.8	7.8	8.0	8.0	7.9	7.5	7.5	8.2	7.6	7.1
Mean	7.8	7.9	7.5	7.6	7.5	7.7	8.0	7.9	7.7	7.7	7.9	7.9	7.1	7.7	7.9	7.8	7.6
								30-60 cm soil depth									
1	8.3	8.9	8.4	8.2	8.4	8.9	8.1	8.1	7.9	8.2	8.3	8.3	7.8	8.3	8.3	8.4	8.9
2	8.0	8.8	7.6	7.2	8.3	7.8	8.7	8.1	8.3	8.6	8.7	7.8	6.8	8.3	7.8	8.5	7.9
3	8.3	7.3	8.2	8.3	8.0	7.0	8.1	8.3	8.0	8.1	8.1	8.4	7.7	8.0	8.3	8.0	8.4
4	8.2	8.2	7.0	8.2	6.9	8.2	8.6	7.9	8.2	8.4	8.2	8.0	8.5	8.4	8.3	7.7	7.2
Mean	8.2	8.3	7.8	8.0	7.9	8.0	8.4	8.1	8.1	8.3	8.3	8.1	7.7	8.2	8.2	8.1	8.1
								60-90 cm soil depth									
1	8.7	9.2	8.7	8.3	8.5	9.3	8.7	8.4	8.6	8.5	8.6	8.7	8.3	8.7	8.5	8.8	9.2
2	8.6	8.9	8.3	8.0	8.6	8.0	9.3	8.6	8.8	8.6	8.8	8.5	8.0	8.7	8.2	8.8	8.3
3	8.6	8.0	8.6	8.5	8.3	8.2	8.5	8.6	8.5	8.2	8.3	8.7	8.2	8.4	8.5	8.2	8.6
4	8.7	8.5	7.9		7.9	8.5	8.8	8.4	8.7	8.6	8.4	8.4	9.4	8.7	8.7	8.1	8.3
Mean	8.6	8.6	8.4	8.3	8.3	8.5	8.8	8.5	8.6	8.5	8.5	8.6	8.5	8.6	8.5	8.5	8.6
								90-120 cm soil depth									
1	8.9	9.1	9.0	8.4	8.9	9.3	8.9	8.5	8.7	8.6	9.0	8.9	8.3	8.8	8.6	9.0	9.1
2	8.7	9.0	8.4	8.3	8.8	8.4	9.4	8.6	9.0	8.7	8.9	8.5	8.3	8.7	8.4	9.0	8.5
3	8.8	8.4	8.7	8.6	8.4	8.5	8.7	8.6	8.6	8.6	8.6	8.9	8.5	8.5	8.6	8.5	8.7
4	9.0	8.7	8.2	8.6	8.2	8.7	8.9	8.6	8.8	8.7	8.8	8.7	9.3	9.0	8.6	8.3	8.9
Mean	8.8	8.8	8.6	8.5	8.6	8.7	9.0	8.6	8.8	8.6	8.8	8.7	8.6	8.7	8.5	8.7	8.8
								120-150 cm soil depth									
1	8.8	9.0	8.9	8.5	8.8	8.9	8.9	8.4	8.7	8.6	9.0	9.0	8.4	8.6	8.5	8.6	9.0
2	8.6	9.0	8.2	8.2	8.6	8.4	9.3	8.4	8.9	8.6	8.8	8.2	8.3	8.7	8.3	9.0	8.3
3	8.6	8.3	8.5	8.5	8.5	8.3	8.6	8.6	8.6	8.6	8.6	8.9	8.3	8.3	8.5	8.4	8.7
4	8.9	8.6	8.0	8.4	7.8	8.5	8.9	8.6	8.8	8.9	9.0	8.4	9.1	8.8	8.8	8.3	8.8
Mean	8.7	8.7	8.4	8.4	8.4	8.5	8.9	8.5	8.7	8.7	8.8	8.6	8.5	8.6	8.5	8.6	8.7

[z] Control: No manure application; each replicate value is a mean of four control plots.
[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).
[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.77. Soil pH at the Airdrie site in 2001.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	7.4	7.5	7.7	7.2	7.8	7.5	7.5	7.5	7.5	7.4	7.7	7.6	7.5	7.0	7.4	7.1	7.0
2	7.2	7.8	7.1	7.3	7.7	7.5	7.6	7.5	7.8	7.3	7.2	6.9	6.5	6.8	6.6	7.3	5.9
3	7.5	7.4	7.3	7.5	8.0	7.2	7.6	7.4	7.4	7.4	6.9	7.8	7.3	7.3	7.9	7.3	7.2
4	7.5	7.4	7.4	7.3	7.0	7.3	8.0	7.2	7.5	7.9	7.7	7.6	8.1	7.4	7.8	7.5	6.9
Mean	7.4	7.5	7.4	7.3	7.6	7.4	7.7	7.4	7.5	7.5	7.4	7.5	7.3	7.1	7.4	7.3	6.7
								15-30 cm soil depth									
1	7.6	7.5	7.9	6.8	7.8	7.9	7.5	7.3	7.6	7.4	7.9	7.6	7.6	7.3	7.2	7.4	7.5
2	7.3	8.1	7.0	7.0	7.8	7.7	7.9	7.9	7.9	7.9	7.4	7.1	6.9	7.0	6.7	7.8	6.4
3	7.8	7.4	7.5	7.8	8.0	7.1	7.8	7.6	7.0	7.6	7.4	7.9	7.6	7.5	8.0	7.9	7.7
4	7.9	8.1	6.9	7.4	6.7	7.5	8.1	7.4	7.4	8.2	7.9	7.9	9.4	8.0	8.0	7.8	7.0
Mean	7.7	7.8	7.3	7.2	7.6	7.5	7.8	7.5	7.5	7.8	7.6	7.6	7.9	7.4	7.5	7.7	7.1
								30-60 cm soil depth									
1	8.1	7.6	8.2	6.9	8.1	7.9	7.5	7.4	7.4	8.0	8.0	8.0	8.1	7.5	7.6	7.7	7.5
2	7.7	8.7	7.5	7.2	8.2	7.6	8.2	7.4	8.1	8.2	8.3	7.7	7.3	7.6	6.9	8.1	7.5
3	8.1	7.5	7.9	8.1	8.1	7.2	8.0	7.9	7.3	8.0	7.9	8.1	7.9	7.8	8.0	8.2	8.0
4	8.4	8.2	7.0	8.0	7.0	8.2	8.3	8.0	8.1	8.5	8.0	8.2	9.6	8.5	8.1	8.1	7.7
Mean	8.1	8.0	7.6	7.5	7.8	7.7	8.0	7.7	7.7	8.2	8.0	8.0	8.2	7.8	7.6	8.0	7.7
								60-90 cm soil depth									
1	8.6	8.1	8.4	7.9	8.8	8.5	7.8	7.4	8.1	8.5	8.6	8.3	8.4	8.2	8.2	8.3	8.6
2	8.4	8.9	8.2	7.4	8.0	7.8	8.8	7.6	8.6	8.5	8.4	8.4	8.0	8.0	7.9	8.4	6.3
3	8.4	8.0	8.2	8.4	8.4	7.7	8.4	8.2	8.2	8.6	8.4	8.6	8.3	8.3	8.1	8.4	8.6
4	8.6	8.4	7.7	8.3	7.7	7.7	8.6	8.3	8.6	8.7	8.4	8.6	9.4	8.8	8.4	8.1	8.5
Mean	8.5	8.3	8.1	8.0	8.2	7.9	8.4	7.9	8.4	8.6	8.4	8.5	8.5	8.3	8.1	8.3	8.0
								90-120 cm soil depth									
1	8.5	8.5	8.4	8.3	9.0	8.8	8.2	8.0	8.3	8.6	9.2	8.4	8.5	8.4	8.3	8.7	8.8
2	8.5	8.9	8.2	8.2	8.7	8.2	9.0	8.3	8.8	8.6	8.4	8.7	8.3	8.4	8.2	8.8	7.9
3	8.6	8.2	8.3	8.4	8.7	8.1	8.7	8.4	8.6	8.7	8.5	8.7	8.6	8.4	8.3	8.7	8.6
4	8.9	8.6	8.4	8.5	8.2	8.1	8.6	8.6	8.7	8.8	8.7	8.7	9.3	8.8	8.7	8.5	8.7
Mean	8.6	8.5	8.3	8.3	8.6	8.3	8.6	8.3	8.6	8.7	8.7	8.6	8.7	8.5	8.4	8.7	8.5
								120-150 cm soil depth									
1	8.6	8.5	8.2	8.3	9.0	8.8	8.5	8.2	8.4	8.6	9.2	8.7	8.5	8.6	8.4	8.7	8.7
2	8.5	8.6	8.1	8.3	8.9	8.3	8.9	8.3	8.8	8.6	8.4	8.8	8.3	8.4	8.3	9.0	8.0
3	8.4	8.4	8.4	8.6	8.7	8.3	8.8	8.4	8.7	8.8	8.5	8.8	8.5	8.5	8.5	8.6	8.7
4	8.8	8.6	8.6	8.5	8.3	8.6	8.7	8.6	8.7	8.9	8.8	8.8	9.1	8.7	8.8	8.5	8.9
Mean	8.6	8.5	8.3	8.4	8.7	8.5	8.7	8.4	8.6	8.7	8.7	8.8	8.6	8.5	8.5	8.7	8.6

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.78. Soil electrical conductivity (dS m^{-1}) at the Lethbridge site in 1996.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	1.1	0.6	0.6	0.6	0.7	2.8	0.6	0.6	0.6	1.1	0.6	0.9	0.9	0.7	0.7	1.1	0.7
2	0.6	0.6	0.6	0.7	0.7	0.7	0.6	0.5	0.5	1.2	0.6	0.6	0.6	0.5	0.7	0.7	0.6
3	0.6	0.6	0.5	0.9	0.7	0.6	0.5	0.6	0.5	0.7	0.5	0.6	0.7	0.7	0.6	0.6	0.7
4	0.6	0.6	0.5	0.7	0.9	0.6	0.5	0.7	0.7	0.6	0.6	0.4	0.7	0.6	0.5	0.4	0.6
Mean	0.7	0.6	0.5	0.7	0.7	1.2	0.5	0.6	0.6	0.9	0.6	0.6	0.7	0.6	0.6	0.7	0.6
								15-30 cm soil depth									
1	1.4	0.9	0.8	0.7	0.6	2.1	0.6	0.6	1.4	1.8	2.5	1.0	2.3	1.1	0.6	1.3	0.7
2	0.6	2.3	0.6	0.6	0.6	0.9	0.6	0.6	0.5	1.2	0.6	1.0	0.5	0.9	0.6	0.6	0.6
3	0.8	0.8	0.9	0.9	1.2	1.2	0.7	1.0	0.6	0.7	0.5	0.8	0.7	0.5	0.6	0.6	0.6
4	0.9	0.7	0.5	0.6	0.7	1.0	0.5	1.2	0.8	0.6	0.6	0.5	0.7	0.6	0.5	0.5	0.5
Mean	0.9	1.2	0.7	0.7	0.8	1.3	0.6	0.8	0.8	1.1	1.0	0.8	1.0	0.8	0.6	0.7	0.6
								30-60 cm soil depth									
1	1.2	0.8	0.6	0.7	0.5	0.9	0.6	0.7	1.3	1.7	0.7	0.8	0.8	1.9	0.6	0.8	1.2
2	0.6	1.9	0.7	0.6	0.6	0.6	0.9	0.5	0.6	0.9	1.0	0.6	1.2	0.9	0.8	0.6	0.7
3	0.7	0.7	0.8	0.8	1.4	0.8	0.6	0.9	0.5	0.6	0.5	0.6	0.5	0.6	0.5	0.5	0.6
4	0.8	0.6	0.5	0.6	0.9	0.8	0.5	0.8	0.9	0.6	1.0	0.5	0.7	0.6	0.6	0.5	0.6
Mean	0.8	1.0	0.6	0.7	0.8	0.8	0.6	0.7	0.8	0.9	0.8	0.6	0.8	1.0	0.6	0.6	0.8
								60-90 cm soil depth									
1	1.0	1.0	0.6	0.6	0.6	0.9	0.6	0.7	0.9	1.0	0.7	1.0	0.7	0.8	0.6	0.7	0.8
2	0.6	1.0	0.6	0.5	0.5	0.7	0.6	0.6	0.6	0.7	0.8	0.7	0.7	0.7	0.6	0.6	0.6
3	1.4	0.5	0.6	0.9	0.9	0.5	0.6	1.0	0.5	0.6	0.6	0.6	0.6	0.6	0.5	0.5	0.7
4	0.7	0.8	0.9	0.6	1.0	0.9	0.5	0.9	4.6	1.1	0.7	0.5	4.3	0.7	0.6	0.5	0.7
Mean	0.9	0.8	0.7	0.6	0.7	0.7	0.6	0.8	1.6	0.8	0.7	0.7	1.6	0.7	0.6	0.6	0.7
								90-120 cm soil depth									
1	1.3	3.8	0.8	0.6	0.5	5.6	0.7	0.8	4.4	1.4	0.9	1.4	0.6	1.3	1.1	0.8	0.9
2	2.4	0.7	0.8	0.7	0.6	4.1	0.8	0.7	0.7	0.7	1.1	5.3	0.8	0.7	1.2	0.6	0.6
3	1.7	0.7	0.5	4.5	2.5	0.6	0.6	1.0	0.6	0.6	0.6	0.8	0.6	0.5	0.5	0.6	0.7
4	1.6	0.8	0.5	0.6	4.5	4.3	0.6	0.8	5.0	0.6	0.8	0.6	1.4	0.8	0.7	0.5	0.6
Mean	1.8	1.5	0.6	1.6	2.0	3.6	0.7	0.8	2.7	0.8	0.8	2.0	0.8	0.8	0.9	0.6	0.7
								120-150 cm soil depth									
1	3.2	5.4	3.6	0.8	0.6	5.9	0.6	5.2	4.6	1.0	5.3	5.0	0.7	1.7	1.1	4.9	1.2
2	2.9	0.8	1.4	0.8	0.6	5.1	0.9	0.9	4.7	3.1	4.7	5.0	0.8	4.5	3.2	0.7	0.8
3	2.5	0.9	0.7	5.0	4.7	1.0	0.7	1.2	0.7	0.5	0.6	4.5	0.9	0.5	0.6	0.6	0.8
4	2.7	4.5	0.6	0.7	5.0	4.3	0.7	0.7	5.2	4.7	4.5	0.5	0.6	3.3	0.9	0.6	2.1
Mean	2.8	2.9	1.6	1.8	2.7	4.1	0.7	2.0	3.8	2.3	3.8	3.8	0.7	2.5	1.4	1.7	1.2

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.79. Soil electrical conductivity (dS m^{-1}) at the Lethbridge site in 1997.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	0.6	1.1	0.7	0.8	0.7	0.8	0.6	1.3	0.8	0.6	0.6	0.8	0.7	0.7	0.5	0.5	0.7
2	0.6	0.5	0.6	0.8	0.6	0.9	0.5	0.6	0.5	0.7	1.0	0.6	0.5	0.6	0.6	0.6	0.6
3	0.6	0.6	0.6	0.7	0.8	0.6	0.6	0.6	0.7	0.6	0.5	0.6	0.7	0.6	0.6	0.6	0.6
4	0.6	0.7	0.5	0.6	0.7	0.8	0.6	0.6	1.0	0.5	0.6	0.5	0.7	0.6	0.6	0.5	0.6
Mean	0.6	0.7	0.6	0.7	0.7	0.8	0.6	0.8	0.7	0.6	0.7	0.6	0.6	0.6	0.6	0.5	0.6
								15-30 cm soil depth									
1	0.5	0.6	0.5	0.6	0.5	0.6	0.6	0.6	0.6	0.5	0.6	0.8	0.5	0.6	0.9	0.7	0.6
2	0.5	0.4	0.6	1.2	0.6	0.9	0.5	0.5	0.5	0.6	0.6	0.6	0.5	0.6	0.5	0.6	0.7
3	0.5	0.5	0.5	0.7	0.7	0.5	0.6	0.5	0.8	0.6	0.5	0.6	0.7	0.6	0.7	0.5	0.8
4	0.7	0.5	0.6	0.5	0.7	0.7	0.6	0.6	0.8	0.5	0.5	0.5	0.7	0.6	0.5	0.6	0.8
Mean	0.6	0.5	0.5	0.7	0.6	0.7	0.6	0.5	0.7	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.7
								30-60 cm soil depth									
1	0.5	0.6	0.5	0.5	0.5	0.9	0.6	0.6	0.7	0.8	0.6	0.6	0.6	0.6	0.5	0.5	0.7
2	0.5	0.5	0.6	0.6	0.5	0.9	0.5	0.6	0.5	0.5	0.7	0.5	0.6	0.5	0.4	0.7	0.6
3	0.5	0.5	0.4	0.7	0.9	0.5	0.6	0.5	0.6	0.5	0.5	0.6	0.6	0.5	0.6	0.4	0.7
4	0.6	0.5	0.6	0.5	0.7	0.9	0.5	0.6	0.9	0.5	0.6	0.5	0.7	0.7	0.8	0.5	0.9
Mean	0.5	0.5	0.5	0.6	0.6	0.8	0.5	0.6	0.7	0.6	0.6	0.5	0.6	0.6	0.6	0.5	0.7
								60-90 cm soil depth									
1	0.6	0.7	0.7	0.7	0.5	0.6	0.6	0.6	0.7	0.5	0.7	0.6	0.5	0.7	0.5	0.6	0.6
2	0.7	0.5	0.6	0.7	0.6	0.7	0.5	0.6	0.5	0.5	1.0	0.6	0.6	0.6	0.5	0.6	0.5
3	0.5	0.6	0.5	0.7	0.8	0.5	0.6	0.5	0.7	0.5	0.5	0.7	1.1	0.5	0.7	0.5	0.9
4	0.6	0.6	0.6	0.5	0.8	0.9	0.5	0.7	0.8	0.5	0.8	0.5	0.6	0.7	0.5	0.6	0.6
Mean	0.6	0.6	0.6	0.6	0.7	0.7	0.5	0.6	0.7	0.5	0.7	0.6	0.7	0.6	0.5	0.6	0.6
								90-120 cm soil depth									
1	0.7	1.0	1.1	0.7	0.5	0.7	0.7	1.3	0.7	0.5	0.7	0.8	0.6	0.8	0.6	0.6	0.8
2	1.5	0.6	1.1	0.5	0.5	0.7	0.6	0.7	1.0	0.9	1.3	0.8	0.9	0.7	0.9	0.6	0.7
3	1.5	0.8	0.5	3.5	0.9	0.6	1.0	0.6	0.8	0.5	0.6	0.9	0.9	0.6	0.6	0.5	0.9
4	0.9	0.7	0.5	0.6	3.1	4.5	0.5	1.5	4.3	0.8	1.2	0.5	0.7	0.8	0.7	0.6	0.6
Mean	1.1	0.8	0.8	1.3	1.2	1.6	0.7	1.0	1.7	0.7	0.9	0.7	0.8	0.7	0.7	0.6	0.7
								120-150 cm soil depth									
1	1.7	5.2	5.7	0.8	0.6	5.4	0.7	4.7	0.8	0.6	0.9	1.2	0.6	4.3	1.3	4.5	2.0
2	2.6	0.6	2.4	0.8	0.6	4.3	4.2	1.1	4.3	4.4	4.8	4.2	1.0	4.8	1.2	0.9	1.3
3	2.4	0.9	0.5	4.3	4.7	1.1	4.5	0.7	1.0	0.5	0.6	4.4	4.7	0.6	0.6	0.8	4.4
4	1.4	4.1	0.7	0.6	4.7	4.3	0.7	2.6	4.7	4.5	4.6	0.5	0.7	4.8	0.8	0.6	1.0
Mean	2.0	2.7	2.3	1.6	2.6	3.8	2.5	2.3	2.7	2.5	2.7	2.6	1.7	3.6	1.0	1.7	2.2

[z] Control: No manure application; each replicate value is a mean of four control plots.
[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).
[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.80. Soil electrical conductivity (dS m^{-1}) at the Lethbridge site in 1998.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	1.0	0.8	0.7	0.9	0.7	1.3	0.7	0.9	2.0	0.5	0.7	1.2	0.8	0.9	0.8	1.0	0.8
2	0.6	0.8	0.8	2.1	1.0	0.7	1.0	0.9	1.1	0.8	0.8	1.1	1.0	0.8	0.6	0.8	0.6
3	0.8	0.7	0.7	0.9	1.1	0.6	0.9	0.4	0.8	0.6	0.8	1.0	0.7	0.8	0.7	1.0	0.9
4	0.7	0.7	0.7	0.9	0.9	2.0	1.0	1.0	1.8	0.7	0.6	0.7	1.0	0.7	1.0	1.2	0.7
Mean	0.8	0.7	0.7	1.2	0.9	1.1	0.9	0.8	1.4	0.6	0.7	1.0	0.9	0.8	0.8	1.0	0.7
								15-30 cm soil depth									
1	0.6	0.7	0.6	0.7	0.6	0.9	0.8	0.7	0.9	0.6	0.7	1.0	0.7	0.8	0.6	0.8	0.7
2	0.7	0.6	0.7	0.7	0.7	0.6	0.9	0.8	0.9	0.8	0.7	0.7	1.1	0.8	0.6	0.7	0.6
3	0.7	0.6	0.5	0.7	0.7	0.6	0.7	0.6	0.7	0.5	0.6	0.9	0.6	0.8	0.6	0.8	0.8
4	0.6	0.8	0.6	0.7	0.7	0.8	0.7	0.8	1.2	0.7	0.7	0.7	0.8	0.6	0.8	1.0	0.6
Mean	0.7	0.7	0.6	0.7	0.7	0.7	0.8	0.7	0.9	0.6	0.7	0.8	0.8	0.7	0.6	0.8	0.7
								30-60 cm soil depth									
1	0.7	0.6	0.7	0.6	0.6	1.0	0.6	0.7	0.7	0.5	0.6	0.6	0.6	0.6	0.5	0.6	0.6
2	0.6	0.6	0.7	0.6	0.8	0.6	0.7	0.7	0.8	0.7	0.7	0.7	0.6	0.8	0.5	0.6	0.8
3	0.6	0.5	0.5	0.9	0.8	0.6	0.6	0.5	0.6	0.5	0.6	0.7	0.6	0.7	0.5	0.6	0.6
4	0.6	0.6	0.6	0.6	1.2	0.9	0.6	0.7	0.9	0.5	0.8	0.6	0.6	0.6	0.6	0.6	0.6
Mean	0.6	0.6	0.6	0.7	0.8	0.8	0.6	0.6	0.7	0.5	0.7	0.6	0.6	0.7	0.5	0.6	0.6
								60-90 cm soil depth									
1	0.6	0.8	1.5	0.6	0.5	0.7	0.7	0.9	1.1	0.5	0.6	1.1	0.6	0.6	0.5	0.6	0.6
2	1.3	0.7	0.7	0.7	0.7	0.8	0.6	0.6	0.8	0.6	1.7	2.7	1.0	0.9	0.7	0.6	0.6
3	1.6	0.7	0.7	0.9	0.8	0.8	0.6	0.5	0.7	0.5	0.6	0.8	0.6	0.6	0.5	0.6	0.8
4	0.6	0.7	0.6	0.6	0.8	2.3	0.6	1.0	2.0	0.7	0.7	0.6	0.6	0.8	0.6	0.7	0.6
Mean	1.0	0.7	0.9	0.7	0.7	1.1	0.6	0.7	1.1	0.6	0.9	1.3	0.7	0.7	0.6	0.6	0.6
								90-120 cm soil depth									
1	1.0	1.0	4.1	0.7	0.6	3.7	0.7	0.6	4.5	0.8	1.2	3.5	0.8	0.8	0.9	0.7	0.7
2	2.0	0.7	1.0	0.6	0.6	2.9	0.7	0.7	2.1	0.8	4.7	4.7	0.9	1.8	1.1	0.6	0.8
3	2.5	0.9	0.5	2.7	4.7	0.7	2.9	2.3	0.7	0.4	0.6	2.3	1.1	0.5	0.6	0.5	1.0
4	1.2	1.0	0.6	0.6	3.7	4.3	0.5	1.8	4.5	5.2	1.4	0.6	0.6	3.3	0.7	0.5	0.9
Mean	1.7	0.9	1.5	1.1	2.4	2.9	1.2	1.3	2.9	1.8	2.0	2.8	0.8	1.6	0.8	0.6	0.8
								120-150 cm soil depth									
1	2.0	5.4	6.0	1.3	0.8	5.8	0.6	0.6	5.0	1.0	5.0	5.0	0.7	4.5	1.2	4.5	1.0
2	3.2	0.7	4.7	0.9	0.7	5.0	5.0	0.9	4.3	3.3	5.0	5.2	1.2	4.7	4.7	0.5	1.1
3	2.6	4.1	0.6	4.5	5.0	1.0	4.5	5.0	0.9	0.6	1.3	4.5	1.3	0.5	0.6	0.6	4.7
4	2.7	4.7	0.8	0.6	4.5	4.5	0.5	3.7	5.0	5.2	5.2	0.5	1.4	5.0	0.8	0.5	1.2
Mean	2.6	3.7	3.0	1.8	2.7	4.1	2.6	2.5	3.8	2.5	4.1	3.8	1.1	3.7	1.8	1.5	2.0

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.81. Soil electrical conductivity (dS m^{-1}) at the Lethbridge site in 1999.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	0.6	1.0	0.8	0.6	0.2	1.3	1.1	0.9	0.9	0.6	0.7	0.7	0.9	1.0	0.6	0.7	0.9
2	0.6	0.7	0.6	0.9	0.9	0.7	0.6	0.7	0.9	0.8	0.8	0.6	0.7	0.7	0.8	1.8	0.8
3	0.7	0.6	1.1	1.0	1.0	1.2	0.7	1.2	0.8	0.4	0.5	0.6	0.7	0.5	0.8	0.8	1.2
4	0.6	0.7	0.7	0.6	1.0	1.0	0.8	0.9	1.2	0.5	0.6	0.5	0.9	0.7	1.1	1.0	1.5
Mean	0.6	0.7	0.8	0.8	0.8	1.0	0.8	0.9	0.9	0.6	0.6	0.6	0.8	0.7	0.8	1.1	1.1
								15-30 cm soil depth									
1	0.5	0.6	0.7	0.6	1.2	0.8	0.6	0.6	0.8	0.4	0.5	0.6	0.7	0.9	0.6	0.7	0.5
2	0.5	0.7	0.6	0.6	0.8	0.6	0.8	0.6	1.0	0.8	0.6	0.6	0.5	0.8	0.5	0.8	0.7
3	0.6	0.5	0.7	0.8	0.9	0.6	1.0	0.8	0.6	0.4	0.5	0.6	0.5	0.5	0.6	0.5	0.7
4	0.5	0.6	0.7	0.6	0.8	0.6	0.5	0.6	0.8	0.4	0.6	0.5	0.7	0.6	0.6	0.6	0.9
Mean	0.6	0.6	0.7	0.6	0.9	0.6	0.7	0.6	0.8	0.5	0.5	0.6	0.6	0.7	0.6	0.6	0.7
								30-60 cm soil depth									
1	0.5	0.8	0.7	0.7	0.7	0.5	0.6	0.6	0.8	0.5	0.5	0.6	0.8	0.6	0.5	0.6	0.6
2	0.7	0.7	0.7	0.8	0.8	0.7	0.7	0.7	0.8	0.6	0.7	0.6	0.5	0.6	0.5	0.6	0.6
3	0.5	0.5	0.6	1.1	0.8	0.5	0.7	0.6	0.7	0.5	0.5	0.6	0.5	0.5	0.5	0.5	1.0
4	0.5	0.6	0.8	0.8	1.2	0.6	0.6	0.8	0.9	0.5	0.6	0.5	0.6	0.7	0.5	0.5	0.6
Mean	0.6	0.6	0.7	0.8	0.9	0.6	0.6	0.7	0.8	0.5	0.6	0.6	0.6	0.6	0.5	0.5	0.7
								60-90 cm soil depth									
1	0.5	0.8	0.7	0.9	0.7	0.6	0.6	0.7	0.6	0.5	0.5	0.7	0.6	0.6	0.6	0.6	0.5
2	1.1	0.7	0.8	0.8	0.8	0.7	0.7	0.4	0.7	0.6	0.8	0.9	0.6	0.6	0.7	0.6	0.7
3	1.8	0.7	0.7	1.0	1.1	0.5		0.9	0.7	0.4	0.6	0.8	0.6	0.6	0.5	0.6	0.9
4	0.8	0.8	0.6	0.8	4.5	1.5	0.6	0.9	3.3	0.6	0.7	0.5	0.7	0.8	0.6	0.6	0.6
Mean	1.1	0.7	0.7	0.9	1.8	0.8	0.6	0.7	1.3	0.5	0.6	0.7	0.6	0.6	0.6	0.6	0.7
								90-120 cm soil depth									
1	1.0	5.0	0.9	1.0	0.7	0.7	0.6	4.0	0.6	0.5	0.6	0.8	0.6	0.7	0.9	0.7	0.8
2	2.0	0.8	5.4	0.8	0.7	1.5	0.9	0.9	1.1	1.9	4.6	4.4	0.8	3.3	1.2	0.6	0.8
3	2.2	0.8	0.7	2.4	4.5	0.3		4.6	0.8	0.5	0.6	1.3	0.7	0.6	0.6	0.6	0.8
4	1.4	1.1	0.7	0.7	4.3	3.9	0.6	0.8	4.5	0.7	1.1	0.5	2.5	1.2	0.7	0.5	0.6
Mean	1.7	1.9	1.9	1.2	2.5	1.6	0.7	2.6	1.7	0.9	1.7	1.7	1.1	1.4	0.8	0.6	0.7
								120-150 cm soil depth									
1	1.8	5.2	4.6	1.0	0.6	4.8	0.6	5.0	1.0	0.7	0.8	4.3	0.8	3.0	1.4	4.5	4.5
2	3.4	0.7	1.3	0.9	0.7	5.0	4.6	1.1	4.3	3.4	4.7	5.2	1.1	4.7	4.5	3.0	1.2
3	2.5	1.3	3.0	3.9	5.1	2.5	3.0	4.9	0.8	0.4	0.7	4.5	1.2	0.9	0.6	0.6	2.6
4	2.3	3.9	0.6	0.7	4.7	4.3	0.6	0.8	3.9	3.1	4.8	0.5	4.3	5.0	0.8	0.7	2.9
Mean	2.5	2.8	2.4	1.6	2.8	4.1	2.2	2.9	2.5	1.9	2.7	3.6	1.8	3.4	1.8	2.2	2.8

[z] Control: No manure application; each replicate value is a mean of four control plots.
[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).
[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.82. Soil electrical conductivity (dS m^{-1}) at the Lethbridge site in 2000.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	0.8	1.4	1.1	0.9	1.2	1.5	1.2	1.8	1.9	0.9	0.9	1.0	0.7	0.9	0.8	1.7	1.5
2	0.9	0.9	0.9	1.3	1.4	0.9	1.1	2.2	1.9	0.9	0.9	1.3	0.8	1.0	1.2	1.2	1.3
3	0.8	0.8		1.2	1.7	1.1	2.2	2.5	2.2	0.6	0.7	1.2	1.1	0.6	0.8	0.8	1.3
4	0.8	1.0	0.7	1.1	1.2	1.9	1.4	1.9	2.9	1.0	0.7	0.8	1.0	0.9	0.9	1.3	1.2
Mean	0.8	1.0	0.9	1.1	1.4	1.3	1.5	2.1	2.2	0.8	0.8	1.1	0.9	0.8	0.9	1.2	1.3
								15-30 cm soil depth									
1	0.6	0.8	0.8	0.7	0.7	0.9	0.8	1.0	3.3	0.6	0.6	0.6	0.8	0.4	0.8	1.0	1.2
2	0.7	0.6	0.6	0.9	0.9	0.8	0.9	1.5	2.0	0.6	0.7	0.8	0.6	1.0	1.0	1.0	0.9
3	0.7	1.0	0.7	1.1	1.1	0.7	1.3	1.9	1.3	0.5	0.5	0.7	1.0	0.7	0.7	0.8	1.4
4	0.5	0.5	0.5	0.8	0.9	1.2	1.0	1.0	1.2	0.8	0.6	0.6	0.7	0.6	0.9	0.7	0.9
Mean	0.6	0.7	0.6	0.9	0.9	0.9	1.0	1.3	1.9	0.6	0.6	0.7	0.8	0.7	0.8	0.9	1.1
								30-60 cm soil depth									
1	0.5	0.8	0.7	0.6	0.8	0.6	0.6	0.6	1.2	0.5	0.5	0.6	0.5	0.6	0.5	0.8	0.8
2	0.5	0.5	0.8	0.8	1.0	0.6	0.7	0.8	1.5	0.5	0.7	0.8	0.5	0.6	0.7	0.6	0.6
3	0.6	0.6	0.5	0.9	1.0	0.5	1.1	1.2	1.3	0.5	0.5	0.8	0.5	0.5	0.6	0.6	1.0
4	0.5	0.6	0.7	0.8	1.0	0.7	0.7	0.9	1.0	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.7
Mean	0.5	0.6	0.7	0.8	0.9	0.6	0.8	0.9	1.2	0.5	0.6	0.7	0.5	0.6	0.6	0.6	0.8
								60-90 cm soil depth									
1	0.5	0.9	0.8	0.7	0.9	0.6	0.8	0.7	0.9	0.5	0.6	0.6	0.5	0.5	0.5	0.9	0.6
2	1.1	0.6	0.9	1.0	0.9	0.8	0.7	0.8		0.5	0.7	5.4	0.6	0.7	0.7	0.5	0.6
3	1.8	0.8	0.6	1.3	1.0	0.5	1.0	1.0	0.9	0.5	0.6	0.7	0.6	0.5	0.6	0.6	0.8
4	0.6	0.7	0.8	1.0	1.2	0.8	0.8	1.0	1.0	0.5	0.7	0.6	0.6	0.8	0.6	0.5	0.8
Mean	1.0	0.7	0.8	1.0	1.0	0.7	0.8	0.9	0.9	0.5	0.6	1.8	0.6	0.6	0.6	0.6	0.7
								90-120 cm soil depth									
1	0.6	6.2	1.2	0.8	0.8	5.1	0.8	0.8	1.0	0.6	0.7	0.8	0.5	0.6	0.6	1.2	0.7
2	3.0	0.8	1.1	1.0	0.9	3.0	0.8	0.8	0.9	0.7	3.9	5.3	0.7	1.0	1.0	1.7	0.8
3	2.6	0.9	0.8	4.3	1.4	0.7	2.1	1.1	0.9	0.5	0.7	1.0	0.9	0.6	0.6	0.6	0.9
4	1.5	1.0	0.6	0.7	5.0	5.0	0.8	3.3	5.0	0.8	1.1	0.5	0.7	1.2	0.7	0.5	0.8
Mean	1.9	2.2	0.9	1.7	2.0	3.4	1.1	1.5	1.9	0.6	1.6	1.9	0.7	0.8	0.7	1.0	0.8
								120-150 cm soil depth									
1	2.6	5.4	5.5	0.8	0.9	5.6	0.7	4.5	4.7	0.8	4.7	3.7	1.7	1.0	0.9	4.7	1.7
2	3.1	0.8	3.6	1.0	0.8	5.0	4.7	0.8	4.4	4.7	5.1	5.5	0.9	5.0	5.2	0.6	1.1
3	2.8	2.2	0.7	5.0	5.4	0.9	5.1	5.5	4.7	0.6	0.7	4.8	5.8	0.7	0.6	0.6	5.1
4	2.4	5.2	0.6	0.6	5.0	5.0	1.0	3.5	5.2	5.2	5.3	0.5	0.7	5.6	0.9	0.5	0.9
Mean																	

