WEED CONTROL IN PERENNIAL PASTURES:

HERBICIDE RESISTANCE - A POTENTIAL PROBLEM FOR PERENNIAL PASTURES?

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Abstract: *Herbicide resistance is a problem world-wide. Since the first confirmed case in 1970, 113 species of weeds have developed resistance to herbicides. In Australia, seven weeds have developed resistance to herbicides with the most widespread and economically important being annual ryegrass (Lolium rigidum). It is now estimated that something in excess of 600 paddocks have resistant populations of annual ryegrass in Australia. With these statistics in mind, it is logical that most producers would be concerned about the problem. In this paper, we will report on several aspects of herbicide resistance and show that: (1) The problem is caused by persistent use of the same or similar herbicides.; (2) The problem can be avoided readily; (3) It is extremely unlikely to develop in normal perennial pasture situations.*

Anyone who knows something about breeding plants or animals will not have trouble understanding the resistance story.

Breeding animals or plants to produce a more desirable or different product is possible because of naturally occurring genetic variability:

eg. **For animals**

- Coat colour
- Conformation
- Milk production

For plants

- Seedling vigour
- Winter growth
- Dry matter production

Just as there is variability in animals for traits which can be selected for or against, weeds have variability in their susceptibility to herbicides.

HOW DOES RESISTANCE ORIGINATE?

Take the now common situation of annual ryegrass resistance to Hoegrass(R). It has been estimated that in any field of ryegrass about 1 in 100,000 plants will already be resistant to Hoegrass(R). This frequency can vary quite a bit depending on previous herbicide use.

Each time Hoegrass(R) is applied to the paddock, the susceptible plants are killed leaving the resistant ones alive. If Hoegrass(R) is used annually for about four seasons, it is probable that the frequency of resistant biotypes will increase from 1 in 100,000 to 100%! That is, repeated use of this herbicide is applying extremely strong selection pressure in favour of the resistant types.

Ryegrass is a cross-pollinating species. Therefore, any surviving susceptible plants (from the hard seed pool in the soil or spray misses) will probably cross with resistant types. So, as well as the selection pressure imposed by the herbicide, ryegrass cross-pollinating in nature increases the proportion of resistant biotypes.

The resistant weed types tend to be slightly less competitive than normal susceptible ones. This partly explains their very low initial frequency. Once herbicide selection pressure is removed, the population will begin to return to normal albeit very slowly. It has been estimated that if left unassisted the return to normal would take about 40 years!

ARE ALL HERBICIDES AT EQUAL RISK?

Some herbicides such as Hoegrass(R) have specific modes of action within the target plant. This specific mode of action makes the herbicide far more prone to resistance than 2,4D which has several modes of action within the plant.

Table 1 compares the length of time taken to produce high levels of resistance in weed populations with a variety of herbicides.

Table 1: Time taken to produce resistance in weeds

Herbicide	Weed	Years of continuous herbicide application to produce high levels of resistance
Paraquat	barley grass	13
Diuron	annual ryegrass	10–14
Glean(R)	annual ryegrass	6–7
Hoegrass(R)	annual ryegrass	3–4

It appears that, in respect to the development of resistance, the major difference between herbicides is the number of years of continued use required to generate the problem.

Some herbicides, notably glyphosate, have not generated a resistance problem yet.

THE CROSS RESISTANCE PROBLEM

Due to the similar modes of action of herbicides within each group, it is not surprising that a resistance problem with one is also likely with others in that group.

Herbicides are classified into groups based on chemical similarity and mode of action. Table 2 lists those herbicides which show activity against ryegrass.

One of the more disturbing features of the resistance problem is cross resistance. This occurs when selection pressure by one herbicide (*eg.* Hoegrass(R), a group 1 herbicide) produces resistant ryegrass. At the same time, and without being exposed to it, the ryegrass develops resistance to an unrelated herbicide (*eg.* Glean(R), a group 2 herbicide).

The bad news does not end there. In one case in South Australia, an annual ryegrass population developed resistance through persistent use of Hoegrass(R). Subsequent tests showed cross resistance had developed to eleven herbicides across four chemical groups.

SOME CASE HISTORIES OF RESISTANCE

RAILWAY LINE IN WESTERN AUSTRALIA

In this example, the Railway Department in Western Australia used a mixture of amitrole and atrazine for weed control along its tracks. About 5000 km of tracks were treated annually for ten years with the mixture which until recently gave excellent results. The mix began failing and testing showed that annual ryegrass strains resistant to both amitrole and atrazine had developed.

