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THE OCCURRENCE OF SOME ANNUAL GRASS WEED SEEDS IN SAMPLES TESTED BY THE OFFICIAL SEED TESTING STATION, CAMBRIDGE

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Summary A survey has been made of the occurrence of seeds of Alopecurus myosuroides, Avena fatua, and A. ludoviciana, Bromus mollis, Poa annua and Vulpia spp. in samples tested by the Official Seed Testing Station during the 1967-68 season, and the present position compared with figures recorded on previous surveys. In general the data are based on the number of seeds found in the small sample examined for percentage purity, but for A. fatua, A. ludoviciana and A. myosuroides in cereals figures are also presented based on the 8 oz sample which must be examined for injurious weed seeds under the Seeds Regulations 1961. The survey showed that, though some of these weeds were frequently found in samples of cereal and grass seed, most types of crop seed were more frequently contaminated by seeds of dicotyledons than by seeds of monocotyledons. In most seasons A. myosuroides appears in less than 3% of the cereal samples but A. fatua and A. ludoviciana are of more frequent occurrence and in the 1963-4 season were recorded in 10% of the barley samples.

INTRODUCTION

The association between different crop and weed seeds in samples tested by the Official Seed Testing Station has been discussed by Broad (1952) and Gooch (1963.) Their surveys showed that, in general, there is a characteristic weed seed population for each kind of crop seed. Many factors may affect the frequency with which a species occurs in a particular weed seed population. These factors include the geographical origin of the seed, the methods of crop cultivation and the use of selective herbicides, the relative growth habits of the weed and crop species, particularly in relation to time of seed set, the method of harvesting, the morphology of the weed seed and the difficulty of separating it from the crop seed by cleaning machinery, voluntary certification schemes and seed legislation. The effect of some of these factors on the dissemination of weeds by crop seed has been considered by Wellington (1960).

The sowing of weed seeds with the crop has been considered the most important single agency for the introduction of alien species (Salisbury, 1961). Early legislation in the United Kingdom, however, aimed to prevent the sowing of excessive quantities of weed seeds, rather than to avoid the introduction of foreign species or the contamination of clean land by native species (MacKay, 1964), differing in this respect from legislation in many countries. The 1922 Seeds Regulations prohibited the sale or sowing of seeds containing more than 5% by weight of five injurious weeds: docks and sorrels (Rumex spp.), cranesbills (Geranium spp.), wild carrot (Daucus carota L.), Yorkshire fog (Holcus lanatus L.) and soft brome grass (Bromus mollis L. et spp.). However, a declaration of the number of seeds of dodder (Cuscuta spp.) in a specified weight of clover seed was also required. The effectiveness of this provision in virtually eliminating dodder in home-produced red clover seed has been contrasted with the failure of the injurious weed provision to reduce the frequency of occurrence of Rumex spp. in samples of herbage seed (Wellington, 1960). The 1961 Seeds Regulations introduced a requirement for declaration of the number of seeds of specified injurious weeds; these are wild oat (Avena fatua L. and A. ludoviciana L.), dodder (Cuscuta spp.), docks and sorrels

(Rumex spp.), black grass (Alopecurus myosuroides Huds.) and couch grass (Agropyron repens (L) Beauv.).

In this paper the occurrence of seeds of the common annual grass weeds A. fatua and A. ludoviciana, A. myosuroides, B. mollis, Poa annua L. and Vulpia spp. are discussed. Comparisons are made between their occurrence in samples tested in the year 1st August 1967 to 31st July 1968 and their frequency in previous seasons. Most of the data presented are based on the weeds found in the small portion of crop seed examined in the detailed purity analysis, which usually contains about 3,000 seeds of the crop species. However, additional data are reported for A. fatua, A. ludoviciana and A. myosuroides based on the examination of 8 ozs of cereal seed required under the 1961 Seeds Regulations.

CEREALS

Of the annual grass weeds being considered only A. fatua and A. myosuroides occur in cereal samples with any frequency. Table 1 shows their occurrence, as well as that of P. annua, in purity tests on samples of the four major cereal crops for the last seven years. During this period B. mollis was usually found in only 0.1% or less of the samples, with a tendency to occur more frequently in oats than in wheat, barley or rye. Vulpia spp. was found even less frequently, and in many seasons was not recorded in one or more of the four cereals.

Table 1

Percentage frequency of A. myosuroides, A. fatua and P. annua in samples of wheat, barley, oats and rye 1961-1968

Season	1961-2	1962-3	1963-4	1964-5	1965-6	1966-7	1967-8
Wheat							
Number of samples	8585	9883	7549	5714	6790	5805	4789
A. myosuroides	1.1	1.6	2.2	1.3	1.5	2.8	1.9
A. fatua	0.9	1.9	2.1	0.7	2.6	1.8	0.7
P. annua	0.1	0.2	0.3	0.3	0.3	0.6	0.4
Barley							
Number of samples	5640	9080	11,175	7073	9870	8249	7118
A. myosuroides	2.0	1.6	2.2	1.1	1.7	1.9	1.6
A. fatua	4.9	3.7	4.5	2.3	4.5	2.7	1.9
P. annua	0.2	0.1	0.2	0.4	0.6	0.8	0.6
Oats							
Number of samples	2955	2332	1695	1354	1330	1255	1139
A. myosuroides	1.8	1.5	1.4	1.7	1.7	2.2	1.1
A. fatua	1.9	2.3	2.6	1.5	3.1	2.6	1.6
P. annua	0.5	0.1	0.5	0.5	0.5	0.5	0.9
Rye							
Number of samples	228	237	275	240	204	140	121
A. myosuroides	-	0.4	1.1	1.7	0.5	-	0.8
A. fatua	1.8	0.4	2.2	0.8	0.5	1.4	1.7
P. annua	-	-	1.5	1.7	1.5	1.4	0.8

\- This species was not recorded

Comparisons with figures reported for cereals before 1961 are complicated by differences in size of sample examined. However, there is a suggestion that the 1961 Seeds Regulations were effective in bringing a slight drop in the frequency of A. fatua, particularly in barley and wheat. Table 1 shows that A. fatua occur most frequently in barley, confirming the reports by Broad (1952) and Gooch (1963). In the period 1952-59 (unpublished) A. fatua and A. ludoviciana were found more frequently on average in 4 oz samples of barley than they were in 8 oz samples between 1961-68 (table 2). There does not, however, appear to be a similar decline in the occurrence of A. myosuroides, for which Broad (1952) and Gooch (1963) show very similar figures to those recorded in this paper. The figures for P. annua in table 1 suggest a slight increase in the frequency of its occurrence, though it still only occurs infrequently. Unpublished figures for the years 1952 to 1960 show P. annua as not recorded in many seasons, and rarely does it occur as frequently as 0.1%.

A number of broad leaved weed species are found more frequently than annual grass weeds in cereal samples. The surveys by Broad (1952), Gooch (1963) and Tonkin (1968) show that Polygonum convolvulus L. and Galium aparine L. are the most common weed seeds in cereal samples. The highest percentage frequency of 16.9% for any species in 1951-2 was for P. convolvulus in barley. This compares with the 7.2% of barley samples containing A. fatua in that season, a frequency considerably higher than that found in samples of the other three cereals; the highest figure for A. myosuroides was 1.7% in rye. In the 1967-8 season the highest frequency for any weed species was 9.3%, again for P. convolvulus in barley.

Table 2 shows the frequency of occurrence of three of the injurious weeds in the 1961 Seeds Regulations in 8 oz samples. Data are presented for the seven years since the regulations came into operation; figures for A. repens are included for comparison as this, in many seasons, is the most frequently found injurious weed in samples of wheat, oats and rye. In samples of barley, however, A. fatua and A. ludoviciana represent the commonest injurious weed.

Table 2

Percentage frequency of three injurious weeds in 8 ounce samples of cereal seed

	A. fatua & A. ludoviciana				A. myosuroides				A. repens			
	Wheat	Barley	Oats	Rye	Wheat	Barley	Oats	Rye	Wheat	Barley	Oats	Rye
1961-2	2	7	5	3	2	2	3	-	5	6	5	4
1962-3	4	8	5	3	3	3	2	tr	7	6	6	7
1963-4	5	10	6	3	3	4	2	2	6	5	6	8
1964-5	2	5	3	3	2	2	2	2	6	7	7	4
1965-6	5	9	6	5	3	3	2	2	6	6	4	9
1966-7	4	6	5	3	4	3	3	-	6	6	6	5
1967-8	2	5	4	3	3	2	2	1	9	10	11	5

Number of samples examined as in table 1

- This species not recorded
tr (trace) frequency of less than 1%

So far no indication ha been given of the number of seeds found in a sample. Table 3 shows the number of A. fatua, A. ludoviciana and A. myosuroides seeds found in 8 oz searches of wheat, barley and oats. The majority of samples in which these weeds are found contain only a few seeds; however, even if only one seed is found this is equivalent to the sowing of some 2-300 weed seeds at a sowing rate of 1-1½ cwt. per acre; if six seeds are found some 1,000 weed seeds may be expected to the acre.

Table 3

The numbers of seeds of A. fatua and A. ludoviciana and A. myosuroides found in 8 oz searches of wheat, barley and oats in the 1967-8 season

	A. fatua and A. ludoviciana			A. myosuroides		
	Wheat	Barley	Oats	Wheat	Barley	Oats
No. of samples tested	4789	8709	1139	4789	8709	1139
No. of samples containing 1	77	188	24	36	41	4
2	23	48	11	14	23	2
3	8	25	3	12	8	-
4	3	12	1	8	14	1
5	2	9	-	18	6	2
6	-	6	-	8	2	-
7-12	4	21	3	12	19	2
over 12	1	22	1	29	54	9
Highest figure recorded	15	194	22	402	569	303

Also reported in Table 3 are the highest figures recorded in an 8 oz search. These give a clear indication of how serious the infestation must have been in the crop.

