THE NATURE OF DORMANCY IN WILD OATS

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Summary

New Zealand-grown wild oat (*Avena fatua*) seeds when freshly harvested were extremely dormant. Dormancy was broken by after-ripening at room temperature, treatment with gibberellic acid, cold stratification, and by certain treatments which involve cutting the layers covering the caryopsis. In all cases, dormancy inherent in the caryopsis was more readily overcome than the more prolonged hull-imposed dormancy. Leaching of the seeds did not in itself overcome dormancy although it was noted that certain other dormancy-breaking treatments were effective only when the seed was subsequently leached. There was no obvious relationship between dormancy and inhibitor levels within the seed.

INTRODUCTION

Wild oat (*Avena fatua*) is a weed which can cause a significant reduction in yield, especially when present in cereal and grass seed crops (Allen and Smallridge 1972; Matthews 1974). In these situations it is difficult, if not impossible, to separate the wild oat seeds from those of the crop. Thus spatial and temporal dissemination of the weed occurs on subsequent use of the crop seed.

Wild oat seeds, like those of many other plant species, exhibit a period of dormancy during which germination will not occur even under apparently favourable environmental conditions. It is the marked variations in the degree of this dormancy which enables wild oats, once introduced to soil, to persist for a number of years. Under environmental conditions favourable to growth, the dormancy of the seed can be either innate or it can be an induced or secondary dormancy resulting from factors such as a restricted oxygen supply to the embryo (Hay and Cumming 1959).

The aim of this investigation was to examine the nature of innate dormancy in wild oats grown under New Zealand conditions and attempt to elucidate the controlling mechanism.

MATERIALS AND METHODS

Plant material

The seeds were collected from two localities in Canterbury (a) Southbridge and (b) Lincoln, from where material was collected both in 1975 and 1976.

The seeds were collected at the stage when approximately half had ripened and fallen from the panicle. The panicles were removed to the laboratory where the remaining seeds were separated and dried in the sun for about 1 week before testing. No significant difference was observed in the response of the seeds from the two localities although the grain collected in 1976 was significantly less dormant than that collected in 1975.

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Germination tests

The wild oat seeds were surface sterilised with a solution containing 1.5% sodium hypochlorite and allowed to germinate in a 9 cm Petri dish on filter paper moistened with 4 ml of the appropriate solution or distilled water. The dishes were incubated at 25° C in a 16-hour photoperiod except when a stratification treatment was required and the imbibed seeds were incubated at 1-4° C in dim light. The number of seeds germinated was recorded daily and, except where otherwise stated, the results presented are the percentage of seeds in which germination, as defined by radicle or coleoptile emergence, occurred within 30 days.

Extraction and fractionation of inhibitors

A number of extraction procedures were compared. These included extraction by (a) water at room temperature, (b) boiling water, (c) 5% sodium bicarbonate in water, (d) 1% sodium bicarbonate in water, (e) 1% sodium carbonate in water and (f) 70% methanol in water. The extraction of whole seeds was also compared with that of homogenised seeds.

It was found that extraction of whole seeds for two periods of 24 hours by a solution of 1% sodium bicarbonate in distilled water was satisfactory and this technique was used in most experiments.

After extraction the filtered aqueous phase was adjusted to pH 3 with sulphuric acid and partitioned 3 times with ethyl acetate. The resulting ethyl acetate phase was designated the "acidic phase". The aqueous phase was then adjusted to pH 8 with 5% sodium bicarbonate and extracted 3 times with ethyl acetate. The resulting ethyl acetate and aqueous phases were designated the 'basic' and 'aqueous' phases respectively.

The 3 phases were then further fractionated by separation on Whatman 3MM chromatography paper. The chromatograms were developed in the descending direction using benzene : acetic acid : water (125 : 72 : 3) for the acidic and basic phases and 2% acetic acid for the aqueous phase.

The chromatograms were dried, divided into 10 equal zones and moistened with distilled water. In the initial experiments all 10 zones were bioassayed but it was apparent that there was no inhibitory activity below Rf 0.5, and Rf zones 0.1 to 0.4 were not bioassayed in later experiments. Germination inhibitory activity was detected using a lettuce seed germination bioassay (McWha *et al* 1973) or an oat germination bioassay. Both assays gave comparable results although the lettuce seed germination assay was more sensitive and convenient. The results are expressed as the time required for 50% of the seeds to germinate.

