CHALLENGES IN WEED BIOLOGY RESEARCH ON ANNUAL WEEDS OF ANNUAL CROPS

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Summary. Most biology research on annual weeds has been on their morphogenesis (dormancy, germination and growth). Despite a vast amount of this research, it has not contributed to improved control of annual weeds in annual crops. Laboratory measured requirements for germination or information on the mechanism of dormancy cannot usually be used directly in the field. In addition the physiology of seeds is changed by burial, and the complexity of the field environment makes extrapolation of any laboratory data very difficult. This argument is supported by data showing changes in soil temperature with depth and time of the year. What is required is an understanding of the factors that regulate weed populations, particularly those factors which can or could possibly be controlled by farmers. Such understanding is best obtained by field studies, supported if necessary by laboratory investigations.

INTRODUCTION

The ultimate objective of research on the biology of weeds is to improve weed control (perhaps the only exception is research to find the limits of spread of a species). Yet very little of the vast amount of research that has been done on weed biology has contributed to improved control of annual weeds in annual crops. Voluminous research worldwide on dormancy and germination requirements of wild oats (*Avena* spp.), for example, has contributed little, if anything, to wild oat control. In contrast research on the biology of perennial weeds and annual weeds in perennial crops has had immediate application; for example knowing the age at which nutgrass (*Cyperus rotundus*) shoots produce new tubers is clearly useful in the timing of control measures.

Annual weeds of annual crops is a weed situation of great economic importance. There is therefore a great challenge to do research on the biology of annual weeds that will lead to improved control in annual crops.

A thorough consideration of the nature of the weed biology research is also necessary because of our limited resources for weed research. There are no large centres or teams for crop weed research in Australia.

The limits of weed biology are not clearcut but in this paper attention is concentrated on weed morphogenesis (seed dormancy, germination and growth) and population dynamics (numbers of weeds and their regulation); weed taxonomy and competition are not discussed.

INADEQUACIES OF PRESENT INFORMATION

Laboratory-derived information on weed seed biology cannot usually be used to adjust farm operations so as to improve weed management. The extrapolation of laboratory-derived information to the field is limited by the complexities of the field environment and by the nature of the information. For example, knowing that weeds will not germinate because they are in a particular state of dormancy, innate or induced, is of no immediate practical use.

Furthermore the germination physiology of seed often changes after burial in the field. For example, seeds of at least several species acquire light sensitivity after burial (e.g. Wesson and Wareing 1969a,b) and a further complexity is that this sensitivity varies with the time of year (Froud-Williams *et al*. 1984). Also, seeds of chickweed (*Stellaria media*) lose dormancy (after-ripen) much faster when buried; after four weeks, buried seeds had a germination of 50 to 100% whereas the germination of dry stored seeds was neglible (Roberts and Lockett, 1975). Martin and Carnahan (1983) showed that storage site in the field affects subsequent germination physiology. Seeds of Noogoora burr (*Xanthium occidentale*) were placed in the soil, on the soil surface and on a stake 1 m high (to simulate seeds remaining on standing dead plants). When recovered after 11 and 15 months, the seeds differed in their response to germination conditions.

The usefulness of other aspects of weed biology could be questioned. Weed surveys are useful in establishing research priorities but are sometimes done to determine changes in the weed flora over a long period. Unless the reasons for changes can be found and exploited, the information is of very limited use.

Laboratory research on seed germination requirements and ways of overcoming dormancy can, however, be useful to support other research. For example, where seeds are recovered from the soil and viability is to be tested, a method for germinating 100% of the viable seed is very useful.

The concept of applying dormancy breaking chemicals to the soil and getting all the seeds to germinate has long been a dream of scientists. Success in searching for such a method would be a great leap forward but to date progress has been very limited and the search is something of a "long shot". Where research is done to provide information for a service role or a "long shot" type of objective, this should be clear. Where the objective is biological information that can be used directly in the field, the kind of research that I believe should be done, is described later.

COMPLEXITITES OF THE FIELD ENVIRONMENT

The complexities of the field environment can be illustrated by considering the factors which affect weed seeds in the soil. The primary factors are temperature, moisture, light, gaseous environment, chemical environment (e.g. solutes, allelopathic chemicals) and soil flora (e.g. fungi). These factors are affected by weather conditions (rainfall, air temperature, sunlight) and soil conditions (texture, structure, compaction, colour, pH) and modified by variables such as cultivation, stubble, fertilizer and presence of crops and weeds. The type and timing of cultivation has obvious consequences for seeds. It affects changes in seed depth during the year, the chance of light exposure for seeds, alters the gaseous environment and alters soil moisture content and compaction.

