Agriculture and Agri-Food Canada | Agriculture et Agroalimentaire Canada

# Glyphosate-resistant kochia

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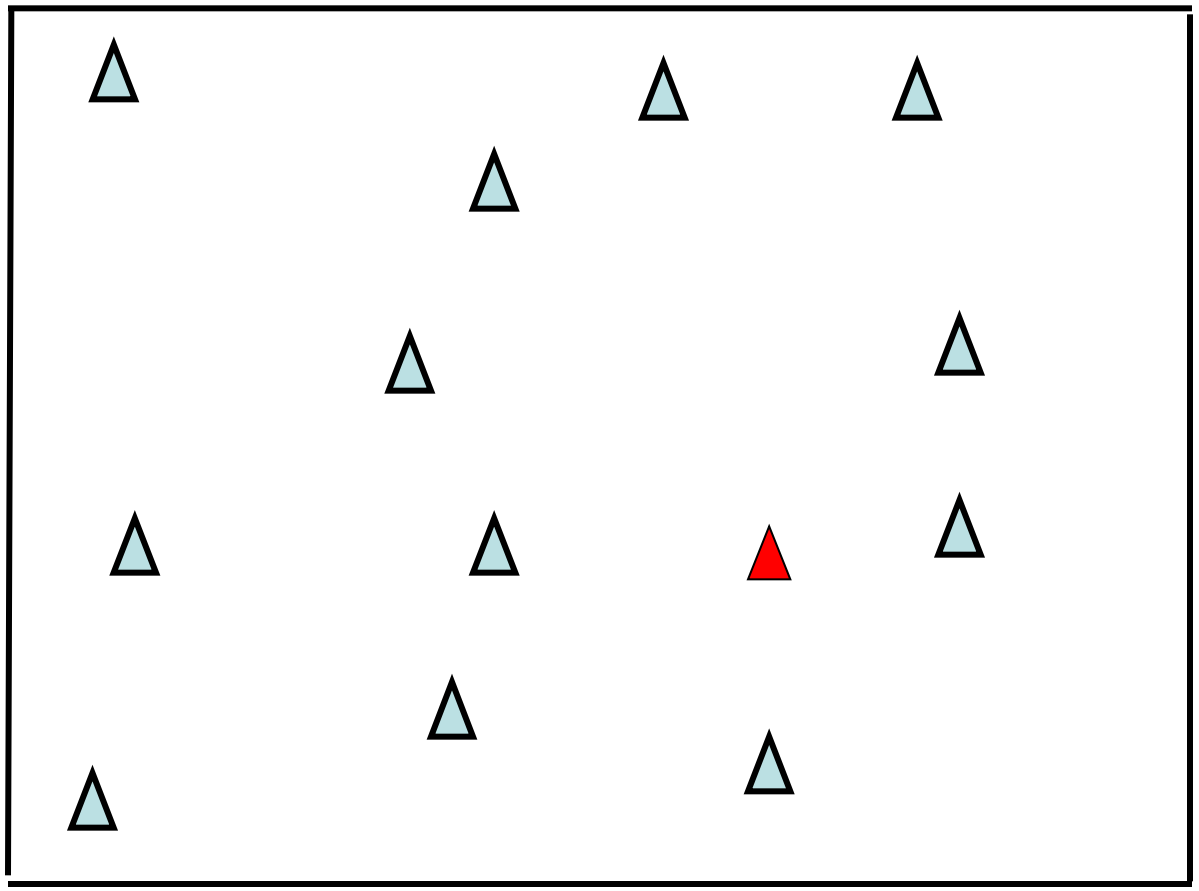
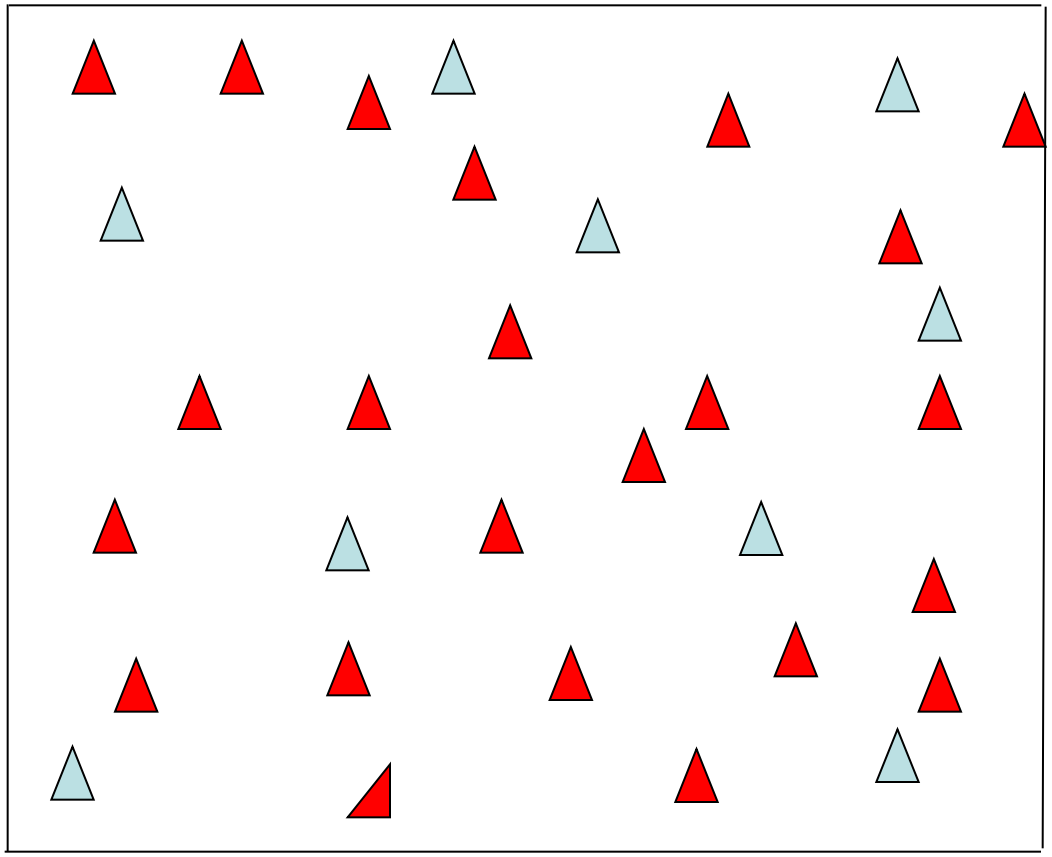
# Prior to any herbicide being applied to a field

