Bio4Ag Toolbox Indicators: weed seedbank

Background

Within cultivated fields, weeds are the primary source of plant diversity and crucial to the functioning of arable systems, regenerating annually from cultivated soil after disturbance and providing resources for above and below ground foodwebs and associated ecosystem services. Weed seeds can persist in the soil for decades, providing a buffer and a degree of resilience to climate change and agricultural intensification. Taxonomic and functional diversity of species in the seedbank are an indicator of the long-term filtering effects of management, both negative (losses of biodiversity from intensive herbicide use) and positive (where beneficial species are left to return seed to the soil). Dominance by beneficial species may have an antagonistic effect on noxious weeds and, with application of appropriate weed management filters, can reduce the impact of competitive species to achieve a long-term balance between biodiversity and crop productivity.

Integrated cropping strategies

At the Centre for Sustainable Cropping (CSC) long-term experiment, we combine management interventions into a single cropping system for multiple benefits. A key goal for management is to maintain sufficient diversity of plant resources to support above and below ground foodwebs without incurring a yield penalty. Given that the in-field flora is dependent on annual regeneration from the soil seedbank, it is important to apply management filters to the above-ground vegetation that result in seedbank communities comprising primarily of beneficial species with low numbers of pernicious weeds. In theory, this can be achieved by varying the timing of disturbance (cultivation and herbicide) in relation to flowering periods and seed set by beneficial and competitive weed functional groups. The integrated crop system at the CSC uses a semi-targeted approach, omitting pre-emergence herbicides, and using post-emergence sprays where the weed burden becomes an issue, e.g. in fields where seedbank populations of competitive weeds are high, or after several years of direct drilling where weed densities exceed threshold levels at the soil surface before cultivation for potato provides an opportunity for burial. Further work is required to refine this strategy and better understand the effect of management filters on the proportional contribution of each species to the existing seedbank.

Results from the CSC

The arable weed seedbank at the CSC was assessed annually from soil samples collected in March 2010 to 2024. Soil was collected from 350 permanent GPS locations across the six fields of the CSC each year, sieved and laid out in seed trays in a glasshouse. All emerging seedlings were identified where possible to species or otherwise to genus. Data were analysed using non-parametric Kruskal-Wallis ANOVA to assess the effect of integrated cropping on seedbank richness and abundance. Variability across fields was high, but species richness was significantly greater than conventional cropping in four of the six fields (Fig1A, $p<0.001$), dicot abundance was greater in integrated systems in three fields (Fig1B, $p<0.001$), and monocot abundance was not statistically different from conventional practice apart from in one field (Fig1C, $p = 0.056$) though there was a trend overall for higher numbers in the integrated treatments. Species composition was less affected by treatment but varied across fields with distinct communities characterising each, dominated by: oilseed volunteers and ragwort (K); speedwell and forget-me-not (L); mayweeds and field pansy (M); cudweed and speedwells (N), shepherd's purse and speedwells (O) and; mayweeds (P). Differences in the functional traits of these species (time to flowering, shade tolerance, germination requirements etc.) may explain the varied responses to cropping system.

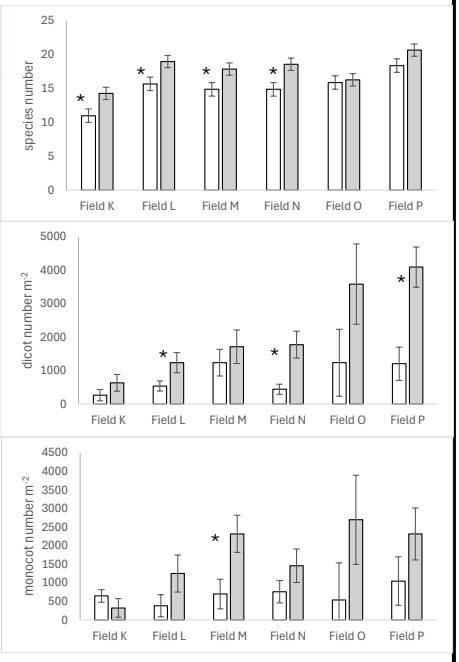

Figure 1. Total seedbank species number averaged per year (A), average number of dicots (B) and monocots (C) m^{-2} yr^{-1} (and standard errors) in conventional (open) and integrated (shaded) crop systems.

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How to measure weed seedbank assemblages

Knowledge of the species present in the soil seedbank of a field is the first step in designing the best weed management strategy to minimise the risk of yield penalty due to competition with the crop but without having to resort to complete eradication of beneficial types. The most straightforward technique is the emergence method where weed seeds are allowed to germinate from soil samples collected across a field.

Equipment: 20 x 20 cm quadrat, trowel, labelled bags, 2 litre plant pot, seed trays.

Timing: Collect soil samples around mid-March, when the ground isn't too frozen but before spring crops are sown.

Location: Collect soil from about of 20 locations in a W shape to cover the whole field.

Procedure:

1. At each sample location, remove any surface debris, dig a 20 x 20cm pit to 20 cm depth and mix the soil thoroughly.

2. Fill up 2 litre pot to the top with loose, mixed soil (avoiding stones) and tip into a plastic bag labelled with the field name and sample number. Repeat for all sample locations.

3. Sieve each soil sample through a 10mm sieve into a seed tray and add a plant label with the field name and sample number.

4. Place all seed trays in a glasshouse for emergence assessments. A standard greenhouse will work fine, but at the Hutton the glasshouse conditions are set to:

Light intensity set to 300µmol.m2.sec-1, 12-hour day length, 18°C day, 15°C night. Shade screens operative at 600µmol.m2.sec^{-1} and 22°C

5. Water trays as required over the next 4-6 weeks to ensure that the soil is kept constantly damp but not too wet and not allowed to dry out.

6. As the seedlings emerge, record the species of each seedling as soon as it is big enough to correctly ID and handle. Remove seedlings as you record them and photograph any that can't be identified for future reference.

7. Continue assessments until no new seedlings emerge for at least 2 weeks.

8. For a second flush, re-sieve the soil in each tray through the 10 mm sieve and repeat the emergence assessments as before, recording the species ID and removing the seedlings as they emerge.

9. When emergence has finished, add up the total number of individuals of each species present and rank by abundance from high to low. This will show which species are dominant or rare in the field and allow comparison across fields in terms of species composition and abundance.

Useful links

- Hawes, C., Iannetta, P.P.M., Squire, G.R. (2021) Agroecological practices for whole system sustainability. CAB Reviews, 16, no. 005.https://doi.org/10.1079/PAVSNNR202116005

- Hawes, C., Alexander, C.J., Begg, G.S., Iannetta, P.P.M., Karley, A.J., Squire, G.R., Young, M. (2018). Plant Responses to an Integrated Cropping System Designed to Maintain Yield Whilst Enhancing Soil Properties and Biodiversity, Agronomy, 8(10), 229. https://doi.org/10.3390/agronomy8100229

- https://csc.hutton.ac.uk
- https://csc.hutton.ac.uk/resource/Handbook_of_indicators_v1.pdf

- Weed seedling ID guides: AHDB Weed identification pocket guide.pdf https://media.ahdb.org.uk/media/Default/Imported%20Publication%20Docs/Weed%20identification%20pocket%20guide.pdf

- BASF UK weed ID app https://www.agricentre.basf.co.uk/en/Services/Mobile-Tools/Weed-ID-app/

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