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Phosphorus Fertilizer Application in Crop Production

Introduction

Phosphorus (P) is a nutrient required in relatively large amounts by plants. Phosphorus deficiencies are corrected with phosphate fertilizer (P_2O_5). Generally, P is the second most crop limiting nutrient in most Alberta soils. It is second only to nitrogen (N) in fertilizer use in Alberta.

Effect of phosphorus on crop growth

Plants need phosphorus for growth, utilization of sugar and starch, photosynthesis, nucleus formation and cell division, fat and albumen formation. Phosphorus compounds are involved in the transfer and storage of energy within plants. Energy from photosynthesis and the metabolism of carbohydrates is stored in phosphate compounds for later use in growth and reproduction.

Phosphorus is readily translocated within the plants, moving from older to younger tissues as the plant forms cells and develops roots, stems and leaves.

Adequate P results in rapid growth and earlier maturity, which is important in areas where frost is a concern. Frequently, the quality of vegetative growth is improved.

A good supply of P has been associated with increased root growth, which means the plant can explore more soil for nutrients and moisture. Phosphorus occurs in most plants in concentrations between 0.1 and 0.4 per cent. A deficiency of P will slow overall plant growth.

Phosphorus content and crop requirements

In young, growing plants, phosphorus is most abundant in the actively growing tissue. By the time plants have attained about 25 per cent of their total dry weight, they may have accumulated as much as 75 per cent of their total phosphorus requirements. Therefore, most crops require significant quantities of P during the early stages of growth.

Phosphorus requirements for optimum yields vary with different crops (see Table 1). For example, wheat requires less P than canola due to the lesser protein content of the seed. A 2700 kg/ha (40 bu/ac) wheat crop requires about 33 kg/ha (29 lb/ac) of phosphate as indicated in Table 1.

Table 1. Phosphate requirements of wheat, barley and canola

Crop	Crop part	Phosphate kg/ha	Phosphate lb/ac
Wheat	Seed	27	24
2690 kg/ha	Straw	6	5
(40 bu/ac)	Total	33	29
Barley	Seed	25	22
3226 kg/ha	Straw	9	8
(60 bu/ac)	Total	34	30
Rapeseed	Seed	36	32
1960 kg/ac	Straw	16	14
(35 bu/ac)	Total	52	46

Phosphorus deficiency symptoms

A mild P deficiency results in somewhat stunted crop growth, which cannot always be seen. In severe cases of P deficiency, symptoms include characteristic purpling or browning, appearing first on the lower leaves and base of the stem and working upward on the plant. The effect is first evident at the leaf tip, and then progresses toward the base. Eventually, the leaf tip dies.

Symptoms are most pronounced in young plants because their more rapid growth makes greater demands on the available supply. Crops seldom completely

outgrow a P deficiency; the symptoms usually persist to delay maturity.

Soil Phosphorus

The term “plant available soil phosphorus” is used to indicate the portion of soil P that can be used for crop growth. It also refers to the portion of soil P removed by various methods in soil testing laboratories.

Soils of Alberta, in their native condition, often had total soil P levels in the range of 1,100 to 1,350 kg/ha (1,000 to 1,200 lb/ac) in the top 15 cm (6 inches). However, the portion of usable or plant available P in native soils was very low. Much of the native soil P is contained in soil minerals and in soil organic matter in forms that remain unavailable to plants.

The phosphorus availability to plants can be assessed by measuring the phosphate concentration in the soil solution and the soil’s ability to maintain the soil solution concentration. The quantity of P in the soil solution, even when at relatively high levels, is only in the range of 0.3 to 3.0 kg/ha (0.3 to 3.0 lb/ac). Rapidly growing crops will absorb about 1 kg/ha (1.0 lb/ac) of P per day. Therefore, soil solution P must be replenished by the “labile” pool of soil P. Labile P is a pool of soil P, which is less available to plants but can undergo rapid chemical or biological changes to recharge or replenish the available P.

Field research in Alberta, with different P soil testing methods, has shown that a soil test method for determining plant available P called the Kelowna method, or modifications of this method, perform reasonably effectively over a wide range of Alberta soil types.