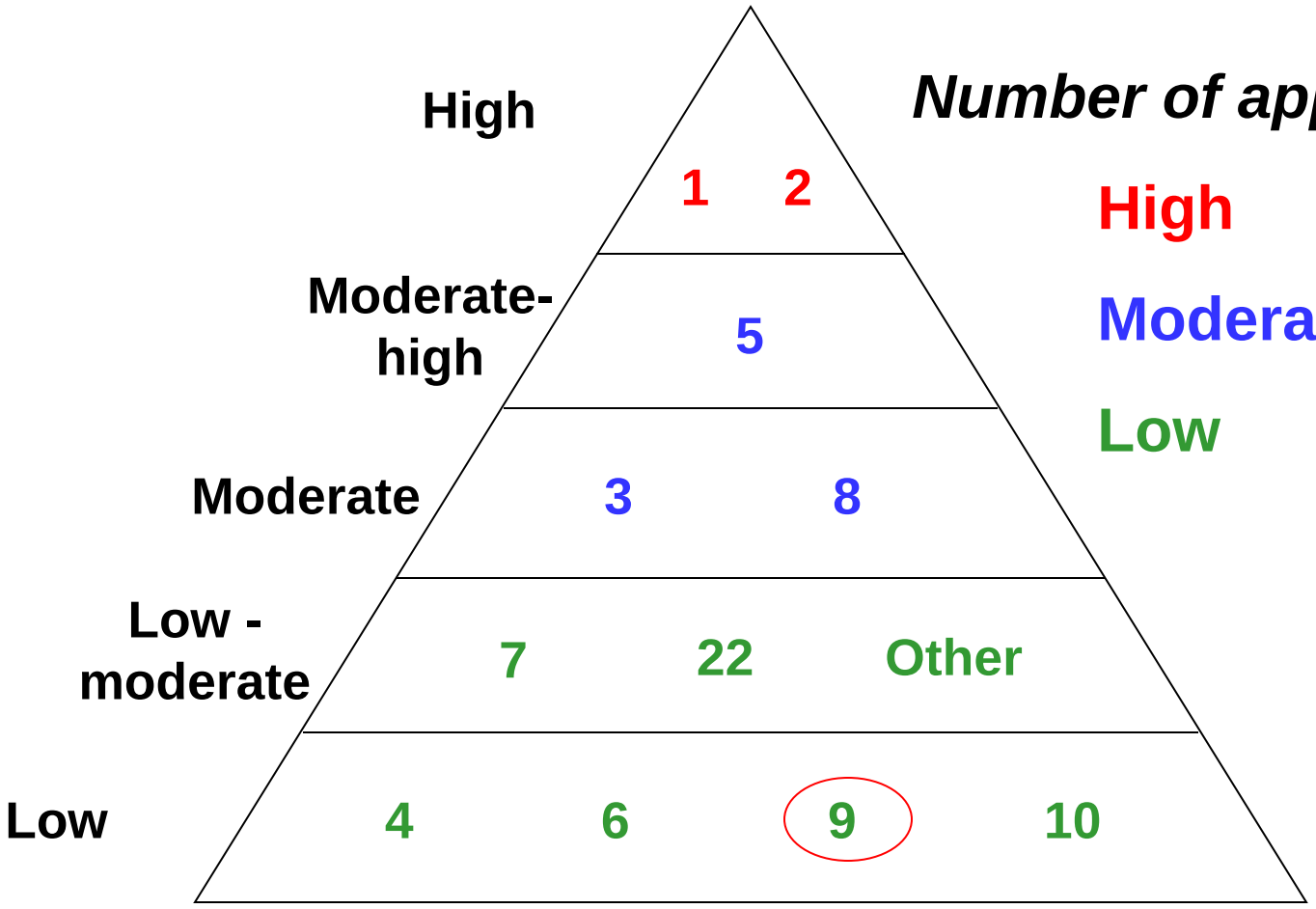


-- 1 in a million; 1 in a billion

# After repeated herbicide use…



# Risk of selection for resistance by herbicide group




***Number of applications:***

**High** **≤ 10**

**Moderate** **11 - 20**

**Low** **> 20**

# Risk of resistance by weed species

**Distribution and density:** commonly occurring weeds in a region, e.g. wild oat on the Canadian prairies
- kochia is the 3rd most abundant weed in southern Alberta
- resistance is a numbers game

**Genetic diversity:** greater chance of having the resistant gene in the first place

**High seed production:** increase in resistant biotype relative to susceptible population after herbicide application
- kochia produces 10,000 to 25,000 seeds per plant

# Kochia biology

. Annual $C_4$ species (like corn)

. Tolerant of heat, drought, salinity

. Germinates at low soil temperatures of 2-4 C

. Emerges in early spring but additional flushes occur throughout the growing season

