Herbicide residues in low rainfall sandy soils

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RESEARCH

Key messages

- **A study of herbicide residues in sandy soils in the southern low rainfall region found glyphosate and its breakdown product AMPA at all nine sampled sites.**
- **The combined residue load (glyphosate plus AMPA, 0-30 cm) represented between 0.7 and 6.1 typical applications. The majority (~85%) of the herbicide residue was found in the top 10 cm, and was predominantly AMPA (~80%) rather than glyphosate.**
- **Little is known of the toxic effects of AMPA and how it may affect root growth and function across different crop species. Identifying threshold levels of AMPA that negatively impact crop productivity would be valuable.**
- **The study detected trifluralin (8/9 sites) and 2,4D (4/9 sites) at low concentrations unlikely to be damaging to crops. We did not detect prosulfocarb, imidazolinones (imazapic, imazapyr, imazamox), triclopyr, or MCPA. Spray history details are being collated to further understand the glysphosate results and assess whether non-detection of other herbicide residues is due to infrequent use or to breakdown.**

Why do the trial?

There is a lot of concern amongst farmers and advisers about damage to following crops from herbicide residues in sandy soils. The fate and behaviour of herbicides in soils is complex and is governed by a range of processes. The type of herbicide, the soil characteristics, and the environment all play an important role in where herbicides move in the soil profile, and how long they persist there. Herbicides break down through chemical and biological reactions. The opportunity for biological breakdown in sandy soils may be limited due to a relatively small microbial biomass, limited organic matter to fuel microbial activity, and reduced activity due to limited soil moisture. Where acidic soils exist, the microbial community is likely to be further limited. It is important to understand: a) whether the breakdown of herbicides is slower in sandy soils; b) what factors result in longer residence times; and c) what aspects of management can be changed to avoid reduced crop vigour.

Anecdotal evidence of damage from herbicide residues in following crops has been widespread in sandy soils across the low-medium rainfall region. However, there has been little measurement of how much, and what type, of herbicide residues may persist in sandy soils. The work reported here aimed to assess the presence/absence of a range of herbicides in typical sandy soils of the southern region.

How was it done?

The GRDC Sandy Soils project (CSP00203) undertook a study in early 2017 to quantify the amount of a broad range of herbicides present in sandy soils. Soils were sampled from nine typical paddocks from south western NSW, the Victorian and South Australian Mallee, the Yorke Peninsula, and the upper Eyre Peninsula. Soil samples were taken at 0-10, 10-20, and 20-30 cm depths to understand where herbicides were in each profile. Samples were analysed for glyphosate and its break-down product AMPA (aminomethylphosphonic acid), trifluralin, prosulfocarb, three imidazolinone herbicides (imazapic, imazapyr, imazamox), and three acidic herbicides (2,4-D, triclopyr, and MCPA). Germination assays (lucerne) were also carried out on these soils and compared to a herbicide-free sand control.

What happened?

The presence of herbicides and their amounts in the top 30 cm of soil profile are summarised in Table 1. MCPA, triclopyr, and prosulfocarb were not detected at any of the nine sites. 2,4-D was detected at four sites, and trifluralin at eight sites, both at low levels (<0.1 kg/ha) unlikely to be damaging to crops.

Table 1. Herbicides measured in soils across nine sandy sites in the LRZ of the Southern region. Data include the presence (# sites found out of 9 sampled) and the average, minimum and maximum herbicide load (kg/ha, 0-30 cm) of a range of herbicides. Nine sites were included with 6 sampling points across the sand dune/area.

	Herbicide load (0-30 cm, kg/ha)						
	Glyphosate	**AMPA**	**2,4-D**	**MCPA**	**Triclopyr**	**Trifluralin**	**Prosulfocarb**
Average	0.30	1.39	0.01	nd	nd	0.04	nd
Presence	9/9	9/9	4/9	0/9	0/9	8/9	0/9
Minimum	0.10	0.27	nd	nd	nd	nd	nd
Maximum	0.56	3.25	0.05	nd	nd	0.10	nd

nd= not detected.

Glyphosate and AMPA were found at all sites (Table 1), with AMPA detected at higher levels (average 1.4 kg/ha) compared to the parent compound, glyphosate (average 0.3 kg/ha). Across the nine sites, the glyphosate content varied from 0.1 to 0.56 kg/ha, while AMPA varied from 0.27 to 3.25 kg/ha. These results are in line with previous work that included a few sandy soils from the southern region.

Glyphosate and AMPA were always higher in the top 10 cm (0.28 and 1.14 kg/ha), and declined rapidly with depth (Figure 1a). Typically 85% or more of the combined load was in the top 10 cm. In soils with known texture changes or chemical gradients (e.g. pH) a finer level of depth stratification may be important as these differences may concentrate herbicides in more discrete soil layers. Sampling at smaller intervals of depth would provide a more detailed picture of what the growing plant root is exposed to. There was no evidence that glyphosate or AMPA were moving down the profile and accumulating at the sites sampled in this study.