Note that in this example, resistance took about 10 years to develop, partly because of the non-selective nature of the herbicides and partly because two different herbicides were used.

CANOLA/CEREAL/LUPIN FARM AT WAGGA

On this property, the producer had developed a rotation of canola, lupins and cereals. His crop and herbicide application history are shown in Table 3.

In 1990, there was a complete failure to control ryegrass. Trials were conducted immediately which confirmed resistance to Sertin, Fusilade and Hoegrass.

Table 3: Crop rotation and herbicide program for a farm near Wagga Wagga.

YEAR	CROP	HERBICIDES
1985	Canola	2 L/ha Treflan
1986	Wheat	1.5 L/ha Hoegrass
1987	Wheat	1.5 L/ha Hoegrass
1988	Lupins	375 ml/ha Fusilade
1989	Wheat	1.5 L/ha Hoegrass
1990	Lupins	350 ml Sertin plus 150 ml Fusilade

Note that in this example, from 1986 onwards, only Group 1 herbicides were involved, and resistance appeared in only 4- 5 seasons.

GRASS SEED PRODUCER IN SOUTHERN NSW

Perennial grass seed is produced in semi- permanent paddocks where the seed in harvested each year. Until recent resistance problems began to surface, weed control was achieved using the same herbicides every year.

In the cocksfoot paddock, the producer used the standard method of ryegrass control in his cocksfoot stand, *ie.* Hoegrass (R) @1.25L/ha. After only three

Table 2: Agricultural herbicides grouped according to biochemical mode of action

GROUP 1
(Inhibitors of lipid synthesis)

GROUP 1A:
ARYLOXYPHENOXYPROPIONATES ("Fops)

Hoegrass(R) Nugrass(R) Digrass(R)	diclofop
Fusilade(R)	fluazifop
Verdict(R)	haloxyfop
Assure(R)	quizalofop
Puma(R)	fenoxafop

GROUP 1B:
CYCLOHEXANEDIONES ("Dims)

Sertin(R)	sethoxydim
Grasp(R)	tralkoxydim
Focus(R)	cycloxydim
Select(R)	clethodim

GROUP 2
(Inhibitors of amino acid synthesis)

GROUP 2A:
SULFONYLUREAS

Glean(R)	chlorsulfuron
Ally(R)	metsulfuron
Logran(R)	triasulfuron

GROUP 2B:
IMIDAZOLINONES

Pursuit(R)	imazethapry

GROUP 3
(Inhibitors of cell division and tubulin formation)

GROUP 3A:
DINITROANILINES

Treflan(R)	trifluralin
Stomp(R)	pendimethalin
Yield(R)	trifluralin/oryzalin
Surflan(R)	oryzalin

GROUP 3B:
THIOCARBAMATES

Avadex BW(R)	triallate

GROUP 4
(Inhibitors of cell division and other processes)

GROUP 4A:
AMIDES

Kerb(R)	propyzamide
Dual(R)	metolachlor

GROUP 4 (Cont'd)
(Inhibitors of cell division and other processes)

GROUP 4B:
CARBAMATES

Carbetamex(R)	carbetamide
Propham	propham
Chlorpropham	chlorpropham

GROUP 5
(Inhibitors of photosynthesis)

GROUP 5A:
UREAS

Diuron(R)	diuron
Linuron(R)	linuron
Dosanex(R)	metoxuron

GROUP 5B:
TRIAZINES

Simazine	simazine
Atrazine	atrazine
Bladex(R)	cyanazine
Igran(R)	terbutryn

GROUP 5C:
TRIAZINONES

Metribuzin	metribuzin

GROUP 6
(Inhibitor of aromatic amino acid synthesis)

GROUP 6:
GLYCINES

Roundup(R) Glyphosate(R)	glyphosate

GROUP 7
(Inhibitors of photosynthesis PSI respiration and cell membrane damage)

GROUP 7:
BIPYRIDYLS

Reglone(R)	diquat
Gramoxone(R) Shirquat(R)	paraquat
Sprayseed(R)	diquat/paraquat

GROUP 8
(Inhibitor of carotenoid synthesis)

GROUP 8:

Amitrole	amitrole

years, weed control had begun to deteriorate because of resistance.

In great contrast, he had used diuron at 3.3 kg/ha for ryegrass control in his phalaris seed paddocks. Unlike the Hoegrass(R) this chemical proved to be effective over a much longer time (many years). However, as in the railway example, resistance to diuron did develop in the long run.

Once again, these examples highlight that:-

- Resistance comes from repeated use of the same or similar herbicides.

