Lessons from Argentina: Mitigating the devastation of Amaranthus

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Palmer amaranth and its close native relative, *Amaranthus hybridus* (*A. hybridus*), are currently the most troublesome weeds in Argentina. *Amaranthus palmeri* (*A. palmeri*) was first detected in the country in 2010 and has been expanding since. This species produces massive amounts of seed and since it is native to the southwestern deserts in the United States (US), it can germinate rapidly (two to three days) with little rainfall.

Another biological feature that makes it the 'perfect weed' is its extended germination period during the growth season. In northwestern Argentina, it starts germinating in early October and will have five to eight cohorts until March or April. It also has an impressive growth rate, being able to double in size in approximately five to seven days. *A. hybridus* behaves in a similar way, with lower growing rates and generally fewer cohorts throughout the season.

One of the biological features that makes Palmer amaranth the 'perfect weed' is its extended germination period during the growth season. (Photograph: revistacampoenegocios.com.br)

Main aspects to take note of

Considering these traits, management of the *Amaranthus* species is based on three main aspects:

Continuous field scouting

In order to detect the presence of these species as early as possible, the systematic scouting of fields is one of the key aspects in managing these intruders. This will allow the control of 'founder' individuals early enough to prevent seed dispersion in each field. When a population of amaranth species is already present on a farm, it is also necessary to reinforce monitoring activities to ensure timely herbicide applications.

Timing is important for the use of both post-emergent and residual herbicides. In the case of post-emergence, most of the protoporphyrinogen oxidase (PPO) inhibitors (Group 14 herbicides) have a short application window, and herbicide efficiency can drop drastically when plants are more than 7 to 10cm tall. Residual herbicides are much more effective for controlling these species, but proper timing is crucial to optimise the protection period. In addition, since new cohorts will still develop, an eye needs to be kept on germinations even after residual applications.

Use of multiple residual herbicides

Considering the local experience and the valuable information available in the US, the management of amaranth populations with only one effective residual herbicide is not enough to control their expansion. Factors such as multiple resistance populations, timing of applications, and environmental conditions make it necessary to implement management strategies that include two or more effective residual herbicides with different sites of action.

In certain cases, it can be achieved by using labelled formulations or approved in-tank mixes of various active ingredients at pre-emergence of the crop. Another alternative is to use a technique called 'overlapping', which entails spraying different sequential herbicides throughout the season to prevent the natural decay of herbicide activity in the soil.

Zero tolerance for seed production

When dealing with any weedy species, we need to understand that the most threatening element is the large amount of seed each plant can produce. That is why it is necessary to eliminate any surviving weeds or 'scapes' before flowering.

According to the development stages of crops and weeds, this can be achieved by means of post-emergence herbicides, hand weeding, or harvest weed seed control tools. Growers need to consider these labours as an investment to reduce the impact of severe weed competition in the future.

Waging war against resistant weeds

It goes without saying that there is an increase in the production costs in the areas affected by resistant amaranth weeds. In Argentina, there is currently a heavy reliance on PPO pre- and post-emergence herbicides (sulfentrazone, flumioxazin, fomesafen, and lactofen). In addition, VLCFA inhibitor herbicides (Group 15) such as s-metolachlor,

Amaranthus palmeri where it was first confirmed in South Africa (April 2018) in a cotton field in the Douglas district. (Photograph: Dr Charlie Reinhardt)

acetochlor, or pyroxasulfone, and inhibitors of photosynthesis at the photosystem II (Group 5), such as metribuzin, are used in tank mixes. As the use of herbicides increased in response to these weeds, so did the selection of new resistant populations.

Back in 2012 there were two main *A. palmeri* populations in Argentina: one with resistance to glyphosate, and another with resistance to ALS inhibitors. Nevertheless, *A. hybridus* was the first resistant weed registered in Argentina in 1996, with widespread ALS inhibitor resistance at the time. Nowadays, there is evidence of resistance to PPO and growth regulators in both species in different areas.

It is important to note that in the US, Palmer amaranth has developed a resistance to seven different modes of action, leaving very few effective herbicide options for control. Therefore, different agronomic and integrated management strategies are being developed, such as cover crops, planting dates, row width, and artificial intelligence assisted spraying.

