Miraculous Molecule – Glyphosate

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The world's best-seller and most widely used herbicide has turned 40! Well might this "1 in 100 years" herbicide be applauded for not only its unique herbicidal efficacy but also for the way in which it revolutionized crop production on a global scale. Glyphosate's pivotal role in the success of Conservation Agriculture, in particular the advent and uptake of reduced tillage practices, cannot be extolled enough. This unique herbicide not only made crop production more profitable but concomitantly reduced human-footprint pressure on the environment through soil and water conservation that accrued from reduced tillage.

Glyphosate is the best-known inhibitor of amino acid biosynthesis in plants. The target enzyme of glyphosate is EPSPS, the penultimate enzyme in the shikimate pathway. This pathway produces critically important compounds that drive several key life processes in plants. Glyphosate can be considered a non-selective herbicide, which implies that it can kill all plant species. Exceptions are plants that can withstand glyphosate, such as glyphosate-resistant weeds and crops that have been engineered to be glyphosate-tolerant.

The remarkable efficacy of glyphosate can be attributed to its high target-site activity, efficient translocation within plants, and accumulation in meristems (tissues where growth is most rapid). These attributes combined make glyphosate an excellent choice for perennial weed control and the management of "hard-to-control" weeds.

Glyphosate only affects plants if it would make contact with live, green foliage and green bark. Its residual activity in soil and water is negligible to absent due to rapid bonding of the molecule to soil colloids, and because predation by microbes rapidly degrades this herbicide to the benign elements C (carbon), H (hydrogen), O (oxygen), N (nitrogen) and P (phosphorus).

Reports that from time to time stir up sensation and emotions on the so-called 'disadvantages' of glyphosate typically fail to prove the practical relevance of research which is often restricted to laboratories. Sorely lacking in such superficial investigations is the linking of claimed negative effects with the relatively low number of glyphosate molecules that actually can interact with soil, water, atmosphere, fauna and flora. Simply put, the dilution effect of the environment on glyphosate at the dosages and frequency it is used at contradicts claims that are often based on findings obtained with impractical dosages under laboratory conditions. In a highly acclaimed review article, Duke et al. (2012) concluded that, despite there being contradicting research findings on the role of glyphosate in the promotion of plant diseases and nutritional imbalances, the preponderance of studies have found that such effects, if they exist, have low incidence, are transient, and do not have appreciable effects on crop yield.

Space does not allow elaboration on recent sensational claims in the press about glyphosate being a carcinogenic compound, suffice to say these reports failed to mention that glyphosate has been placed in the same category as coffee and wood smoke by the International Agency for Research on Cancer (IARC). Here follows the best possible unbiased perspective on this issue: "European Food Safety Authority (EFSA) has today (November 12, 2015) published the EU's peer review of the active substance glyphosate. The report concludes that glyphosate 'is unlikely to pose a carcinogenic hazard to humans'. This is a direct contradiction to the International Agency for Research on Cancer (IARC), which classified glyphosate as ‘probably’ carcinogenic to humans in March 2015”.

Contradictory research findings on glyphosate sensitivity of rhizobacteria symbionts of soya bean appeared soon after the commercial release of Roundup Ready™ soya beans in 1996. Concerns were that the possible sensitivity of rhizobacteria could interfere with nodulation and nitrogen fixation. In an in-depth study, Reddy et al. (2000) reported non-significant effects of glyphosate on nodulation, chlorophyll content, and biomass accumulation of soya bean cultivars. Their findings showed that glyphosate treatment of the legume host may cause transient inhibition of certain strains of rhizobacteria, without significant effects on nodulation, nitrogen fixation and crop yield.

To date, there are 462 unique cases of weeds (248 species) reported to be resistant to various herbicides (Heap, 2016). The first case of resistance to glyphosate was reported for *Lolium rigidum* in Australia in 1996, about 20 years after glyphosate appeared on the market. Of the 248 weed species currently listed as resistant to various herbicides, 32 have been found to be glyphosate-resistant. Although 20 of the glyphosate-resistant types also occur in South Africa, resistance to glyphosate has been proven for only three, namely: *Lolium* spp (rye grass), *Plantago lanceolata* (small-leaf plantain) and flax-leaf fleabane (*Conyza bonariences*). Important to note is that although all three cases have been confirmed only in the Western-Cape, these weeds occur throughout South Africa.

The growing popularity of reduced tillage in the summer rainfall region has created ideal conditions for the development of herbicide resistance, through: (1) reduced or zero tillage which eliminates mechanical weed control as a management tool, (2) over-reliance on, or over-use of, highly active herbicides such as glyphosate. Fundamental to effective resistance management strategies is preventing weeds from producing seed, year round, and the use of multiple herbicide mechanisms-of-action, preferably in the form of flexible tank mixtures.

Weed resistance to herbicides is a research focus at the University of Pretoria, with Dr Reinhardt as project leader – to learn more about our work and herbicide resistance visit the website: http://www.up.ac.za/sahri

Literature references

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