The 'wicked' problem that is herbicide resistance

By Dr Charlie Reinhardt

A severe infestation of fleabane (Conyza spp.) on a field soon to be planted to maize or soya bean. During their development, the weed plants withdraw valuable soil moisture from deep in the soil profile. Roots of this weed easily grow approximately 600mm deep. Therefore, plants are well adapted to survive the dry winters of the summer rainfall region. (Photograph: C Reinhardt)

Sociologists define a 'wicked' problem as one without clear causes or solutions, and therefore difficult or impossible to solve. According to Shaw (2016), herbicide resistance meets the requirements of a wicked problem, since the causes of resistance are obscured by a complex mix of biological and technological factors and are fundamentally driven by the whims of human decision-making.

From the scientific-technical viewpoint, we know a lot about herbicide resistance, arguably enough to deal successfully with the challenge, and yet, the problem is escalating at an alarming rate. A study conducted in the United States (US) by Frisvold et al. (2007) estimated the economic impact of glyphosate-resistant *Conyza canadensis* (horseweed, *Kanadese skraalhans*), which is closely related to *Conyza bonariensis* (hairy fleabane, *kleinskraalhans*) and that has proven resistance to both glyphosate and paraquat in South Africa (Livingstone et al., 2016).

Management increases profit

The conclusion of that study is that across a 20-year horizon period, the estimated annual profit margin benefit attributable to resistance management of horseweed was R2 370/ha for maize (calculation based on $158/ha, $1 = R15). For soya bean, the increase in profit margin was R825/ha, and R2 055/ha in the case of a maize-soya bean rotation system.

In South Africa, there is virtually no information available on the economic impact that herbicide resistance has on the crop production and crop protection industries. Considering the direct growth and yield reductions caused by weed interference in all types of crop production, together with additional costs of managing herbicide-resistant weeds, the rand value of losses probably reach hundreds of millions on an annual basis.

Currently, based on information compiled by Dr Ian Heap (*www.weedscience.org*), 470 unique cases of herbicide-resistant weeds have been reported globally, involving 250 plant species (145 dicotyledons and 105 monocotyledons). A most disturbing factor is that weeds have evolved to develop resistance to 23 of the 26 known herbicide sites of action and to 160 different herbicides. Herbicide-resistant weeds have been reported in 86 crops in 66 countries.

In South Africa, there are nine weed species for which resistance to one or the other herbicide has been confirmed over the years, and alarmingly, some of these weeds have developed multiple resistance, i.e. resistance to more than one herbicide mechanism of action (MOA) (Pieterse, 2010).

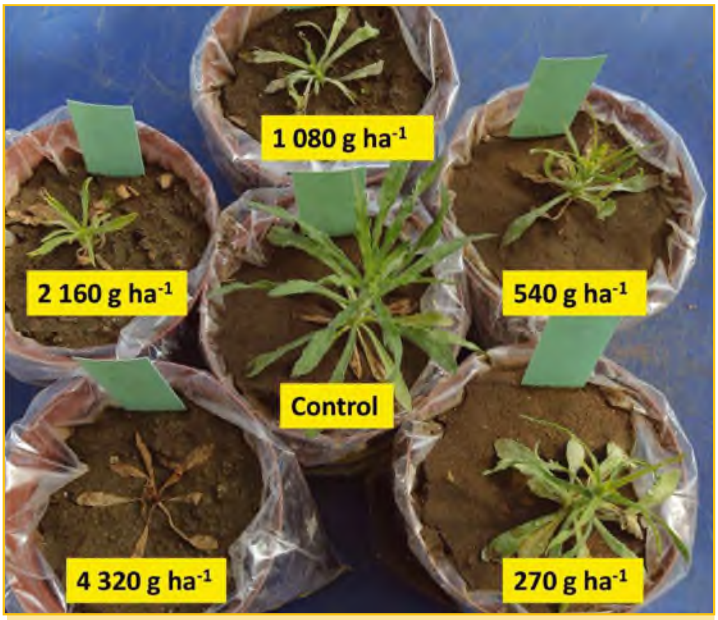
Numerous resistant weeds

When seen in the global context of 250 species, nine local herbicide-resistant species may not seem like much to be concerned over, but when considering that these types represent some of South Africa's worst weeds occurring in major crops, the magnitude of the problem is realised.

Consider the case of glyphosate-resistant weeds, where globally 33 species have been recorded to date. Of the 33, three also occur in South Africa, namely: hairy fleabane (*Conyza bonariensis*), narrow-leaved ribwort (*Plantago lanceolata*) and the complex of ryegrasses (*Lolium multiflorum, L. perenne, L. multiflorum* × *perenne*, *L. rigidum*).

