RELATIONSHIP BETWEEN SOIL SEEDBANK AND FIELD POPULATIONS OF GRASS WEEDS IN MAIZE

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ABSTRACT

The relationship between laboratory enumerations of the weed seedbank and field populations of major grass weeds was studied in several maize fields over a three year period. After planting the crop, 1 m² areas were protected from the pre-emergence herbicide application. Soil samples were collected soon after spraying from each area to a depth of 100 mm, and the seeds of the major grass weeds enumerated at a seed testing laboratory. Emerged weed seedlings were counted in each sampling area over the following 8 weeks. Grasses present at these sites included: summer grass (*Digitaria sanguinalis*), smooth witchgrass (*Panicum dichotomiflorum*), barnyard grass (*Echinochloa crus-galli*) and rough bristle grass (*Setaria verticillata*). On average 6-12% of the seed in the soil seedbank emerged in any one year depending on species. Significant linear relationships were established between seed numbers in the soil and the seedlings that emerged in the field.

Keywords: weed seedbank, weed emergence, grass weeds, seedbank enumeration.

INTRODUCTION

The weed seedbank as a reservoir of weed seeds in the soil largely determines the potential density and species composition of weeds that subsequently interfere with crops during the growing season (Forcella 1993). In this respect, knowledge of the total seedbank and an ability to predict the germination and behaviour of weed species presents a number of practical opportunities to develop integrated and environmentally sound weed management programmes. Grundy (2003) has recently reviewed the current state of research using the methodologies presently available to predict weed emergence.

Roberts & Ricketts (1979) postulated that the density of weed plants arising after cultivation would be the product of the weed seedbank and the proportion of seeds expected to give rise to emerged seedlings at that time of year. Weed species vary in the fraction of their seedbanks emerging as seedlings because of species-specific dormancy and germination characteristics (Egley 1986). Also many species are capable of extended flushes of emergence over several weeks under certain environmental conditions (Forcella et al. 2000).

Estimating the size of the seedbank of arable weeds and predicting the emergence of different weed species is very difficult (Forcella et al. 1992). To address this problem, previous studies have optimised soil seedbank sampling and enumeration methodologies for collecting information on seed abundance and distribution (Rahman et al. 2001). This paper reports on the relationship between laboratory enumerations of the seedbank and field weed populations so that the prediction of seedling emergence from a known weed seedbank can be improved.

MATERIALS AND METHODS

This study was conducted from 1999 to 2002 on nine maize growers' properties in Waikato, three properties in Bay of Plenty and three in Poverty Bay. In total there were

30 study sites. A study site refers to a single maize field and most properties had two sites. At each site, six replicate 1 m² areas were protected from pre-emergence herbicides by covering with a sheet of polythene immediately prior to the herbicide application. After spraying the sheet was removed and the area pegged and sampled according to Figure 1. The soil samples (10 cores of 25 mm diameter and 100 mm deep) were brought to the laboratory, thoroughly mixed and immediately oven dried at 65°C for 24 h to arrest seed germination. A subsample of 500 g dry weight was then sent to the NZ National Seed Laboratory (Palmerston North) for extraction and quantification of the weed seedbank by methods previously described (Rahman et al. 1998). Briefly, individual samples were washed through a fine mesh to remove soil particles. The remainder was air dried and passed through a descending series of sieves. Whole and empty seeds were extracted by hand, identified and counted. Seed viability was determined by crushing the seed and examining the endosperm, with only those seeds exhibiting white healthy endosperm included in the final count. At about 4 and 8 weeks after sampling the seedlings that emerged from the centre 0.1 m² quadrat (Fig. 1) were identified, counted and removed. As seedlings that emerge later than 8 weeks after planting are not likely to compete with the maize crop, they were not included in the emergence counts (James et al. 2000).

Data from the 6 plots at each site were averaged and sites used as replications during analysis. All the data were log transformed and then regression analyses were conducted to compare the data.

FIGURE 1: Layout of sampling area. This was replicated six times at each site.