[z] Control: No manure application; each replicate value is a mean of four control plots.
[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).
[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.83. Soil electrical conductivity (dS m^{-1}) at the Lethbridge site in 2001.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	1.7	1.1	1.3	1.0	1.8	1.7	1.8	2.2	3.0	0.6	1.2	1.2	1.1	1.5	1.0	1.5	2.0
2	0.9	1.4	1.1	1.4	1.8	1.4	1.7	2.0	3.3	1.4	1.4	0.9	1.1	1.4	1.7	1.7	1.9
3	1.0	0.9	1.2	1.5	2.3	1.3	1.9	2.0	3.5	0.6	0.8	1.1	0.9	0.8	0.9	0.9	1.1
4	1.1	1.7	0.8	1.1	1.9	1.7	1.4	2.0	2.3	0.7	0.7	0.8	1.5	0.9	1.1	1.1	1.7
Mean	1.2	1.3	1.1	1.2	1.9	1.5	1.7	2.0	3.0	0.8	1.0	1.0	1.1	1.1	1.2	1.3	1.7
								15-30 cm soil depth									
1	0.9	1.1	1.1	0.9	1.3	1.5	1.0	1.4	1.5	0.8	1.0	1.0	0.9	1.0	0.9	1.3	1.5
2	0.9	1.0	0.9	1.0	1.2	1.1	1.3	1.7	2.0	1.2	1.4	1.2	1.0	1.0	1.2	1.1	1.4
3	0.8	0.7	1.1	1.2	1.4	1.0	1.2	1.5	1.8	0.6	0.7	0.8	0.8	0.7	0.8	1.2	0.8
4	0.7	1.0	0.8	1.0	1.2	1.0	1.0	1.3	1.4	0.8	0.8	0.7	1.7	0.8	1.0	0.9	1.3
Mean	0.8	0.9	1.0	1.0	1.3	1.1	1.1	1.5	1.7	0.8	1.0	0.9	1.1	0.9	1.0	1.1	1.2
								30-60 cm soil depth									
1	0.6	1.0	0.9	0.8	1.0	1.3	0.9	1.1	1.1	0.5	0.9	1.0	1.0	1.0	0.7	0.8	1.0
2	0.7	1.0	0.9	0.8	1.2	0.8	0.9	1.3	1.7	1.1	1.1	0.8	0.9	0.9	0.8	0.9	0.9
3	0.6	0.6	0.8	1.2	1.9	0.8	1.0	1.0	1.5	0.6	0.6	0.7	0.8	0.6	0.6	1.0	0.6
4	0.6	0.8	0.8	0.8	1.1	0.9	1.0	1.2	1.2	0.6	0.6	0.8	0.9	0.6	0.7	0.7	0.9
Mean	0.6	0.8	0.8	0.9	1.3	0.9	0.9	1.1	1.4	0.7	0.8	0.8	0.9	0.8	0.7	0.8	0.8
								60-90 cm soil depth									
1	0.7	1.1	1.0	0.8	0.9	1.1	0.8	1.2	1.1	0.5	0.8	0.9	0.8	0.7	0.6	0.6	0.9
2	0.7	0.7	1.0	1.2	1.5	0.8	1.0	1.2	1.5	0.6	1.2	0.9	0.8	0.9	0.8	0.7	0.8
3	1.2	0.6	0.8	1.4	2.3	0.6	1.1	1.1	1.7	0.5	0.6	1.0	0.7	0.6	0.6	1.0	0.8
4	0.7	0.8	0.9	1.2	1.4	2.1	1.3	1.2	1.2	0.6	0.8	0.8	1.1	0.6	0.7	0.7	0.7
Mean	0.8	0.8	0.9	1.1	1.5	1.1	1.0	1.2	1.4	0.5	0.8	0.9	0.8	0.7	0.7	0.7	0.8
								90-120 cm soil depth									
1	1.5	6.0	1.3	1.0	1.0	6.2	0.9	2.9	1.0	0.7	0.7	4.5	0.8	0.7	0.8	0.9	0.8
2	1.5	0.9	1.3	1.3	1.3	3.9	1.0	1.1	1.4	0.8	5.2	4.7	0.9	5.4	1.3	0.7	0.9
3	2.8	0.7	1.2	2.5	5.8	0.7	1.1	1.1	1.2	0.6	0.7	2.3	1.0	0.7	0.6	0.7	0.9
4	1.8	5.6	0.8	1.2	5.8	5.2	1.0	1.3	3.9	0.9	1.3	0.6	5.0	0.8	0.9	0.7	0.8
Mean	1.9	3.3	1.1	1.5	3.5	4.0	1.0	1.6	1.9	0.7	2.0	3.0	1.9	1.9	0.9	0.7	0.8
								120-150 cm soil depth									
1	1.9	6.0	5.8	1.0	1.0	6.9	0.8	5.7	5.1	0.9	5.4	3.6	0.9	0.8	1.2	4.5	2.6
2	2.1	0.9	6.0	1.2	1.1	5.2	0.9	1.3	5.2	5.0	5.6	5.2	1.4	5.6	5.2	0.7	1.3
3	2.9	0.9	6.0	5.0	5.6	0.7	1.1	1.2	1.0	0.5	0.9	5.0	1.3	1.1	0.6	0.8	1.7
4	2.7	5.6	0.8	0.8	5.8	5.2	0.9	1.3	5.2	5.6	5.6	0.6	5.0	1.2	0.9	0.6	0.9
Mean	2.4	3.3	4.6	2.0	3.4	4.5	0.9	2.4	4.1	3.0	4.4	3.6	2.1	2.2	2.0	1.6	1.6

[z] Control: No manure application; each replicate value is a mean of four control plots.
[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).
[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.84. Soil electrical conductivity (dS m^{-1}) at the Airdrie site in 1997.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	0.5	0.5	0.4	0.5	0.5	0.4	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5
2	0.5	0.4	0.5	0.8	0.5	0.5	0.6	0.5	0.4	0.5	0.6	0.8	0.4	0.7	0.3	0.4	0.6
3	0.4	0.7	0.4	0.5	0.4	0.7	0.4	0.5	0.6	0.4	0.5	0.4	0.6	0.4	0.4	0.5	0.4
4	0.5	0.6	0.5	0.5	0.4	0.5	0.5	0.4	0.5	0.5	0.4	0.4	0.6	0.3	0.5	0.5	0.4
Mean	0.5	0.5	0.4	0.6	0.4	0.5	0.4	0.4	0.5	0.4	0.5	0.5	0.5	0.4	0.4	0.4	0.5
								15-30 cm soil depth									
1	0.4	0.5	0.4	0.4	0.6	0.2	0.6	0.4	0.4	0.5	0.4	0.4	0.4	0.4	0.5	0.3	0.3
2	0.3	0.4	0.4	0.3	0.5	0.3	0.4	0.5	0.4	0.4	0.4	0.5	0.4	0.5	0.3	0.4	0.5
3	0.4	0.4	0.3	0.4	0.4	0.6	0.5	0.4	0.4	0.4	0.4	0.4	0.3	0.4	0.4	0.4	0.3
4	0.4	0.4	0.3	0.4	0.4	0.4	0.4	0.5	0.4	0.4	0.4	0.4	0.5	0.3	0.4	0.5	0.3
Mean	0.4	0.4	0.3	0.4	0.5	0.4	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.3
								30-60 cm soil depth									
1	0.4	0.7	0.5	0.4	0.6	0.4	1.2	0.4	0.4	0.4	0.4	0.5	0.4	0.5	0.4	0.6	0.8
2	0.4	0.4	0.4	0.6	0.5	0.3	0.4	0.4	0.4	0.3	0.4	0.4	0.4	0.5	0.5	0.4	0.4
3	0.4	0.5	0.3	0.4	0.4	0.5	0.4	0.4	0.4	0.4	0.3	0.5	0.3	0.4	0.4	0.4	0.3
4	0.6	0.3	0.4	0.5	0.3	0.4	0.4	0.5	0.4	0.4	0.4	0.4	0.6	0.3	0.4	0.3	0.5
Mean	0.5	0.5	0.4	0.5	0.4	0.4	0.6	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5
								60-90 cm soil depth									
1	0.5	0.8	0.6	0.3	0.5	0.4	1.7	0.5	0.6	0.4	0.5	0.6	0.4	0.4	0.5	0.6	0.6
2	0.4	0.6	0.4	0.5	0.4	0.4	0.7	0.4	0.5	0.3	0.4	0.4	0.4	0.3	0.4	0.4	0.5
3	0.5	0.4	0.4	0.6	0.4	0.5	0.5	0.4	0.4	0.4	0.4	0.5	0.6	0.3	0.6	0.4	0.4
4	0.4	0.4	0.4	0.5	0.5	0.4	0.4	0.4	0.5	0.7	0.5	0.4	0.6	0.4	0.4	0.5	0.6
Mean	0.5	0.5	0.4	0.5	0.4	0.4	0.8	0.4	0.5	0.4	0.4	0.5	0.5	0.3	0.5	0.5	0.5
								90-120 cm soil depth									
1	0.4	0.5	0.5	0.3	0.5	0.6	0.7	0.4	0.4	0.4	0.9	1.0	0.3	0.5	0.4	0.4	0.6
2	0.4	0.6	0.4	0.3	0.4	0.4	1.0	0.3	0.5	0.3	0.4	0.3	0.3	0.3	0.3	0.6	0.3
3	0.4	0.3	0.4	0.4	0.4	0.3	0.4	0.4	0.3	0.4	0.3	0.5	0.4	0.4	0.5	0.4	0.4
4	0.4	0.3	0.4	0.5	0.4	0.4	0.4	0.4	0.5	0.7	0.5	0.4	0.5	0.6	0.4	0.3	0.4
Mean	0.4	0.4	0.4	0.4	0.4	0.4	0.6	0.4	0.4	0.4	0.5	0.5	0.4	0.4	0.4	0.4	0.4
								120-150 cm soil depth									
1	0.4	0.4	0.4	0.3	0.6	0.6	0.7	0.3	0.4	0.4	0.7	1.2	0.3	0.4	0.4	0.4	0.5
2	0.3	0.6	0.4	0.3	0.4	0.4	1.0	0.3	0.6	0.3	0.4	0.3	0.3	0.3	0.3	0.5	0.2
3	0.4	0.3	0.4	0.4	0.4	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.4	0.5	0.5	0.4
4	0.4	0.4	0.4	0.5	0.3	0.3	0.5	0.4	0.6	0.6	0.6	0.4	0.5	0.8	0.5	0.3	0.4
Mean	0.4	0.4	0.4	0.4	0.4	0.4	0.6	0.3	0.5	0.4	0.5	0.6	0.3	0.5	0.4	0.4	0.4

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.85. Soil electrical conductivity (dS m^{-1}) at the Airdrie site in 1998.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	0.5	0.5	0.6	0.6	0.5		0.7	0.7	0.8	0.6	0.6	0.6	0.5	0.6	0.6	0.7	0.6
2	0.5		0.7	0.7	0.5	0.5	0.5	0.7	0.6	0.6	0.7	0.8	1.0	0.8	0.7	0.6	0.9
3	0.5	0.5	0.6	0.6	0.6	0.7	0.6	0.5	0.6	0.4	0.6	0.7	0.9	0.6	0.6	1.0	1.2
4	0.5	0.6	0.7	0.6	0.6	0.6	0.4	0.6	0.8	0.5	0.5	0.7	0.8	0.9	0.7	0.9	2.3
Mean	0.5	0.5	0.6	0.6	0.5	0.6	0.5	0.6	0.7	0.5	0.6	0.7	0.8	0.7	0.6	0.8	1.2
								15-30 cm soil depth									
1	0.5	0.5	0.5	0.4	0.4	0.4	0.6	0.6	0.6	0.6	0.5	0.5	0.5	0.6	0.4	0.5	0.6
2	0.5	0.4	0.6	0.7	0.4	0.5	0.5	0.6	0.7	0.5	0.5	0.8	0.6	0.6	0.6	0.5	0.8
3	0.5	0.6	0.5	0.5	0.5	0.4	0.5	0.5	0.6	0.4	0.5	0.5	0.5	0.6	0.6	0.5	0.6
4	0.4	0.4	0.5	0.6	0.5	0.5	0.4	0.6	0.5	0.5	0.5	0.5	0.5	0.7	0.6	0.7	0.9
Mean	0.5	0.5	0.5	0.5	0.4	0.4	0.5	0.6	0.6	0.5	0.5	0.6	0.5	0.6	0.5	0.5	0.7
								30-60 cm soil depth									
1	0.4	0.6	0.6	0.4	0.5	0.5	1.0		0.5	0.4	0.5	0.5	0.5	0.5	0.4	0.7	0.5
2	0.4	0.4	0.4	0.6	0.4	0.3	0.7	0.5	0.6	0.4	0.4	0.7	0.5	0.4	0.4	0.4	0.5
3	0.4	0.4	0.4	0.3	0.5	0.5	0.6	0.4	0.5	0.4	0.4	0.6	0.7	0.5	0.5	0.6	0.6
4	0.4	0.4	0.6	0.6	0.5	0.4	0.4	0.6	0.4	0.5	0.4	0.4	1.0	0.4	0.5	0.5	0.5
Mean	0.4	0.4	0.5	0.5	0.5	0.4	0.7	0.5	0.5	0.4	0.4	0.5	0.7	0.4	0.4	0.5	0.5
								60-90 cm soil depth									
1	0.4	0.7			0.6	0.6	0.7	0.4	0.4	0.3	0.7	0.7	0.3	0.4	0.3	0.6	0.6
2	0.4	0.5	0.3	0.3	0.5	0.5	1.0		0.6	0.3	0.4	0.6	0.5	0.4	0.4	0.5	0.3
3	0.4	0.5	0.3	0.4	0.5	0.4	0.6	0.4	0.4	0.4	0.3	0.5	0.6	0.4	0.5	0.4	0.4
4	0.5	0.4	0.4	0.6	0.5	0.4	0.4	0.5	0.4	0.5	0.6	0.4	0.9	0.4	0.4	0.5	0.4
Mean	0.5	0.5	0.3	0.4	0.5	0.5	0.7	0.4	0.4	0.4	0.5	0.5	0.6	0.4	0.4	0.5	0.4
								90-120 cm soil depth									
1	0.4	0.4	0.5	0.3	0.5	0.5	0.6	0.4	0.4	0.3	0.8	0.8	0.3	0.3	0.3		0.5
2	0.4	0.6	0.3	0.3	0.6	0.3	0.8	0.3		0.3	0.3	0.5	0.4	0.5	0.3	0.4	0.2
3	0.4	0.4	0.3	0.4	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.4	0.4	0.5	0.3	0.4
4	0.5	0.3	0.3	0.5	0.4	0.4	0.4	0.4	0.5	0.6	0.5	0.4	0.7	0.5	0.5	0.4	0.4
Mean	0.4	0.4	0.3	0.4	0.5	0.4	0.5	0.4	0.4	0.4	0.5	0.5	0.4	0.4	0.4	0.4	0.4
								120-150 cm soil depth									
1	0.4	0.4	0.4	0.3	0.5	0.5	0.6	0.4	0.3	0.3	0.7	0.9	0.2	0.4	0.3	0.3	0.5
2	0.4	0.6	0.4	0.3	0.7	0.4	0.9	0.3	0.6	0.3	0.3	0.5	0.3	0.3	0.3	0.5	0.3
3	0.4	0.4	0.4	0.4	0.5	0.4	0.3	0.4	0.3	0.4	0.4	0.6	0.4	0.4	0.5	0.4	0.3
4	0.5	0.3	0.4	0.5	0.3	0.4	0.4	0.4	0.7	0.5	0.5	0.4	0.7	0.9	0.5	0.4	0.4
Mean	0.4	0.4	0.4	0.4	0.5	0.4	0.5	0.4	0.5	0.4	0.5	0.6	0.4	0.5	0.4	0.4	0.4

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.86. Soil electrical conductivity (dS m^{-1}) at the Airdrie site in 1999.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	0.5	0.6	0.6	0.6	0.6	0.8	0.7	0.7	2.7	0.6	0.6	0.7	0.8	0.8	0.9	1.1	1.3
2	0.5	0.5	0.5	0.7	0.6	0.7	1.1	0.9	1.1	0.5	0.9	1.0	1.0	0.6	0.8	1.2	2.3
3	0.5	0.6	0.7	0.6	0.7	0.6	0.6	0.8	1.7	0.5	0.6	0.8	1.0	1.1	0.8	1.1	1.7
4	0.6	0.6	0.6	0.7	0.9	0.7	0.9	0.9	1.2	0.6	0.7	0.7	1.3	1.0	1.1	1.2	1.4
Mean	0.5	0.6	0.6	0.6	0.7	0.7	0.8	0.8	1.7	0.5	0.7	0.8	1.0	0.9	0.9	1.1	1.7
								15-30 cm soil depth									
1	0.5	0.5	0.5	0.4	0.6	0.6	0.6	0.6	1.1	0.4	0.6	0.8	0.6	0.6	0.5	0.8	1.0
2	0.5	0.4	0.5	0.6	0.6	0.5	0.7	0.6	0.3	0.4	0.6	0.7	0.7	0.4	0.6	1.0	0.7
3	0.5	0.4	0.5	0.5	0.5	0.4	0.5	0.5	1.0	0.5	0.6	0.9	1.0	0.8	0.4	1.0	1.0
4	0.5	0.4	0.6	0.7	0.6	0.5	0.8	0.5	0.6	0.5	0.6	0.6	1.8	0.6	1.0	0.8	0.7
Mean	0.5	0.4	0.5	0.5	0.6	0.5	0.6	0.5	0.7	0.4	0.6	0.7	1.0	0.6	0.6	0.9	0.8
								30-60 cm soil depth									
1	0.6	0.5	0.6	0.3	0.6	0.7	0.6	0.5	0.6	0.5	0.5	0.8	0.6	0.6	0.4	0.7	0.9
2	0.4	0.4	0.4	0.5	0.5	0.4	0.9	0.5	0.6	0.4	0.5	0.5	0.5	0.5	0.4	0.5	0.5
3	0.5	0.3	0.4	0.5	0.5	0.3	0.6	0.5	0.5	0.4	0.4	0.8	0.6	0.5	0.4	0.5	0.7
4	0.6	0.4	0.6	0.8	0.6	0.5	0.5	0.4	0.5	0.5	0.6	0.6	1.5	0.4	0.6	0.5	0.6
Mean	0.5	0.4	0.5	0.5	0.5	0.5	0.6	0.5	0.5	0.4	0.5	0.7	0.8	0.5	0.4	0.5	0.7
								60-90 cm soil depth									
1	0.5	0.6	0.4	0.3	0.5	0.6	0.6	0.4	0.4	0.4	0.6	0.7	0.4	0.5	0.3	0.6	0.6
2	0.4	0.5	0.3	0.5	0.6	0.4	0.9	0.5	0.7	0.4	0.5	0.4	0.4	0.5	0.4	0.9	0.5
3	0.5	0.4	0.5	0.4	0.5	0.4	0.5	0.5	0.5	0.4	0.5	0.7	0.7	0.4	0.5	0.4	0.6
4	0.6	0.4	0.5	0.6	0.4	0.4	0.5	0.4	0.6	0.7	0.5	0.6	1.2	0.6	0.5	0.4	0.6
Mean	0.5	0.5	0.4	0.4	0.5	0.4	0.6	0.4	0.5	0.5	0.5	0.6	0.7	0.5	0.4	0.6	0.6
								90-120 cm soil depth									
1	0.5	0.4	0.4	0.3	0.5	0.8	0.6	0.4	0.4	0.4	0.8	0.8	0.3	0.5	0.4	0.4	0.6
2	0.4	0.5	0.3	0.3	0.6	0.4	0.8	0.5	0.6	0.4	0.4	0.4	0.4	0.5	0.4	0.9	0.4
3	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.4	0.5	0.4	0.4	0.6	0.5	0.4	0.5	0.5	0.4
4	0.5	0.4	0.5	0.5	0.4	0.4	0.5	0.4	0.7	0.6	0.5	0.5	1.1	0.7	0.5	0.4	0.5
Mean	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.4	0.5	0.4	0.5	0.6	0.6	0.5	0.4	0.5	0.5
								120-150 cm soil depth									
1	0.4	0.4	0.4	0.3	0.5	0.7	0.6	0.3	0.4	0.3	0.7	0.8	0.3	0.4	0.4	0.3	0.6
2	0.4	0.5	0.3	0.3	0.6	0.3	0.8	0.4	0.6	0.3	0.4	0.4	0.3	0.4	0.4	0.7	0.3
3	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.4	0.4	0.4	0.4	0.6	0.4	0.4	0.6	0.5	0.4
4	0.5	0.4	0.4	0.5	0.4	0.5	0.5	0.4	0.7	0.6	0.5	0.5	1.1	0.9	0.5	0.4	0.6
Mean	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.4	0.5	0.4	0.5	0.6	0.5	0.5	0.5	0.5	0.5

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.87. Soil electrical conductivity (dS m^{-1}) at the Airdrie site in 2000.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	0.6	0.5	0.6	0.9	1.0	0.7	0.7	1.1	1.4	0.6	1.3	1.0	1.1	1.0	0.9	1.5	1.0
2	0.5	0.6	0.7	1.1	1.2	0.7	0.9	0.8	1.5	0.6	0.5	0.8	1.9	1.0	1.2	2.2	2.0
3	0.5	0.8	0.7	0.7	1.1	0.8	0.7	1.1	1.2	0.4	0.8	0.9	1.1	0.6	1.1	1.0	1.7
4	0.5	0.6	0.7	0.8	1.4	0.7	0.8	0.9	1.8	0.6	0.7	0.7	1.5	0.9	1.2	1.2	2.5
Mean	0.5	0.6	0.7	0.9	1.2	0.7	0.8	1.0	1.5	0.5	0.8	0.8	1.4	0.9	1.1	1.5	1.8
								15-30 cm soil depth									
1	0.5	0.6	0.7	0.7	1.0	0.7	0.6	0.7	1.0	0.6	0.7	0.9	0.8	0.5	0.7	0.7	0.7
2	0.5	0.7	0.4	0.5	0.7	0.5	0.5	0.7	1.1		0.6	0.8	1.0	0.6	0.8	1.2	1.2
3	0.5	0.5	0.6	0.6	0.6	0.6	0.5	0.8	0.8	0.4	0.4	0.6	1.0	0.5	0.6	0.7	1.0
4	0.4	0.5	0.5	1.0	0.9	0.6	0.7	0.6	0.8	0.5	0.6	0.8	1.5	0.6	0.6	0.7	1.4
Mean	0.5	0.6	0.5	0.7	0.8	0.6	0.6	0.7	0.9	0.5	0.6	0.8	1.1	0.5	0.7	0.8	1.1
								30-60 cm soil depth									
1	0.6	1.0	0.7	0.5	0.8	0.6	0.6	0.8	0.8	0.5	0.7	1.0	0.8	0.6	0.5	0.8	0.6
2	0.4	0.6	0.6	0.5	0.6	0.5	1.0	0.8	1.0	0.4	0.6	0.8	0.8	0.6	0.6	0.8	0.6
3	0.5	0.7	0.6	0.5	0.7	0.7	0.8	0.6	0.8	0.5	0.4	0.9	1.2	0.6	0.6	0.6	0.8
4	0.5	0.6	0.5	0.7	0.6	0.5	0.5	0.7	0.8	0.6	0.6	0.6	1.5	0.5	0.6	0.6	0.8
Mean	0.5	0.7	0.6	0.5	0.7	0.6	0.7	0.7	0.8	0.5	0.6	0.8	1.1	0.6	0.6	0.7	0.7
								60-90 cm soil depth									
1	0.5	0.8	0.6	0.4	0.6	0.5	0.5	0.6	0.5	0.4	0.6	0.6	0.5	0.5	0.4	0.7	0.5
2	0.4	0.6	0.3	0.5	0.5	0.5	0.9	0.4	0.7	0.4	0.5	0.5	0.6	0.6	0.5	0.7	0.4
3	0.5	0.4	0.4	0.4	0.6	0.4	0.6	0.4	0.6	0.4	0.5	0.8	1.0	0.5	0.6	0.6	0.6
4	0.6	0.4	0.5	0.5	0.5	0.4	0.4	0.5	0.5	1.0	0.6	0.6	1.1	0.4	0.5	0.5	0.7
Mean	0.5	0.5	0.4	0.4	0.5	0.4	0.6	0.5	0.6	0.5	0.5	0.6	0.8	0.5	0.5	0.6	0.5
								90-120 cm soil depth									
1	0.5	0.5	0.5	0.3	0.5	0.6	0.5	0.5	0.4	0.3	0.7	0.6	0.4	0.4	0.4	0.5	0.6
2	0.4	0.6	0.3	0.4	0.5	0.4	0.9	0.4	0.6	0.4	0.4	0.4	0.4	0.5	0.4	0.9	0.3
3	0.4	0.3	0.4	0.3	0.6	0.3	0.4	0.4	0.4	0.4	0.4	0.6	0.6	0.6	0.5	0.5	0.7
4	0.5	0.3	0.4	0.5	0.4	0.4	0.4	0.4	0.4	1.0	0.4	0.4	0.8	0.6	0.5	0.4	0.5
Mean	0.5	0.4	0.4	0.4	0.5	0.4	0.5	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.4	0.6	0.5
								120-150 cm soil depth									
1	0.4	0.5	0.5	0.3	0.6	0.6	0.5	0.5	0.4	0.3	0.6	0.6	0.3	0.4	0.5	0.4	0.6
2	0.4	0.6	0.3	0.4	0.6	0.4	1.0	0.5	0.6	0.3	0.4	0.5	0.4	0.5	0.4	0.9	0.4
3	0.4	0.4	0.4	0.4	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.6	0.6	0.5	0.5	0.5	0.7
4	0.5	0.4	0.4	0.6	0.6	0.4	0.4	0.4	0.6	0.8	0.4	0.5	0.8	0.7	0.5	0.4	0.5
Mean	0.4	0.5	0.4	0.4	0.6	0.4	0.6	0.4	0.5	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.88. Soil electrical conductivity (dS m^{-1}) at the Airdrie site in 2001.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	0.6	0.7	0.8	1.0	1.3	0.8	0.8	1.8	1.2	0.8	1.1	1.1	1.4	1.0	1.3	3.0	1.5
2	0.6	0.6	0.8	1.2	1.4	0.7	0.9	1.5	2.8	0.7	1.5	1.4	2.6	1.8	2.5	1.3	2.6
3	0.6	0.6	0.8	0.9	1.5	0.6	0.7	1.7	2.6	0.6	1.0	0.7	1.5	0.8	0.9	1.3	1.5
4	0.5	0.6	0.8	1.1	2.5	0.7	0.7	1.2	1.4	0.6	0.6	0.9	1.8	0.8	1.0	1.0	2.6
Mean	0.6	0.6	0.8	1.0	1.7	0.7	0.8	1.5	2.0	0.7	1.0	1.0	1.8	1.1	1.4	1.6	2.0
								15-30 cm soil depth									
1	0.6	0.6	0.7	0.7	1.1	0.9	0.6	1.3	1.0	0.6	1.2	2.8	2.9	0.8	0.8	2.0	1.1
2	0.6	0.9	0.7	1.2	1.1	0.5	0.8	0.7	1.3	0.6	1.9	1.9	1.8	0.8	2.1	0.9	0.9
3	0.5	0.6	0.6	0.7	1.0	0.6	0.5	1.2	1.9	0.5	0.8	1.1	1.3	0.6	0.6	0.6	1.5
4	0.5	0.5	0.6	0.8	1.8	0.6	0.8	0.7	1.1	0.5	0.8	1.0	1.9	0.6	0.9	0.8	1.5
Mean	0.5	0.6	0.6	0.8	1.2	0.6	0.7	1.0	1.3	0.5	1.2	1.7	2.0	0.7	1.1	1.1	1.2
								30-60 cm soil depth									
1	0.8	0.6	0.8	0.4	1.2	0.7	0.7	1.0	1.1	0.6	1.3	2.8	2.1	0.6	0.5	1.3	0.6
2	0.6	0.8	0.6	0.9	1.0	0.5	0.8	1.1	1.3	0.6	0.7	1.5	1.2	0.9	0.7	0.5	0.6
3	0.4	0.5	0.5	0.6	0.8	0.5	0.5	0.8	1.2	0.6	0.6	1.1	1.0	0.5	0.6	0.5	1.5
4	0.5	0.5	0.4	0.7	1.0	0.4	0.5	0.7	0.9	0.7	0.6	0.9	2.0	0.5	0.7	1.7	0.9
Mean	0.6	0.6	0.6	0.6	1.0	0.5	0.6	0.9	1.1	0.6	0.8	1.6	1.6	0.6	0.6	1.0	0.9
								60-90 cm soil depth									
1	0.5	0.7	0.7	0.4	0.6	0.5	0.8	0.7	0.7	0.5	1.1	0.9	0.5	0.5	0.4	0.8	0.6
2	0.5	0.7	0.4	0.7	0.9	0.4	0.7	0.9	0.7	0.5	0.5	0.9	0.7	1.5	0.6	0.4	1.5
3	0.4	0.4	0.4	0.4	0.6	0.5	0.5	0.5	0.6	0.5	0.6	0.8	0.6	0.4	0.5	0.5	0.6
4	0.6	0.4	0.6	0.5	0.7	0.6	0.4	0.5	0.6	0.7	0.5	0.6	1.7	0.5	0.5	0.6	0.7
Mean	0.5	0.5	0.5	0.5	0.7	0.5	0.6	0.6	0.6	0.5	0.7	0.8	0.9	0.7	0.5	0.6	0.8
								90-120 cm soil depth									
1	0.5	0.7	0.8	0.3	0.6	0.5	0.7	0.5	0.5	0.4	0.9	0.8	0.4	0.4	0.4	0.5	0.5
2	0.4	0.6	0.3	0.4	0.7	0.4	0.9	0.4	0.6	0.5	0.4	0.6	0.4	0.5	0.4	0.5	0.5
3	0.4	0.4	0.3	0.4	0.5	0.4	0.4	0.4	0.4	0.6	0.4	0.6	0.4	0.4	0.6	0.4	0.6
4	0.6	0.4	0.6	0.4	0.5	0.5	0.4	0.5	0.6	0.5	0.5	0.5	1.2	0.6	0.5	0.6	0.5
Mean	0.5	0.5	0.5	0.4	0.6	0.4	0.6	0.4	0.5	0.5	0.5	0.6	0.6	0.5	0.5	0.5	0.5
								120-150 cm soil depth									
1	0.5	0.5	1.0	0.3	0.6	0.5	0.5	0.4	0.4	0.4	0.8	0.8	0.3	0.4	0.4	0.4	0.5
2	0.4	0.6	0.4	0.3	0.7	0.3	0.9	0.4	0.6	0.4	0.4	0.6	0.3	0.4	0.4	0.5	0.5
3	0.6	0.3	0.3	0.3	0.5	0.4	0.3	0.3	0.4	0.5	0.4	0.6	0.4	0.4	0.7	0.5	0.5
4	0.6	0.4	0.5	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.4	0.9	0.8	0.5	0.5	0.5
Mean	0.5	0.4	0.5	0.3	0.5	0.4	0.5	0.4	0.5	0.4	0.5	0.6	0.5	0.5	0.5	0.5	0.5