GRASSES

As might be expected the annual grass weeds, apart from A. fatua because of its size, are most frequently found in samples of grass seed. Table 4 shows their occurrence in purity tests on samples of grass seed of British origin.

Table 4

Percentage frequency of occurrence of annual grass weeds in purity tests on samples of grass seed of British origin tested in 1960-61 and 1967-8

Kind and Number of samples analysed

	Perennial Ryegrass		Italian Ryegrass		Cocksfoot		Meadow Fescue		Timothy	
	60-1	67-8	60-1	67-8	60-1	67-8	60-1	67-8	60-1	67-8
	797	722	409	319	1662	432	554	297	352	229
A. myosuroides	12.9	6.2	10.0	6.0	12.5	10.0	19.3	8.7	6.3	2.7
A. fatua	tr	tr	4.2	2.2	tr	tr	tr	-	tr	-
B. mollis	17.1	4.0	5.1	1.9	1.7	tr	20.4	3.9	-	-
P. annua	23.0	28.1	17.4	24.4	7.2	11.6	23.6	33.6	23.6	28.0
Vulpia spp.	4.6	tr	4.2	-	tr	-	2.8	-	-	-

- The species was not recorded
tr (trace) frequency of less than 1%

The data suggests a decline in frequency of occurrence of A. myosuroides and B. mollis since the 1960-1 season but an increase in P. annua from an already high level. This increase in P. annua supports that suggested by the data for cereal samples.

Much of the grass seed used in this country is of foreign origin. Table 5 shows the occurrence of annual grass weeds in samples from a number of countries.

Table 5

Percentage frequency of occurrence of annual grass weeds in purity tests on samples of grass seed of foreign origin tested in 1967-67

Kind, number and origin of samples analysed

	Perennial Ryegrass			Italian Ryegrass			Cocksfoot	Timothy	
	Irish	Danish	New Zealand	Irish	Danish	New Zealand	Danish	Swedish	Canadian
	29	70	195	35	85	100	20	37	78
A. myosuroides	-	-	-	-	1.2	-	5.0	-	-
A. fatua	-	-	1.0	-	-	-	-	-	-
B. mollis	89.7	-	62.6	74.3	2.4	30.9	-	-	-
P. annua	62.1	55.1	2.6	40.0	21.1	9.1	15.0	2.7	-
Vulpia spp.	34.5	-	25.6	20.0	-	31.8	-	-	-

A. myosuroides and A. fatua are either rarely found or in many cases not at all. B. mollis and Vulpia spp. are very commonly found in seed of Irish and New Zealand origin and P. annua is particularly frequently found in seed of Irish and Danish origin. In perennial ryegrass and Italian ryegrass P. annua is found more frequently in Irish and Danish seed than in British seed. None of the weeds considered were noted in timothy seed of Canadian origin and only P. annua was found in Swedish timothy. This contrasts with the high incidence of P. annua in British timothy.

OTHER CROP SPECIES

Because of shape and size these annual grass weeds are readily cleaned out from most other crop seeds. Gooch (1963) shows only A. myosuroides and P. annua as present in white and red clover samples, showing little difference between the 1951-52 and 1960-61 seasons. In the 1967-8 season again these were the only two species recorded, A. myosuroides occurring in 0.8% of white clover samples and 1.3% of red clover samples and P. annua in 6.6% of white clover samples and 0.5% of red clover samples. In these crop seeds weeds such as Melandrium album (Mill.) Garcke, Rumex acetosella L and Rumex crispus L. are the most frequently found weed species.

In the fodder, root and vegetable seeds again annual grass weeds are found only infrequently. Gooch (1963) only records A. fatua and P. annua in her analysis. In this group of seeds, Chenopodium album L., Galium aparine L. and P. convolvulus are three of the most commonly occurring weed species.

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ECOLOGY OF BLACKGRASS (ALOPECURUS MYOSUROIDES HUDS.)

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Summary In dry storage some seeds of *Alopecurus myosuroides* (blackgrass) remain viable for more than 9 years. Freshly-collected seeds are light-sensitive but sensitivity decreases with age. Germination is best between 10°C and 25°C, and better at the surface than when the seeds are buried, although under favourable conditions a few seedlings can emerge from seeds buried at 12 cm. Germination rises to a maximum as soil moisture content is increased to field capacity. In clays and loams it remains high if this figure is exceeded but in sands germination decreases sharply as the soil becomes waterlogged.

Blackgrass (*Alopecurus myosuroides* Huds.) is linked with the presence of man, and never far from cultivated land. It is common throughout France and particularly abundant in the north, favoured by rape-cultivation and by frequent cereal-growing. It is an annual, the seeds of which, (about 600 per plant), fall separately on to the soil between mid-June and mid-July.

The seeds are capable of germination almost immediately after they are shed; their dormancy is always short, although varying from one year to another. Maximum germination is reached in less than 7 months, which explains the abundant autumn germination. Moreover, it would seem that seeds germinate better at harvest if the end of the spring was dry.

In dry storage, the longevity of the seeds exceeds 9 years, seeds harvested in 1959 still exceeding 25% germination. But in the soil the viability is considerably less, on account of the higher humidity to which the buried seeds are subjected, apparently causing some deaths, and to the micro-organisms which can damage them.

Blackgrass seeds are light-sensitive and germinate less well in the dark, so germination is less when seeds are buried in soil, but this inhibition by darkness decreases with age of the seeds. Buried seeds can germinate easily from 4 cm deep, quite well from 8 cm and in the most favourable conditions even from 12 cm.

Temperature affects the germination of blackgrass seeds: at 3°C the seeds do not come up but at 5°C germination starts; on filter-paper in an incubator there is little difference in germination-rate between 10°C and 25°C, but from 30°C germination slackens. In open ground, for a population buried between 0 and 12 cm deep, the mean % germination was 0% at 3°C, 25% at 13°C, 34.5% at 17°C, 23.5% at 24°C and 4% at 30°C.

Table 1.

Changes in germination with age of seeds. (Blackgrass from 1965 harvest)

Date of sowing			Germination percentage 12 h light	Dark
1965	July	22nd	48	1
	Aug.	10th	59	4
	Oct.	18th	69	21
1966	Feb.	15th	77	19
	June	6th	85	62
	Dec.	5th	81	58
1967	Jan.	4th	88	49
	June	21st	84	63
	Dec.	8th	82	57
1968	Feb.	1st	70	63
	July	19th	84	51

Table 2.

Effect of depth of sowing on seedling-emergence of blackgrass

Depth of sowing	0 cm	2 cm	4 cm	8 cm	12 cm
Emergence percentage	32.8	10.6	10.5	4.2	0.5

Table 3.

Interaction of temperature and depth of sowing on emergence of seedlings from non-dormant blackgrass seeds

Depth of sowing (cm)	Temperature °C 3	13	17	14	30
0 cm	0	32	54	62	20
2	0	43	44	23	1
4	0	37	40	17	0
8	0	12	28	14	0
12	0	2	7	2	0

The moisture content of soil is very important for blackgrass germination. The % germination increases as the moisture content rises from wilting point to field capacity, at which the germination % is maximum. When this value is exceeded, germination remains high in soils rich in fine particles (clays and loams) although it decreases rapidly in coarser soils (sands). The high water-requirement of blackgrass explains its abundance on heavy soils of poor structure where drainage is bad, and its rarity on well-drained sandy soils.

Table 4.

Effect of soil moisture on per cent seedling emergence from non-dormant seeds of blackgrass

Clay soil		Sandy soil	
Water content	% germination	Water content	% germination
25.0	25	6.7	59
30.0	37	8.0	44
31.5	36	9.8	50
36.0	52	12.0	35
63.5	34	41.5	0

The resistance of blackgrass seedlings to winter cold depends on the stage of development of the plant. Thus at the 1-2 leaf stage the seedlings can withstand -8°C but freeze at or below -10°C, whereas at the fully-tillered stage they do not freeze until -25°C. After being subjected to winter cold, when the weather becomes milder again in spring, young plants which were frozen during tillering become green again and develop normally, fruiting during June, while the plants frozen at the seedling stage are definitely dead. The frost-resistance of older seedlings explains why crops of rape and early-sown cereals favour the introduction and multiplication of blackgrass, the young plants of which reach a sufficiently advanced stage to withstand the winter cold.

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PRELIMINARY OBSERVATIONS OF COMPETITION BETWEEN ALOPECURUS MYOSUROIDES (BLACKGRASS) AND GRASS SEED CROPS

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Summary Blackgrass at various densities was sown over plots of six grass varieties grown at various spacings for seed production. The black-grass sown three weeks after crop sowing was normally more competitive than blackgrass sown ten weeks after crop sowing, even though the second blackgrass sowing was at a heavier rate. The effect of competition was measured in number of seed heads per unit area, the lengths of seed heads and seed yield. The crop varieties withstood competition in the order S.23 perennial ryegrass, S.48 timothy, S.143 cocksfoot, S.22 Italian ryegrass, S.215 meadow fescue and S.53 meadow fescue. Figures are given to illustrate the reduced blackgrass competition in narrow row crops and the negative correlation between head numbers and head length in crop grasses and blackgrass.

INTRODUCTION

The aim of this investigation were (1) to study competition between blackgrass and some grass species grown for seed production and (2) to devise techniques to measure such competition, in terms of:

(a) Head numbers, (b) Head length and (c) Seed yield of crop.

De Gournay (1963) relates work done with blackgrass competition in winter cereals and this paper parallels this work in respect of grass seed crops.

METHOD AND MATERIALS

All the grass seed species were sown in mid-July at the row spacings and seed rates shown in Table 1.

Table 1

Species	Row spacing			Seed rate in lb. per acre in a row spacing of 7 in.	14 in.	21 in.
Timothy	7 in.	14 in.	21 in.	5	2.5	1.6
Cocksfoot	7 in.	14 in.	21 in.	15	7.5	5.0
Meadow fescues	7 in.	14 in.	-	15	7.5	-
Ryegrasses	7 in.	-	-	15	-	-

In the first week of August a band of blackgrass, 3 ft. wide was oversown at right angles to the crop rows and thoroughly raked in. Two rates of blackgrass equivalent to 25 and 5 lbs. of seed to the acre were used. A second sowing of blackgrass was made in September at 50 and 10 lbs. to the acre. Each treatment was replicated three times.

