Weed Control in Canola: An integrated approach

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Outline

- Canada canola acres and productivity
  - HR varieties and hybrids
- Integrated approach to weed management
- Background on herbicides and resistance
- Herbicide intervention pre-seeding, in crop
- Avoiding herbicide resistance selection
- Is canola a weed? In fields and ruderal areas.

Canadian Canola Production

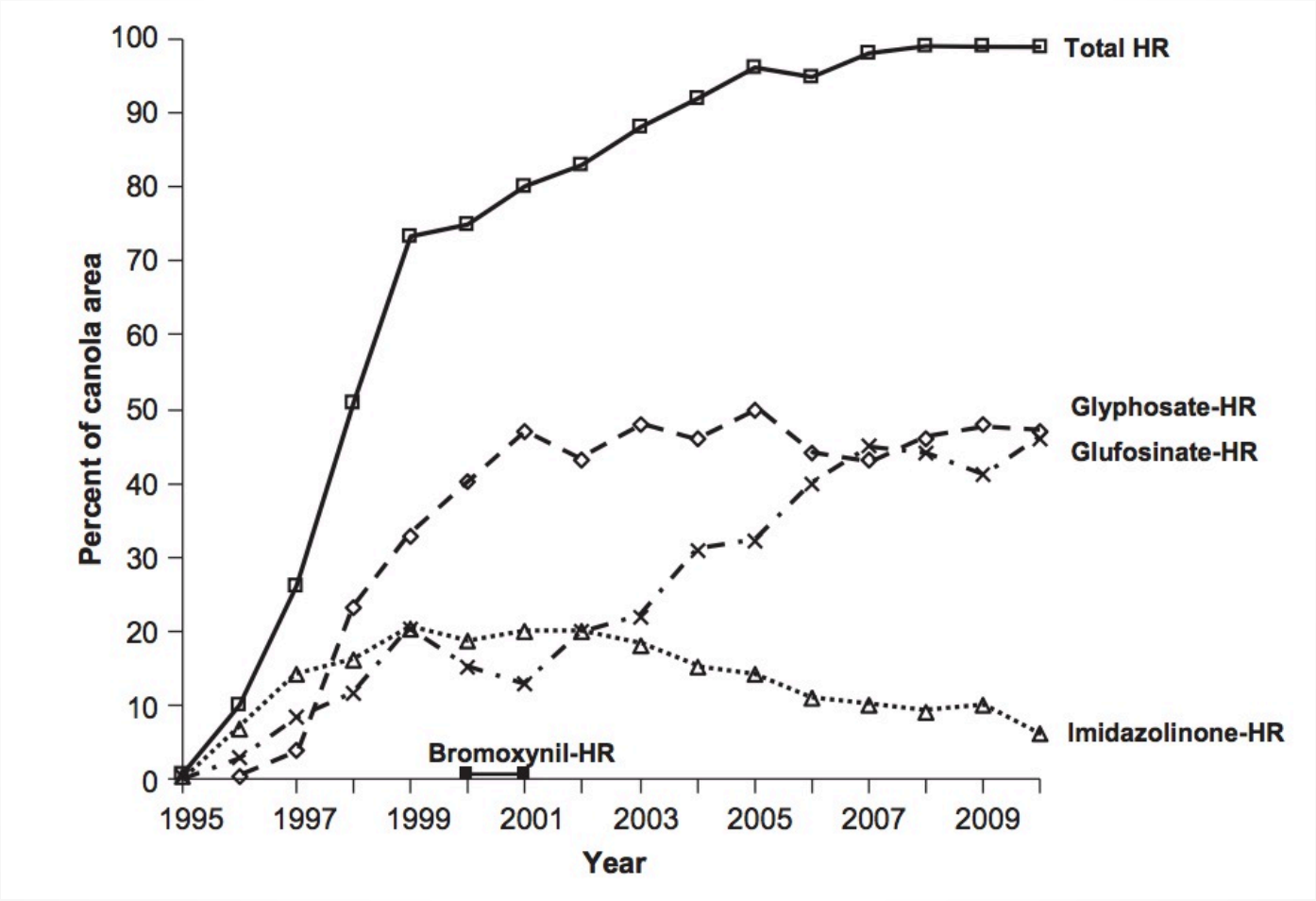
- In 1990, 2.5 million ha were seeded with a total production of 3.26 M tonnes
  - (1.3 tonnes ha^{-1})
- By 2012, 6.8 M ha and 3.26 M tonnes
  - (2.08 tonnes ha^{-1})
- Due to optimized fertilizer use, timely herbicides, enhanced HR hybrid varieties, enhanced management practices

Weed management is one of dozens of key management variables affecting canola establishment and yield