Remember that soil tests cannot predict with 100 per cent accuracy when crops will respond to added phosphate fertilizer. The frequency of crop response to added phosphate fertilizer can be strongly influenced by environmental conditions, particularly soil temperature and moisture.

For example, at research sites in Alberta with wetter, cooler spring soil conditions, the observed visual response to phosphate fertilizer, particularly with wheat and barley, tended to be greater than in warmer, drier spring soil conditions. Therefore, farmers can expect greater crop response to phosphate fertilizer in a year with wetter, cooler spring conditions than in a year with warmer, drier conditions. This fact is why soil test recommendations may not be 100 per cent accurate at predicting when crops will respond to phosphate fertilizer.

It is also important to note that P levels in some soils have increased over the years as a result of repeated annual P fertilization. As a result, crops grown on some soils are less responsive to fertilizer P application. Additionally, factors such as rate of P fertilizer applied, method of application and chemical form used can all affect P uptake.

Crop response to applied P fertilizer depends, to a large extent, on the quantity of plant available P already in the soil. Table 2 gives the general soil test ratings for P. The soil test ratings are normally based on a 0-15 cm (0-6 inch) or a 0-30 cm (0-12 inch) sample depth because P is not very mobile in the soil. Therefore, the concentration of P is greatest in the surface soil.

Table 2. Soil test rating for plant available P levels

Soil test level rating	Phosphorus (P) (lb/ac)
Very low	0-20
Low	20-35
Medium	35-50
High	50-80
Very high	80

Soil P occurs in both organic and inorganic (mineral) forms. Most Alberta soils are relatively low in minerals that contain P, resulting in low plant available P. Organic P is contained in organic matter and is released slowly by soil microorganisms.

Microorganisms

Some soil P is contained in soil microorganisms. A significant proportion of inorganic P may be “biologically fixed” by microorganisms when soil P levels are low. In some cases, microorganisms may even compete with plants for P when soil P levels are low. Phosphorus is temporarily tied up in the organic components of micro-organisms; however, the P is eventually returned to soil when the microbes die. After mineralization (conversion form organic P to inorganic P), it may be used again by plants.

Soil pH

Plant availability of P can be affected by soil pH. For example, some P forms are absorbed more readily than other forms. Generally, absorption of P is better at slightly acid (pH of 6.5) or neutral (7.0) pH than higher pH.

At higher pH levels (>7.5), calcium may react with phosphorus, creating forms that have different levels of plant availability. Magnesium acts in the same manner forming different types of magnesium phosphates.

In more acidic soils (pH <6.0), iron and aluminum increase, which causes fixing or removing P from the soil

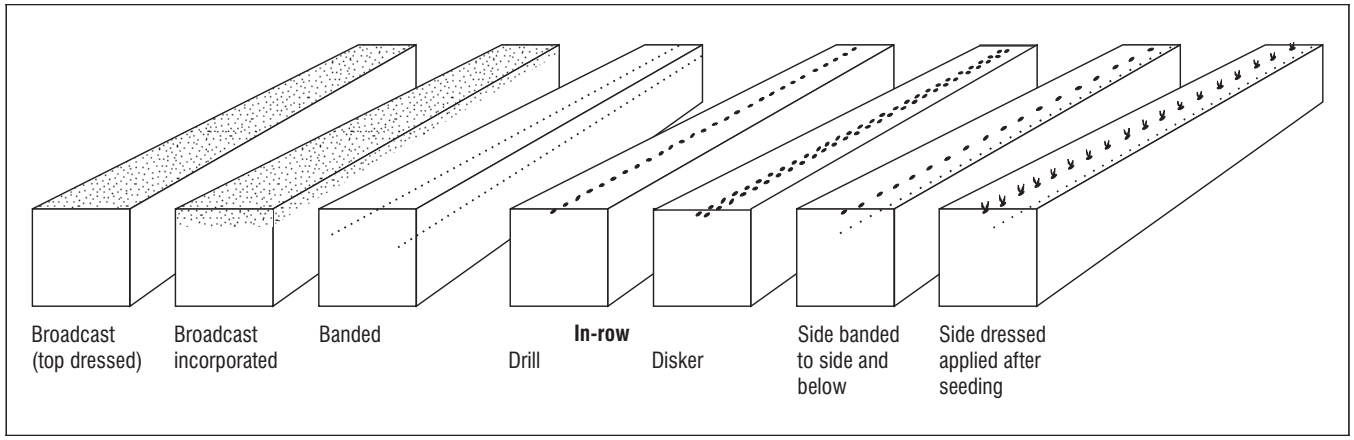

Figure 1. Various methods of phosphate fertilizer application

solution. This action greatly limits the availability of inorganic P to plants.