. Optimal emergence from 0-2 cm soil depth

. Produces 10,000-25,000 seeds per plant

. Tumbleweed seed dispersal mechanism

. Little seed dormancy

. Seed bank persistence of 1-2 years

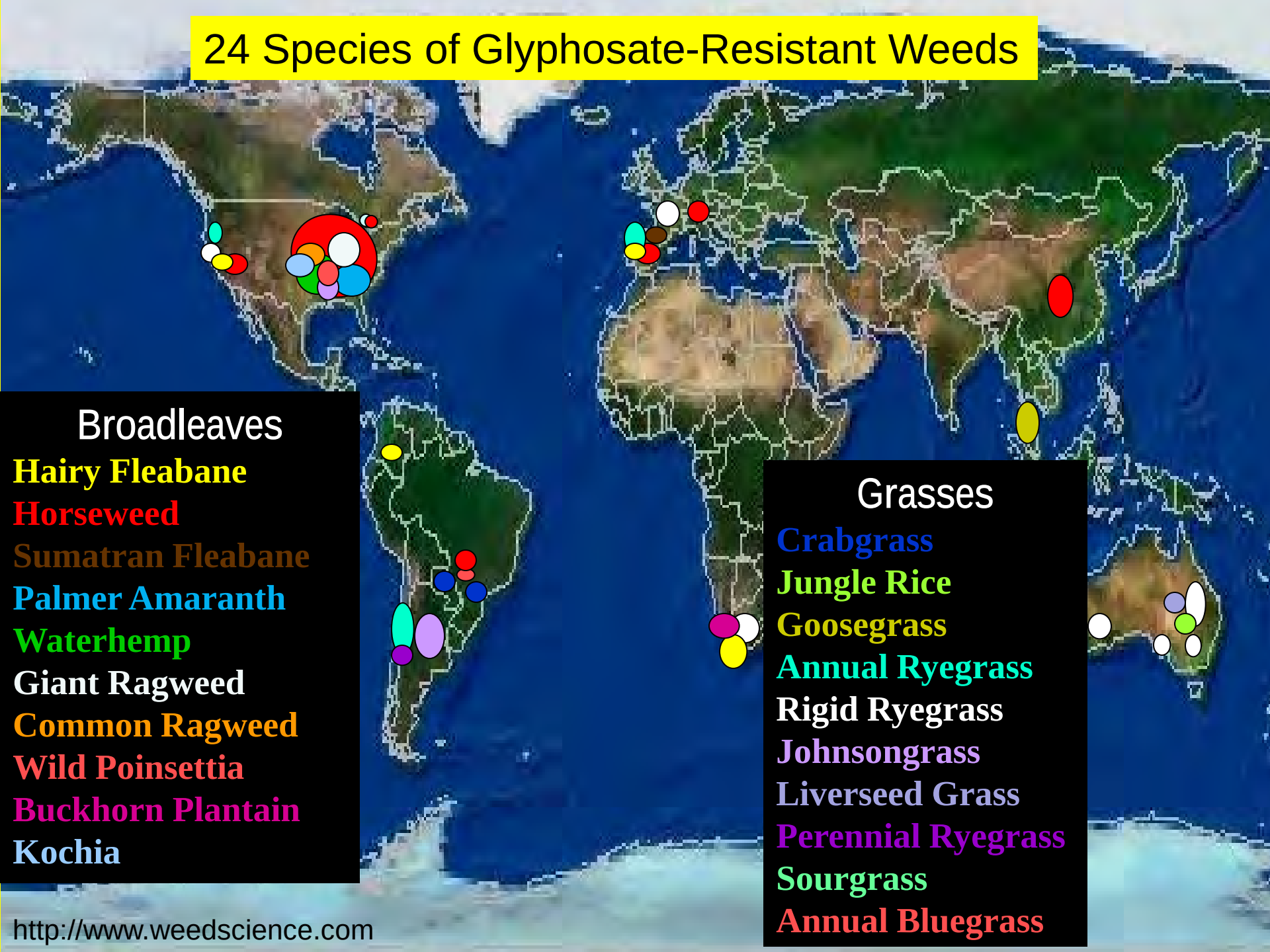
# Previous herbicide resistance in kochia

**Group 5:** confirmed in the 1970s
- triazine herbicides (atrazine, simazine)

**Group 2:** confirmed in the late 1980s
- ALS-inhibiting herbicides (17 herbicides in Canada)
- Express, Odyssey, Everest, Frontline, Simplicity
- **90% of kochia is Group 2 resistant in western Canada**