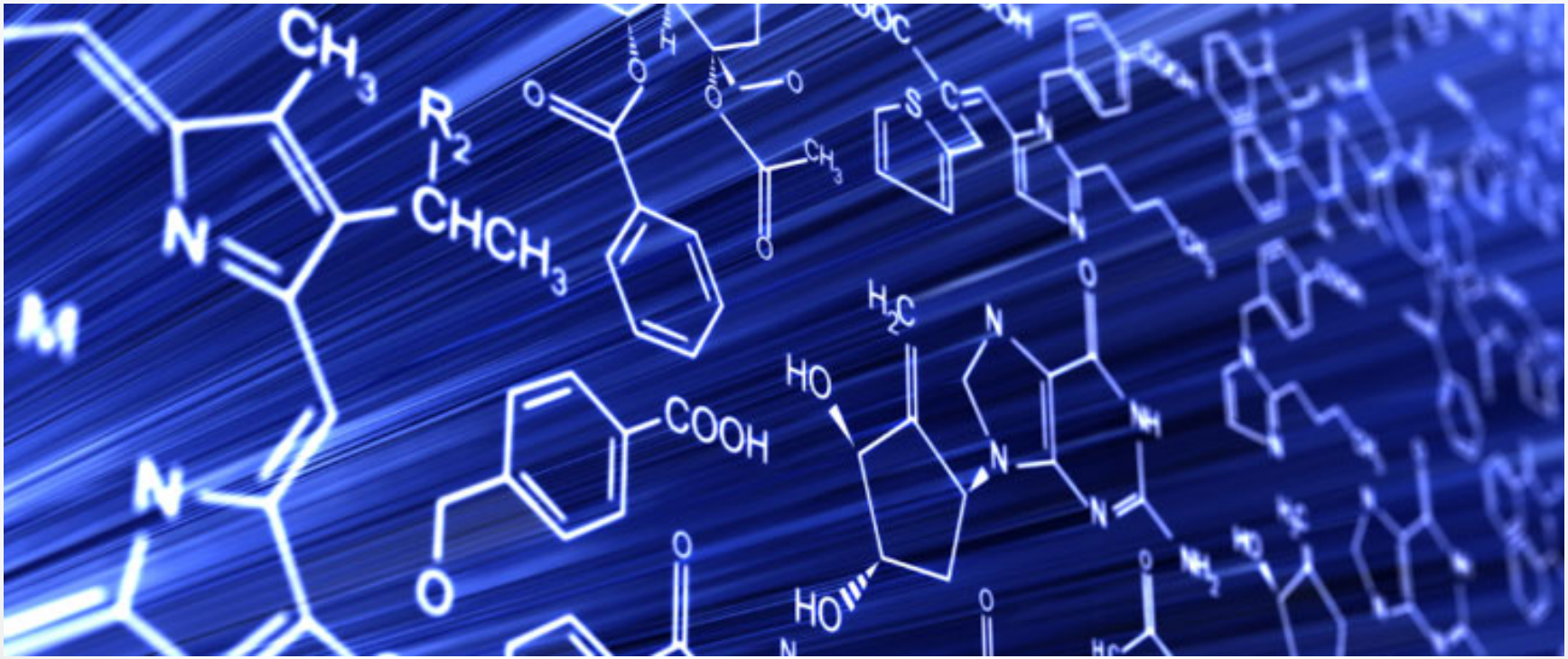
Weed management depends on

- rotational diversity and
- crop establishment

Adoption of herbicide resistant (HR) varieties in Canada



If you rely only on chemistry, it will fail

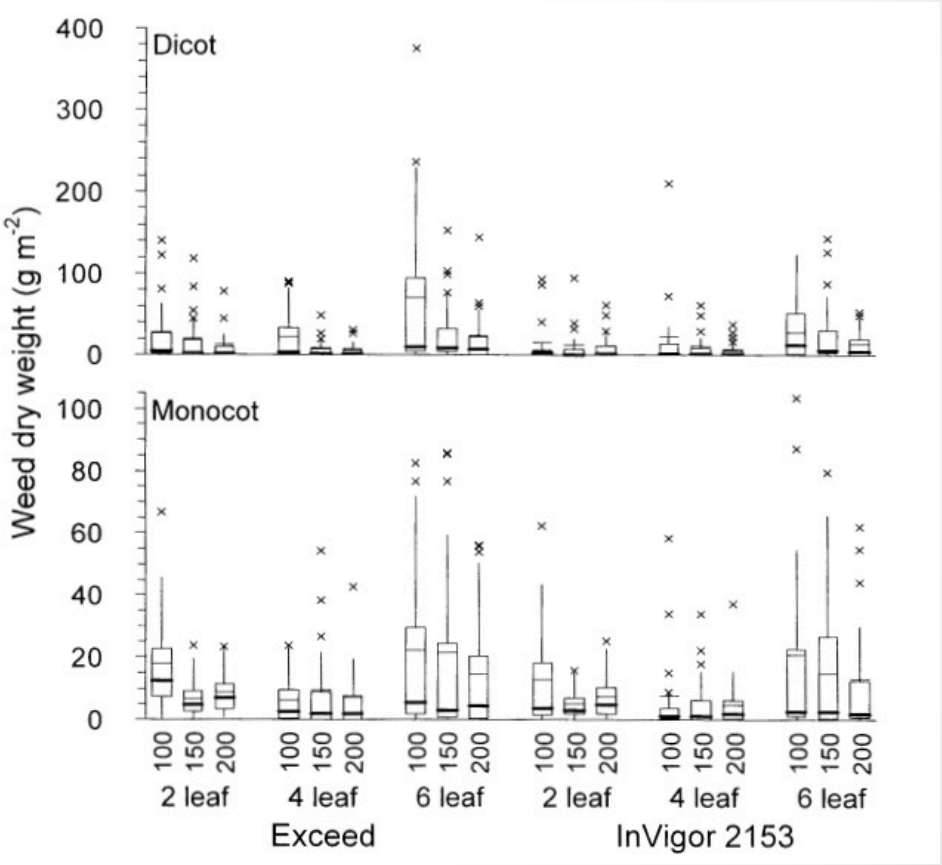


Crop health/vigor increases weed control and yield

- Factors affecting crop health
  - Fertility
  - Variety choice (G*E)
  - Weather/climate/soil
  - Direct seeding
  - Time of herbicide application
  - Seeding rate (but wait – there is more to it than seeds in the ground!)
  - Depth of seeding
  - Speed of seeding
  - Time of seeding
  - Precision seeding
  - Crop rotation
- Ask a simple question – get a simple answer
- Ask a complex question and experimental variability increases
  - Multiple sites, multiple years and multi-factorial experiments
  - (expensive and require consistency in research skills)
- Survey of grower practices (large scale) provide more complex responses

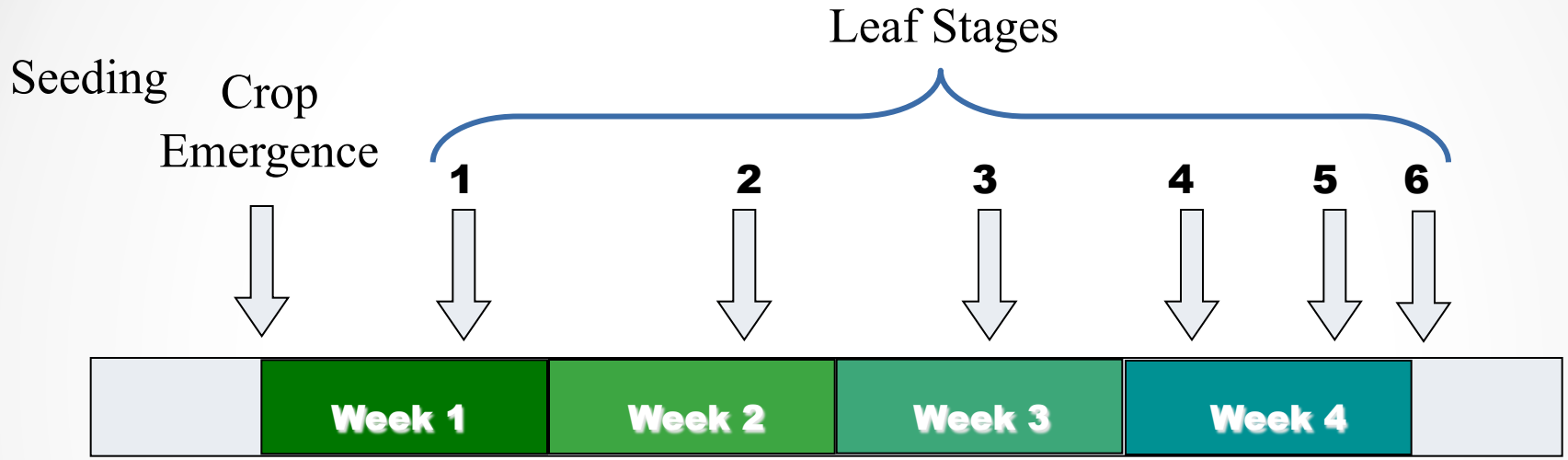
Early weed removal

- Two LL varieties, open pollinated Exceed and Hybrid InVigor
  - Non residual herbicide
- Seed rate (100,150 and 200)
- Time of weed removal (2, 4 and 6 leaf)
- Early emerging weeds are the most competitive and have the largest effect on yield
- Combining cultivar, high seeding rate and early removal resulted in a 42% increase in yield



Harker, K. N., et al. "Seeding rate, herbicide timing and competitive hybrids contribute to integrated weed management in canola (Brassica napus)." Canadian journal of plant science 83.2 (2003): 433-440.

Timing is Everything!