As a general rule, the maximum availability of P occurs in Alberta soils within a pH range of 6.0 to 7.5.

Soil moisture and temperature

In general, soil moisture and temperature affect P availability and root growth. In cool, wet soils, P availability and movement are reduced. As a result, crops are more responsive to phosphate fertilizer in cool, wet spring conditions than in warmer, drier spring conditions.

Optimal soil moisture and temperature can help accelerate microbe activity, thereby releasing more P from organic matter. Adequate soil moisture will enhance fertilizer solution and reaction in the soil. As well, moisture will promote plant growth, so, P and other nutrient requirements are generally higher for crops grown under irrigation or in higher rainfall areas.

Types of phosphorus fertilizers

Two of the more common phosphate fertilizers sold in Alberta are shown in Table 3.

Mono ammonium phosphate, which is the most common form of phosphate available in Alberta, can be blended with either ammonium nitrate or urea to produce various blends. It can also be blended with muriate of potash (0-0-60; 0-0-62) or with most sulfur fertilizers as well.

Most soil testing laboratories in Alberta report soil test levels of P in lb/ac, but fertilizer recommendations are made in terms of P_2O_5 in lb/ac. To convert P to P_2O_5, multiply by 2.3 (e.g. 10 lb/ac of P = 23 lb/ac of P_2O_5). Phosphorus fertilizer in Canada is sold on the basis of P_2O_5 in percent of total product.

Table 3. Common types of phosphate fertilizers sold in Alberta

Name	Type	Form
Mono ammonium phosphate	12-51-0	Granular
Ammonium polyphosphate	10-34-0	Liquid

Phosphate fertilizer application

There are a number of methods of applying P fertilizer. Figure 1 shows examples of fertilizer placement; however, some methods are more efficient than others. To obtain good P fertilizer efficiency, adequate rates of nitrogen and other nutrients must be available to the crop.

Broadcast and incorporation

This method involves uniformly broadcasting and incorporating P fertilizer into the soil before seeding. At low and medium soil test levels for P, the broadcast and incorporation method is less effective than seed-placed or banded P.

When P is broadcast and incorporated, application rates may have to be two to four times the in-row banded rate to obtain an equal crop response when soil test P is very low. Therefore, broadcast and incorporation of P may not be economical or practical if high rates are needed to increase yield.

High rates of broadcast and incorporated P on eroded soil areas or knolls are recommended to even out the fertility of eroded fields because they are low in soil P.

Broadcasting P at high rates involves a high initial cost, but these costs can be recovered over several years. The availability to plants of applied P decreases over a period of years because of the reaction products formed in the soil.

When high rates of P fertilizer are applied, it is possible to induce micronutrient deficiencies, particularly zinc (Zn) and copper (Cu). In southern Alberta, where high rates of P have been applied, isolated cases of zinc deficiency have been observed during cool, wet spring conditions in both irrigated field beans and in corn, grown on sandy soils where high P rates have been used. In central Alberta, copper deficiency in cereal crops has been associated with higher phosphate fertilizer applications.

Top dress (broadcast – no incorporation)

Broadcasting P fertilizer without incorporation is only recommended for established forage crops because it is the only practical method currently available.

Phosphorus fertilizer is immobile; therefore, plant uptake of fertilizer P may be low in the first year after application. However, alfalfa and grasses do have feeder roots very near the soil surface and can take up some broadcast P fertilizer when surface soil moisture conditions are good. For forage crops, a three- to six-year supply of P can be either deep banded or broadcast and incorporated before establishment. Subsequent applications may be top dressed.

