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THE RESPONSE TO DEFOLIATION OF DIFFERENT STRAINS OF AGROPYRON REPENS AND AGROSTIS GIGANTEA

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Summary In box experiments with three *Agropyron repens* clones and an *Agrostis gigantea* strain, shoot removal every 14 days always reduced the proportion of active rhizome buds, suppressed new rhizome growth and reduced the carbohydrate content of the planted rhizomes. However there were differences in the degree of response to this treatment. The carbohydrate reserves of a local *Agropyron* clone were less affected than were the reserves of clones from other areas. When shoots were not removed there were differences in the number and weight of tillers produced and in the rate of carbohydrate accumulation.

INTRODUCTION

In previous box experiments with a local strain of *Agropyron repens*, repeated defoliation at 10-14 day intervals reduced rhizome carbohydrate reserves to a low level within 60-80 days, particularly if ample soil nitrogen was present (Turner 1966; 1968).

This paper discusses two further experiments which were undertaken to check the application of these results to other *Agropyron* clones and to *Agrostis gigantea*, a rhizomatous grass which is typical of lighter arable soils. The growth and response to nitrogen of non-defoliated plants were also compared.

MATERIALS AND METHODS

Experiment 1. The experiment was carried out in wooden boxes of size 24 x 15 x 6 in., divided with plastic sheeting so as to allow harvesting at three dates. A 3^3 design with 2 replications was used:

Clones	Frequency of defoliation	Added N
W.R.O. Collection no. 9	14 days	Nil
" " no. 25	28 "	100 lb/ac
" " no. 31	No defoliation	200 " "

Planting material of each clone was obtained from stock beds which had received similar treatment and had been established about a year previously. Clones 9 and 25 were of contrasting type, and were originally collected in Flintshire and Derbyshire respectively. Clone 9 is upright, broad-leaved, with thick rhizomes while clone 25 has narrow leaves, prostrate habit, and thin rhizomes. Clone 31, of local origin, is of intermediate type and similar to the strain used in previous experiments (Turner, 1966; 1968).

Four 9 in. long unbranched rhizome pieces of approximately uniform age and appearance were planted at 2 in. depth in each box section, using a sandy loam soil. Where added nitrogen was given appropriate weights of nitrochalk were mixed with the soil before planting. The experiment began on 15/8/67. The boxes were placed in the open and watered to capacity twice weekly. In all clones shoots first appeared on 23/8/67 and thereafter growth was removed at 14 or 28 day intervals by cutting at soil level. At 36, 59 and 90 days the plants in one section were dug up, washed, dried at 100°C for 12 hr, and the weights of the parent rhizomes, new rhizomes and shoots were determined. The proportion of rhizome buds with a shoot was recorded. The available carbohydrate content of rhizomes was estimated by hydrolysing dried ground material for 1 hr at 85°C. (Schirman & Buchholtz, 1966). After neutralising the hydrolysate the reducing sugars present were determined by the alkaline picrate method (Snell & Snell, 1953).

The experiment finished on 13/11/67. During its course mean air temperatures ranged from about 15°C in August and September to 5°C in early November. At this time there was slight air frost.

Experiment 2. In this experiment all the plants were to be harvested at one date and therefore plastic divisions were not needed. In other respects the methods of planting and harvesting were as in Experiment 1. A 2 x 3 x 3 factorial design with 3 replications was used:-

Species	Frequency of defoliation	Added N
Agropyron repens	14 days	Nil
Agrostis gigantea	28 days	100 lb/ac.
	No defoliation	200 " "

Rhizomes of *Agropyron* Clone 31 and of non-clonal but apparently uniform *Agrostis* plants collected near Chipping Norton, Oxon, were used. As few long unbranched *Agrostis* rhizomes could be found 3 in. segments of both species were used. The *Agrostis* rhizomes were thinner and lighter than most *Agropyron* rhizomes and to reduce this disparity relatively thin *Agropyron* rhizomes were selected. Twelve 3 in. pieces were planted in each box. The experiment began on 24/8/67 and shoots of both species had emerged on 4/9/67. Thereafter, defoliation was carried out every 14 or 28 days. The experiment was concluded on 6/11/67, 74 days from planting, when all plants were harvested. As in Experiment 1 mean air temperatures ranged from about 15°C at planting to about 5°C at the end of the experiment.

RESULTS

Experiment 1. Table 1 gives details of the planting material. The clone 9 rhizomes were heavier and contained more carbohydrate than the other material.

Table 1.

Rhizome characters of three *Agropyron* clones

	Clone 9	Clone 25	Clone 31
Dry wt. per 36 in. (g)	2.76	1.13	1.76
% hydrolysable carbohydrate	54.6	44.5	57.3
Wt. of carbohydrate per 36 in. (g)	1.51	0.50	1.01
Axillary buds per 36 in.	34.2	37.5	42.1

Shoot removal reduced the proportion of active buds, particularly in the case of Clone 31 (Table 2).

Table 2

% of nodes with a shoot over ¼ in. long (90 days)

Frequency of defoliation	Clone 9	Clone 25	Clone 31	Mean
14 day	48.1	35.1	29.9	37.7
28 "	49.7	37.7	31.0	39.5
No defoliation	57.9	55.3	53.7	55.6
		S.E.± 0.78		S.E.± 0.45
Mean	51.9	42.7	38.2	
		S.E.± 0.45		

Table 3

Total weight of shoots produced during experiment (g.)

Frequency of defoliation	Clone 9	Clone 25	Clone 31	Mean
14 day	1.10	0.53	0.69	0.77
28 "	2.16	1.13	1.47	1.59
No defoliation	2.94	2.06	2.00	2.33
		S.E.± 0.117		S.E.±0.068
Mean	2.06	1.24	1.39	
		S.E.± 0.068		

With all defoliation treatments Clone 9 produced a greater total weight of shoots than the other clones (Table 3). This was partly a result of its greater bud activity (Table 2) but was mainly due to the production of more tillers and larger heavier leaves. When shoots were not removed added nitrogen increased the weight of aerial growth by about 25%. This effect of nitrogen was smaller than in a previous experiment (Turner, 1966).

Fig. 1 shows the effect of the defoliation treatments on the weight of hydrolysable carbohydrate in the rhizomes. Added nitrogen had only a small and non significant effect on carbohydrate accumulation and loss. In all cases defoliation at 14 day intervals prevented new rhizome growth and reduced the weight of hydrolysable carbohydrate in the planting material. However, in Clone 31 this effect was relatively small; at 36 days the rhizomes had lost 40% of the initial quantity. In Clones 9 and 25 the respective losses were 53% and 70% of the original weights. At subsequent harvests the relative positions of the three clones were similar. Shoot removal every 28 days prevented new rhizome growth but the carbohydrate content of the planted rhizomes was not reduced, except in Clone 9. When shoots were not removed Clone 9 made little new rhizome growth and at 90 days had increased its reserves by only 0.40 g. of hydrolysable carbohydrate, 26% of the original weight. In clones 25 and 31 reserves increased by 0.87 g. and 1.04 g., 174% and 103% of the initial weights.

In all clones some new rhizomes originated directly from a bud on the parent rhizome. This growth habit was not observed in previous experiments (Turner, 1966; 1968) but has recently been reported by Hakansson (1967).

<u>Experiment 2</u>. Details of the planting material are shown in Table 4. The *Agrostis* rhizomes carried more buds than *Agropyron* clone 31, and were lighter and contained less carbohydrate reserve.

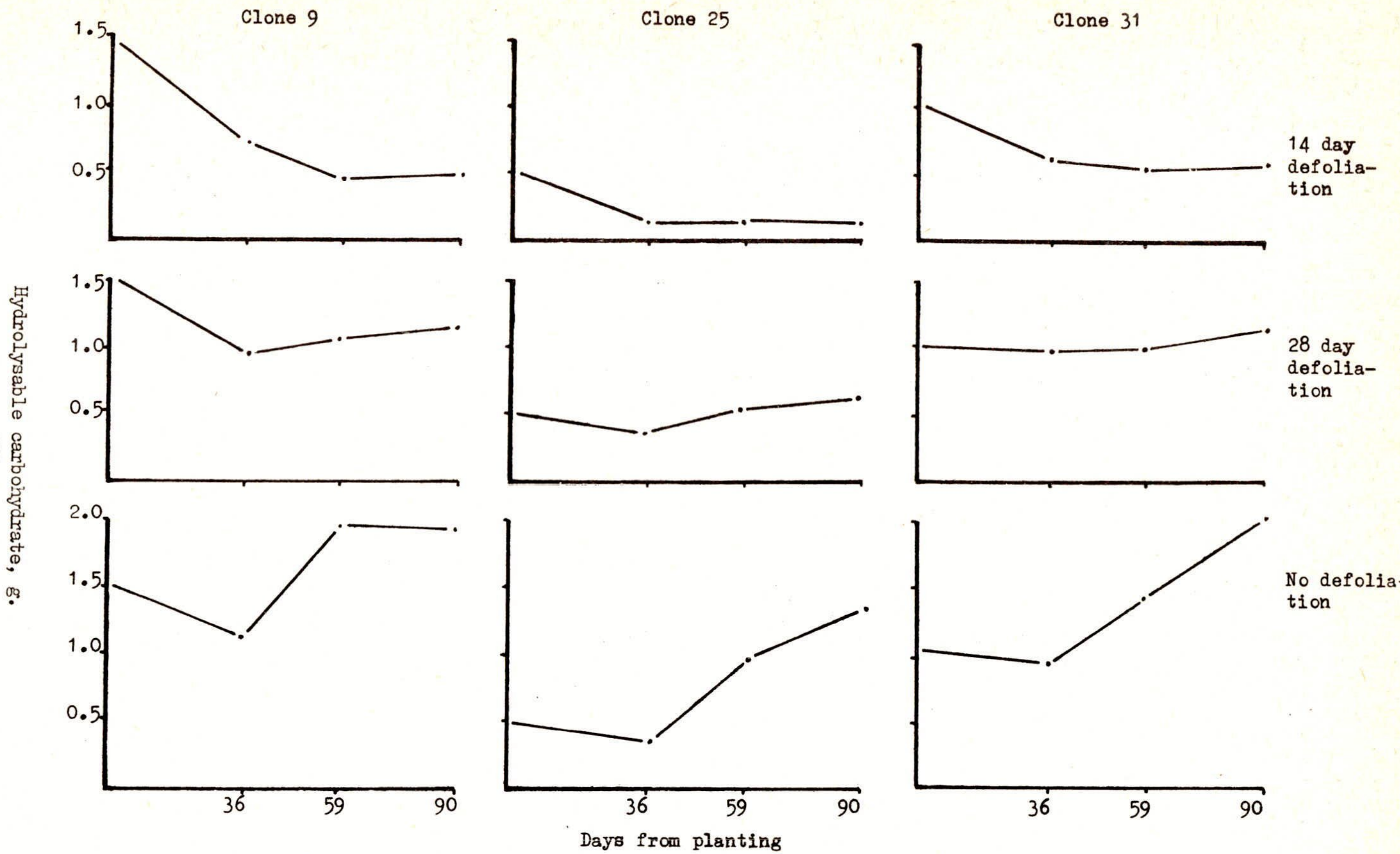

Figure I Effect of defoliation on rhizome carbohydrate reserves of three _Agropyron_ clones

Table 4

Rhizome characters of an Agropyron and Agrostis clone

	Agropyron	Agrostis
Dry wt. per 36 in. (g)	1.08	0.72
% hydrolysable carbohydrate	51.5	43.0
Wt. of carbohydrate per 36 in. (g)	0.56	0.31
Axillary buds per 36 in.	32.4	67.3

The bud activity of both species was reduced by defoliation, the reduction being greater in *Agrostis* (Table 5). In all cases a larger proportion of *Agrostis* buds remained dormant but as the rhizomes of this species carried more buds per inch there were more primary shoots than in *Agropyron*. In both species most shoots reached the surface, but there was more extensive tillering in *Agrostis*.