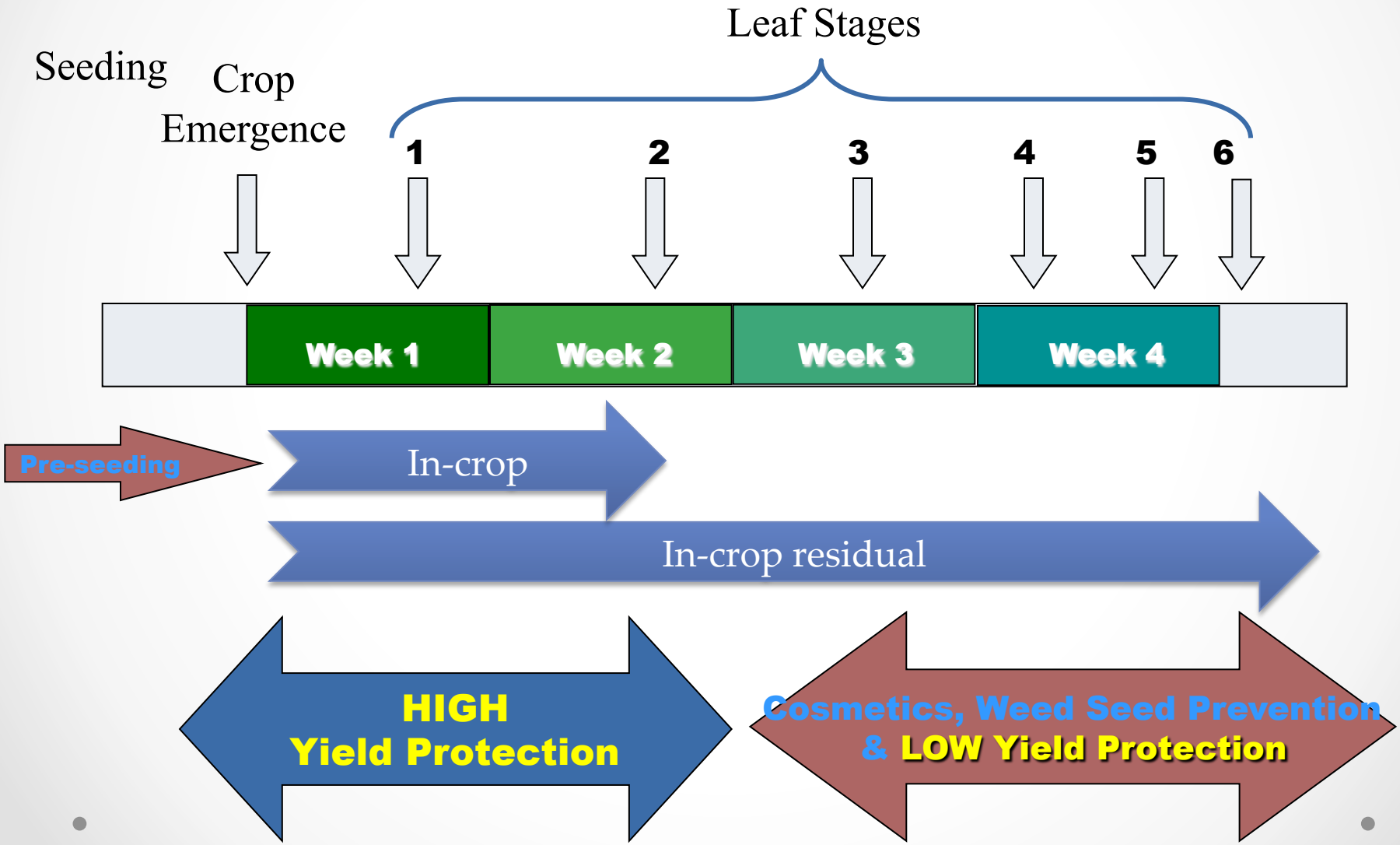


Weeds Emerging Here Cause Crop Loss

HIGH Yield Protection

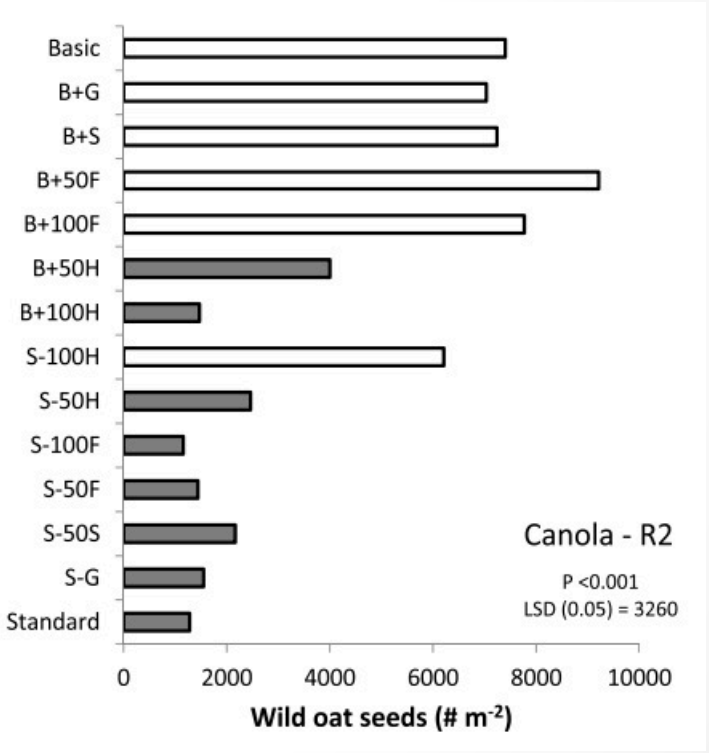
Cosmetics, Weed Seed Prevention & LOW Yield Protection

Time of intervention



Interactions of agronomic practices on wild oat populations in canola

- It may be possible to enhance the effectiveness of herbicides through agronomic practices
  - Reduce weed populations
  - Add cultural control to herbicide control
- Add and removal of treatments



Stand uniformity with precision seeding

Up to 32 % yield increase with optimized spatial patterns of canola plant establishment in western Canada. 2014. Chao Yang & Yantai Gan & K. Neil Harker &

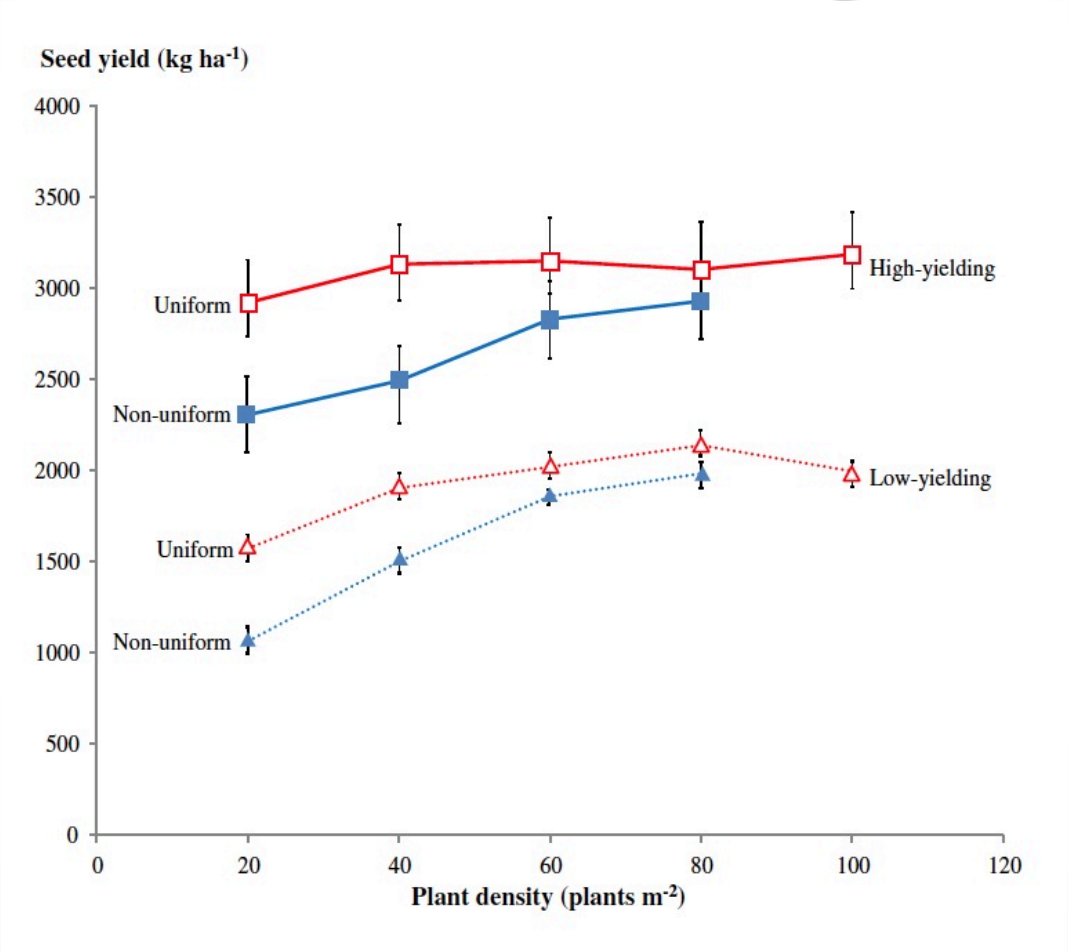
H. Randy Kutcher & Rob Gulden & Byron Irvine & William E. May

