OPTIMISING CONDITIONS FOR WEED SEED EMERGENCE FROM SOIL TRAYS IN A GLASSHOUSE

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ABSTRACT

Estimates of the weed seed bank were made by extracting the weed seeds from the soil and by germinating seedlings in soil samples in a glasshouse and in field plots. Modifying seed tray conditions in the glasshouse, viz. soil depth, soil ameliorants, water placement and temperature affected the numbers of different weed species that emerged. Most species tested emerged best from soil 10-20 mm deep over vermiculite watered from below and from soil mixed with vermiculite watered from above. For most species only a small proportion of the seed in the soil emerged as seedlings, but there was generally a useful relationship between emergence in the glasshouse and emergence in the field.

Keywords: weed seeds, seedling emergence, seed extraction

INTRODUCTION

If potential weed populations could be predicted before crops were sown, it might be possible to reduce the impact of weeds by altering crop selection or changing sowing times to avoid major problem weeds (Ball and Miller 1989; Radosevich 1984). A pre-requisite for making such predictions is an effective technique of sampling the soil and enumerating the viable seeds present in the samples. Soil weed populations can be determined by physical extractions of seeds from soil samples, but that technique examines small samples and requires specialised expertise and equipment. Also after successfully enumerating the seeds, information is needed on the proportion of viable seeds of each species which is likely to give rise to seedlings following soil disturbance (Roberts and Ricketts 1979). An alternative method is to germinate the weed seeds from a known amount of soil and record the seedling emergence.

A project was initiated in 1994 to compare the two main techniques for seed enumeration as the first step towards assessing the potential of using the weed seed content in the soil to predict future weed problems (Rahman *et al.* 1995). It soon became apparent that the seedling germination method requires continuous maintenance of optimum glasshouse and soil conditions to ensure maximum seed germination, especially in soils like the Mangateretere silt loam of Hawkes Bay. The experiments reported in this paper were established to test a range of conditions on weed seedling emergence. These conditions included soil depth, soil ameliorants, water placement, under soil material and the effect of shade.

METHOD

On 20 January 1995, dry soil was collected from a cultivated field, sieved twice through 10 mm and 6.7 mm mesh sieves and mixed thoroughly. Measured aliquots of this soil were used for comparison of germinating conditions and for weed seed extraction. Seed extraction was done by the MAF Quality Management Official Seed Testing Station, Palmerston North by differential dry sieving after an initial wash to extract the seeds which were then identified and counted (Rahman *et al.* 1995).

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The different conditions tested for their effects on weed seed emergence were:

1. Soil depths of 10, 20, 30 and 40 mm which were obtained by placing the appropriate soil volume over a complementary volume of vermiculite separated by a water permeable cloth. The 40 mm soil had no vermiculite layer as trays were only 40 mm deep. Trays were impervious and watered by pouring water into the vermiculite layer in sufficient quantity to keep the soil surface moist. For the 40 mm soil water was poured into a "well" at the corner of the tray from where it spread in time (not very satisfactory as water dispersal was very slow without the vermiculite layer).
2. Soil ameliorants of vermiculite or peat, were mixed separately with equal volumes of soil to give a 40 mm layer in the trays and watered by sprinkler from above.
3. Water placement. A 20 mm layer of soil was placed over 20 mm of vermiculite, separated by a water permeable cloth, in perforated trays and watered either by sprinkler from above, or by dipping the base of the trays into water for a few minutes.
4. Under bed. A 20 mm layer of soil was placed over 20 mm of either vermiculite or sand, separated as above, and watered from above.
5. Shade. Soil mixed with equal volume of peat was placed 40 mm deep in trays placed either in an unshaded glasshouse or in a covered area outside away from direct sun and watered from above.

Treatments were replicated three times. Trays were placed in a glasshouse (except 5. above), covered by shade cloth and watered three times a week with amounts adjusted by apparent need. Maximum and minimum air temperatures were recorded at 2-3 day intervals.

Weed seedlings were removed when they could be identified and numbers recorded over consecutive 2-weekly periods starting 4 days after the soil trays were filled. After a final count on 13 March 1995 (completion of Run 1), the soil in one replicate of each treatment was stirred and replaced in the tray in the glasshouse, while two replicates were placed in a coolstore (at 2°C) for 2 or 4 weeks, after which they were stirred and returned to the glasshouse (Run 2).

