Zero tillage promotes dominance of certain weed species

By Dr Charlie Reinhardt

In general terms, the many positive attributes of minimum and zero tillage for the achievement of sustainable and profitable crop production is beyond reproach. However, the saying 'for every human action in nature there are reactions' is very true in agriculture, where farmers deal with the convergence of human and natural factors in agro-ecosystems that may pose formidable management challenges. Ineffective weed management in zero tillage systems could spoil the advantages offered by the practice.

Effective weed management depends on the success of the application of three primary methods of weed control, either used singly or in an integrated approach. These methods are chemical control using herbicides, mechanical control using implements, and biological control (biocontrol) using crop litter or cover crops.

In zero tillage systems mechanical weed control is not an option, which may lead to a greater dependence on herbicides. Biocontrol is very popular in zero-till systems for weed suppression and can be a valuable tool to augment chemical weed control.

Eliminating mechanical weed control

With no mechanical weed control, there is a real risk that weeds may escape other means of control, such as herbicide use and/or biocontrol, to the extent that excessive weed numbers may cause unacceptable crop losses.

A delay in the use of herbicides can result in spraying the weeds too late, when they are beyond the optimum growth stage for effective control with post-emergence herbicides; generally, the optimum growth stage is considered to be the six-leaf stage or younger.

The very important class of pre-emergence grass herbicides – the acetanilide group with members such as acetochlor, alachlor and metolachlor – gives effective control of grass weeds only during the weed growth stage when the underground plant parts that develop above the seed are emerging through the soil.

This is post seed germination, but prior to seedling emergence above ground. It is important to note that not a single herbicide (excluding soil fumigant products) on the market today inhibits seed germination, although several types of herbicides act on weed seedlings during the period between seed germination and seedling emergence.

Tillage knocks weeds back

Mechanical weed control with tractor-drawn implements allows the burying of weed seeds at soil depths where they encounter conditions that are unfavourable for germination. Alternatively, if they do germinate, especially the small-seeded seedlings lack the energy to reach the soil surface and die off.

Primary tillage actions can control weeds in the process of preparing the seedbed, which represents pre-planting weed control, and it can be specially employed for controlling deep-rooted weeds. Secondary tillage operations, with the specific purpose of controlling weeds physically by breaking contact between plant roots and soil and/or by covering plants with soil, can only provide weed control between crop rows and not on the rows. Weed-crop competition is fiercest on the crop row where the foliage above ground and the roots below the surface are most entangled, and the competition for growth factors, i.e. light, water and nutrient elements, is strongest.

For a good 20 years after its introduction to the crop seed market in 1996, Roundup Ready™ (RR) biotechnology, which rendered crops tolerant to the non-selective herbicide glyphosate, led to the displacement of many other herbicides from major crops such as maize, soya beans and cotton. This technology slotted seamlessly into zero tillage systems based on RR maize, soya beans or cotton.

A non-selective herbicide, glyphosate, was rendered selective through genetic modification of the crop, which allowed the control of a broad spectrum of weeds, while not compromising crop safety. In effect, glyphosate use on RR-crops in zero tillage systems compensated for the 'loss' of mechanical weed control. Now, farmers could spray glyphosate only when the weed infestation warranted control, in-row weed control was possible, and wet soil need not thwart the spray operation because aerial application of glyphosate was possible.

Glyphosate and RR biotechnology

The hugely effective biotechnological tool which married glyphosate and glyphosate-tolerant crops, simplified weed control and boosted profitable crop production. Unfortunately, it has inadvertently been compromised by new challenges in the form of glyphosate-resistant weeds and dominant hard-to-control weeds. High dependence on glyphosate for weed

control, particularly in zero tillage systems, led to its overuse and non-compliance with instructions on the correct and responsible use of this herbicide.