A compound fertiliser was applied to the seed bed but to avoid lodging and to emphasize competition no additional fertilizer was given in the following spring.

The plots were all hand harvested at the binder ripe stage, each harvested area covering three to four 2 ft. lengths of crop row and inter-row space. The harvested material was put into paper bags to facilitate drying and to minimize seed losses. The heads of crop and blackgrass were counted and the average length of head of crop and blackgrass was measured. The harvested material was then threshed in order to obtain the seed.

RESULTS

Figure 1 shows how the head length of blackgrass alone and in competition with cocksfoot and Italian ryegrass, varies according to the variation in head number occurring per square yard.

Figure 2 shows the number of heads per square yard of crop and of blackgrass for each of the blackgrass sowing dates and seed rates.

Figure 3 shows the yield in cwt. per acre of crop and blackgrass seed, again plotted one against the other under their respective sowing dates and seed rates.

No statistical significance is given for these figures and the information is treated only as observations.

Figure 1

Relation between density of head numbers and head lengths of blackgrass (Alopecurus myosuroides) and S.22 Italian ryegrass

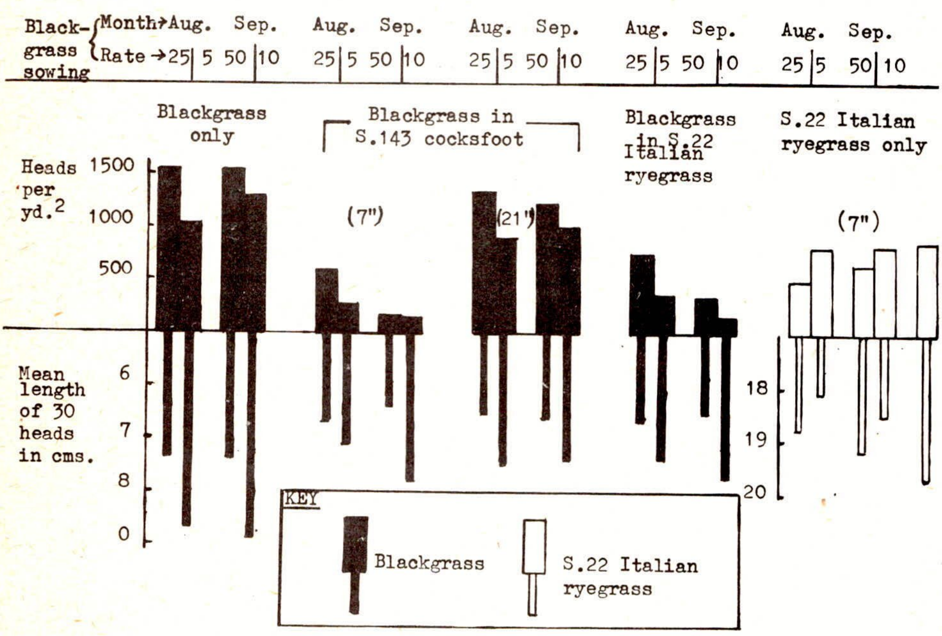


Figure 2. Competition between blackgrass (Alopecurus myosuroides) and crop grasses

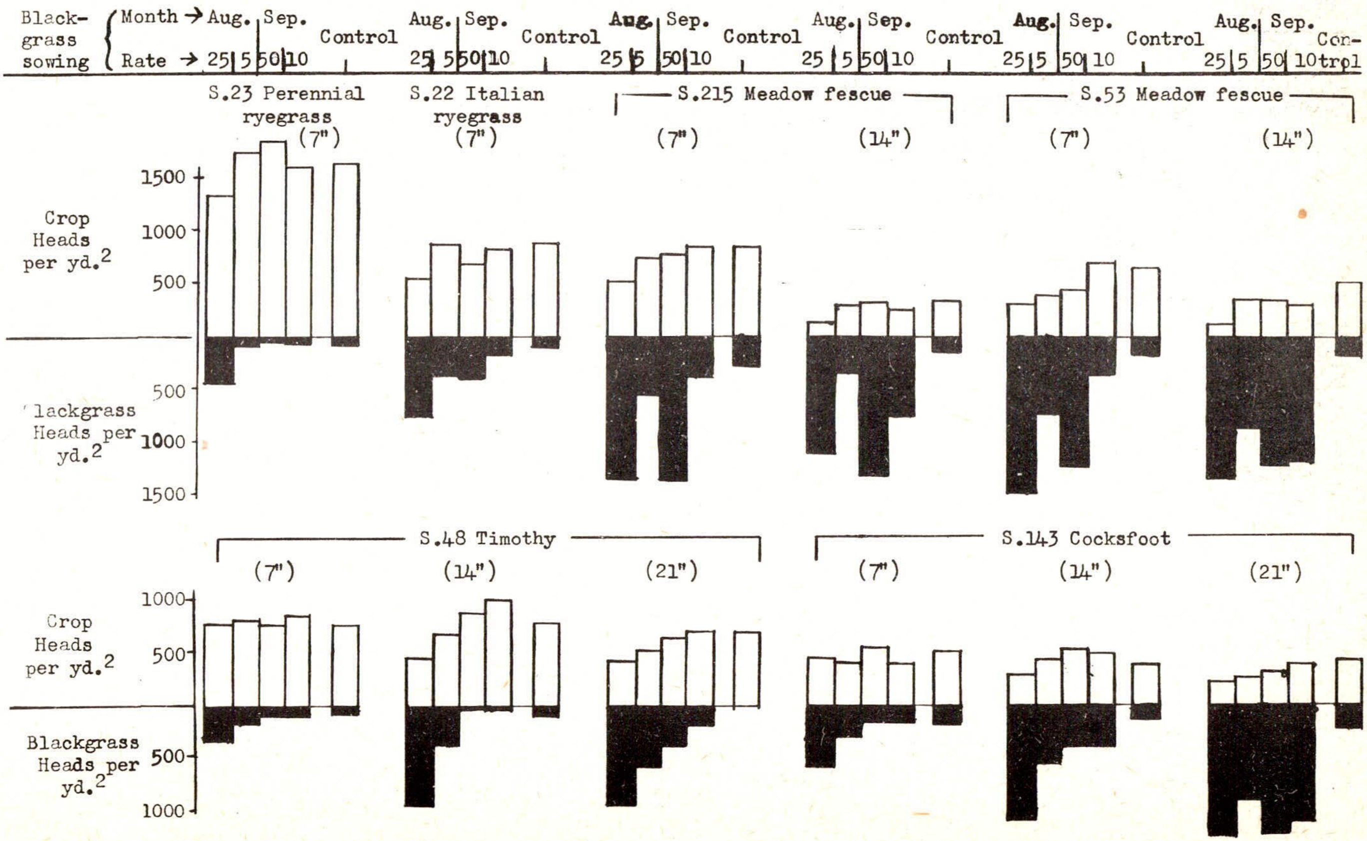
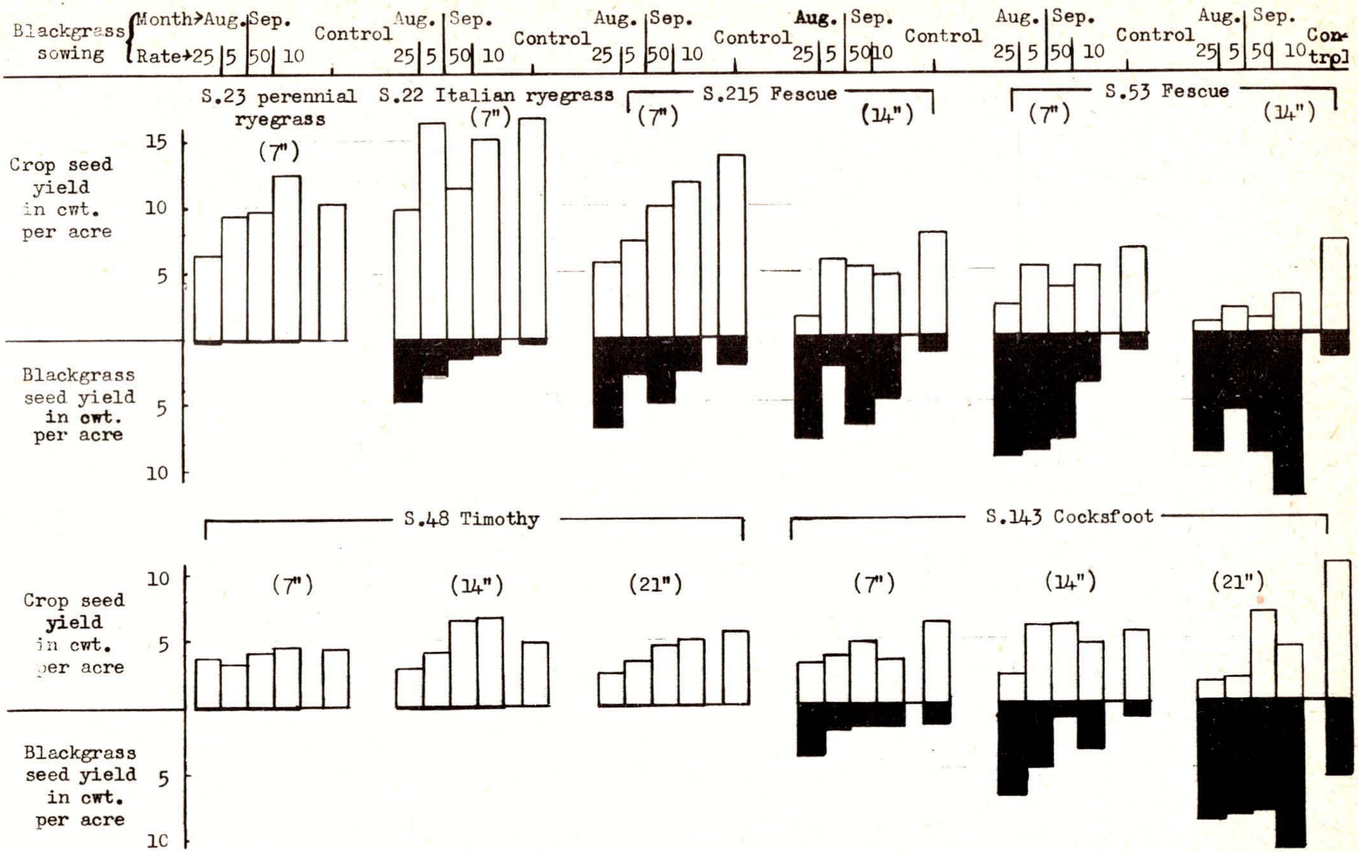