Seed-placed phosphorus (banded with seed in the seed row)

The maximum safe rate of P that can be applied with the seed for cereal crops is 50 to 70 kg/ha (45 to 65 lb/ac) of $P_2 0_5$ depending on soil moisture conditions and the opener used. For oilseed crops, seed-placed $P_2 0_5$ rates should not exceed 25 kg/ha (23 lb/ac) especially when a seeding implement that places the seed and fertilizer in a narrow band (double disc drill) is used. For peas, seed-placed $P_2 0_5$ rates should not exceed 30 to 35 kg/ha (27 to 33 lb/ac) especially when a seeding implement that places the seed and fertilizer in a narrow band (double disc drill) is used.

Standard single and double disc drills cut a fairly narrow furrow and place the seed and fertilizer together in the bottom of the furrow. These drills place the fertilizer in a concentrated band close to the seed and are most likely to result in damage to sensitive crops at high rates of application. When soil moisture conditions are good to excellent, higher rates of seed-placed $P_2 0_5$ can be used.

Disker and hoe type drills cut a wider furrow and the seed and fertilizer are scattered across the bottom of the furrow. This scattering in a wide band results in a lower concentration of fertilizer close to the seed and is less likely to cause damage to sensitive crops when high rates of fertilizer are applied.

Seeding implements that scatter the seed in wide bands (diskers, air seeders, hoe drills) reduce the seed-fertilizer contact. As a result, higher seed-placed P rates can safely be used. However, because of the wide variation in furrow opener design and spacing, and width of seed row, specific maximum safe seed-placed P rates have not been determined for these implements. Generally, rates can be increased by 25 to 50 per cent over the safe rates for a double disc drill. At low rates of fertilizer application, response to seed-placed P may be slightly less when the seed and fertilizer are spread out in broad bands as compared to narrow bands.

Side banding phosphorus

This method places the P in a band near the seed row during the seeding operation. The fertilizer is normally banded 2.5 to 5 cm (1 to 2 inches) below and to the side of the seed row for small seeded crops and row crops such as sugar beets, potatoes, sunflowers, corn and beans.

Phosphate at all recommended rates can be safely applied with this method. However, specialized seeding equipment is required. Yield increases obtained with this placement are nearly equal to seed-placement at low rates of application, but much superior when application rates are too high for safe placement with the seed. Phosphorus side banded near the seed of cereal crops in most cases is close in efficiency to seed-placed phosphorus.

Some new minimum till and no-till seed drills are using a mid-row or paired-row technique. Two rows are seeded about 7.5 to 12 cm (3 to 5 inches) apart, and P is banded between the two rows about 2.5 to 5 cm (1 to 2 inches) below the seeding depth. There is an 18 to 25 cm (7 to 10 inch) space between the next pair of rows.

Banding phosphorus

This method of application places P in concentrated bands in the fall or spring before seeding. A cultivator type implement with shovels or knives is used with a shank spacing of 20 to 35 cm (8 to 14 inches). Depth of application is normally 8 to 15 cm (3 to 6 inches).

Banded P is often somewhat less effective than seed-placed P. However, both are much more effective than broadcast and incorporated P when soil test levels are low. In some locations and years, particularly on very low P soils and when soil temperature is low following seeding, the “starter” effect of phosphate placed with or near the seed can be important and cannot be achieved by banded phosphate alone. For this reason, seed placement of a portion of the P at 11 to 17 kg/ha (10 to 15 lb/ac) $P_2 0_5$ is advised when phosphate is banded.

Banded P may be more effective than seed-placed P under dry surface soil conditions. The major advantages of banding P are as follows:

- rates considered too high for seed-placement with oilseeds and pulse crops can be used where low soil P warrants such rates,
- the amount of fertilizer handled at seeding time can be reduced or, in some situations, eliminated.

The disadvantage of banding P in the spring is that it may dry out the seed bed, which could reduce germination and limit crop yield under dry spring moisture conditions.

Application of phosphate both with the seed and deep banded (split application) is an effective way to achieve the benefits of both methods.

Narrow spacing between phosphate bands is preferred so that phosphate uptake is not delayed during early growth owing to long distances between the bands and some of the seedlings. On very low P soils, “stripping” can occur. This is caused by poorer growth of plants midway between phosphate bands when the bands are too widely spaced. For phosphate, banded spacings of more than 30 cm (12 inches) are not recommended, and narrower spacings may be more effective particularly where no phosphate is seed-placed.