The field area from which the soil was collected was cultivated on 25.1.95 and irrigated to stimulate weed emergence. Weeds were recorded and removed from sixteen 200 x 200 mm quadrats on 22.2.95 and 22.3.95.

RESULTS

Of the major weeds that could be identified at an early growth stage 74% of the total recorded over the 6 week period emerged in the first 2 weeks (Table 1). The weeds in this category, in order of dominance, were *Amaranthus* spp., scrambling speedwell (*Veronica persica*), wild portulaca (*Portulaca oleracea*), black nightshade (*Solanum nigrum*), summer grass (*Digitaria sanguinalis*), twin cress (*Coronopus didymus*), mallow (*Malva* sp.), parsley piert (*Aphanes arvensis*), fathen (*Chenopodium album*) and bitter cress (*Cardamine hirsuta*). However, there was considerable variation in the emergence pattern among the weed species (Table 1). For example, 93% of the summer grass and fathen emerged in the first 2 weeks with virtually nothing in the last 2 weeks, while 63% of the twin cress emerged in the last 2 weeks.

Weed species also varied in their response to the various conditions tested (Table 2). Emergence of all except black nightshade, summer grass and toad rush (*Juncus bufonius*) was reduced by increasing soil depth (maximum 40 mm). Emergence of *Amaranthus* spp., portulaca and mallow was enhanced by the addition of vermiculite or peat to the soil, whereas emergence of scrambling speedwell, twin cress, parsley piert and toad rush were enhanced only by the addition of vermiculite. Twin cress, toad rush, speedwell and parsley piert emerged in very much higher numbers from trays watered from below than from trays watered from above, while *Amaranthus* spp. and summer grass emerged more readily from soil over vermiculite than over sand. The C-4 species, *Amaranthus* spp., portulaca and summer grass emerged best in the glasshouse, while the "winter" weeds speedwell, twin cress and mallow emerged best in the cooler outside conditions.

TABLE 1: Periodic distribution of weed seedling emergence by species over a 6 week period (24.1.95 - 7.3.95) in the glasshouse (mean of all treatments).

Weed species emerged/litre soil	Total No. seedlings	Percent emergence by time		
		Weeks 1-2	Weeks 3-4	Weeks 5-6
All species	88.1 ± 5.1 ¹	74	17	9
<i>Amaranthus</i> spp.	21.4 ± 1.3	84	12	4
Bitter cress	0.7 ± 0.1	60	34	6
Black nightshade	8.7 ± 0.5	91	7	2
Fathen	1.5 ± 0.1	93	7	0
Mallow	3.5 ± 0.3	79	13	8
Parsley piert	2.4 ± 0.4	7	47	46
Portulaca	18.3 ± 1.4	80	16	4
Scrambling speedwell	19.5 ± 2.5	58	30	12
Summer grass	8.6 ± 0.5	93	5	2
Twin cress	3.6 ± 0.7	22	15	63

¹Standard error of the mean**TABLE 2: Response of weed species to varying conditions of growth based on weed emergence/litre of soil.**

Weed species	Soil depth	Soil amel	Water placement	Under bed	Shade ¹
<i>Amaranthus</i> spp.	S	N#	N	Y*	--
Black nightshade	N	N	N	N	N
Fathen	S	N	N	N	N
Mallow	*	N#	S	N	+
Parsley piert	**	*	**	N	
Portulaca	Y	N#	N	S	---
Scarlet pimpernel	*	N	S	N	
Scrambling speedwell	***	*	**	N	+++
Summer grass	N	N	N	*	--
Toad rush	N	**	**	N	
Twin cress	*	***	***	N	+

Data analysed by ANOVA

N = no effect

S = apparent trend but not significant

*, **, *** = significant effect ((P < 0.05, 0.01, 0.001)

no difference between ameliorants but both produced more seedlings than 20 mm soil placed over a vermiculite layer

¹+ indicates higher emergence in shade and - higher emergence in glasshouse

All species affected exhibited the same trends:

- more emerged from shallow soil than from deep soil;
- more emerged from vermiculite mix than from peat mix;
- more emerged from bottom watering than from top watering;
- more emerged from soil over vermiculite than from soil over sand;

Seedling emergence after stirring the soil, with and without a period in coolstore, was much less than the initial glasshouse emergence for all species except twin cress where emergence was high after stirring/cooling (run 2) (Table 3). All species showed

similar emergence on run 2, whether stirred only, or stirred following 2 or 4 weeks in the coolstore, except twin cress where emergence was 60% higher after cooling and stirring than stirring alone.