DOI 10.1007/s13593-014-0218-5

Stand uniformity optimizes the use of available resources and increases weed competition

Influence of seeding rate and plant stand uniformity on yield

16 Site years in western Canada



Rotational benefits

- From farm survey, cumulative influence of rotations on canola yield
- Causal factors?
- Weeds, insect, disease? Loss of diversity?

	Canola Yield Relative to Rotation Breaks of 1 and 2 years		
Alberta soil zone	Canola on canola	1 and 2 year break	3 year break
Dark Brown	-	100%	107
Thin Black	89	100	110
Black	79*	100	105
Black Dark Grey East	83	100	108
Black Dark Grey West	86	100	97*
Peace region	82	100	-

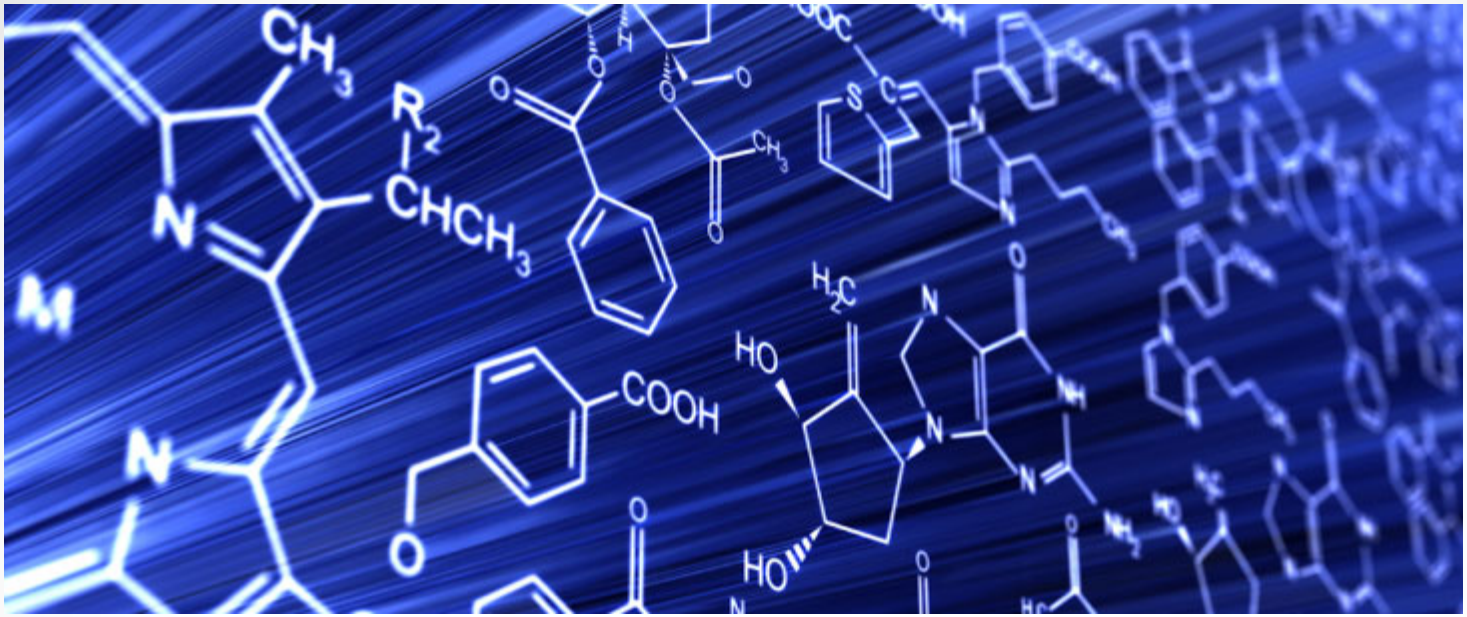
*Limited data, only 3 of 6 years

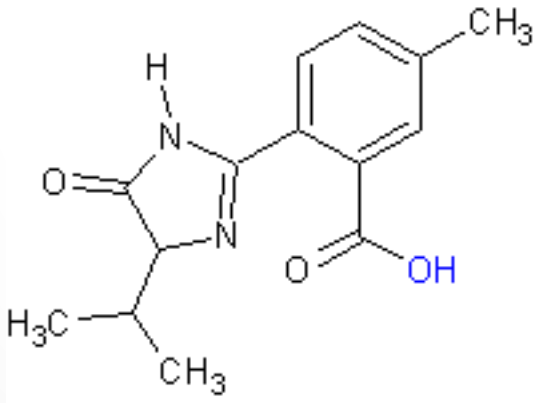
Crop Rotations

- Crop rotation leads to reduced weed populations
  - Changes in herbicides
  - Changes in competition
  - Changes in time of application

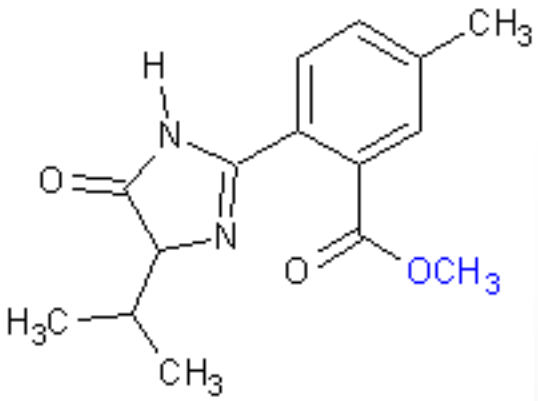
Effect of agronomic inputs and crop rotation on biodiesel quality and fatty acid profiles of direct-seeded canola

