Doublegee (*Emex australis* Steinh.) seed banks

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Abstract

Farmers can control doublegee, *Emex australis*, on an annual basis by integrating cultural and chemical control methods, but it is still not possible to achieve long-term control or eradication of this weed. It is suggested that any control measure that reduces the seed dormancy or destroys the dormant seed bank would be of immense value in the long-term management of this weed. Unfortunately, practical methods for achieving this are still unavailable. Nevertheless, some important studies on its seed dormancy behaviour and the persistence of its seed banks have been undertaken in Western Australia. This paper discusses the findings of these studies.

Introduction

The vast majority of seeds entering the seed bank in arable land come from annual weeds growing on that land (Roberts 1981, Hume and Archibold 1986). Seed dormancy is a major factor contributing to persistence of seed banks (Bewley and Black 1982). The persistence of doublegee, *Emex australis* (Steinh.), in cropping systems is due to its seed dormancy and longevity. Any long-term management strategy against this weed therefore requires a good understanding of the functioning of its seed banks.

Dormancy in relation to seed bank

The most recent contribution to our knowledge on dormancy in doublegee seed comes from the work of Panetta and Randall (1993a). An understanding of the seed dormancy behaviour is an important prerequisite for developing strategies of weed management.

Using four Western Australian accessions of doublegee, they found that seeds of all accessions were dormant when freshly harvested, but gradually after-ripened over the summer months. A peak in germinability was reached during autumn. Depending on accessions, the phases of maximum germinability varied from a matter of weeks (or days) to a number of months. In a separate experiment, they found that plants from two accessions that were grown in a common environment produced seeds with virtually identical dormancy/non-dormancy cycles, thus suggesting that such cycles are influenced primarily by the environment in which the seeds are produced. They also found that a fall in temperatures preceded a drop in germinability for three of the accessions. This suggests that the induction of secondary dormancy in doublegee seeds may be related to decreasing soil temperatures during early winter. The proportion of the populations which became dormant ranged from 50 to 90%. The existence of these dormancy cycles in doublegee seeds therefore indicates that the dormant bank of seeds in the soil is in a state of continual physiological change which ensures that their dormancy status is always appropriate for the prevailing seasonal conditions.

Seedling emergence

Although the proportion of non-dormant seeds could range from 70 to nearly 90% during the phases of maximum germinability (Panetta and Randall 1993a), only a small proportion of the seed bank can produce seedlings each growing season. In one study, Panetta and Randall (1993b) recorded 17.6% emergence which is close to our figure of 17%, based on the mean over 4 depths (Cheam 1987). In any one year it is the seeds near the surface, within the top 5 cm of soil, which are likely to cause weed problems (Table 1). At depths greater than 5 cm the numbers of seed capable of completing emergence declined sharply so that no doublegee emerged from 15 cm or deeper. If the soil is left undisturbed, most seeds are confined to the soil surface, resulting in few established seedlings. A higher germination level of the buried seeds is expected because the better seed-soil contact allows the seeds to imbibe sufficient water for germination. The higher level of germination of the shallow-buried seeds suggests that shallow cultivation before sowing a crop would improve seed germination and so reduce the size of the seed bank. The resulting seedlings are then easily controlled by herbicides. However, the overall low emergence in any one year means that under normal herbicide treatment, only a small percentage of the total population is destroyed.

Table 1. Emergence per year (per cent of sown viable seeds) of doublegee from seeds sown at five depths. The data are means over three sites.

Depth (cm)	Year 1	Year 2	Year 3	Year 4
0	11.0	5.3	5.6	1.6
1	42.8	7.4	2.0	1.7
5	13.3	11.4	2.0	1.4
10	1.3	2.0	0	0
15	0	0	0	0