**Group 4:** confirmed in the 1990s
- dicamba resistance (Montana, Nebraska, North Dakota)

# 24 Species of Glyphosate-Resistant Weeds



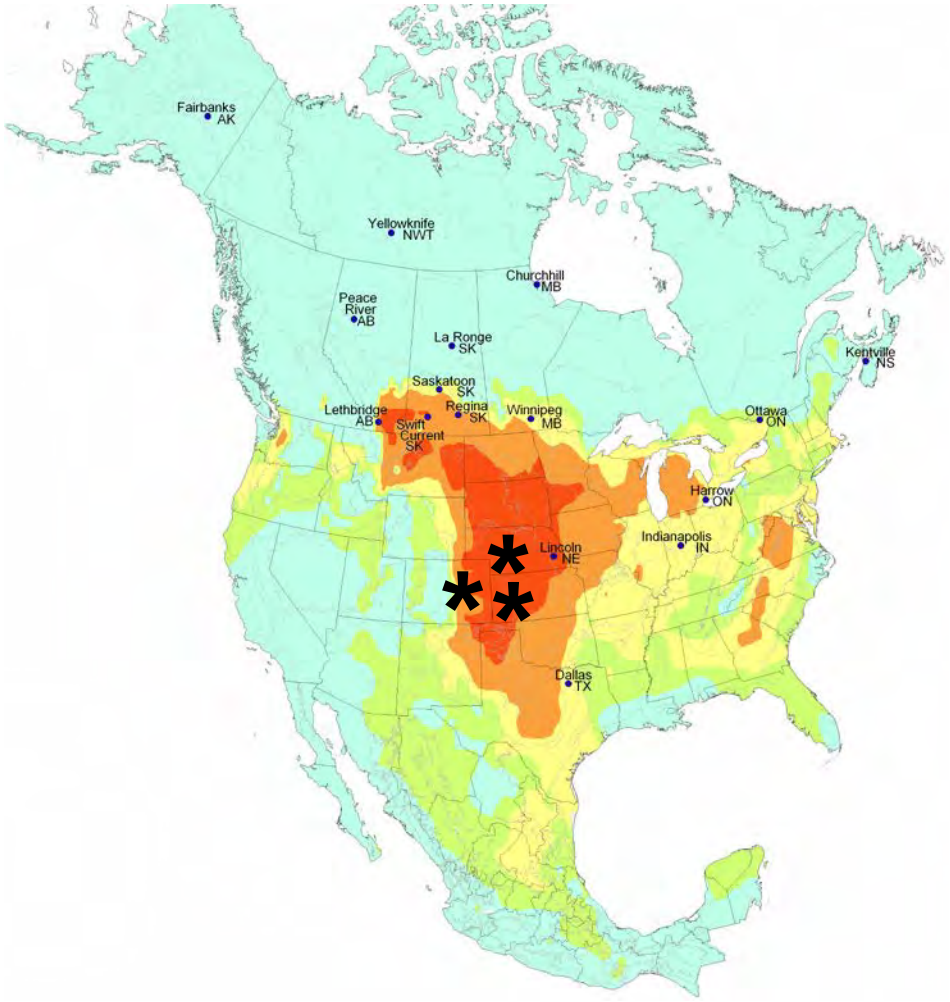
## Broadleaves

- Hairy Fleabane
- Horseweed
- Sumatran Fleabane
- Palmer Amaranth
- Waterhemp
- Giant Ragweed
- Common Ragweed
- Wild Poinsettia
- Buckhorn Plantain
- Kochia

## Grasses

- Crabgrass
- Jungle Rice
- Goosegrass
- Annual Ryegrass
- Rigid Ryegrass
- Johnsongrass
- Liverseed Grass
- Perennial Ryegrass
- Sourgrass
- Annual Bluegrass

http://www.weedscience.com




. Glyphosate-resistant (GR) kochia confirmed in Kansas (2007), Colorado (2011), Nebraska (2011) and North Dakota (2012)