K. N. Harker[1], J. T. O'Donovan[1], R. E. Blackshaw[2], L. M. Hall[3], C. J. Willenborg[4], H. R. Kutcher[4], Y. Gan[5], G. P. Lafond[6], W. E. May[6], C. A. Grant[7], V. Barthet[8], T. McDonald[9], D. Wispinski[10], and M. Hartman[11]





imazamethabenz-methyl



imizethapyr

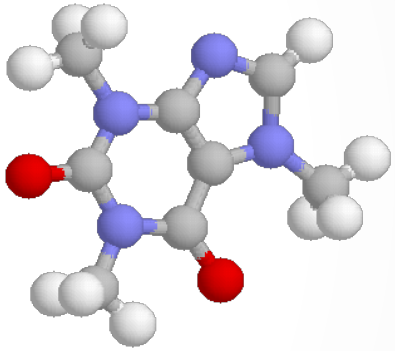
Entry into the plant (foliar or root)

Entry into the cell

Translocation via xylem or phloem

Entry into subcellar organelle

Metabolism – activation or degradation

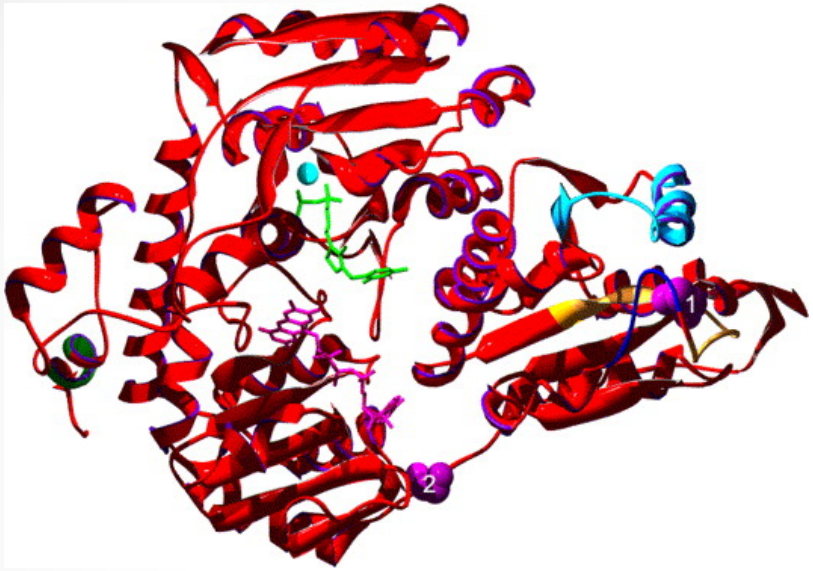


Interaction at the target site

Sequestration

Physio-chemical Properties
Pka and K_{ow}

Whole plant response



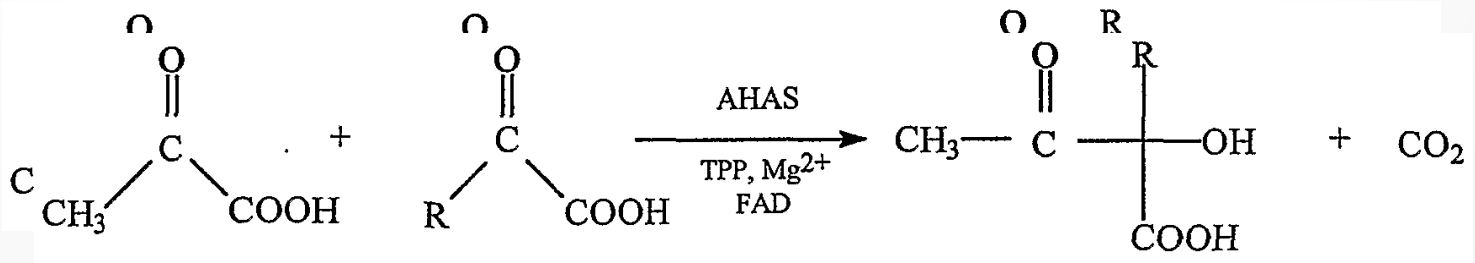
ALS (or AHAS) Acetolactate synthase

Mixed inhibition by four families of herbicides

Enzyme is a key in the synthesis of branched chain amino acids

Catalyzes two reactions

ALS



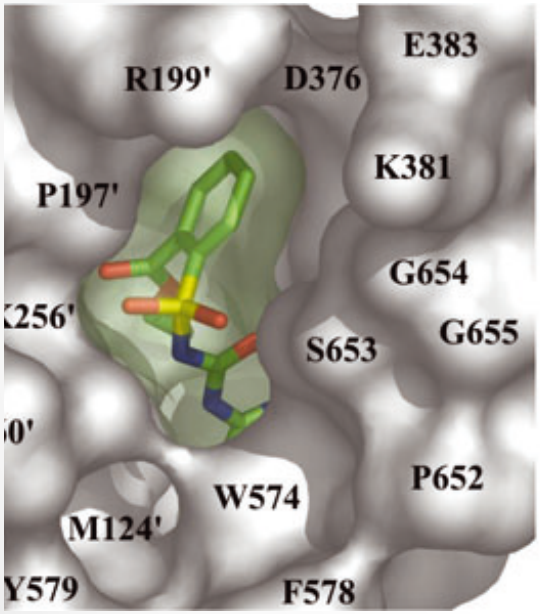
Imidazolinone herbicides

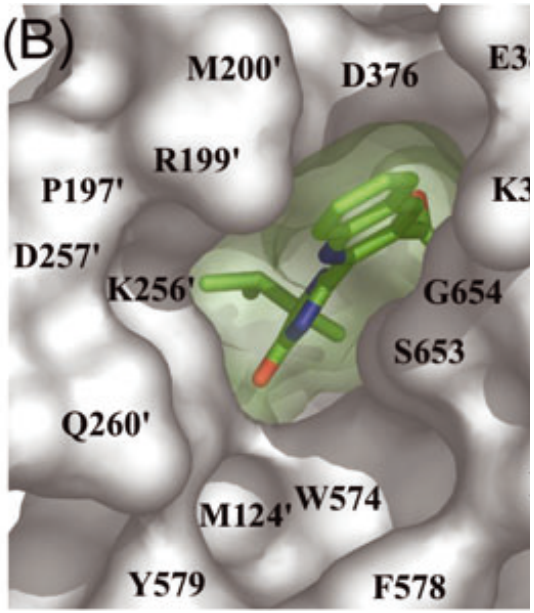
Common Name	Product name	Residual (half life days)
Imazapyr		25-122
Imazapic		120
Imazethapyr		60-90
Imazamox		20-30
Imazaquin		60
Imazamethabenz		25-36

Herbicide Handbook WSSA 2007

Sulfonylurea	thifensulfuron	RefineExtra*
	tribenuron	RefineExtra* Express
	metsulfuron	Ally
	sulfosulfuron	Sundance
Imidazolinone	imazamethabenz	Assert
	imazapyr	Pursuit
	imazamox	Odyssey*
Triazolprimidine	florasulam	Spectrum, Frontline
	pyroxsulam	Simplicity
Sulfonyl amino carbonyl triazolinones	flucarbazone-sodium	Everest

Binding of sulfonylurea and imidazolinone to the ALS site of action





The ALS binding site is very susceptible to genetic changes without reductions in fitness

Clearfield crops

- Selected for a modified ALS which binds with low affinity to imidazolinone herbicides
- Wheat, sunflower, lentils, canola, others

Group 2 - Symptoms

Slow to appear

- Inhibition of plant growth
- **chlorosis**
- **terminal bud death**
- purple coloration
- death is slow
- ALS in young meristematic regions