Table 5

% of nodes with a shoot over ¼ in. long (74 days)

Frequency of defoliation	Agropyron	Agrostis	Mean
14 day	58.1	32.3	45.2
28 "	64.1	54.6	59.4
No defoliation	75.7	58.0	66.9
	S.E.±2.62		S.E.±1.85
Mean	66.0	48.3	
	S.E. 1.51		

Table 6

Weight of shoots, including tillers (74 days)

Frequency of defioliation	Agropyron	Agrostis	Mean
14 day	0.21	0.18	0.19
28 "	1.08	1.62	1.35
No defoliation	3.81	7.79	5.80
	S.E.±0.275		S.E.±0.195
Mean	1.70	3.20	
	S.E.±0.159		

Table 6 shows the total weight of shoots which were present at the end of the experiment. In the absence of defoliation, or when shoots were removed every 28 days *Agrostis* carried much more aerial growth. With 14-day defoliation both species carried about the same weight of shoots. Added nitrogen had little effect on bud activity but increased shoot weights in both species when aerial growth was not removed. The response was greater in *Agropyron*, where the increase due to 200 lb/ac.N was 74%. In *Agrostis* this treatment increased the weight of shoots by only 12%.

Table 7 shows the weight of hydrolysable carbohydrate in the rhizomes at the end of the experiment, expressed as a percentage of the weights present at planting. Added nitrogen had little effect upon carbohydrate accumulation and loss.

Table 7
Weight of hydrolysable rhizome carbohydrate (74 days)
(Weight at planting = 100)

Frequency of defoliation	Agropyron	Agrostis	Mean
14 day	34	35	35
28 "	121	116	119
No defoliation	179	216	197
	S.E.±7.4		S.E.±5.3
Mean	111	122	
	S.E.±4.4		

In both species shoot removal every 14 days prevented new rhizome growth and reduced the weight of reserves in the planted rhizomes to about one third of the weight present at planting. When shoots were removed every 28 days there was no new rhizome growth but in both species the weight of hydrolysable carbohydrate in the planted rhizomes increased. When shoots were not removed both species gained new carbohydrate. In relation to the weights of hydrolysable carbohydrate present at planting, the rate of accumulation was greatest in *Agrostis*. In both species some new rhizome growth came directly from a node on the parent rhizome.

DISCUSSION

In general, the results of the present studies confirm those of previous experiments (Turner, 1966; 1968). However it has been shown that the response of individual *Agropyron* strains to defoliation may vary. When shoots are not removed there may also be differences in ability of strains to accumulate carbohydrate. *Agrostis* appears to build up reserves more rapidly than *Agropyron*. These results might perhaps have been anticipated since there are obvious differences in growth habit and morphology both within *Agropyron repens* and between this species and *Agrostis gigantea*.

On general principles it might be expected that plants with many vigorous shoots would be more susceptible to defoliation than strains with few or smaller shoots. To some extent the results support this expectation: for example clone 9, which produced a large weight of shoots, lost reserves more quickly than the other clones. Similarly it might be expected that plants with abundant shoot growth would be best able to build up carbohydrate reserves when shoots are not removed. Thus *Agrostis* plants carrying a greater weight and number of shoots than the corresponding *Agropyron* plants, were also more efficient accumulators of carbohydrate. However *Agropyron* clone 9, which produced a large weight of aerial shoots, performed comparatively poorly. It appears that other factors may also influence the rate of carbohydrate accumulation. The experiments do not provide any information about these factors, but it is of interest that clone 31, which was able to accumulate carbohydrate rapidly, was originally collected near Oxford and is therefore perhaps better adapted to local conditions than the other material in the experiment.

Acknowledgement

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THE GROWTH OF *Agropyron repens* (L.) BEAUV. AND ITS RESPONSE TO DISTURBANCE PRODUCED BY CULTURAL AND CHEMICAL METHODS OF CONTROL

A Review of Recent Research in Sweden

by

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Summary A series of field experiments which were carried out in central Sweden with transplanted *Agropyron repens* are reviewed. The capacity of the plant to regenerate after burial was shown to decrease with advancement of the growth stage at burial until the aerial shoots had 3 to 4 leaves and usually a length of 12-15 cm. Burial repeated throughout the growing season as soon as new aerial shoots had reached that stage was as effective, or nearly as effective, in controlling the weed as were burials repeated when the shoots were 5 cm. When rhizomes, cut into pieces of different lengths from 4 to 36 cm, were planted, there were fairly small differences in the production of new rhizomes during the growing season when planting depth was from 2.5 to 7 cm. With an increase in planting depth, shoot emergence and rhizome production then decreased continuously, and decreased more rapidly the shorter the rhizome pieces were, the relationships between production and depth following sigmoid curves. The relative effect of competition from a crop (white mustard) was greater on *A. repens* plants after deeper than after shallower planting of the rhizome pieces, and it also increased with decreasing piece length. TCA produced its best effect in the very early stages of the shoot and co-existing root development. In regions with a cold winter it can therefore be used for its effect when growth starts in the spring. It may be used in other seasons in combination with soil cultivation and probably also in combination with other methods of destroying the foliage.

INTRODUCTION

Agropyron repens, couch, is a troublesome weed of arable land throughout large areas of the temperate regions, and its biology and general behaviour has therefore been studied by many weed biologists (see Palmer & Sagar, 1963, and literature referred to by these authors). In the Scandinavian countries *A. repens* is surely, on an average, the most important weed, and its behaviour and control in these areas has been studied and discussed by many authors (e.g. Bylterud, 1958, 1965; Granström, 1960).

In a series of experiments with transplanted material originally collected near Uppsala in central Sweden the author has studied the development and growth and the response to various treatments. In this paper some of the experimental results are summarized, and possible control measures are discussed on the basis of that material. When not stated otherwise, the experiments were carried out in a sandy field at Ultuna, near Uppsala.

The results summarized in section 1 have been published in more detail by Håkansson (1967) and those summarized in section 3 by Håkansson (1968a, 1968b). The details of the results discussed in sections 3 and 4 will appear in two papers under publication.

1. UNDISTURBED GROWTH AND THE RESPONSE TO BURIAL IN DIFFERENT SEASONS OR DEVELOPMENTAL STAGES

Under the climatic conditions usually prevailing in central Sweden, very few aerial shoots of A. repens survive the winter. In a series of experiments it was shown that the first spring development was associated with a decrease in the dry weight of the plant, leading to a minimum weight when the primary aerial shoots had 2 leaves on an average and a mean length of 8-10 cm. Tillers and new rhizomes began to develop soon after this minimum had been passed.

A similar course of development was also found to occur after planting of rhizome pieces of different ages later in the growing season, in May, June and July.

The conclusion from these experiments is that soil tillage causing burial of the aerial shoots is followed by a development, the early stages of which always follow the same pattern. When soil tillage is carried out late in the growing season, the pattern is disturbed by the winter, but there is a comparable development starting again in the spring.

Irrespective of the season when the aerial shoots started to develop from underground buds; the capacity for regeneration after burial decreased continuously at least until the dry weight minimum had been passed. A minimum regenerative capacity was usually found at the stage when new rhizome branches just began to develop. At that time the primary aerial shoots had 3-4 leaves and a length usually of 12-15 cm.

2. THE EFFECT OF BURIAL DEPTH, RHIZOME BREAKING AND COMPETITION FROM A CROP

When rhizome pieces were planted on the soil surface, there was a high mortality and a rather low and very erratic production of aerial and underground shoots due to drought and/or unfavourable temperature. The greatest rate of emergence and the highest production occurred at a depth of 2.5-5 cm. Below this depth region, the emergence rate and the production decreased with an increasing depth. The relationship between depth and emergence, or depth and production, followed sigmoid curves. These show a more rapid and unfavourable effect of the depth increase, the shorter the planted rhizome pieces were. Thus, when for instance 8 cm long pieces were planted, shoots rarely emerged from depths exceeding 10-15 cm. When 32 cm pieces were planted, shoots usually emerged to a certain extent even from a depth of 30 cm, though the emergence rate decreased rapidly with the depth from about 15 cm. The shoot emergence was delayed in time with increasing depth.

For a given total length (or weight) of planted rhizome pieces per unit area and for shallow planting (depths from 2.5 to 7 cm); differences in the length of the individual planted pieces (degree of breaking) from 4 to 36 cm resulted in fairly small differences in weight production of underground shoots within a growing season. There were often much greater differences in the number of primary aerial shoots. After a deeper planting (10 or 15 cm) the weight production of underground shoots was not only lower than after a more shallow planting, but it was also heavily reduced with a decreased length of the individual rhizome pieces planted.

This is demonstrated in Table 1, which shows the production in an experiment where rhizome pieces of different lengths had been planted at two depths (5 and 10 cm). The growth and production was studied both for pure stands of A. repens and for stands in competition with a crop (white mustard). The percentage values in Table 2 show the influence of the crop on the production of underground couch shoots. Thus, the competitive effect of the crop increased both with increasing degree of breaking and increasing depth. Among the reasons for this must be the fact that the primary aerial shoots were weaker with a decreasing piece length and that the emergence was delayed with an increase in the planting depth.

Table 1.

Weight of young underground shoots in the autumn of 1963 after planting of pieces of 1962 rhizomes in mid May 1963

Stand character and planting depth		Ratio of dry weight of young underground shoots to planted rhizome pieces of the following lengths		
		4+6 cm	9+12 cm	18+36 cm
Pure stand	5 cm	11.4	11.6	12.5
	10 cm	3.8	5.8	6.5
In white mustard	5 cm	2.53	3.20	3.63
	10 cm	0.46	0.98	1.48

Table 2.

Dry weight of young underground shoots of couch in white mustard as a percentage of the corresponding pure-stand weight

Planting depth	Percentage values for the following lengths of the planted rhizome pieces		
	4+6 cm	9+12 cm	18+36 cm
5 cm	22	28	29
10 cm	12	17	23

3. EFFECT OF REPEATED BURIALS

In an experiment involving repeated burial at a depth of 7.5 cm during a period of eight weeks starting on different dates, burial intervals of 1, 2 and 4 weeks (9, 5 and 3 burials respectively) were compared. When the burial periods started in the spring or early summer, the rhizomes often died before the end of the experiment, and no distinct differences in the effect could be noted for the different intervals. When the periods of burial started later in the summer, there was a markedly lesser effect with intervals of 4 weeks than with intervals of 1 or 2 weeks, which gave nearly equal effects. Thus, under conditions comparable with those in the experiment, an interval of somewhere between 2 and 4 weeks might give nearly as good an effect as an interval of only 1 week.

In two experiments the burials were repeated when aerial shoots of an approximate average length of 5, 10, 15, 20 and 30 cm were visible. Burials were carried out from late spring throughout the growing season, as long as regrowth of shoots reaching the stipulated lengths occurred. The reburials were carried out with as little fragmenting of the plants as possible. Different burial depths for different lengths of the originally planted rhizome pieces were compared.

In one experiment (in 1962) the depths were 2.5, 5 and 10 cm and the lengths of the rhizome pieces were 8 and 32 cm, in the other one (in 1964) the depths were 3 and 7 cm and the piece lengths 10 and 30 cm. The effects were finally determined by weighing underground and aerial shoots with intact structures in the spring following the burials.

In both experiments and in all combinations of burial depths and rhizome piece lengths there were as good, or nearly as good, effects of burials repeated when the aerial shoots were 15 cm as when they were 5 cm, but then the effect decreased rapidly with an increasing delay in reburial. This could be expected as a logical consequence of the results presented in section 1. Thus, when the intention is to reach a certain effect by the smallest number of burials, these should not be repeated until the aerial shoots have an average length of 12-15 cm. However, the effect can be reached within a somewhat shorter time with shorter intervals between burials. Thus, in the 1964 experiment, complete kill was obtained in most cases when the operations were repeated at shoot lengths of 5, 10 and 15 cm, and it was reached about one month earlier on average when repeated at 5 cm shoot lengths than it was when repeated at lengths of 15 cm.

The burial depth and the length of the original rhizome pieces influenced the length of the intervals between burials carried out at a certain aerial shoot length. Thus, the number of burials required within a certain time decreased with an increased burial depth and a decreased piece length.

4. EFFECT OF TCA APPLIED AT DIFFERENT STAGES OF DEVELOPMENT

TCA applied to the soil was most effective after application in the first stages of shoot and root growth from the nodes of the underground stems. Then its effect decreased rapidly with advancing development of the weed. This was shown both in pot experiments in the laboratory and in field experiments. In the field TCA had a good effect when applied in the spring at the time when new aerial shoots started to develop from underground buds.