Overuse implies 'creeping' dosages as the label-recommended rate is progressively increased to get the same level of control originally achieved. This is typical of one way in which weed resistance to any herbicide evolves. When injudicious use of a herbicide is combined with high frequency of use, e.g. three or more applications in a season, the risk of herbicide resistance developing in certain weed populations is increased.

Weed resistance and chemical dilution

The zero tillage crop system attracts certain weed species in the sense that the practice provides conditions conducive to their establishment and dominance. In the case of the abundant weed *Conyza bonariensis* (flaxleaf fleabane), and its cousin *Conyza sumatrensis* (tall fleabane), the prevalence especially in zero tillage systems is boosted by a key characteristic of seed germination.

Research in Australia has revealed that *C. bonariensis* seeds predominantly germinate on the soil surface or at a depth of 5mm. Very few seeds germinate at a depth of 10mm, and none at a depth of ≥ 20mm. (H. Wu *et al*., 2007, *Weed Biology and Management* 7: 192-199). The authors attributed the fleabane problem in minimum tillage systems in Australia to better emergence on or near the soil surface due to moist conditions provided by minimum tillage compared to conventional tillage.

Obviously, in zero tillage situations seed burial for weed control purposes is not possible. Other weeds that predominantly germinate at shallow depth are small-seeded broadleaf weeds, e.g. *Amaranthus* (pigweed) species, *Chenopodium album* (white goosefoot) and *Portulaca oleracea* (purslane), as well as the grass weeds.

The perennial grass *Cynodon dactylon* (couch grass) depends more on vegetative (plant segments) growth than on sexual (seed) reproduction, and lack of soil tillage as a control method aids the formation of a dense underground system of roots and rhizomes. This high underground biomass has a dilution effect on herbicides such as glyphosate when the chemical is applied to the foliage.

Consequently, treated couch grass tends to regrow from rhizomes (underground stems). Such dilution of the herbicide, which is essentially inadvertent underdosing, is another risk for the evolvement of herbicide resistance.

The pervasive weed Conyza bonariensis (flaxleaf fleabane) often dominates the weed spectrum of especially minimum tillage systems in summer and winter rainfall regions.

The same rationale applies in the case of weeds being sprayed only when the plants are beyond the effective growth stage for best control; spraying of mature (high biomass) weeds constitutes herbicide underdosing.

Varying approaches for best control

Glyphosate only has post-emergence activity on weeds and repeated application is required for weeds with staggered emergence throughout the growing season. For the control of broadleaf weeds that emerge during the growing season and have inherent tolerance to glyphosate, such as *Conyza* spp. (fleabane species), *Ipomoea purpurea* (morning glory) and *Commelina benghalensis* (wandering Jew), broadleaf herbicides that persist in soil are required.

The latter is a unique plant in that it produces aerial seed as well as subterranean seed on a single plant, and the temperature requirement for germination is different for the two types of seed. Hence the species shows staggered germination across the growing season (Ferreira and Reinhardt).

In the case of morning glory, M. Singh *et al.* reported that maximum germination of seed was 83% and 94% when sown 0mm and 20mm deep, respectively, but germination was significantly reduced to 76% for seed placed at a depth of 40mm and deeper.

For highly problematic weed species such as these, soil-persistent herbicides should be used. Seed burial done with soil tillage operations would likely assist with control.

Effective combinations

Fortunately, current herbicide recommendations are aimed at combining the use of glyphosate with different modes-of-action herbicides for the sake of avoiding herbicide resistance, as well as improving efficacy of weed control. An example of a popular herbicide mixture applied pre-planting in zero tillage systems, is glyphosate + 2,4-D which, in optimum dosages, improves weed control of certain weeds beyond that provided by glyphosate alone.

The 'double-knock' approach of applying glyphosate and paraquat separately in a sequential manner is another effective pre-planting treatment that can assist with the reduction of weed pressure later in the season.

Just as no single herbicide should ever be regarded as the panacea for all weed problems, zero tillage practice ought not to be mooted as a 'silver bullet' solution for sustainable crop production.

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