Figure 3. Competition between blackgrass (Alopecurus myosuroides) and crop grasses



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DISCUSSION

1. Effect of row width

A negative correlation exists between blackgrass and crop when competing in the various row spacings. In S.48 timothy and S.143 cocksfoot the 7 in. rows suppressed the blackgrass better than the wider rows but in both meadow fescues this effect did not occur. This may have been due to the poor establishment of the Fescues thereby giving little suppression of blackgrass in the narrow rows. Reduced yield of Fescue in the 14 in. rows is a reflection of low crop population.

2. Effect of species and variety

In 7 in. rows the crops suppressed the blackgrass in the following order:

1. S.23 perennial ryegrass
2. S.48 timothy
3. S.143 cocksfoot
4. S.22 Italian ryegrass
5. S.215 meadow fescue
6. S.53 meadow fescue

The S.22 Italian ryegrass appears rather lower in the list than might have been expected but, as already mentioned, the plots had no spring dressing of nitrogenous fertilizer. Experience has shown that this variety responds strongly to such treatment and, had one been given, it is considered that the variety would have competed with the blackgrass at least as strongly as S.23 perennial ryegrass.

3. Effect of time and rate of sowing the blackgrass

The August sowing of blackgrass at 25 lb/ac produced more blackgrass heads than the September sowing at 50 lb/ac in every treatment except in S.215 meadow fescue in which, at 7 in. rows, the 50 lb/ac in September produced the same number while in 14 in. rows the September sowing produced slightly more blackgrass. The reason for this has been discussed in 1. In both meadow fescues the blackgrass sowing rate appeared to have more effect than the time of application.

4. Effect of density of head numbers on head lengths

As head numbers of crop and blackgrass per yd^2 increase so the head lengths decrease. When blackgrass grown alone is compared with blackgrass competing with S.143 cocksfoot, head lengths of the former are significantly longer despite the influence of larger head numbers. It seems, therefore, that blackgrass in competition with other crop species suffers greater suppression in head numbers and head length than it would when competing alone.

5. Effect of time of crop harvesting on blackgrass

Figure 2 when compared with Figure 3, indicates a similarity between head numbers and seed yield, particularly in the crop species. The dissimilarity in seed yield of blackgrass in S.48 timothy is accounted for by the fact that this crop species is harvested approximately two months after the blackgrass is ripe and consequently most of the seed of the latter has long since shed on to the ground. This also occurred to a lesser extent in S.23 perennial ryegrass.

The results reported show that competition between crop and blackgrass can be measured in terms of head numbers, seed yield and head length.

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ENVIRONMENTAL FACTORS AFFECTING THE GERMINATION OF SOME ANNUAL GRASSES

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Summary Mature "seeds" (caryopsis enveloped by the lemma and palea) of Alopecurus myosuroides Huds. and Avena fatua L. were almost completely dormant when freshly harvested. Those of Apera spica venti P.B. and Poa annua L. showed relatively little dormancy at that stage. The effects of removing glumes or giving gibberellin differed according to species. The range of (constant) temperature under which one year old "seeds" of these four species would germinate and the influence of soil moisture on germination was determined.

The results are discussed in respect to time of emergence in the year and dependence of the species on soil moisture.

INTRODUCTION

These investigations were made in southwestern Germany using seeds from only one place. In this paper "seed" means the caryopsis enveloped by the glumes.

Poa annua germinates throughout almost the whole year. The depth of germination and emergence is usually less than 10 mm and it germinates best under moist to wet conditions. Alopecurus myosuroides germinates mainly in autumn and in early spring. Crops sown in late spring are seldom heavily infested. The depth of germination and emergence may be 10 cm (HANF 1943), but most germinate in the upper 4 cm of the soil. FRUWIRTH (1908) and SNOY (1952) differ in that the former found that Al. myosuroides germinated better under wet conditions whilst SNOY found that germination was better under dry to moist conditions. Apera spica venti germinates mainly in autumn and early winter. The depth of germination and emergence is usually not more than a few millimeters (HANF 1943). Ap. spica venti germinates best under moist to wet conditions but can germinate in drier soils (SNOY 1952). Avena fatua germinates mainly in early spring. The depth of germination and emergence may be 20 cm or more (THURSTON 1963, BACHTHALER 1957). Av. fatua germinates best under dry to moist conditions (SNOY 1952).

MATERIALS AND METHODS

1. Dormancy of mature "seeds" during the first six weeks after harvest.
200 "seeds" stored dry at $18-20^{\circ}C$ of each of the four species were put on moist filter paper at $18-20^{\circ}C$ in the light at intervals (see table 1) for germination with and without 0.05% gibberellin A3. Caryopses of *Avena fatua* and *Alopecurus myosuroides* were also tested with the glumes removed. In table 1 the standard error of the mean is given.

Table 1

% Germination of dry stored seed during the first 6 weeks after harvest (harvested 1968) and after 1 year (harvested 1967)

weeks after harvest	seed without gibberellin	seed with gibberellin	caryopsis without gibberellin	caryopsis with gibberellin	seed without gibberellin	seed with gibberellin
	Avena fatua				Apera spica venti	
at harvest	0-	30±3	0-	92±8	45±5	85±7
1	0-	31±2	3-	94±4	29±2	86±8
2	1-	33±3	34±2	91±5	43±4	82±5
4	1-	48±5	31±2	96±3	68±5	93±6
6	2-	41±4	30±2	92±6	57±5	83±6
52	23±3	75±8	79±7	95±4	68±8	74±7
	Alopecurus myosuroides				Poa annua	
at harvest	1-	0-	16±2	50±5	53±6	91±4
1	1-	1-	16±2	70±7	33±4	86±6
2	0-	2-	25±3	65±6	64±7	80±7
4	1-	7-	33±3	68±6	70±6	95±3
6	3-	15±3	36±4	63±6	68±7	94±4
52	44±3	48±5	96±3	98±2	94±5	91±6

2. Influence of temperature on germination.
Three replicates of 400 "seeds" (about 1 year old) of each of the four species were kept on moist filter paper in the light under different temperatures (see Fig.1). These tests were part of a bigger programme. Details of the method and a literature review on this subject are given elsewhere (KOCH, in press).

3. Influence of soil moisture on germination and emergence.

300 "seeds" of the four species were sown in pots in sandy loam with about 3% organic matter. The pots were kept at 18-20°C at different moisture levels, expressed as per cent of the total water capacity of this soil (see Fig.2). Apera spica venti and Poa annua were sown 2-4 mm deep, Alopecurus myosuroides 2-3 cm deep, and Avena fatua 3-4 cm deep. The experiment was repeated 3 times.

RESULTS

1. Dormancy of mature "seeds" during the first six weeks after harvest.

About half of the "seeds" of Poa annua and Apera spica venti could germinate at harvest (table 1). Gibberellin increases the germination of both species but the germination percentage did not alter greatly during the first weeks after harvest. The "seeds" of Avena fatua and Alopecurus myosuroides were completely dormant at harvest and during the first weeks of dry storage. Gibberellin stimulated germination of Av. fatua but not Al. myosuroides. Very few caryopses of Av. fatua germinated at harvest time. After 2 weeks their germination increased markedly. The germination of the caryopsis of Al. myosuroides was low at harvest but increased steadily. Gibberellin stimulated the germination of Av. fatua to a greater extent than the germination of Al. myosuroides.

2. Influence of the temperature on germination.

Figure 1 shows that the temperature responses are somewhat different for these four species.

3. Influence of soil moisture on germination and emergence.

Avena fatua germinates better under moist to wet than under dry conditions (Fig.2). Al. myosuroides germinates better under dry to moist than under wet conditions. The germination of Apera spica venti and Poa annua was good in a wide range of soil moistures. Most of the germinated seeds also emerged. There was no significant difference between germination and emergence under different moisture levels.

DISCUSSION

The stimulation of germination with gibberellin has been demonstrated repeatedly for Avena fatua and other species but is unlikely to be used for weed control in the field. A more detailled discussion of this problem is given elsewhere (KOCH, in press). Gibberellin is useful for laboratory studies of the mechanism of dormancy, and has sometimes been used to obtain plants for use in herbicide tests. Growth and height of wild oat plants is increased for the first few weeks after the germination of treated seeds, but the effect does not persist until flowering (THURSTON unpublished). The reason for the different reactions of Alopecurus myosuroides and Avena fatua to treatment with gibberellin has not yet been investigated.

The temperature determines mainly the germination and emergence of weeds during the year and their dependence on certain crops (KOCH, in press). The results of the experiments under constant temperature conditions correspond well with the seed-behaviour under natural conditons even though fluctuating temperatures may not only increase the germination percentage, but also change the range of temperature under which the seed will germinate (SNOY 1952, KOCH, in press). The wide range of temperature under which Poa annua will germinate shows that there are hardly any limiting temperatures (except frost) for the germination of this species under natural conditions. Whether the germination of Av. fatua and Al. myosuroides may be limited by high temperatures later in the year is not quite clear, but both species are well able to germinate under low and medium temperature conditions. This may explain why Al. myosuroides germinates mainly in autumn and from early to mid spring. It can also explain the germination of Av. fatua in spring, but in autumn factors other than temperature must control its germination.