The results explain those obtained by Bylterud (1958) in his early work on TCA in Scandinavia. The use of TCA for the control of A. repens in Scandinavia has mainly been based on its good effect in the spring (Granström, 1960). In the field experiments mentioned above even TCA applied later in the growing season had good effects in combination with burial, when new aerial shoots had to develop from the bud stage.

DISCUSSION

From the results presented in the sections above, the following view-points may be given on the control of couch in arable land:

Soil cultivation. - When only a short period of time is available for soil cultivation, a combination of operations is desirable which breaks the under-ground system into as short pieces as possible and then buries them at as great depths as the situation permits. If deep ploughing is not possible, even a moderate depth of burial will give a good result after intense breaking of the rhizomes.

An interval of time between the breaking operation and the burial by deeper tillage, which would result in a decrease in the amount of reserve food before the deeper burial, is desirable if sufficient time is available. According to the evidence in section 3, the suitable interval length varies, but 15-20 days would be an average time for the warmer periods of the growing season in southern and central Sweden, and 20-30 days would be appropriate for the colder periods of that season. These intervals will be suitable also when soil cultivations are repeated during longer periods. The period from the harvest of a crop to the sowing or planting of a following spring crop could be regarded as one control period interrupted by the winter.

Crop competition should be utilized as much as possible in order to depress growth from stems which have not been killed by the previous cultivation. The weaker the aerial shoots of the weed are at emergence and the later they emerge compared with the crop, the greater is the competitive effect of this. With an intention of killing as much as possible of the vegetative system of *A. repens* by soil cultivation and then of utilizing the competition from the following crop as much as possible, combinations of cultivation methods suitable for different situations (time available for soil operations, soil type, existing implements etc.) may be worked out on the basis of this knowledge. The sowing or planting of the crop should always follow immediately after the last operation that destroys the couch foliage.

When the crop situation permits application of TCA, this herbicide may be applied at any time of the year in combination with cultivation followed by planting of a resistant crop or followed by repeated cultivations. It might also be applied in combination with other methods of destroying the foliage. In many cases TCA may be used in the stubble fields in combination with cultivation. It seems worth studying whether breakdown and/or leaching is not, under certain conditions, rapid enough to allow the use of moderate amounts of TCA in the Swedish stubble fields, even when cereals are to be sown in the following spring. Alternatively, a herbicide applied to the foliage, such as amitrole the residue of which is broken down rather rapidly in the soil, may be used in areas where the growing season is not too short. Such an application is probably best after a previous soil cultivation leading to regrowth. Cultivations connected with TCA application or previous to amitrole spray will be better, the more they break the underground system because of the increase in the number of buds activated with increased breakage.

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CHEMICAL CONTROL OF PERENNIAL GRASS WEEDS IN CEREAL STUBBLES

N.A.A.S. (SOUTH WEST REGION) EXPERIMENTS 1966-68

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Summary

A series of trials testing Paraquat at different dose rates, Dalapon and Aminotriazole is reported.

Accepted recommendations for the use of Dalapon and Aminotriazole for the control of *Agrostis gigantea* have proved unreliable and uneconomic in these trials but encouraging results have been obtained with Dalapon (2.25 lb. a.i./ac) applied in September followed by Paraquat (0.5 lb. a.i./ac) applied in October.

Recent work has shown that repeated low doses of Paraquat (1 oz. a.i./ac + wetter) are capable of giving good control of *Agrostis gigantea* and are economic.

INTRODUCTION AND METHOD

The investigations reported at the 8th British Weed Control Conference have continued with some modification (Banks 1966).

The original trials compared Paraquat at doses of $\frac{3}{4}$ and 1 lb. a.i./ac with the normally recommended doses of Dalapon and Aminotriazole.

In 1966 a further treatment was added; it involved a low dose of Dalapon (2.25 lb. a.i./ac) applied in September followed by Paraquat (0.5 lb. a.i./ac) in October. This treatment gave encouraging results and in 1967 a series of trials commenced to test the effect of repeated low doses of Dalapon (2.25 lb. a.i./ac), Aminotriazole (1 lb. a.i./ac) and Paraquat (1 oz. a.i./ac).

The Dalapon and Aminotriazole treatments were to be applied in early September and early October and the Paraquat treatment from as soon as possible after harvest until the end of October, repeated at 2-3 weekly intervals.

At some centres a comparison was made between the low dose of Paraquat applied directly to the stubble with a low dose application to regrowth on previously cultivated ground. An individual plot size of $^1/20$th acre was used and all treatments were replicated three times. The sites were permanently marked so that plots could be retreated over a 3 year period.

The creeping grass weeds present were identified at the commencement of each trial and the percentage ground cover assessed. *Agrostis gigantea* was the main species at all sites. Crop scorch was recorded ten days after each treatment and an attempt was made to assess the amount of competitive regrowth occurring in late April and May.

Grain yields were obtained by harvesting a combine width down the length of each plot for each treatment and the ground cover of perennial grass weeds was assessed as soon as possible after harvest.

At one centre rhizomes and leaf were collected from sample areas in each treatment. The rhizomes were examined for take-all, *Ophiobolus graminis*, to see if there was any correlation with the take-all assessed in the crop.

RESULTS

1. This work has been mainly carried out on Agrostis gigantea although at some sites this occurred in association with Agropyron repens. The chemical treatments over a three year period have not appreciably altered the relative balance of these species.

2. The officially recommended treatments of Dalapon and Aminotriazole have on the whole given variable results and their use must be considered uneconomic. (See tables 1, 2 and 3a)

TABLE 1. SUMMARY OF RESULTS - 1966 HARVEST

Treatments	Mean yield cwt./ac. (15% moisture)				% Ground cover after harvest (1966)			
	Site No.				Site No.			
	1	2	3	Mean	1	2	3	Mean
Control	Estimated 24	20.6	27.8	24.2	31	75	93	66
Dalapon 10 lb. a.i./ac.	-	20.9	30.4	25.6	-	41	53	47
Aminotriazole 4 lb. a.i./ac.	-	30.5	29.6	30.0	-	35	77	56
Dalapon 2.25 lb. a.i./ac. + Paraquat 0.5 lb. a.i./ac.	-	-	31.0	31.0	-	-	62	62
Paraquat 0.75 lb. a.i./ac.	-	27.8	30.3	29.0	22	65	88	58
Paraquat 1.0 lb. a.i./ac.	-	25.4	-	25.4	21	63	-	42
Mean of all treatments	-	28.6	32.8		21	51	70	
% Change	-	+38	+18	+28	-10	-24	-23	-19
Date sprayed	12 Nov.	4 Oct. and 8 Nov.	1 Oct. and 4-9 Nov.		**Sites:**			
Date ploughed	31 March	25 Nov.	4 Nov.		1. Bridgwater, Somerset			
Crop	S. Barley	S. Barley	S. Barley		2. Pewsey, Wiltshire			
Species	Agropyron repens & Poa pratensis	Agrostis spp. and Agropyron repens	Agrostis gigantea		3. Whiteparish, Wiltshire			

3. The treatment involving 2.25 lb. a.i./ac. Dalapon applied in September followed by 0.5 lb. a.i./ac. Paraquat in October has been as effective as the standard Dalapon and Aminotriazole treatments for half the cost. This treatment is just economic. (See tables 1, 2 and 3a)

4. Repeated doses of 1 oz. a.i./ac. Paraquat (+ wetter) have given encouraging results for a minimum cost.

Cultivation before applying the Paraquat has not resulted in any improvement in grass weed control. (See table 3b)

TABLE 2. SUMMARY OF RESULTS - 1967 HARVEST

Treatment	Mean yield cwt./ac. (15% moisture)					% Ground cover after harvest (1967)				
	Site No.					Site No.				
	1	2	3	4	Mean	1	2	3	4	Mean
Control	33.0	38.4	30.8	24.5	31.7	20	70	86	-	58
Dalapon 10 lb. a.i./ac.	33.7	33.8	35.3	26.8	32.4	17	75	36	-	43
Aminotriazole 4 lb. a.i./ac.	33.6	36.6	35.5	26.9	33.1	20	77	60	-	52
Dalapon 2.25 lb. a.i./ac. + Paraquat 0.5 lb. a.i./ac.	33.6	36.3	34.7	26.6	32.8	15	73	43	-	44
Paraquat 0.75-1.0 lb./ac.	32.6	39.3	33.2	27.4	33.1	15	67	60	-	47
Mean yield of all treatments (or %)	33.4	36.5	34.7	26.9		17	73	49	-	
% Change	+1	-5	+12	+9	+5	-3	+3	-37		-11
Date sprayed	19 Oct. & 1 Nov.	19 Oct. & 1 Nov.	18 Oct. and 1 Nov. (ATA. 4 Oct.)	21 Sept. & 28 Oct.		**Sites:** 1. Enford, Wiltshire				
Date ploughed	End Nov.	19 Dec.	End Oct.	Mid Mar.		2. Broad Hinton, Wilts.				
Crop	S. Barley	S. Wheat	S. Barley	S. Barley		3. Whiteparish, Wilts.				
Species	Agrostis gigantea	Agrostis gigantea	Agrostis gigantea	Agrostis gigantea and Agropyron repens		4. Charfield, Glos.				

TABLE 3(a). SUMMARY OF RESULTS - 1968 HARVEST

Treatment	Mean yield - cwt./ac. (15% moisture)				% Ground cover after harvest (1968)			
	Site No.				Site No.			
	1	2	Mean		1	2		
Control	32.9	36.6	34.7		85	-		
Dalapon 10 lb. a.i./ac.	37.4	37.3	37.3		25	-		
Aminotriazole 4 lb. a.i./ac.	37.4	36.8	37.1		42	-		
Dalapon 2.5 lb. a.i./ac. + Paraquat 0.5 lb. a.i./ac.	36.3	36.9	36.6		35	-		
Paraquat 0.75-1 lb. a.i./ac.	34.1	36.6	35.3		72	-		
Mean yield of all treatments (or %)	36.3	36.9			43			
% Change	+10	+1			-42			
Species	Agrostis gigantea and Agropyron repens	Agrostis gigantea			**Sites:** 1. Whiteparish, Wilts. 2. Chisenbury, Wilts.			

TABLE 3(b). SUMMARY OF RESULTS - 1968 HARVEST

Treatment	Yield - cwt./ac. (15% moisture)		
	Site No.		
	3	4	
Control	10.9	27.2	
Dalapon 2.25 lb. a.i./ac. + Paraquat 0.5 lb. a.i./ac.	-	30.0	
Dalapon 2.25 lb. a.i./ac. + Dalapon 2.25 lb. a.i./ac.	-	30.1	
Aminotriazole 1 lb. a.i./ac. + Aminotriazole 1 lb. a.i./ac.	-	30.6	
Paraquat 1 oz. a.i./ac. repeated at 2-3 week intervals	15.0	29.4	
Paraquat 0.75 lb. a.i./ac. early September	14.6	-	
Paraquat 0.75 lb. a.i./ac. late September	13.8	-	
Cultivate - then Paraquat 1 oz. a.i./ac. every 2 weeks	13.4	-	
Mean yield of all treatments	14.2	30.0	
% Change	+30	+10	
Species	Agrostis gigantea	Agrostis gigantea	

Site 4

Rhizome and green part assessments on 5 x 1 ft. square areas/treatment dug to a depth of 6 inches

	Rhizomes and green parts gms.	Rhizomes only gms.
Control	756	170
Dalapon + Paraquat	68	18
Dalapon + Dalapon	280	70
Aminotriazole + Aminotriazole	270	62
Paraquat repeated	299	76

Sites:

3. Pewsey, Wiltshire

4. Guiting Power, Gloucestershire

5. There was no take-all, Ophiobolus graminis, on the rhizomes of the Agrostis gigantea examined on site 4. Take-all assessments in the crop indicated less of this disease on the control plots than on the treated plots. At another site cultivation prior to the application of the chemical appeared to reduce the take-all level.

The results indicate that accepted recommendations for Aminotriazole and Dalapon are both unreliable and uneconomic for the control of Agrostis gigantea.

Agropyron repens appeared to react to the chemical treatments in the same way as Agrostis gigantea and the treatments did not appreciably alter the relative balance where these species occurred in mixed associations. The results show that cheap chemical control of Agrostis gigantea is possible using repeated small doses of suitable chemicals. Paraquat at 1 oz. a.i./ac. repeated at 2-3 weekly intervals seems the most promising treatment both for efficiency and low cost.