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.89. Soil organic matter (Mg ha^{-1}) at the Lethbridge site in 1996.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	102	99	88	102	102	97	97	97	102	123	104	105	95	105	105	89	100
2	94	107	91	93	104	91	101	107	103	91	97	106	94	102	94	106	104
3	101	98	93	94	102	99	105	106	97	104	104	102	104	112	109	104	91
4	98	84	104	106	94	95	97	89	97	103	93	105	110	97	99	103	96
Mean	99	97	94	99	101	96	100	100	100	105	100	104	101	104	102	100	98
								15-30 cm soil depth									
1	93	90	83	92	82	94	103	82	89	84	98	77	90	100	85	91	100
2	83	90	96	68	91	83	92	101	96	81	94	88	72	95	94	98	97
3	90	88	83	77	83	85	91	90	98	97	94	87	84	108	106	92	78
4	93	75	105	104	61	91	86	78	85	84	85	94	96	89	96	95	65
Mean	90	86	92	85	79	88	93	88	92	87	93	86	86	98	95	94	85
								30-60 cm soil depth									
1	163	146	147	171	125	153	176	137	167	191	137	139	163	143	136	158	200
2	151	172	174	106	156	135	175	180	173	145	121	151	178	150	144	164	190
3	161	163	156	103	157	155	173	156	169	190	175	160	116	197	146	207	121
4	145	113	195	185	124	142	155	138	151	154	183	167	140	148	188	194	123
Mean	155	148	168	141	141	146	170	153	165	170	154	154	149	160	153	181	158
								60-90 cm soil depth									
1	137	139	127	142	125	134	134	132	144	148	107	130	133	101	120	109	156
2	120	141	144	94	114	117	155	150	156	114	121	123	123	126	122	141	196
3	143	120	103	125	142	118	158	143	149	144	157	158	104	161	120	176	126
4	132	111	171	165	137	126	116	136	134	149	167	144	121	129	164	161	118
Mean	133	128	136	132	130	124	141	140	146	139	138	139	120	129	131	147	149
								90-120 cm soil depth									
1	116	131	117	121	81	145	135	113	124	98	108	129	113	102	108	86	122
2	110	115	125	97	98	94	125	132	138	93	118	131	104	111	129	92	151
3	118	113	90	112	124	113	141	134	138	111	136	133	106	122	113	131	119
4	120	121	143	146	121	133	117	126	121	121	122	120	131	123	138	149	99
Mean	116	120	119	119	106	121	130	126	130	106	121	128	114	115	122	114	123
								120-150 cm soil depth									
1	115	125	117	110	116	124	110	104	116	122	139	120	107	113	104	90	107
2	105	116	114	99	96	99	116	104	118	118	104	126	98	130	119	102	130
3	102	121	111	114	126	109	126	131	130	95	119	116	129	117	100	121	120
4	105	113	130	135	106	126	112	112	120	111	118	94	159	100	118	125	84
Mean	107	119	118	114	111	115	116	113	121	112	120	114	123	115	110	109	110

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.90. Soil organic matter (Mg ha^{-1}) at the Lethbridge site in 1997.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	108	131	103	178	152	140	108	188	199	113	132	139	122	116	101	108	106
2	99	109	106	116	103	115	108	103	96	98	101	88	86	95	109	104	107
3	101	95	115	100	118	100	104	108	102	109	97	99	79	110	101	118	80
4	102	92	108	106	100	105	105	90	91	94	99	96	104	104	109	106	94
Mean	103	107	108	125	118	115	106	122	122	104	107	105	98	106	105	109	97
								15-30 cm soil depth									
1	86	99	76	87	88	95	89	100	79	91	73	95	90	88	88	90	106
2	83	88	103	95	93	97	106	98	88	96	96	81	91	94	91	91	97
3	93	85	93	72	90	75	89	93	99	87	94	90	64	111	96	101	60
4	89	90	110	93	63	87	83	77	148	85	91	101	83	77	98	88	88
Mean	88	90	95	87	84	89	92	92	103	90	88	92	82	93	93	93	88
								30-60 cm soil depth									
1	147	156	139	215	147	180	149	188	182	156	111	140	155	155	155	108	167
2	135	186	155	179	197	141	202	150	193	136	141	104	124	146	138	141	139
3	158	141	120	117	139	129	155	131	170	148	188	154	133	179	169	177	129
4	130	127	212	205	124	110	162	132	124	127	162	175	125	123	174	178	122
Mean	142	152	156	179	152	140	167	150	167	142	150	143	134	151	159	151	139
								60-90 cm soil depth									
1	118	139	133	146	120	132	144	157	148	131	115	136	122	116	114	113	126
2	131	160	158	135	144	122	166	134	182	112	131	94	133	124	117	114	138
3	130	125	83	132	118	107	157	112	151	149	186	160	136	163	144	183	128
4	123	112	149	186	120	114	136	130	123	124	131	146	122	125	179	151	111
Mean	126	134	131	150	126	119	151	133	151	129	141	134	128	132	138	140	126
								90-120 cm soil depth									
1	112	104	118	110	90	114	141	113	157	113	105	130	116	116	106	100	104
2	104	99	132	87	109	101	135	123	132	109	117	106	111	116	134	94	118
3	108	121	89	122	133	98	143	112	124	98	137	139	124	116	122	177	121
4	134	122	137	143	101	123	133	109	111	109	138	113	119	118	111	139	99
Mean	114	112	119	116	108	109	138	115	131	107	124	122	118	116	118	128	111
								120-150 cm soil depth									
1	112	106	109	102	114	107	127	108	100	118	87	116	109	115	119	111	109
2	97	101	127	84	109	75	109	127	115	127	119	83	114	118	111	99	115
3	98	124	103	99	134	93	125	117	126	80	121	124	120	119	127	115	114
4	125	124	124	142	104	106	125	102	108	113	121	85	108	114	128	122	130
Mean	108	114	116	107	115	95	121	113	112	110	112	102	113	116	121	112	117

[z] Control: No manure application; each replicate value is a mean of four control plots.
[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).
[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.91. Soil organic matter (Mg ha^{-1}) at the Lethbridge site in 1998.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	103	110	112	144	95	153	113	119	109	94	102	109	120	112	134	113	121
2	103	161	116	104	194	113	121	114	126	103	118	117	116	112	113	95	96
3	98	100	106	139	138	105	104	110	108	117	117	111	121	133	110	114	96
4	108	94	111	153	124	106	141	119	147	128	100	117	139	81	131	174	105
Mean	103	116	111	135	138	119	120	115	122	110	109	114	124	110	122	124	104
								15-30 cm soil depth									
1	89	77	91	86	68	109	94	99	102	79	77	93	112	98	91	82	107
2	92	102	109	86	113	97	110	100	125	85	97	103	91	102	108	102	96
3	94	84	75	94	94	89	95	93	84	96	99	79	94	97	96	111	84
4	90	70	114	118	91	84	85	85	87	97	86	108	83	76	103	119	88
Mean	91	83	97	96	91	95	96	94	100	89	90	96	95	93	100	103	94
								30-60 cm soil depth									
1	153	148	162	158	138	209	161	163	161	113	110	137	182	159	151	115	161
2	149	180	178	110	186	135	195	180	197	131	138	153	160	135	139	146	165
3	153	134	107	115	142	128	147	138	148	169	168	138	120	168	172	199	126
4	136	103	192	207	125	129	153	139	139	123	133	198	133	137	189	178	119
Mean	148	141	160	148	148	150	164	155	161	134	137	156	149	150	163	160	143
								60-90 cm soil depth									
1	121	140	147	137	96	105	138	136	150	105	107	125	149	135	128	103	125
2	126	171	116	89	145	115	153	165	172	107	138	140	145	123	142	106	144
3	128	113	82	125	115	107	137	122	151	152	165	127	120	157	166	161	121
4	125	109	170	179	115	111	131	133	120	125	135	169	117	123	157	157	106
Mean	125	133	128	132	118	109	140	139	148	122	136	141	133	135	148	132	124
								90-120 cm soil depth									
1	112	133	141	107	109	96	106	91	113	107	109	132	132	109	111	112	119
2	112	150	117	92	111	92	120	117	146	109	131	112	124	116	126	84	125
3	100	117	71	112	126	98	123	115	131	108	125	111	102	115	129	114	121
4	109	110	136	149	108	109	103	121	114	132	137	104	114	130	121	119	116
Mean	108	128	116	115	114	99	113	111	126	114	125	115	118	117	122	107	120
								120-150 cm soil depth									
1	104	126	153	106	103	86	76	93	107	134	122	126	109	118	109	126	110
2	103	110	106	100	135	100	117	107	116	124	107	95	116	122	106	85	125
3	95	116	83	100	122	92	123	122	124	117	113	88	94	112	118	100	116
4	107	108	127	142	93	96	93	103	114	133	141	90	106	94	114	109	120
Mean	102	115	117	112	113	94	102	106	115	127	121	100	106	111	112	105	118

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.92. Soil organic matter (Mg ha^{-1}) at the Lethbridge site in 1999.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	91	143	109	103	45	137	119	114	112	98	124	117	98	107	92	87	116
2	82	95	83	84	92	78	87	82	93	90	82	72	88	85	78	87	80
3	95	92	95	90	102	98	93	105	105	84	98	94	96	93	103	102	76
4	87	92	104	110	93	93	90	68	94	96	98	87	89	80	102	94	89
Mean	89	106	98	97	83	101	97	92	101	92	101	93	93	91	94	93	90
								15-30 cm soil depth									
1	77	76	70	81	55	78	84	85	84	70	87	70	69	94	69	64	94
2	64	75	59	58	79	56	88	69	82	67	57	53	63	80	61	70	73
3	76	73	68	71	81	82	76	87	89	83	85	70	79	81	90	88	57
4	69	68	91	82	67	61	76	48	63	74	85	78	67	63	91	81	70
Mean	72	73	72	73	70	69	81	72	79	74	79	68	70	79	78	76	73
								30-60 cm soil depth									
1	115	119	132	168	107	102	143	144	138	122	119	113	116	130	128	94	147
2	112	129	115	87	115	93	128	130	150	96	108	86	106	104	87	107	150
3	130	116	99	116	134	117	152	116	151	148	152	137	114	131	166	149	111
4	110	97	157	146	121	110	136	90	111	119	125	139	100	123	163	158	118
Mean	117	115	126	129	119	105	140	120	137	121	126	118	109	122	136	127	132
								60-90 cm soil depth									
1	101	120	129	126	113	78	141	131	93	99	111	130	97	104	120	95	112
2	98	115	125	80	88	79	170	120	139	83	105	90	96	96	88	76	128
3	114	115	90	124	124	90		124	157	131	140	140	104	124	140	128	120
4	119	110	138	123	108	123	125	103	107	108	129	115	110	99	138	137	110
Mean	108	115	121	113	108	93	145	119	124	105	121	119	102	106	122	109	118
								90-120 cm soil depth									
1	116	114	106	115	105	69	113	109	90	100	118	106	94	110	123	86	116
2	88	103	100	80	79	64	116	103	114	103	97	79	86	98	87	73	106
3	104	111	102	109	114	93		125	132	118	117	121	119	118	131	110	122
4	107	116	127	111	86	123	119	99	98	92	133	98	96	95	124	119	96
Mean	104	111	109	104	96	87	116	109	109	103	116	101	99	105	116	97	110
								120-150 cm soil depth									
1	112	116	108	109	78	63	100	107	76	109	106	111	93	111	119	97	110
2	85	103	105	89	90	75	116	87	107	97	97	85	86	98	75	73	105
3	93	115	93	110	120	95	128	115	123	117	114	117	108	117	127	97	116
4	98	117	125	105	93	87	120	89	88	85	121	87	94	89	102	112	103
Mean	97	113	108	103	95	80	116	100	98	102	109	100	95	104	106	95	109

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.93. Soil organic matter (Mg ha^{-1}) at the Lethbridge site in 2000.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	116	133	147	119	131	140	126	165	134	124	117	120	128	125	102	127	134
2	104	118	122	154	142	123	116	135	146	109	127	125	123	132	117	135	105
3	99	108	118	122	142	114	114	116	127	99	96	121	136	108	117	104	125
4	103	110	115	131	141	117	119	104	161	109	114	113	98	91	107	128	126
Mean	105	117	125	132	139	123	119	130	142	110	113	120	121	114	111	124	123
								15-30 cm soil depth									
1	99	93	117	79	85	109	98	102	173	100	91	83	110	97	94	82	106
2	86	100	101	98	111	93	102	108	164	85	98	90	99	121	92	93	96
3	91	106	91	103	113	96	100	97	102	86	89	98	113	95	97	94	125
4	87	78	100	98	101	102	91	79	96	97	94	99	78	68	95	91	101
Mean	91	94	102	95	102	100	98	96	134	92	93	93	100	95	95	90	107
								30-60 cm soil depth									
1	152	131	166	159	123	177	157	163	192	157	127	135	158	162	149	99	167
2	146	175	171	125	176	119	187	167	203	130	146	147	145	155	123	139	156
3	145	148	127	128	161	138	150	131	207	159	171	159	144	160	165	195	163
4	126	109	186	182	130	133	151	118	137	127	138	160	117	118	159	171	132
Mean	142	141	162	149	148	142	161	145	185	143	145	150	141	149	149	151	154
								60-90 cm soil depth									
1	111	126	147	164	111	115	148	134	155	103	116	128	126	110	122	98	134
2	124	146	124	98	130	117	160	151		99	141	127	141	164	121	103	141
3	124	120	78	136	125	112	129	119	154	131	140	142	107	127	140	162	127
4	126	121	153	158	130	112	132	134	124	105	123	118	118	108	134	144	126
Mean	121	128	126	139	124	114	142	134	144	109	130	129	123	127	129	127	132
								90-120 cm soil depth									
1	116	120	129	178	93	106	124	126	125	107	111	123	120	111	114	98	115
2	111	124	110	102	115	90	123	125	144	122	136	107	141	164	108	94	123
3	99	123	75	110	120	111	121	118	131	106	124	129	95	108	135	138	128
4	113	125	103	131	104	107	123	104	112	105	131	92	112	104	115	118	123
Mean	110	123	104	130	108	104	123	118	128	110	125	113	117	122	118	112	122
								120-150 cm soil depth									
1	112	114	126	148	110	95	113	101	105	120	123	113	123	139	117	114	114
2	107	139	109	115	135	103	117	106	113	124	122	103	125	143	96	98	124
3	97	135	88	103	113	103	135	119	118	122	116	125	111	108	114	124	123
4	109	108	100	123	87	100	123	102	100	114	114	94	107	116	108	116	103
Mean	106	124	106	122	111	100	122	107	109	120	119	109	116	127	109	113	116

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.94. Soil organic matter (Mg ha^{-1}) at the Lethbridge site in 2001.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	114	135	146	161	175	154	129	159	184	121	116	114	150	136	135	131	143
2	108	186	171	183	180	142	157	149	257	122	132	117	171	108	131	137	153
3	108	148	151	218	200	164	149	179	232	110	138	143	149	124	129	136	106
4	107	118	136	147	194	120	124	105	129	114	110	119	171	120	125	128	149
Mean	109	147	151	177	187	145	140	148	200	117	124	123	160	122	130	133	138
								15-30 cm soil depth									
1	101	94	115	116	114	132	110	118	130	101	106	84	114	116	104	105	122
2	97	113	133	119	123	113	147	118	127	104	103	119	115	93	96	109	115
3	89	119	104	117	116	127	101	128	120	106	107	96	104	103	104	119	73
4	85	94	116	112	109	84	88	81	88	91	85	102	107	103	105	94	110
Mean	93	105	117	116	116	114	112	111	116	100	100	100	110	104	102	107	105
								30-60 cm soil depth									
1	153	142	176	209	201	202	179	191	209	127	155	141	160	193	174	132	200
2	155	196	212	166	219	175	236	192	197	163	161	169	158	142	141	176	159
3	146	197	146	156	184	208	173	174	188	198	181	155	174	188	194	232	123
4	139	137	202	224	160	109	167	145	129	144	146	184	155	146	195	164	161
Mean	148	168	184	189	191	174	189	176	181	158	161	162	162	167	176	176	161
								60-90 cm soil depth									
1	133	127	151	180	109	165	154	152	160	96	121	130	146	140	139	104	170
2	133	151	169	121	148	134	190	157	178	109	138	144	139	130	118	117	124
3	131	156	84	134	136	135	164	146	179	161	155	151	109	169	171	191	130
4	132	152	178	191	146	117	122	131	103	122	131	159	147	120	146	158	141
Mean	132	146	145	156	134	138	157	147	155	122	136	146	135	140	143	143	141
								90-120 cm soil depth									
1	115	116	123	137	95	150	142	132	121	107	111	118	132	103	129	115	128
2	121	144	133	93	123	106	141	137	139	90	124	121	129	120	128	106	106
3	117	93	95	118	120	118	106	119	144	103	132	111	132	149	154	156	119
4	125	147	144	157	104	98	114	114	117	114	138	115	120	131	130	126	134
Mean	120	125	124	126	111	118	126	125	130	104	126	116	128	126	135	126	122
								120-150 cm soil depth									
1	115	112	128	129	103	129	96	121	99	118	109	126	134	104	118	108	116
2	112	112	123	92	138	98	125	126	127	100	115	103	121	119	106	160	103
3	104	137	108	102	116	97	131	135	147	106	117	105	142	125	137	141	120
4	111	142	129	147	100	93	125	97	108	132	127	124	114	123	111	116	125
Mean	111	126	122	117	114	104	119	120	120	114	117	114	128	118	118	131	116

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.95. Soil organic matter (Mg ha^{-1}) at the Airdrie site in 1997.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	207	233	191	159	108	197	195	247	252	212	183	171	182	210	221	176	196
2	147	174	193	255	236	240	211	210	179	175	160	239	216	174	258	192	196
3	157	270	180	220	167	273	211	167	214	127	221	140	264	181	125	178	213
4	198	140	207	207	272	182	165	90	114	166	163	208	250	207	146	232	230
Mean	177	204	193	210	196	223	195	179	189	170	182	190	228	193	188	195	209
								15-30 cm soil depth									
1	164	192	117	153	49	95	141	258	195	208	178	129	101	203	170	120	133
2	106	88	81	199	227	170	116	155	93	79	106	129	107	107	97	151	110
3	109	178	96	157	120	152	184	90	98	106	92	111	166	105	98	121	136
4	112	107	86	161	225	119	81	75	86	134	112	160	131	112	122	166	99
Mean	123	141	95	167	155	134	130	144	118	132	122	132	126	132	122	140	120
								30-60 cm soil depth									
1	130	217	138	182	73	127	149	214	153	254	237	118	123	151	145	158	98
2	110	85	116	224	227	161	128	148	78	80	90	123	144	97	110	177	125
3	129	119	118	181	149	179	226	85	155	127	90	197	144	154	109	162	135
4	120	124	90	143	172	129	92	93	130	143	143	193	142	156	142	160	137
Mean	122	136	115	182	155	149	148	135	129	151	140	158	138	139	126	165	124
								60-90 cm soil depth									
1	87	160	109	66	51	94	110	129	101	108	96	94	82	130	92	110	62
2	80	70	76	139	118	121	68	128	55	59	61	59	94	70	80	61	111
3	104	82	90	89	91	122	107	76	54	66	101	160	129	87	106	138	83
4	67	87	58	73	134	75	74	62	73	138	83	106	76	68	67	109	91
Mean	85	100	83	92	99	103	90	99	71	93	85	105	95	89	86	104	87
								90-120 cm soil depth									
1	64	53	95	40	49	56	60	76	51	57	71	99	56	64	85	60	59
2	62	69	112	74	89	73	89	63	71	47	47	57	68	55	60	101	51
3	50	62	58	55	61	88	69	60	48	60	50	124	81	74	70	113	60
4	61	53	59	56	69	70	58	67	70	134	85	76	36	66	66	53	63
Mean	59	59	81	56	67	72	69	66	60	74	63	89	60	65	70	82	58
								120-150 cm soil depth									
1	64	52	56	41	53	53	53	73	56	57	45	90	50	47	84	75	62
2	68	63	108	61	73	61	94	97	75	66	46	56	65	67	68	63	31
3	55	56	80	59	65	61	57	64	51	49	58	98	47	42	77	117	62
4	68	62	56	65	58	49	54	74	91	124	85	80	38	128	78	52	60
Mean	63	58	75	57	62	56	65	77	69	74	58	81	50	71	76	77	54

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.96. Soil organic matter (Mg ha^{-1}) at the Airdrie site in 1998.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	175	205	194	187	160		187	133	233	150	150	145	171	121	135	176	129
2	131		159	274	197	219	213	182	171	208	187	214	168	195	153	157	85
3	172	239	144	242	172	228	194	195	259	206	208	174	212	194	171	174	220
4	191	193	274	201	269	196	119	208	201	150	159	194	225	202	159	225	294
Mean	167	213	193	226	200	215	179	180	216	179	176	182	194	178	154	183	182
								15-30 cm soil depth									
1	117	144	135	95	113	85	109	112	114	123	137	109	103	74	57	114	111
2	131	73	106	172	114	234	141	149	143	123	88	152	131	120	89	118	76
3	110	137	111	156	142	163	151	127	225	127	155	134	121	157	109	127	112
4	114	99	236	118	230	165	64	136	113	104	126	168	121	150	130	181	173
Mean	118	113	147	135	150	162	116	131	149	119	126	141	119	125	96	135	118
								30-60 cm soil depth									
1	147	198	154	84	103	120	131		131	114	156	129	143	79	68	137	118
2	159	75	94	214	116	155	109	173	141	100	93	145	171	134	72	105	85
3	103	126	95	116	174	156	185	113	176	127	129	178	120	141	166	174	105
4	148	98	270	136	276	171	80	143	118	121	141	181	136	129	226	206	140
Mean	139	124	153	137	167	151	126	143	141	116	130	158	143	121	133	155	112
								60-90 cm soil depth									
1	86	115			70	62	50	94	74	51	102	75	68	48	60	99	70
2	65	60	74	87	108	99	76		104	47	72	73	102	78	55	73	59
3	58	93	53	61	74	67	85	58	72	81	62	98	77	74	147	101	51
4	82	81	115	73	116	110	69	87	64	73	95	103	58	75	142	105	91
Mean	73	87	81	74	92	84	70	80	78	63	83	87	76	69	101	95	68
								90-120 cm soil depth									
1	63	75	89	60	62	61	46	122	57	63	78	73	64	36	35		64
2	63	64	91	59	103	60	63	62		33	49	56	72	141	52	58	42
3	55	62	69	49	79	40	52	61	48	58	54	79	54	63	93	77	49
4	59	57	64	63	79	129	54	71	60	55	78	75	54	77	117	57	65
Mean	60	65	78	58	81	73	54	79	55	52	65	71	61	79	74	64	55
								120-150 cm soil depth									
1	64	63	76	53	65	66	57	103	61	58	71	73	49	39	38	55	69
2	60	66	94	50	122	52	87	52	74	50	43	60	77	66	45	49	56
3	51	51	89	73	92	42	52	75	41	56	68	100	63	66	71	68	47
4	59	58	67	52	70	104	53	63	116	61	84	56	61	174	95	64	66
Mean	59	60	81	57	87	66	62	73	73	56	67	72	62	86	62	59	60

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.97. Soil organic matter (Mg ha^{-1}) at the Airdrie site in 1999.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	168	189	191	135	143	205	147	121	257	202	187	154	154	221	186	183	183
2	162	148	136	240	167	228	160	185	165	103	156	151	162	226	196	195	173
3	202	270	228	244	200	221	243	239	254	191	221	157	266	244	161	208	223
4	157	138	230	218	211	160	163	147	147	144	176	202	202	205	187	226	180
Mean	172	186	196	209	180	203	178	173	206	160	185	166	196	224	182	203	190
								15-30 cm soil depth									
1	133	172	148	32	115	183	126	120	199	124	193	172	138	183	82	165	146
2	83	82	61	150	185	209	125	124	122	46	77	52	66	97	132	190	92
3	186	174	145	194	149	171	199	151	229	190	245	143	237	252	105	243	216
4	114	52	249	219	140	93	142	64	79	103	145	205	110	114	173	183	93
Mean	129	120	151	149	147	164	148	115	157	116	165	143	138	161	123	195	137
								30-60 cm soil depth									
1	151	219	148	28	79	320	124	121	131	173	161	214	122	183	76	213	175
2	85	76	80	169	166	217	81	125	131	62	73	65	88	124	119	211	106
3	174	175	148	210	228	166	183	156	191	145	191	224	166	204	143	239	271
4	118	58	206	177	136	138	120	88	95	138	186	263	89	78	208	181	105
Mean	132	132	145	146	152	210	127	122	137	130	153	192	116	147	136	211	164
								60-90 cm soil depth									
1	71	127	70	27	51	69	65	71	77	78	100	77	69	96	49	83	103
2	54	48	74	130	104	112	58	90	76	57	79	46	60	65	67	127	100
3	85	97	87	78	111	86	88	110	80	65	88	142	108	97	128	95	82
4	88	47	104	85	103	94	104	84	88	124	122	211	52	73	141	107	83
Mean	74	80	84	80	92	90	79	89	80	81	97	119	72	83	97	103	92
								90-120 cm soil depth									
1	58	74	63	25	43	67	61	72	64	66	75	56	53	63	54	63	94
2	50	47	70	62	79	74	60	130	55	86	66	50	50	68	52	90	87
3	60	77	65	57	77	69	53	61	79	82	53	131	85	69	120	135	49
4	77	49	83	57	80	88	113	74	91	89	86	165	49	78	113	74	67
Mean	61	62	70	50	70	74	72	84	72	81	70	101	59	69	85	91	74
								120-150 cm soil depth									
1	59	67	61	35	49	79	77	49	70	54	59	50	45	46	48	46	81
2	59	58	70	69	65	56	75	105	57	69	67	52	51	67	50	67	69
3	57	73	74	54	74	69	61	57	59	69	54	135	68	61	118	115	64
4	74	53	90	56	86	84	86	66	106	74	78	105	70	151	120	68	72
Mean	62	63	74	54	68	72	75	69	73	66	64	85	59	81	84	74	71

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.98. Soil organic matter (Mg ha^{-1}) at the Airdrie site in 2000.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	163	167	152	152	154	74	157	216	238	170	157	136	160	170	165	181	94
2	167	96	178	242	195	204	171	198	161	146	140	200	162	211	264	170	158
3	179	254	185	165	170	214	174	219	210	184	219	159	231	205	138	181	184
4	184	162	237	185	281	188	140	208	205	163	204	187	201	200	187	193	250
Mean	174	170	188	186	200	170	161	210	203	166	180	170	188	197	188	181	171
								15-30 cm soil depth									
1	136	158	141	116	113	58	118	187	199	112	167	137	130	114	153	159	91
2	127	74	118	168	140	226	92	158	118		99	111	100	145	167	145	101
3	135	172	98	104	132	169	154	126	178	115	134	151	146	133	95	148	102
4	129	133	229	165	248	140	87	175	105	143	204	196	152	132	143	138	195
Mean	132	134	146	139	158	148	113	162	150	124	151	149	132	131	140	147	123
								30-60 cm soil depth									
1	166	158	169	106	125	65	141	222	181	125	177	171	185	154	166	177	81
2	141	88	138	206	133	200	125	144	139	98	91	148	103	114	166	149	92
3	151	210	123	90	201	179	201	122	156	125	131	205	139	196	143	177	127
4	162	128	285	227	260	175	85	197	119	141	321	244	203	131	206	183	219
Mean	155	146	179	157	179	155	138	171	149	122	180	192	158	149	170	171	130
								60-90 cm soil depth									
1	109	123	115	95	118	42	89	140	99	83	123	112	109	81	101	131	50
2	78	67	61	139	100	152	89	89	88	80	89	84	91	85	126	113	71
3	93	89	73	70	168	91	149	70	112	104	119	127	113	107	112	133	101
4	90	56	204	117	127	99	68	93	85	122	141	144	88	105	126	132	113
Mean	92	84	113	105	128	96	99	98	96	97	118	117	100	95	116	127	84
								90-120 cm soil depth									
1	80	78	80	64	65	54	73	133	79	55	103	91	107	72	71	80	52
2	63	64	59	90	87	64	83	75	80	58	70	65	64	86	95	127	56
3	65	60	81	49	154	58	87	63	71	87	60	106	65	124	99	90	119
4	75	41	106	107	108	93	54	75	67	139	87	98	72	105	154	103	71
Mean	71	61	81	78	104	67	74	87	74	85	80	90	77	97	105	100	75
								120-150 cm soil depth									
1	101	93	90	66	86	123	79	144	92	58	108	99	75	115	129	127	69
2	82	78	90	134	136	90	94	146	103	73	73	111	67	113	133	137	92
3	101	90	99	81	137	90	86	81	83	109	64	108	116	126	130	123	127
4	87	63	188	145	203	127	57	88	81	127	58	139	100	153	118	109	79
Mean	93	81	117	107	140	108	79	115	90	92	76	114	89	127	128	124	92

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 7.99. Soil organic matter (Mg ha^{-1}) at the Airdrie site in 2001.

		Beef manure								Hog manure							
		Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
								0-15 cm soil depth									
1	184	224	211	206	218	180	177	244	231	201	148	158	163	222	191	184	205
2	216	159	203	266	199	235	203	261	238	197	191	191	217	244	285	234	215
3	174	237	206	190	191	261	198	241	298	185	226	174	181	226	186	174	208
4	160	114	238	232	283	164	151	171	255	137	195	201	127	184	178	204	181
Mean	184	184	214	224	222	210	182	229	256	180	190	181	172	219	210	199	202
								15-30 cm soil depth									
1	117	184	170	102	145	64	146	192	81	119	114	122	106	132	127	180	122
2	157	106	121	231	197	202	148	69	186	104	127	136	128	146	203	147	66
3	110	181	118	83	148	206	133	192	204	110	161	153	111	123	142	93	116
4	110	76	207	125	218	117	91	114	215	137	178	175	75	83	143	202	105
Mean	124	137	154	135	177	147	129	142	172	118	145	147	105	121	154	156	102
								30-60 cm soil depth									
1	143	223	206	119	160	165	308	227	393	149	162	148	59	184	136	236	267
2	171	102	142	257	211	274	159	457	202	142	101	133	129	138	143	148	82
3	127	202	108	97	213	226	188	173	215	119	181	178	126	143	256	141	156
4	121	92	312	131	286	104	99	129	125	194	265	203	92	92	222	291	139
Mean	140	155	192	151	218	192	189	247	234	151	177	165	101	139	189	204	161
								60-90 cm soil depth									
1	80	131	181	67	88	83	263	168	93	88	122	116	48	91	118	171	81
2	93	82	90	123	303	145	89	252	103	100	81	93	94	152	99	83	296
3	87	133	75	56	157	148	116	84	104	81	102	155	80	97	182	102	106
4	103	98	171	93	160	216	85	86	104	119	161	112	81	69	142	193	103
Mean	91	111	130	85	177	148	138	148	101	97	116	119	76	102	135	137	146
								90-120 cm soil depth									
1	101	81	138	47	67	70	180	112	69	60	74	155	36	61	73	95	51
2	76	64	60	96	143	89	78	81	70	66	61	80	76	91	74	59	100
3	69	99	65	78	80	113	62	59	65	75	66	113	77	71	149	94	110
4	80	71	110	73	93	153	95	71	85	86	119	98	71	69	100	115	81
Mean	81	79	93	74	96	106	104	81	72	72	80	112	65	73	99	91	86
								120-150 cm soil depth									
1	73	90	111	62	67	56	127	70	72	53	74	130	37	69	80	58	63
2	72	74	94	72	99	86	91	86	80	73	58	78	71	94	72	60	91
3	71	67	60	55	97	85	45	59	53	68	70	104	75	86	125	109	110
4	84	68	100	80	88	71	82	67	76	79	109	63	71	88	88	97	76
Mean	75	75	91	67	88	74	86	71	70	68	78	94	63	84	91	81	85

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Appendix 8. Statistical analysis results for the soil chemistry, crop yield, and crop-tissue chemistry data for the Lethbridge and Airdrie sites.

The following 12 tables summarizes the results of the statistical analysis of the data. Results for the soil data are in Tables 1 to 9, and the results for the crop data are in Tables 10 to 12. Each table is divided into three sections: top; middle; and bottom. The top section shows the results the treatment (treat) effect, year effect, and treat-by-year interactions for each site-by-application time combination. There were nine treatments: the control; four beef-manure application rates; and four hog-manure application rates. In the middle section the results comparing manure treatments (by manure type) with the control are shown. Negative differences indicate the manure treatments are greater than the control, and positive differences indicate the manure treatments are less than the control. The bottom section show the results of the tests, without the control, for significant main treatment effects of manure type (beef versus hog), manure rate (rates 1, 2, 3, 4), year , and their possible interactions.

