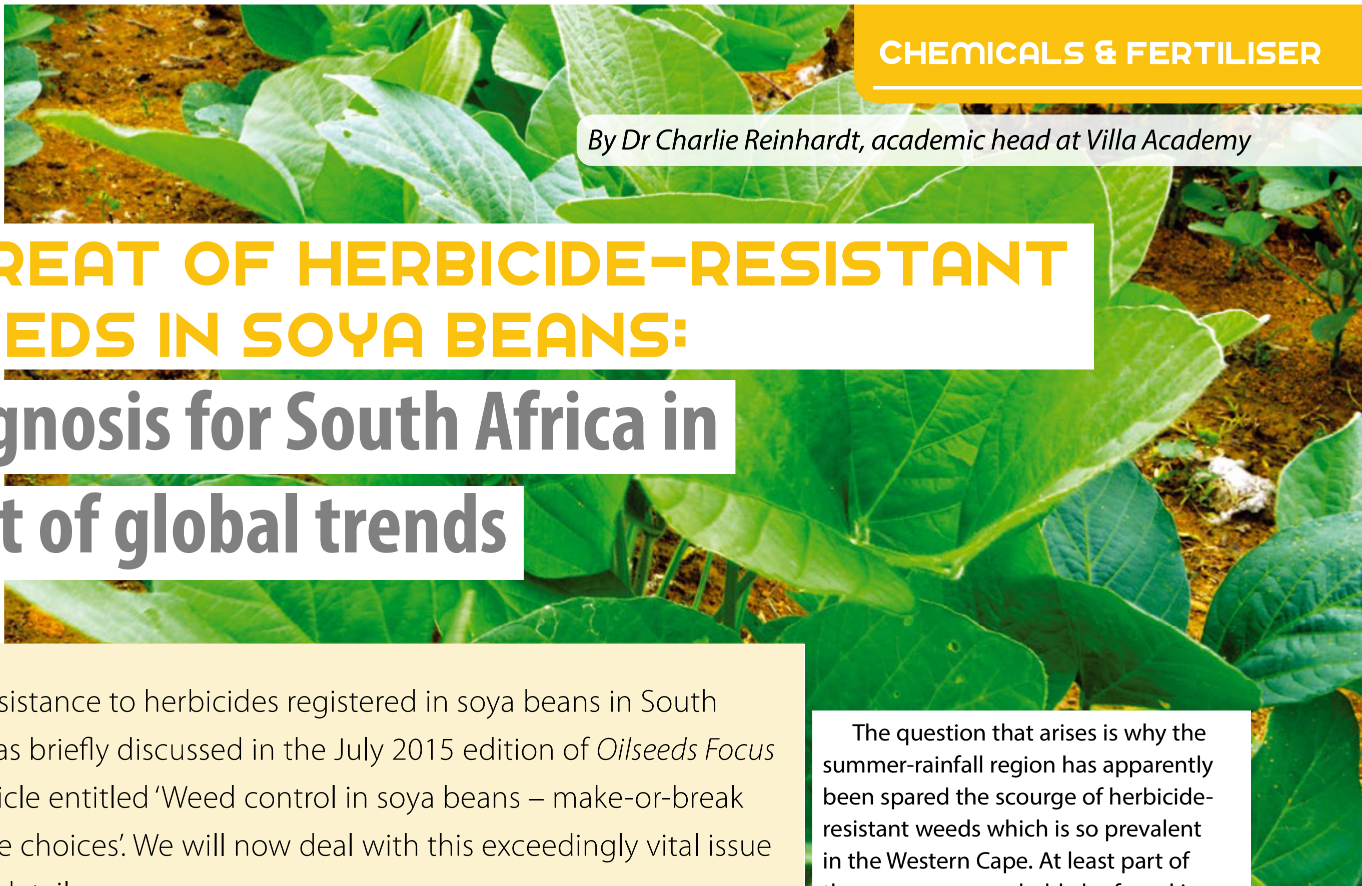

By Dr Charlie Reinhardt, academic head at Villa Academy

THREAT OF HERBICIDE-RESISTANT WEEDS IN SOYA BEANS:

Prognosis for South Africa in light of global trends

Weed resistance to herbicides registered in soya beans in South Africa was briefly discussed in the July 2015 edition of *Oilseeds Focus* in an article entitled 'Weed control in soya beans – make-or-break herbicide choices'. We will now deal with this exceedingly vital issue in more detail.

