Palmer amaranth:
A threat to soya bean production in South Africa

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Palmer amaranth is the latest addition to South Africa's growing list of *Amaranthus* species (commonly known as pigweed or marog). Some of these *Amaranthus* species are indigenous to Africa, while others originate from other continents.

Before Palmer amaranth reached our shores, the most important weedy *Amaranthus* species which South African crop producers had to contend with was *Amaranthus hybridus* (commonly known as pigweed or Cape pigweed). *Amaranthus hybridus (A. hybridus)* is a serious problem in basically all annual cropping systems in the summer rainfall region. *Photo 1* shows a decidedly harmful common pigweed infestation on a soya bean field in the eastern Highveld region.

Recent research by the South African Herbicide Resistance Initiative (SAHRI) at the University of Pretoria has for the first time revealed glyphosate-resistant *A. hybridus* populations in the country, specifically in Winterton in KwaZulu-Natal and Cradock in the Eastern Cape.

The prospect of having to contend with glyphosate-resistant common pigweed in glyphosate-tolerant crops is already daunting and now, added to this, there is the frightening spectre of another, even more competitive glyphosate-resistant *Amaranthus* species, Palmer amaranth. The possibility of hybridisation between common pigweed and Palmer amaranth is a real threat – the amaranth plant seen in *Photo 2* shows morphological characteristics of both these weeds.

Palmer amaranth's spread in SA

Early in 2018, Palmer amaranth was conclusively identified in South Africa for the first time by the SAHRI research team on a farm in the Douglas district in the Northern Cape. Since then, other populations have been confirmed in the Howick and Winterton districts of KwaZulu-Natal, as well as in proximity to the Limpopo River in the Kruger and Mapungubwe national parks (Sukhorukov *et al.*, 2021).

A crop-debilitating infestation of common pigweed in soya bean in the eastern Highveld region.

Further afield in Southern Africa, also in 2018, a Palmer amaranth population was confirmed in Kasane, Botswana. Additional populations from other parts of South Africa are currently undergoing herbicide resistance evaluation and DNA analysis through the SAHRI research programme.

Photo 3 shows a Palmer amaranth plant. Palmer amaranth is a dioecious (sexes on separate plants) annual summer forb, originating from the desert washes and riparian areas of the Sonoran Desert, which covers large parts of the southwestern United States and northwestern Mexico. Because of its origins, it is considered pre-adapted to agricultural systems where regular soil disturbances and nutrient fluctuations are the norm. Based on its origins and adaptation to harsh environmental conditions, Palmer amaranth can also flourish in most parts of Southern Africa, particularly in annual summer crops.

In the United States, increased seed pressure attributed to long-distance grain, feed and machinery transport have been linked to the range expansion of Palmer amaranth from the natural habitats which it has occupied for thousands of years.

Climate change, soil disturbances and elimination of competitor species through the use of highly effective herbicides (e.g. glyphosate) are also coupled with the rapid expansion of Palmer amaranth infestations across most states in the ecologically brief time frame of ten to

15 years (from approximately 2000 to 2015). A similar scenario exists in South Africa.

A near-inexorable weed

Among the alarming characteristics of Palmer amaranth is its high fecundity – one female plant can produce up to 500 000 seeds which can survive in soil for about three years, and seeds show staggered germination over several months. Plants grow at an extremely high rate, which explains the strong competition ability of this species.

A two-year field study by Bensch *et al*. (2003) in the United States found that Palmer amaranth caused up to 78,7% yield loss in soya bean at a density of eight plants per metre of row, whereas common waterhemp (*A. rudis*) and redroot pigweed (*A. retroflexus*) caused 56,2% and 38% yield loss, respectively. In the same study, maximum seed production for Palmer amaranth, common waterhemp and redroot pigweed was 32 300, 51 800, and 9 500 seeds per square metre, respectively.

Palmer amaranth infestations may appear innocuous from the onset when relatively few plants occupy a site, but once critical seed numbers have accumulated in the soil seedbank, there will be a veritable explosion of plant numbers. This critical period lasts two to five years, or over entire summer seasons.