Table 8.1	soil data	nitrate-N
Table 8.2	soil data	ammonium-N
Table 8.3	soil data	phosphate-P
Table 8.4	soil data	sodium
Table 8.5	soil data	potassium
Table 8.6	soil data	sulphate-S
Table 8.7	soil data	pH
Table 8.8	soil data	electrical conductivity
Table 8.9	soil data	organic matter
Table 8.10	crop data	yield, dry matter, protein, ADF, nitrate, phosphorus
Table 8.11	crop data	calcium, magnesium, sodium, potassium, aluminum, copper
Table 8.12	crop data	Selenium, sulphur, zinc, boron, manganese, iron

Table 8.1. Statistical analysis results of the soil extractable nitrate-N data.[z]

			0-15 (cm)	15-30 (cm)	30-60 (cm)	60-90 (cm)	90-120 (cm)	120-150 (cm)	0-90 (cm)
Lethbridge	spring	treat	***	***	*	**	**	*	***
		year	***	***	***	***	***	***	***
		treat*year	***	*	***	**	ns	ns	***
Lethbridge	fall	treat	***	***	***	*	ns	ns	***
		year	***	***	***	***	***	***	***
		treat*year	***	**	***	ns	ns	ns	***
Airdrie	spring	treat	***	***	***	ns	ns	ns	***
		year	***	***	***	***	*	ns	***
		treat*year	***	***	***	**	ns	ns	***
Airdrie	fall	treat	***	***	**	*	ns	ns	***
		year	***	***	***	**	ns	**	***
		treat*year	**	***	ns	ns	ns	*	**
Lethbridge	spring	cont-beef	-46 ***	-14 ***	-10 **	-4 ns	-2 ns	-2 ns	-74 ***
		cont-hog	-31.4 **	-11 **	-4 ns	-7 ns	-2 ns	-2 ns	-53 **
Lethbridge	fall	cont-beef	-62 ***	-22 ***	-17 ***	-7 ns	-2 ns	-1 ns	-109 ***
		cont-hog	-68 ***	-35 ***	-30 ***	-12 **	-5 *	-3 ns	-144 ***
Airdrie	spring	cont-beef	-17 ns	-10 ns	-4 ns	-3 ns	-1 ns	-2 ns	-35 ns
		cont-hog	-57 ***	-69 ***	-104 **	-56*	-43 ns	-44 ns	-285 ***
Airdrie	fall	cont-beef	-79 ns	-8 ns	-4 ns	-3 ns	-4 ns	-2 ns	-32 ns
		cont-hog	-111 ***	-48 ***	-30 *	-13 **	-16 *	-13	-202 ***
Lethbridge	spring	manure	*	ns	*	ns	ns	ns	ns
		rate	***	**	ns	*	**	ns	***
		manure*rate	ns	ns	ns	ns	ns	ns	ns
		year	***	***	***	***	***	***	**
		manure*year	ns	ns	**	ns	ns	ns	*
		rate*year	***	*	**	ns	ns	ns	***
		manure*rate*year	ns	ns	ns	ns	ns	ns	ns
Lethbridge	fall	manure	ns	*	*	ns	ns	ns	ns
		rate	**	***	**	*	ns	ns	***
		manure*rate	ns	ns	ns	ns	ns	ns	ns
		year	***	***	***	***	***	***	***
		manure*year	***	ns	ns	ns	ns	ns	*
		rate*year	***	ns	***	ns	ns	ns	**
		manure*rate*year	ns	ns	ns	ns	ns	ns	ns
Airdrie	spring	manure	***	***	***	**	*	ns	***
		rate	***	***	**	ns	ns	ns	**
		manure*rate	ns	*	*	ns	ns	ns	*
		year	***	***	***	***	ns	ns	***
		manure*year	**	***	***	***	ns	ns	***
		rate*year	***	**	*	ns	ns	ns	***
		manure*rate*year	ns	ns	ns	ns	ns	ns	ns
Airdrie	fall	manure	***	***	**	**	*	*	***
		rate	***	**	*	*	ns	ns	***
		manure*rate	*	*	ns	*	ns	ns	*
		year	***	***	***	*	ns	***	***
		manure*year	***	**	ns	ns	ns	**	***
		rate*year	ns	ns	ns	ns	ns	ns	ns
		manure*rate*year	ns	ns	ns	ns	ns	ns	ns

[z] Level of significance: * (P<0.05), ** (P<0.01), and *** (P<0.001). ns = not significant

Table 8.2 Statistical analysis results of the soil extractable ammonium-N data.[z]

			0-15 (cm)	15-30 (cm)	30-60 (cm)	60-90 (cm)	90-120 (cm)	120-150 (cm)	0-60 (cm)
Lethbridge	spring	treat	***	***	***	***	ns	ns	**
		year	***	***	***	**	**	***	***
		treat*year	***	***	***	**	**	ns	**
Lethbridge	fall	treat	**	*	**	ns	ns	ns	***
		year	***	***	***	***	***	***	***
		treat*year	***	***	***	*	ns	ns	***
Airdrie	spring	treat	ns	ns	ns	ns	ns	ns	ns
		year	**	***	***	***	***	***	***
		treat*year	ns	ns	ns	ns	ns	ns	ns
Airdrie	fall	treat	ns	ns	ns	ns	ns	ns	ns
		year	***	***	ns	***	*	***	***
		treat*year	ns	ns	ns	ns	ns	ns	ns
Lethbridge	spring	cont-beef	-11 ***	-6 ***	-8 ***	-0.5 ns	-1.1 ns	-6 ns	-26 ***
		cont-hog	-3 ns	-5 *	-7 **	-2 ns	-3 ns	-9 ns	-16 **
Lethbridge	fall	cont-beef	-17 **	-8 *	-9 *	-3 ns	-1 ns	-2 ns	-34 **
		cont-hog	-19 **	-12 ***	-13 **	-3 ns	2 ns	4 ns	-44 ***
Airdrie	spring	cont-beef	-5 ns	-2 ns	-2 ns	-2 ns	-1 ns	-1 ns	-9 ns
		cont-hog	-2 ns	-3 ns	-6 ns	-4 ns	-2 ns	-0.2 ns	-11 ns
Airdrie	fall	cont-beef	-4 ns	0.01 ns	-1 ns	-0.03 ns	-2 ns	-0.5 ns	-5 ns
		cont-hog	-2 *	0.1	-3 ns	-2 ns	-4 ns	-2 ns	-9 ns
Lethbridge	spring	manure	**	ns	ns	ns	ns	ns	ns
		rate	***	***	***	ns	ns	ns	***
		manure*rate	ns	ns	ns	ns	ns	ns	ns
		year	***	***	***	**	***	***	***
		manure*year	***	*	ns	ns	ns	ns	***
		rate*year	***	***	***	*	ns	ns	***
		manure*rate*year	ns	ns	ns	ns	ns	ns	ns
Lethbridge	fall	manure	ns	ns	ns	ns	ns	ns	ns
		rate	*	ns	*	*	ns	ns	*
		manure*rate	ns	ns	ns	ns	ns	ns	ns
		year	***	***	***	***	***	***	***
		manure*year	ns	ns	**	ns	ns	ns	ns
		rate*year	***	ns	***	*	ns	ns	***
		manure*rate*year	ns	ns	ns	ns	ns	ns	ns
Airdrie	spring	manure	ns	ns	ns	ns	ns	ns	ns
		rate	ns	ns	ns	ns	ns	ns	ns
		manure*rate	ns	ns	ns	ns	ns	ns	ns
		year	*	**	*	***	***	***	***
		manure*year	ns	ns	ns	ns	ns	ns	ns
		rate*year	ns	ns	ns	ns	ns	ns	ns
		manure*rate*year	ns	ns	ns	ns	ns	ns	ns
Airdrie	fall	manure	ns	ns	ns	ns	ns	ns	ns
		rate	ns	ns	ns	ns	ns	ns	ns
		manure*rate	ns	ns	ns	ns	ns	ns	ns
		year	***	***	**	***	ns	*	***
		manure*year	ns	ns	ns	ns	ns	ns	ns
		rate*year	ns	ns	ns	ns	ns	ns	ns
		manure*rate*year	ns	ns	ns	ns	ns	ns	ns

[z] Level of significance: * (P<0.05), ** (P<0.01), and *** (P<0.001). ns = not significant

Table 8.3 Statistical analysis results of the soil extractable phosphate-P data.[z]

			0-15 (cm)	15-30 (cm)	30-60 (cm)	60-90 (cm)	90-120 (cm)	120-150 (cm)
Lethbridge	spring	treat	*	ns	ns	ns	ns	ns
		year	***	***	***	***	***	***
		treat*year	***	***	ns	ns	ns	ns
Lethbridge	fall	treat	**	*	ns	ns	ns	ns
		year	***	***	***	***	***	***
		treat*year	***	***	ns	ns	ns	ns
Airdrie	spring	treat	***	ns	ns	ns	ns	ns
		year	***	**	*	***	***	***
		treat*year	***	ns	ns	ns	ns	ns
Airdrie	fall	treat	***	**	ns	ns	ns	ns
		year	***	***	**	**	***	***
		treat*year	***	*	ns	ns	ns	ns
Lethbridge	spring	cont-beef	-47 *	-8 ns	-2 ns	-1 ns	-1 ns	-1 ns
		cont-hog	-50 *	-10 ns	-1 ns	-1 ns	1 ns	1 ns
Lethbridge	fall	cont-beef	-40 **	-13 *	-3 ns	-0.1 ns	-0.04 ns	-0.01 ns
		cont-hog	-36 **	-6 ns	-2 ns	-0.1 ns	-0.4 ns	-0.3 ns
Airdrie	spring	cont-beef	-31 ***	-4 ns	-1 ns	0.1 ns	-0.4 ns	-0.3 ns
		cont-hog	-22 ***	-6 *	-3 ns	-3 ns	-4 ns	-2 ns
Airdrie	fall	cont-beef	-45 ***	-8 **	-5 ns	-1 ns	-0.2 ns	-1 ns
		cont-hog	-36 ***	-8 **	-1 ns	-1 ns	0.2 ns	-1 ns
Lethbridge	spring	manure	ns	ns	ns	ns	ns	ns
		rate	*	ns	ns	ns	ns	ns
		manure*rate	ns	ns	ns	ns	ns	ns
		year	***	***	***	***	***	***
		manure*year	ns	ns	ns	ns	ns	ns
		rate*year	***	***	ns	ns	ns	ns
		manure*rate*year	ns	ns	ns	ns	ns	ns
Lethbridge	fall	manure	ns	ns	ns	ns	ns	ns
		rate	*	*	ns	ns	ns	ns
		manure*rate	ns	ns	ns	ns	ns	ns
		year	***	***	***	***	***	***
		manure*year	ns	**	ns	ns	ns	ns
		rate*year	***	***	ns	ns	ns	ns
		manure*rate*year	ns	**	ns	ns	ns	ns
Airdrie	spring	manure	*	ns	ns	ns	ns	ns
		rate	***	ns	ns	ns	ns	ns
		manure*rate	ns	ns	ns	ns	ns	ns
		year	***	*	ns	***	**	**
		manure*year	ns	ns	ns	*	*	ns
		rate*year	**	ns	ns	ns	ns	ns
		manure*rate*year	ns	ns	ns	ns	ns	ns
Airdrie	fall	manure	ns	ns	ns	ns	ns	ns
		rate	***	ns	ns	ns	ns	ns
		manure*rate	ns	ns	ns	ns	ns	ns
		year	***	***	**	*	***	***
		manure*year	*	**	ns	ns	ns	ns
		rate*year	***	ns	ns	ns	ns	ns
		manure*rate*year	ns	ns	ns	ns	ns	ns

[z] Level of significance: * (P<0.05), ** (P<0.01), and *** (P<0.001). ns = not significant

Table 8.4 Statistical analysis results of the soil extractable sodium data.[z]

			0-15 (cm)	15-30 (cm)	30-60 (cm)	60-90 (cm)	90-120 (cm)	120-150 (cm)	0-60 [y] (cm)
Lethbridge	spring	treat	***	***	**	ns	ns	ns	***
		year	***	***	**	**	ns	ns	***
		treat*year	**	***	***	ns	ns	ns	***
Lethbridge	fall	treat	***	***	***	ns	ns	ns	***
		year	***	***	***	**	ns	ns	***
		treat*year	***	***	***	ns	ns	ns	***
Airdrie	spring	treat	ns	ns	ns	ns	ns	ns	ns
		year	***	*	*	ns	ns	ns	**
		treat*year	ns	ns	ns	ns	ns	ns	ns
Airdrie	fall	treat	***	***	ns	ns	ns	ns	***
		year	***	***	ns	ns	**	ns	***
		treat*year	***	***	ns	ns	ns	ns	***
Lethbridge	spring	cont-beef	-50 ***	-67 ***	-124 **	-116 ns	-188 ns	-262 ns	-242 ***
		cont-hog	-7 ns	-14 ns	-21 ns	-24 ns	-18 ns	-19 ns	-44 ns
Lethbridge	fall	cont-beef	-100 ***	-80 ***	-95 **	-17 ns	36 ns	135 ns	-275 **
		cont-hog	-3 ns	-6 ns	-15 ns	8 ns	-5 ns	-3 ns	-24 ns
Airdrie	spring	cont-beef	-50 **	-34 ns	52 ns	241 ns	269 ns	253 ns	-82 ns
		cont-hog	-59 **	-92 ns	-53 ns	140 ns	90 ns	48 ns	-150 ns
Airdrie	fall	cont-beef	-106 ***	-80 ***	-173 ns	-241 ns	-319 ns	-355 ns	-187 ***
		cont-hog	-114 ***	-64 ***	-70 ns	-94 ns	-144 ns	-218 ns	-179 ***
Lethbridge	spring	manure	***	***	***	ns	ns	ns	***
		rate	ns	***	*	ns	ns	ns	**
		manure*rate	ns	*	ns	ns	ns	ns	ns
		year	**	***	***	ns	ns	ns	***
		manure*year	***	***	***	**	ns	ns	***
		rate*year	ns	ns	***	**	ns	ns	***
		manure*rate*year	ns	ns	*	ns	ns	ns	*
Lethbridge	fall	manure	***	***	***	ns	ns	ns	***
		rate	***	***	ns	ns	ns	ns	**
		manure*rate	**	***	**	ns	ns	ns	***
		year	***	***	***	**	ns	ns	***
		manure*year	***	***	***	*	ns	ns	***
		rate*year	*	***	***	ns	ns	ns	***
		manure*rate*year	*	**	*	ns	ns	ns	***
Airdrie	spring	manure	ns	ns	ns	ns	ns	ns	ns
		rate	ns	ns	ns	ns	ns	ns	*
		manure*rate	ns	ns	ns	ns	ns	ns	ns
		year	***	ns	ns	ns	ns	ns	***
		manure*year	ns	ns	ns	ns	ns	ns	ns
		rate*year	ns	ns	ns	ns	ns	ns	ns
		manure*rate*year	ns	ns	ns	ns	ns	ns	ns
Airdrie	fall	manure	ns	ns	ns	ns	ns	ns	ns
		rate	***	***	ns	ns	ns	ns	***
		manure*rate	ns	ns	*	ns	ns	ns	*
		year	***	***	ns	ns	**	ns	***
		manure*year	***	ns	ns	ns	ns	ns	*
		rate*year	***	***	ns	ns	ns	*	***
		manure*rate*year	ns	*	ns	ns	ns	ns	*

[z] Level of significance: * (P<0.05), ** (P<0.01), and *** (P<0.001). ns = not significant

[y] 0-60 cm for the Lethbridge site and 0-30 cm for the Airdrie site.

Table 8.5 Statistical analysis results of the soil extractable potassium data.[z]

			0-15 (cm)	15-30 (cm)	30-60 (cm)	60-90 (cm)	90-120 (cm)	120-150 (cm)	0-30 (cm)
Lethbridge	spring	treat	***	***	ns	ns	ns	ns	***
		year	***	***	***	***	***	***	***
		treat*year	***	***	ns	ns	ns	ns	***
Lethbridge	fall	treat	***	***	ns	ns	ns	ns	***
		year	***	***	***	***	***	***	***
		treat*year	***	***	***	ns	ns	ns	***
Airdrie	spring	treat	***	ns	ns	ns	ns	ns	***
		year	***	***	*	***	*	*	***
		treat*year	***	*	ns	ns	ns	ns	***
Airdrie	fall	treat	***	*	ns	ns	ns	ns	***
		year	***	***	***	***	***	*	***
		treat*year	***	ns	ns	ns	ns	ns	***
Lethbridge	spring	cont-beef	-998***	-329***	-169 ns	-117 ns	-95 ns	-175 ns	-1337***
		cont-hog	-117 ns	-22 ns	-10 ns	3.7 ns	20 ns	-1.5 ns	-148 ns
Lethbridge	fall	cont-beef	-1052***	-236 **	-133 ns	-90 ns	-16 ns	-77 ns	-1288***
		cont-hog	-201 ns	-26 ns	-103 ns	-158 ns	-118 ns	-141 ns	-227 ns
Airdrie	spring	cont-beef	-552 ***	-150 *	-206 ns	-152 ns	-90 ns	-126 ns	-698 ***
		cont-hog	-132 ns	-79 ns	-86 ns	-71 ns	-81 ns	-100 ns	-200 ns
Airdrie	fall	cont-beef	-546 ***	-133 ns	-27 ns	1.1 ns	34 ns	45 ns	-682 ***
		cont-hog	-60 ns	24 ns	-23 ns	-26 ns	-22 ns	-38 ns	-46 ns
Lethbridge	spring	manure	***	***	ns	ns	ns	ns	***
		rate	**	ns	ns	ns	ns	ns	**
		manure*rate	*	ns	ns	ns	ns	ns	*
		year	***	***	***	***	***	***	***
		manure*year	***	**	ns	ns	ns	ns	***
		rate*year	**	ns	ns	ns	ns	ns	***
		manure*rate*year	ns	ns	ns	ns	ns	ns	*
Lethbridge	fall	manure	***	**	ns	ns	ns	ns	***
		rate	**	ns	ns	ns	ns	ns	**
		manure*rate	*	**	ns	ns	ns	ns	**
		year	***	***	***	***	***	ns	***
		manure*year	***	***	***	ns	ns	ns	***
		rate*year	***	***	**	ns	ns	ns	***
		manure*rate*year	**	**	ns	ns	ns	ns	**
Airdrie	spring	manure	***	ns	ns	ns	ns	ns	***
		rate	**	ns	ns	ns	ns	ns	*
		manure*rate	ns	ns	ns	ns	ns	ns	ns
		year	***	***	*	***	ns	*	***
		manure*year	***	ns	ns	ns	ns	ns	***
		rate*year	***	ns	ns	ns	ns	ns	***
		manure*rate*year	***	ns	ns	ns	ns	ns	***
Airdrie	fall	manure	***	*	ns	ns	ns	ns	***
		rate	***	*	ns	ns	ns	ns	***
		manure*rate	*	ns	ns	ns	ns	ns	***
		year	***	*	***	***	***	*	***
		manure*year	***	ns	ns	ns	ns	ns	***
		rate*year	**	ns	ns	ns	ns	ns	***
		manure*rate*year	*	ns	ns	ns	ns	*	***

[z] Level of significance: * (P<0.05), ** (P<0.01), and *** (P<0.001). ns = not significant

Table 8.6 Statistical analysis results of the soil extractable sulphate-S data.[z]

			0-15 (cm)	15-30 (cm)	30-60 (cm)	60-90 (cm)	90-120 (cm)	120-150 (cm)	0-30 (cm)
Lethbridge	spring	treat	ns	ns	ns	ns	ns	ns	ns
		year	*	***	***	ns	ns	ns	***
		treat*year	ns	ns	ns	ns	ns	ns	ns
Lethbridge	fall	treat	ns	ns	ns	ns	*	ns	ns
		year	**	***	**	ns	ns	ns	**
		treat*year	ns	ns	ns	ns	ns	ns	ns
Airdrie	spring	treat	***	ns	ns	ns	ns	ns	**
		year	***	***	***	ns	**	**	***
		treat*year	***	ns	ns	ns	ns	ns	*
Airdrie	fall	treat	***	**	ns	ns	ns	ns	***
		year	***	***	ns	*	**	**	***
		treat*year	*	ns	ns	ns	ns	ns	ns
Lethbridge	spring	cont-beef	28 ns	-13 ns	-28 ns	110 ns	-71 ns	-1174 ns	6.2 ns
		cont-hog	21 ns	-22 ns	-2.2 ns	13 ns	261 ns	-1428 ns	5.5 ns
Lethbridge	fall	cont-beef	21 ns	17 ns	16 ns	412 ns	-50 ns	118 ns	38 ns
		cont-hog	92 *	55 **	40 ns	612 ns	1307 ns	1405 ns	147 **
Airdrie	spring	cont-beef	-4.0 **	-2.8 ns	26 ns	14 ns	5.0 ns	4.8 ns	-6.7 ns
		cont-hog	-2.7 *	-3.1 ns	16 ns	2.6 ns	-1.1 n	-5.1 ns	-5.6 ns
Airdrie	fall	cont-beef	-8.9 **	-5.5 *	-5.7 ns	-7.5 ns	0.6 ns	-3.6 ns	-14 ***
		cont-hog	-15 ***	-8.5 ***	-3.0 ns	-1.5 ns	1.9 ns	-0.9 ns	-24 ***
Lethbridge	spring	manure	ns	ns	ns	ns	ns	ns	ns
		rate	ns	ns	ns	ns	ns	ns	ns
		manure*rate	ns	ns	ns	ns	ns	ns	ns
		year	***	***	***	ns	*	ns	***
		manure*year	ns	ns	ns	ns	ns	ns	ns
		rate*year	ns	ns	ns	ns	ns	ns	ns
		manure*rate*year	ns	ns	ns	ns	ns	ns	ns
Lethbridge	fall	manure	*	*	ns	ns	**	ns	*
		rate	ns	ns	ns	ns	*	ns	ns
		manure*rate	ns	ns	ns	ns	ns	ns	ns
		year	**	***	**	ns	ns	ns	**
		manure*year	ns	ns	ns	ns	ns	ns	ns
		rate*year	ns	*	ns	ns	ns	ns	ns
		manure*rate*year	ns	ns	ns	ns	ns	ns	ns
Airdrie	spring	manure	ns	ns	ns	ns	ns	ns	ns
		rate	***	*	ns	ns	ns	ns	**
		manure*rate	ns	ns	ns	ns	ns	ns	ns
		year	***	***	***	ns	*	**	***
		manure*year	ns	*	ns	ns	ns	ns	ns
		rate*year	***	ns	ns	ns	ns	ns	*
		manure*rate*year	ns	ns	ns	ns	ns	ns	ns
Airdrie	fall	manure	**	ns	ns	ns	ns	ns	**
		rate	***	*	ns	ns	ns	ns	***
		manure*rate	ns	ns	*	ns	ns	ns	ns
		year	***	***	ns	ns	**	*	***
		manure*year	ns	ns	ns	ns	ns	ns	ns
		rate*year	*	ns	ns	ns	ns	ns	ns
		manure*rate*year	ns	ns	ns	ns	ns	ns	ns

[z] Level of significance: * (P<0.05), ** (P<0.01), and *** (P<0.001). ns = not significant

Table 8.7 Statistical analysis results of the soil pH data.[z]

			0-15 (cm)	15-30 (cm)	30-60 (cm)	60-90 (cm)	90-120 (cm)	120-150 (cm)
Lethbridge	spring	treat	**	ns	ns	ns	ns	ns
		year	***	***	***	***	***	***
		treat*year	***	ns	ns	ns	ns	ns
Lethbridge	fall	treat	*	ns	ns	ns	ns	ns
		year	***	***	***	***	***	***
		treat*year	ns	*	ns	ns	ns	ns
Airdrie	spring	treat	ns	ns	ns	ns	ns	ns
		year	***	***	***	***	***	***
		treat*year	ns	*	ns	ns	ns	ns
Airdrie	fall	treat	ns	ns	ns	ns	ns	ns
		year	***	***	***	***	***	***
		treat*year	*	ns	ns	ns	ns	ns
Lethbridge	spring	cont-beef	0.06 ns	-0.04 ns	0.02 ns	0.00 ns	-0.01 ns	0.09 ns
		cont-hog	0.08 *	-0.02 ns	-0.02 ns	-0.03 ns	0.01 ns	0.14 ns
Lethbridge	fall	cont-beef	0.07 *	0.07 ns	0.09 ns	0.04 ns	0.04 ns	-0.01 ns
		cont-hog	0.10 **	0.11 *	0.13 ns	0.01 ns	-0.12 ns	-0.14 ns
Airdrie	spring	cont-beef	-0.02 ns	0.14 ns	0.34 ns	0.39 ns	0.29 ns	0.24 ns
		cont-hog	0.00 ns	0.06 ns	0.19 ns	0.24 ns	0.17 ns	0.11 ns
Airdrie	fall	cont-beef	0.05 ns	0.01 ns	0.00 ns	-0.01 ns	-0.02 ns	-0.05 ns
		cont-hog	0.27 ns	0.13 ns	0.07 ns	0.05 ns	-0.04 ns	0.02 ns
Lethbridge	spring	manure	ns	ns	ns	ns	ns	ns
		rate	**	ns	ns	ns	ns	ns
		manure*rate	ns	ns	ns	ns	ns	ns
		year	***	***	***	***	***	***
		manure*year	ns	ns	ns	ns	ns	ns
		rate*year	***	ns	ns	ns	ns	ns
		manure*rate*year	ns	ns	ns	ns	ns	ns
Lethbridge	fall	manure	ns	ns	ns	ns	*	ns
		rate	*	ns	ns	ns	ns	ns
		manure*rate	ns	ns	ns	ns	ns	ns
		year	***	***	***	***	***	***
		manure*year	ns	ns	ns	ns	ns	ns
		rate*year	ns	ns	ns	ns	ns	ns
		manure*rate*year	ns	ns	ns	ns	ns	ns
Airdrie	spring	manure	ns	ns	ns	ns	ns	ns
		rate	ns	ns	ns	ns	ns	ns
		manure*rate	*	ns	ns	ns	ns	ns
		year	***	***	***	***	***	***
		manure*year	ns	ns	ns	ns	ns	ns
		rate*year	ns	ns	ns	ns	ns	ns
		manure*rate*year	ns	ns	ns	ns	ns	ns
Airdrie	fall	manure	*	ns	ns	ns	ns	ns
		rate	ns	ns	ns	ns	ns	ns
		manure*rate	ns	ns	ns	ns	ns	ns
		year	***	***	***	***	***	***
		manure*year	ns	ns	ns	ns	ns	ns
		rate*year	ns	ns	ns	ns	ns	ns
		manure*rate*year	ns	ns	ns	ns	ns	ns

[z] Level of significance: * (P<0.05), ** (P<0.01), and *** (P<0.001). ns = not significant

Table 8.8 Statistical analysis results of the soil electrical conductivity data.[z]

			0-15 (cm)	15-30 (cm)	30-60 (cm)	60-90 (cm)	90-120 (cm)	120-150 (cm)
Lethbridge	spring	treat	ns	ns	*	ns	ns	ns
		year	***	***	***	ns	***	**
		treat*year	*	ns	ns	ns	ns	ns
Lethbridge	fall	treat	***	***	***	ns	ns	ns
		year	***	***	***	ns	*	ns
		treat*year	***	***	***	ns	ns	ns
Airdrie	spring	treat	***	***	*	ns	ns	ns
		year	***	***	***	***	***	ns
		treat*year	***	***	***	ns	ns	ns
Airdrie	fall	treat	***	***	*	*	ns	ns
		year	***	***	***	***	***	***
		treat*year	***	**	**	ns	ns	ns
Lethbridge	spring	cont-beef	-0.16 ns	-0.13 *	-0.15 *	-0.08 ns	-0.14 ns	-0.86 ns
		cont-hog	-0.02 ns	-0.10 ns	-0.05 ns	-0.02 ns	0.14 ns	-1.0 ns
Lethbridge	fall	cont-beef	-0.39***	-0.21 **	-0.16 **	0.17 ns	-0.02 ns	0.20 ns
		cont-hog	-0.07 ns	-0.03 ns	-0.03 ns	0.41 ns	0.96 ns	1.2 ns
Airdrie	spring	cont-beef	-0.16 *	-0.10 ns	-0.02 ns	0.02 ns	0.05 ns	0.05 ns
		cont-hog	-0.23 **	-0.26***	-0.15 *	-0.06 ns	-0.03 ns	0.00 ns
Airdrie	fall	cont-beef	-0.36***	-0.16***	-0.12 *	-0.08 ns	-0.06 ns	-0.06 ns
		cont-hog	-0.56***	-0.24***	-0.10 ns	-0.06 ns	-0.05 ns	-0.06 ns
Lethbridge	spring	manure	*	ns	*	ns	ns	ns
		rate	*	ns	ns	ns	ns	ns
		manure*rate	ns	ns	ns	ns	ns	ns
		year	***	***	***	ns	***	***
		manure*year	***	ns	*	ns	ns	ns
		rate*year	***	ns	*	ns	ns	ns
		manure*rate*year	*	ns	ns	ns	ns	ns
Lethbridge	fall	manure	***	***	***	*	**	ns
		rate	***	**	***	ns	ns	ns
		manure*rate	ns	ns	ns	ns	ns	ns
		year	***	***	***	**	*	*
		manure*year	***	**	***	ns	ns	ns
		rate*year	***	***	*	ns	ns	ns
		manure*rate*year	*	ns	ns	ns	ns	ns
Airdrie	spring	manure	ns	***	*	ns	ns	ns
		rate	***	***	**	ns	ns	ns
		manure*rate	ns	*	ns	ns	ns	ns
		year	***	***	***	***	**	ns
		manure*year	ns	***	***	*	ns	ns
		rate*year	***	***	***	ns	ns	ns
		manure*rate*year	ns	ns	ns	ns	ns	ns
Airdrie	fall	manure	**	*	ns	ns	ns	ns
		rate	***	***	*	ns	ns	ns
		manure*rate	ns	ns	ns	*	ns	ns
		year	***	***	***	**	***	***
		manure*year	ns	ns	ns	ns	*	*
		rate*year	**	*	**	ns	ns	ns
		manure*rate*year	ns	ns	ns	ns	ns	ns

[z] Level of significance: * (P<0.05), ** (P<0.01), and *** (P<0.001). ns = not significant

Table 8.9 Statistical analysis results of the soil organic matter data.[z]

			0-15 (cm)	15-30 (cm)	30-60 (cm)	60-90 (cm)	90-120 (cm)	120-150 (cm)
Lethbridge	spring	treat	***	ns	ns	ns	ns	ns
		year	***	***	***	***	***	***
		treat*year	***	ns	ns	ns	ns	ns
Lethbridge	fall	treat	***	ns	ns	ns	ns	ns
		year	***	***	***	***	***	***
		treat*year	**	ns	ns	ns	ns	ns
Airdrie	spring	treat	ns	ns	ns	ns	ns	**
		year	ns	ns	ns	***	***	***
		treat*year	ns	ns	ns	ns	ns	ns
Airdrie	fall	treat	ns	ns	ns	ns	ns	ns
		year	**	ns	***	***	***	***
		treat*year	ns	ns	ns	ns	ns	ns
Lethbridge	spring	cont-beef	-18 ***	-2.5 ns	-8.0 ns	-5.5 ns	-5.1 ns	-12 *
		cont-hog	-7.0 *	-0.4 ns	-0.4 ns	-3.1 ns	-5.5 ns	-11 *
Lethbridge	fall	cont-beef	-21 ***	-10 *	-16 ns	-13 ns	-4.4 ns	-0.7 ns
		cont-hog	-11 *	-7.7 ns	-13 ns	-9 7 ns	-3.7 ns	-4.8 ns
Airdrie	spring	cont-beef	-21 ns	-18 ns	-21 ns	-18 ns	-9.8 ns	-10 ns
		cont-hog	-3.2 ns	-7.1 ns	-13 ns	-14 ns	-12 ns	-5.8 ns
Airdrie	fall	cont-beef	-26 ns	-16 ns	-20 ns	-12 ns	-4.9 ns	-3.1 ns
		cont-hog	21 ns	-8.6 ns	-13 ns	-16 ns	-9.5 ns	-10 ns
Lethbridge	spring	manure	***	ns	ns	ns	ns	ns
		rate	*	ns	ns	ns	ns	ns
		manure*rate	ns	ns	ns	ns	ns	ns
		year	***	***	***	***	***	***
		manure*year	***	ns	**	ns	ns	ns
		rate*year	*	ns	ns	ns	ns	ns
		manure*rate*year	ns	ns	ns	ns	ns	ns
Lethbridge	fall	manure	**	ns	ns	ns	ns	ns
		rate	ns	ns	ns	ns	ns	ns
		manure*rate	ns	ns	ns	ns	ns	*
		year	***	***	***	***	***	***
		manure*year	*	ns	ns	ns	ns	ns
		rate*year	ns	ns	ns	ns	ns	ns
		manure*rate*year	ns	ns	ns	ns	ns	ns
Airdrie	spring	manure	ns	ns	ns	ns	ns	ns
		rate	ns	ns	ns	ns	ns	ns
		manure*rate	ns	ns	ns	ns	*	**
		year	ns	ns	ns	***	***	***
		manure*year	ns	ns	ns	ns	ns	ns
		rate*year	ns	ns	ns	ns	ns	ns
		manure*rate*year	ns	ns	ns	ns	ns	ns
Airdrie	fall	manure	ns	ns	ns	ns	ns	ns
		rate	ns	ns	ns	ns	ns	ns
		manure*rate	ns	ns	ns	ns	ns	ns
		year	**	ns	***	***	***	***
		manure*year	ns	ns	ns	ns	ns	ns
		rate*year	ns	ns	ns	ns	ns	ns
		manure*rate*year	ns	ns	ns	ns	ns	ns

[z] Level of significance: * ($P<0.05$), ** ($P<0.01$), and *** ($P<0.001$). ns = not significant

Table 8.10 Statistical analysis results of the plant yield and tissue analysis data.[z]

			Yield	Dry matter	Protein	ADF	Nitrate	Phosphorus
Lethbridge	spring	treat	**	ns	***	ns	***	***
		year	***	***	***	***	***	***
		treat*year	**	ns	ns	ns	*	ns
Lethbridge	fall	treat	*	ns	***	ns	*	***
		year	***	***	***	***	***	***
		treat*year	***	ns	ns	ns	***	***
Airdrie	spring	treat	***	ns	***	***	***	***
		year	***	***	***	***	ns	***
		treat*year	**	ns	***	***	ns	ns
Airdrie	fall	treat	***	ns	***	***	*	***
		year	***	***	***	***	ns	***
		treat*year	***	ns	***	***	*	***
Lethbridge	spring	cont-beef	-1.4***	-0.2 ns	-2.3 ***	-0.8 ns	-2833***	-534***
		cont-hog	-1.4***	-0.3 ns	-1.3 **	-1.4 *	-2586***	-306 ***
Lethbridge	fall	cont-beef	-1.1**	-0.4 ns	-2.3 ***	-0.6 ns	-1565**	-467 ***
		cont-hog	-1.1***	-0.2 ns	-1.7 ***	-0.3 ns	-1575**	-334 ***
Airdrie	spring	cont-beef	-1.8***	-0.1 ns	-2.7***	-4.4***	-66.4 ns	-745 ***
		cont-hog	-1.7***	-0.1 ns	-5.4***	-4.5***	-948***	-1017 ***
Airdrie	fall	cont-beef	-0.61 *	-0.1 ns	-1.4 **	-2.4 *	-4.4 ns	-389 ***
		cont-hog	-1.2***	-0.1 ns	-2.8 ***	-3.4 ***	-169***	-526 ***
Lethbridge	spring	manure	ns	ns	**	ns	ns	***
		rate	ns	ns	ns	ns	**	ns
		manure*rate	ns	ns	ns	ns	ns	ns
		year	***	***	***	***	***	***
		manure*year	ns	**	ns	ns	*	ns
		rate*year	ns	ns	ns	ns	ns	ns
		manure*rate*year	ns	ns	ns	*	ns	ns
Lethbridge	fall	manure	ns	ns	*	ns	ns	**
		rate	ns	ns	ns	ns	ns	*
		manure*rate	ns	ns	ns	ns	ns	ns
		year	***	***	***	***	***	***
		manure*year	ns	ns	ns	*	***	*
		rate*year	ns	ns	ns	ns	ns	*
		manure*rate*year	ns	ns	ns	ns	ns	ns
Airdrie	spring	manure	ns	ns	***	ns	***	***
		rate	*	ns	***	ns	***	***
		manure*rate	ns	ns	ns	**	**	ns
		year	***	***	***	***	ns	***
		manure*year	ns	*	**	ns	ns	*
		rate*year	ns	ns	**	*	ns	ns
		manure*rate*year	ns	ns	**	ns	ns	ns
Airdrie	fall	manure	**	ns	***	*	ns	*
		rate	ns	ns	***	ns	ns	***
		manure*rate	*	ns	**	ns	ns	ns
		year	***	***	***	***	ns	***
		manure*year	**	ns	***	ns	ns	*
		rate*year	ns	ns	***	*	ns	*
		manure*rate*year	ns	ns	**	ns	ns	ns

[z] Level of significance: * (P<0.05), ** (P<0.01), and *** (P<0.001). ns = not significant.

