THE EFFECT OF GERMINATION STIMULANTS ON SEEDLING EMERGENCE OF WILD OAT (*AVENA FATUA*) FROM SOIL

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Summary. The effect of potassium nitrate (200 mM) and ethephon (1 mM - an ethylene releasing chemical) on promoting emergence from buried seed was variable with both treatments similar to one another and no synergism noted when used together. Examination of exhumed seeds showed that these treatments had a secondary effect, reducing seed viability. By counting the number of dead and adding to the proportion stimulated to emerge, a value for removing seeds from the soil was obtained. Under this type of analysis it was clear that all treatments had the ability to remove seed from the soil seed bank especially when the seed was old, near the soil surface, were primary (large) seed or from low or intermediate dormancy isogenic lines. However, based on overall considerations, it is unlikely that either potassium nitrate or ethephon could be recommended for future field application to remove a significant proportion of the wild oat seeds from the seed bank.

INTRODUCTION

Wild oat (*Avena fatua* L.) is a persistent annual weed in most winter cereals throughout the world. It owes its success to seed dormancy and to long term viability of seeds in the soil (6). Consequently seedlings emerge irregularly over a period of several weeks to many years. Repeated application of conventional herbicides can be used to control seedlings, however, such treatments have little or no effect on the dormant seeds in the soil seed bank. Application of germination stimulants to force early, synchronous germination and eliminating the seedlings with herbicides has been suggested as a way to eradicate the dormant, persistent portion of the weed seed bank (5). Several chemicals are known to overcome wild oat dormancy under laboratory conditions. Of these ethylene and nitrate are perhaps the best suited for field simulations. Ethylene can be conveniently applied as ethephon, a water soluble compound that releases ethylene into the soil and plant materials. The response of wild oat seed to nitrate and ethylene will depend on seed age (1, 3), with young seeds less responsive than older seeds. The response will also depend on whether the seed is primary or secondary seed from the spikelet (1).

The objects of this study are to: Determine the effects of potassium nitrate and ethephon on wild oat germination and emergence in a pot trial, determine the difference, if any, between isogenic lines, and determine if factors such as age, depth of planting, and whether the seeds are primary or secondary will influence the loss of seed from the seed bank.

MATERIALS AND METHODS

Seed material. Seed collected from three growth cabinet grown isogenic lines were used (3). These lines represent dormancy types from low dormant (CS166), intermediately dormant (AN51), to deeply dormant (M73). Seeds were used at harvest (young seeds) or after-ripened (4) for six months (old seeds). At the time of harvest a distinction was made between primary (largest seed, basal position in the spikelet) and secondary (smallest seed, top position in the spikelet) seed. The viability of all seed lots used was *ca.* 100%.

Burial of seed. The soil used in this study was a composite sandy loam clay having a pH of 7.0 and 5% organic matter. Weighed amounts (4.5 kg) of the soil were placed into plastic bags; and distilled water or treatment solution added to obtain negative 0.03 MPa (field capacity). The sealed bags were shaken occasionally to ensure uniform solution distribution. The moist soil was then transferred to 20 cm diameter plastic pots (2 L) and planted with 20 seeds at a depth of 2 or 5 cm. Lost water was replaced daily. The pots were placed in a glasshouse maintained at approximately 25°C day, 18°C night and a natural photoperiod of 13 hours day. Coleoptile protrusion was the emergence criterion and counts were made daily until emergence was complete. All remaining seeds were washed free of soil, counted and transferred onto filler paper in 9 cm Petri dishes. Seeds were microscopically examined to determine both intact, non-germinated seeds, and empty seeds that had germinated or lost viability.

Treatments. In a preliminary experiment, potassium nitrate (KNO_3) and ethephon were applied to bring the air dried soil to field capacity to produce final soil concentrations of 0, 100, 200, 350 or 500 mM KNO_3 and 0, 0.1, 1.0, 10 or 50 mM ethephon. Each treatment was replicated 3 times and applied to primary, hulled seed of lines CS166 and AN51 (both after-ripened for 3 months) planted at a depth of 2 cm. The results of this experiment were used to select one concentration each of KNO_3 and ethephon to be used in subsequent trials. The first trial investigated the effect of KNO_3 and ethephon, alone and in combination, on primary, hulled, young and old seeds of CS166, AN51 and M73, planted at either 2 cm or 5 cm below the soil surface. The second trial consisted of exactly the same treatments but the seed used was secondary seed.