The germination of Apera spica venti during the year, however, cannot be explained by its temperature requirement alone. It can germinate at low temperatures but would do better at higher ones. Its germination under natural conditions is confined mainly to autumn and early winter probably because of the short life-span of these seeds near the surface of the soil (KOCH, in press).

Several factors may determine the water requirement of a seed during germination, e.g. seed size and nature of the seed coat (HARPER and BENTON 1966), and the physiological optimum need not always be the same as the ecological optimum. In this respect one has to consider mainly the different depth of germination of the different species. The water content in the surface layer of the soil fluctuates more than in deeper parts. This might be the reason why Poa annua and Ap. spica venti occur more on moist to wet soils than on drier ones, even though they are quite well able to germinate under dry conditions. The behaviour of growing plants might also be somewhat different from the requirements during germination (SNOY 1952). So the more frequent occurence of Av. fatua on well aerated and moist, but not wet, soils

(ELLENBERG 1950) is obviously not due to its germination behaviour. Al. myosuroides is able to germinate at a depth where the moisture content is better than near the surface during a dry period. Thus this species may well occur on sites which are unsuitable for Ap. spica venti because of lack of moisture near the surface during the germination period. On the other hand Al. myosuroides cannot germinate well under very wet conditions. This explains why it is less abundant on those sites which suit Ap. spica venti best. In southwestern Germany Apera spica venti is therfore often found mainly in the lower parts of fields with moist to wet soil and Al. myosuroides is usually more abundant in the upper parts which are a little drier.

This brief discussion on the role of temperature and moisture in the establishment of 4 grass weeds did not consider the importance of their interaction under natural conditions, as demonstrated for some other species by LAUER (1953).

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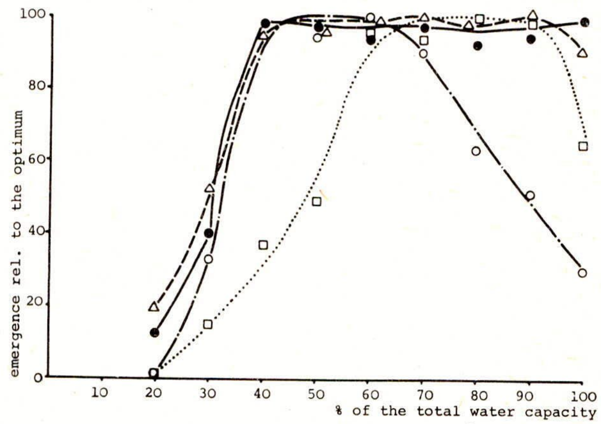

Fig. 1. Influence of temperature on the germination of four annual grass species ●———● Apera spica venti, o—·—o Alopecurus myosur., △– – –△ Poa annua, □·········□ Avena fatua

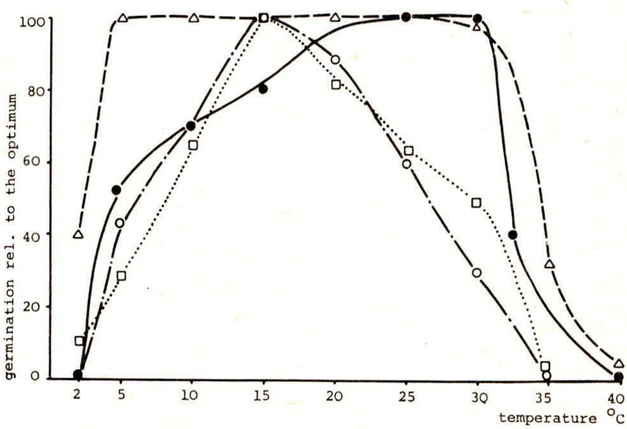

Fig. 2. Influence of soil moisture on the germination of four annual grass species (Legend see Fig. 1)

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Preliminary experiments on γ-irradiation of weed seeds

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Summary. With a view to using γ-irradiation to kill weed seeds in soil, the doses required to kill seeds of *Avena fatua*, *Alopecurus myosuroides* and *Sinapis arvensis* were determined in laboratory experiments. *Apera spica venti* was used in one experiment. All non-dormant seeds (i.e., those capable of germinating within 2 to 3 weeks of sowing when not irradiated) were killed by 20-50 kR; *Avena fatua* and possibly also *Apera spica venti* were more sensitive to irradiation than *Alopecurus myosuroides* and *Sinapis arvensis.* If dormant seeds of these and other species are equally sensitive, the method would be feasible for small amounts of soil, e.g., in glasshouses and gardens, but is at present too expensive for field use. Lower doses, especially 2-4 kR, stimulated germination of *A. fatua*.

INTRODUCTION

The use of radiation energy in agriculture is becoming increasingly important. Radioactivity can be used in pest control and food storage, as well as in plant breeding. Soil sterilization by radioactivity has also been successful more than once and has been accompanied by increased availability of manganese and ammonium-nitrogen. But the very high doses employed ($<$ 500 kR) also damaged the useful soil fauna and micro-organisms.

At a Symposium of the International Atomic Energy Authority on "Isotopes in Weed Research" (1965), it was suggested that radioactive irradiation could be used to obtain soil free from weeds. In order to pursue this problem, it was necessary to discover the sensitivity of weed seeds to irradiation. In this paper, the effect of γ-irradiation on seeds of *Avena fatua* (wild oats), *Alopecursus myosuroides* (blackgrass) and *Sinapis arvensis* (charlock) is investigated.

MATERIALS AND METHODS

After normal air-drying, the weed-seeds from the 1967 harvest were stored under strictly constant conditions of temperature and humidity. At the time of irradiation, the moisture content of the seeds was 10-12 %. Irradiation was given in a γ-ray source (1150 Ci ^{137}Cs) with an output of 72 R/min. After irradiation the seeds were laid in quartz sand in plastic dishes and kept in an incubator at constant temperature (15^{o}C), humidity (50 % R.H.) and light (8500 Lux). In each plastic dish (24.5 x 12.5 x 5 cm), 100 seeds were sown, in five replicates, and germination and seedling- development were followed.

RESULTS

Avena fatua (wild oats).

Infestation of soil by wild oats is widespread in W.Germany and can be assumed to represent about 30-40% of the total grass-weed population of arable land.

The % germination of wild oat seeds with a 1,000-grain weight of 18.6 g is progrssively decreased by irradiations exceeding 10 kR (Table 1).

Table 1

Effect of γ-irradiation of seeds on germination of Avena fatua

Germination after	Untreated (% of seeds sown)	Treated as % of germination in untreated control = 100				
		10 kR	15 kR	20 kR	25 kR	30 kR
13 days	7.3± 6.1	21	-	-	-	-
15 days	46.3±10.7	97	37	1	2	-
19 days	58.0± 7.0	105	97	31	21	1

As well as decreasing the % viable non-dormant seeds, doses above 15 kR also decreased the germination-rate, the decrease being greater the larger the dose. After 19 days, germination was 5% higher following 10 kR than for untreated seeds. Stimulation was greater at doses below 10 kR and most at 2-4 kR.

Table 2

Effect of seed irradiation on plant number and plant weight of Avena fatua after 8 weeks

	Untreated	Treated as % of untreated control = 100				
		10 kR	15 kR	20 kR	25 kR	30 kR
Number of plants	59.5±7.0	106	101	47	36	3
Dry weight (g/100 plants)	8.28±0.64	102	89	58	69	0

Plant growth was significantly damaged and delayed by 20 kR and at 30 kR the plants did not grow (Table 2). Wild oats are less sensitive to radiation than cultivated oats.

Alopecurus myosuroides (blackgrass)

Blackgrass, with a 1.000-grain-weight of only 2.1 g, is less sensitive to irradiation than wild oats. Germination % is decreased at 25 kR but is only supressed at 100 kR (Table 3).

Table 3

Effect of γ-irradiation of seeds on germination of Alopecurus Myosuroides

Germination after	Untreated (% of seeds sown)	Treated as % of germination in untreated control = 100			
		10 kR	25 kR	50 kR	100 kR
12 days	4.7±0.6	100	64	14	-
15 days	7.3±2.6	100	78	32	-

Because of the low % viable seeds, these results are based on very few seedlings. Nevertheless, they show clear trends with time and dose. At 50 kR damage is so severe that no plants are capable of competition. In other experiments the number of plants also varied with radiation dose (Table 4).

Table 4

Number of living plants of Alopecurus myosuroides after different periods of growth following γ-irradiation

Number of plants after	Untreated (% of seeds sown)	Treated as % of plants in untreated 10 kR	25 kR	50 kR	100 kR
31 days	12.0 ± 2.0	117	89	33	-
38 days	19.3 ± 6.1	89	73	21	-
44 days	20.3 ± 5.1	89	75	30	-
51 days	23.0 ± 4.4	91	68	26	-

It could be also observed that seedlings are damaged by radiation (50 kR/38 d), while other seeds showed a related germination process (50 kR/44 d).

Apera spica venti (silky bent)

Because of their genetic structure and higher content of fat and protein, charlock seeds with a 1.00-grain weight of 1.83 g are relatively resistant to radiation.

Slight damage, shown by fewer plants and decreased growth, occurs at 10 kR. Damage increases with higher doses, and at 70 kR is so great that no plants are vigorous.

DISCUSSION

These experiments are the first attempt to kill weed seeds by γ-rays. The question is, how far this method can be used in practice.

The radiation dose for killing seeds of the four weed-species tested is about 20-25 kR. With present irradiation techniques, this dose is not difficult to apply and could be used for smaller areas, e.g., glasshouses and gardens, although technical requirements are still too difficult and expensive for field-scale application. But radiation technology is advancing rapidly and developments suitable for use in this context are to be expected.