Table 8.11 Statistical analysis results of the plant tissue analysis data.[z]

			Calcium	Magnesium	Sodium	Potassium	Aluminum	Copper
Lethbridge	spring	treat	ns	ns	**	ns	ns	**
		year	***	***	***	***	***	***
		treat*year	*	ns	*	ns	*	ns
Lethbridge	fall	treat	ns	ns	ns	*	ns	ns
		year	***	***	***	***	***	***
		treat*year	ns	ns	***	ns	ns	ns
Airdrie	spring	treat	**	***	*	***	ns	**
		year	***	***	***	***	***	***
		treat*year	***	**	***	***	ns	*
Airdrie	fall	treat	**	***	**	***	ns	***
		year	***	***	***	***	***	***
		treat*year	***	***	***	***	ns	***
Lethbridge	spring	cont-beef	0.03 ns	-760 **	-160 ***	-0.30 **	17 ns	0.61 ns
		cont-hog	0.05 ns	-582 *	-179 ***	-0.06 ns	-25 ns	1.6 ***
Lethbridge	fall	cont-beef	0.04 ns	-352 ns	-104 *	-0.33 **	-15 ns	-0.21 ns
		cont-hog	0.03 ns	-278 ns	-108 *	-0.17 ns	-34 ns	0.50 ns
Airdrie	spring	cont-beef	-0.12 **	-276 ns	-39 **	-0.42 ***	-24 ns	-1.4 *
		cont-hog	-0.15 **	-361 *	-12 ns	-0.55 ***	27 ns	-1.3 *
Airdrie	fall	cont-beef	-0.07 ns	-348 ***	-22 **	-0.31 ***	-402 ns	-1.8 ***
		cont-hog	-0.09 *	-259 **	-12 ns	-0.33 ***	-199 ns	-1.1 ***
Lethbridge	spring	manure	ns	ns	ns	**	ns	***
		rate	ns	ns	ns	ns	*	ns
		manure*rate	ns	ns	ns	ns	ns	ns
		year	***	***	***	***	***	***
		manure*year	ns	ns	ns	ns	ns	ns
		rate*year	ns	ns	ns	ns	**	ns
		manure*rate*year	ns	ns	ns	ns	ns	ns
Lethbridge	fall	manure	ns	ns	ns	ns	ns	*
		rate	ns	ns	ns	ns	ns	ns
		manure*rate	ns	ns	ns	ns	ns	ns
		year	***	***	***	***	***	***
		manure*year	ns	ns	**	ns	ns	ns
		rate*year	ns	ns	*	ns	ns	ns
		manure*rate*year	ns	ns	ns	ns	ns	ns
Airdrie	spring	manure	ns	ns	**	**	ns	ns
		rate	**	***	ns	***	ns	**
		manure*rate	ns	ns	ns	ns	ns	ns
		year	***	***	***	***	***	***
		manure*year	***	***	***	ns	ns	ns
		rate*year	**	ns	ns	***	ns	ns
		manure*rate*year	ns	ns	ns	ns	ns	ns
Airdrie	fall	manure	ns	ns	ns	ns	ns	**
		rate	*	**	**	**	ns	***
		manure*rate	ns	ns	ns	ns	ns	ns
		year	***	***	***	***	***	***
		manure*year	***	***	*	ns	ns	ns
		rate*year	**	**	**	**	ns	**
		manure*rate*year	*	ns	ns	ns	ns	ns

[z] Level of significance: * (P<0.05), ** (P<0.01), and *** (P<0.001). ns = not significant.

Table 8.12 Statistical analysis results of the plant tissue analysis data.[z]

			Selenium	Sulphur	Zinc	Boron	Manganese	Iron
Lethbridge	spring	treat	*	ns	ns	ns	*	ns
		year	***	***	***	***	***	***
		treat*year	ns	ns	*	ns	ns	ns
Lethbridge	fall	treat	ns	*	**	ns	**	ns
		year	***	***	***	***	***	***
		treat*year	ns	ns	***	ns	***	ns
Airdrie	spring	treat	*	***	***	**	***	ns
		year	***	***	***	***	***	***
		treat*year	*	**	*	ns	ns	ns
Airdrie	fall	treat	ns	***	***	ns	*	ns
		year	***	***	***	***	***	***
		treat*year	*	***	***	ns	**	ns
Lethbridge	spring	cont-beef	0.24 **	-322***	-5.18 *	4.1 **	-5.94 *	-32 ns
		cont-hog	0.25 **	-169 ns	0.68 ns	4.8 ***	-1.60 ns	-22 ns
Lethbridge	fall	cont-beef	0.11 ns	-392***	-8.43 **	5.0 *	-6.00 **	-33 ns
		cont-hog	-0.05 ns	-321 **	-0.38 ns	4.1 *	-2.35 ns	-30 ns
Airdrie	spring	cont-beef	0.06 **	-221 ns	-13 ***	1.06 **	-5.50 ns	26 ns
		cont-hog	0.07 ***	-522 ***	-12 ***	0.98 *	-29.0 **	-11 ns
Airdrie	fall	cont-beef	0.02 ns	-166 *	-12 ***	-0.60 ns	-7.52 ns	-298 ns
		cont-hog	0.04 ns	-246 **	-7.1 **	-0.22 ns	-13.7 *	-209 ns
Lethbridge	spring	manure	ns	ns	**	ns	*	ns
		rate	**	ns	ns	ns	ns	ns
		manure*rate	*	ns	ns	ns	ns	ns
		year	***	***	***	***	***	***
		manure*year	ns	ns	ns	ns	ns	ns
		rate*year	ns	ns	ns	ns	*	*
		manure*rate*year	ns	ns	ns	ns	ns	ns
Lethbridge	fall	manure	*	ns	*	ns	*	ns
		rate	ns	ns	ns	ns	*	ns
		manure*rate	ns	ns	ns	ns	ns	ns
		year	***	***	***	***	***	***
		manure*year	ns	ns	***	ns	***	ns
		rate*year	ns	ns	ns	ns	*	ns
		manure*rate*year	ns	ns	ns	ns	ns	ns
Airdrie	spring	manure	ns	***	ns	ns	**	ns
		rate	ns	***	***	**	***	ns
		manure*rate	ns	ns	ns	*	ns	ns
		year	***	***	***	***	***	***
		manure*year	***	***	**	ns	ns	ns
		rate*year	*	ns	ns	ns	*	ns
		manure*rate*year	ns	ns	ns	ns	ns	ns
Airdrie	fall	manure	ns	ns	**	ns	ns	ns
		rate	ns	***	***	ns	**	ns
		manure*rate	ns	ns	ns	ns	ns	ns
		year	***	***	***	***	***	***
		manure*year	ns	**	*	ns	*	ns
		rate*year	ns	**	ns	ns	**	*
		manure*rate*year	ns	ns	ns	ns	ns	ns

[z] Level of significance: * (P<0.05), ** (P<0.01), and *** (P<0.001). ns = not significant.

Appendix 9. Crop yield and tissue analysis data from the Lethbridge and Airdrie sites.

Table 9.1	crop yield	Lethbridge site	1996 to 2000
Table 9.2	crop yield	Airdrie site	1997 to 2000
Table 9.3	dry matter content	Lethbridge site	1997 to 2000
Table 9.4	dry matter content	Airdrie site	1997 to 2000
Table 9.5	protein content	Lethbridge site	1997 to 2000
Table 9.6	protein content	Airdrie site	1997 to 2000
Table 9.7	ADF content	Lethbridge site	1997 to 2000
Table 9.8	ADF content	Airdrie site	1997 to 2000
Table 9.9	nitrate content	Lethbridge site	1997 to 2000
Table 9.10	nitrate content	Airdrie site	1997 to 2000
Table 9.11	phosphorus content	Lethbridge site	1997 to 2000
Table 9.12	phosphorus content	Airdrie site	1997 to 2000
Table 9.13	calcium content	Lethbridge site	1997 to 2000
Table 9.14	calcium content	Airdrie site	1997 to 2000
Table 9.15	magnesium content	Lethbridge site	1997 to 2000
Table 9.16	magnesium content	Airdrie site	1997 to 2000
Table 9.17	sodium content	Lethbridge site	1997 to 2000
Table 9.18	sodium content	Airdrie site	1997 to 2000
Table 9.19	potassium content	Lethbridge site	1997 to 2000
Table 9.20	potassium content	Airdrie site	1997 to 2000
Table 9.21	copper content	Lethbridge site	1997 to 2000
Table 9.12	copper content	Airdrie site	1997 to 2000
Table 9.23	selenium content	Lethbridge site	1997 to 2000
Table 9.24	selenium content	Airdrie site	1997 to 2000
Table 9.25	sulphur content	Lethbridge site	1997 to 2000
Table 9.26	sulphur content	Airdrie site	1997 to 2000
Table 9.27	zinc content	Lethbridge site	1997 to 2000
Table 9.28	zinc content	Airdrie site	1997 to 2000
Table 9.29	manganese content	Lethbridge site	1997 to 2000
Table 9.30	manganese content	Airdrie site	1997 to 2000
Table 9.31	aluminum content	Lethbridge site	1997 to 2000
Table 9.32	aluminum content	Airdrie site	1997 to 2000
Table 9.33	boron content	Lethbridge site	1997 to 2000
Table 9.34	boron content	Airdrie site	1997 to 2000
Table 9.35	iron content	Lethbridge site	1997 to 2000
Table 9.36	iron content	Airdrie site	1997 to 2000

Table 9.1. Alfalfa yield data (Mg ha^{-1}) from the Lethbridge site from 1996 to 2000.

			Beef manure								Hog manure							
			Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Year	Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1996	1	8.40	8.97	9.59	11.54	7.40	8.16	7.54	9.97	8.94	7.92	8.16	9.88	10.40	8.39	10.04	10.83	8.42
1996	2	6.88	9.12	8.83	7.06	9.38	7.62	8.18	7.35	7.86	8.80	8.64	6.45	8.10	6.92	5.93	7.14	6.61
1996	3	7.50	7.20	7.77	8.52	11.09	6.71	6.65	6.98	7.27	10.95	9.52	7.41	7.36	8.73	7.79	8.87	7.02
1996	4	7.67	6.62	10.37	12.23	8.94	7.28	8.31	6.86	8.18	7.84	6.62	10.65	7.15	7.72	8.59	8.81	5.37
1996	Mean	7.59	8.43	8.73	9.04	9.29	7.49	7.46	8.10	8.02	9.22	8.77	7.91	8.62	8.01	7.92	8.95	7.35
1997	1	5.45	5.42	4.81	5.60	4.30	5.91	5.31	5.56	5.12	5.28	4.67	4.66	5.62	5.72	5.93	5.30	5.67
1997	2	6.03	5.73	6.01	5.05	5.43	5.11	6.18	5.67	5.72	5.36	5.75	5.69	5.68	5.43	5.67	5.20	6.61
1997	3	5.16	5.98	5.57	5.03	5.51	5.66	5.01	5.70	5.76	5.81	5.89	5.17	5.47	6.35	6.22	6.09	5.26
1997	4	5.62	5.15	5.96	5.76	5.65	5.58	5.71	5.82	5.49	5.86	5.26	5.77	5.41	6.04	5.75	5.86	5.28
1997	Mean	5.55	5.71	5.46	5.23	5.08	5.56	5.50	5.65	5.53	5.48	5.44	5.17	5.59	5.83	5.94	5.53	5.85
1998	1	6.68	6.07	7.17	6.41	5.85	6.88	5.57	6.40	6.86	6.57	6.94	6.81	6.96	6.38	6.30	7.40	6.96
1998	2	6.89	8.03	6.96	7.06	6.54	5.67	6.82	6.27	6.22	6.63	7.32	6.67	6.40	6.74	5.65	6.52	6.65
1998	3	5.56	6.50	6.71	6.74	6.54	6.61	5.96	7.28	6.03	6.73	6.89	6.81	6.35	6.99	6.19	6.44	6.83
1998	4	6.13	7.69	6.42	6.50	6.93	6.68	7.15	6.75	6.46	6.30	5.91	6.55	6.51	6.01	6.08	6.35	6.77
1998	Mean	6.37	6.86	6.95	6.74	6.31	6.39	6.12	6.65	6.37	6.64	7.05	6.76	6.57	6.70	6.05	6.79	6.81
1999	1	6.09	6.87	6.69	7.87	7.21	7.48	4.53	8.58	7.17	6.94	7.90	7.84	8.26	8.65	7.71	7.81	8.28
1999	2	6.55	7.40	7.09	7.57	9.78	5.09	7.76	7.56	7.72	7.91	8.12	7.32	7.52	6.75	5.71	8.18	7.61
1999	3	4.85	6.21	8.97	7.88	8.59	6.74	7.60	8.00	8.00	8.31	8.08	7.54	8.96	7.04	8.29	7.29	7.78
1999	4	5.29	7.68	9.08	10.14	8.73	6.81	7.02	8.35	9.08	7.37	6.41	8.05	8.61	6.72	7.86	8.76	6.38
1999	Mean	5.83	6.83	7.58	7.77	8.53	6.44	6.63	8.05	7.63	7.72	8.03	7.57	8.25	7.48	7.24	7.76	7.89
2000	1	7.77	9.93	8.96	8.42	10.00	6.80	10.56	9.21	10.91	9.73	10.25	5.54	8.77	9.37	9.89	9.51	7.02
2000	2	8.50	9.36	10.27	10.25	8.77	10.30	6.25	10.61	11.67	9.95	10.96	11.14	10.65	11.10	10.80	8.64	12.12
2000	3	4.84	10.02	11.33	11.43	11.01	10.79	11.29	12.04	10.64	10.37	13.03	11.36	11.46	9.89	10.48	7.32	10.94
2000	4	6.11	11.20	6.91	10.59	11.41	10.16	10.23	14.47	10.83	10.67	10.79	10.66	12.33	10.56	10.94	10.47	9.73
2000	Mean	7.04	9.77	10.19	10.03	9.93	9.30	9.37	10.62	11.07	10.01	11.41	9.35	10.29	10.12	10.39	8.49	10.03

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 9.2. Timothy yield data (Mg ha^{-1}) from the Airdrie site from 1997 to 2000.

			Beef manure								Hog manure							
			Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Year	Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1997	1	2.42	2.07	1.87	1.88	2.17	1.69	2.20	2.62	2.13	2.45	2.49	2.19	3.05	3.26	1.69	2.07	2.15
1997	2	2.08	2.09	1.86	1.94	2.83	1.75	2.28	2.53	1.57	2.27	2.11	2.44	2.23	2.61	3.02	1.40	1.90
1997	3	2.51	2.20	3.16	2.34	1.85	2.16	3.44	3.89	3.08	2.35	2.10	3.14	2.06	2.51	1.68	1.88	3.24
1997	4	2.69	1.98	2.59	2.06	3.37	2.01	2.01	3.44	2.36	2.06	1.85	3.25	3.72	2.96	1.22	2.73	2.25
1997	Mean	2.34	2.12	2.30	2.05	2.28	1.87	2.64	3.01	2.26	2.36	2.24	2.59	2.45	2.79	2.13	1.79	2.43
1998	1	3.36	6.06	6.91	6.04	5.17	2.70	4.41	7.09	4.45	4.49	3.19	6.59	6.78	5.52	4.79	4.27	4.70
1998	2	3.35	3.15	4.02	5.21	3.81	3.23	2.68	4.04	2.66	2.82	6.25	5.33	4.55	4.42	4.45	3.95	5.80
1998	3	2.26	3.37	4.55	5.31	5.26	2.95	4.00	5.62	5.65	5.49	5.36	4.92	5.46	4.24	6.92	6.45	4.37
1998	4	2.44	3.67	5.12	4.26	4.76	2.75	1.87	3.81	4.71	4.46	5.57	4.90	5.80	3.05	5.31	5.62	5.05
1998	Mean	2.99	4.19	5.16	5.52	4.75	2.96	3.69	5.58	4.25	4.27	4.93	5.61	5.60	4.73	5.39	4.89	4.96
1999	1	3.48	5.10	5.72	5.65	3.34	3.40	4.66	4.82	6.33	4.73	5.01	3.91	4.47	6.00	4.33	4.71	4.26
1999	2	3.74	3.49	5.65	5.43	4.61	3.89	4.67	5.23	5.12	5.90	4.25	4.56	5.31	5.49	5.28	4.23	4.68
1999	3	2.91	4.78	5.48	5.45	3.62	4.96	6.22	6.02	4.97	5.56	5.25	6.00	4.79	5.95	5.00	4.80	5.77
1999	4	3.15	4.76	4.39	5.61	4.16	4.75	4.50	4.97	4.56	5.01	4.18	5.35	5.22	5.65	5.54	4.76	4.67
1999	Mean	3.37	4.46	5.61	5.51	3.86	4.09	5.18	5.36	5.47	5.40	4.84	4.83	4.86	5.81	4.87	4.58	4.91
2000	1	3.49	5.78	1.80	5.57	8.12	3.17	3.76	3.71	4.79	3.85	5.04	6.45	4.80	5.90	4.32	6.74	5.12
2000	2	3.89	5.77	4.22	8.37	8.85	3.25	4.38	3.70	5.45	5.35	6.72	5.94	7.15	7.26	6.07	3.73	3.71
2000	3	2.47	3.91	3.40	4.86	5.41	3.42	3.04	4.10	4.09	3.71	4.34	6.68	6.50	3.53	3.87	5.52	6.35
2000	4	2.83	3.97	9.86	11.90	5.12	2.71	1.99	4.31	3.95	2.97	3.98	5.77	4.75	3.83	2.05	6.80	6.62
2000	Mean	3.28	5.16	3.14	6.26	7.46	3.28	3.73	3.84	4.78	4.30	5.37	6.36	6.15	5.56	4.75	5.33	5.06

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 9.3. Dry matter content (percent) in Alfalfa at the Lethbridge site from 1997 to 2000.

			Beef manure								Hog manure							
			Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Year	Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1997	1	93.9	93.7	93.5	93.7	94.6	94.2	94.2	94.2	94.1	93.6	93.5	93.6	94.2	93.8	93.6	93.6	94.5
1997	2	93.6	94.4	93.2	93.3	94.1	93.7	93.8	93.6	93.8	93.2	93.7	93.4	93.9	94.2	94.1	94.3	93.4
1997	3	93.8	93.8	94.2	94.5	93.8	93.5	93.3	93.9	93.1	92.9	93.4	92.9	94.4	93.1	93.2	93.9	93.8
1997	4	93.2	93.4	94.2	94.0	93.5	93.3	93.7	93.8	93.5	93.6	93.5	93.2	92.9	93.5	93.6	93.6	93.0
1997	Mean	93.6	93.8	93.8	93.9	94.0	93.7	93.7	93.9	93.6	93.3	93.5	93.3	93.8	93.6	93.6	93.8	93.7
1998	1	95.2	96.2	92.6	94.9	93.5	93.5	95.4	95.1	94.8	92.7	94.9	95.4	95.2	94.8	94.6	93.4	93.1
1998	2	92.9	95.5	95.9	89.2	93.1	90.5	93.2	92.2	94.6	94.5	95.2	93.9	95.4	94.8	93.3	91.1	95.7
1998	3	94.6	93.3	93.0	94.7	95.2	93.3	96.8	92.9	95.5	95.2	97.2	95.8	93.2	95.9	95.1	95.5	96.6
1998	4	95.5	92.6	95.9	96.2	94.8	95.3	96.5	95.0	96.4	96.4	95.9	95.8	96.4	95.1	95.2	92.7	90.2
1998	Mean	94.6	94.4	94.3	93.7	94.1	93.1	95.5	93.8	95.3	94.7	95.8	95.2	95.0	95.1	94.5	93.2	93.9
1999	1	90.7	91.0	91.4	91.3	92.3	91.7	91.3	91.8	91.1	91.1	91.4	91.6	91.2	91.1	91.3	91.1	91.8
1999	2	90.9	91.8	91.5	91.4	91.9	91.2	91.7	91.4	91.8	90.9	91.8	91.0	91.1	91.0	91.0	91.5	91.0
1999	3	91.1	91.3	90.7	91.9	91.9	91.2	91.4	91.6	91.8	91.3	91.7	91.5	91.2	91.1	91.6	91.6	91.4
1999	4	90.9	91.3	92.4	91.6	91.7	91.0	92.0	91.8	91.1	91.1	90.9	92.2	91.7	91.4	91.4	92.3	91.9
1999	Mean	90.9	91.3	91.5	91.5	91.9	91.3	91.6	91.6	91.4	91.1	91.4	91.6	91.3	91.1	91.3	91.6	91.5
2000	1	92.4	92.6	92.9	92.9	93.3	92.1	93.0	93.1	93.0	92.7	92.4	92.5	92.9	91.7	92.5	92.8	92.4
2000	2	92.1	93.2	92.9	92.8	93.0	92.4	93.4	93.2	92.6	93.1	93.1	91.7	93.4	92.5	92.0	92.6	93.1
2000	3	92.3	93.2	93.1	93.3	92.8	92.7	92.8	92.7	92.1	92.3	92.5	92.7	92.9	92.3	92.3	92.9	93.0
2000	4	91.9	92.6	92.8	93.0	92.6	92.8	92.6	92.9	92.8	92.6	93.1	93.0	92.7	92.1	92.5	92.2	92.9
2000	Mean	92.2	92.9	92.9	93.0	92.9	92.5	92.9	93.0	92.6	92.7	92.8	92.5	93.0	92.1	92.3	92.6	92.8

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 9.4. Dry matter content (percent) in timothy at the Airdrie site from 1997 to 2000.

			Beef manure								Hog manure							
			Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Year	Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1997	1	92.2	92.8	92.5	91.9	92.2	91.9	92.5	91.5	92.4	92.6	92.4	92.2	92.0	91.7	91.8	92.1	91.6
1997	2	92.5	92.4	92.5	92.7	92.1	92.8	91.9	92.3	91.7	92.2	92.3	92.7	92.6	92.3	92.6	92.8	92.4
1997	3	92.7	92.5	92.5	92.6	92.9	92.7	92.5	92.4	92.7	92.5	92.4	92.3	92.8	92.6	92.3	92.9	92.4
1997	4	92.5	92.4	92.6	92.6	93.0	92.7	92.5	93.1	92.7	92.9	92.7	92.3	92.7	93.0	92.3	92.6	92.6
1997	Mean	92.5	92.5	92.5	92.4	92.5	92.5	92.3	92.3	92.4	92.5	92.4	92.4	92.5	92.4	92.2	92.6	92.2
1998	1	93.5	93.3	93.3	94.2	93.9	92.9	93.4	92.7	94.1	93.5	94.2	93.1	92.4	93.3	94.5	94.3	94.7
1998	2	93.9	93.2	92.5	93.9	93.6	93.7	94.3	93.7	92.7	93.9	93.7	93.8	93.9	93.8	93.1	93.3	93.8
1998	3	93.7	93.7	93.8	94.2	94.3	94.1	92.5	93.8	93.7	92.4	93.2	93.3	93.8	93.3	93.2	93.9	93.8
1998	4	92.7	93.9	93.5	94.2	94.9	94.1	92.6	93.9	93.0	93.5	93.5	93.1	92.5	92.4	93.0	94.1	92.7
1998	Mean	93.5	93.5	93.3	94.1	94.2	93.7	93.2	93.5	93.4	93.3	93.6	93.3	93.1	93.2	93.4	93.9	93.7
1999	1	93.2	93.8	93.0	92.9	93.9	92.9	94.1	92.7	93.3	93.2	93.1	93.5	93.0	93.0	93.5	93.5	93.3
1999	2	92.7	93.2	93.5	93.6	93.6	93.3	93.2	93.5	93.2	92.8	93.5	93.2	93.6	93.5	92.6	92.6	92.9
1999	3	93.0	93.3	93.0	93.4	93.5	92.7	92.9	93.9	93.3	92.9	92.7	92.9	93.0	93.0	93.2	93.1	92.9
1999	4	92.6	94.0	93.0	92.4	93.7	93.0	93.1	93.2	93.2	92.7	93.4	93.5	93.1	92.9	93.0	93.9	93.6
1999	Mean	92.9	93.6	93.1	93.1	93.7	93.0	93.3	93.3	93.2	92.9	93.2	93.3	93.2	93.1	93.1	93.3	93.2
2000	1	94.8	94.2	93.5	94.8	94.6	93.6	93.8	94.4	95.0	94.8	94.9	95.2	95.1	93.3	94.6	94.9	94.3
2000	2	93.8	94.6	93.9	94.6	94.8	93.6	94.4	94.6	94.5	94.0	93.9	93.9	93.9	93.8	94.7	93.7	93.3
2000	3	93.3	93.1	93.3	93.9	93.6	92.9	93.4	94.6	93.6	93.7	93.8	94.0	93.6	93.6	94.6	93.7	94.0
2000	4	93.7	94.1	92.9	93.4	93.3	93.7	93.6	94.8	95.0	94.4	93.4	95.1	94.1	93.4	93.7	94.4	94.4
2000	Mean	93.9	94.0	93.4	94.2	94.1	93.4	93.8	94.6	94.5	94.2	94.0	94.5	94.2	93.5	94.4	94.2	94.0

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 9.5. Protein content (percent) in Alfalfa at the Lethbridge site from 1997 to 2000.

			Beef manure								Hog manure							
			Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Year	Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1997	1	24.3	26.7	23.8	27.7	28.5	21.8	24.8	23.4	27.3	21.7	23.9	28.5	24.4	23.5	26.8	23.7	25.5
1997	2	25.4	26.3	23.9	28.2	28.6	25.0	24.2	27.2	25.4	22.4	25.4	26.5	27.9	22.9	24.4	25.9	24.6
1997	3	25.0	26.1	28.1	25.7	29.2	24.0	25.5	25.7	23.9	24.9	24.4	24.0	26.9	23.7	20.7	24.6	23.8
1997	4	21.9	26.0	22.8	21.1	24.8	24.8	21.6	27.1	21.1	28.8	25.3	20.2	18.0	21.6	21.6	21.3	25.0
1997	Mean	24.2	26.3	24.6	25.7	27.8	23.9	24.0	25.8	24.4	24.4	24.7	24.8	24.3	22.9	23.4	23.9	24.7
1998	1	19.2	21.2	20.9	20.2	17.5	25.2	20.9	23.8	17.6	22.6	19.1	18.3	22.2	22.5	22.4	22.9	21.4
1998	2	20.2	20.6	21.3	22.7	19.8	21.0	21.8	22.2	22.7	21.1	21.0	19.4	23.0	22.5	20.0	20.2	20.1
1998	3	19.5	19.7	21.2	21.3	22.8	17.3	20.4	19.8	17.9	21.1	19.6	17.9	22.9	20.8	22.8	22.8	18.8
1998	4	17.9	20.5	22.8	22.8	21.7	21.9	19.8	21.4	21.9	19.4	18.0	18.7	19.7	21.6	23.3	23.1	20.1
1998	Mean	19.2	20.5	21.5	21.7	20.4	21.3	20.7	21.8	20.0	21.0	19.4	18.6	21.9	21.8	22.1	22.2	20.1
1999	1	24.3	25.5	30.7	26.7	27.1	27.3	27.2	27.2	27.8	28.0	24.8	21.9	24.6	25.1	26.0	25.6	24.2
1999	2	23.3	23.4	27.1	25.8	28.3	27.0	27.1	27.1	25.5	26.3	23.2	26.7	28.5	25.5	25.3	24.0	26.3
1999	3	22.9	26.8	26.3	28.0	23.2	24.5	23.6	28.2	26.9	27.1	24.8	26.4	26.8	25.2	26.7	25.9	22.6
1999	4	23.1	25.3	28.1	28.9	28.8	25.4	27.6	27.8	28.0	26.9	26.9	27.7	25.9	26.3	26.5	25.6	25.8
1999	Mean	23.4	25.2	28.0	27.3	26.8	26.0	26.4	27.6	27.0	27.1	24.9	25.7	26.4	25.5	26.1	25.3	24.7
2000	1	25.9	26.6	26.5	32.2	30.5	26.5	28.0	25.8	32.1	25.6	24.7	29.3	30.1	23.6	26.4	27.6	25.1
2000	2	24.3	28.8	27.2	27.4	26.2	27.8	27.2	28.9	26.5	25.9	27.5	24.6	29.3	25.1	27.1	29.7	24.5
2000	3	23.6	25.6	27.2	26.2	25.7	25.0	27.2	26.8	27.1	24.3	26.8	27.6	25.9	24.0	25.4	27.1	28.3
2000	4	23.6	28.8	27.3	26.2	25.8	25.9	26.7	27.4	28.0	24.1	25.3	25.8	24.6	25.3	25.5	25.0	28.6
2000	Mean	24.4	27.4	27.0	28.0	27.0	26.3	27.3	27.2	28.4	25.0	26.1	26.8	27.5	24.5	26.1	27.3	26.6

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 9.6. Protein content (percent) in timothy at the Airdrie site from 1997 to 2000.

			Beef manure								Hog manure							
			Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Year	Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1997	1	5.8	6.1	6.6	8.6	9.2	5.9	6.2	6.8	5.2	6.8	8.7	9.5	13.3	5.9	5.9	5.7	6.0
1997	2	5.3	6.3	6.8	6.4	8.3	5.6	6.9	6.4	6.2	10.5	9.9	9.4	12.5	5.8	5.2	5.4	7.1
1997	3	5.5	5.8	6.8	7.2	7.2	5.6	6.3	5.9	5.8	7.3	8.7	12.3	11.7	5.6	5.8	4.9	5.8
1997	4	6.6	6.9	6.3	7.6	7.0	5.6	6.0	8.1	6.4	4.9	8.3	10.4	10.4	5.3	5.9	5.0	5.7
1997	Mean	5.8	6.3	6.6	7.4	7.9	5.7	6.3	6.8	5.9	7.4	8.9	10.4	12.0	5.6	5.7	5.2	6.1
1998	1	4.9	6.9	6.9	7.6	7.5	7.7	6.5	7.5	5.7	8.0	9.7	10.8	14.5	5.5	6.5	6.7	7.7
1998	2	5.2	6.6	8.0	8.8	8.0	5.4	5.4	6.2	7.4	8.9	12.2	10.8	14.2	5.3	5.6	5.5	12.2
1998	3	5.5	6.1	6.6	6.6	7.6	5.5	7.6	6.4	6.9	6.9	9.1	14.3	11.6	5.2	5.4	7.6	10.3
1998	4	5.7	6.3	6.2	7.5	8.4	6.2	7.0	5.6	7.6	7.5	10.7	10.8	11.5	6.1	6.3	7.4	10.4
1998	Mean	5.3	6.5	6.9	7.6	7.9	6.2	6.6	6.4	6.9	7.8	10.4	11.7	12.9	5.5	5.9	6.8	10.1
1999	1	5.5	5.2	7.0	9.8	10.2	6.4	5.7	9.2	5.7	10.0	11.8	11.5	12.7	5.6	13.7	10.5	14.3
1999	2	5.4	6.2	4.4	9.3	9.9	4.3	4.8	5.9	6.0	10.1	12.4	11.0	14.0	4.6	6.3	11.9	14.1
1999	3	6.3	6.7	7.0	8.1	12.3	4.9	6.4	6.4	7.9	3.9	10.6	14.4	15.7	3.7	6.2	12.4	10.4
1999	4	5.7	6.8	6.4	6.7	12.4	5.2	6.2	8.8	7.9	5.6	9.9	12.7	12.4	4.8	6.1	10.5	15.5
1999	Mean	5.7	6.2	6.2	8.5	11.2	5.2	5.8	7.6	6.9	7.4	11.2	12.4	13.7	4.7	8.1	11.3	13.6
2000	1	2.2	5.6	6.9	10.1	11.2	5.4	6.6	9.5	5.8	9.2	11.1	10.3	12.2	5.2	8.4	10.0	9.5
2000	2	4.1	7.0	6.9	7.6	13.8	6.1	5.6	6.1	7.9	9.1	10.4	9.9	16.1	5.7	10.9	12.6	15.0
2000	3	4.8	7.1	8.3	9.4	14.4	5.8	6.8	7.8	8.4	6.7	10.4	14.5	10.0	8.1	13.6	10.6	7.2
2000	4	4.3	5.8	9.3	9.3	16.2	6.2	9.0	8.0	10.1	6.6	9.9	10.7	14.2	7.3	13.1	9.4	8.3
2000	Mean	3.9	6.4	7.8	9.1	13.9	5.9	7.0	7.8	8.0	7.9	10.4	11.3	13.1	6.6	11.5	10.6	10.0

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 9.7. Acid detergent fiber (ADF) content (percent) in alfalfa at the Lethbridge site from 1997 to 2000.