Statistical Analyses. Emergence and dead seed counts were added together, normalized by an arc-sine transformation ($[X/100]^{1/2}$) and subjected to a factorial analysis of variance.

RESULTS AND DISCUSSION

Pretrial. Increasing KNO_3 rate from 100 to 200 mM increased seedling emergence (Fig. 1). However, as rate was increased to 500 mM effect on emergence was less pronounced due to a reduction in viability. Ethephon, an ethylene-releasing compound, could also stimulate seedling emergence however in a much narrower band of concentrations than that seen with KNO_3. Increasing ethephon rate from 0.1 to 1 mM increased seedling emergence, however above this rate the chemical progressively reduced viability. At the best concentrations both chemicals could stimulate the emergence of primary, hulled seed of line CS166 planted at a depth of 2 cm by as much as 40% above the control. These two concentrations, 1 mM ethephon and 200 mM KNO_3, were used in all future trials. A similar, but much smaller promotion of emergence (25 and 15% for KNO_3 and ethephon respectively), were observed for AN51 at the peak concentrations.

Effect of chemicals. The effect of KNO_3 and ethephon on promoting emergence from buried seed populations from three biotypes and treated under several conditions was variable with both treatments similar to one another and no synergism noted when the two were used together (data not shown). Examination of exhumed seeds showed that these treatments had had a profound effect on the viability particularly of the larger seeds (primary seed). Unsound seeds were discovered which had either germinated and failed to reach the soil surface or had lost the integrity of their endosperm tissue. By counting the number of dead seeds/seedlings and adding to the proportion stimulated to emerge by the same treatment provided a method for looking at the total effectiveness of these chemical treatments in removing seed from the seed bank. Under this type of analysis it was clear that all treatments had the ability to remove seed from the soil seed bank whether by emergence or by killing the seed. This was dependent on the isogenic line planted, seed age, seed size and depth of planting (Fig. 2).

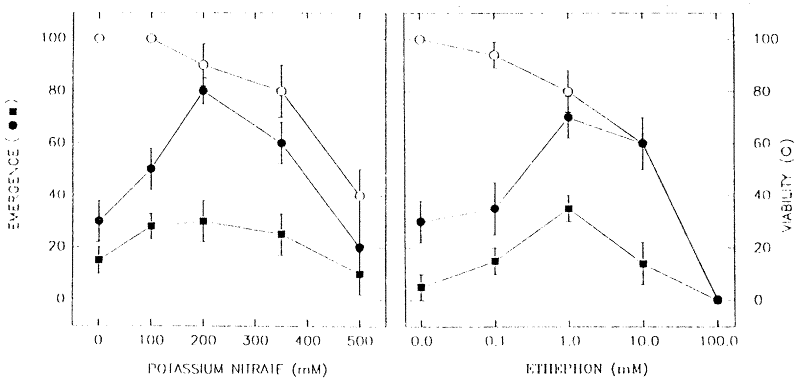

Figure 1. Percentage seedling emergence from primary seeds of wild oat lines CS166 (•) and AN51 (■) following treatment with potassium nitrate and ethephon. The seeds were after-ripened for 3 months and were planted at a depth of 2 cm. The ungerminated seeds of CS166 were recovered and the total viability determined (o). Error bar = ± SE.

Biotypes. Combined killing of the seeds and emergence was greatest in the least dormant (CS166) line (Fig. 2). With the most dormant line (M73) some seeds were killed, especially those planted at depth but little effect on dormancy was observed. The difference between lines in their response to KNO_3 and ethephon observed here is thought to be related to the existence of a persistent block to germination that exists in all lines but is most intense and persistent during after-ripening in the order M73 > AN51 > CS166 (4).