If, as anticipated, irradiation at these doses affects all weed-seeds, including other species and perhaps of also the dormant seeds of the species investigated above, the method would be of universal application.

The stimulation of germination found in some species with doses below 10 kR, and especially about 4 kR, could also be useful in weed-control.
The results of this work are concerned to germinating weed-seeds.

Many problems remain to be investigated, e.g. the effect of irradiation on dormant seeds, the behaviour of seeds of different moisture content, age and possibly also provenance. The results of these preliminary experiments are presented for discussion within this framework.

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FIELD EXPERIMENTS IN THE U.K. WITH N-benzothiazol-2-yl-NN'dimethylurea FOR THE CONTROL OF ALOPECURUS MYOSUROIDES (BLACKGRASS) IN WINTER WHEAT

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Summary In autumn-sown winter wheat Bayer 74283 at 2.8 lb a.i. per acre post-drilling gave excellent control of *Alopecurus myosuroides* (blackgrass) up to an early seedling stage. In these trials where it was present yields were increased significantly. No phytotoxicity was observed throughout the season on three varieties of wheat. 2.8 lb a.i. per acre is proposed as a suitable rate for the control of autumn-germinating blackgrass in wheat.

INTRODUCTION

N-benzothiazol-2-yl-NN'dimethylurea (Bayer 74283)* is a residual herbicide with a low mammalian toxicity. Early screening work by Farbenfabriken Bayer AG. at Leverkusen, West Germany (Hack H. 1968) showed the compound to be a selective broad spectrum herbicide in winter and spring wheat. Certain grass species were controlled, also a range of broad-leaf weeds. Trials in the U.K. were first carried out in spring 1966 and 1967 to test Bayer 74283 for the control of *Alopecurus myosuroides* in winter wheat. These trials showed less effective control of blackgrass when applied in early spring but indicated that with autumn or pre-emergence applications it may be controlled. Consequently a number of trials were laid down in autumn 1967, of which the results and details are given in this paper. It is hoped to publish elsewhere the results of further trials work with Bayer 74283 for use against broad-leafed weeds. Bayer 74283 was shown phytotoxic to U.K. barley varieties.

METHOD AND MATERIALS

Eight replicated trials were laid down on winter wheat during autumn 1967 in East Anglia. Soil types were all heavy loams. Site H.6 had additional blackgrass seed broadcast at the time of drilling to ensure a heavy level of infestation. Applications were made at various times as follows:-

1. Within 1 week of drilling
2. 2½ weeks post-drilling
3. Approximately 4 weeks post-drilling
4. Approximately 8 weeks post-drilling with blackgrass generally in 1 - 2 leaf stage
5. 14 - 20 weeks after drilling (February/March, blackgrass well tillered)

*Available as Tribunil, proposed BSI common name Methabenzthiazuron

For application a Van der Weij Knapsack sprayer fitted with a 2 metre boom and cone nozzles was used. The treatments were applied in 30 gallons of water per acre at a pressure of 45 lb/in^2. Experimental design was a randomised block replicated three times with individual plots of 50 sq yd.

Assessments were carried out during the winter to assess stand of wheat seedlings using a 12 in. x 12 in. quadrat recording total population in 12 squares per plot (see Table 2). A visual score for blackgrass was attempted at some sites but due to the outbreak of "Foot and Mouth" disease visits to farms were curtailed. Blackgrass control was therefore only assessed in all trials at the heading stage (early June). The number of blackgrass and wheat heads were recorded within 3 x $\frac{1}{2}$ sq yd quadrats at random per plot. The results of blackgrass counts and wheat head counts for untreated plots are shown in Table 1 together with percentage of control for all treatments.

Six trials were taken to yield cutting a 4 ft swath through the middle of each plot with a small plot combine harvester (HEGE 125). Yield results are shown in Table 3.

The material used in the trials was a 70% wettable powder of Bayer 74283, (N-benzothiazol-2-yl-NN'dimethylurea), formulation 5653.

RESULTS

Effects on Blackgrass

Blackgrass infestations occurred on six sites. At two sites an initial scoring for blackgrass control was made in early March. Results showed the best treatment to give a 90% reduction in seedling population compared to untreated. A scoring system 0 - 10 was used. 0 = no reduction, 10 = complete absence of blackgrass. Results are given as an average of two observers. (see below)

Bayer 74283 Rate/ac	1.4 lb	2.8 lb	1.4 lb	2.8 lb	Control
Applic. post-drill.	1 week	1 week	4 weeks	4 weeks	
Site H.8	5.5	7.6	8.3	9.1	0
Site H.10	5.3	7.3	6.5	9.1	0

It was not possible to complete these assessments for other sites for reasons explained elsewhere.

Counts of the blackgrass seed heads were made in early June and the results in terms of percentage reduction compared to control can be seen in Table 1.

Effects on crop

No adverse effects were seen throughout the trials on winter wheat varieties Capelle Desprez, Champlein or Elite Lepeuple as a result of applications of Bayer 74283 at either 1.4 or 2.8 lb a.i./ac.

Although there were some slight variations in populations of wheat seedlings in December 1967 these were not significant. It was not possible to assess the remaining 2 trials. Site H.8 had been subject to flooding prior to the assessment and this may have affected subsequent crop growth.

Six trials were subsequently taken to yield and results obtained for four trials with blackgrass populations and two trials without infestation, thus showing the effect of the weed populations on the yield of wheat and also the lack of any adverse effect from the herbicide. See Table 3.

It should be noted that in H.5 there is a rather low figure for yield in the control; this was due to a low figure on one of the 3 untreated plots possibly due to excessive lodging of the crop during adverse weather in July and August.(Table 3)

Table 1

Blackgrass control at 6 sites

Treatment as a.i. per acre	Application weeks after drilling	% Control of blackgrass heads (mean of 3 replicates)					
		H/6	H/8	H/9	H/10	H/11	H/13
74283 1.4 lb " 2.8 lb	1 week 1 week	38.6 86.5	22.6 97.6	61.6 67.3	69.3 83.9	- -	- -
74283 1.4 lb " 2.8 lb	2½ wk 2½ wk	40.7 85.5	- -	- -	- -	69.1 76.6	- -
74283 1.4 lb " 2.8 lb	4 wk 4 wk	42.5 89.0	95.0 96.9	65.0 83.9	60.1 89.1	80.6 92.7	76.4 90.6
74283 1.4 lb " 2.8 lb	8 wk 8 wk	63.0 91.3	- -	- -	- -	- -	- -
74283 1.4 lb " 2.8 lb	14-20 wk	9.0 71.1	74.6 84.8	48.2 53.2	- -	- -	- -
Grower standard	1-3 wk	81.0	13.1	82.4	90.5	60.0	87.7
Date of drilling		11/10	17/10	18/10	19/10	10/10	16/10
Untreated - No. of blackgrass heads No. of wheat heads		3419 304	1779 494	804 468	556 419	909 457	3939 273
Blackgrass emergence in weeks after drilling		6	8	8	8	10	3
Blackgrass tillering weeks after drilling		14	20	20	-	-	-

Table 2

Assessment of wheat population after treatment (mean of 3 plots)

Treatment as a.i. Rate/ac	Wks after drilling	Site : Wheat seedlings per 12 sq ft. Date of Assessment H.6 29.11.67	H.8 20.12.67	H.10 15.12.67	H.11 15.12.67	H.12 15.12.67	H.13 15.12.67
74283 1.4 lb	1 wk	266	183	322	-	286	-
2.8 lb	1 wk	280	191	300	-	292	-
1.4 lb	2½ wk	257	-	-	298	-	-
2.8 lb	2½ wk	243	-	-	335	-	-
1.4 lb	4 wk	269	225	278	301	295	175
2.8 lb	4 wk	268	236	283	294	288	204
Growers Standard	1 wk	297	171	328	307	295	214
Untreated		280	178	319	288	277	199

DISCUSSION

Good control of Alopecurus myosuroides was obtained with Bayer 74283 at 2.8 lb a.i. per acre from applications made four weeks after drilling before the majority of blackgrass had emerged. Later applications, however, showed the ability of the material to control blackgrass providing it had not passed the two-leaf stage. Applications after tillering were not as effective.

Bayer 74283 at 1.4 lb a.i. per acre gave only one instance of good blackgrass control.

At site H.8 a population of Poa trivialis was present and 74% reduction was given by 2.8 lb dose of Bayer 74283 when applied one week post drilling. Later applications (2½ - 4 weeks) gave only 47 and 51% control respectively of Poa trivialis.

At site H.6 where a heavy population of blackgrass was artificially induced control was still satisfactory. It must be pointed out that the germination of blackgrass was generally rather slow due to dry conditions after most trials were drilled during the period 10th - 19th October.

With regard to crop tolerance no adverse effect on the crop was observed throughout the season. This is supported by two yield results H.5 and H.12 in Table 3 where no blackgrass was present.

In all trials with blackgrass yield increases were statistically significant for 2.8 lb Bayer 74283 a.i. per acre. The rate of 1.4 lb a.i. per acre gave significant yield increases in only two trials (Table 3).

Examination of the figures for blackgrass head and wheat head populations shown in Table 1 suggest that the highest population of blackgrass heads was associated with the lowest populations of wheat.