			Beef manure								Hog manure							
			Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Year	Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1997	1	35.9	35.9	39.5	35.3	31.3	38.7	38.7	38.0	32.8	41.8	40.2	32.3	38.1	37.4	34.3	38.4	32.4
1997	2	34.1	32.5	39.9	32.0	29.7	35.1	35.8	32.3	34.6	43.1	36.7	38.1	33.4	36.6	34.7	33.7	36.1
1997	3	31.4	33.6	34.2	36.1	32.9	36.8	31.4	32.1	36.5	33.0	39.4	38.4	33.0	34.7	39.8	33.6	37.9
1997	4	37.3	37.0	38.7	44.7	35.0	33.8	41.9	29.4	42.8	33.1	35.1	43.2	50.1	38.4	39.2	42.3	34.6
1997	Mean	34.7	34.7	38.1	37.0	32.2	36.1	36.9	32.9	36.7	37.7	37.8	38.0	38.6	36.8	37.0	37.0	35.2
1998	1	38.0	38.4	40.2	38.3	46.6	33.5	37.3	33.4	44.8	33.9	39.2	42.4	32.1	32.8	35.8	33.6	38.0
1998	2	38.9	35.4	36.4	34.8	41.9	37.5	39.5	34.6	36.0	35.8	38.9	40.6	33.8	34.8	34.9	38.9	35.1
1998	3	37.3	40.7	36.6	36.5	38.2	43.9	36.3	40.0	40.3	40.2	37.9	39.8	35.8	35.3	37.1	35.6	36.6
1998	4	40.2	38.1	37.7	37.9	38.1	37.8	38.8	38.1	38.0	38.2	40.9	40.8	36.7	34.5	34.5	36.7	38.9
1998	Mean	38.6	38.1	37.7	36.9	41.2	38.2	38.0	36.5	39.8	37.0	39.2	40.9	34.6	34.3	35.6	36.2	37.1
1999	1	32.4	33.0	25.8	30.5	30.1	31.5	30.9	31.5	30.5	29.3	31.6	35.0	35.4	34.0	34.1	32.3	33.8
1999	2	31.8	35.4	30.2	31.7	30.2	31.5	33.1	31.9	33.6	31.2	33.1	30.3	30.0	31.6	33.5	34.2	32.6
1999	3	28.8	30.8	32.1	30.6	35.8	34.4	36.1	30.4	31.5	30.1	33.6	31.2	30.8	34.1	30.1	31.8	33.6
1999	4	31.1	34.5	30.3	29.1	32.1	33.1	30.4	31.9	30.1	32.3	30.7	28.6	32.8	31.8	32.7	33.3	30.6
1999	Mean	31.0	33.4	29.6	30.5	32.0	32.6	32.6	31.4	31.4	30.7	32.2	31.3	32.2	32.9	32.6	32.9	32.6
2000	1	31.1	29.6	29.7	26.0	31.0	32.3	35.6	33.0	28.6	33.4	32.7	27.9	27.8	33.2	31.2	28.8	32.3
2000	2	30.2	35.5	30.0	31.3	31.8	30.5	33.4	30.0	32.3	32.7	33.8	33.0	28.6	28.5	30.3	31.3	33.0
2000	3	29.5	34.2	30.6	29.9	35.5	33.7	32.0	31.7	31.0	35.2	28.6	28.7	33.7	33.4	35.0	33.1	29.9
2000	4	31.7	31.8	37.3	34.7	32.3	32.1	30.8	35.2	33.1	36.2	35.7	32.8	35.0	32.0	31.8	33.8	33.8
2000	Mean	30.7	32.8	31.9	30.5	32.6	32.1	32.9	32.5	31.2	34.4	32.7	30.6	31.3	31.8	32.1	31.7	32.2

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 9.8. Acid detergent fiber (ADF) content (percent) in timothy at the Airdrie site from 1997 to 2000.

			Beef manure								Hog manure							
			Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Year	Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1997	1	37.0	40.7	38.2	39.8	36.4	33.6	37.5	34.5	38.5	39.4	40.1	39.9	39.2	36.5	36.9	38.1	35.2
1997	2	39.1	35.7	40.2	41.7	39.4	37.8	35.3	35.9	35.7	38.2	39.2	40.3	37.7	38.6	37.7	36.0	37.6
1997	3	37.1	40.2	39.3	39.6	41.6	37.8	35.4	38.8	36.5	40.0	40.9	37.6	39.5	37.3	34.4	34.8	36.4
1997	4	38.0	37.6	40.4	36.7	40.8	36.3	36.7	37.5	38.5	40.8	39.5	36.8	39.5	36.8	35.7	36.1	38.3
1997	Mean	37.8	38.5	39.5	39.4	39.5	36.4	36.2	36.7	37.3	39.6	39.9	38.6	39.0	37.3	36.2	36.2	36.9
1998	1	37.1	43.9	46.5	48.3	42.0	39.9	44.7	44.8	46.8	48.2	46.1	45.2	41.4	41.2	45.8	48.6	49.4
1998	2	40.7	39.3	45.6	45.9	46.2	41.3	41.4	45.4	47.1	46.6	45.1	46.5	42.5	43.3	46.8	44.6	45.4
1998	3	37.8	42.3	43.9	44.3	47.3	42.4	42.4	45.5	46.5	43.7	42.6	41.1	46.4	43.7	44.1	46.8	46.7
1998	4	37.4	43.8	39.6	45.4	47.4	45.3	40.1	42.5	44.8	44.0	43.8	45.2	43.9	45.8	46.3	48.3	44.1
1998	Mean	38.2	42.3	43.9	46.0	45.7	42.2	42.1	44.5	46.3	45.6	44.4	44.5	43.5	43.5	45.7	47.1	46.4
1999	1	31.1	33.8	39.9	42.7	39.1	31.9	34.9	37.1	43.5	39.5	40.1	39.7	36.9	40.8	36.1	40.2	35.8
1999	2	34.6	35.7	41.2	41.2	38.7	38.2	40.7	43.8	38.8	42.5	37.6	41.6	38.9	40.6	43.0	37.7	41.6
1999	3	32.0	39.2	39.6	43.4	38.9	40.3	39.6	38.7	38.8	42.6	42.0	37.7	39.0	40.9	43.1	38.7	40.3
1999	4	34.9	39.7	37.5	42.1	38.7	41.8	39.7	35.8	41.0	40.9	40.3	36.1	39.9	42.0	40.8	43.0	38.0
1999	Mean	33.1	37.1	39.5	42.3	38.8	38.0	38.7	38.8	40.5	41.4	40.0	38.8	38.7	41.1	40.7	39.9	38.9
2000	1	38.0	36.4	41.8	42.8	35.5	39.6	37.3	39.4	40.0	42.3	38.7	35.7	40.1	43.7	41.4	39.5	45.5
2000	2	39.0	37.8	39.7	39.7	40.1	39.4	38.5	42.6	41.0	41.8	40.2	41.6	29.6	43.5	39.9	36.6	39.6
2000	3	36.2	40.6	37.7	40.1	34.2	42.8	39.6	36.2	40.3	40.7	43.8	36.6	37.8	40.5	39.3	40.8	39.8
2000	4	38.1	37.7	42.8	41.5	36.1	41.4	37.6	36.4	37.1	41.2	42.4	35.5	38.9	40.5	34.8	40.1	38.9
2000	Mean	37.8	38.1	40.5	41.0	36.5	40.8	38.2	38.6	39.6	41.5	41.3	37.3	36.6	42.0	38.8	39.2	40.9

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 9.9. Nitrate content (mg kg^{-1}) in alfalfa at the Lethbridge site from 1997 to 2000.

			Beef manure								Hog manure							
			Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Year	Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1997	1	987	1750	2130	1510	1140	1090	410	990	460	1400	2010	2300	4330	1170	1570	450	1210
1997	2	745	2870	2480	2330	2820	390	1290	1620	910	1330	2820	4680	3370	740	320	260	1560
1997	3	445	740	3220	3380	3640	410	290	920	910	2390	2750	3240	3190	1310	860	2120	750
1997	4	362	1210	2020	4220	3510	290	1260	550	830	1390	1700	3000	5460	880	1240	1080	1270
1997	Mean	635	1642	2462	2860	2777	545	812	1020	777	1627	2320	3305	4087	1025	997	977	1197
1998	1	257	640	950	2320	390	1160	100	1010	3020	430	1630	2240	3840	990	1430	420	2220
1998	2	267	1220	1820	1540	1070	90	1510	840	850	550	1900	650	8810	230	640	170	1990
1998	3	162	580	1630	580	2890	260	280	290	1020	2560	2600	1860	1440	880	1800	2990	550
1998	4	110	750	3770	8480	3720	250	870	580	1690	270	1030	7220	2320	290	980	2260	790
1998	Mean	199	797	2042	3230	2017	440	690	680	1645	952	1790	2992	4102	597	1212	1460	1387
1999	1	450	1970	2480	4670	3180	3300	1070	2180	1990	1200	1000	1710	4890	1910	3450	1970	6870
1999	2	382	1990	1810	2620	5670	1980	4450	2810	3790	770	2070	2200	5070	930	1350	1200	4500
1999	3	355	930	1540	1270	2910	620	1470	1560	2310	2000	2840	1350	2130	3340	2890	4820	1110
1999	4	315	2130	5710	7300	3680	1500	2500	3160	1790	2440	2500	5580	2790	1810	4080	10270	2980
1999	Mean	376	1755	2885	3965	3860	1850	2372	2427	2470	1602	2102	2710	3720	1997	2942	4565	3865
2000	1	177	1090	4770	4430	3370	1560	1480	3210	3200	1950	1660	870	7010	980	1020	380	3520
2000	2	187	2680	2830	6780	10190	2010	5050	3940	4190	1030	1940	5130	7680	1510	1420	490	5190
2000	3	162	3910	5010	5360	7140	2740	4840	4730	4800	4610	3650	2040	7730	2370	2410	4680	1060
2000	4	182	5150	4780	7310	8760	3210	6080	3230	3950	3940	2660	8250	3540	920	2930	2180	1810
2000	Mean	177	3207	4347	5970	7365	2380	4362	3777	4035	2882	2477	4072	6490	1445	1945	1932	2895

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 9.10. Nitrate content (mg kg^{-1}) in timothy at the Airdrie site from 1997 to 2000.

			Beef manure								Hog manure							
			Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Year	Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1997	1	65	110	110	50	50	50	50	50	50	110	1620	2710	1960	50	50	50	50
1997	2	50	50	50	50	50	50	50	50	50	220	1300	1290	1400	50	50	50	50
1997	3	50	50	50	50	110	50	50	50	50	50	220	1950	2800	50	50	50	50
1997	4	92	50	50	50	50	50	50		50	50	320	650	1830	50	50	50	50
1997	Mean	64	65	65	50	65	50	50	50	50	107	865	1650	1997	50	50	50	50
1998	1	50	80	50	50	50	50	50	50	50	170	800	3360	1630	50	50	270	210
1998	2	50	50	50	110	50	50	50	50	50	440	2130	1720	3360	50	50	50	1050
1998	3	52	50	50	50	150	50	50	50	90	50	240	900	2240	50	50	500	1710
1998	4	50	50	50	50	80	50	50	50	400	50	580	1160	1050	50	50	580	850
1998	Mean	51	57	50	65	82	50	50	50	147	177	937	1785	2070	50	50	350	955
1999	1	50	50	50	70	210	50	50	70	50	440	660	1040	3910	50	50	420	330
1999	2	50	50	50	170	240	50	50	50	50	640	420	630	2120	50	50	50	
1999	3	60	50	50	50	660	50	50	50	80	50	560	990	660	50	60	360	110
1999	4	50	70	50	50	480	50	50	50	50	50	140	690	1660	50	50	460	140
1999	Mean	52	55	50	85	397	50	50	55	57	295	445	837	2087	50	52	322	193
2000	1	50	50	80	120	270	50	50	50	50	160	570	650		50	80	490	750
2000	2	60	50	50	410	120	50	50	50	50	190	1710	690	1090	50	190	290	
2000	3	50	50	50	50	410	50	50	50	50	60	530	1150	850	50	100	360	290
2000	4	52	50	50	50	1740	50	50	50	50	50	470	460	1350	50	50	260	1430
2000	Mean	53	50	57	157	635	50	50	50	50	115	820	737	1097	50	105	350	823

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 9.11. Phosphorus content (mg kg^{-1}) in alfalfa at the Lethbridge site from 1997 to 2000.

			Beef manure								Hog manure							
			Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Year	Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1997	1	2700	3300	2900	3300	3200	2700	2800	2700	3100	2900	3000	3500	2900	2800	3000	2800	2800
1997	2	2775	3100	3300	3300	3400	2700	2900	3000	2800	2900	2900	3300	3200	2700	2700	3000	2900
1997	3	2625	2900	3200	2900	3700	2800	2700	2800	3000	2900	3200	3000	2900	2800	2600	2700	2900
1997	4	2600	3400	2600	2900	3100	2700	2600	2800	2700	3500	2900	2600	2600	2500	2600	2800	3000
1997	Mean	2675	3175	3000	3100	3350	2725	2750	2825	2900	3050	3000	3100	2900	2700	2725	2825	2900
1998	1	2575	2800	3000	2800	2900	3100	3200	2800	2700	3000	2700	2500	2800	2700	2800	2900	2900
1998	2	2700	2800	2900	3000	2800	3000	3000	3100	3000	2700	2700	2800	2800	2800	2600	3000	2600
1998	3	2450	2900	3000	2900	3200	2500	2800	2800	2800	3000	2500	2500	2900	2700	3000	2900	2500
1998	4	2325	3000	3300	3100	3200	2800	2900	2900	2900	2600	2700	2700	2600	2700	3000	3000	2900
1998	Mean	2512	2875	3050	2950	3025	2850	2975	2900	2850	2825	2650	2625	2775	2725	2850	2950	2725
1999	1	2950	3200	3600	3000	3500	3800	3700	3700	3300	3100	2600	2700	3300	3300	3400	3300	3000
1999	2	2800	3000	3700	3300	3900	3300	3600	3400	3400	3200	3300	3400	3700	3000	3100	3300	3200
1999	3	2875	3800	3300	3400	3300	3100	3400	3100	3500	3400	3100	3200	3200	3400	3200	3500	2900
1999	4	2850	3100	3900	4000	3600	3100	3500	3700	3600	3300	3200	3700	3500	3500	3400	3400	3000
1999	Mean	2869	3275	3625	3425	3575	3325	3550	3475	3450	3250	3050	3250	3425	3300	3275	3375	3025
2000	1	3100	3300	3500	4000	4100	3600	3700	3600	4200	3100	3000	3900	3600	2900	3300	3500	3100
2000	2	2875	4000	3400	3600	3400	3500	3700	3600	3400	3400	3500	3000	3700	3000	3300	4000	3300
2000	3	2725	3300	3400	3400	3500	3200	3400	3300	3500	3000	3100	3300	3400	3000	3300	3400	3600
2000	4	2825	3600	3800	3600	3400	3300	3400	3800	3600	3000	3300	3200	3300	3000	3300	3400	3700
2000	Mean	2881	3550	3525	3650	3600	3400	3550	3575	3675	3125	3225	3350	3500	2975	3300	3575	3425

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 9.12. Phosphorus content (mg kg^{-1}) in timothy at the Airdrie site from 1997 to 2000.

			Beef manure								Hog manure							
			Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Year	Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1997	1	1600	1900	2100	2400	2200	1400	1900	1800	1500	2200	2300	2400	3200	1600	1500	1400	1600
1997	2	1550	1700	2200	2100	2500	1500	1400	1100	1500	2500	2500	2500	2800	1600	1300	1400	1500
1997	3	1600	1800	2000	1900	2200	1600	1400	1600	1500	2300	2600	2700	3100	1200	1000	1100	1300
1997	4	1600	1700	2100	2000	2300	1500	1400	1700	1300	1700	2300	2100	2500	1300	1500	1500	1500
1997	Mean	1587	1775	2100	2100	2300	1500	1525	1550	1450	2175	2425	2425	2900	1425	1325	1350	1475
1998	1	1275	1900	1800	2300	1900	1700	1700	2100	1800	2400	2200	2400	2900	1500	1900	1800	2000
1998	2	1275	1600	2300	2200	2000	1600	1500	1800	2000	2200	2500	2500	2600	1500	1500	1600	2500
1998	3	1100	1600	1800	2000	2100	1400	2300	1500	2200	1900	2200	2500	2700	1500	1900	2100	2100
1998	4	1175	1700	1500	2000	2100	1500	1500	1400	1900	1800	1900	2300	2300	1800	1800	2000	2200
1998	Mean	1206	1700	1850	2125	2025	1550	1750	1700	1975	2075	2200	2425	2625	1575	1775	1875	2200
1999	1	1100	800	1700	2400	2700	1500	1800	1900	2000	2700	1900	1900	2000	1500	2100	1600	2600
1999	2	950	1600	1200	2600	2100	800	1200	1900	1700	1900	2200	1900	2300	1200	1900	1800	2300
1999	3	875	1900	1400	1400	1400	1800	1500	900	1600	1300	2000	2000	1800	700	1200	2600	2100
1999	4	750	1700	1900	2100	2500	1200	1400	1500	1400	1900	2000	2300	2100	900	1000	2000	1500
1999	Mean	919	1500	1550	2125	2175	1325	1475	1550	1675	1950	2025	2025	2050	1075	1550	2000	2125
2000	1	725	900	1700	2100	1800	1400	1500	1700	1400	1600	1500	1200	2700	1500	1800	1300	2100
2000	2	975	1900	1400	1600	2200	1100	1600	1400	1800	1800	2200	1700	2400	1200	1600	1800	3000
2000	3	875	1200	1500	1900	1600	900	1300	1400	1600	1700	1800	1800	1800	1400	2000	2000	1900
2000	4	900	1400	2100	2000	2100	1100	2000	1100	1100	1400	1800	1300	2200	1600	2000	1600	1500
2000	Mean	869	1350	1675	1900	1925	1125	1600	1400	1475	1625	1825	1500	2275	1425	1850	1675	2125

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 9.13. Calcium content (percent) in alfalfa at the Lethbridge site from 1997 to 2000.

			Beef manure								Hog manure							
			Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Year	Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1997	1	2.22	2.38	2.19	2.37	2.48	2.23	2.31	2.27	2.61	2.06	2.18	2.45	2.41	2.29	2.26	2.18	2.44
1997	2	2.39	2.42	2.24	2.49	2.49	2.37	2.29	2.48	2.50	2.02	2.28	2.25	2.45	2.32	2.51	2.45	2.35
1997	3	2.40	2.42	2.26	2.34	2.42	2.22	2.47	2.28	2.21	2.24	2.12	2.09	2.62	2.20	1.95	2.38	2.22
1997	4	2.14	2.29	2.27	1.89	2.10	2.33	2.08	2.30	2.04	2.48	2.46	1.82	1.67	2.04	2.06	2.14	2.40
1997	Mean	2.29	2.38	2.24	2.27	2.37	2.29	2.29	2.33	2.34	2.20	2.26	2.15	2.29	2.21	2.19	2.29	2.35
1998	1	2.17	2.11	2.08	2.06	1.77	2.14	2.11	2.17	1.80	2.31	2.05	1.94	2.18	2.19	2.13	2.20	2.08
1998	2	2.04	2.13	1.88	2.67	1.99	2.28	2.11	2.34	2.14	2.12	2.10	2.11	2.13	2.19	2.28	2.28	2.24
1998	3	2.16	2.06	2.26	2.07	1.91	1.84	2.13	2.12	2.03	1.94	2.01	1.85	2.30	2.05	1.99	2.05	2.29
1998	4	2.07	2.24	1.85	1.79	1.94	2.04	1.99	2.05	2.04	2.37	2.04	1.76	2.08	2.17	2.10	2.17	2.30
1998	Mean	2.11	2.13	2.02	2.15	1.90	2.07	2.08	2.17	2.00	2.18	2.05	1.91	2.17	2.15	2.12	2.17	2.23
1999	1	2.05	1.89	2.20	2.26	2.05	2.03	1.96	2.18	2.20	2.13	2.14	1.98	1.65	2.06	1.97	1.96	2.00
1999	2	2.10	1.87	2.28	2.26	2.15	2.17	2.18	2.02	2.17	2.05	1.98	2.00	2.13	2.08	2.00	1.95	2.12
1999	3	2.26	2.28	2.28	2.34	1.83	1.95	1.96	2.14	2.24	2.25	1.91	2.13	2.04	2.06	2.30	2.24	2.04
1999	4	2.17	1.95	2.38	2.19	2.16	1.98	2.03	2.07	2.17	2.05	2.09	2.26	1.98	2.28	2.07	2.01	2.13
1999	Mean	2.15	2.00	2.28	2.26	2.05	2.03	2.03	2.10	2.19	2.12	2.03	2.09	1.95	2.12	2.08	2.04	2.07
2000	1	2.43	2.31	2.26	2.52	2.13	2.36	2.49	2.50	2.53	2.17	2.36	2.75	2.69	2.30	2.72	2.73	2.50
2000	2	2.34	2.35	2.46	2.34	2.10	2.55	2.46	2.29	2.30	2.39	2.43	2.46	2.39	2.19	2.46	2.71	2.35
2000	3	2.56	2.26	2.39	2.37	2.17	2.23	2.44	2.13	2.53	2.20	2.56	2.46	2.33	2.22	2.27	2.23	2.44
2000	4	2.43	2.34	2.28	2.21	2.26	2.07	2.44	2.16	2.43	2.09	2.34	2.43	2.30	2.22	2.23	2.34	2.41
2000	Mean	2.44	2.31	2.35	2.36	2.16	2.30	2.46	2.27	2.45	2.21	2.42	2.52	2.43	2.23	2.42	2.50	2.42

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 9.14. Calcium content (percent) in timothy at the Airdrie site from 1997 to 2000.

			Beef manure								Hog manure							
			Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Year	Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1997	1	0.43	0.43	0.36	0.54	0.52	0.37	0.43	0.48	0.39	0.31	0.38	0.44	0.53	0.39	0.47	0.46	0.44
1997	2	0.37	0.40	0.43	0.38	0.45	0.39	0.55	0.61	0.47	0.40	0.36	0.43	0.46	0.40	0.42	0.31	0.55
1997	3	0.38	0.39	0.45	0.40	0.38	0.46	0.44	0.40	0.47	0.38	0.37	0.54	0.49	0.49	0.54	0.31	0.43
1997	4	0.43	0.49	0.43	0.48	0.39	0.44	0.49	0.46	0.46	0.23	0.35	0.42	0.43	0.39	0.42	0.44	0.38
1997	Mean	0.40	0.43	0.42	0.45	0.43	0.41	0.48	0.49	0.45	0.33	0.36	0.46	0.48	0.42	0.46	0.38	0.45
1998	1	0.40	0.68	0.43	0.57	0.40	0.72	0.41	0.39	0.51	0.44	0.54	0.33	0.72	0.39	0.54	0.40	0.44
1998	2	0.39	0.56	0.46	0.56	0.46	0.43	0.39	0.40	0.49	0.42	0.50	0.56	0.71	0.34	0.37	0.38	0.43
1998	3	0.47	0.55	0.52	0.36	0.45	0.50	0.40	0.49	0.40	0.46	0.51	0.67	0.49	0.33	0.29	0.36	0.34
1998	4	0.47	0.63	0.44	0.27	0.53	0.43	0.47	0.14	0.22	0.61	0.52	0.63	0.66	0.34	0.40	0.31	0.45
1998	Mean	0.43	0.60	0.46	0.44	0.46	0.52	0.42	0.35	0.40	0.48	0.52	0.55	0.64	0.35	0.40	0.36	0.41
1999	1	0.45	0.57	0.49	0.74	0.28	0.61	0.25	0.43	0.31	0.30	0.63	0.75	1.39	0.43	1.14	0.72	1.05
1999	2	0.42	0.38	0.35	0.32	0.71	0.00	0.28	0.40	0.29	0.65	0.86	0.81	0.72	0.32	0.45	0.53	1.32
1999	3	0.49	0.16	0.51	0.71	0.72	0.27	0.34	0.87	0.45	0.12	0.80	1.02	0.91	0.41	0.60	0.72	0.63
1999	4	0.40	0.19	0.48	0.49	0.72	0.31	0.40	0.56	0.45	0.60	0.75	1.00	0.77	0.15	0.63	0.72	1.03
1999	Mean	0.44	0.32	0.46	0.56	0.61	0.30	0.32	0.56	0.37	0.42	0.76	0.89	0.95	0.33	0.70	0.67	1.01
2000	1	0.24	0.46	0.65	0.83	0.78	0.50	0.58	0.49	0.53	0.47	0.58	0.55	0.65	0.26	0.44	0.36	0.27
2000	2	0.31	0.87	0.64	0.32	1.13	0.58	0.66	0.47	0.77	0.40	0.52	0.59	0.66	0.33	0.35	0.54	0.91
2000	3	0.48	0.58	0.70	0.76	1.04	0.35	0.63	0.76	0.51	0.64	0.33	0.61	0.39	0.51	0.61	0.56	0.48
2000	4	0.36	0.51	1.06	0.81	0.59	0.44	0.81	0.79	0.79	0.45	0.40	0.68	0.64	0.44	0.78	0.56	0.31
2000	Mean	0.35	0.60	0.76	0.68	0.88	0.47	0.67	0.63	0.65	0.49	0.46	0.61	0.58	0.38	0.54	0.50	0.49

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 9.15. Magnesium content (mg kg^{-1}) in alfalfa at the Lethbridge site from 1997 to 2000.

			Beef manure								Hog manure							
			Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Year	Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1997	1	5446	7357	7090	6612	6662	4436	5295	5179	6490	5550	5818	5933	6931	4472	7041	5304	5099
1997	2	5780	5585	5835	5891	4851	6108	4853	5341	4638	5234	5356	6205	6145	4898	5896	5800	5193
1997	3	4341	5847	5845	4993	5692	5017	3570	5409	4290	3571	4046	5361	6092	3177	3937	3504	6213
1997	4	4025	5233	3387	3813	4017	4373	3608	4519	3563	4793	5060	3171	3285	4108	3072	3311	5400
1997	Mean	4898	6006	5539	5327	5306	4984	4332	5112	4745	4787	5070	5168	5613	4164	4987	4480	5476
1998	1	3989	5125	5001	4937	3651	5109	4324	4860	4005	5015	4549	4021	4963	4181	5394	4780	4870
1998	2	4694	3939	4856	4848	3871	4770	4606	4446	3981	4402	4807	4498	5484	5086	4988	4221	4710
1998	3	4046	4590	4130	3925	4570	3467	4086	4345	4009	3933	4447	3569	4990	3912	4092	4000	4938
1998	4	3858	4663	4175	4020	4406	4924	3816	4564	4575	4656	4603	3158	3842	4883	4333	3985	4565
1998	Mean	4147	4579	4541	4433	4125	4568	4208	4554	4143	4502	4602	3812	4820	4516	4702	4247	4771
1999	1	4059	4805	4837	5113	4307	4203	5416	4468	4519	4548	4239	4586	4761	3930	4930	4427	3734
1999	2	3519	4107	5610	4064	5104	5439	4872	4558	1705	3842	2666	3008	5116	3746	1691	4794	5608
1999	3	4393	6274	4888	5440	4666	4913	4969	5544	5328	4222	4531	5526	5542	4122	4719	4241	6849
1999	4	4840	5569	4030	3619	4478	4729	4321	4419	4914	5158	6240	4124	4993	5608	5061	3822	6679
1999	Mean	4203	5189	4841	4559	4639	4821	4895	4747	4117	4443	4419	4311	5103	4352	4100	4321	5718
2000	1	5239	6431	6719	6653	7528	7418	7619	6548	6086	6738	5392	8131	6724	4478	7064	6404	5133
2000	2	5151	6828	5627	8010	4742	6448	5521	5769	6751	5326	7568	5867	7849	5484	5608	6564	5820
2000	3	4732	5976	5863	6609	6080	5307	4928	6154	6829	4696	4703	5174	6970	4183	5061	5343	6931
2000	4	4839	6146	5240	4693	5896	6075	4739	6431	5874	5766	6584	4804	5141	6087	4931	4428	7836
2000	Mean	4990	6345	5862	6491	6062	6312	5702	6226	6385	5632	6062	5994	6671	5058	5666	5685	6430

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 9.16. Magnesium content (mg kg^{-1}) in timothy at the Airdrie site from 1997 to 2000.

			Beef manure								Hog manure							
			Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Year	Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1997	1	1309	1433	1371	1662	1880	1512	1378	1002	1193	1436	1713	1933	1847	1095	982	1364	1288
1997	2	1251	1439	1074	1317	1612	1201	1956	1202	1067	1614	1510	1877	1865	1242	1481	1351	1069
1997	3	1330	1413	1574	1494	1612	1193	1371	1356	1491	1532	1708	2836	2298	1265	1396	980	1259
1997	4	1448	1438	1562	1817	1574	1470	1538	1559	1321	1352	1599	2428	2464	1537	1318	1462	1193
1997	Mean	1334	1431	1395	1573	1670	1344	1561	1280	1268	1484	1633	2269	2119	1285	1294	1289	1202
1998	1	1284	1568	1377	1696	2068	1486	1393	1162	1346	1375	1741	1892	2200	891	1361	1554	1635
1998	2	956	1653	1334	1387	1598	1063	1299	1720	1609	1628	1848	1946	2520	980	1253	1165	1679
1998	3	1152	1213	1317	1279	1393	1141	1214	1419	1523	1005	1468	2203	1931	952	916	1540	1661
1998	4	1200	1757	1357	1596	1473	1532	1222	1706	1218	1551	1797	2099	1058	1183	1293	1854	
1998	Mean	1148	1548	1346	1490	1633	1306	1282	1502	1424	1390	1714	2035	1927	1002	1206	1528	1658
1999	1	1272	1740	1170	1617	1580	1241	1272	1077	1350	2004	1757	2283	1141	1410	1841	1787	
1999	2	992	1115	1087	1299	1212	1034	1130	1108	1025	1502	1760	1731	1647	873	1259	1645	1988
1999	3	1542	857	984	1082	1614	686	1219	1259	1148	987	1808	2538	1775	1050	1164	1537	1587
1999	4	1039	641	986	1109	1461	1170	1060	1170	1122	819	833	2084	1940	1190	1043	1646	991
1999	Mean	1211	1088	1057	1277	1467	1033	1170	1154	1161	1328	1540	2159	1626	1131	1327	1654	1522
2000	1	1879	2928	3103	3098	3059	2166	2128	2037	2261	1744	2610	3047	2869	1540	1468	2807	1777
2000	2	1470	3548	1820	1990	4969	2317	2958	1400	3340	1381	1635	1646	2985	1335	2511	1863	2577
2000	3	1849	1932	1769	2752	3731	1563	2188	2690	2548	1472	1611	2333	2367	1548	1942	1923	1963
2000	4	2034	1612	4701	3535	2430	1658	2778	3499	3842	1904	1462	3476	2350	1865	2277	2134	2628
2000	Mean	1808	2505	2848	2844	3547	1926	2513	2407	2998	1625	1830	2626	2643	1572	2050	2182	2236

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 9.17. Sodium content (mg kg^{-1}) in alfalfa at the Lethbridge site from 1997 to 2000.

			Beef manure								Hog manure							
			Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Year	Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1997	1	150	252	248	354	155	279	82	214	163	169	265	202	269	123	475	222	171
1997	2	257	246	279	231	86	159	156	281	94	228	256	441	320	192	318	105	159
1997	3	74	151	168	131	148	140	137	221	175	103	254	229	286	97	100	139	387
1997	4	177	303	124	179	196	187	180	167	215	275	347	131	401	273	161	121	271
1997	Mean																	
1998	1	159	205	332	379	204	242	138	211	236	304	251	367	294	166	428	188	289
1998	2	269	214	345	461	281	194	189	272	144	259	332	496	312	330	371	162	254
1998	3	98	312	251	199	345	185	188	267	151	131	219	341	421	139	107	163	297
1998	4	178	237	194	260	270	183	158	177	191	273	314	168	280	321	147	115	307
1998	Mean																	
1999	1	194	399	517	499	412	298	321	374	341	324	533	425	430	235	807	424	338
1999	2	200	230	471	326	419	397	264	347	149	259	223	236	408	310	47	309	436
1999	3	108	291	267	556	308	274	333	351	273	115	200	426	409	122	137	151	607
1999	4	129	273	191	224	298	191	237	294	343	349	370	157	338	404	267	134	560
1999	Mean																	
2000	1	196	312	336	383	545	486	394	418	505	526	257	413	415	322	598	309	434
2000	2	285	446	441	586	364	322	379	572	688	419	599	567	501	368	504	422	532
2000	3	124	506	378	544	513	408	478	727	659	240	375	510	608	179	187	234	576
2000	4	153	355	302	339	394	332	544	459	591	737	437	208	446	559	480	230	660
2000	Mean	150	252	248	354	155	279	82	214	163	169	265	202	269	123	475	222	171

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 9.18. Sodium content (mg kg^{-1}) in timothy at the Airdrie site from 1997 to 2000.