MoA groupings

Herbicide groups, which are based on mechanism of action (MoA), currently registered for use in soya beans are listed in *Table 1*. A total of 24 different herbicides belong to the eight MoA groupings. This represents a healthy situation with regard to diversity in herbicide MoA, because the use of herbicide combinations representing multiple MoA is universally regarded as one of the cornerstones of a successful resistance management strategy.

Of the eight MoA available to soya bean producers, only one (Group 1 in *Table 2*) is not linked to weed resistance anywhere in the world. The six acetamide (acetanilide) herbicides inhibit long-chain fatty acid synthesis in many grass weeds, and to a lesser extent also in yellow (*Cyperus esculentus*) and purple nutsedge (*C. rotundus*).

The implication is that all the herbicides in the other seven MoA groupings are associated with weed resistance to a lesser or greater extent (*Table 2*). Even more disconcerting is the fact that all those herbicides that control mainly broadleaf weeds have a record of resistance on one or another weed species somewhere in the world.

Moreover, many of those weeds are damaging to crop production in this country as well (*Table 2*).

From the information presented in *Table 2*, it is clear that herbicides with a single site of action (Groups 2, 3, 4, 5, 7 and 8), in particular a single protein or enzyme, are especially prone to the evolvement of resistance. The reason for this is that even a slight mutation of the particular enzyme, which might not alter the enzyme's natural function in the plant, is sufficient to render ineffective the herbicide attacking that site.

Summer- and winter-rainfall

Although no proven cases of weed resistance to any of the herbicides listed in *Table 2* have hitherto been reported in the summer-rainfall region of the country, many of the weeds mentioned in *Table 2* as having evolved resistance in other parts of the world include our toughest weeds. One fierce weed, the flax leaf fleabane or 'kleinskraalhans' (*Conyza bonariensis*) has proven resistance to both glyphosate and Paraquat in the Western Cape (Pieterse, 2010). This weed is highly competitive and often dominates weed communities in all the key crop-producing regions of South Africa.

The question that arises is why the summer-rainfall region has apparently been spared the scourge of herbicide-resistant weeds which is so prevalent in the Western Cape. At least part of the answer can probably be found in the historical greater dependence on mechanical weed control (ploughing and secondary tillage) in the summer- rather than in the winter-rainfall region.

This apparent advantage is fast disappearing, as reduced tillage is gaining ground in the summer-rainfall region. Reduced dependence on mechanical weed control increases dependence on herbicides. This situation can be managed without undue risk, provided that there is judicious use of herbicides and adherence to resistance management strategies.

Managing herbicide resistance

- Keep weed numbers low. Reduce the '1 in 1 000 000' chance that an individual weed plant in a population could evolve herbicide resistance in a natural way.
- Prevent weed seed production, as resistance is genetically inherited and is spread through seed.
- Do not rely on a single herbicide or a single MoA. Employ more than one herbicide MoA. Success is achieved with formulated herbicide and tank mixtures.
- Avoid under- and overdosing, since both promote resistance.
- Integrate different weed control methods where applicable.

Table 1: Summary of herbicide mechanisms of action registered in South African soya beans.

MoA (= plant process inhibited)	Number of herbicides per MoA	Number of herbicides per weed category		
		Mainly grass	Mainly broadleaf	Grass and broadleaf
1. Long-chain fatty acid	6	6	0	0
2. Photosystem II	2	0	0	2
3. Carotenoid	1	0	0	1
4. Acetyl-CoA carboxylase (ACC)	6	6	0	0
5. Acetolactase synthase (ALS)	4	0	4	0
6. Cell division	2	2	0	0
7. Protoporphyrinogen (PPO or Protox)	2	0	2	0
8. Enolpyruvylshikimate-3-phosphate synthase (EPSPS)	1	0	0	1
	Total: 24			

Table 2: Global herbicide resistance scenario for herbicides registered in South African soya beans.