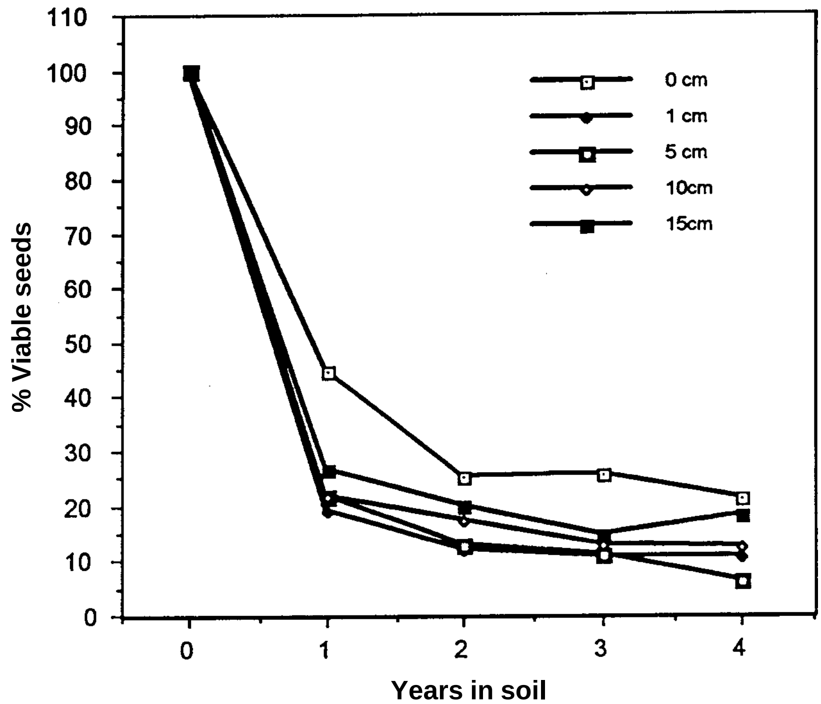

Figure 1. Decline of doublegee seeds at various depths.

Table 2. State of doublegee seeds after four years of burial.

Depth (cm)	Enforced dormant (%)	Induced / innate dormant (%)	Total viable (%)	Field germ. / rotted (%)
0	2.7	18.3	21.0	79.0
1	1.5	9.0	10.5	89.5
5	1.2	4.8	6.0	94.0
10	2.3	9.9	12.2	87.8
15	3.1	15.2	18.3	81.7

Table 3. Pre-planting soil compaction and other operations on the emergence of doublegee seedlings.

Treatment	Seedling no. m^{-2}
Compaction with flexi-coil land packer	620
Compaction with plain roller	1132
Compaction with ribbed roller	767
Direct drilling	20
Conventional cultivation	281

Seed survival

The depth of seed burial appears to have an effect on the rate of decline of viable doublegee seeds. The mean results over three sites indicated the greatest decline within the 1-5 cm depth, the slowest for the surface and deeply buried seeds (Figure 1) (Cheam 1987).

It was also noted that there was a higher retention of dormant seeds at cooler and wetter sites. Cooler temperatures may induce secondary dormancy as suggested by Panetta and Randall (1993a) and hence the more slowly seed viability declines (Schafer and Chilcote 1970, Harrington 1972) particularly at greater soil depths (Egley and Chandler 1983). The extended life-span of seeds in wetter conditions could be due to self-repair or replacement of cellular components (Villiers 1974). Thus, climate has a significant role in the rate of decline of viable doublegee seeds.

The persistence of doublegee and its ability to survive control measures is therefore directly related to the dormancy and longevity of its seeds. Survival of up to eight years was reported by Gilbey (1987) in one study. Cheam (1987) found that the seeds that survived after four years of burial were mainly in a state of induced or innate dormancy (Table 2). Hence, any measure that reduces seed dormancy or destroys the dormant seeds would be of immense value in the long-term management of doublegee. Unfortunately, practical methods for achieving this are still unavailable. Until we succeed, we are merely treating the symptom rather than the cause of doublegee infestations.

Stimulating germination to reduce seed bank

An attempt has been made to stimulate doublegee seed germination and then eliminate the seedlings as part of a strategy to reduce its seed bank (Cheam unpublished). Doublegee seeds are extremely sensitive to water stress. When the seeds were incorporated into the soil as soon as there was sufficient germinating rain, immediate compaction of the soil using a plain roller resulted in four times more emergence than the cultivation treatment and 57 times that of the direct-drilled (Table 3). Compaction gives better seed-soil contact resulting in better moisture movement from soil to seed. However, this technique of depleting the seed bank may not appeal to growers because it delays the sowing programme. Delayed sowing often results in less competitive crop stands and reduced yield.

Research needs

It is apparent that current weed control technology does not attempt to reduce the dormant seed bank of doublegee. Any measure (physical, chemical or biological) that reduces seed dormancy or destroys the dormant seeds would be of immense value in the long-term management of this weed. There is also a continuing need to quantify the relationship between weed density and crop yield with a view to provide threshold guidelines for farmers. In this regard, a study of its population dynamics under various cropping systems is required.

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