Sunflower in this good a state of development will exert high interference stress (competition + allelopathy) for suppressing weed growth plus weed seed production, the latter being key to the depletion of weed seeds in the soil seedbank.

Weed control: The benefits and challenges of crop rotation

By Prof Charlie Reinhardt, North-West University

The time-honoured expression 'know your enemy', which originates from military intelligence circles, is also applied in weed management to give credit to the tricky nature of certain plant species which we classify as weeds. For herbicide-resistant weeds, the term 'wicked weeds' is used to denote something perceived as extremely harmful and which defies understanding.

Temporal diversification in crop production systems, better known as crop rotation, is an important step in the right direction for allaying concerns regarding farming practices perceived by some as unsustainable.

Managing plant diversity

In all crop production systems, the least dynamic or diverse component is that of the crop, given its fixed numbers and spacing per unit area as well as uniformity in biomass at any point in time. In contrast, the weed community is usually species-rich with high diversity in numbers, spatial distribution and biomass. Thus, a community of plant species exists in crop fields and rather complex interactions occur between them and the environment.

The term 'interference' best describes interactions among plants because it encompasses both the competition and allelopathy phenomena. Competition is when plants compete for the critical growth resources of water, light and nutrients. Allelopathy describes plant interactions that are based on the production and release of natural chemical substances called allelochemicals into the environment. The interference between crops and weeds is not one-directional – crops can also interfere with weed growth through competition and allelopathy.

From a weed control perspective, the biodiversity conundrum is to attain a level of weed control that, on the one hand, is sufficient to prevent unacceptable crop yield loss and, on the other, is also eco-friendly. Herbicides are valuable tools in the management of weeds in ways that are both effective and sustainable in the long run.

Unfortunately, there is still a disappointingly high level of ignorance regarding the potential negative impacts that wrong or inappropriate habits and advice, and consequently, malpractices can have on sustainable crop production.

Preventing crop interference

Weed management is aimed at reducing diversity in the weed community to levels that prevent interference with the crop to the extent that unacceptable yield loss is incurred. Technological tools for

weed control are limited to herbicide use, mechanical methods (tillage/ploughing), physical methods (slashing, burning, inorganic mulching) and cultural methods (crop rotation, intercropping, cultivar choice, cover crops, organic mulches, planting date, crop density). In addition, biological methods can include all the aforementioned crop or plant factors, plus natural enemies (insects and pathogens) of weeds.

Technological tools for weed control have not undergone much change in type over the past 80 years or so, but they have become more refined in both design and efficacy, especially through the adoption of the strategy of integrated weed management under the broader concept of integrated pest management.

Crop rotation for weed control

Crop rotation not only promotes plant diversity in cropping systems, but also contributes much-needed variation to weed control programmes, especially regarding herbicide diversification. Diversity in herbicide mechanisms of action is key to the successful management of herbicide-resistant weeds.

Crop rotation makes other possible changes in practices that automatically benefit weed control, such as shifts in planting date, differences in seedbed preparation, and alternative cultural weed control opportunities, namely crop type and cultivar selection based on the ability to suppress weeds through competition and allelopathy.

Biomass of plants is a measure of their ability to acquire growth resources such as water, nutrients and light, therefore the plant with the most biomass is likely to win the battle against others with less biomass. As far as allelopathy is concerned 'the dose is in the density/biomass', meaning that the amount and type of allelochemicals produced and released are directly related to weed numbers and biomass, as well as the type of weed.

In the case of crop species, the ability to interfere with weeds is vested to a large extent in plant numbers and biomass attained per unit area, although crop type and even cultivar selection also play important roles.

Crop characteristics that promote successful interference with weeds are:

- Dense canopy that shades weeds.
- A root system that is more efficient for better acquisition of water and nutrients than that of weeds.
- Production and release of phytotoxic (plant-toxic) allelochemicals that inhibit or suppress weed growth and development.

Likewise, the aforementioned scenarios would be reversed in favour of weeds, should they possess superior characteristics, as they often do. Successful weed control is all about not allowing weeds to attain ascendancy over the crop.

Exploitation of crop allelopathy

As is the case with weeds, crop species have allelopathic potential to a greater or lesser extent. This biochemical characteristic of crops is already well entrenched in allelopathic rice cultivar development in support of a reduction in herbicide use. Crop and cultivar differences in allelochemical production have been reported for a wide range of crops, including various cover crops, canola, wheat, rye, oats, sunflower, maize, grain sorghum and soya beans. Because allelochemicals are released from live plants and their dead material, crop allelopathy for weed suppression can be exploited by managing crop litter.

For maximum effect, plant litter should be concentrated more in the vicinity of weeds and to a lesser extent in proximity of the crop (reminder, the dose is in the biomass). In general, allelochemicals do not show selectivity in their effect as most synthetic herbicides do, therefore crops could be harmed by too high concentrations of even their own plant litter (allelochemicals).

In South Africa, relatively little research has been done on the topic of exploitation of crop allelopathy for weed control – glowing exceptions are the PhD studies of Dr Suzette Bezuidenhout of the Department of Agriculture, Forestry and Fisheries, Cedara, KwaZulu-Natal, and Dr Mike Ferreira of the Western Cape Department of Agriculture, Elsenburg, who demonstrated significant weed control ability of various rotational crops in maize and small grain production, respectively.

Allelopathic effects on soya bean

Mallik and Tesfai (1988) reported that extracts from foliage material of sunflower and the weeds *Cyperus esculentus* (yellow nutsedge, *geel uintjie*) and *Chenopodium album* (white goosefoot, *withondebossie*) reduced soya bean seed germination. The 2% extract concentration of white goosefoot completely inhibited *Bradyrhizobium* nodulation on soya bean, with 60% nodulation suppression measured at the 1% extract level.

White goosefoot foliage incorporated in soil at levels of 0,5% and 1% (mass/mass) caused a respective reduction of 85 and 95% in soya bean seed germination. Soil-incorporated sunflower material at the 1% level reduced soya bean seed germination by 40 to 70%, but germination was not affected at the 0,5% level. Reinhardt *et al*. (1997) found that the growth of sunflower seedlings was significantly reduced on soil into which dried white goosefoot foliage was incorporated at a 1% level.

Pay close attention to the amount of weed litter left on the soil surface following pre-planting herbicide use, such as the popular 'double-knock' treatment of first glyphosate followed by paraquat if there would be survivors of glyphosate. At planting, be mindful of the amount of both crop and weed litter on the soil surface and in the zone of crop seed placement, because too much may not only suppress weeds but also inhibit the crop's early growth.

Unfortunately, South Africa is sorely lacking this type of research, same as for studies on weed population dynamics (e.g., species shifts and species dominance), crop-weed interference (allelopathy and competition), and long-term effects of crop rotation systems on weed seeds hidden away in a dormant state in the soil seedbank.

Prof Charlie Reinhardt is a professor in the agricultural sciences programme at North-West University (Potchefstroom campus) and research leader in the South African Herbicide Resistance Initiative (SAHRI) at the University of Pretoria. He can be reached at 083 442 3427 or dr.charlie.reinhardt@gmail.com.