Imidazolinone – soil interactions

- Imizaolinones are adsorbed to soil and adsorption effects the activity and persistence of these products
- Adsorption is influence by pH, organic matter and time
- The weak acid nature of these products plays an important role in soil activity
- At soil ph, the negatively charged anionic form predominates and this form is repelled from the negative charge of the soil colloids, resulting in low adsorption to neutral and high pH soils
- As soil pH decreases (ph <6) herbicide adsorption increases and so does persistence
- This is moderated by both organic matter and water, more organic matter increases adsorption

Soil persistence and microbial degradation

- Soil degradation is through microbial degradation and any factor that influences microbial activity affects degradation
  - Temperature, moisture, pH
- Soil residual is measured in herbicide half life ($T_{0.5}$) days
- For long residual herbicides (imazapyr, sulfometuron) the half lives can be significant

Herbicide	Half life (days)
Imazapyr	25-142
Sulfometuron methyl	20-28
Florasulam	2-8

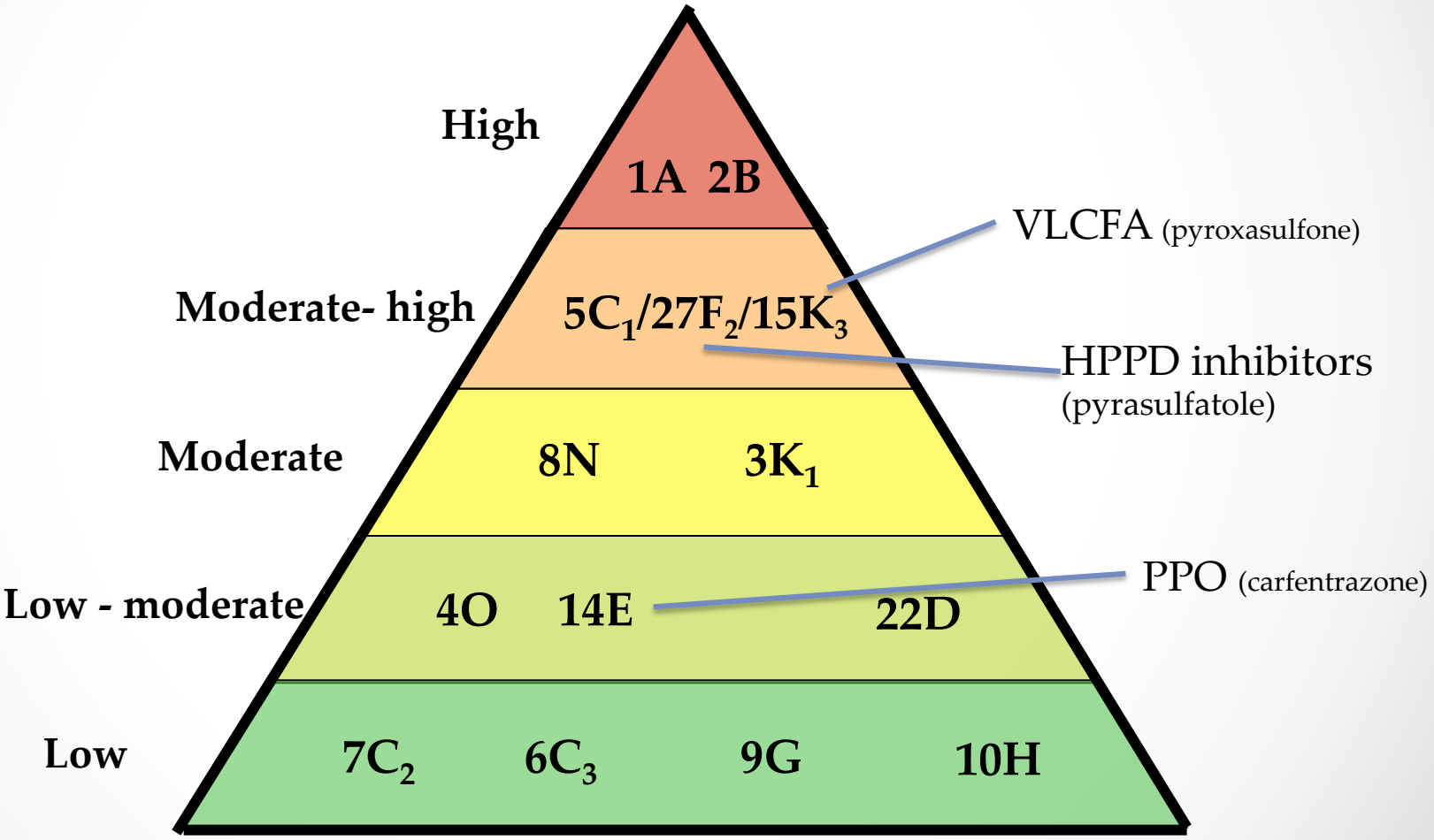
Relative Toxicity Categories

Mammals (people)

Relative Toxicity Category	Oral LD_{50} (mg/kg)	Dermal LD_{50} (mg/kg)
Slightly Toxic	> 500	> 1000
Moderately Toxic	51 - 500	201 - 1000
Very Toxic	0 - 50	0 – 200

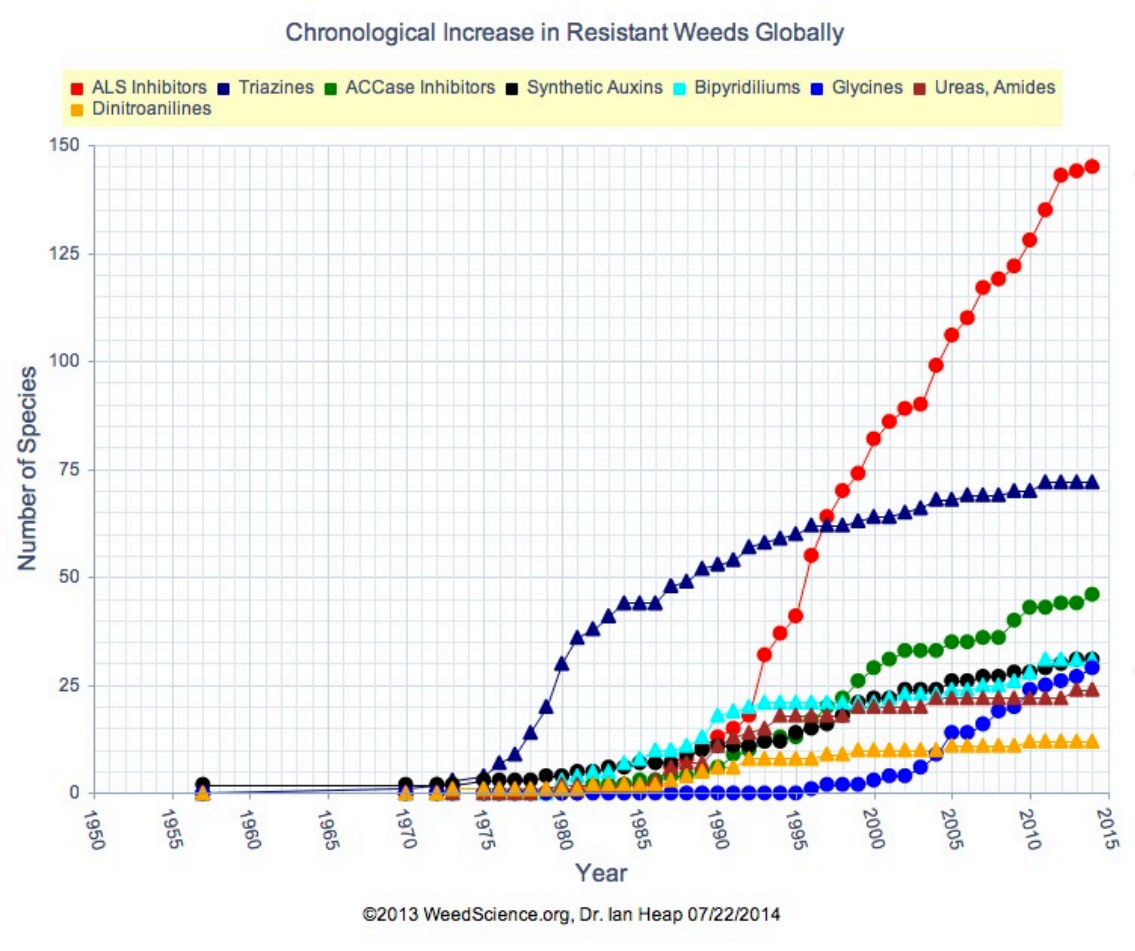
Product	Oral LD_{50}
Refine	>5000 mg/kg
Odyssey	>5000 mg/kg