When banding phosphate, the bands must be sufficiently deep to avoid disruption by subsequent tillage and seeding operations. Time of phosphate banding (fall versus spring) appears to have little effect on fertilizer efficiency.

Plant uptake of phosphate placed in the same band with nitrogen (N) can be restricted. For example, Alberta research has shown that when 60 kg/ha (54 lb/ac) of phosphate was banded with 120 kg/ha (108 lb/ac) of N, phosphate uptake efficiency was only 12 to 15 per cent compared to 30 to 35 per cent when the same rate was placed in a separate band away from the N band. Generally, phosphate should not be banded with N fertilizer if the N rate is higher than 70 to 80 kg/ha (63 to 72 lb /ac) to avoid reduced uptake efficiency of the P fertilizer. The major reason is that plant roots cannot penetrate the concentrated nitrogen band and, therefore, cannot take up the P effectively.

Some of the advantages of banding before planting include the following:

- Application of fertilizer during the busy seeding period is avoided. However, some growers may still wisely place some P fertilizer with the seed for starter effects.
- Fertilizer nutrients are strategically placed at depths in the root zone where soils tend to remain moist longer during the early parts of the growing season and where they are beyond reach of shallow germinating and rooting weeds.

Comparison of phosphate fertilizer placement methods

Placing P fertilizers in bands minimizes the contact between the soil and the P fertilizer. In contrast, mixing the P with soil exposes it to more soil, resulting in reduced plant availability.

Alberta research suggests that placement of P with the seed is frequently better than banded P. Table 4 shows the wheat, barley and canola response to seed-placed versus banded phosphate fertilizer in southern Alberta in 1991 on summer fallow and stubble.

Seed-placed P is recommended as it is one of the most efficient means of P application, provided the amounts applied do not injure the germinating seed and seedling. When higher rates of P are used in dry and/or coarse-textured soils, banding away from the seed at planting at times may be superior to placing phosphate with the seed.

Table 4. Response to seed-placed versus banded phosphate fertilizer

	Wheat		Barley		Canola	
	Fallow	Stubble	Fallow	Stubble	Fallow	Stubble
No. of sites	7	17	7	19	7	15
P Responsive sites	6	10	6	13	6	14
Seed-placed > banded	4	6	4	8	5	6
Banded > seed-placed	2	3	1	0	0	2
Seed-placed = banded	0	1	1	5	1	7

Seed placement of 17 kg/ha (15 lb/ac) is advised when phosphate is banded to obtain a starter effect when soil P levels are very low 0 to 20 kg/ha (0 to 18 lb/ac) or cool soil temperatures occur after seeding, conditions common in the black, gray-black and gray soil zones.

Table 5. Summary of responsive and non responsive sites by soil zone based on yield differences

Crop	Type of Response†	Brown	Dark Brown	Thin Black	Black	Gray Wooded (Central)	Gray Wooded (Peace R.)	Total	Sites
Wheat	Response	9	10	14	21	10	10	74	
	Marginal Response	1	10	9	8	6	9		43
	No response	6	8	3	6	3	2		28
Barley	Response	9	14	19	32	14	13	101	
	Marginal Response	5	12	14	3	2	6		42
	No response	2	0	4	4	3	3		16
Canola	Response	3	2	1	9	6	8	29	
	Marginal Response	8	14	11	12	8	7		60
	No response	5	9	6	8	1	5		34

†Response-yield increase greater than 5 bu/ac.
Marginal response-yield increase between 2 and 5 bu/ac.
No response-less than 2 bu/ac yield increase.

Phosphorus fertilizer recommendations

An Alberta research project was conducted from 1991 to 1993 to evaluate the responsiveness of wheat, barley and canola to phosphate fertilizer. The research was done on a wide range of soil types across Alberta to determine the frequency of when each crop will respond to phosphate fertilizer. Table 5 summarizes the number of responsive and unresponsive sites by soil zone based on a two-bushel yield difference between the control treatment and phosphate fertilized treatments from 1991 to 1993.