RESULTS AND DISCUSSION

In total, five grass weeds were identified but not all these were found at each of the 30 sites. The grass weeds were smooth witchgrass (*Panicum dichotomiflorum*) at 20 sites, summer grass (*Digitaria sanguinalis*) at 22 sites, annual poa (*Poa annua*) at 25 sites, barnyard grass (*Echinochloa crus-galli*) at 5 sites and rough bristle grass (*Setaria verticillata*) at 5 sites. The presence of a particular grass weed at a site was also strongly influenced by region. For example, rough bristle grass was found only in Poverty Bay, barnyard grass was mostly in Poverty Bay with only 1 site in Waikato, no summer grass and very little smooth witchgrass were found in Poverty Bay and very little summer grass was found in Bay of Plenty.

Significant linear relationships were established between the number of seeds in the soil samples and the emerged seedlings for four of the grass weeds (Table 1, Fig. 2). Although a good range of populations was obtained for all four grasses, barnyard grass and rough bristle grass were found at fewer sites, so the emergence patterns for them will not be as robust as those for summer grass and smooth witchgrass. The emergence

of annual poa was not plotted since emergence numbers were very low (Table 1). This is understandable as annual poa is a winter-growing grass weed that normally germinates in the autumn and winter with very little germinating in spring and summer (Standifer & Porche-Sorbet 1984).

TABLE 1: Regression statistics for the number of emerged grass seedlings (y) relative to the number of seeds in the soil samples (x), as well as the mean percentage of grass seed that emerged.

Grass species	% of seed that emerged	Regression equation ¹	R ²	Probability
Summer grass	7.76	$y = 0.982x - 1.05$	91.8	0.000
Smooth witchgrass	11.95	$y = 0.843x - 0.41$	72.8	0.000
Barnyard grass	6.25	$y = 0.712x - 0.38$	98.4	0.015
Rough bristle grass	6.70	$y = 1.11x - 1.61$	98.7	0.001
Annual poa	0.26	$y = 0.687x - 2.43$	13.9	0.067

¹For log-transformed data.

While the regression analyses of the grass weed data assumed a linear relationship between seed numbers and seedling emergence (Table 1), in complex biological systems, such as the soil, this assumption is not necessarily valid (Forcella 1993). In particular, asymptotic behaviour might be expected when soil seedbank numbers become very large. However, of the four species presented here only smooth witchgrass showed any indication of seedling emergence levelling off at high seed numbers, and then only slightly (Fig. 2). Therefore the use of a linear regression is justified in the case of these data.

FIGURE 2: Emergence of four grass weeds compared to the presence of their seed in the soil seedbank.

Over the sites evaluated summer grass emergence ranged from 4–15% while smooth witchgrass emergence varied from 7–42%. There are likely to be a number of factors affecting seedling emergence when compared to the number of seeds in the soil, although the most influential factor is probably the seed depth (Rahman et al. 2000). It has previously been reported that different grass weeds are able to emerge from different depths, with smooth witchgrass able to emerge freely from depths of up to 50 mm while summer grass only emerged freely from the top 20 mm (James et al. 2002). Since the soil samples in this study were taken to a depth of 100 mm, even if there were no other influences, it would be expected that only about 20% of the summer grass seed and 50% of the smooth witchgrass seed would normally emerge. This is assuming that the seed is evenly distributed through the sampled profile. As this is highly unlikely, it is the uneven spread of seed that probably accounts for the variation in emergence.

The grass weeds emerged naturally in association with broadleaf weeds that were also present at the sites. At some sites grass weeds dominated while at others broadleaf weeds were the major component (A. Rahman, unpubl. data). However, the presence of broadleaf weeds, even in large numbers, did not appear to have influenced the proportion of grass weeds that emerged.

The proportion of the active weed seedbank emerging as seedlings in the field reported here is in line with our earlier observations and overseas findings (Zhang et al. 1998; Rahman et al. 2000). However, just as important as being able to provide a realistic estimate of the density of emergence, is being able to predict the timing and spread of the flush of weed emergence over time or relative to environmental variables. As stated by Forcella et al. (2000), many species are capable of extended flushes of emergence under certain environmental conditions. It is often the very early and very late germinating individuals that can make the most significant contributions to competition and seed return respectively. Prior information on the likely magnitude, composition and timing of weed flushes all contribute towards better forward planning, management of resources and tailoring of appropriate control regimes. The data presented here will be valuable in aiding the prediction of likely grass weed infestations in spring planted crops. This ability to predict weed emergence would provide a valuable input to population dynamics models that can be used in much wider context than simply the timing of weed control, as discussed by Grundy (2003).

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