Three out of 33 may not appear to be significant, but mere numbers discount the prominent weed status of the aforementioned three species. Moreover, 16 other weeds among the 33 for which glyphosate resistance has been proven in some or other part of the world are well-established in South Africa. In light of this dooming scenario of 19 out of 33 species evolving glyphosate resistance in a single country, lax approaches to herbicide resistance management can neither be afforded nor tolerated.

Equally perplexing is that, the world over, there is very little understanding of the 'wicked' problem of herbicide resistance. Moreover, poor implementation of resistance management strategies generally prevails. A survey conducted in the US among more than 1 000 maize, cotton and soya bean growers revealed that only 39% "always or often" use herbicides with more than one MOA, while 28% employed this best practice "seldom or never".



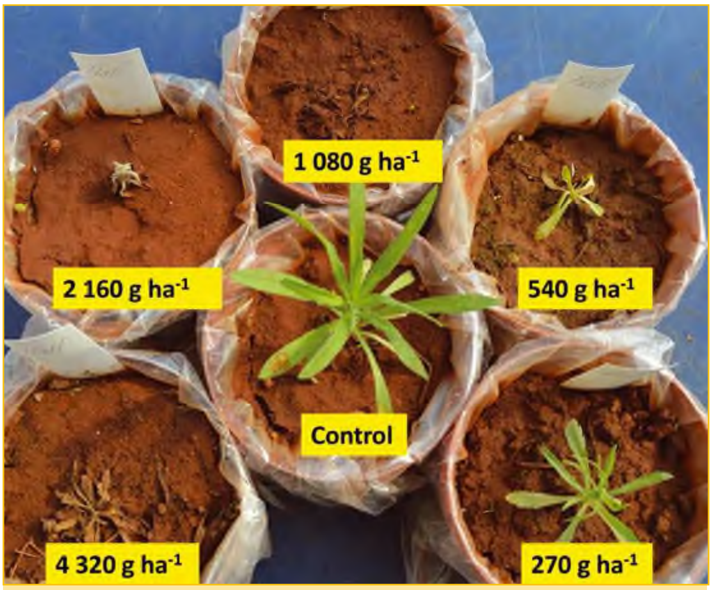
Response of a glyphosate-tolerant flaxleaf fleabane population to different glyphosate dosages. (Source: Heilbron district)

Poor implementation

Even in a country such as Australia where there is tremendous hype over best practices for resistance management, there is disappointingly low uptake and little consistency in adherence to these practices. Similar information for South Africa either does not exist or is unavailable in the public domain.

Confounding factors explaining low adoption rates of resistance management practices are generally accepted to be twofold – firstly because gains from managing resistance only accrue in the future and there is uncertainty attached to it, and secondly, there are real short-term costs associated with resistance management implementation which represent unwanted increases in already high input costs.

The conundrum is that it is expected of crop producers to spend money, time and effort on a problem that may not yet exist or is still evolving, and which is therefore uncertain. According to most experts who do research or provide advice on herbicide resistance, it is hard to generate hype around a problem that may or may not develop at an unpredictable time in the future. However, experience tells us that herbicide resistance is real and that it is with us already.



Response of a glyphosate-susceptible flaxleaf fleabane population to different glyphosate dosages. (Source: Hatfield, Pretoria). Note: 1 080g/ha^{-1}is the recommended glyphosate dosage. The control was not treated with glyphosate.

Strategies and tactics by means of which to successfully manage resistance are well documented and proven. Yet despondency still exists in certain quarters over a supposed lost battle. Shaw (2016) believes that "doing something different" is key to successful resistance management.

A brand-new weed

There is a powerful truth to be found in the simple statement made by Amy Asmus, someone who is not a scientist but works in agriculture, at the 20th annual conference of the International Consortium on Applied Bioeconomy Research (ICABR) (July 2016, Italy): "My advice for successful resistance management is to regard any herbicide-resistant weed as a brand-new weed".

This approach could introduce a rethink on weed management options for combatting the resistance problem, and would be vital for creative thinking, something which we desperately need for tackling herbicide resistance head-on.

According to Shaw (2016), the rethinking of herbicide resistance management strategies should include a greater emphasis on integrated weed management (IWM) that incorporates mechanical, biological and chemical tools, as well as a multidisciplinary approach that brings together a team of agronomists, weed scientists, economists, sociologists, extension advisers, consultants and farmers. This is certainly the way forward. In this case, as in most areas in life, we should heed these wise words by Albert Einstein: "Insanity: doing the same thing over and over again and expecting different results."

References are available from Dr Charlie Reinhardt, dean of the Villa Academy, extraordinary professor of weed science at the University of Pretoria (UP) and extraordinary professor at the Department of Agronomy, Stellenbosch University (SU). Contact him on 011 396 2233 or email creinhardt@villaacademy.co.za. He also leads a research project on the assessment of herbicide resistance at UP. Learn more about the South African Herbicide Resistance Initiative (SAHRI) at UP by visiting *www.up.ac.za/sahri*.