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A suspected hybrid of Palmer amaranth and common pigweed. A SAHRI research team has confirmed glyphosate resistance to this population in KwaZulu-Natal. Research is ongoing.

3

A Palmer amaranth female plant which could be mistaken for other amaranth species. A guide to identifying Palmer amaranth is available from the authors.

Another two-year study (Klingman and Oliver, 1994) in the United States reported that soya bean canopy cover ranged from 77cm in the weed-free check, to 35cm in plots with ten Palmer amaranth plants per metre of row at twelve weeks after crop emergence. Soya bean yield reduction was 17, 27, 32, 48, 64 and 68%, respectively, for Palmer amaranth densities of 0,33; 0,66; 1; 2; 3,33; and ten plants per metre of row. At the latter density, the Palmer plants competed against one another (intra-species competition), which explains the relatively small increment (64 to 68%) in yield reduction between 3,33 and ten plants per metre of row.

In January 2022, the number of herbicide resistance cases reported worldwide for Palmer amaranth was 70 (Source: *www.weedscience/org*). This weed has proven resistance to a staggering total of nine extremely important herbicide modes of action (MOA) or sites of action (SOA).

The following Herbicide Resistance Action Committee (HRAC) groups are implicated:

- Group 9 (EPSPS inhibitors, e.g. glyphosate).
- Group 2 (ALS inhibitors, e.g. chlorimuron-ethyl and imazethapyr).
- Group 3 (microtubule assembly inhibitors, e.g. trifluralin).
- Group 5 (Photosystem 2 inhibitors, e.g. atrazine).
- Group 27 (HPPD inhibitors, e.g. mesotrione).
- Group 14 (PPO inhibitors, e.g. fomesafen).
- Group 4 (auxin mimics, e.g. 2,4-D and dicamba).
- Group 15 (long chain fatty acid inhibitors, e.g. metolachlor).
- Group 10 (Glutamine synthetase inhibitors, e.g. glufosinate ammonium).

The worst-case scenario in the United States regarding herbicide resistance of Palmer amaranth, was recorded in 2016 in Arkansas in cotton and soya bean. Multiple resistance to five SOAs was recorded, i.e. HRAC groups 2, 14, 9, 3, and 15. In this case, the herbicides implicated were flumetsulam, fomesafen, glyphosate, imazethapyr, pendimethalin, and s-metolachlor. The most common herbicide resistance of Palmer amaranth in the United States is multiple resistance to the combination glyphosate and ALS-inhibitors.

Only one possible non-resistant SOA

Weed resistance to herbicides registered in soya beans in South Africa was discussed by Prof Charlie Reinhardt in the July 2015 edition of *Oilseeds Focus* in the article titled, "Weed control in soya beans – make-or-break herbicide choices". Twenty-four different herbicides (actives, not products) belong to the eight HRAC groups registered in South African soya bean.

Superficially viewed, this represents a healthy situation regarding diversity in herbicide MOA/SOA, because the use of herbicide combinations representing multiple MOAs/SOAs is universally regarded as one of the cornerstones of a successful resistance management strategy. However, of the eight SOAs available to soya bean producers, only one – Group 11 (carotenoid inhibitors) – has not yet been linked to Palmer amaranth resistance globally.

Even more disconcerting for South Africa, is the fact that all those herbicides that control mainly broadleaf weeds in soya bean have a record of resistance in one or the other weed species somewhere in the world. Moreover, many of those weeds are damaging to crop production in this country as well.

Research into herbicide resistance

Researchers in the SAHRI, principally the authors of this article, have conducted research into herbicide resistance in Palmer amaranth since it was first confirmed in South Africa in 2018. To date, 14 herbicide actives have been assessed by the SAHRI for their ability to control this weed.

Resistance to two herbicides, glyphosate and chlorimuron-ethyl, was confirmed while varying tolerance levels were recorded for other herbicides; the upshot is that several of the herbicides tested, gave good control. Prof Vorster also determines mechanisms of herbicide resistance in weeds, and conducts DNA analysis for confirmation of plant identity. The information generated will thus assist with the design of an effective weed management strategy for this weed in South Africa.

The authors encourage readers to contact them about sightings of real or apparent Palmer amaranth. Available on request from the authors is a guide for identification.

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