Techniques for monitoring seed banks of annual grass weeds on arable soils

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Summary
Techniques and equipment developed to adequately monitor weed seed banks in arable systems are described. Estimations of processing speed are given for a number of separate steps for alternative methods developed for small and large seeded species. The usefulness of seed bank data for assessing population changes is illustrated.

Introduction

A number of problems are evident with current weed management technology. Many weed problems persist from year to year, and farmers are concerned about the increasing costs of weed control, the more frequent incursion of herbicide resistant weed biotypes and the environmental hazards associated with relying too heavily on pesticides in general. It would help, therefore, if techniques were available to monitor weed populations, rather than infestations.

The weed flora of arable lands consists primarily of annuals that regenerate from a reservoir of seeds in the soil which is rarely considered, or measured, when assessing the impact of management tactics or strategies. Instead, assessments of control invariably concentrate on changes to weed density or biomass. However, this is changing slowly, and as techniques are developed to monitor seed banks then the importance of this parameter will be increasingly recognised.

Many difficulties are encountered, however, in obtaining estimates of seed bank populations in arable systems. A number of these problems have been overcome with the mechanising of several steps to achieve a desirable intensity of sampling.

Sample size

The optimal sample size is one which, for the resources available, provides an estimate of seed populations with minimal error. This can be determined by preliminary survey but experience with a number of projects has indicated that between 30 and 50 cores of 9cm dia. taken from a 10 by 2m plot is satisfactory. These should be systematically collected from within the entire plot, rather than from a few random locations.

To achieve such a level of sampling, corers were coupled via bayonet mounts to two movable hydraulic rams mounted at the rear of a tractor. Axels on the tractor were widened to give 2.4m wheel clearance so as to avoid undue disturbance to field plots. With three operators, about 2,500 cores can be obtained per day.

Processing

Seeds can be enumerated either by grow-out procedures or by extraction. Although labour intensive, extraction has many advantages and seems a more appropriate method for demographic type studies.

Separate techniques were consequently developed for small and large seeded species to speed-up processing.

To estimate small seeded species it was found expedient to reduce the total soil mass to about 15% of the total sampled. Thorough crushing and mixing was essential to obtaining a representative subsample. Two pieces of equipment, a roller mill and a rotary subsampler were fabricated for these operations.

Up to 25kg of soil can be placed inside the cylindrical drum of the mill along with one or two 2.5kg rollers. As the drum rotates at about 30rpm, the soil is mixed and crushed until it passes through the 5mm perforations. The thoroughly mixed free flowing soil is then passed through the subsampler which consists of a collecting tray rotating at 60rpm. Pots or wedges placed within the tray collect portions of the sample flowing from an overhead hopper. The size of the portion may be varied by using collecting containers of different sizes. Two operators can process approx. four samples per hour through the combined steps.

The above steps are unsuitable for large seeded species which are easily damaged. To separate these, therefore, a $4m^3$ tank housing a cradle designed to hold six canisters made of 1mm perforated steel was constructed. The cradle rotates at 6rpm, plunging the canisters into the water bath, sluicing out the soil. Up to 12 samples, each of 50kg can be washed per day.

Samples were then dried at a maximum of $30^{0}C$ and stored. Final separation in the laboratory is completed by hand by passing samples through a series of wet sieving, flotation and winnowing steps. Soils containing heavy clay are dispersed in a solution of sodium hexametaphosphate and sodium bicarbonate (10g + 5g respectively in 200ml of water per 100g of soil). The sample is then rinsed through a tier of sieves and the residue floated in a saturated calcium chloride solution (1.36g cm^3). The organic fraction is decanted and rinsed. Sometimes it is helpful to pass the sample through absolute ethanol (0.78g cm^3) to further partition the material prior to winnowing and counting.

Processing speed varies with species, seed size and the density of seeds. *Vulpia* spp., silver grasses, with up to 800 seeds per sample may take four hours, whereas a sample containing 200 seeds of *Avena* spp., wild oats, can be completed in half to one hour. A 500g sample containing 100 *Polygonum aviculare* seeds can be processed in 15 minutes.

Conclusions

The customised soil sampling and processing equipment has enabled extensive studies of seed banks of a range of important annual weeds in agronomic systems. The information has been especially valuable in permitting an incisive analysis of the reasons for the persistence of wild oats and has opened the way towards developing improved strategies aimed to reduce the weed management costs (see references 1 to 10).

Acknowledgments

I am particularly grateful to Kim Jones, Barry Kay and David Pickering who assisted with the design, and Jack Bono for constructing much of the equipment; all of which was funded by the Grains Research and Development Corporation of Australia. Thanks also go to Belinda Gersbach for preparing the poster describing this work.

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