RESULTS AND DISCUSSION

The wild oat seeds were tested for dormancy immediately after drying in the sun. Even after incubation for 30 days in conditions suited to germination, no intact seeds had germinated nor had any of those seeds from which the hull was removed to give a naked caryopsis. The seeds were assayed at regular intervals and it was found that after 3 months after-ripening (dry storage at room temperature) less than 7% of the intact seeds germinated although the naked caryopses achieved 20% germination (1975 seeds) and 64% (1976 seeds). After-ripening the 1975 seeds for 1 year and then imbibing them at 25° C for 4 days resulted in 47% germination of the intact seeds. However, if the hull was removed before imbibition, 100% of the naked caryopses germinated within 1 day in the germination test. It thus appears there may be two factors involved in dormancy of wild oat seeds. One factor is associated with the caryopsis and the dormancy resulting from this disappears after

Weed Biology

several months after-ripening whereas the hull-imposed dormancy disappears much more slowly.

Stratification also overcame dormancy although again the caryopsis dormancy was overcome more readily than that of the intact seeds. When freshly harvested caryopses were imbibed at 4° C for 18 days and then transferred to a temperature of 25° C, 86% germination occurred after only 10 days whereas intact seed even after 8 weeks stratification achieved only 12% germination after a further 30 days at 25° C. Stratification may represent the mechanism which results in the germination each spring of a percentage of the wild oat seeds in the surface layers of soil.

Gibberellic acid (GA₃) also broke the dormancy and 28% of intact seeds and 80% of naked caryopses treated with 10⁻⁴M GA₃ had germinated after 30 days. Higher GA₃ concentrations were even more effective (10⁻³M GA₃ gave 100% germination of naked caryopses after 96 hours). The synthetic cytokinin-like compound, kinetin, however, was ineffective in breaking dormancy of intact seeds as was potassium nitrate. Potassium nitrate has been suggested to be capable of breaking dormancy (Hay and Cumming 1959) and is often present in the field situation. In this study, no effect on intact seeds was observed.

The other treatment frequently effective in breaking dormancy was damaging or cutting the seed. Care was exercised to ensure that the embryo itself was not damaged. When whole seeds were cut transversely in half, the dormancy was largely overcome and the percentage germination after 96 hours rose from 13% to 96% which was not significantly different from non-dormant caryopses. Pricking the intact seeds, however, did not break dormancy, although the dormancy of naked caryopses could be overcome by this treatment. This method of breaking dormancy could be important where the seeds are damaged by organisms in the soil or by cultural techniques.

Other treatments such as increasing the oxygen supply or treating the seeds with ethylene were largely ineffective in breaking the dormancy of intact seeds despite reports to the contrary in the literature (Black 1959).

Leaching the dormant seeds did not cause germination, although caryopses where the dormancy was broken by cutting the tissues covering the embryo would germinate only if placed in a leaching environment. Attempts to germinate them in a non-leaching environment failed, although half seeds germinated quite readily. It could be suggested that reduction in the level of an inhibitor is essential before germination can take place and this can be achieved either by cutting away a significant portion of inhibitor containing tissues or by damaging the tissues covering the caryopsis and allowing the inhibitor to leach away.

Various attempts have been made to implicate inhibitors in the control of dormancy in wild oat seeds and they have achieved, at best, only a very limited success. Some of the results of our extraction and fractionation experiments are shown in Fig. 1. Each portion of the chromatograms was assayed for germination-inhibitory activity using lettuce seeds and the time required for 50% of the lettuce seeds to germinate was calculated.

No inhibitor was found in the 'basic' fraction, although the 'acidic' and 'aqueous' fractions each contained at least one inhibitor. The 'aqueous' inhibitor, not previously reported in the literature, was more potent than the 'acidic' one and the levels of both were different in the 1975 and 1976 seeds. There was, however, no obvious correlation between their levels and the amount of dormancy possessed by the seeds.

Thus, if inhibitors play a role in the dormancy of wild oats, it is not through metabolically controlled changes in their levels unless these changes are remarkably small, but rather by some mechanism such as the leaching response described earlier.

Fig. 1. Effect of wild oat seed extracts on germination of lettuce seeds (A) 'Aqueous' extract of 0.25 g of dormant seeds; (B) 'Aqueous' extract of 0.25 g of non-dormant seeds (after-ripened for 12 months); (C) 'Acidic' extract of 5 g of non-dormant seeds; and (D) 'Acidic' extract of 5 g of non-dormant seeds. The dotted lines are the controls and were determined using chromatography paper subjected to the same experimental procedures as the corresponding treatments.

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