Although it was suggested that dormancy could be induced by these small dose treatments this has not been a problem.

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A TECHNIQUE FOR THE APPLICATION OF TCA IN THE CONTROL OF AGROPYRON REPENS AND AGROSTIS GIGANTEA

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Summary Basically this technique consists of the incorporation of TCA into the soil as a rotavator works to a depth of about 4 in. Essentially, therefore, rotavation and couch control are achieved in a one pass operation by the use of a tractor fitted with saddle tanks and a suitable spray boom to discharge 30 lb TCA in 100 gal water per acre per hour. Results from the late summer, autumn and spring treatments were consistent with a high degree of control. The contributory factor leading to the high degree of control is undoubtedly the placement aspect of the soil-acting chemical at the root zone of the developing rhizome buds.

INTRODUCTION

Agropyron repens and *Agrostis gigantea* known as couch is widespread and is the most pressing weed problem in the United Kingdom. Its success in invading arable fields is due primarily to propagation by seeds and underground rhizome buds. The sub-surface buds are amply protected by the soil against severe weather conditions, mechanical and/or chemical treatments and grazing animals. Erskine (1968), Hughes (1966) and others have pointed out that the selective chemical control of broad-leaved weeds in cereals without similar effects on couch has reduced the interweed competition. In the west of Scotland Waterston, Craig and Joice (1964) concluded from their experiences with the available chemicals for couch control that none of them performed satisfactorily enough to warrant field use. Similar results were obtained by the Edinburgh School of Agriculture (1967).

Unlike post-harvest weather conditions in the south where two and sometimes three series of chemical defoliation can be carried out on regrowth after rhizome fragmentation (Elliott 1968); there is seldom the same condition in the north. The traditional summer fallow with mechanical and/or herbicidal treatment is becoming prohibitive for economic reasons; and without any alternative control measure the couch problem is a grave one.

In view of the alarming situation and the rapid spread of couch without any substantial check, studies were made on different lengths of rhizome to ascertain whether or not length had any effect on the development of bud root growth after disturbance. Fortunately, each bud, regardless of rhizome length produced initial root growth until such time as apical dominance suppressed further growth. This physiological response of the rhizome buds was grasped as a means of controlling the weed. Greenhouse investigations (unpublished) showed that TCA gave complete kill of the rhizome buds when it was thoroughly mixed into the soil and in contact with the rhizome. Further field work led to the construction of a prototype machine to fragment the underground rhizomes and incorporate chemical and vegetation into the soil simultaneously.

METHOD AND MATERIALS

The blade speed of the rotary cultivator was set to give 220 r.p.m. at a tillage

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* Now at the A.R.C. Weed Research Organization.

depth of about 4 in. and, with the back-flap raised, the chemical solution was sprayed into the flying soil thus giving a thorough mix. The simultaneous operation was carried out by a Ford 4000 "select-o-speed" tractor equipped with a sprayer unit and a 70 "Howard selectatilth" rotavator. Two metal 50 gal tanks were mounted on each side of the tractor engine on steel frames; each one being fitted with separate valves to operate independently when small quantities of chemicals are used. The sprayer unit was powered by a one horse-power Villiers petrol engine with a $1\frac{1}{2}$ in. Alcon centrifugal pump combination attached to the front of the tractor. A metal boom with four K80 fan type brass tip nozzles fitted 18 in. apart was situated slightly behind and above the rotary cultivator. Spray pressure and agitation within the tanks were controlled by the return flow valve - the return pipes terminating at the base of each tank to minimise frothing. Spray pressure at 35-38 lb/in^2 gave maximum penetration force without mist, and delivered 100 gal in one hour (including turning time), thus giving a rate of work of 1 ac/hour with a tractor speed of 2.5 m.p.h.

Of these three experiments conducted in the late summer of 1967, I and III were at Langhill (University) Farm and II at Biel Grange Farm in East Lothian. Experiment IV which was carried out in the early spring of 1968 was also at the Langhill Farm. The soil type on both farms was a medium sandy loam. On average the Langhill experimental field had a heavy infestation of about 90% _A. repens_ and 10% _A. gigantea_. The Biel Grange site was a foul patch previously cropped with barley and left to be fallowed, with about 50% of each species - the cleanest area having been sown into turnips. In all the experiments twenty 1 ft^2 quadrats were thrown at random (per plot) and the shoots were counted. The statistical design involved randomised blocks - experiment I was split for date of shoot counts, and III for volumes of water and rolling. The main plots were 12 yd x 4 yd, and sub-plots 12 yd x 2 yd. Late summer treatments were replicated 4 times and the early spring treatment 5 times respectively.

RESULTS

Experiment I The treatment was made on 12.7.67 and assessments were carried out on 16.8.67 and 14.9.67 respectively. There were no pre-treatment cultivations and TCA at rates of 0, 20, 30 and 40 lb in 100 gal water per acre was applied on a mature stand of couch. Height of surface vegetation at the time of treatment was about 2 ft 6 in. and the soil moisture content was 12%.

(See Table I)

The most striking outcome of the treatment was the high degree of control even though there was thick surface vegetation which fouled the rotor blades. The results indicate that increasing the rate of TCA from 20 to 40 lb/ac only slightly further reduced the number of surviving shoots. There were no changes in response from one to the other of the assessment dates, other than could be accounted for by experimental error.

Experiment II The treatment was made on surface vegetation about 2 ft high on 10.8.67 and assessed on 28.9.67. The soil moisture content was 11%. The doses of TCA which were applied in 100 gal water/ac were 0, 20, 25, 30, 35 and 40 lb. The usual spring cultivations were carried out as if for the turnip seedbed.

(See Table II)

The performance of TCA in the control of _A. repens_ was similar to that of experiment I. However it was observed that the majority of shoots surviving in the treated plots were _A. gigantea_.

Table I

The data was transformed to x + 0.5 and actual and transformed values are shown. Transformed data and standard errors in brackets.

<u>Shoot counts on two dates after treatment</u>

means of 20 ft^2 quadrats/plot

Dose lb/ac	Dates		Mean/plot	Degree of reduction (%)
	16.8.67	14.9.67		
Rotary cultivation TCA nil	398.3 (63.11)	426.5 (65.31)	412.30 (64.21)	0
	I(±0.186;	*±0.306)	(±0.131)	
20	12.90 (3.59)	12.84 ([illegible]58)	12.87 (3.58)	96.8
30	9.67 (3.11)	8.98 (2.99)	9.33 (3.05)	97.7
40	7.32 (2.71)	8.32 (2.88)	7.81 (2.79)	98.1
Mean	9.83 (3.136)	9.95 (3.15)	9.90 (3.17	

I S.E. for comparison of rates and same date
* S.E. for all other rate x date comparisons

Table II

The data was transformed to x + 0.5 and detransformed.

<u>The effects of TCA on a mixed mature stand of A. repens and A. gigantea</u>

Mean shoot counts per plot on 28.9.67

Dose lb/ac	Transformed mean/plot	Detransformed mean/plot	Degree of reduction (%)
Rotary cultivation only	75.12	282.20	0
20	21.93	14.05	95.0
25	18.64	7.38	97.3
30	17.37	5.08	98.2
35	19.74	9.48	97.2
40	18.64	7.37	97.3
S.E.	±1.18		

Experiment III The experimental area was rotary cultivated on the 24.7.67 and treatment was made on the 29.8.67 on an even braird of couch when the shoots were about 4 in. high. TCA was applied at the rates of 0, 15, 20, 30 and 40 lb in 100, 150 and 200 gal water/ac. Rolling was carried out with a flat roll on split plots immediately after treatment. Soil moisture content at time of treatment was 4.5%.

Table III

The data was transformed to x + 0.5 and detransformed. Transformed data and S.E. are shown in brackets.

The effects of four rates of TCA with split rolled and unrolled treatments

Mean numbers of shoots per plot on 29.8.67

Rate lb/ac	Rolled	Unrolled	Mean	Degree of reduction (%)
			(S.E. = ±0.162)	
Rotary cultivation only	91.5 (9.54)	114.5 (10.70)	101.75 (10.12)	0
	(S.E. = ±0.066)		(S.E. = ±0.170)	
15	6.10 (2.57)	3.50 (2.00)	4.72 (2.28)	95
20	4.21 (2.17)	3.74 (2.06)	3.96 (2.11)	96
30	1.25 (1.14)	0.46 (0.98)	0.62 (1.06)	99
40	1.52 (1.42)	0.44 (0.97)	0.93 (1.20)	99
Mean	2.82 (1.84)	1.76 (1.50)	2.26 (1.66)	

S.E. of means in body of table
S.E. for comparison at same rate (±0.131)
S.E. for other comparisons (±0.194)

The treatments were applied at 100, 150 or 200 gal/ac. As the statistical analysis showed no significant effect of volume rate, the results have been pooled in Table III.

The results show that the effects due to rates of TCA from 15 to 40 lb/ac and between rolled and unrolled plots were significant. However the lowest dose of TCA resulted in a mean of 95% reduction in shoot numbers and higher doses were as good or better. Although nothing significantly increased survival (as measured by shoot numbers) the differences were in reality very small and all treatments achieved a successful supression.

Experiment IV The treatment was made on 12.2.68 and assessed on the 7.5.68. There were no pre-treatment cultivations. Height of surface vegetation at time of treatment was about 2 ft with soil moisture at field capacity. (See Table IV).

Table VI

The effects of 3 rates of TCA applied in dry weather conditions

Mean numbers of shoots

Chemical	Rate lb/ac	Transformed mean/ft^2	Actual mean/ft^2	Degree of reduction (%)
Rotary cultivation	0	5.417	29.35	0
		SE = $\pm$0.1244		
TCA	15	0.6573	0.43	98.5
"	25	0.4247	0.18	99.4
"	35	0.3850	0.15	99.5
Mean		0.4890	0.24	

The results show that the reduction in shoot numbers given by the 15 lb/ac was almost as good as the 35 lb/ac and would indicate that lower doses may be useful in cases where spring crops are likely to suffer from residues of TCA.

DISCUSSION

The most striking outcome of the technique is the high degree of control of A. repens with doses less than those normally recommended for TCA (Fryer and Evans, 1968). Every dose tried gave better than 90% control as judged by shoot numbers. However, a weakness of the experiments lies in the time interval between treatment and assessment which was rather short. It might be that some of the buds escaped the full effect of the treatment and could emerge later. Nevertheless the results were assessed two and three months respectively after the summer and early spring treatments.

The high degree of control obtained by the lowest dose (15 lb/ac), and the lowest volume rate (100 gal/ac) would suggest than an even lower dose and volume might be effective with consequent economies in cost and effort.

It is relevant to point out that consistent suppression of A. repens was obtained by this technique in all experiments. However, in Experiment 2 it was noted that most of the surviving shoots were A. gigantea - originally a minor constituent of the couch population. The reason for this greater resistance of A. gigantea would seem to lie in its habit of growth, which tends to be rather clumped. During rotary cultivation the clumps are lifted bodily and the rhizomes perhaps did not receive as complete a cover of TCA as those of A. repens.

Although these experiments gave a high degree of control, they were carried out in dry weather conditions. Another experiment not reported, was carried out during a fall of sleet in the early spring; in this experiment there was a poorer control at comparable doses to those achieved in the more favourable weather conditions. The implication of these differences may be that weather at the time of application can affect the outcome.

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COMPARISONS OF SYSTEMS OF CONTROL OF AGROPYRON REPENS IN SPRING BARLEY

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Summary A comparison was made of four systems of control of A. repens based on cultivations and herbicides. Treatments were applied during the immediate post-harvest period between cereal crops on a Gault clay on large non-replicated plots laid down in two successive years on the same field. Two types of herbicide were compared, a mainly desiccant spray (paraquat) and translocated herbicides (based on a dalapon/amitrole mixture) applied direct to the stubble or to regrowth of A. repens produced by cultivations immediately after harvest. Two systems of cultivations were compared, one based on rotary action to fragment the rhizomes of A. repens and the other based on tined cultivations to achieve desiccation of the rhizomes. Responses in crop yield were obtained where treatments were effective in reducing the dry weight of rhizomes of A. repens per unit area measured twelve months after treatment.