Table 3

Crop yield (Cwt/Acre)

Treatments	Rate a.i. lb/ac	Application No. of Weeks Post-Drilling	Trial No.					
			H.5	H.6	H.9	H.10	H.12	H.13
Bayer 74283	1.2	1	34.6	30.8	43.2	44.0	39.4	-
"	2.4	1	38.2	41.2	47.5	47.5	39.0	-
Bayer 74283	1.2	2.5	-	32.4	-	-	-	-
"	2.4	2.5	-	35.8	-	-	-	-
Bayer 74283	1.2	4	36.9	30.8	43.4	46.2	42.0	32.2
"	2.4	4	39.3	36.0	46.5	48.1	41.5	38.5
Bayer 74283	1.2	8	-	32.4	-	-	-	-
"	2.4	8	-	39.1	-	-	-	-
Bayer 74283	1.2	14-20	40.1	29.2	39.6	-	-	-
"	2.4	14-20	36.8	31.4	40.6	-	-	-
Growers Standard			39.5	34.6	46.5	48.6	41.0	35.2
Untreated Control			26.1	25.0	37.4	36.0	39.4	28.9
Least significant difference at 5% level			N.S.	4.9	5.4	4.0	N.S.	3.4

Acknowledgments

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THE PRE-EMERGENCE USE OF NITROFEN FOR THE CONTROL OF ALOPECURUS MYOSUROIDES IN CEREALS

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Summary Previous work in France using nitrofen for the pre-emergence control of blackgrass in winter wheat prompted trial work to be carried out in the U.K. in 1967/68. In 16 grower trials nitrofen was applied at 2lb/ac a.i. within 21 days after drilling. Results in winter wheat have shown an average control of *Alopecurus myosuroides* of 83% and an increase in crop tiller number over the untreated of 39%. Trials in spring wheat and barley gave an average control of *A. myosuroides* of 88%, a control of *Avena fatua* of 73% and a crop tiller increase of 20%. Crop yield increases in the nitrofen treated plots, were found in the winter wheat but not in the spring cereals.

INTRODUCTION

The herbicides at present available for the control of *A. myosuroides* in cereal crops all have various disadvantages which have previously been described (Holroyd 1966). These include the need for soil incorporation, restrictions on use on type of crop and time of application - both seasonal and crop growth stage. Nitrofen is not subject to most of these restrictions, being a pre-emergence herbicide which can be applied to winter and spring wheat and to spring barley.

Nitrofen was first marketed in the U.K. in 1966 for pre- and post-emergence weed control in drilled Brassica crops, but it was first tested for the pre-emergence control of *A. myosuroides* (blackgrass) in winter wheat in France in 1964 (Rognon 1966). Successful results in France using rates up to 4lb/ac a.i. enabled full commercialization in the autumn of 1967. In view of this work it was decided to carry out grower trials in autumn 1967 in the main areas of cereals infested with *A. myosuroides*, i.e. Essex, Huntingdonshire and Cambridgeshire, using a standard pre-emergence application of 2lb/ac a.i.

METHODS AND MATERIALS

Nitrofen (2,4-dichlorophenyl 4-nitrophenyl ether) was used as (TOK E-25) an emulsifiable concentrate containing 2.4 lb a.i./Imp.gal.

All the nitrofen treatments at the sixteen trial sites were grower applied and varied in size from half to two acres. Application rate was 2 lb/ac a.i. in 40-60 gal/ac applied within twenty-one days of drilling. At site No. 4 there was a direct comparison with terbutryne and no untreated area, while at site No. 5 there was a comparison with both barban and untreated. Of the sixteen trials laid down results were obtained from eleven sites, the other five sites were rejected due to insufficient emergence of *A. myosuroides*.

Site details are given in Table 1.

Table 1.

Site details

Site No.	Location	Crop and variety	Date of appln. and (no. days after drilling)	Soil type	Rainfall in inches for six weeks after application 1	2	3	4	5	6
1.	Essex	winter wheat var.Cappelle	12.11.67 (7)	clay loam	0.09	0.04	0.16	0.23	0.22	0.93
2.	Cambs.	winter wheat var.Cappelle	19.11.67 (7)	silt loam	0.02	0.06	0.25	0.26	0.64	0.56
3.	Hunts.	winter wheat var.Cappelle	2.11.67 (3)	clay loam	0.02	0.06	0.25	0.26	0.64	0.56
4.	Essex	winter wheat var.Cappelle	17.11.67 (3)	clay loam	0.42	0.18	0.04	0.03	0.21	0.30
5.	Essex	spring wheat var. Kloka	18. 3.68 (10)	clay loam	0.48	0.28	0.55	0.00	0.85	0.69
6.	Essex	spring wheat var. Kloka	3. 4.68 (7)	sandy clay loam	0.03	0.08	1.21	0.43	0.44	0.74
7.	Essex	spring wheat var. Troll	25. 3.68 (21)	clay loam	0.04	0.08	0.19	0.06	0.12	0.01
8.	Essex	spring barley var. Impala	18. 3.68 (3)	clay loam	0.48	0.28	0.55	0.00	0.85	0.69
9.	Essex	spring barley var. Impala	6. 4.68 (11)	clay loam	0.00	0.85	0.44	0.47	0.75	0.41
10.	Hunts	spring barley var. Rika	24. 3.68 (2)	silty clay loam	0.04	0.16	0.01	0.35	0.11	1.02
11.	Cambs	spring barley var. Rika	28. 4.68 (5)	silt loam	0.35	0.03	0.21	0.12	0.25	0.18

An assessment of control of *A. myosuroides* and *Avena fatua/ludoviciana* and also a crop tiller count was made at time of crop heading by taking 10 counts of 200 in^2 per treatment. Crop yield data was obtained by taking combine cuts through the sprayed and unsprayed areas. All grain moistures were corrected to 16%.

RESULTS

Details of weed control and crop tiller counts are shown in Table 2 where the untreated weeds are expressed as number/yd^2. Yield data are shown in Table 3.

Table 2.

Details of weed control and crop tiller counts taken at time of crop heading

Site No.	Crop	*Avena fatua* Untreated no./yd^2	*Avena fatua* % control by nitrofen	*A. myosuroides* Untreated no./yd^2	*A. myosuroides* % control by nitrofen	Tiller no. as % of untreated
1.	winter wheat	-	-	255	95.2	162.4
2.	winter wheat	-	-	312	80.4	127.8
3.	winter wheat	54	30.6*	272	74.2	127.2
**4.	winter wheat	-	-	123	56.1	123.4
Average for winter wheat				258	83.3	139.1
Standard deviation					±10.8	±20.2
5.	spring wheat	62	77.9 (64.2)	132	94.2 (0.0)	122.7 (95.3)
6.	spring wheat	47	80.8	84	92.3	117.5
7.	spring wheat	-	-	246	68.4	99.4
8.	spring barley	-	-	53	92.7	130.3
9.	spring barley	-	-	260	91.6	119.9
10.	spring barley	79	60.4	219	90.3	131.2
11.	spring barley	94	71.2	129	84.5	121.2
Average for spring wheat and barley		71	72.6	161	87.7	120.3
Standard deviation					± 9.1	±10.5

* *A. ludoviciana*

** Results at site No. 4 are expressed as a % of terbutryne because no untreated area was present, these figures are not included in the averages for winter wheat, nor in the calculation of standard deviation.

The figures in brackets () at site 5 are for barban.

Table 3.

Details of crop yield

Site No.	Crop	Area in acres of treatment harvested	Yield in lb from untreated plot	Yield in cwt/ ac from untreated plot	Nitrofen yield as % untreated
1.	winter wheat	0.506	1,588	28.3	112.1
2.	winter wheat	0.692	1,692	37.8	111.6
3.	winter wheat	-	-	-	-
**4.	winter wheat	0.195	641	29.4	98.0
	Average and standard deviation				111.9 ±2.2
5.	spring wheat	0.160	432	24.1	100.5
6.	spring wheat	0.169	480	28.4	103.8
7.	spring wheat	-	-	-	-
8.	spring barley	0.160	594	33.1	90.2
9.	spring barley	0.358	1,186	29.6	101.4
10.	spring barley	0.350	855	21.8	102.1
11.	spring barley	0.210	553	24.0	104.5
	Average and standard deviation				100.6 ±12.4

** Results at site 4 are expressed as % of terbutryne because no untreated was present, these figures are not included in the averages for winter wheat, or the calculation of standard deviation.

DISCUSSION

The trial results, at all sites, show a very good control of A. myosuroides by nitrofen; only at site No. 7 did the control fall below 70% of the untreated. A. fatua was also well controlled at the four spring cereal sites where it occurred. Most of the A. myosuroides and A. fatua were killed at or soon after germination, but some were not killed until the 1-2 leaf stage, particularly if the soil surface was rather dry at germination.

Observations at site No. 1 indicated that there was a control of spring germinated A. mysuroides by an autumn application of nitrofen. The Authors are of the opinion that a strongly growing autumn crop will effectively suppress any spring germinating A. myosuroides.

At site No. 4 the rest of the field was treated with terbutryne over which the nitrofen gave a further 44% reduction in numbers of A. myosuroides and a further crop tiller increase of 23%

At site No. 5 barban was applied by the grower and gave nil control of A. myosuroides and 64% of A fatua which was 14% less than the nitrofen. When the crop was viewed it appeared that only the barban had controlled the A. fatua, but a closer inspection revealed that in the nitrofen plot the heads of A. fatua were above the crop, whereas in the barban the A. fatua plants had been stunted and the heads were amongst the crop. The barban also reduced the crop tiller number to 95% of the untreated, whilst the nitrofen increased it to 123% of the untreated. The nitrofen also gave a 96.1% control of Polygonum convolvulus.

The only observed crop damage was at site No. 9 where twelve days elapsed between drilling and application of nitrofen. The crop emerged and grew normally, until the three leaf stage when heavy rain fell on soil already at field capacity. A few days afterwards necrotic lesions appeared on the first two leaves. Some leaves died but the growing point was unaffected and the plants soon recovered and gave an increase in tiller number of 20% over the untreated; no yield depression was recorded.

The only site where less than a 17% increase in crop tillers occurred was at site No. 7 where 21 days elapsed between drilling and application of nitrofen.

The removal of A. myosuroides and A. fatua probably encouraged the increased crop tiller counts on the nitrofen treated plots. This tiller increase was reflected in yield increase only in the winter wheat. The reason for this may be that only the winter wheat was growing for a sufficient time to benefit from competition removal; alternatively regarding the spring cereals the growing conditions in the summer of 1968 were so unfavourable that the increased tiller number did not fulfil its potential increase in yield as would be expected under normal conditions.

The only reduction in crop yield was at site No. 8, here the treated area lodged due to funnelling of the wind through a gap in a hedge.