- Non site-specific herbicides take much longer to generate a problem than sight specific herbicides.

PREVENTING RESISTANCE

Graziers, who are concerned only with running stock on their pastures have the perfect prevention technique already functioning. That is, very little, if any herbicide use. Materials that are used (2,4-D, M.C.P.A., Sprayseed(R), Roundup(R)) are from groups which, history indicates, are least likely to cause rapid selection.

Ley farmers whose paddocks are in pasture 50% of the time, have several powerful, non-selective techniques which are used during the pasture phase:

- Grazing
- Hay or silage production
- Spring ploughing
- Spray fallowing
- Spray topping

In the crop phase, providing some care is used in selecting the herbicides, selection pressure will be relatively low and so resistance unlikely. This is especially the case if a relatively short crop phase (3-4 years) is used in the rotation.

Continuous crop producers and pasture seed producers need to be extremely careful in their choice of herbicides. In fact, in cases where herbicide resistance has appeared, these producers must introduce a grazing pasture phase to reduce the annual reliance on herbicides.

The example of a crop rotation given in Table 4 shows how the risk of herbicide resistance might be reduced or minimised by an informed choice of appropriate herbicies.

Look at the chemical choice column. Under "poor" choice the herbicides have all been selected from the Group 1. This is the perfect scenario for resistance with high selection pressure being maintained for five seasons.

Under the "better choice "column, the herbicides are from four different chemical groups. This is much less likely to generate resistance.

Herbicide rotation is much more feasible if crop rotation is used at the same time.

Table 4: Crop rotation with "poor" and "better" choice of herbicides with regard to herbicide resistance.

CROP ROTATION	WEED	HERBICIDE PROGRAM Poor choice	Better choice
Canola	Ryegrass	Hoegrass	Trifluralin
Wheat	Ryegrass	Hoegrass	Glean
Lupin	Ryegrass	Verdict	Simazine
Wheat	Ryegrass	Hoegrass	Hoegrass
Peas	Ryegrass	Sertin	Sertin

COMBINATIONS OF ALL AVAILABLE METHODS

It should be reasonably obvious if, in association with herbicide group rotation, we can introduce a pasture phase, where no chemical methods can be used.

Take the example given in Table 4, and rather than the pea crop, begin a pasture phase. This program (Table 5) has a balance of all techniques and given the current knowledge of resistance, is less likely to generate problems.

Table 5: Crop/pasture rotation designed to minimise herbicide resistance problems.

CROP	WEED/PASTURE PLANT	CONTROL METHODS
Canola	Annual ryegrass	Trifluralin
Wheat	Annual ryegrass	Glean
Lupins	Annual ryegrass	Simazine
Wheat	Annual ryegrass	Hoegrass
Pasture	Annual ryegrass	Haycut
Pasture	Annual ryegrass	Grazing
Pasture	Annual ryegrass	Grazing
Pasture	Annual ryegrass	Spraytop

RAMIFICATIONS OF RESISTANCE IN PERMANENT PASTURES

WILL RESISTANCE DEVELOP IN PASTURES?

In most permanent pastures herbicide use is infrequent and can usually be combined with other non-selective methods of weed control *eg.* grazing and spraytopping. Under these conditions herbicide resistance is unlikely to develop.

WHAT IF RESISTANT RYEGRASS IS SOWN UNWITTINGLY?

There is a risk that purchased perennial grass seed will be contaminated with herbicide resistant annual ryegrass. The degree of risk obviously being related to

the herbicide use pattern of the certified seed producer.

However, even if the annual ryegrass is resistant it will cause no problems in your pasture paddock providing:

- The level of ryegrass seed is within the certification limits (a higher level of annual ryegrass will compete with the establishing perennial grasses); and,
- Normal grazing and herbicide use patterns are maintained in the paddock after sowing.

In most respects other than its resistance to herbicides, the "resistant" ryegrass is the same as the susceptible type, *ie.* a good component of a balanced pasture.

However, resistant ryegrass is slightly less competitive than "susceptible" ryegrass. Therefore, in a stable pasture which is not subject to further herbicide selection pressure, the resistant ryegrass will eventually fade into the background.

Herbicide resistant ryegrass is not a "super weed" and will not take over your farm unless repeated herbicide applications remove other plants.

CONCLUSION

Herbicide resistance is a problem associated with intensive use of herbicides when no thought is put into rotating between chemical groups.

The only impact it could have on perennial pastures is where sowing seed is contaminated with high levels of resistant seeds. Providing these seeds are within the normally accepted limits, few problems are likely.