INTRODUCTION

Rhizomatous grasses, particularly Agropyron repens and Agrostis gigantea, are important weeds in the mainly grass/cereal rotations of the Southern counties. The problem has been accentuated by an intensification of cereals in the rotation, the introduction of shorter strawed varieties and the removal of Dicotyledonous weeds. Besides direct competition with the cereal crop and difficulty at harvest the perennial grass weeds are associated with the spread of soil borne diseases and the formation of a favourable microclimate for the development of foliar diseases.

The reasons for variability in the efficiency of translocated herbicides has been discussed by Sagar (1961) in terms of the physiological stage of development of the grass weed and in terms of the efficiency of spray application as affected by environmental factors. In spring, the commencement of aerial shoot growth of A. repens is followed by tillering and the formation of new rhizomes. Disturbance of the intact dormant rhizome system in the autumn will initiate this cycle, and the spraying of the regrowth with systemic herbicides should allow maximum translocation following the commencement of new rhizome production when metabolites are largely moving to the rhizomes from the leaves (Sagar, 1961). This hypothesis pre-supposes that disturbance of the rhizomes has been early enough in the autumn for temperature and light to promote growth.

Fragmentation of rhizomes by rotary cultivation results in dormant buds sending out shoots which can be destroyed by a second cultivation (Fail, 1956) or by a desiccant spray, e.g. paraquat. These treatments result in loss of food reserves and regenerating buds. As an alternative the rhizomes of A. repens can be brought to the soil surface free of soil so rendering them susceptible to desiccation by the weather. Traditionally this is achieved by tined cultivators which 'comb' the rhizomes to the surface, desiccation is then dependent on subsequent climatic conditions.

METHOD AND MATERIALS

The first set of treatments were laid down in the stubble left after the harvest of barley in the autumn of 1966 on a level, 8 acre field of Gault clay at Stoke Mandeville, Bucks. The plots were of ½ acre size except where split for the two types of herbicide. These plots were not treated again in 1967 but a similar series was laid down in the rest of the field. Stubble assessments showed that the perennial grasses present consisted almost entirely of *Agropyron repens*.

The treatments that were applied were as follows:-

1. No treatment except mouldboard ploughing.

2. Herbicides applied direct to the stubble, ploughed 3 weeks later.

3. Herbicides applied to the regrowth of *A. repens* produced by rotary cultivation shortly after cereal harvest.

4. Repeated rotary cultivation.

5. Repeated tined cultivation.

Each herbicide plot was split for the application of paraquat at $1\frac{1}{2}$ lb/ac or a mixture of translocated herbicides consisting of 5 lb/ac dalapon with 2 lb/ac amitrole-T. To initiate regrowth for herbicide application the stubble was worked twice with a rotary cultivator to the depth of rhizomes at 4-6 in. The first pass was at a tractor speed of 1 m.p.h. and a rotor speed of 210 r.p.m. in order to achieve maximum chop of the rhizomes as the blades could bite into firm soil. The second pass was made at 2 m.p.h. tractor speed and 180 r.p.m. rotor speed. The same treatments were applied to the rotary cultivation plot with a third pass of the implement after 3-4 weeks when the rhizomes had produced aerial shoots. Length of rhizome after the first pass of the rotovator was 3-4 inches in 1966 and 7-8 inches in 1967 when the soil was less compacted. The second pass went a little deeper than the first but did not appear to chop up the rhizomes further.

The cultivations were started as soon as the straw had been removed. The tined treatment started with two passes of a chisel plough at an angle of 30°. This implement gave very good disturbance of the soil but depth of work was limited to the soil containing rhizomes. Subsequent cultivations were done with spring tine harrows to break down the large clods brought up by the chisel plough, as these clods were protecting the rhizomes they contained.

In 1966 all plots were winter ploughed. After the wet autumn of 1967 only the herbicide treated plots were ploughed, the tined and rotary cultivated plots being too wet to plough after late cultural disturbance. Spring barley, variety Impala, was drilled across all the plots on the 18th March in both 1967 and 1968.

Times of application of treatments in the two years were as follows:

Table 1

<u>Details of Operations</u>

Stubble Treatment	Operations 1966	Operations 1967
1. Nil	Ploughed Dec.	Ploughed Dec.
2. <u>Herbicides to stubble</u>		
Dalapon/amitrole Paraquat	) Sprayed 20.9.66.) Ploughed 12.10.66.	Sprayed 25.9.67. Ploughed 13.10.67.
3. <u>Herbicides to regrowth</u>		
Dalapon/amitrole Paraquat	) Rotovated twice on) 9.9.66.) Sprayed 31.10.66.) Ploughed Dec.	Rotovated twice on 30.8.67. Sprayed 18.10.67. Ploughed Dec.
4. Rotary cultivation	Rotovated twice 9.9.66. Rotovated 15.9.66. Ploughed Dec.	Rotovated twice 30.8.67. Rotovated 28.9.67. Not ploughed (too wet).
5. Tined cultivation	Chisel ploughed twice on 9.9.66. Spring tined on 15.9.66. 20.9.66. 22.9.66. Ploughed Dec.	Chisel ploughed 31.8.67. and 13.9.67. Spring tined on 22.9.67. 20.10.67. Not ploughed (too wet)

To obtain yields of spring barley two sample combine cuts of 10 ft by 200 ft were taken from each plot and weighed separately. An attempt was made to assess the effect of treatment on <u>A. repens</u> by measuring dry weights of rhizome per unit volume of soil before and after treatment 12 months later. This was obtained by digging 6 x 1 ft^2 samples per plot, washing the rhizomes free of soil and removing the aerial shoots. The rhizomes were then oven dried and weighed. The treatment samples represented mainly live material but no attempt was made to isolate dead rhizome sections contained in each sample.

RESULTS

Yield of grain per acre of spring barley in the year following treatment and the dry weight of rhizome per ft^2 after harvest for the two years are given in table 2.

Table 2

Effect of herbicides and cultivations on the rhizome production of A. repens and on the yield of spring barley in the following year

Stubble Treatment	1967 Yield cwt/ac	1967 Rhizome dry weight g/ft^2 (20.9.67)	1968 Yield cwt/ac	1968 Rhizome dry weight g/ft^2 (3.9.68)
1. Nil	21.9	42.3	21.0	67.6
2. Herbicides to stubble				
Dalapon/amitrole	26.6	56.3	28.8	46.0
Paraquat	21.9	57.3	28.4	23.0
3. Herbicides to regrowth				
Dalapon/amitrole	32.1	5.5	31.8	39.5
Paraquat	30.0	9.1	30.8	23.0
4. Rotary Cultivation	32.2	0.8	33.1	21.0
5. Tined Cultivation	31.7	5.1	31.4	5.0

Agropyron repens

With the exception of tine cultivation there was no consistent pattern of reduction in total rhizome production due to treatments applied in both years. In 1966 the application of herbicides to undisturbed stubble produced inferior results compared to the application of the same herbicides to regrowth after rotary cultivation. In 1967 however there were only marginal differences in terms of rhizome reduction between the various herbicide treatments. Repeated rotary cultivation was less effective in 1967 compared to the previous year's performance. The treatment that led most consistently, in the two years, to a low rhizome weight in the subsequent stubble was repeated tined cultivation.

Spring barley

A substantial reduction in total rhizome weight was associated with a marked increase in cereal yield up to a maximum of 12 cwt of grain per acre. In both years application of herbicide to regrowth of A. repens, after earlier rotary cultivation, resulted in higher barley yields than where the same herbicide was applied to the weed remaining in undisturbed stubble. The 1967 harvest data showed a substantial difference in yield in favour of spraying regrowth. There were minor differences in cereal yield following repetitive cultural treatments in both years. These resulted in grain yield increases exceeding 9 cwt per acre and at an average cost of 140 shillings per acre, based on current UK contract prices, give financial margins in excess of 80 shillings per acre. The comparable financial benefits following the use of the herbicide treatments, adopted in this two year project, lie within the range of 45 to 120 shillings per acre.

DISCUSSION

Systems of perennial grass weed control demand an early start with cultivations after harvest to take advantage of suitable weather conditions. Current commercial translocated and desiccatory herbicides are more effective when applied to young aerial shoots of A. repens so a flexible programme of control would best be based on a start with cultivations followed by herbicides applied to regrowth if soil conditions prevent further effective cultivations. In this context it is worth noting that regrowth of A. repens is more vigorous after rotary than tined cultivation but rotovation is not suitable for all soil types and is a slow technique for large acreages.

A trend towards the intensification of cereal production has emphasised the need for stubble treatment to eliminate the hosts for cereal pests and diseases. This demands early disturbance of stubbles by cultural means to incorporate straw residues with soil and thus hasten decomposition. Early disturbance of stubbles also helps to promote rapid germination of shed grain to allow for early kill of volunteer cereal plants. Immediate post-harvest cultural disturbance of rhizomatous grass weeds, which can be disease-hosts (Brooks, 1965) and encouragement for the build up of cereal diseases (Hughes, 1966) is complimentary to the other necessary actions for effective stubble hygiene. Further disturbance of the perennial weed grasses using tined or rotary cultivators or the application of herbicides to the regrowth can attain good weed control and result in economic grain yield increases.

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HERBICIDES FOR THE CONTROL OF AGROPYRON REPENS IN FIELD BEANS

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Summary In two experiments EPTC caused little or no injury to field beans when applied and incorporated before planting. Useful control of *Agropyron repens* was obtained from incorporation of 4 lb/ac of EPTC. Both R 7465 incorporated and TCA applied to the surface before planting severely damaged the crop and reduced freshweight yields taken when the crop was fully podded.

INTRODUCTION

Field beans are often used as a break in a continuous cereal rotation. For this break to be effective it is essential to eliminate as far as possible perennial grass weeds such as *Agropyron repens* which can act as alternative hosts for many cereal diseases.

The two experiments described in this paper were designed to evaluate three candidate herbicide treatments for the selective control of *A. repens* in field beans.

The effectiveness of TCA as a herbicide for the control of perennial grass weeds has been known for many years. Current recommendations for use in field beans suggest that treatments should be applied at least two months before drilling and the land cultivated before and after spraying (Fryer and Evans, 1968). On heavy land in particular this is often impossible. The first of these experiments (1967) was designed to investigate the possibility of reducing this time interval and dispensing with the cultivations. EPTC which has given good control of *Agropyron repens* in potatoes (Bartlett and Marks 1966; Elliott, Cox and Wilson 1966) was also included.

The 1968 experiment was designed primarily as a crop tolerance experiment, and in addition to EPTC included R 7465 (2-(α-naphthoxy)-N,N-dimethylpropionamide) which had shown promise for the control of both *A. repens* and annual weeds in brassica crops (Holroyd 1968).

METHOD AND MATERIALS

1967 Experiment

This experiment was sited in a field with a moderate infestation of *A. repens*. The soil was heavy Oxford clay at a commercial farm near Oxford. A randomised block design was used, with three replicates and a plot size of 12 ft x 40 ft. A commercially available formulation of TCA containing 92% of the sodium salt and a granular formulation of EPTC containing 5% a.i. were used. Rates quoted are lb/ac of sodium salt of TCA and lb a.i./ac EPTC. TCA sprays were applied with an Oxford Precision Sprayer at a volume rate of 40 gal/ac. EPTC was spread by hand after first subdividing the plots to facilitate uniform application.

The field had been ploughed the previous autumn, and was cultivated deeply in the spring when the ground was sufficiently dry leaving a rough tilth at the time of application.

TCA was applied at two rates, 15 and 30 lb/ac each at three dates, 13th March, 23rd March and 3rd April. EPTC 4 lb/ac was applied on 4th April, and incorporated immediately by rotary cultivation to 3-4 in. The beans, variety Minor, were drilled across the plots on 19th April, using a seedrate of 2 cwt/ac and a row spacing of

7 in. At the same time 1 cwt/ac of triple superphosphate was applied. Relatively few broad-leaved weeds emerged and no herbicide for such weeds was used. Counts of beans and A. repens were made using six fixed quadrats per plot, each quadrat was 3 ft x 3 ft and was located at random positions within the plot. Scores for crop damage were made on three occasions during the early life of the crop. In early August when the crop was fully podded, freshweights of the total crop (pods + haulm) were taken by cutting a 3.5 ft swathe with an Allen scythe down the plot centres. In addition plant height and pod numbers per plant were measured on 24 standing plants adjacent to the cut swathe.