Herbicides grouped according to MoA	Weed spectrum	Global weed resistance history
	1. MoA: Inhibit fatty acid synthesis	
Acetochlor	Grasses/sedges mainly	No cases reported.
Alachlor	Grasses mainly	No cases reported.
Dimethenamid-P	Grasses/sedges/broadleaf	No cases reported.
Metazachlor	Grasses mainly	No cases reported.
Metolachlor	Grasses/sedges mainly	No cases reported.
s-Metolachlor	Grasses/sedges mainly	No cases reported.
	2. MoA: Inhibit electron transport in photosystem II	
Bendioxide (= Bentazone)	Broadleaf/sedges	One weed, *Amaranthus hybridus* in Canada.
Metribuzin	Broadleaf/grasses	Multiple weeds (22 cases), e.g. *Chenopodium album*, *Eleusine indica*.
	3. MoA: Inhibit carotenoid biosynthesis (DOXP enzyme 1-deoxy-D-xylose5-phosphate synthase)	
Clomazone	Broadleaf and grasses	Few weeds (two cases), e.g. *Echinochloa crus-galli* in USA.

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Weed resistance to herbicides is a research focus at the University of Pretoria, with Dr Charlie Reinhardt as project leader. To learn more, visit the website *www.up.ac.za/sahri*. Dr Reinhardt is an extraordinary professor of weed science at the University of Pretoria and dean of the Villa Academy. Contact him on 011 396 2233 or email creinhardt@villaacademy.co.za, or visit *www.villaacademy.co.za* for more information.

Table 2: Global herbicide resistance scenario for herbicides registered in South African soya beans.

4. MoA: Inhibit acetyl-coenzyme A carboxylase (ACCase)		
Cycloxydim	Grasses	Multiple weeds, e.g. *Digitaria sanguinalis*.
Fluazifop-p-butyl	Grasses	Multiple weeds, e.g. *Digitaria sanguinalis, Sorghum halepense, Eleusine indica*.
Haloxyfop-R-methyl	Grasses	Several weeds, e.g. *Sorghum halepense*.
Propaquizafop	Grasses	Several weeds, e.g. *Digitaria ciliaris*, *Sorghum halepense, Eleusine indica*.
Quizalofop-P-ethyl	Grasses	Multiple weeds, e.g. *Digitaria sanguinalis, Sorghum halepense*.
Quizalofop-P-tefuryl	Grasses	Limited to few winter grass weeds.
5. MoA: Inhibit acetolactase synthase (ALS or AHAS)		
Imazethapyr	Broadleaf weeds	Multiple weeds (>100 cases), e.g. *Xanthium strumarium, Bidens pilosa, Parthenium hysterophorus, Ambrosia artimisiifolia, Euphorbia heterophylla, Sorghum halepense, Sorghum bicolor, Chenopodium album, Digitaria sanguinalis*.
Chlorimuron-ethyl	Broadleaf weeds	Multiple weeds (53 cases), e.g. *Xanthium strumarium, Bidens pilosa, Parthenium hysterophorus*.
Diclosulam	Broadleaf weeds and nutsedge	Few weeds (four cases), e.g. *Ambrosia artimisiifolia*, *Euphorbia heterophylla*.
Flumetsulam	Broadleaf weeds	Several weeds (14 cases), e.g. *Amaranthus hybridus, Lactuca serriola, Euphorbia heterophylla*.
6. MoA: Inhibit cell division		
Pendimethalin	Grasses mainly	Several weeds (nine cases), e.g. *Eleusine indica, Echinochloa crus-galli, Poa annua, Sorghum halepense*.
Trifluralin	Grasses mainly	Multiple weeds (25 cases), e.g. *Eleusine indica*.
7. MoA: Inhibit protoporphyrinogen oxidase (PPO or Protox)		
Flumioxazin	Broadleaf	Single case of *Ambrosia artimisiifolia*.
Fomesafen	Broadleaf	Several weeds (nine cases), e.g. *Ambrosia artimisiifolia, Euphorbia heterophylla, Amaranthus hybridus*.
8. MoA: Inhibit enolpyruvylshikimate-3-phosphate (EPSP) synthase		
Glyphosate	Pre-plant burndown and in glyphosate-tolerant soya bean	Multiple weeds (32 species, 242 cases), e.g. *Conyza bonariensis*. Note: Certain populations of *C. bonariensis* in the Western Cape are resistant to both glyphosate and Paraquat. Many other populations of this weed are either highly tolerant or resistant to glyphosate in that region.

Source: www.weedscience.org

Note: Listed weeds also occur in South Africa, but no cases of resistance have yet been recorded in the summer-rainfall region.