In summary, 81 per cent of wheat sites, 90 per cent of barley sites and 72 per cent of canola sites responded to added phosphate fertilizer at the 427 research sites. The high number of sites seen to respond was similar in each of the three years of the project.

This research project clearly indicated the importance of phosphate fertilizer in crop production throughout Alberta. Results suggest that approximately 75 per cent of Alberta soils are marginally to severely deficient in soil P depending on interpretation of results. Responses were observed in all major soil zones across Alberta.

The frequency of crop response to added phosphate fertilizer was partly influenced by environmental conditions. For example, at sites with wetter, cooler spring conditions, the noticable response of crops, particularly wheat and barley, tended to be greater than in warmer drier spring conditions.

Phosphate fertilizer recommendations and the probability of response are provided for barley (Tables 6 and 7), wheat (Tables 8 and 9) and canola (Tables 10 and 11). General phosphate fertilizer recommendations for general groupings of other crops are provided in Table 12. The placement recommendation for each group of crops is discussed in relation to soils low in available P where crop response is lower and more variable.

Note that the P recommendations in Alberta are currently designed for placing the phosphate with or near the seed for most crops. These rates are not applicable when P is broadcast and incorporated.

Cereal Crops

Soils low in available P

On most soils low in available P, seed-placed phosphate at recommended rates is equal to or better than banding near the seed and far superior to surface application and incorporation.

If P is broadcast and incorporated, the annual application rate must be two to four times the rate recommended for seed-placement to obtain equal crop response in the year of application.

Soils medium to high in available P

Seed-placed or banded fertilizer P at rates up to 20 to 30 kg/ha (18 to 27 lb/ac) of $P_2 0_5$ may result in a crop response 25 to 60 per cent of the time.

Canola, mustard and annual legumes

Soils low in available P

On these soils, P rates up to 28 kg/ha (25 lb/ac) $P_2 0_5$ can be seed-placed.

Table 6. Phosphate fertilizer recommendations for barley on a medium to fine textured soil with a neutral pH, based on the Kelowna soil test method. Recommendations are given for each soil zone at three soil moisture condition levels at the time of seeding.

Soil test P (lb/ac)	Brown			Dark Brown			Thin Black			Black			Gray Wooded			Irrigated
	D	M	W	D	M	W	D	M	W	D	M	W	D	M	W	
	P_2O_5 lb/ac															
0-10	30	35	40	35	40	45	40	45	50	40	45	50	40	45	50	50
10-20	25	30	35	30	35	40	35	40	45	35	40	45	35	40	45	45
20-30	20	25	30	25	30	35	30	35	40	30	35	40	30	35	40	40
30-40	15	20	25	20	25	30	25	30	35	25	30	35	25	30	35	35
40-50	15	15	20	20	20	25	25	25	30	25	25	30	25	25	30	35
50-60	15	15	20	15	15	25	20	20	30	20	20	30	20	20	30	30
60-70	15	15	15	15	15	20	15	20	25	15	15	25	15	15	25	25
70-80	0	15	15	0	15	15	0	15	20	0	15	20	0	15	20	20
80-90	0	0	15	0	0	15	0	0	15	0	0	15	0	0	15	15
>90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Seedbed soil moisture conditions at seeding D = 25%; M = 50%; W = 75% of field capacity.

Table 7. Approximate probability of a greater than 2 bu/ac and 5 bu/ac barley response to phosphate fertilizer when following recommendations

Soil test P (lb/ac)	Brown		Dark Brown		Thin Black		Black		Gray Wooded		Irrigated
	>2	>5	>2	>5	>2	>5	>2	>5	>2	>5	
	%										
0-10	95	80	95	85	95	95	95	95	95	90	80
10-20	90	70	90	80	95	90	95	90	95	85	70
20-30	90	60	90	70	90	80	90	80	90	80	60
30-40	80	55	80	60	85	70	85	70	85	70	55
40-50	70	50	70	50	80	60	80	60	80	60	50
50-60	60	35	60	35	70	50	70	50	70	50	35
60-70	50	30	50	30	50	30	50	30	50	30	30
70-80	40	30	40	30	40	30	40	30	40	30	30
>80	35	25	35	25	35	25	35	25	35	25	25

Rates greater than 28 kg/ha (25 lb/ac) P_2O_5 should be either banded prior to seeding or side-banded at the time of seeding.