Herbicide Risk Triangle



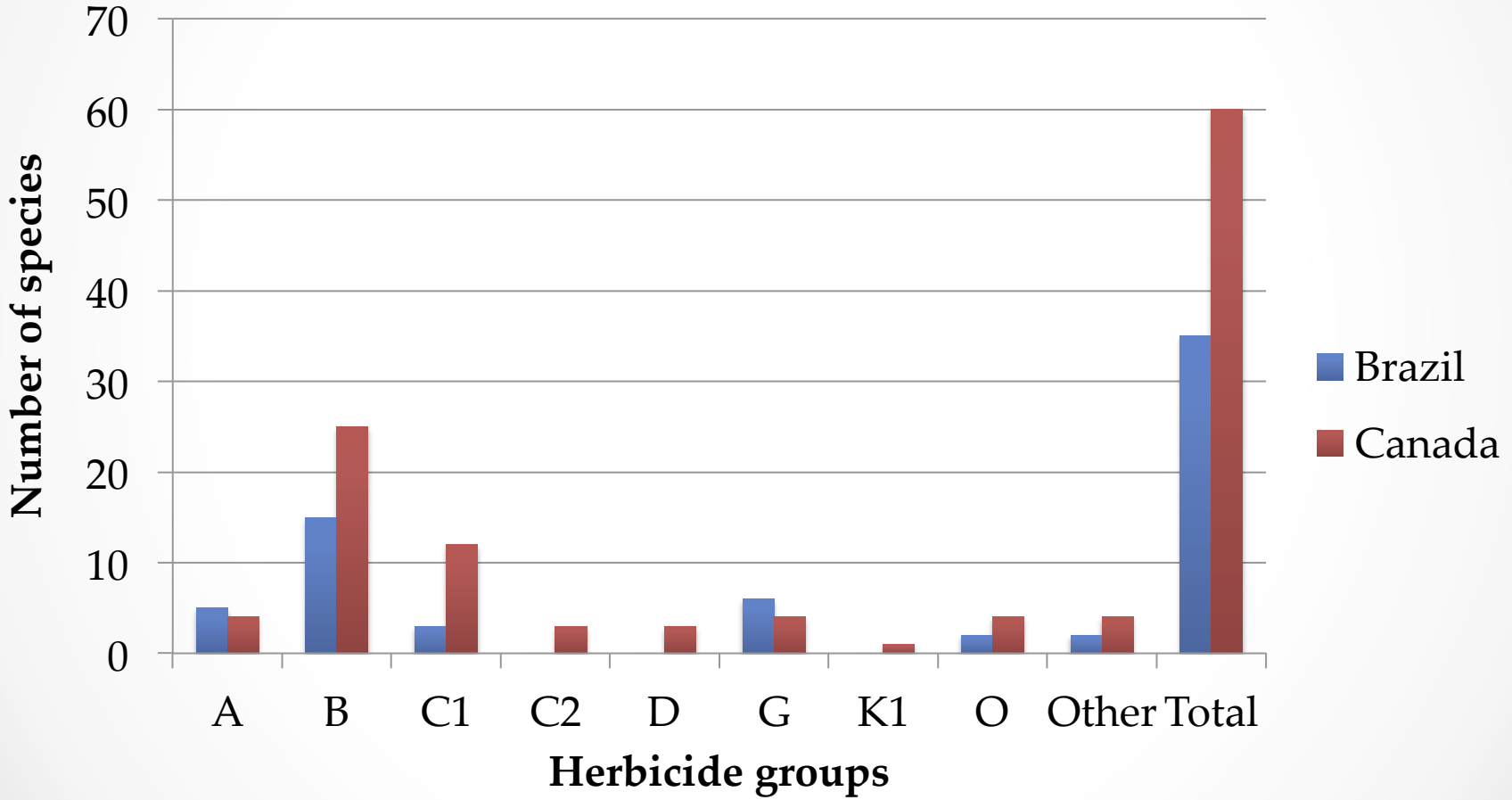
Beckie et al 2006

ALS (Group B) herbicides are the products most prone to select for resistance



Glyphosate/ Glufosinate resistant canola decrease the concern with Group A and B herbicides when introduced

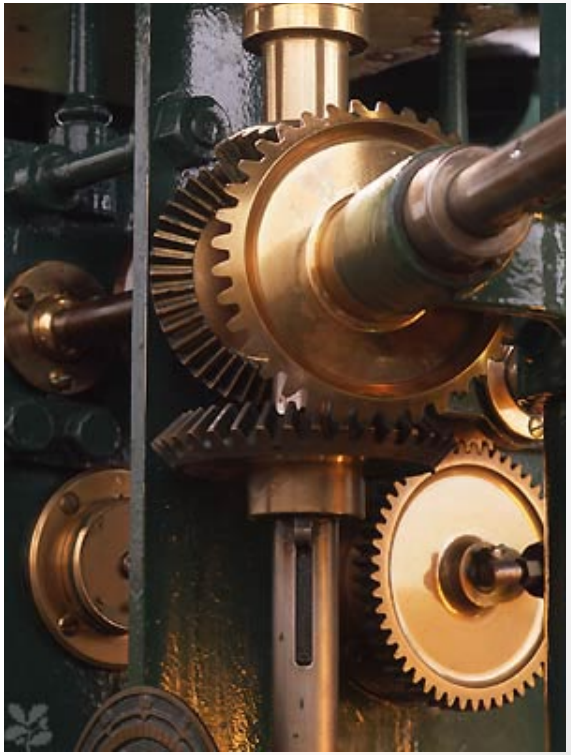
Herbicide resistant weeds reported in Brazil and Canada



Potential Mechanisms of Resistance

Anything that works!