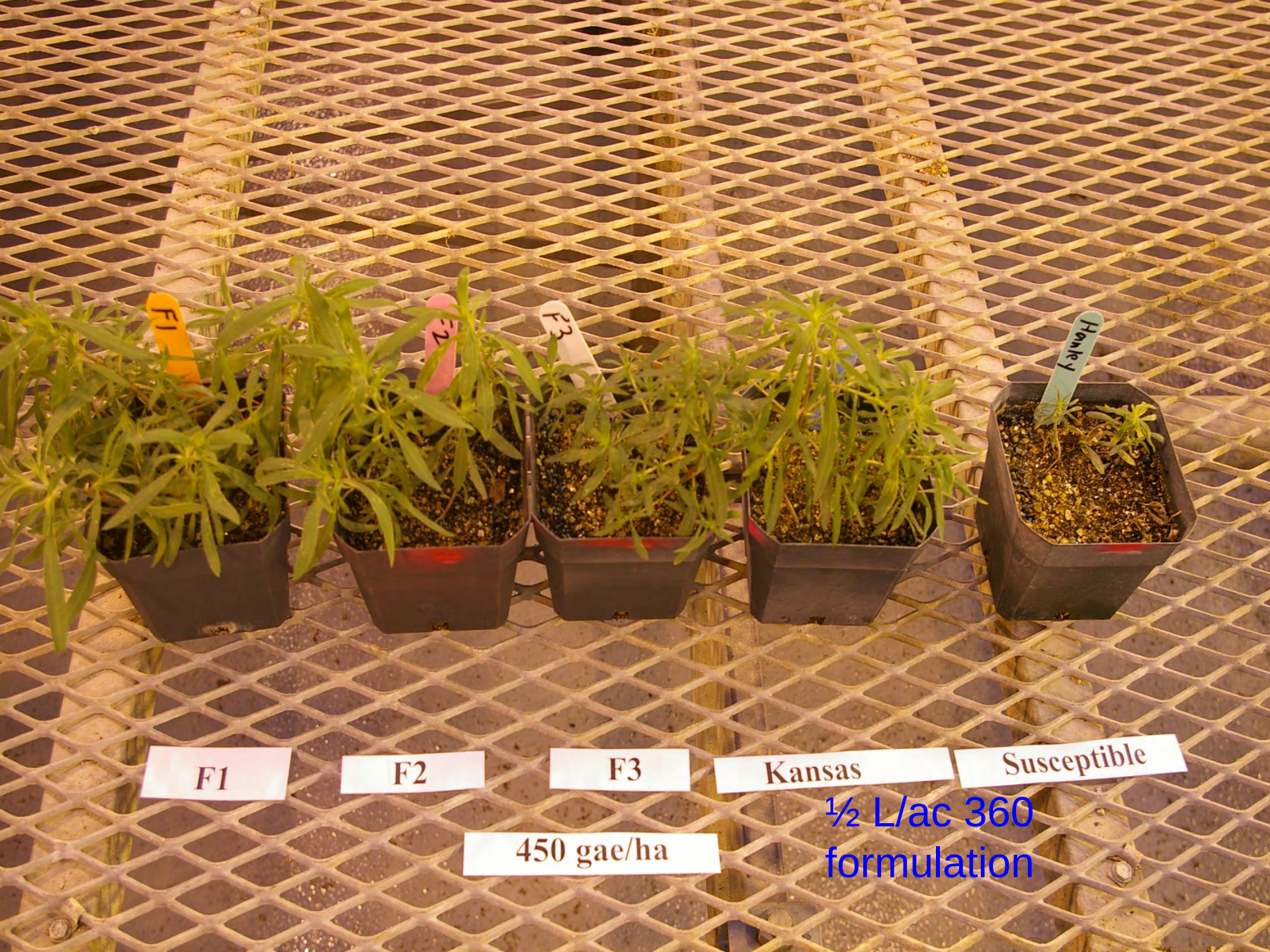
# Kansas: confirmed glyphosate resistance in 2007 (Dr. Phil Stahlman, Kansas State University)