			Beef manure								Hog manure							
			Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Year	Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1997	1	19	18	19	24	19	48	16	19	23	16	22	29	29	20	16	17	22
1997	2	11	14	11	12	20	10	41	12	28	14	17	16	17	10	12	11	9
1997	3	11	15	14	13	15	10	11	12	12	12	13	18	19	13	14	9	11
1997	4	11	12	14	15	15	11	14	12	10	12	13	15	27	10	11	15	10
1997	Mean																	
1998	1	23	20	23	32	38	43	60	24	17	19	40	34	32	15	16	21	26
1998	2	12	64	27	22	21	16	24	74	155	19	34	34	38	13	17	15	33
1998	3	17	13	19	18	25	18	18	31	24	14	19	30	35	12	15	22	30
1998	4	15	31	22	29	33	26	19	48	17	27	26	28	14	17	25	29	
1998	Mean																	
1999	1	18	38	14	27	28	21	52	18	20	17	33	29	80	13	19	34	45
1999	2	9	14	11	28	18	11	11	18	50	21	29	32	20	11	21	34	100
1999	3	23	8	13	22	24	9	14	25	26	11	21	26	37	12	25	37	21
1999	4	12	10	6	25	23	17	56	22	21	11	12	43	70	12	13	45	21
1999	Mean																	
2000	1	38	94	274	216	252	96	25	52	96	21	68	95	106	24	23	66	38
2000	2	24	226	46	121	466	52	68	19	219	29	54	33	204	30	89	46	101
2000	3	39	53	48	146	251	22	53	114	92	39	34	46	66	25	49	45	53
2000	4	34	42	409	234	63	22	67	91	105	29	21	115	46	20	25	53	126
2000	Mean	19	18	19	24	19	48	16	19	23	16	22	29	29	20	16	17	22

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 9.19. Potassium content (percent) in alfalfa at the Lethbridge site from 1997 to 2000.

			Beef manure								Hog manure							
			Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Year	Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1997	1	2.22	2.30	2.29	2.23	2.35	2.08	2.21	2.21	2.29	2.25	2.20	2.28	2.23	2.22	2.21	2.27	2.18
1997	2	2.14	2.09	2.17	2.18	2.16	2.26	2.16	2.08	2.15	2.21	2.17	2.20	2.15	2.17	2.14	2.24	2.28
1997	3	2.33	2.14	2.10	2.10	2.12	2.06	3.05	2.15	3.05	3.16	3.05	2.14	2.15	3.15	3.14	3.01	2.00
1997	4	3.19	3.13	3.21	3.33	3.27	3.19	3.17	3.22	3.09	3.05	3.05	3.29	2.94	3.07	3.13	3.15	3.12
1997	Mean	2.47	2.42	2.44	2.46	2.47	2.40	2.65	2.42	2.64	2.67	2.62	2.48	2.37	2.66	2.66	2.67	2.40
1998	1	2.88	3.04	3.21	3.13	2.87	3.25	2.73	3.22	2.82	2.87	2.71	2.97	2.82	3.31	3.12	3.32	3.32
1998	2	2.89	2.90	3.00	3.20	2.99	3.20	3.11	3.13	2.84	2.97	2.99	2.67	2.99	2.84	2.96	3.19	3.00
1998	3	2.89	2.98	3.01	3.18	2.91	2.82	2.65	3.18	2.92	2.95	3.02	2.59	2.53	2.91	2.90	2.90	2.81
1998	4	2.77	3.10	3.10	2.82	2.84	2.96	2.90	2.81	2.91	2.67	2.77	2.97	2.76	2.96	2.88	3.03	2.58
1998	Mean	2.86	3.00	3.08	3.08	2.90	3.06	2.85	3.08	2.87	2.87	2.87	2.80	2.78	3.00	2.96	3.11	2.93
1999	1	3.37	4.00	3.84	4.24	4.13	3.78	4.30	4.04	4.09	3.49	3.19	3.34	3.77	3.61	3.20	3.32	3.36
1999	2	2.25	2.76	2.82	2.70	2.99	3.33	3.02	2.81	1.74	2.31	1.81	1.87	2.66	2.37	1.28	3.35	2.75
1999	3	2.86	3.05	3.12	3.00	2.97	2.78	2.90	3.17	3.07	3.17	2.80	3.07	2.57	2.92	2.98	2.69	3.30
1999	4	2.99	2.98	2.97	2.36	2.86	2.96	2.81	2.78	2.96	2.85	3.04	2.88	3.11	2.76	2.97	3.00	2.97
1999	Mean	2.87	3.20	3.19	3.08	3.24	3.21	3.26	3.20	2.96	2.95	2.71	2.79	3.03	2.91	2.61	3.09	3.09
2000	1	2.51	2.47	2.76	2.33	3.54	4.57	2.90	4.40	2.73	2.65	2.26	3.24	2.54	3.10	2.44	2.85	3.10
2000	2	2.70	4.11	3.52	4.35	3.73	3.17	3.78	3.69	4.15	3.07	3.56	2.69	3.83	2.76	2.77	3.46	3.13
2000	3	2.92	3.26	3.51	4.02	3.91	3.28	3.01	3.37	4.11	3.38	2.98	3.03	2.95	3.13	3.62	4.12	3.11
2000	4	2.86	4.08	3.26	3.06	4.13	3.79	2.66	4.11	3.76	2.68	2.95	2.81	2.76	2.64	2.62	2.93	3.36
2000	Mean	2.75	3.48	3.26	3.44	3.83	3.70	3.09	3.89	3.69	2.94	2.94	2.94	3.02	2.91	2.86	3.34	3.17

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 9.20. Potassium content (percent) in timothy at the Airdrie site from 1997 to 2000.

			Beef manure								Hog manure							
			Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Year	Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1997	1	1.41	1.55	1.65	1.83	1.80	1.45	1.53	1.25	1.40	1.77	1.85	1.91	2.00	1.33	1.24	1.38	1.39
1997	2	1.39	1.50	1.71	1.86	1.79	1.43	1.49	1.31	1.29	1.78	1.85	1.78	1.93	1.47	1.44	1.32	1.32
1997	3	1.40	1.57	1.61	1.79	1.90	1.34	1.34	1.54	1.27	1.76	1.81	1.98	1.85	1.32	1.26	1.14	1.27
1997	4	1.38	1.54	1.60	1.68	1.81	1.45	1.34	1.48	1.21	1.58	1.73	1.62	1.75	1.31	1.35	1.32	1.29
1997	Mean	1.40	1.54	1.64	1.79	1.83	1.42	1.42	1.39	1.29	1.72	1.81	1.82	1.88	1.36	1.33	1.29	1.32
1998	1	1.28	1.90	1.87	2.13	2.11	1.92	1.88	1.94	1.95	2.09	2.42	2.30	2.38	1.36	1.70	1.84	2.10
1998	2	1.26	1.54	2.14	2.13	1.88	1.61	1.53	1.72	2.04	1.85	2.18	2.36	2.73	1.43	1.41	1.52	2.46
1998	3	1.25	1.65	1.69	1.80	1.78	1.41	1.67	1.63	1.99	1.73	1.79	2.15	2.11	1.47	1.57	1.79	2.01
1998	4	1.25	1.28	1.35	1.99	1.58	1.50	1.48	1.48	1.61	1.55	1.61	1.41	2.07	1.28	1.73	1.79	1.46
1998	Mean	1.26	1.59	1.76	2.01	1.84	1.61	1.64	1.69	1.90	1.80	2.00	2.05	2.32	1.39	1.60	1.73	2.01
1999	1	0.95	1.17	1.38	1.83	1.81	1.30	1.23	1.71	1.57	1.48	1.60	1.61	2.12	1.12	1.82	1.39	1.75
1999	2	0.93	1.26	1.41	1.76	1.74	1.09	1.23	1.55	1.53	1.66	1.74	1.83	1.88	1.17	1.52	1.99	1.96
1999	3	1.04	1.03	1.47	1.71	2.12	1.01	1.39	1.11	1.89	1.11	1.75	1.91	1.70	0.97	1.57	1.90	1.58
1999	4	0.96	0.72	1.51	1.55	2.16	1.35	1.72	1.46	1.56	0.68	0.79	1.75	2.10	1.29	1.10	1.70	0.87
1999	Mean	0.97	1.04	1.44	1.71	1.96	1.19	1.39	1.46	1.64	1.23	1.47	1.78	1.95	1.14	1.50	1.74	1.54
2000	1	1.11	1.37	1.46	1.67	1.73	1.37	1.56	1.70	1.56	1.64	1.55	1.53	1.87	1.32	1.42	1.29	1.71
2000	2	1.17	1.37	1.48	1.71	1.40	1.34	1.32	1.55	1.46	1.60	1.82	1.55	1.68	1.32	1.16	1.86	2.14
2000	3	1.19	1.23	1.40	1.41	1.60	1.18	1.44	1.27	1.49	1.64	1.49	1.95	1.32	1.48	1.52	1.62	1.66
2000	4	1.13	1.38	1.13	1.38	2.00	1.19	1.59	1.34	1.45	1.39	1.46	1.23	1.62	1.22	1.74	1.52	1.53
2000	Mean	1.15	1.34	1.36	1.54	1.68	1.27	1.48	1.46	1.49	1.57	1.58	1.56	1.62	1.34	1.46	1.57	1.76

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 9.21. Copper content (mg kg^{-1}) in alfalfa at the Lethbridge site from 1997 to 2000.

			Beef manure								Hog manure							
			Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Year	Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1997	1	9.75	10.13	10.79	10.31	10.74	8.53	9.18	9.48	11.58	8.47	8.88	9.15	8.84	9.27	10.16	9.84	9.41
1997	2	10.26	9.60	9.91	9.61	8.68	10.31	9.56	10.70	10.15	9.44	9.30	9.84	9.05	10.12	9.88	10.54	10.27
1997	3	9.76	10.70	10.58	9.76	10.27	10.74	8.74	10.64	9.22	8.92	8.78	8.65	8.65	8.87	9.88	8.69	9.43
1997	4	9.88	10.76	8.61	8.31	8.79	10.59	8.80	10.54	9.15	9.17	9.82	7.15	7.03	9.24	8.43	8.88	10.87
1997	Mean	9.91	10.30	9.97	9.50	9.62	10.04	9.07	10.34	10.02	9.00	9.19	8.70	8.39	9.37	9.59	9.49	9.99
1998	1	9.01	8.71	8.56	8.67	7.19	9.75	8.66	9.34	8.13	7.90	7.04	7.20	6.79	8.96	9.20	9.46	9.30
1998	2	10.03	8.11	9.82	8.48	8.06	9.37	9.28	9.15	8.80	8.26	7.89	7.72	7.96	9.34	9.07	8.66	8.58
1998	3	9.11	8.58	7.96	8.04	8.82	8.20	8.27	9.96	8.33	7.99	7.22	6.81	6.79	8.38	9.01	8.39	8.22
1998	4	9.01	8.73	8.63	7.99	7.92	9.20	8.22	8.93	9.02	7.97	7.85	6.34	6.67	9.41	8.77	8.07	8.29
1998	Mean	9.29	8.53	8.74	8.29	8.00	9.13	8.61	9.34	8.57	8.03	7.50	7.02	7.05	9.02	9.01	8.64	8.60
1999	1	12.00	10.14	9.85	9.07	8.98	10.70	12.45	10.73	10.53	10.26	8.32	9.79	7.92	10.72	10.56	10.75	8.79
1999	2	8.62	8.60	9.49	7.84	9.05	10.50	9.81	9.73	4.03	7.60	5.13	5.28	7.42	9.23	3.40	10.50	9.79
1999	3	10.09	11.61	9.20	14.59	9.64	10.85	9.27	10.40	9.29	9.60	8.38	7.87	7.69	9.86	9.98	8.92	10.11
1999	4	11.69	10.49	8.65	7.65	9.85	11.27	9.97	10.74	9.96	9.67	9.23	7.16	10.00	10.80	10.37	8.28	10.81
1999	Mean	10.60	10.21	9.30	9.79	9.38	10.83	10.37	10.40	8.45	9.28	7.76	7.52	8.26	10.15	8.58	9.61	9.87
2000	1	13.59	12.46	13.98	11.51	13.50	16.31	16.52	14.75	14.74	11.85	10.10	18.21	12.34	12.63	13.68	15.43	11.51
2000	2	13.08	13.49	11.99	13.21	12.59	12.55	12.35	14.65	22.04	11.78	12.84	12.98	13.54	13.11	12.42	14.65	11.22
2000	3	12.36	11.26	12.48	13.66	12.87	12.01	11.30	22.45	16.14	11.18	10.41	10.31	10.78	10.75	12.37	12.13	12.19
2000	4	12.56	13.06	12.03	10.52	11.26	11.80	10.88	12.96	12.91	10.36	10.59	9.35	12.66	12.67	11.18	12.67	13.40
2000	Mean	12.90	12.57	12.62	12.22	12.55	13.17	12.76	16.20	16.46	11.29	10.98	12.71	12.33	12.29	12.41	13.72	12.08

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 9.22. Copper content (mg kg^{-1}) in timothy at the Airdrie site from 1997 to 2000.

			Beef manure								Hog manure							
			Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Year	Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1997	1	2.12	2.33	2.64	3.79	3.33	2.95	2.18	2.24	2.07	2.23	3.01	3.18	4.15	2.08	2.17	2.11	2.08
1997	2	2.04	2.45	2.38	1.93	3.23	1.71	3.03	2.42	2.02	2.80	2.51	2.47	3.40	2.14	2.12	1.96	2.52
1997	3	2.29	2.36	3.09	2.79	4.01	2.25	2.59	2.50	2.52	3.11	3.03	4.06	3.49	2.65	2.47	1.91	2.28
1997	4	2.43	2.92	3.09	3.02	3.19	2.77	2.54	2.90	2.41	2.16	2.66	3.75	3.07	2.51	2.32		2.16
1997	Mean	2.22	2.51	2.80	2.88	3.44	2.42	2.58	2.51	2.25	2.57	2.80	3.36	3.53	2.34	2.27	1.99	2.26
1998	1	3.43	3.11	3.80	4.92	5.18	3.37	4.54	4.18	3.29	3.33	4.66	5.78	7.22	2.51	2.87	3.15	3.22
1998	2	2.92	3.71	4.00	3.73	4.40	3.21	3.82	7.88	4.82	4.03	4.73	4.76	5.96	3.04	3.61	2.66	4.29
1998	3	2.83	4.06	3.30	3.48	3.77	3.56	3.81	4.46	4.23	2.88	3.92	5.80	5.02	2.61	2.66	3.80	3.55
1998	4	2.95		5.01	4.47	4.21	6.02	5.35	4.65	5.76	3.41	4.52	4.46	4.30	2.69	2.69	3.51	3.59
1998	Mean	3.03	3.63	4.03	4.15	4.39	4.04	4.38	5.29	4.52	3.41	4.46	5.20	5.62	2.71	2.96	3.28	3.66
1999	1	3.29	4.79	3.71	4.86	4.84	3.30	6.41	4.13	3.71	3.23	4.70	5.04	5.51	3.01	4.57	4.82	4.97
1999	2	2.34	3.12	3.06	3.72	4.24	2.21	3.85	3.62	4.04	3.74	4.38	3.85	5.28	2.53	3.13	4.68	4.87
1999	3	3.33	1.98	2.84	3.24	4.10	1.79	3.46	3.47	3.70	2.31	3.85	5.18	4.09	2.29	3.44	3.86	3.47
1999	4	2.23	1.67	2.52	3.20	3.46	3.38	2.63	2.90	3.28	1.65	1.75	4.04	4.46	2.32	2.29	3.65	2.14
1999	Mean	2.80	2.89	3.03	3.75	4.16	2.67	4.09	3.53	3.68	2.73	3.67	4.53	4.83	2.54	3.36	4.25	3.86
2000	1	4.94	7.70	9.55	9.02	10.69	5.68	5.35	7.05	7.58	4.04	7.90	9.37	9.16	4.06	4.63	10.56	4.50
2000	2	3.53	11.32	6.19	7.62	17.57	7.02	10.52	4.99	13.38	4.29	4.87	4.38	24.10	3.41	13.53	4.89	8.11
2000	3	4.07	5.16	4.79	8.59	10.28	3.32	6.10	8.75	8.95	3.63	4.38	6.92	10.04	3.45	6.73	7.40	5.80
2000	4	4.70	4.65	15.01	11.08	4.69	3.65	6.53	10.06	10.35	4.05	3.90	10.63	6.28	3.15	4.18	5.33	8.04
2000	Mean	4.31	7.21	8.88	9.08	10.81	4.92	7.12	7.71	10.06	4.00	5.26	7.82	12.39	3.52	7.27	7.04	6.61

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 9.23. Selenium content (mg kg^{-1}) in alfalfa at the Lethbridge site from 1997 to 2000.

			Beef manure								Hog manure							
			Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Year	Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1997	1	0.64	1.13	0.86	1.14	0.26	0.79	0.82	0.71	0.65	0.81	0.63	0.37	0.91	0.45	1.37	0.36	0.53
1997	2	0.89	0.89	0.78	0.79	0.29	0.60	0.79	0.97	0.46	0.46	0.35	0.75	0.63	0.69	0.90	0.52	0.57
1997	3	0.78	0.72	0.56	0.22	0.36	0.64	0.28	0.82	0.64	0.62	0.82	0.37	0.73	0.57	1.40	1.52	0.70
1997	4	0.66	0.86	0.77	0.82	0.21	0.79	0.47	1.05	0.34	0.64	0.81	0.44	0.16	1.02	0.41	0.97	0.94
1997	Mean	0.74	0.90	0.74	0.74	0.28	0.70	0.59	0.89	0.52	0.63	0.65	0.48	0.61	0.68	1.02	0.84	0.68
1998	1	0.47	0.44	0.51	0.47	0.11	0.79	0.48	0.63	0.23	0.53	0.40	0.30	0.42	0.33	0.60	0.34	0.47
1998	2	0.77	0.52	0.46	0.56	0.24	0.37	0.61	0.57	0.44	0.28	0.26	0.49	0.65	0.79	0.56	0.26	0.51
1998	3	0.55	0.48	0.41	0.19	0.21	0.41	0.28	0.38	0.44	0.45	0.40	0.20	0.37	0.55	1.12	1.01	0.35
1998	4	0.44	0.34	0.47	0.56	0.18	0.56	0.38	0.49	0.22	0.55	0.66	0.18	0.11	0.91	0.63	0.62	0.57
1998	Mean	0.56	0.44	0.46	0.44	0.18	0.53	0.44	0.52	0.33	0.45	0.43	0.29	0.39	0.64	0.73	0.56	0.47
1999	1	0.47	0.58	0.53	0.49	0.10	0.49	0.60	0.47	0.40	0.64	0.24	0.42	0.44	0.33	0.58	0.33	0.30
1999	2	0.62	0.28	0.36	0.32	0.11	0.38	0.27	0.42	0.07	0.35	0.18	0.39	0.42	0.67	0.46	0.57	0.44
1999	3	0.63	0.44	0.36	0.35	0.14	0.43	0.16	0.38	0.32	0.40	0.41	0.34	0.40	0.45	0.66	0.70	0.34
1999	4	0.58	0.47	0.29	0.32	0.13	0.39	0.24	0.46	0.26	0.40	0.69	0.26	0.34	0.93	0.42	0.47	0.62
1999	Mean	0.57	0.44	0.38	0.37	0.12	0.42	0.32	0.43	0.26	0.45	0.38	0.35	0.40	0.59	0.53	0.52	0.42
2000	1	0.49	0.96	0.39	0.38	0.15	0.33	0.43	0.28	0.30	0.67	0.23	0.28	0.38	0.33	0.66	0.12	0.40
2000	2	1.18	0.61	0.60	0.63	0.28	0.53	0.35	0.77	0.48	0.24	0.41	0.79	0.40	1.18	0.96	0.46	0.54
2000	3	0.68	0.71	0.56	0.25	0.25	0.52	0.20	0.69	0.41	0.58	0.55	0.21	0.55	0.50	0.98	0.78	0.31
2000	4	0.51	0.44	0.56	0.53	0.20	0.60	0.26	0.48	0.23	0.64	0.67	0.40	0.24	0.88	0.69	0.80	0.63
2000	Mean	0.72	0.68	0.53	0.45	0.22	0.49	0.31	0.55	0.35	0.53	0.46	0.42	0.39	0.72	0.82	0.54	0.47

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 9.24. Selenium content (mg kg^{-1}) in timothy at the Airdrie site from 1997 to 2000.

			Beef manure								Hog manure							
			Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Year	Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1997	1	0.16	0.15	0.13	0.07	0.11	0.17	0.25	0.11	0.09	0.12	0.10	0.13	0.08	0.23	0.12	0.17	0.25
1997	2	0.14	0.09	0.02	0.04	0.11	0.11	0.29	0.14	0.16	0.15	0.06	0.14	0.11	0.12	0.16	0.23	0.04
1997	3	0.19	0.09	0.13	0.11	0.09	0.08	0.20	0.14	0.14	0.15	0.13	0.15	0.09	0.25	0.14	0.17	0.14
1997	4	0.17	0.08	0.14	0.07	0.04	0.14	0.12	0.24	0.16	0.11	0.08	0.09	0.12	0.22	0.20	0.20	0.08
1997	Mean	0.17	0.10	0.10	0.07	0.09	0.12	0.21	0.16	0.14	0.13	0.09	0.13	0.10	0.20	0.15	0.19	0.13
1998	1	0.12	0.08	0.07	0.03	0.09	0.09	0.19	0.02	0.05	0.09	0.07	0.08	0.04	0.09	0.05	0.08	0.05
1998	2	0.07	0.15	0.02	0.01	0.05	0.04	0.09	0.12	0.05	0.11	0.03	0.06	0.05	0.04	0.07	0.03	0.02
1998	3	0.12	0.01	0.08	0.06	0.05	0.06	0.07	0.12	0.05	0.07	0.06	0.10	0.06	0.08	0.02	0.04	0.07
1998	4	0.14	0.20	0.07	0.02	0.05	0.13	0.09	0.06	0.09	0.09	0.10	0.03	0.05	0.06	0.03	0.06	0.06
1998	Mean	0.11	0.11	0.06	0.03	0.06	0.08	0.11	0.08	0.06	0.09	0.06	0.07	0.05	0.07	0.04	0.05	0.05
1999	1	0.10	0.08	0.01	0.03	0.02	0.06	0.14	0.02	0.01	0.06	0.04	0.02	0.05	0.04	0.03	0.03	0.05
1999	2	0.06	0.04	0.02	0.03	0.01	0.05	0.03	0.02	0.01	0.04	0.04	0.09	0.01	0.03	0.06	0.09	0.01
1999	3	0.16	0.03	0.04	0.05	0.07	0.01	0.08	0.10	0.03	0.10	0.07	0.10	0.07	0.08	0.04	0.06	0.07
1999	4	0.11	0.01	0.01	0.02	0.01	0.02	0.01	0.03	0.01	0.02	0.02	0.04	0.04	0.03	0.03	0.03	0.03
1999	Mean	0.11	0.04	0.02	0.03	0.03	0.03	0.06	0.04	0.01	0.05	0.04	0.06	0.04	0.04	0.04	0.05	0.04
2000	1	0.16	0.18	0.18	0.18	0.22	0.11	0.06	0.08	0.12	0.08	0.13	0.18	0.07	0.03	0.02	0.20	0.03
2000	2	0.09	0.30	0.05	0.18	0.36	0.16	0.20	0.03	0.25	0.05	0.03	0.05	0.31	0.04	0.26	0.09	0.06
2000	3	0.21	0.10	0.08	0.18	0.36	0.05	0.14	0.18	0.18	0.11	0.05	0.17	0.21	0.08	0.09	0.11	0.10
2000	4	0.28	0.07	0.41	0.30	0.09	0.09	0.19	0.22	0.23	0.07	0.05	0.24	0.10	0.07	0.18	0.07	0.21
2000	Mean	0.18	0.16	0.18	0.21	0.26	0.10	0.15	0.13	0.19	0.08	0.06	0.16	0.17	0.05	0.14	0.12	0.10

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 9.25. Sulphur content (mg kg^{-1}) in alfalfa at the Lethbridge site from 1997 to 2000.

			Beef manure								Hog manure							
			Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Year	Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1997	1	4103	4487	4284	3934	4421	2840	3695	3858	5158	3910	4317	4466	3987	3456	4529	4147	3550
1997	2	3365	3328	3098	3458	3605	3416	3355	3469	3672	3386	3704	3416	3166	3040	3141	3504	3209
1997	3	3261	3158	3410	3385	3632	3068	3977	3254	4190	4267	4047	2930	3060	3878	4178	4122	2953
1997	4	3868	4464	3830	3884	3896	3823	3649	4449	3672	4193	4048	3502	2862	3530	3126	3614	4336
1997	Mean	3649	3859	3656	3665	3889	3287	3669	3758	4173	3939	4029	3579	3269	3476	3744	3847	3512
1998	1	3433	3750	3749	3948	3070	4557	3528	4157	3431	3986	3642	3460	3850	4201	4098	4161	4246
1998	2	3604	3586	3705	3947	3490	3594	4202	3756	4011	3659	3705	3263	3975	3755	3773	3529	3865
1998	3	3432	3235	3228	3414	3720	2655	3420	3437	3222	3845	3609	2971	3630	3623	3878	4029	3459
1998	4	3043	3595	3853	3985	3619	3748	3664	3649	3883	3405	3036	3180	3132	3773	4095	4172	3223
1998	Mean	3378	3542	3634	3824	3475	3639	3704	3750	3637	3724	3498	3219	3647	3838	3961	3973	3698
1999	1	3826	4022	4165	4448	3955	4146	4353	4051	4528	4463	3986	4527	4132	4052	4064	4165	3624
1999	2	2907	3852	4386	3840	4912	4672	4564	4209	1853	3682	2532	2516	4014	3438	1378	3972	4859
1999	3	3570	4556	4342	4425	4037	4031	4078	4769	4592	4318	4168	4284	4186	3974	4293	4155	4518
1999	4	3921	4311	4117	3850	4204	3962	4243	3618	4600	4000	4552	4205	4063	4143	4703	3852	4098
1999	Mean	3556	4185	4253	4141	4277	4203	4310	4162	3893	4116	3810	3883	4099	3902	3610	4036	4275
2000	1	4066	4199	4157	4334	5096	4816	5100	4134	4429	4292	3858	5559	4206	3654	4160	4203	4054
2000	2	3701	5012	3903	5229	4067	4201	4326	4579	4638	3776	4771	4237	4745	4175	4000	4718	3956
2000	3	3950	3827	4047	4706	4132	3719	3876	4363	4410	4101	3194	3910	3803	3690	4131	4660	4142
2000	4	3813	4221	4331	3777	4368	3861	3986	4394	4026	3930	3623	4119	3815	3655	4080	4095	4228
2000	Mean	3882	4315	4110	4512	4416	4149	4322	4368	4376	4025	3862	4456	4142	3794	4093	4419	4095

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 9.26. Sulphur content (mg kg^{-1}) in timothy at the Airdrie site from 1997 to 2000.

			Beef manure								Hog manure							
			Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Year	Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1997	1	956	985	1087	2863	1513	1194	987	890	854	1371	1539	1694	2034	926	862	881	947
1997	2	945	1085	888	996	1251	863	1301	1212	933	1460	1377	1712	2035	901	995	1006	1230
1997	3	994	928	1079	1215	1343	732	1017	907	1032	1313	1451	2390	1832	993	1246	833	993
1997	4	936	994	1028	1124	1119	1048	1069	1377	864	911	1188	1667	1638	870	921	1047	757
1997	Mean	958	998	1021	1550	1307	959	1094	1097	921	1264	1389	1866	1885	923	1006	942	982
1998	1	1159	1171	1206	2016	1314	1142	1111	1154	1023	1480	1799	1767	2224	904	1168	1288	1461
1998	2	986	1311	1560	1418	1366	933	1182	1467	1447	1555	1896	1804	2354	855	1115	965	1907
1998	3	1164	1208	1079	1128	1168	939	1205	1169	1261	973	1438	2271	1890	844	860	1415	1608
1998	4	1286	1328	1371	1238	1497	1351	1403	1087	1329	1253	1618	1699	1896	888	1020	1376	1838
1998	Mean	1148	1255	1304	1450	1336	1091	1225	1219	1265	1315	1688	1885	2091	873	1041	1261	1704
1999	1	973	945	1076	1933	1427	956	1050	1201	1077	1346	1887	1692	2262	901	1780	1485	1752
1999	2	894	1006	1118	1405	1151	862	1037	1252	1066	1483	1664	1610	1925	752	1145	1647	2461
1999	3	1123	744	997	1133	1709	660	1074	893	1181	848	1935	2036	1515	866	1155	1613	1526
1999	4	941	606	890	1017	1678	1111	1146	1078	1167	811	753	1930	2246	876	1069	1749	885
1999	Mean	983	825	1020	1372	1491	897	1077	1106	1123	1122	1560	1817	1987	849	1287	1624	1656
2000	1	1204	1542	1766	1958	1913	1350	1476	1645	1418	1570	1815	1900	2229	1063	1554	1898	1577
2000	2	1230	1792	1476	1420	2283	1541	1677	1372	1886	1466	1585	1607	2286	1200	1919	1822	2505
2000	3	1549	1357	1557	1897	2372	1215	1526	1813	1733	1351	1723	2389	1805	1362	1887	1796	1524
2000	4	1487	1361	2191	1874	2430	1395	2252	1929	1959	1420	1636	1792	2139	1390	2125	1588	1786
2000	Mean	1367	1513	1748	1787	2250	1375	1733	1690	1749	1452	1690	1922	2115	1254	1871	1776	1848

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 9.27. Zinc content (mg kg^{-1}) in alfalfa at the Lethbridge site from 1997 to 2000.

			Beef manure								Hog manure							
			Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Year	Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1997	1	32.4	37.4	48.7	35.5	37.6	27.4	29.4	32.3	41.4	28.2	32.9	37.8	33.8	33.0	37.1	34.1	32.0
1997	2	31.2	31.2	29.0	29.9	28.4	33.1	31.5	32.5	34.3	38.0	34.6	37.0	31.5	32.4	29.1	34.5	32.4
1997	3	30.9	33.3	34.0	33.5	31.6	31.4	30.4	33.8	30.5	24.8	26.9	33.7	31.9	24.5	26.7	24.1	29.8
1997	4	32.6	32.1	24.0	24.1	26.9	31.8	25.4	33.0	27.8	26.2	27.6	23.3	21.7	26.6	21.4	22.9	28.1
1997	Mean	31.8	33.5	33.9	30.7	31.2	30.9	29.2	32.9	33.5	29.3	30.5	33.0	29.7	29.1	28.6	28.9	30.6
1998	1	28.5	32.6	30.2	30.1	24.9	36.9	26.5	33.3	25.1	28.1	27.1	26.5	29.9	32.6	34.2	35.7	35.6
1998	2	29.4	25.1	43.4	28.4	31.9	29.7	30.0	28.2	29.3	29.8	30.1	24.6	30.9	30.4	28.0	27.6	30.5
1998	3	31.7	25.6	24.7	26.3	31.1	22.0	28.3	27.3	26.3	26.5	26.7	21.3	23.1	28.7	28.6	29.0	27.6
1998	4	30.1	28.7	28.4	25.6	27.0	30.3	25.1	29.9	33.0	24.6	22.7	21.3	21.5	34.1	30.5	30.5	23.4
1998	Mean	29.9	28.0	31.7	27.6	28.7	29.7	27.5	29.7	28.4	27.3	26.6	23.4	26.4	31.5	30.3	30.7	29.3
1999	1	39.5	34.3	34.6	35.8	41.0	38.1	39.8	41.6	37.3	36.5	33.8	40.3	35.0	42.0	35.7	40.2	35.4
1999	2	28.3	39.4	42.0	30.2	45.7	38.8	42.4	36.5	15.7	33.5	22.8	21.9	32.9	33.8	31.6	36.0	44.6
1999	3	36.0	45.9	39.0		34.3	38.6	40.1	43.9	41.1	39.0	37.7	38.6	36.7	38.0	42.4	37.3	42.6
1999	4	41.6	40.5	35.3	30.6	37.0	43.6	36.2	33.6	39.5	38.0	38.0	36.7	37.0	44.9	41.3	37.3	37.6
1999	Mean	36.4	40.0	37.7	32.2	39.5	39.8	39.6	38.9	33.4	36.8	33.1	34.4	35.4	39.7	37.7	37.7	40.1
2000	1	37.8	41.2	44.8	43.0	62.4	61.8	76.0	63.3	59.5	36.2	31.6	54.8	44.2	34.8	44.4	41.3	33.8
2000	2	34.0	50.1	48.3	56.9	68.9	36.4	47.7	80.5	177.0	31.9	42.1	38.2	53.4	37.1	37.2	41.7	35.1
2000	3	34.1	31.5	51.0	69.7	58.5	38.4	37.5	159.1	96.0	32.8	52.6	31.4	34.3	30.4	38.9	40.2	36.3
2000	4	35.6	41.8	46.9	50.3	44.3	36.8	36.8	52.0	50.6	28.4	32.2	34.2	39.9	36.5	33.3	36.1	34.3
2000	Mean	35.4	41.2	47.7	55.0	58.6	43.3	49.5	88.7	95.8	32.3	39.6	39.6	42.9	34.7	38.5	39.8	34.9

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 9.28. Zinc content (mg kg^{-1}) in timothy at the Airdrie site from 1997 to 2000.