Diversifying management strategies is the best alternative, at least for the time being. Ideally, we need to consider diversification of both space and time. Diversification of space refers to the planning of different crops and herbicide schemes for the different fields on the farm, as shown in *Figure 1*. In addition, making use of crop rotation and different herbicide mixtures throughout the years for each field should be considered – this should include planning an estimated management strategy for at least three to five years.

Prevention is better than cure

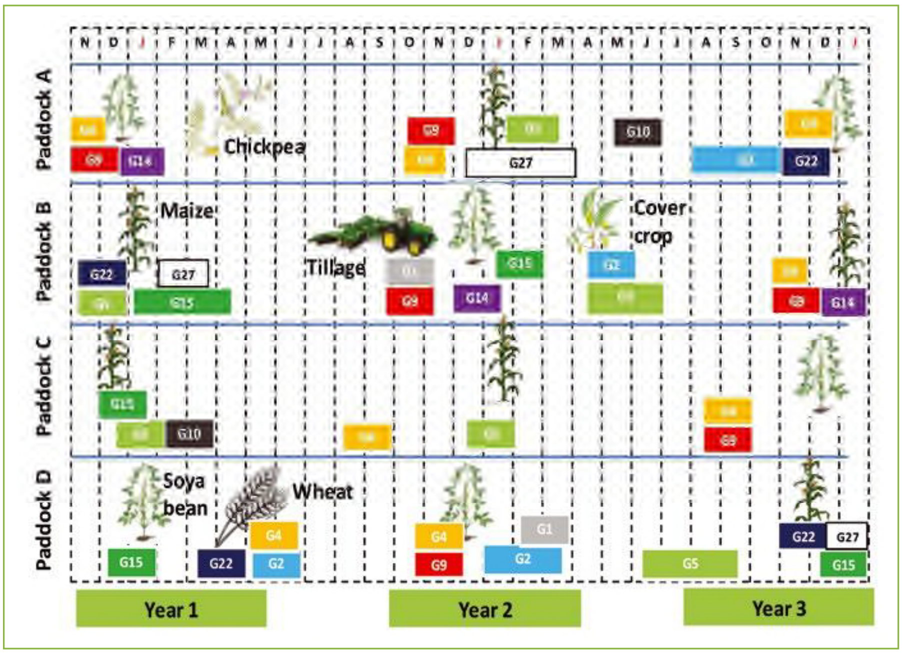
Considering the experience gained in Argentina over the past 15 years, it is recommended that this issue be addressed as soon as possible. Growers need to be aware of the risks imposed by these weeds and learn to identify them in the field early in the season. It is therefore vital to offer weed identification courses and to provide online and printed material, indicating the key aspects of species identification and scouting strategies.

The different herbicides registered in the country need to be evaluated in order to identify the best alternatives according to soil, weather, and weed biology traits. It is recommended that the establishment of regional research plots – where herbicide efficacy can be thoroughly tested – be promoted.

It is also important to study germination and growth rates, as well as the influence of planting dates and crop rotation in these variables. Beyond the growth season, winter fallow conditions and the viability of cover crops to prevent the early germination of weeds may be of interest to diversify management strategies.

It is usually difficult to foresee the impact of herbicide resistance when a single post-emergence herbicide is flawlessly controlling everything in the field. However, leaving this issue unattended can rapidly escalate into a situation where even the complex strategies that were previously described may fail. The sooner you can incorporate integrated management strategies into your production scheme, the longer you will delay herbicide resistance development and thus be able to maintain the efficacy of herbicides.

Figure 1: Schematic of crop and herbicide diversification scheme.



Different colour bars indicate the timing of herbicide application and the different groups of herbicides available (according to the Herbicide Resistance Action Committee's 2020 classification).
The specific herbicides used will depend on the active ingredients registered for the specific use in each country. G1: Inhibition of ACCase, G2: inhibition of ALS, G4: auxin mimics herbicides, G5: inhibition of photosynthesis at PSII, G9: inhibition of EPSPs, G10: inhibition of glutamine synthetase, G14: inhibition of PPO, G15: inhibition of VLCFA synthesis, G22: PSI electron diversion, G27: inhibition of HPPD.

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