Final assessments of the maturity of the remaining crop, and for the presence of A. repens were made on 6th September.

1968 Experiment.

This experiment was on a sandy loam soil at the Weed Research Organization. The design was a randomised block replicated three times. Plot size was 36 ft x 6 ft and the beans, variety Blue Rock were drilled in four rows at 18 in. spacing down each plot on 22nd March. The seed was sown at an approximate spacing of 2 in. in the rows and at a depth of 2 in.

Herbicide treatments were applied on 22nd March from an Oxford Precision Sprayer using Allman 00 jets and a pressure of 30 psi at a volume rate of 21 gal/ac. The pre-drilling treatments with EPTC (72% e.c.) and R 7465 (50% w.p.) were mixed with the soil by a single pass with a rotary cultivator working at a depth of approximately 4 in. within 10-15 min of the herbicide application. Post drilling treatments were applied to the soil surface on 26th March.

There was a slight to moderate infestation of broad-leaved and grass weeds present on the experimental area but as this was intended as a crop tolerance experiment they were more or less eliminated by a treatment with 2 lb paraquat/ac, applied between the rows from a shielded inter-row sprayer on 17th May, when the beans were 6-10 in. high.

Effect on the crop was determined by measuring the total freshweight of the two middle rows from each plot when the beans on the control plots were fully podded, on 29th July.

RESULTS

1967 Experiment

Effects on A. repens.

All the treatments substantially reduced the numbers of shoots of A. repens emerging in the crop. Best results of over 90% reduction were recorded with TCA 30 lb/ac applied at the two later dates. EPTC was slightly less effective.

The reduction in A. repens was still evident in September when all treated plots were seen to contain less A. repens than the unsprayed plots.

Effects on the Crop.

The beans emerged uniformly except for a slight delay visible on plots treated with EPTC. Symptoms of damage began to appear on the TCA plots towards the end of May about three weeks after emergence. Affected plants were stunted, and leaves were inrolled at the margins; where damage was more severe the leaf blades were hinged at the midrib with the upper surfaces adhering and failing to unfold. Damage was more severe on plots treated with the higher rate at each date of application, and symptoms persisted throughout the summer.

Table 1.

Numbers of shoots of A. repens/6 yd^2 and mean scores for crop damage
(Scores on 0-3 basis where 0 = unaffected,
3 = severe distortion and stunting)

		Shootcounts	Crop scores		
		31st May	31st May	8th June	21st June
TCA 15 lb/ac	13th March	28	0.7	1.0	1.0
30 lb/ac	13th March	10	1.7	2.2	2.2
TCA 15 lb/ac	23rd March	7	1.3	1.3	1.3
30 lb/ac	23rd March	3	2.2	2.2	2.5
TCA 15 lb/ac	4th April	10	1.2	1.5	1.7
30 lb/ac	4th April	3	2.2	2.7	3.0
EPTC 4 lb/ac		15	0.8	0.8	0.8
Unsprayed		65	0.2	0.2	0.1
S.E.	±	12.4			

EPTC caused very little injury; plants were slightly stunted and yellow at first but outgrew these symptoms and appeared normal by the time of flowering in July.

All treatments of TCA reduced the total freshweight, the plant height and the number of pods on each plant. Reductions were significant where the higher rate was used at each date of application. With EPTC, crop weight, height and pod numbers were unaffected and approximated those on the unsprayed plots.

Table 2.

Freshweight, Height and Pod Numbers of Beans

		Fresh Wt ($lb/120ft^2$)	Plant Height (in)	No. Pods/Plant
TCA 15 lb/ac	13th March	62	34.0	6.3
30 lb/ac	13th March	57	33.5	4.8
TCA 15 lb/ac	23rd March	53	33.1	6.0
30 lb/ac	23rd March	46	30.7	2.9
TCA 15 lb/ac	4th April	60	35.1	5.6
30 lb/ac	4th April	48	30.8	3.7
EPTC 4 lb/ac		70	37.0	6.6
Unsprayed		71	37.6	6.6
S.E.		± 4.0	± 1.2	± 0.45

TCA also delayed the maturity of the crop; on all the TCA plots, bean plants were green or only partially defoliated in early September while on the EPTC and unsprayed plots defoliation was complete.

1968 Experiment.

The treatments with EPTC (mixed with the soil) and R 7465 (left on the soil surface) had relatively minor visible effects on the initial growth of the beans. The top doses of both herbicides slightly delayed emergence and height growth. The beans on the plots in which R 7465 was mixed with the soil, were very severely affected even by the lowest dose of 1 lb/ac. Germination and emergence was slow and uneven, and on the plots treated with 4 lb/ac the population was very reduced. Those which did emerge remained stunted and slow in growth.

Table 3.

Freshweight (lb) Pods + Haulm/60 ft row of beans
(Means of three replicates)

EPTC	3	lb/ac	incorporated	98.3
	4.5	lb/ac	"	83.7
	6.75	lb/ac	"	88.0
R 7465	1	lb/ac	incorporated	23.3*
	2	lb/ac	"	9.7*
	4	lb/ac	"	0.8*
R 7465	1	lb/ac	applied to surface	100.7
	2	lb/ac	" " "	101.7
	4	lb/ac	" " "	82.7
Unsprayed rotary cultivated				100.0
Unsprayed undisturbed				98.5
			S.E.±	6.2

*These treatments not included in calculation of S.E. to avoid necessity for transformation.

The yields (Table 3) illustrate the very severe effects of these treatments - 1 lb/ac reduced the yield by more than 75%. The top dose of the surface treatment with R 7465 and the two higher doses of EPTC also reduced yields but to a lesser extent.

DISCUSSION

The 1967 experiment showed that although TCA can give good control of A. repens at 15-30 lb/ac, its selectivity in field beans is normally inadequate. If an extended time interval is left between treatment and sowing, the amount of TCA actually present at the time of sowing is reduced, but the size of this reduction is very dependent on soil type and prevailing weather conditions such as rainfall. In this experiment the minimum time interval required to produce a marked reduction in the TCA toxicity to the beans appeared to be 5-6 weeks, and even at this interval damage was considerable. In practice there is a limit to the time for which sowing can be delayed without reducing crop yield and early applications are often impossible on heavier land. For effective and selective use in beans, there should be a toxic amount of TCA in the neighbourhood of the rhizomes when growth commences and a non-toxic amount in the soil when the beans are sown. Unfortunately factors beyond normal control have too great an influence to make this consistently and predictably possible.

Field beans however have a very definite tolerance to EPTC, although on the lighter soil at the Weed Research Organization, when sown immediately after the application and incorporation of 4.5 and 6.75 lb/ac, there was a marked reduction in the ultimate growth of the crop. Good control of A. repens can be obtained by a dose of 4 lb/ac as is shown by the 1967 experiment on the heavier soil but the absence of crop damage was probably due to the 14 day interval between treatment and sowing. The reductions caused by the 4.5 and 6.75 lb/ac at WRO, which were not very severe, may be acceptable if the infestation of A. repens is heavy. Further work is however required to determine whether a higher dose applied 7-14 days before sowing is more effective than a lower dose applied at the time of drilling, and also whether the type of formulation is important.

The high toxicity of the incorporated treatments of R 7465 to the beans showed that it has no inherent selectivity. If left on the soil surface 'depth protection' gave some selectivity but probably at the expense of effectiveness on A. repens as was apparent in an experiment on the control of A. repens in Brassica crops reported elsewhere (Holroyd, 1968).

These experiments suggest therefore that EPTC is more satisfactory than either TCA or R 7465 for the control of A. repens in field beans. Unfortunately it controls only a limited range of broad-leaved weeds. However it may be possible to overcome this limitation by the addition of another herbicide effective on a wider range of broad-leaved weeds. Alternatively numbers of broad-leaved weeds present could be reduced by suitable stubble treatments or use of the appropriate herbicides in the cereal rotation.

Acknowledgements

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AN EXPERIMENT WITH ATRAZINE TO CONTROL AGROPYRON REPENS AND AGROSTIS GIGANTEA IN SWEETCORN

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Summary On a light sandy soil the use of atrazine in sweetcorn for two successive seasons did not provide complete eradication of the rhizomatous grassy *Agropyron repens* and *Agrostis gigantea* even when 4 lb a.i./ac was used in both seasons. A single dose of 2 lb/ac, however, gave excellent control for 12 months and such a treatment is of potential value for bringing these weeds under control in a one-year break crop of maize or sweetcorn. In the experiment reported, this dose would have permitted the safe sowing of a spring cereal the following year, but a small residue was detectable in one of the two years and under other conditions of soil and climate some risk is possible. In a two-year break, the safest and most economical treatments were 2 lb/ac in the first season, followed by 1 lb/ac in the second.

INTRODUCTION

Although maize has so far been of limited importance in British agriculture, it is attracting increasing interest, both as a forage crop for use in intensive beef or milk producing enterprises and as a grain crop to provide a break from small grain cereals on wholly arable farms. In addition a small but expanding acreage of sweetcorn is grown in Southern England for the fresh vegetable market. Whatever the use made of the crop, it offers a valuable opportunity to control and perhaps to eradicate *A. repens* and *A. gigantea*. Experience in the U.S.A. has shown that atrazine can be used at doses up to 4 lb/ac to achieve a very high degree of control of *A. repens* in maize (Buchholtz, 1963).

The aim of the experiment described in this report was to determine, at least for one particular site:

(i) the doses of atrazine required to control or eradicate the grass weeds when applied either in one season or in two successive seasons in a sweetcorn crop;

(ii) the residues of atrazine persisting in the soil at intervals after spraying;

(iii) whether the couchgrasses could be eradicated by a heavy dose of atrazine in conjunction with a single crop of maize or sweetcorn or whether herbicide residues in the soil would necessitate two successive crops.

METHOD AND MATERIALS

The experiment was conducted on a light sandy soil near Frilford Heath, Berkshire. Prior to 1965 the site had become densely infested with both *A. repens* and *A. gigantea*. Over the winter 1964 and spring 1965 it received five rotary

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cultivations and one discing, prior to being sown to sweetcorn (var. Northern Belle) on 25th May. Immediately after sowing, the first spray applications were applied by "Kestrel" knapsack sprayer, with a 6 ft boom and Allman "OO" nozzles. The four "main plot" treatments sprayed in this first season were 0, 1, 2 and 4 lb/ac atrazine, and were replicated in three randomised blocks. The area of each main plot was 12 yd x 8 yd.

No inter-row cultivations were carried out. The crop was harvested commercially and no yields were taken. Several further rotary cultivations were carried out the following winter and spring, before sweetcorn was again sown on 16th May, 1966. The main-plots were then each sub-divided into four sub-plots and treated with atrazine at 0, 1, 2 and 4 lb/ac. Hence there were all combinations of 0, 1, 2 and 4 lb/ac in the two seasons.

The experimental area was ploughed in November, 1966 and left untouched until 18th April, 1967, when the density of the couchgrass infestation was assessed by counting shoots in ten 1 sq ft quadrats per plot. No counts were made in the marginal 1 yd of the plots to avoid carry-over effects from cultivation treatments.

Dates of sampling for atrazine residues are shown in Table 1.

Table 1

Dates and depths of sampling for bio-assay of atrazine residues

Date	Stage of experiment	Depths sampled
25.10.65	Crop removed but soil undisturbed	0-2, 2-4 and 4-6 in.
16. 5.66	At time of second spraying	0-2 in.
24.10.66	Crop removed and soil shallowly rotovated	0-4 in.
18. 4.67	Uncultivated since ploughing	0-4, 4-8 in.

Eight cores of soil were taken from each plot (or sub-plot), using a 2.25 in. diameter "bulb-corer". The cores from each plot were bulked, weighed, partially dried if necessary, passed through a 0.25 in. mesh sieve and thoroughly mixed. A small sub-sample was taken for measurement of moisture content. Untreated soil was taken from control plots for the preparation of standard treatments for the bio-assays and also for dilution of treated soil wherever a dilution series as described by Holly & Roberts (1963), was required.

Initially, the Lemna minor/paraquat assay was used (Parker, 1965) but as this appeared to be giving somewhat anomalous results, a bio-assay using turnip as the test plant was employed on later samplings. For the turnip assay, soil was placed in 2.5 in. diameter plastic pots in the glasshouse and 10 pre-germinated seeds were sown on the surface and covered with a shallow layer of sand. The pots were watered from above as necessary and the fresh weight of above-ground parts was measured about three weeks later.