			Beef manure								Hog manure							
			Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Year	Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1997	1	17.0	18.8	19.3	23.6	23.2	16.3	17.0	19.0	17.1	24.9	25.9	24.9	36.8	15.8	17.9	16.3	14.7
1997	2	18.2	16.0	21.5	22.8	24.6	18.5	18.3	19.4	16.7	26.4	27.8	27.2	33.2	19.4	17.8	15.4	21.0
1997	3	17.4	22.3	20.0	21.8	28.1	18.5	18.5	20.0	20.1	23.4	27.8	31.1	33.6	17.0	19.1	15.9	18.2
1997	4	19.8	20.5	21.4	19.4	27.7	19.8	19.0	16.4	18.9	25.0	27.6	29.7	36.3	20.6	17.4	23.3	23.4
1997	Mean	18.1	19.4	20.5	21.9	25.9	18.3	18.2	18.7	18.2	24.9	27.2	28.2	35.0	18.2	18.0	17.7	19.3
1998	1	24.2	19.0	26.7	37.4	42.5	23.6	30.6	34.6	22.8	32.4	36.4	34.9	57.8	19.6	25.3	24.3	28.4
1998	2	22.3	27.5	33.4	35.7	37.6	26.9	25.4	51.1	34.6	30.2	43.7	40.3	40.7	21.0	27.6	20.7	37.8
1998	3	22.2	25.3	26.4	31.0	26.3	26.1	28.6	33.9	35.3	22.4	31.1	40.0	36.7	19.8	19.4	25.3	30.4
1998	4	24.9		38.6	38.1	34.3	36.0	38.1	34.2	38.7	27.9	31.3	34.4	36.8	22.3	21.9	29.1	35.5
1998	Mean	23.4	23.9	31.3	35.6	35.2	28.1	30.7	38.4	32.8	28.2	35.6	37.4	43.0	20.7	23.5	24.9	33.0
1999	1	23.7	29.5	26.7	39.4	35.0	22.5	39.0	30.7	34.5	27.8	31.3	33.9	34.5	25.4	38.3	29.0	35.9
1999	2	21.6	24.3	27.6	41.0	30.3	27.1	27.1	32.6	30.9	33.2	35.8	35.0	52.9	23.7	33.6	32.9	46.1
1999	3	24.1	21.4	26.0	34.7	35.1	19.0	29.6	30.7	36.8	20.1	34.6	32.1	34.9	22.3	24.3	29.4	28.5
1999	4	21.8	15.5	26.0	31.1	43.6	28.2	25.4	21.7	33.8	17.2	16.0	34.0	52.6	24.0	19.4	31.9	19.3
1999	Mean	22.8	22.7	26.6	36.6	36.0	24.2	30.3	28.9	34.0	24.6	29.4	33.7	43.7	23.9	28.9	30.8	32.4
2000	1	27.8	41.4	65.4	65.9	61.8	34.1	33.0	50.4	48.7	29.0	43.8	46.6	47.5	30.6	36.4	55.6	35.8
2000	2	22.9	71.3	39.0	48.1	111.4	56.7	68.4	34.2	98.0	34.7	44.4	33.1	130.0	29.4		32.8	58.5
2000	3	29.1	46.2	38.8	68.8	73.9	31.1	46.2	61.5	72.1	26.4	35.7	39.2	69.1	33.4	37.6	50.3	35.9
2000	4	34.6	37.0	121.0	87.5	37.6	31.6	52.2	77.4	84.1	33.3	34.4	61.2	51.8	36.0	26.9	40.6	58.7
2000	Mean	28.6	49.0	66.1	67.6	71.2	38.4	50.0	55.9	75.7	30.9	39.6	45.1	74.6	32.4	33.6	44.8	47.2

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 9.29. Manganese content (mg kg^{-1}) in alfalfa at the Lethbridge site from 1997 to 2000.

			Beef manure								Hog manure							
			Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Year	Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1997	1	45.0	52.0	52.2	50.8	61.4	30.2	35.8	40.4	57.2	35.3	46.3	64.6	46.0	38.3	52.6	46.8	48.9
1997	2	43.2	50.1	38.9	45.9	47.4	38.7	37.5	40.5	43.5	45.7	41.7	42.9	43.5	42.2	38.4	51.8	37.5
1997	3	36.8	49.0	46.8	47.3	49.6	43.5	40.5	41.3	32.9	31.8	35.2	41.5	42.1	30.2	33.7	27.0	40.5
1997	4	31.5	39.9	29.7	32.1	31.4	31.5	28.8	36.6	26.6	32.0	32.7	26.5	24.4	26.5	24.2	26.4	34.4
1997	Mean	39.1	47.7	41.9	44.0	47.5	36.0	35.7	39.7	40.1	36.2	39.0	43.9	39.0	34.3	37.2	38.0	40.3
1998	1	29.4	37.5	35.6	40.1	27.6	33.5	31.1	36.3	28.5	32.5	31.4	28.5	33.0	33.4	35.1	35.7	32.4
1998	2	29.7	30.8	37.7	36.8	34.3	29.0	33.4	31.9	30.7	31.4	29.9	27.9	29.5	31.5	33.3	31.1	32.2
1998	3	29.7	32.4	29.1	32.0	37.2	22.3	31.7	26.9	29.0	29.8	28.8	22.8	28.8	27.4	26.8	26.3	26.8
1998	4	26.7	32.8	33.8	30.3	32.8	29.2	29.3	36.4	33.1	27.5	22.0	21.8	26.2	32.7	31.1	29.7	24.4
1998	Mean	28.9	33.4	34.1	34.8	33.0	28.5	31.4	32.9	30.3	30.3	28.0	25.2	29.4	31.3	31.6	30.7	29.0
1999	1	33.7	34.9	35.9	38.6	43.3	32.8	43.5	37.4	37.4	36.6	34.7	39.8	35.6	33.7	33.0	37.2	28.1
1999	2	25.5	35.5	37.6	31.1	47.9	38.9	40.1	36.8	14.5	30.6	20.9	22.3	32.2	33.3	64.1	33.2	41.0
1999	3	33.2	48.8	39.3	66.2	35.0	41.5	35.3	43.8	38.4	36.7	33.8	37.6	36.0	32.3	34.0	32.1	40.6
1999	4	36.1	37.0	35.0	30.1	35.1	32.3	36.8	27.7	39.6	34.4	39.1	35.1	38.1	40.2	36.4	36.2	49.5
1999	Mean	32.1	39.1	37.0	41.5	40.3	36.4	38.9	36.4	32.5	34.6	32.2	33.7	35.5	34.9	41.9	34.7	39.8
2000	1	48.9	50.3	58.0	59.5	92.9	62.6	76.6	68.0	68.6	47.0	46.8	111.0	72.4	39.8	58.8	70.4	40.1
2000	2	42.1	58.1	42.6	62.4	63.3	41.5	62.9	72.9	112.5	47.9	61.6	52.0	79.9	49.5	39.1	62.8	48.1
2000	3	50.1	40.7	51.2	66.6	63.1	40.7	44.6	93.5	76.0	41.0	50.5	47.5	50.1	38.0	40.1	41.8	50.6
2000	4	49.7	49.9	51.1	52.4	49.5	35.6	44.1	50.6	61.8	33.4	46.2	59.2	56.4	40.3	40.8	49.7	49.8
2000	Mean	47.7	49.8	50.7	60.2	67.2	45.1	57.1	71.2	79.7	42.3	51.3	67.4	64.7	41.9	44.7	56.2	47.2

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 9.30. Manganese content (mg kg^{-1}) in timothy at the Airdrie site from 1997 to 2000.

			Beef manure								Hog manure							
			Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Year	Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1997	1	37.2	46.0	50.2	32.9	44.0	32.3	27.2	36.9	32.1	28.8	66.1	72.6	63.1	27.3	30.0	44.3	24.6
1997	2	34.6	28.7	33.6	42.9	48.1	25.3	34.4	26.7	28.3	49.0	44.9	49.9	64.7	50.5	27.8	40.4	28.4
1997	3	31.8	30.9	43.8	42.3	63.5	22.6	26.1	29.7	25.9	36.4	45.1	85.8	74.1	25.2	47.3	24.1	38.4
1997	4	31.0	28.6	34.4	31.4	39.1	30.8	36.4	43.8	28.4	37.9	50.1	70.8	68.3	33.4	42.7	32.0	24.4
1997	Mean	33.7	33.6	40.5	37.4	48.7	27.8	31.0	34.2	28.7	38.1	51.5	69.8	67.6	34.1	37.0	35.2	29.0
1998	1	53.4	53.9	56.1	45.8	97.2	38.8	48.1	35.0	42.2	42.5	84.8	94.4	104.3	42.8	37.8	45.0	40.0
1998	2	44.9	64.9	47.2	59.9	61.5	33.9	46.8	73.1	48.8	58.1	68.0	75.3	96.4	43.9	49.5	36.9	44.1
1998	3	43.3	31.8	41.0	49.5	65.5	34.2	43.7	52.5	37.4	29.0	52.0	91.3	74.7	24.4	21.2	39.3	44.7
1998	4	35.5		65.1	45.0	50.6	66.4	95.9	41.0	96.5	47.4	77.3	73.2	89.5	27.9	40.7	45.2	44.0
1998	Mean	44.3	50.2	52.3	50.1	68.7	43.3	58.6	50.4	56.2	44.2	70.5	83.6	91.3	34.7	37.3	41.6	43.2
1999	1	49.0		49.9	50.2	45.1	43.8		52.0	44.3	46.7	86.0	91.4	91.1	41.8	50.7	98.7	62.5
1999	2	50.3	34.1	38.3	57.0	41.4	37.1	37.7	42.4	37.9	80.1	62.3	65.6	130.8	46.0	52.3	61.1	89.3
1999	3	52.5	23.7	36.3	35.2	67.6	24.5	48.2	65.5	45.0	36.1	80.1	99.2	115.0	42.3	54.5	59.6	55.8
1999	4	39.9	20.8	24.6	35.9	53.0	38.6	31.7	47.3	37.2	22.4	39.8	84.6	117.4	51.3	46.8	64.5	46.2
1999	Mean	47.9	26.2	37.3	44.6	51.8	36.0	39.2	51.8	41.1	46.3	67.0	85.2	113.6	45.3	51.1	71.0	63.5
2000	1	96.6	140.4	109.8	103.3	137.1	47.9	56.9	72.1	105.6	61.4	162.4	197.3	149.2	47.3	56.0	190.5	83.2
2000	2	51.9	130.3	60.4	193.2	191.8	85.7	116.1	43.3	119.6	68.9	107.3	81.0	264.6	74.1	198.6	71.0	174.2
2000	3	80.8	54.9	59.0	109.3	138.9	44.0	88.2	153.0	95.3	51.0	90.3	109.8	283.7	57.1	91.7	107.1	103.0
2000	4	103.1	76.8	198.6	133.3	84.1	41.5	78.3	146.8	141.6	77.0	64.0	333.0	174.4	62.8	67.9	112.1	228.3
2000	Mean	83.1	100.6	106.9	134.8	138.0	54.8	84.8	103.8	115.5	64.6	106.0	180.3	217.9	60.3	103.5	120.2	147.2

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 9.31. Aluminum content (mg kg^{-1}) in alfalfa at the Lethbridge site from 1997 to 2000.

			Beef manure								Hog manure							
			Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Year	Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1997	1	145	125	126	344	268	183	114	139	149	116	139	112	139	153	162	129	136
1997	2	202	132	146	160	193	150	132	245	191	129	185	185	380	179	298	242	
1997	3	153	165	159	262	144	183	154	147	147	153	225	129	237	152	187	140	157
1997	4	116	133	104	267	80	145	110	127	101	125	160	222	91	99	108	131	113
1997	Mean	154	139	134	258	171	165	128	165	147	131	177	162	212	146	189	161	135
1998	1	103	110	121	125	97	172	106	157	122	171	157	137	100	118	100	114	120
1998	2	121	90	87	105	115	117	93	161	126	155	134	119	129	158	281		
1998	3	126	103	94	117	132	77	121	120	152	145	165	129	106	122	107	110	103
1998	4	107	120	105	78	108	113	99	97	148	141	97	102	104	134	110	113	134
1998	Mean	114	106	102	106	113	120	105	134	137	153	138	122	110	133	150	112	119
1999	1	125	109	105	101	325	111	135	210	103	131	177	192	173	132	150	129	130
1999	2	90	90	80	70	184	129	90	79	37	130	74	76	78	105	145	83	
1999	3	119	117	108	178	82	86	107	98	131	117	130	98	89	95	101	118	
1999	4	131	84	111	86	103	82	92	79	87	88	105	106	150	122	94	93	168
1999	Mean	116	100	101	109	174	102	106	117	90	117	122	118	123	114	123	106	149
2000	1	333	510	503	580	1603	388	716	640	513	576	378	1462	644	302	981	509	280
2000	2	670	507	442	534	995	377	436	636	1711	791	635	1248	1049	795	402	867	1106
2000	3	824	267	793	909	831	342	292	1693	957	828	1038	646	550	714	472	716	434
2000	4	862	323	757	729	527	289	374	578	553	401	735	874	1431	769	772	1297	551
2000	Mean	672	402	624	688	989	349	455	887	934	649	697	1058	919	645	657	847	593

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 9.32. Aluminum content (mg kg^{-1}) in timothy at the Airdrie site from 1997 to 2000.

			Beef manure								Hog manure							
			Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Year	Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1997	1	107	125	85	66	144	105	125	96	75	86	152	93	93	63	74	118	91
1997	2	89	96	37	67	137	82	264	116	54	41	35	56	54	56	110	72	54
1997	3	86	94	150	55	58	60	76	78	98	42	52	102	76	94	123	43	117
1997	4	84	72	101	86	70	84	120	98	109	101	49	48	63	114	55	102	67
1997	Mean	92	97	93	69	102	83	146	97	84	68	72	75	72	82	91	84	82
1998	1	262	141	356	431	2454	194	570	234	173	101	332	588	219	186	98	126	100
1998	2	162	675	212	200	357	231	285	1260	220	85	243	143	234	112	557	200	124
1998	3	216	107	132	193	302	326	185	564	237	72	174	455	269	67	71	169	99
1998	4	196	1004	297	172	929	1069	443	2527	121	676	86	129	82	66	166	108	
1998	Mean	209	482	249	249	1011	455	371	1146	188	234	209	329	201	108	223	151	108
1999	1	269		198	242	379	329	2561	157	232	156	264	320	380	141	171	685	168
1999	2	164	134	193	575	100	224	147	203	134	261	194	279	160	209	467	566	194
1999	3	230	82	103	151	112	176	400	1342	219	128	149	475	1473	128	181	124	156
1999	4	377	269	119	249	122	484	96	390	148	134	450	118	110	342	139	350	705
1999	Mean	260	162	153	304	178	303	801	523	183	170	264	298	531	205	240	431	306
2000	1	1610	2561	1542	1585	2590	752	990	814	1800	352	2491	3014	1993	601	257	2512	373
2000	2	536	2551	671	5098	3000	1813	1994	287	1572	349	711	561	3130	541	4000	600	1211
2000	3	1505	791	592	1700	2271	553	1716	4300	1628	294	368	976	6122	275	1775	1183	2342
2000	4	2335	1831	4122	2872	674	509	1458	4096	4139	1545	453	9286	1371	258	345	2704	6363
2000	Mean	1496	1934	1732	2814	2134	907	1540	2374	2285	635	1006	3459	3154	419	1594	1750	2572

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 9.33. Boron content (mg kg^{-1}) in alfalfa at the Lethbridge site from 1997 to 2000.

			Beef manure								Hog manure							
			Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Year	Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1997	1	62.5	61.7	58.9	58.8	67.7	53.1	54.1	61.2	61.4	53.1	59.6	70.8	59.1	60.9	68.5	62.5	57.7
1997	2	56.8	53.3	53.9	53.6	58.9	58.0	57.3	56.7	58.0	58.0	56.4	51.4	53.2	47.5	52.4	72.6	53.2
1997	3	55.2	49.7	51.0	50.9	55.6	51.6	51.3	51.0	49.3	43.7	46.1	47.7	50.9	43.1	46.8	46.4	56.2
1997	4	44.8	47.1	39.0	43.6	45.4	42.8	40.9	47.5	42.1	39.5	43.3	36.2	34.9	43.5	34.8	38.3	50.8
1997	Mean	54.9	53.0	50.7	51.7	56.9	51.4	50.9	54.1	52.7	48.6	51.4	51.5	49.5	48.7	50.6	54.9	54.5
1998	1	47.2	45.8	45.9	47.0	40.3	58.3	42.8	52.2	42.7	47.3	44.5	44.2	47.9	53.9	47.4	52.3	52.3
1998	2	47.4	40.9	43.1	43.6	42.0	44.2	51.9	43.8	45.8	47.8	44.4	40.6	45.0	45.5	40.4	52.0	46.0
1998	3	49.0	38.2	38.1	44.8	44.5	34.1	43.1	41.7	39.3	46.7	43.3	35.2	40.2	44.8	46.5	46.3	42.8
1998	4	42.3	38.8	46.0	43.9	41.4	44.1	41.8	39.8	43.6	39.2	35.2	36.0	39.3	46.6	44.8	46.3	38.4
1998	Mean	46.4	40.9	43.3	44.9	42.1	45.2	44.9	44.4	42.8	45.3	41.9	39.0	43.1	47.7	44.8	49.2	44.9
1999	1	49.3	42.7	48.7	51.5	50.8	45.7	49.0	46.5	51.5	50.3	50.8	53.0	50.1	44.0	50.2	49.1	43.2
1999	2	36.8	40.6	48.7	43.2	48.9	51.1	47.6	43.8	19.6	42.3	27.8	27.6	44.1	39.0	5.3	46.9	52.9
1999	3	49.0	48.1	45.2	46.5	46.5	45.3	44.4	50.1	52.9	45.4	46.4	48.3	44.2	43.8	46.2	47.3	55.1
1999	4	54.3	47.1	42.6	38.9	45.0	46.9	42.4	39.0	47.8	42.6	49.0	42.1	48.9	45.7	48.0	36.2	48.8
1999	Mean	47.3	44.6	46.3	45.1	47.8	47.2	45.8	44.9	42.9	45.2	43.5	42.7	46.8	43.1	37.4	44.9	50.0
2000	1	67.4	53.8	52.4	56.3	63.0	64.5	63.9	56.9	59.9	60.4	56.6	70.0	55.5	54.5	55.6	62.1	57.6
2000	2	57.7	62.8	48.8	61.1	39.8	51.2	47.1	52.6	50.7	55.9	67.2	47.6	56.8	52.4	48.0	61.7	49.9
2000	3	66.5	48.9	47.5	55.7	51.7	45.5	45.5	38.6	56.8	52.9	41.6	54.6	48.8	48.4	57.0	54.8	62.5
2000	4	62.4	46.0	47.5	43.7	52.0	52.0	45.9	50.2	54.7	46.6	48.6	47.4	52.4	48.9	51.0	54.3	57.8
2000	Mean	63.5	52.9	49.0	54.2	51.6	53.3	50.6	49.6	55.5	53.9	53.5	54.9	53.4	51.1	52.9	58.2	56.9

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 9.34. Boron content (mg kg^{-1}) in timothy at the Airdrie site from 1997 to 2000.

			Beef manure								Hog manure							
			Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Year	Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1997	1	7.4	6.5	6.4	8.1	8.0	10.7	7.6	5.6	7.0	6.3	6.0	7.3	7.7	6.2	5.3	5.9	8.3
1997	2	6.0	7.4	4.8	4.5	6.9	4.9	13.2	7.0	6.8	6.3	4.1	5.9	6.4	5.5	6.9	5.9	6.3
1997	3	7.0	7.2	6.9	6.7	5.9	6.5	6.5	7.2	8.1	5.4	6.2	8.3	7.7	7.8	8.7	5.2	7.5
1997	4	6.4	8.1	6.2	8.4	6.2	7.7	9.1	6.6	7.6	5.5	6.5	5.9	6.4	7.3	7.1	7.0	6.0
1997	Mean	6.7	7.3	6.1	6.9	6.8	7.4	9.1	6.6	7.4	5.9	5.7	6.8	7.1	6.7	7.0	6.0	7.0
1998	1	8.0	6.8	6.4	7.8	8.6	9.2	7.0	6.1	6.3	6.4	7.3	6.2	8.0	6.1	8.1	7.0	7.4
1998	2	5.6	8.2	6.6	6.6	6.1	5.2	7.2	7.8	6.1	6.4	6.5	6.4	7.7	5.1	6.8	5.3	7.0
1998	3	6.8	5.4	5.7	4.4	5.1	4.4	5.0	5.2	5.6	5.2	6.0	7.1	6.8	4.6	4.2	5.5	5.7
1998	4	7.4	10.5	6.4	5.5	6.9	6.8	7.1	5.9	8.8	6.0	7.0	5.5	6.6	5.0	6.4	6.0	6.7
1998	Mean	7.0	7.7	6.3	6.1	6.7	6.4	6.6	6.2	6.7	6.0	6.7	6.3	7.3	5.2	6.4	6.0	6.7
1999	1	5.0	6.8	4.1	5.5	4.3	5.6	8.0	3.9	3.5	3.7	4.5	4.8	8.8	3.6	4.4	4.7	4.6
1999	2	4.5	3.6	3.9	4.7	3.5	3.9	3.6	4.1	4.1	4.8	4.0	4.4	4.1	3.8	4.5	4.9	8.1
1999	3	6.2	2.7	3.4	4.0	3.8	3.0	4.0	4.9	3.6	4.0	5.0	4.9	5.4	4.5	4.4	4.5	4.5
1999	4	5.0	2.1	2.8	3.5	5.5	4.1	4.7	3.8	4.4	4.3	2.6	6.6	7.0	4.9	5.3	5.0	3.2
1999	Mean	5.2	3.8	3.5	4.4	4.3	4.1	5.1	4.2	3.9	4.2	4.0	5.2	6.3	4.2	4.7	4.8	5.1
2000	1	8.8	8.2	7.3	12.3	7.7	10.6	9.1	8.8	7.8	7.0	8.6	9.5	8.7	7.6	7.7	9.8	6.5
2000	2	7.4	8.6	8.6	8.9	9.6	7.1	9.5	7.7	8.1	6.6	5.7	5.6	10.5	6.9	9.8	6.2	10.5
2000	3	9.0	7.3	7.6	7.5	6.6	7.6	8.7	9.6	8.2	7.9	6.2	6.6	10.0	7.7	8.2	9.2	7.3
2000	4	8.5	6.3	9.7	7.5	6.3	7.4	8.0	9.9	9.1	6.6	5.8	14.1	9.8	8.5	6.6	6.6	8.9
2000	Mean	8.4	7.6	8.3	9.1	7.6	8.1	8.8	9.0	8.3	7.0	6.6	9.0	9.7	7.7	8.1	8.0	8.3

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 9.35. Iron content (mg kg^{-1}) in alfalfa at the Lethbridge site from 1997 to 2000.

			Beef manure								Hog manure							
			Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Year	Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1997	1	266	200	204	355		230	248	189	265	182	233	409	210	201	236	200	212
1997	2	270		179	300	248	312	209	195	332	280	214	277	249	420	315	548	295
1997	3	230	268	252	351	313	264	188	247	205	186	241	225	330	209	217	164	193
1997	4	186	249	145	250	152	211	171	225	168	206	217	237	142	139	138	155	203
1997	Mean	238	239	195	314	238	254	204	214	243	214	226	287	233	242	227	267	226
1998	1	147	150	151	151	167	204	145	194	139	195	181	157	153	156	142	173	160
1998	2	145	124		122	293	145	156	150	140	179	160	163	157	148	174	225	263
1998	3	144	142	134	166	161	114	145	164	166	184	178	148	136	152	142	130	133
1998	4	130	157	146	130		156	148	147	179	163	122	129	124	164	157	170	137
1998	Mean	141	143	144	142	207	155	149	164	156	180	160	149	143	155	154	175	173
1999	1	194	152	181	138	457	168	233	200	190	249	212	301	191	178	166	200	135
1999	2	116	155	150		226	198	167	148	60	178	93	88	136	140		186	160
1999	3	158	167	181	896	214	171	152	181	200	188	168	204	157	128	142	163	180
1999	4	162	230	187	129	150	135	169	112	157	125	178	145	183	177	150	147	257
1999	Mean	157	176	175	388	262	168	180	160	152	185	163	185	167	156	153	174	183
2000	1	295	390	395	479	1457	406	599	532	429	440	305	1069	488	254	679	409	268
2000	2	478	440	350	469	768	324	374	534	1411	561	490	844	792	553	348	665	797
2000	3	567	232	645	735	688	286	254	1254	767	576	725	460	406	505	376	537	340
2000	4	593	281	573	569	441	255	300	454	460	310	513	595	979	529	528	862	418
2000	Mean	483	336	491	563	839	318	382	694	767	472	508	742	666	460	483	618	456

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Table 9.36. Iron content (mg kg^{-1}) in timothy at the Airdrie site from 1997 to 2000.

			Beef manure								Hog manure							
			Spring application[y]				Fall application[y]				Spring application[x]				Fall application[x]			
Year	Rep	Control[z]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1997	1	132	165	130	100	158	257	146	146	89	117	190	122	189	134	102	139	181
1997	2	120	117	84	90	397	114		153	103	83	67	93	121	85	148	96	99
1997	3	119	113	171	83	89	81	115	97	156	108	95	158	127	138	242	112	133
1997	4	106	95		230	99	107	174	126	135	109	81	112	105	149	101	325	95
1997	Mean	119	123	128	126	186	140	145	131	121	104	108	121	136	127	148	168	127
1998	1	261	156	347	424		213	478	230	176	140	366	518	257	186	126	156	142
1998	2	164	553	217	260	368	227	273		279	118	255	182	238	129	483	177	149
1998	3	197	105	152	208	286	283	178	426	238	78	171	372	240	88	71	167	127
1998	4	200		901	307	186			405		145	497	108	143	83	70	172	140
1998	Mean	205	271	404	300	280	241	310	354	231	120	322	295	220	122	188	168	140
1999	1	284		274	352	533	329		216	287	229	369	404	361	211	233	673	255
1999	2	173	142	218	499	139	204	188	250	162	296	216	282	214	202	504	748	240
1999	3	263	99	115	170	147	155	332	1403	217	169	225	422	1723	151	188	165	186
1999	4	333	226	131	237	160	432	116	312	168	132	370	155	143	305	149	301	579
1999	Mean	263	156	185	315	245	280	212	545	209	207	295	316	610	217	269	472	315
2000	1	1918	2727	1533	1593	2856	691	868	747	1820	390	2673	4247	1809	515	273	3086	393
2000	2	530	2720	619	4421	4265	1681	2197	519	1753	358	585	510	4664	477	3850	521	1008
2000	3	1306	722	516	1554	2084	498	1501	4044	1618	269	373	818	6224	293	1392	1043	2161
2000	4	2297	1429	4098	2753	679	436	1241	3874	4112	1171	822	10526	1144	261	312	2231	5883
2000	Mean	1513	1900	1692	2580	2471	827	1452	2296	2326	547	1113	4025	3460	387	1457	1720	2361

[z] Control: No manure application; each replicate value is a mean of four control plots.

[y] Solid beef manure application rates: 1 = 31 Mg ha^{-1}, 2 = 61 Mg ha^{-1}, 3 = 92 Mg ha^{-1}, and 4 = 123 Mg ha^{-1} (wet-weight basis).

[x] Liquid hog manure application rates: 1 = 42 Mg ha^{-1}, 2 = 84 Mg ha^{-1}, 3 = 126 Mg ha^{-1}, and 4 = 168 Mg ha^{-1} (wet-weight basis).

Appendix 10. List of publications arising from the project.

Olson, B.M. and Papworth, L. 1999. Application of manure on forages in southern Alberta. Pages 410-416 *in* Manure management '99 conference proceedings. Saskatoon, Saskatchewan. June 22-25, 1999.

Olson, B.M. and Papworth, L. Manure application on forages in southern Alberta. *In* 39th Annual Alberta Soil Science Workshop Proceedings. Nisku, Alberta, Canada, February 19-20, 2002 (in press).

Appendix 11. Biographical data of primary researchers.

Name (surname first): PAPWORTH, Lawrence W.

Post-secondary education and training relevant to proposal:

Institution	Field Specialization	Degree/Diploma	Year Completed
University of Alberta	Mechanical Engineering	B.Sc.	1982

Relevant professional experience:

Dates	Position or Function	Employer	Location
Sept 2000-present	Project Engineer	Agricultural Technology Centre	Lethbridge, Alberta
1988-2000	Project Engineer	Alberta Farm Machinery Research Centre	Lethbridge, Alberta
1984-1987	Project Manager	Prairie Farm Machinery Research Centre	Lethbridge, Alberta

Research activities related to research proposal:

Title	Date
- The effectiveness of double shoot openers for applying anhydrous ammonia and urea while seeding wheat, barley and canola.	1994 - 1995
- Investigation into use of liquid fertilizer with Flexi-coil openers.	1998 - 2000
- Investigation into row spacing with direct seeded barley, canola and wheat.	1998 - 2000
- Investigation into row width and spacing with direct Seeded barley, canola and wheat.	2000 - 2002

Relevant articles published in refereed journals and other relevant works:

Metzger, B., Papworth, L., and Ragan, G. 2002. Investigation into row width and spacing with direct seeded barley, canola and wheat 2000 and 2001 results. 19 pp.
Metzger, B., Papworth, L., and Ragan, G. 1999. Investigation into row spacing with direct seeded barley, canola and wheat. Alberta Farm Machinery Research Centre Publication. 9 pp.
Metzger, B., Papworth, L., and Ragan, G. 1999. Investigation into use of liquid fertilizer with Flexi-coil openers. Alberta Farm Machinery Research Centre Publication. 7 pp.
Maze, R., Metzger, B., Murray, V., Papworth, L., and Ragan, G. 1996. The effect of urea and cold and hot flow anhydrous ammonia on emergence and yield of wheat, barley and canola. Alberta Farm Machinery Research Centre Publication. 7 pp.
Maze, R., B. Metzger, V. Murray and L. Papworth. 1996. Effectiveness of double shoot openers for applying anhydrous ammonia while seeding wheat, barley and canola. Alberta Farm Machinery Research Centre Publication. 7 pp.

Name (surname first): OLSON, Barry M.

Post-secondary education and training relevant to proposal:

Institution	Field Specialization	Degree/Diploma	Year Completed
Univ. of Sask.	Soil Science	B.S.A. (Honours)	1979
Univ. of Sask.	Soil Science	M.Sc.	1982
Aberdeen Univ., Scotland	Soil Science	Ph.D.	1987

Relevant professional experience:

Dates	Position or Function	Employer	Location
Nov/94-present	Research Scientist	Alberta Agriculture	Lethbridge, AB
Sept-90-Oct/94	Research Consultant	Self employed	Lethbridge, AB
July/88-Aug/90	Research Scientist	Agriculture Canada	Lethbridge, AB
Feb/87-June/88	Post-Doc Research Fellow	University of B.C.	Vancouver, B.C.

Research activities related to research proposal:

Title	Date
- Developing soil phosphorus limits for Alberta	Sep/99-present
- Effects of manure land application on soil and groundwater quality	Nov/94-present
- Soil and water quality monitoring under a feedlot	Mar/96-present
- Nitrate leaching in crop rotation studies in Alberta	1993-1997
- The influence of soil quality parameters on crop growth	1990-1994
- Modeling N transformations in long-term annual manured soil	1990-1993

Relevant articles published in refereed journals and other relevant works:

Olson, B.M., Bennett, D.R., McKenzie, R.H., Ormann, T, and Atkins, R.P. 1998. Manure nutrient management to sustain groundwater quality near feedlots. Alberta Agriculture, Food and Rural Development, Lethbridge, Alberta. CAESA Research Report RES-028-93. 214 pp.
Olson, B.M., Bennett, D.R., McKenzie, R.H., Ormann, T., and Atkins, R.P. 1999. Effects of feedlot manure on soil and groundwater quality under irrigation in southern Alberta. Pages 198-206 in Manure management '99 conference proceedings. Saskatoon, Saskatchewan. June 22-25, 1999.
Olson, B. and Papworth, L. 1999. Effects of feedlot manure on soil and groundwater quality under irrigation in southern Alberta. Pages 410-416 in Manure management '99 conference proceedings. Saskatoon, Saskatchewan. June 22-25, 1999.
Howard, A.E., Olson, B.M., and Cooke, S. 1999. Impact of soil phosphorus loading on water quality in Alberta: A review. Alberta Agriculture, Food and Rural Development, Lethbridge, Alberta. 44 pp.
Larney, F.J., Olson, B.M., Janzen, H.H., and Lindwall, C.W. 2000. Early impact of topsoil removal and soil amendments on crop productivity. Agron. J. 92: 948-956.
Larney, F.J., Janzen, H.H., Olson, B.M., and Lindwall, C.W. 2000. Soil quality and productivity responses to simulated erosion and restorative amendments. Can. J. Soil Sci. 80: 515-522.
Whalen, J.K., Chang, C., and Olson, B.M. 2001. Nitrogen and phosphorus mineralization potentials of soils receiving repeated annual cattle manure applications. Biol. Fertil. Soils 34: 334-341.