Soils medium to high in available P

Seed-placed or banded fertilizer P at rates up to 28 kg/ha (25 lb/ac) of P_2O_5 may result in a crop response 25 to 40 per cent of the time.

Flax

This crop does not respond as readily to fertilizer P banded with the seed. Also, flax is sensitive to seed-placed P.

Soils low in available P

On these soils, P can be seed-placed: rate should not exceed 20 kg/ha (18 lb/ac), side banded at seeding or banded prior to seeding.

Soils medium to high in available P

Banding P prior to seeding or side-banding at seeding at rates of 28 kg/ha (25 lb/ac) P_2O_5 may result in a crop response, particularly in cool, wet spring conditions.

Table 8. Phosphate fertilizer recommendations for spring wheat on a medium to fine textured soil with a neutral pH, based on the Kelowna soil test method. Recommendations are given for each soil zone at three soil moisture condition levels at the time of seeding.

Soil test P (lb/ac)	Brown			Dark Brown			Thin Black			Black			Gray Wooded			Irrigated
	D	M	W	D	M	W	D	M	W	D	M	W	D	M	W	
	P_2O_5 lb/ac															
0-10	30	35	40	35	40	45	40	45	50	40	45	50	40	45	50	50
10-20	25	30	35	30	35	40	35	40	45	35	40	45	35	40	45	45
20-30	20	25	30	25	30	35	30	35	40	30	35	40	30	35	40	40
30-40	15	20	25	20	25	30	25	30	35	25	30	35	25	30	35	35
40-50	15	15	20	20	20	25	25	25	30	25	25	30	25	25	30	35
50-60	15	15	20	15	15	25	20	20	30	20	20	30	20	20	30	30
60-70	15	15	15	15	15	20	15	20	25	15	15	25	15	15	25	25
70-80	0	15	15	0	15	15	0	15	20	0	15	20	0	15	20	20
80-90	0	0	15	0	0	15	0	0	15	0	0	15	0	0	15	15
>90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Seedbed soil moisture conditions at seeding D = 25%; M = 50%; W = 75% of field capacity.

Table 9. Approximate probability of a greater than 2 bu/ac and 5 bu/ac wheat response to phosphate fertilizer when following recommendations

Soil test P (lb/ac)	Brown		Dark Brown		Thin Black		Black		Gray Wooded		Irrigated
	>2	>5	>2	>5	>2	>5	>2	>5	>2	>5	
	%										
0-10	95	75	95	80	95	95	95	95	95	90	80
10-20	90	70	90	75	95	80	95	90	90	80	70
20-30	80	60	80	65	90	70	90	80	80	70	60
30-40	80	50	70	55	85	60	85	70	75	60	50
40-50	60	40	60	45	80	50	80	60	70	50	40
50-60	50	30	50	35	70	40	70	50	60	40	30
60-70	40	30	40	30	50	30	50	30	50	30	30
70-80	30	20	30	25	40	25	40	25	40	25	25
>80	25	20	25	20	30	25	30	25	35	25	25

Corn, potatoes and sunflowers

Soils low in available P

On these soils, all P should be banded away from the seed row.

Soils medium to high in available P

Banding of P on these soils may result in a crop response 25 to 60 per cent of the time.

Sugar Beets

Soils low in available P

On these soils, up to 22 kg/ha (20 lb/ac) P_2O_5 should be seed-placed. Rates greater than 22 kg/ha (20 lb/ac) P_2O_5 should be banded prior to seeding or side-banded near the seed.

Soils medium to high in available P

Banding of P with or near the seed in these soils may increase seedling vigour but may or may not carry through to increase yield.

Table 10. Phosphate fertilizer recommendations for canola and mustard on a medium to fine textured soil with a neutral pH, based on the Kelowna soil test method. Recommendations are given for each soil zone at three soil moisture condition levels at the time of seeding.