These trials have shown that nitrofen gives commercially acceptable control of A. myosuroides with indications of acceptable control of A. fatua in winter wheat, spring wheat and barley, with no adverse effects on crop yields.

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The control of *Alopecurus myosuroides* and *Apera spica venti* by BAS 2440 H in winter-cereals

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Summary In several experiments in winter-barley, winter-rye and winter-wheat containing moderate to heavy infestations of *Alopecurus myosuroides* and *Apera spica venti* BAS 2440 H was applied either as a pre-emergence, early post-emergence or late post-emergence treatment. The percentage control of *Alopecurus myosuroides* and *Apera spica venti* ranged between 83 % to 95 % and yield increases were obtained ranging between 5 % to 19 %. Besides these two grasses mentioned broadleaved weeds, especially *Matricaria recutita*, can also be controlled.

INTRODUCTION

The annual grasses *Alopecurus myosuroides* and *Apera spica venti* are a big problem in several parts of Germany in winter-cereals and sometimes in spring-cereals. Two thousand spikes of *Alopecurus myosuroides* per m^2 and five hundred panicles of *Apera spica venti* per m^2 are not infrequent and this heavy infestation hardly permits a profitable yield. There are many causes of such infestations such as changes in soil preparation, the use of the combine harvester, the use of selective hormone type weedkillers, higher amounts of fertilizer, etc. A suitable herbicide for the control of these grasses as well as broadleaf weeds in winter-cereals was needed.

The herbicide BAS 2440 H was developed for this purpose. Preliminary results were published previously (Fischer 1965 and 1967, Sipos 1968), and this paper will give further information.

METHODS AND MATERIALS

The trials consisted of a minimum of four replicates in randomized blocks, each plot being 25 m^2. The trials were located in different parts of Germany. Applications were carried out using a Knapsacksprayer and a tractor fitted with spraying equipment. The nozzles used were Teejet No. 8003 and the pressure was 2 - 3 atmospheres.

The pre-emergence treatments were applied in 400 l water/ha immediately after planting and the post-emergence treatments were applied in the spring when the wheat growth had started again and no extended periods of frosts were expected.

At the time of the post-emergence application *Alopecurus m.* possessed a max. of six leaves in winter-wheat, three leaves up to the first tillering stage in winter-barley and three leaves up to the first tillering stage in winter-rye. *Apera spica venti* was in three to seven leave stage at time of application.

Assessment of cereal injury was made according to the following scale:

scale	injury rating	scale	injury rating
1	no injury	6	heavy injury
2	very slight injury	7	very heavy injury
3	slight injury (commercial acceptable)	8	extreme injury
		9	almost killed
4	some injury	10	all plants killed
5	considerable injury		

The material used was a mixture of 25 % 1-Phenyl-4-amino-5-brom-pyridazon-6 and of 25 % N- 1- or 2-(3a,4,5,6,7,7a-hexahydro-)4,7-methanoindanyl -N'-dimethyl-urea formulated as a 50 % wettable powder known as Basanor(R), hereinafter referred to as the code number BAS 2440 H. The standard I used was a product based on 4-ethylamino-2-methylthio-6-t-butyl-amino-1,3,5-triazine and standard II contained methoprotryne + simazine.

RESULTS

The product BAS 2440 H can be applied at different times. Table 1 shows the results obtained from the emergence applications against Alopecurus myosuroides and broadleaved weeds in winter-barley, winter-rye and winter-wheat.

Table 1

Percentage control of Alopecurus myosuroides and broadleaved weeds by BAS 2440 H applied pre-emergence

crop	winter-barley (mean of 7 trials)			winter-rye (mean of 6 trials)			winter-wheat (mean of 6 trials)		
product	control	2440 H	standard I	control	2440 H	standard I	control	2440 H	standard I
kg/ha	-	3	3	-	3	3	-	3	3
injury rating	1	1,2	2,0	1	1,7	2,0	1	1,5	2,0
broadl. weeds	0	86	90	0	92	93	0	88	92
Alopecurus myosuroides	0	88	86	0	84	86	0	91	90
mean yield kg/ha	100 4020	113	105	-	-	-	-	-	-

The injury rating data seem to indicate that BAS 2440 H is slightly more selective than the standard I used, and that the yield of the standard I was insignificantly lower than the yield of BAS 2440 H. However, both treatments BAS 2440 H and the standard I produced in comparison to the untreated plots a yield increase of 13 % and 5 %, respectively. The herbicidal activity of both products for broadleaved weeds and Alopecurus m. was estimated to be between 84 - 92 %. The small variations within the weed control rating values found in these trials did not appear to differ significantly for either broadleaf weeds or Alopecurus myosuroides.

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The effect of the post-emergence treatments against broadleaved weeds and Apera spica venti are summarized in Table 2.

Table 2

Percentage control of Apera spica venti and broadleaved weeds by BAS 2440 H applied post-emergence

crop	winter-barley (mean of 15 trials)			winter-rye (mean of 15 trials)			winter-wheat (mean of 20 trials)		
Product kg/ha	con-trol -	2440 H 2	stan-dard II 2	con-trol -	2440 H 2	stan-dard II 2	con-trol -	2440 H 2	stan-dard II 2
injury rating	1	1,0	1,2	1	1,5	1,2	1	1,0	1,2
broadl. weeds	0	85	78	0	95	88	0	93	91
Apera sp. venti	0	88	74	0	93	85	0	95	90
mean yield	100 3670 kg/ha	119	109	100 3880 kg/ha	115	111	100 5360 kg/ha	107	109

There were no notable differences among treatments in their effect on the three winter-cereals. Only some very slight injury was observed in winter-rye which seemed to be more susceptible than winter-barley and winter-wheat. No thinning of the plants was recorded.

The herbicidal effect of both products on broadleaved weeds and Apera spica venti was in winter-barley less than in the others. Particularly in the experiments with barley and with rye BAS 2440 H gave better results than the standard II. The figures obtained for weed control varied between 7 % to 14 %, so that in these trials BAS 2440 H increased the yield per ha more than the standard II.

Whereas 2 kg BAS 2440 H/ha were able to control Apera spica venti in the spring 3 kg BAS 2440 H/ha had to be applied for a commercially acceptable effect for the control of Alopecurus myosuroides. The results are summarized in Table 3.

Table 3

Percentage control of Alopecurus myosuroides and broadleaved weeds by BAS 2440 H applied post-emergence

crop	winter-barley (mean of 10 trials)			winter-rye (mean of 7 trials)			winter-wheat (mean of 20 trials)		
product	control	2440 H	standard II	control	2440 H	standard II	control	2440 H	standardII
kg/ha	-	3	3	-	3	3	-	3	3
injury rating	1	1,0	1,2	1	2,0	2,5	1	1,2	1,3
broadl. weeds	0	85	85	0	87	90	0	93	90
Alopecurus myosuroides	0	83	74	0	87	86	0	91	85
mean yield kg/ha	100 4940	117	114	100 3730	117	116	100 5830	107	104

According to the results given in Table 2 the increased dosage caused, very slight injury especially in winter-rye, which appeared as a light yellow coloration of the leaves for three weeks after application.

In general the vegetative and generative development of the plants were not influenced by the herbicide treatments. The yield per ha could be increased from 6 % to 17 %.

In the trials carried out with BAS 2440 H in winter-barley and in winter-wheat a better control of Alopecurus m. was noted than with the standard II. The yields which were obtained did express this difference. BAS 2440 H applied in winter-rye showed the same herbicidal effectiveness as the competitive product.

Nearly all weed species found in the field of winter-cereals, except the perennial weeds, were controlled by the herbicide treatment. One exception seemed to be Galium aparine, but an effectiveness of 80 % with the 3 kg/ha application of BAS 2440 H was achieved. BAS 2440 H can controll the following weeds:

Capsella bursapastoris, Centaurea cyanus, Galeopsis tetrahit, Lamium ssp., Lithospermum arvense, Matricaria recutita, Myosotis arvensis, Papaver rhoeas, Polygonum convolvulus, Polygonum aviculare, Raphanus raphanistrum, Stellaria media, Thlaspi arvense, Veronica agrestis and Viola tricolor.

DISCUSSION

The results presented here verify the high activity of BAS 2440 H as a pre- or post-emergence herbicide. Effectiveness varies with time of application.

The percentage control of Alopecurus m. in winter barley was higher in the pre-emergence treatment, because the stage of grass development is much more favourable for control at this time. At the time of the post-emergence application the grass had reached the tillering stage and was more difficult to control. It can be concluded that winter barley should be treated after planting.

The experiments in winter-rye and winter-wheat did not show the same tendency as those tests conducted in barley although it is conceivable that experiments in early planted winter-rye would produce similar results to those with barley. The results indicate a high degree of Apera spica venti control with BAS 2440 H. Whereas for commercially acceptable control of Alopecurus m. 3 kg/ha were necessary, Apera spica venti could be adequately controlled with 2 kg/ha of BAS 2440 H/ha. As with Alopecurus m. the percentage of weed control in winter-barley was lower than in rye and wheat. The established plants of Apera spica venti had possibly passed the susceptible stage for herbicide treatment. Other experiments showed the right time for killing Apera spica venti in winter-barley was in the autumn with pre- or post-emergence application.

The crop injury ratings of the plots treated with BAS 2440 H were generally regarded as acceptable. The figures collected from the pre-emergence trials point to a slightly better selectivity of BAS 2440 H than for the standard I used. From the post-emergence trials it can be stated that winter-rye particularly may be more sensitive than barley and wheat.

The present investigations indicate the importance of a herbicide treatment in soil infested heavily with Alopecurus m. and Apera spica venti The yield increases obtained after herbicide treatment run between 5 % to 19 %. The highest yield was achieved in winter-barley which was followed by winter-rye and winter-wheat.

The present work also demonstrated that a broad spectrum of broad-leaved weeds can be controlled. Particularly Matricaria recutita was controlled effectively.

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