# GR kochia in southern Alberta: 3 chemfallow fields (3 separate farms) in Warner-Milk River area in 2011

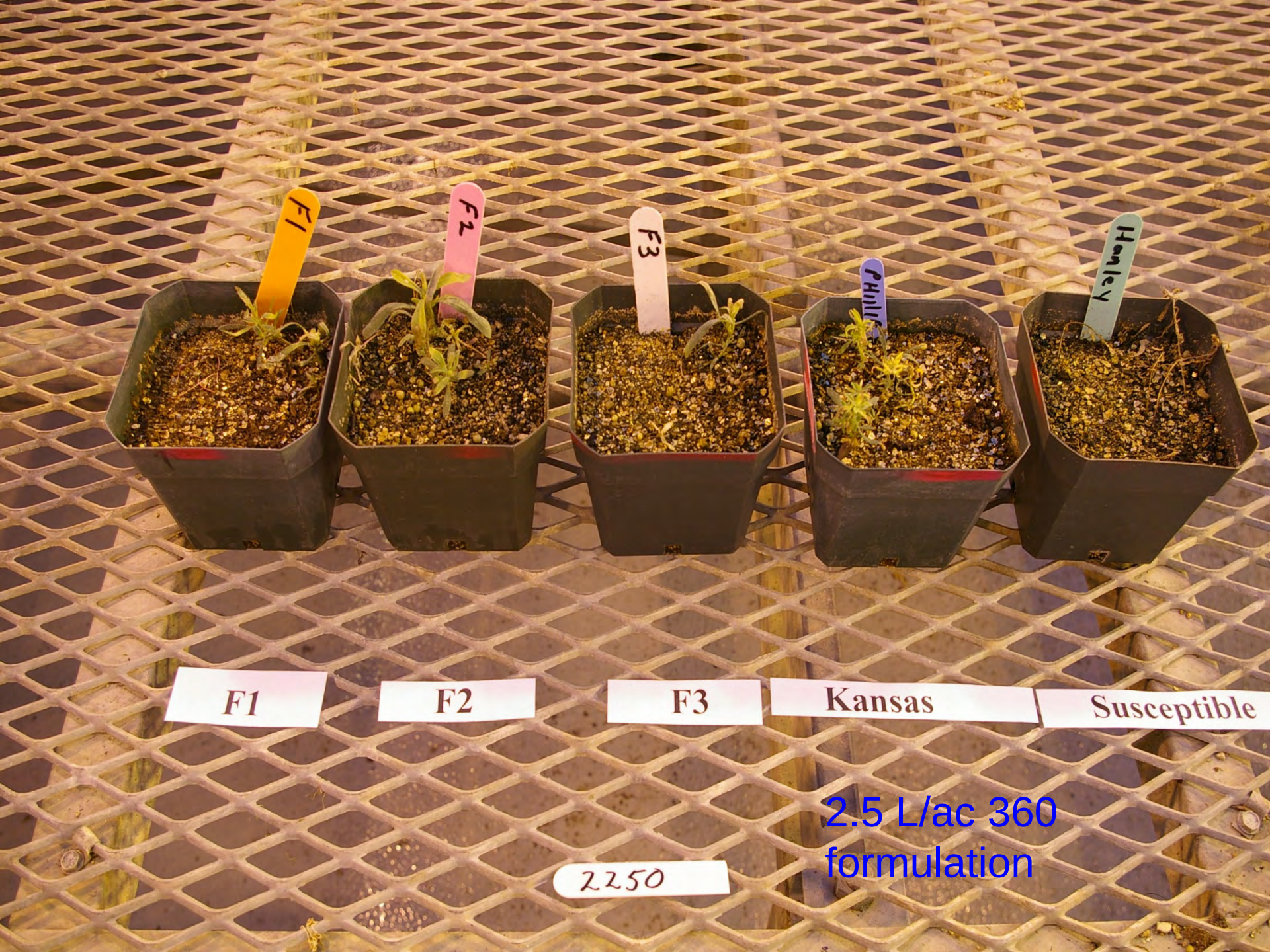
# Greenhouse study

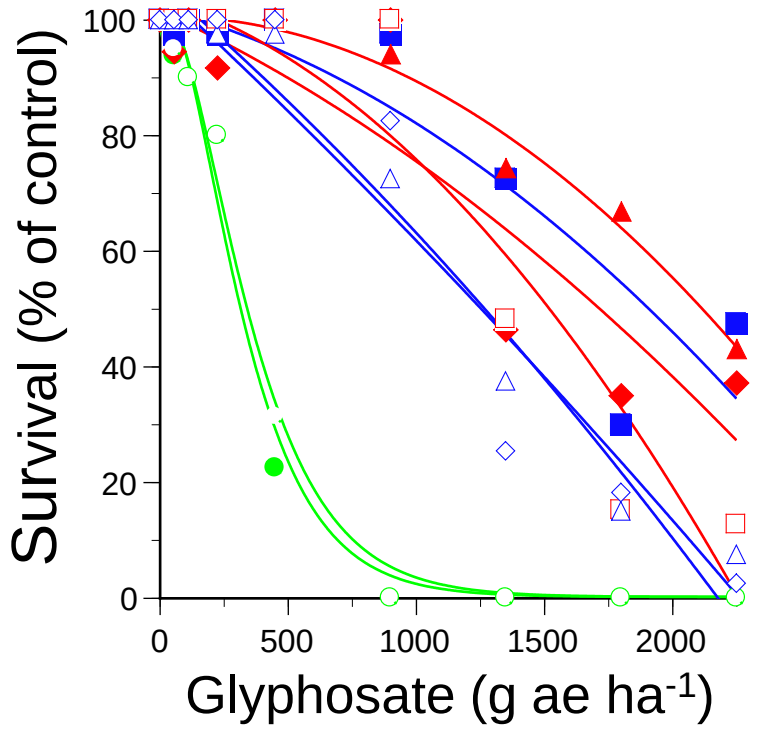
- three suspected Alberta populations (fields 1, 2 and 3)
- three known resistant populations from Kansas
- two known susceptible populations from Saskatchewan and Kansas

- applied glyphosate at 9 rates
- 0, 56 (1/8X), 112 (1/4X), 225 (1/2X), 450 (1X), 900 (2X), 1350 (3X), 1800 (4X), and 2250 (5X) g active/ha
- 450 g/ha = ½ litre product/acre of original (360 g/L) formulation