The complexities of the field environment can be further illustrated by considering the variations in temperature and moisture conditions with soil depth. Variations in soil temperature with depth, and changes during the year from mid-summer to mid-winter, for the Darling Downs are shown in Table 1. At 1 cm depth in mid-summer, weed seeds are subjected to temperatures up to 50°C and a diurnal fluctuation as high as 32°C, whereas seeds at 8 cm deep are subjected to a maximum of 28°C, and 6°C of diurnal fluctuation. In mid-winter, soil depth is also important; the minimum temperature becomes progressively higher with depth, so that seeds at 8 cm would not receive as much chilling as those on or near the surface.

Table 1: Soil and air temperatures at Jondaryan, Queensland, 1967-71 (Leslie, unpublished).

Time of Year		Air temperature[1]	Soil temperature			
			Depth (cm)			
			1.0	2.5	8.0	15
Mid-summer	Max	30	40-50	36-38	28	25
	Min	17	18	19	22	
Mid-winter	Max	17	21	19	15	12
	Min	2	4	5	9	

[1] In a screen, 120 cm high.

Soil depth will also affect the moisture environment of seeds. Seeds near the surface will be subjected to wetting and drying, depending on rainfall, whereas seeds at say 8 cm depth will be in moist soil for much longer periods.

It is therefore clear that a seed may experience any of an almost infinite number of temperature and moisture conditions during a year, depending on the type and frequency of cultivation and the frequency and quantity of rainfall.

WHAT IS REQUIRED?

The weed biology research that is most likely to produce improvements in the paddock in the foreseeable future is that aimed at understanding the factors affecting the population of a weed, and in particular those factors which can or could possibly be controlled by farmers. When annual weed populations in a crop are high (or expected to be high), a herbicide must be used and its cost will be more than recovered by increased yield (or other economic benefits, such as reduced contamination of the produce). However, when weed populations are low, the strategy that a farmer should follow is difficult to decide; the cost of herbicides will not be recovered by increased yield, yet without treatment the seed produced by the weed may lead to a rapid population increase. Every farmer needs to keep weed populations at a minimal level where they have no economic effect. To do this at all, and to do it in the most cost effective way, is not easy and requires the application of a knowledge of the population dynamics of each species.

This type of research has been done in England on wild oats (*Avena fatua*) (Wilson 1981), blackgrass (*Alopecurus myosuroides*) (Cussans and Moss, 1982; Moss, 1980) and barren brome (*Bromus sterilis*) (Pollard, 1982), and in Australia, on wild radish (*Raphanus raphanistrum*) (Code and Reeves 1983). In England, the data have been used for developing population models, based on the number of plants or seeds per unit area surviving from each stage of the life cycle to the next. Clearly the number surviving each stage is influenced by a range of factors, some of which are under the farmer's control. For example, populations of wild oats in England are affected by factors such as the degree of seed shedding at harvest, method of straw disposal, the type and timing of cultivation, the timing of crop sowing, crop density and the efficacy of herbicides on wild oat seed production. The soil seed bank of a weed species is an important part of population dynamics. Features of seed banks are described elsewhere in these proceedings (Medd and Wilson, 1984).

In research on population dynamics, it could be desirable to use laboratory studies to seek an explanation for some findings. Seeking an explanation in this case is very different from trying to predict field behaviour from laboratory research. Research to support field findings must be done on seed recovered from soil storage, for reasons described above. Some of the seeds placed in the soil for later recovery and use in laboratory experiments, will germinate, but this is desirable. It means that research on the recovered seeds is done on the most dormant portion of the seed population.

A common reason for research on the morphogenesis of weeds is to obtain knowledge that will allow us to exploit weaknesses in their life cycles. I do not think there are any instances where such research has improved annual weed control; I would be pleased to hear from anyone who has examples. Much of the knowledge we have today (e.g. dormancy is due to a hard seed coat, the seed requires light exposure for germination, etc.) does make us feel comfortable that to varying degrees we understand the morphogenesis of some of our important weeds, but the harsh reality is that this understanding contributes little, if anything, to control. On the other hand, a knowledge of the population dynamics of annual weeds, so that farmers can join with environmental factors to regulate weed populations, does offer promise.

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