Basic meteorological data for Abingdon Aerodrome, only one mile away, are given in Table 2.

Table 2

Rainfall and mean monthly temperatures

Month	Rain (in.) 1965	1966	1967	Mean monthly temp (^{o}F) 1965	1966	1967
January	-	1.3	1.5	-	37.2	40.0
February	-	2.6	2.4	-	43.8	42.6
March	-	0.3	1.3	-	43.5	45.3

Table 2 (continued)

Rainfall and mean monthly temperatures

Month	Rain (in.) 1965	1966	1967	Mean monthly temp (^{o}F) 1965	1966	1967
April	-	3.5	1.6	-	46.2	46.5
May	2.3	2.2	-	53.4	52.0	-
June	1.8	2.4	-	58.5	60.3	-
July	2.0	2.8	-	58.0	59.7	-
August	1.9	3.0	-	59.5	59.4	-
September	3.0	1.9	-	54.7	57.2	-
October	0.4	4.7	-	51.8	51.0	-
November	2.1	1.4	-	40.8	41.4	-
December	3.4	2.9	-	40.6	42.5	-

RESULTS

The results of residue assays and of grass counts are given in Table 3.

Table 3

Estimated residues of atrazine, and control of grasses, resulting from atrazine applications in two seasons
All quantities of atrazine are in oz/ac

1965 May application	1965 Oct. residue (0-4 in.)	1966 May residue (0-2 in.)	1966 May application	1966 Oct. residue (0-4 in.)	1967 April residue (0-4 in.)	1967 April couchgrass shoots (%)
0	0	0	+ 0	0	0	100 (22.8/sq ft)
			+ 16	0	0	25
			+ 32	2	0	5
			+ 64	4	2	4
16	-	0.5	+ 0	0	0	56
			+ 16	1.5	0	4
			+ 32	2	0	5
			+ 64	4	2	0.3
32	4	0.75	+ 0	0	0	25
			+ 16	1.5	0	4
			+ 32	3	0	2
			+ 64	4	2	1
64	7 (+ 1.5 oz/ac in 4-6 in. layer)	1	+ 0	0	0	4
			+ 16	1.5	1	1
			+ 32	2.5	1	0.1
			+ 64	4	2	1

\- residue not assessed

Residues of atrazine

The statistical precision of the bio-assay results cannot be stated as methods have not yet been fully worked out for the necessary analysis but it can be said that the recovery of freshly applied atrazine in this and other experiments has usually been within 25% of the theoretical amount, and that agreement in residue estimates from different replicates of this experiment have also been good. At worst an estimated residue of 1 oz/ac in the above table is believed likely to represent a "true" residue within the range 0.5-1.5 oz/ac. The limit of detectability was about 0.5 oz/ac in a 2 in. depth, or 1 oz/ac in a 4 in. depth.

The table shows varying residues from atrazine applied at 1 lb/ac. From the application in 1965, a residue was still detectable 12 months later, in May 1966. From the single application in 1966, however, none was detectable even in the autumn of the same year. Similarly 2 lb/ac was detectable 12 months after the 1965 application but not after that in 1966. These differences might be explained by the much higher rainfall in the summer of 1966 (see Table 2). The highest dose of 4 lb/ac left a distinct residue after 12 months in both years. Only 1 oz/ac was detected in the top 2 in. in May 1966, but there was probably a similar amount in the next 2 in. so making a similar figure to that for April 1967. Deeper samplings in October 1965 and April 1967 showed some residues below 4 in. depth which would add to the figures shown in the table but the concentrations were always lower than those in the surface layers.

Where treatments were repeated, there was no indication of any "enrichment" effect resulting in more rapid loss of the second application. Rather to the contrary, the small traces from the first application of 1 lb/ac, undetectable on their own in October 1966, were sufficient to make the second application detectable at this time, whereas it had "disappeared" from previously untreated plots. Similarly, 2 lb/ac applied in May 1966 was detectable in April 1967 where it had followed previous application of 4 lb/ac, but not where it was applied to fresh plots.

The effect of the residues was not assessed in the field, but when spring barley (var. Impala) was compared with turnip as a test plant, it was found to be visibly affected by a residue of 2 oz/ac in the top 4 in., but not by 1 oz/ac per 4 in.

Control of grasses

No attempt was made to distinguish between the two species for the purpose of the counts, but careful observation revealed no selectivity by atrazine. Both species survived the heaviest applications.

In a check to see whether shoot counts were representative of the total amount of weed present in the soil, live rhizome was separated from a few of the soil samples which had been taken for bio-assay purposes. These showed (a) that the dry weight of rhizome in the untreated plots in April 1967 was approximately 3 tons/ac and (b) that atrazine treatment caused a slightly greater reduction in rhizome dry weight than in shoot numbers. In plots where very few shoots were counted, extra digging revealed no rhizome lying dormant.

Although no detailed counts were made in 1966, observations showed that the effects of atrazine were similar in the two years. At 1 lb/ac, control was slow in the year of treatment and only moderately good after 12 months. There was strong recovery after 2 years. At 2 lb/ac, control was excellent in the first year and in the following season, but effects were wearing off after 2 years. A single application of 4 lb/ac was still giving good control after 2 years.

Repeated applications of 2 + 1 or 1 + 1 lb/ac were still giving good control in the 3rd year. All combinations of 4 lb/ac with 1, 2 or 4 lb/ac in the other year gave excellent (99%) control but failed to provide complete eradication.

DISCUSSION

On this particular site, the residue results suggest that an autumn cereal might safely be sown the same year as a spring application of atrazine at 1 lb/ac, or in the year following a 2 or 4 lb/ac application. A spring cereal might be safe one year after a 1 or 2 lb/ac application, but not until two years after a dose of 4 lb/ac.

On this site, therefore, a single dose of 2 lb/ac could provide the desired combination of good grass control in a single "break" crop of maize or sweet corn. However, rigorous follow-up would be needed to see that the grasses did not recover, whilst in a dry year, or on heavier soil, there might be a risk of damage to the cereal crop.

When a 2-year break is considered, it is seen that 1 lb/ac for 2 years has given excellent control, though the sweetcorn suffered serious competition in the first season. The most economical treatment to give good weed control in the crop and lasting suppression of the grasses was 2 lb/ac atrazine applied in the first year, followed by 1 lb/ac in the second. This combination would provide the optimum results with least risk to spring cereals in the third year.

The heavy 4 lb/ac doses of atrazine were disappointing in not giving complete eradication of grass weeds, even when repeated for 2 years. This was in spite of the rotary cultivations which were also included in the winter of 1965/66. These cultivations however may not have been well-timed. With the aid of more suitable cultivations or spot spraying, eradication of established rhizome infestation might be possible, but even such "eradication" is not the final answer. In April 1967, it was noted that even on the cleanest plots, there were new plants of A. gigantea becoming established from seed. Such re-infestation by the seed of either species is a possibility that would have to be considered for many years.

Although having a visible residual effect on annual weeds 12 months after application, 4 lb/ac in one year would not be quite adequate for annual weed control the following year. However, if these annual weeds could be controlled by some other non-persistent herbicide in the second maize crop then the single 4 lb/ac dose would have the advantage of allowing safe sowing of a winter cereal in the autumn of the second year.

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MALEIC HYDRAZIDE FOR CONTROL OF AGROPYRON REPENS (L.) BEAUV. IN FINLAND

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Summary Twenty-three field experiments were conducted in 1964 - 68 to evaluate the effect of maleic hydrazide against *Agropyron repens* (L.) Beauv. (couch grass) in Finland. Foliar sprays of 10 kg/ha a.i. during late autumn, between September 15 and October 15, gave promising results. The treatment has been used successfully on cereal land after the harvest. The area sprayed with maleic hydrazide in Finland was 1300 ha in 1966 and 6000 ha in 1967.

INTRODUCTION

In Finland, *Agropyron repens* (L.) Beauv. (couch grass) is one of the most common weeds on arable land. Almost 50 % of the fields, or 1.2 million hectares, are infested by this species. In cereal crops the average number of shoots of *A. repens* is 25/m^2, and their dry weight is about 225 kg/ha or 3.5 % of the total vegetation.

Owing to the short growing season in Finland, the period before planting or after the harvest of a cereal crop is not long enough for successful mechanical control of *A. repens*. Summer fallow has been employed with better results, and the annual area for summer fallow is 70,000 hectares.

Of the herbicides, TCA has been used on 3000 hectares annually as a late autumn or early spring treatment. Due to the residual effect of TCA in the soil, cereals and several other crops cannot be grown on the field during the year after treatment. The same applies to dalapon, which has not become established as a couch grass herbicide in Finland. Some amitrole has been used against *A. repens* as a post-harvest treatment. Since 1966, maleic hydrazide (MH) has been approved for the same purpose. The area sprayed with MH was 1300 ha in 1966 and 6000 ha in 1967.

MH is a foliar herbicide with very little residual effect in the soil. It is well translocated but only slightly phytotoxic. Experiments with MH against *A. repens* were initiated by Zukel (1950) and Snyder (1951) in the U.S.A. Further field evaluation of MH in the U.S.A. was conducted by Buchholtz (1953). The foliage of *A. repens* was sprayed in the spring and the field was ploughed about a week after the treatment. Despite promising results, the method did not achieve widespread use.

In Finland, the first preliminary experiments with MH against *A. repens* were conducted by Mukula in 1954. Autumn treatment was found to give a significantly better control than spring or summer treatment. This was confirmed by Danish workers, Anon. (1965).

METHODS AND MATERIALS

The present study of the use of MH against A. repens in Finland was started in 1964-65. The subjects investigated were the dose of herbicide, the date of treatment, and the local experiments in various parts of the country. The monoethanolamine salt of MH (Antergon-20) was used in all experiments. The volume of water was 400 l/ha.

The rate of application and the date of treatment were studied in five trials conducted in an abandoned field completely covered by A. repens sod. The field was not cultivated and no crop was grown during the year after the spraying. The rates of MH were 3.75, 7.5 and 15 kg/ha. The dates of treatment fell between August 13 and November 16, at intervals of 1-2 weeks. The plot size was 20 m^2 and the number of replicates varied from 1 to 4. The effects on the shoots were estimated visually once a month in the autumn and twice a month from May to July. The rating scale was 100 - 0 (100 = untreated, 0 = no green growth).

The local experiments were conducted in 10 localities as a post-harvest spray on cereal land. Ten of the experiments were on sandy soil, five on clay and three on peat soil. The plot size was 60 m^2 and the number of replicates 4. The rate of MH was 10 kg/ha and the date of spraying middle of September. The fields were ploughed a month after the spraying and sown with barley in the following spring. The number of shoots was counted and the fresh weight of the rhizomes assessed at the time of harvesting. The counting of shoots was made on four 0.25-m^2 sampling areas in each plot. The rhizome samples were taken with a 143-cm^2 cylinder spade and replicated 10 times in each plot.

RESULTS

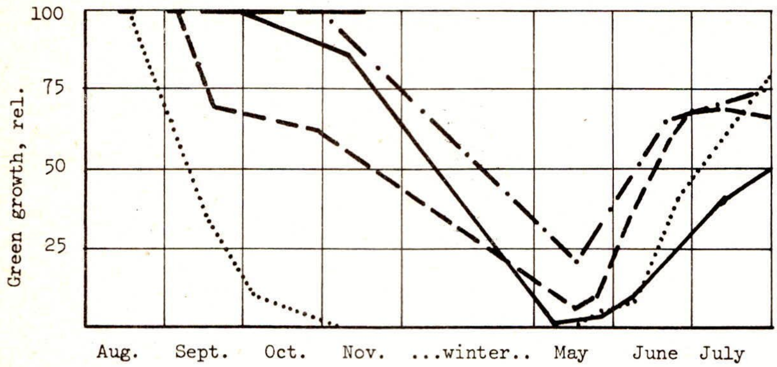
The results of the experiments of the date of treatment are given in Fig. 1. Each curve represents an average from three experiments conducted in three years with two rates, 7.5 and 15 kg/ha. The best control was achieved when the MH was applied between September 15 and October 15. The phytotoxic effect of MH on the foliage of A. repens was not very apparent during the autumn and only slight browning was observed. In the following spring, however, the regrowth from the rhizomes was almost completely checked. The recovery of the stand took place slowly and reached a level corresponding to about 50 % of the untreated by the end of the summer. Earlier treatments showed stronger initial effects in the autumn, but the stand recoveredrapidly during the following summer. The final treatments, after October 15, had only slight phytotoxic effects.