F1
F2
F3
Kansas
Susceptible
450 gae/ha
½ L/ac 360 formulation


F1
F2
F3
Kansas
Susceptible
900 gae/ha
1 L/ac 360 formulation


F1
F2
F3
Kansas
Susceptible
2250
2.5 L/ac 360
formulation




| | $LD_{50}$ | RF |
|---|---|---|
| Phillip | 1900 | 5.8 |
| Hays | 310 | - |
| AB-F1 | 2250 | 6.9 |
| AB-F2 | 1720 | 5.3 |
| AB-F3 | 1740 | 5.4 |
| Hanley | 340 | - |
| Scott | 1260 | 3.9 |
| Russel | 1280 | 3.9 |

Note: Field confirmation experiment at Lethbridge, 2012 indicated a resistance factor of 6.2

# Additional glyphosate-resistant kochia sites

**Fall, 2011**

- collected kochia plants from 46 sites within a 20-km radius of original populations
- 7 of 46 sites were glyphosate-resistant

**April, 2012**

- glyphosate-resistant kochia confirmed in Turin area

**Summer, 2012**

- 8 more kochia populations confirmed resistant (some from Brooks-Medicine Hat area)
- 10 confirmed populations in southern Saskatchewan

**Fall, 2012**

- random kochia samples from 300 sites in southern Alberta

Note: All GR kochia populations were found to be Group 2 resistant but susceptible to dicamba (Group 4).

# Resistance mechanism

. Seed of nine Alberta GR kochia populations were sent to Dr. Phil Westra at Colorado State University

. Target site mutation was ruled out

. Gene amplification is possible mechanism

- 3 to 10 extra gene copies of EPSPS were found in all Canadian and USA populations

. Reduced translocation still to be examined

# Herbicides to control Group 2 and Group 9 resistant kochia – Lethbridge, 2012

| Herbicide treatment | % Control |
|---|---|
| Glyphosate (450 g) | 35 |
| Cadet (fluthiacet) (4 g) | 55 |
| Partner (bromoxynil) (355 g) | 60 |
| Butril M (bromoxynil/MCPA) (560 g) | 65 |
| 2,4-D ester (560 g) | 65 |
| Benchmark [florasulam (5 g) + bromoxynil (285 g)] | 70 |
| 2,4-D ester (560 g) + Chateau (flumioxazin) (70 g) | 70 |
| Cleanstart (carfentrazone) (18 g) | 75 |
| Banvel (dicamba) (140 g) | 75 |

*Glyphosate at 450 g/ha was included in all treatments.

**Kochia was 5 cm tall and 6 cm in diameter when sprayed; density of 30 plants/m2; **non-crop situation**.

# Herbicides to control Group 2 and Group 9 resistant kochia – Lethbridge, 2012

| Herbicide treatment | % Control |
|---|---|
| Attain, Prestige products (fluroxypyr) (100 g) | 85 |
| Fluroxypyr (100 g) + florasulam (5 g) | 85 |
| Fluroxypyr (100 g) + Express (tribenuron) (7.5 g) | 85 |
| Infinity (prasulfotole/bromoxynil) (200 g) | 85 |
| Fluroxypyr (100 g) + 2,4-D ester (400 g) | 90 |
| Fluroxypyr (100 g) + bromoxynil (380 g) | 90 |
| Gramoxone (paraquat) (395 g) | 90 |
| Banvel (dicamba) (210 g) | 90 |
| Optica Trio (MCPA/dichlorprop/mecoprop-P) (1480 g) | 90 |
| Cleanstart (9 g) + Authority (sulfentrazone) (53 g) | 95 |
| Distinct (dicamba/diflufenzopyr) (100 g) | 95 |
| Banvel (dicamba) (300 g) | 98 |

# Herbicide groups

**Group 4:** dicamba, fluroxypyr, MCPA/dichloroprop/mecoprop-P

**Group 6:** bromoxynil

**Group 9:** glyphosate

**Group 14:** carfentrazone, flumioxazin, fluthiacet, saflufenacil, sulfentrazone

**Group 19:** diflufenzopyr

**Group 22:** paraquat

**Group 27:** prasulfutole

www.weedscience.org – listing of weed resistance around the world

# http://www.weedtool.com

- Objectives:
- (1) tool for producers to assess their risk of glyphosate resistance on a field-by-field basis;
- (2) raise awareness for proactive resistance management in western Canada
- Grower/farm advisor answers 10 questions related to crop production system, tillage system, and glyphosate usage (each question with four possible answers)
- Tool indicates relative risk of glyphosate resistance based on the 10 responses