The number of weeds that emerged in the field 28 days after cultivation are shown in Table 3, along with the comparable glasshouse emergence, after 18 days, averaged over 12 trays from four soil depths. For most species there was a consistent correlation between field and early glasshouse emergence. Notable exceptions were portulaca and summer grass, where glasshouse emergence was much greater than field emergence and speedwell where field emergence was greater than glasshouse emergence.

TABLE 3: Weed seedling emergence in the field 28 days after cultivation, and in the glasshouse 18 days after initial mixing (Run 1) or 18 days after stirring/cooling (Run 2) and seed numbers extracted from the soil.

Weed species	Field emergence No. / 400 cm ² ¹	Glasshouse emergence No./litre		No. seed extracted /litre soil
		Run 1	Run 2	
<i>Amaranthus</i> spp.	13.3 ± 1.9	16.1 ± 2.5	1.2 ± 0.28	215 ± 18.9
Black nightshade	10.0 ± 1.6	7.1 ± 1.1	0.4 ± 0.17	14 ± 3.5
Fathen	0.9 ± 0.3	0.9 ± 0.2	0.2 ± 0.06	9 ± 1.1
Mallow	2.3 ± 0.5	2.6 ± 0.4	0.3 ± 0.10	31 ± 11.8
Portulaca	2.9 ± 1.1	12.1 ± 2.2	0.5 ± 0.20	134 ± 5.0
Scrambling speedwell	21.3 ± 4.9	14.2 ± 0.9	8.3 ± 0.84	170 ± 4.9
Summer grass	2.9 ± 0.5	7.2 ± 1.3	0	29 ± 0.6
Twin cress	1.0 ± 0.3	0.8 ± 0.2	25.1 ± 3.52	41 ± 2.7

¹ 400 cm² to 2.5 cm depth = 1 litre

Comparison of seedlings emergence and the number of seeds extracted from the soil (Table 3) shows approximately half the black nightshade seed in the soil produced seedlings in the first 18 days, about one quarter of the summer grass, but only about one tenth or less of the other weed seed produced seedlings. However, on the second run about 60% of the twin cress seed produced seedlings.

DISCUSSION

It is apparent from this work that weed species respond very differently to different growing conditions. However, most species tested emerged in reasonably good numbers from soil 10-20 mm deep over vermiculite watered from below and from soil mixed with vermiculite watered from above. The only condition where the preferred condition for one species was antagonistic to another was temperature. As the two species where emergence was enhanced in the glasshouse, portulaca and summer grass, gave a considerable over estimate of field emergence, a useful estimate of field emergence might be obtained by keeping germination trays outside in the open. The high twin cress emergence in weeks 5-6 suggests this species has a seasonal response, presumably day length, as there was little change in temperature over the 6 week period. The enhanced emergence after 2 or 4 weeks in the coolstore could have been a response to either temperature or season.

Though emerging seedlings gave a reasonably good estimate of the possible field emergence, they represented only a small and variable fraction of the weed seed bank in the soil (Table 3). This low percentage is in line with that found by Ball and Miller (1989) who found 20-30% of the seeds in the soil emerged as seedlings over 8 months but in contrast to the results of Rahman *et al.* (1995) who obtained 65-100% germination for three quarters of the species studied over 6 months. Jensen (1969) also found seedling emergence accounted for only about 25% of the seeds in the soil and that most of those that emerged did so in the first month. If it can be established that there is a reliable relationship between the weed seed bank in the soil and emergence

in trays then either seed extraction or seedling emergence could be used to predict weed emergence in the field, as previously reported by Roberts (1981). The seed extraction technique has the advantage of giving an immediate result. It also could be done at any time of the year but requires specialised expertise and equipment. Seedling emergence, on the other hand, could be done by anyone who can recognise seedling weeds providing suitable conditions are maintained. The strong correlation between immediate seedling emergence in the glasshouse and field emergence suggests only the first flush of seedling emergence need be considered.

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