1. Changes to the target site
    - Changes the binding of herbicide to target site
2. Gene amplification that increases the amount of the target site
3. Changes in the rate or pathway of herbicide metabolism
4. Changes in the translocation of herbicides
5. Ability to withstand toxic effects of the herbicide
6. Altered herbicide uptake
7. Sequestration of the herbicide away from the target site



All Selective Management Practices Change the Nature of a Weed Population

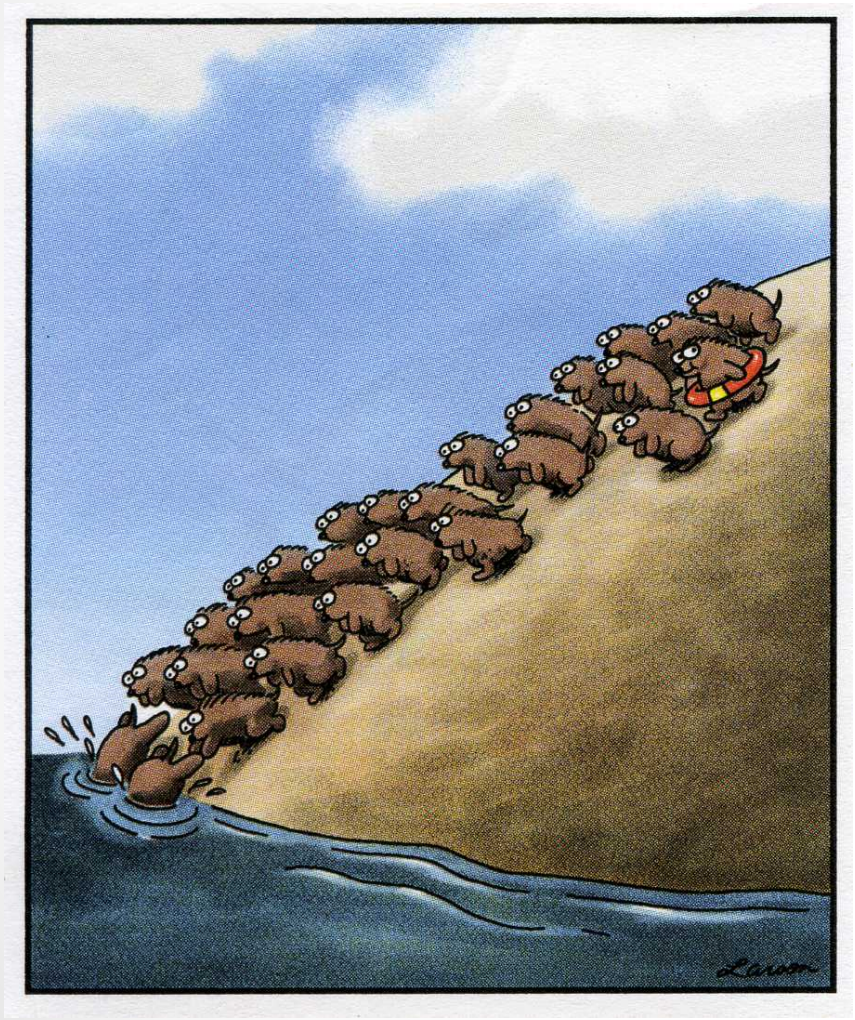
- Weed populations are genetically variable
- Variation via mutation or pre-existing in a population
- Weed populations are dynamic, they respond to shifts in climate, management (like tillage), crop choice, time of seeding, and selection by herbicides

"Make it look like natural selection."

Factors Effecting the Rate of Selection

- Number of weeds selected
- Frequency of use (↑ applications = more selection)
  - duration of selection (residual herbicides)
- Selection pressure
  - herbicide efficacy (↑ control = more selection)
- Genetic nature of the resistance mechanism
- Weeds biology
  - Longevity of weed seeds in soil (buffers selection)
  - Number of weed seeds in the soil
- Fitness

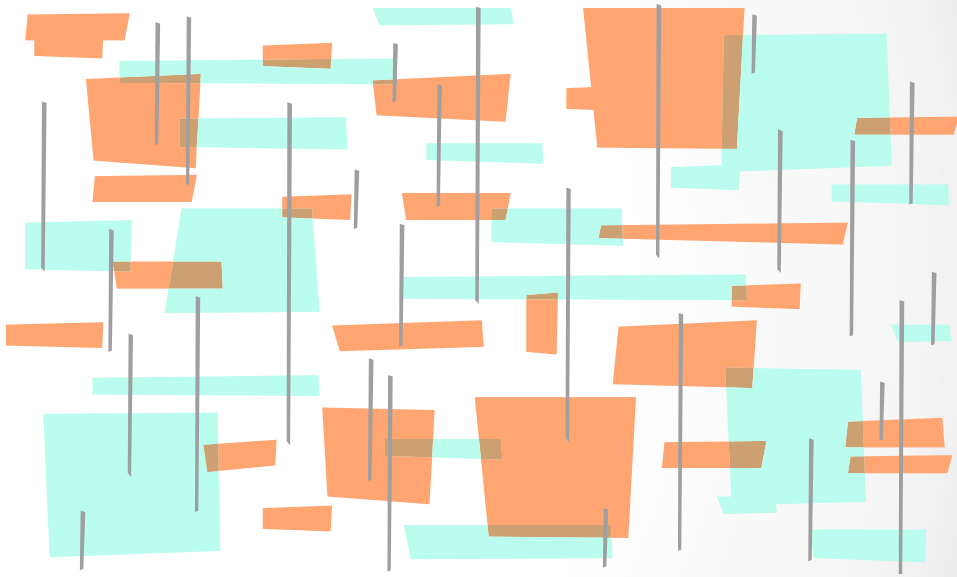
Survival of the fittest?



- Any individual that can survive the application of an ALS inhibitor may reproduce and the genes increase in the population

Herbicide Use Patterns

- Not all chemicals are alike in their ability to select for resistance
- After many years of Group 4 herbicides, resistant individuals are just beginning to be examined
- Resistance to ALS inhibitors can be selected in a field by 5-7 years application



Intervention Options with Herbicides

- ✓ Pre-harvest glyphosate in the preceding crop year (perennials)
- ✓ Pre-seeding control (winter annuals and early germinating spring annuals)
- ✓ Use of pre-emergence herbicides (annuals)
- ✓ Early applied post-emergence herbicides (s&w annuals)
- ✓ Apply an early post-emergence herbicide with soil residual activity (s&w annuals)
- ✓ Split application of post-emergence herbicides (s&w annuals)

Is canola a weed?

- Canola is the 14th most abundant weed in Western Canadian cropping systems
- Average seed loss pre and post harvest is >8,000 plant m^{-2}
- Secondary seed dormancy from seed burial (absence of light, cooler temperatures)
- Limited seed persistence
- At the end of the first winter, only 1/3 remain, 0.5% emerge and in the second year the seed bank is reduced to 0.3%

Canola volunteer control

- **Not** other Group B products
- Mixtures of Group O products
  - 2,4-D, MCPA, fluroxypyr
- With glyphosate
- Bentazon, bromoxynil (C)
- Pyrasulfotole (Group F)
- Carfentazone (Group E)
- Saflufenacil (Group E)

Canola in ruderal areas

- Seed spillage along roadways and railroads is common
- Canola is common ruderal (disturbed) areas, especially along rural roads, in ports and collection areas
- Often seed in Canadian cities where soil has been moved
- Ruderal populations are ephemeral but are maintained by reintroduction
- Not found where environments are undisturbed (natural areas)

Reliance on a few herbicides has lead to resistance all over the world

- Your options for use of imidazolinone herbicides in the same field are limited
  - How many hits before you hit the wall?
- Use the power of competitive hybrids backed by herbicides
- Diversity in rotation, herbicides (by group), time of intervention
- Use them carefully and with additional products if possible
  - Herbicide mixes, herbicides in sequence