Soil test P (lb/ac)	Brown			Dark Brown			Thin Black			Black			Gray Wooded			Irrigated
	D	M	W	D	M	W	D	M	W	D	M	W	D	M	W	
	P_2O_5 lb/ac															
0-10	30	35	40	35	40	45	40	45	50	40	45	50	40	45	50	50
10-20	25	30	35	30	35	40	35	40	45	35	40	45	35	40	45	45
20-30	20	25	30	25	30	35	30	35	40	30	35	40	30	35	40	40
30-40	15	20	25	20	25	30	25	30	35	25	30	35	25	30	35	35
40-50	15	15	20	20	20	25	25	25	30	25	25	30	25	25	30	35
50-60	15	15	20	15	15	25	20	20	30	20	20	30	20	20	30	30
60-70	15	15	15	15	15	20	15	20	25	15	15	25	15	15	25	25
70-80	0	15	15	0	15	15	0	15	20	0	15	20	0	15	20	20
80-90	0	0	15	0	0	15	0	0	15	0	0	15	0	0	15	15
>90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Seedbed soil moisture conditions at seeding D = 25%; M = 50%; W = 75% of field capacity.

Table 11. Approximate probability of a greater than 2 bu/ac and 5 bu/ac canola response to phosphate fertilizer when following recommendations

Soil test P (lb/ac)	Brown		Dark Brown		Thin Black		Black		Gray Wooded		Irrigated
	>2	>5	>2	>5	>2	>5	>2	>5	>2	>5	
	%										
0-10	90	70	95	80	95	90	95	95	95	90	95
10-20	80	60	90	80	95	85	95	90	95	85	90
20-30	70	60	80	70	90	75	90	80	90	75	80
30-40	60	50	70	60	80	65	85	70	80	65	70
40-50	50	40	60	50	70	55	80	60	70	55	60
50-60	40	30	50	40	60	45	70	50	60	45	50
60-70	40	30	40	30	50	35	60	40	50	35	40
70-80	35	20	35	20	40	30	50	30	40	30	30
80-100	30	10	30	15	30	20	40	20	30	20	20

Table 12. General phosphate fertilizer recommendations for crops grown in Alberta at increasing levels of P in the soil based on the Kelowna method of extraction of soil P

Soil test P (lb/ac)	Mustard	Peas	Potatoes	Sugar beets	Corn
	P_2O_5 (lb/ac)				
0	35	40	100	80	0
10	30	35	90	70	60
20	25	30	80	60	50
30	20	25	70	50	40
40	15	20	60	40	30
50	15	15	50	30	20
60	15	15	40	30	20
70	15	15	40	30	20
80-100	10	10	30	20	15
>100	0	0	0	0	0

Forage Crops

The best method and time of fertilizer P application for cultivated grasses, grass-legumes and legumes is broadcast-incorporation or deep banding prior to stand establishment. Phosphorus applied in this manner will suffice for the year of establishment and for up to six years afterward, depending upon rate of application, available P levels and other soil characteristics.

On soils low in available P, a single high rate (150 kg/ha or 135 lb/ac) of $P_2 0_5$ broadcast and incorporated prior to seeding has shown better yield response over a three-year period than an equivalent amount broadcast in annual increments.

However, P requirements for established forage stands can be supplied by broadcast applications, particularly under irrigated conditions and for wetter areas of the province. In the future, it may be possible to band granular or liquid fertilizers into established forage fields by using very narrow openers or by injecting liquid fertilizer using extremely high pressure.

Summary

The ideal situation for optimum crop production is to have a good supply of P close to the seed during the first six weeks of growth and an adequate quantity of P in the soil for the rest of the season. Placement of P in-row with cereal and oilseed crops has been the traditional method used for P fertilization in Alberta. Preplant banding of P with nitrogen has been found to be a good alternative method of application under certain conditions. However, under conditions of low to medium soil P coupled with low soil temperatures, “starter” P in the seed row is frequently very beneficial.

For further information on soil phosphorus and phosphate fertilization, contact:

1. Your nearest Alberta Agriculture Crop Specialist.
2. Your fertilizer company agronomist.
3. Your soil testing laboratory agronomist.

Information prepared by:

Dr. Ross H. McKenzie and *Allan Middleton*
Agronomy Unit, Lethbridge
Phone: (403) 381-5126

1997 04 3M