Age. The effect of KNO_3 and ethephon on promoting seed loss from soil when partly after-ripened seeds were planted was much greater than that seen when freshly harvested seeds were planted (Fig. 2). This was especially true for primary, hulled seeds of the least dormant lines (CS166 > AN51). The difference between seedlots of different ages in their response to KNO_3 and ethephon observed here is thought to be related, as explained above, to the existence of a persistent germination block that exists in freshly harvested seeds of all lines but has been overcome (CS166), partly overcome (AN51) or still present (M73) in partly after-ripened seeds.

Seed size. There is evidence that secondary seeds are less affected by the treatments than primary seeds, especially when planted at depth (Fig. 2). It has been shown before that secondary seeds have a deeper dormancy than primary seeds (1). In addition it may be expected that a small seed will intercept less KNO_3 and ethephon in the soil than larger primary seeds.

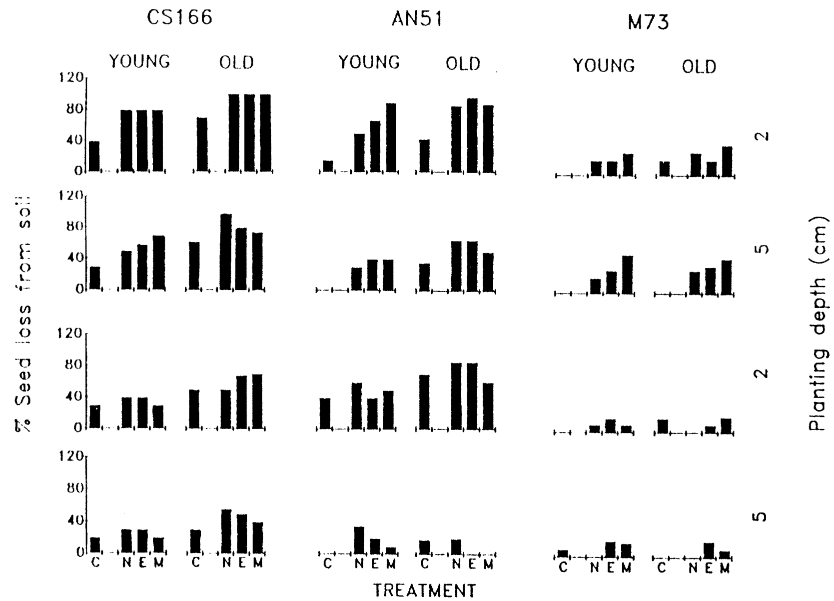

Figure 2. The combined percentages of seedling emergence and seeds killed from primary seeds (Fig. 2A), or secondary seeds (Fig. 2B) of wild oat lines AN51, CS166 and M73 following treatment with distilled water (C), potassium nitrate (100 mM; N), ethephon (1 mM; E) and a mixture of the two substances (M). The seeds were planted at either 2 or 5 cm and were either freshly harvested (young) or partly after-ripened at room temperature for six months (old).

Depth of planting. There is evidence that seed at 2 cm depth are more affected by the chemical treatments than at 5 cm depth. It may be expected that the conditions for germination and emergence are more suitable at the 2 cm depth than the 5 cm depth and this is the reason for better emergence at 2 cm than 5 cm. A further observation is that at the shallower depth seeds are promoted to emerge while at depth viability is upset more.

Conclusions. It is difficult to predict from these data what may happen in the field. It could be speculated that where there is a predominance of low dormancy families (like CS166), as is the case with a continuous cropping situation (6), then application of KNO_3 or ethephon may be of some use cleansing the seed bank. However, in a second situation where there is a predominance of dormant families (like M73), as is the case with a summer fallow situation (6), then application of these chemicals will do little towards reducing the seed bank. Even in the first situation the suggestion is that within the population of seeds a large proportion would fall into the category of being insensitive to promotion, in other words, are freshly shed seeds, are secondary seeds, or are at depth. In a typical situation in the field a large proportion of the seed would fall within one of these difficult-to-stimulate categories. Thus, based on overall considerations, it is unlikely that either KNO_3 or ethepon, alone or in combination, could be recommended for future field application to remove wild oat seeds from the seed bank.

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