Herbicide application history should play an important part in understanding these results (still being collated). However, the data clearly indicate several applications worth of glyphosate and AMPA within the top 30 cm of all sites. On average, the cumulative glyphosate load (glyphosate plus AMPA) was 1.6 kg/ha and ranged from 0.4 to 3.7 kg/ha across sites (Figure 1b). A typical glyphosate application rate provides 0.60 kg/ha of active ingredient (not the product). Therefore, the combined amount measured at these sites represented between 0.7 to 6.1 typical applications.

It is notable that AMPA content was always higher compared to glyphosate. On average AMPA was 80% of the cumulative load, and was largely responsible for the higher cumulative load at sites 7-9 (Figure 1b). The higher AMPA content suggests slower breakdown compared to glyphosate, and accumulation over several applications at most sites. Better understanding of the breakdown rates of both glyphosate and AMPA in these sands, along with sampling at different times after application may help to explain the higher levels of AMPA compared with glyphosate.

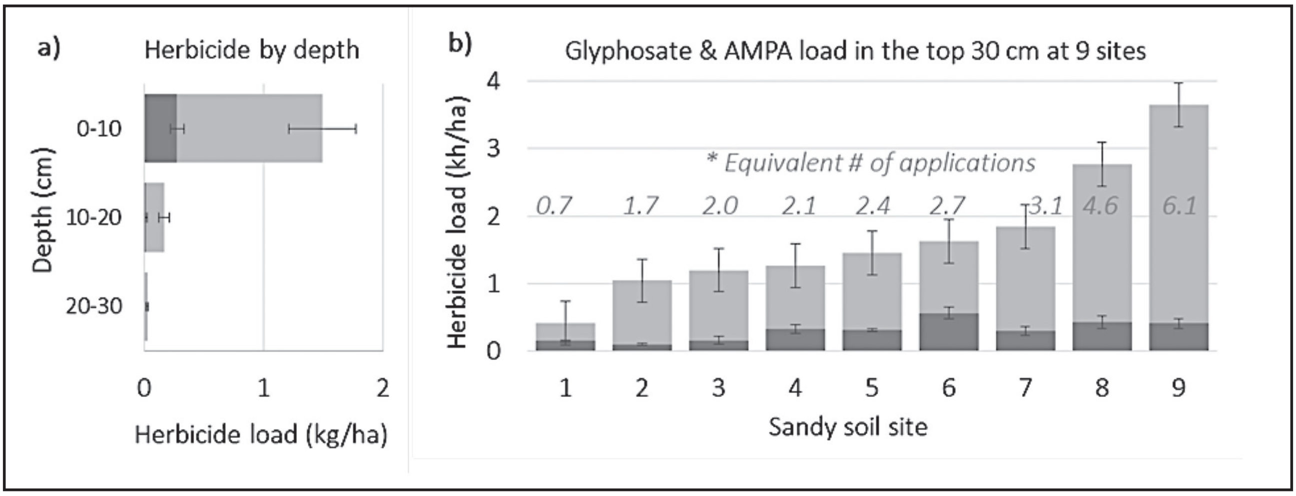

***Figure 1.** a) the distribution of glyphosate and AMPA down the profile at 10 cm increments (n=9, ±standard error); b) the amount (kg/ha) of glyphosate (dark) and AMPA (light) in the top 30 cm across 9 sand soil sites (n=6, ±standard error); where the equivalent number of applications are estimated (*) for each site.*

Both glyphosate and AMPA are toxic to sensitive plant species. A lab-based toxicity test on the same soils (0-10 cm) indicated that the concentrations did not have a negative impact on germination of lucerne. However, lucerne may not be the most sensitive species to AMPA. Further bioassays on sensitive species, and over longer growth periods would be valuable. There is limited information available about the toxicity of AMPA and its potential impact on root growth and function across a broad range of crop species.

Improved knowledge of the effects of AMPA on root function and plant vigour is needed to identify threshold levels that may impact productivity of different crops. Wider research has indicated that glyphosate residues interact with phosphorus fertiliser, making them more bioavailable. Therefore, an understanding of how herbicide residues interact with aspects of management, soil condition, and constraints to plant growth (e.g. high penetration resistance, poor nutrient supply, low biological activity) would be valuable.

Acknowledgements

This work is funded under the GRDC project CSP00203; a collaboration between the CSIRO, the University of South Australia, the SA state government through Primary Industries and Regions SA, Mallee Sustainable Farming Inc., and AgGrow Agronomy and Research P/L. We thank the growers for granting access to paddocks, and providing management history details.

Soils