The effects of the various rates of MH are shown in Fig. 2 as averages from two experiments. The higher rates, 7.5 and 15 kg/ha, reduced the amount of green growth to about 28 % and 8 % of the untreated, respectively. The lowest rate, 3.75 kg/ha, gave poor control.

The results of the 18 local experiments are shown in Table 1. The effects of MH on the number of aerial shoots and the weight of the rhizomes, as measured at the end of the following summer, varied greatly. In sites No. 1-3, 5 and 18, where the spraying day was rainy, almost negligible effects were recorded. Significant variation occurred also in other sites, probably due to the differences in the amounts of green growth at the times of spraying. More than 70 % control was obtained in six experiments (Sites No. 4, 8, 9, 12, 16 and 17).

Fig. 1

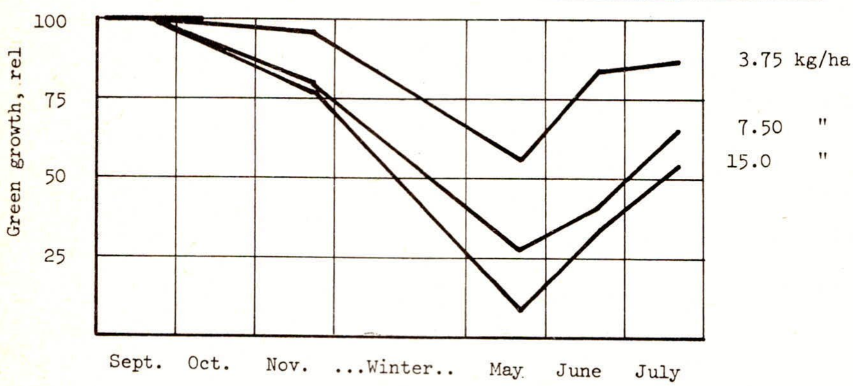
Date of application experiments with MH for the control of A. repens



...... = Sprayed on August 13 - 15
- - - = " September 3 - 7
——— = " September 15 - October 15
-·-·-· = " October 19 - November 16

Fig. 2

Rate of application experiments with MH for the control of A. repens



The grain yield of barley was not significantly affected by the treatments. On clay and peat soils the average yields were much higher than on sandy soil. The improved cereal stands may have further decreased the amount of regrowth after the MH treatment.

Table 1.

Local experiments with 10 kg/ha of MH for control of A. repens in Finland, 1966-68

Site	Agropyron repens shoots no./m² Untreated	MH	Agropyron repens rhizomes g/m² Untreated	MH	Barley grain yield kg/ha Untreated	MH
			Sandy soils			
1	186	156	207	194	1430	1720
2	719	544	603	517	1440	1570
3	715	607	118	91	2040	1780
4	84	21	42	13	2330	2190
5	254	237	119	155	2090	2420
6	190	96	..	..	..	..
7	478	297	..	..	..	..
8	191	49	..	..	..	..
9	138	8	..	..	..	..
10	61	20	..	..	..	..
Average	302	204	218	194	1870	1940
Rel.	100	68 1)	100	89	100	104
			Clay and peat soils			
11	87	30	565	327	3370	3290
12	51	12	10	14	4470	4390
13	80	51	84	58	4700	5000
14	50	16	..	..	..	..
15	234	113	..	..	..	..
16	108	32	..	..	..	..
17	13	3	..	..	..	..
18	31	22	..	..	..	..
Average	82	35	220	133	4170	4230
Rel.	100	43 2)	100	60	100	101

1) F value 27.5 xxx; L.S.D. (P 0.05) 13.9
2) " 12.6 xx " 37.8

DISCUSSION

In the experiments conducted in Finland so far, the effects of MH upon *A. repens* have been variable. Judging by the results, the best control is likely to be obtained if the treatment is conducted a few weeks before the onset of the winter. The great variation in the results calls for further studies in order to find best possible methods of application.

MH, when translocated from the foliage into the rhizomes of *A. repens* is able to cause a prolonged dormancy. Buchholtz (1953) obtained the best control when MH was applied to young shoots 4 - 10 in. high. In post-harvest use of MH on cereal land, better results may be obtained if the regrowth of *A. repens* is stimulated before the MH treatment by means of cultivation of the soil or nitrogen fertilization. The short growing season in Finland affords little opportunity for this, however.

The foliage of *A. repens* should be sprayed in dry conditions. The high precipitation in the autumn does not often permit this in Finland.

An increase of the rate of application from 7.5 to 15 kg/ha improved the effect only slightly. It seems that higher rates than 10 kg/ha, which is the amount used in most experiments in Finland, would not produce significantly better control. The formulation and surfactants of the MH products are aspects that require further study.

The smothering effect of the crop following the MH treatment is probably an important factor in delaying the onset of the regrowth from the rhizomes. No residues of MH have been found in the soil and the chemical can probably be used before the planting of any kind of crop. Furthermore, some promising results were obtained even on humus and peat soils, where TCA is normally inadequate. The present price of MH per hectare is about the same as that of TCA in Finland.

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Proc. 9th Brit. Weed Control Conf. (1968)

THE USE OF EPTC FOR THE CONTROL OF AGROPYRON REPENS AND AGROSTIS GIGANTEA PRIOR TO PLANTING SPRING BARLEY OR SPRING BEANS

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Summary. Results from trials in 1965-1967 indicated that EPTC could be used for the control of couch (Agropyron repens and Agrostis gigantea)prior to drilling spring barley or beans. A trial in 1968 attempted to determine the interval needed between the application of both spray and granule treatments and drilling to allow safe barley growth. Assessments showed that the last drilling of barley, for all treatments except the application of granules at 6lb/ac, recovered from an early check and gave a tiller increase. Levels of couch control from 50-93% were recorded at the first assessment, but later where some EPTC treatments had caused crop suppression the couch regrew to levels higher than the untreated. The control of Avena fatua was at least 86% for all treatments, except cultivations. Farmer trials where spring beans were drilled immediately after an application of EPTC 4lb/ac showed some crop check which was soon out-grown.

INTRODUCTION

With the increase of continuous cereal growing and the decrease in the use of cultivations in break and root crops, the perennial grasses such as couch grass - Agropyron repens and Agrostis gigantea have become a serious problem. It has been estimated that 3,000,000 acres of cereals are infested with couch grass of which 836,000 acres are heavily infested (Anon. 1968). Couch not only competes with cereals and hinders harvesting, but can act as a carrier of cereal diseases such as Ophiobolus graminis (take-all) and Cercosporella herpotrichoides (eyespot). A break crop, such as field beans, might be ineffective for disease control if accompanied by couch.

The control of couch grass after cereal harvest by cultivations is difficult, due usually to inclement autumn weather. The use of foliar herbicides applied to cereal stubbles also has its limitations, but it has been shown that even a partial control of a substantial infestation of couch may result in an increase in yield in the following crop. (Evans 1966)

Following successful trials results (Bartlett and Marks 1966), EPTC was marketed in 1967 for the control of couch in potatoes. In the U.S.A. EPTC is registered for use in several crops including dry and snap beans but is not recommended on blackeye, soy and lima beans or any other flat podded beans except Romano (Anon. 1967).

The high efficiency and relatively short persistence of EPTC, coupled with the fact that barley has demonstrated some tolerance to it, prompted The Murphy Chemical Company Limited to carry out trials for the control of couch prior to drilling spring barley or spring beans. The work reported here concerns an attempt to control or suppress couch in spring barley using EPTC ranging from 2-6lb/ac a.i. and to control couch in spring beans at 4lb/ac a.i.

1965 Trials. Two one-acre areas were sprayed in September 1965 with EPTC at 4lb/ac, incorporation was by rotary cultivation. In March 1966 one area was drilled with spring barley and the other with field beans. No ill effects were noted on either crop and control of A.repens 12 months after treatment was considered to be in excess of 70%.

1966 Trials. In early March 1966 three one-acre sites were treated with EPTC at 4lb/ac by application through band spray nozzles mounted in front of the skim coulters on a two furrow mouldboard plough. The EPTC was ploughed-in to a depth of about 9 inches. Barley was drilled at the three sites on days varying from 1 to 26 and 38 days after application. The barley var. Vada, drilled one day after EPTC application, showed some stunting at emergence but this was soon outgrown and no depression in yield occurred. Barley var. Vada and var. Impala drilled 25 and 38 days respectively after drilling, showed no ill effects. Control of A. repens at all three sites was considered to be sufficiently satisfactory to justify further work.

1967 Trials. In March 1967 three trials were laid down prior to drilling barley to compare different methods of application and formulation of EPTC at 2 and 4lb/ac The methods used were:-

(a) conventional spraying with incorporation by discing or harrowing
(b) injection by A.S.A. Danish injection unit mounted on a two furrow plough
(c) application of 5% a.i. granules using a Horstine Farmery 'air flow' wheel-barrow granule applicator, incorporation by discing.

The results were variable but the general conclusion from these trials was that the herbicidal efficiency of EPTC was increased by competition from a healthy crop. Crop damage occurred when shallow and poor incorporation coincided with a short period between application and drilling. The granule treatments were the most effective against A. repens, but needed the longest time before safe drilling of barley could take place. The A.S.A. Injector plough applications gave streaky control of A. repens which emerged from the furrow bottoms. Better control might have been obtained by cross harrowing after ploughing which would have sealed the furrow against vapour loss of the EPTC.

These results prompted further work in 1968 as described below.

METHOD AND MATERIALS

EPTC: S-ethyl NN dipropylthiolcarbanate (used as Eptam) was applied as an emulsifiable concentrate (e.c.) containing 72% a.i. w/v, and as a 10% granular formulation (g.) based on Fullers Earth SYK 22/44.

EPTC was applied in both formulations to determined the interval required between application and drilling for safe crop emergence. All treatments (except No. 6) were laid out in two randomised blocks.

The following treatments were applied:-

1. EPTC e.c. 2lb/ac a.i.
2. EPTC e.c. 2lb/ac a.i. applied twice with a 5 day interval
3. EPTC e.c. 4lb/ac a.i.
4. EPTC 10% g. 3lb/ac a.i.
5. EPTC 10% g. 6lb/ac a.i.
6. Conventional spring cultivations - rotary cultivated and spring tine harrowed, then cross harrowed 24 hours later.
7. Untreated - incorporation treatments without EPTC.

The trial area was ploughed in the previous autumn, then disc harrowed and spring tine cultivated in the early spring. The soil was heavy, containing over 60% silt and clay and was uniform over the trial area. At the time of application (1.4.68.) the top quarter inch of soil was moist; the underlying three inches was relatively dry. The weather was cold and dry with night frost.

The spray treatments were applied with a 7 ft spray boom mounted on the front of a tractor with a set of discs behind, set to incorporate to a depth of 4 inches at 4 m.p.h. For the granule treatments untreated granules were mixed with 10% granules so that an application rate of 120lb/ac product was made through a corn drill. The partial incorporation by the corn drill was completed by discing soon afterwards. Cross cultivations were then carried out on all plots using Triple K harrows, the ground was then rolled. The plot sizes were 1.85 ac for the spray and 0.9 ac for the granule treatments. The barley, var. Zephyr, was drilled 10, 20 and 24 days after application on sub-plots.

An assessment of barley and couch shoot numbers was made after the last drilling had fully emerged, by taking 10 random quadrats of 200 in^2 from each sub-plot. At the same time visual assessments of vigour were made giving a grading of 1-10 where 1 was the vigour of severely damaged and dying plants and 10 was the vigour of the untreated plants. At time of crop heading a second assessment was made of barley and *Avena fatua* tiller numbers and fresh weight of couch. For this assessment 5 random quadrats of 1 yd^2 were taken from each sub-plot.

Four one-acre farmer applied trials were carried out using EPTC at 4lb/ac prior to drilling field beans. At three sites the EPTC was incorporated into the soil by rotary cultivation to a depth of 4 inches and the beans were drilled within two days. At site 4 application and rotary cultivation took place three days after drilling. Assessments were made by taking 10 random quadrats of 200 in^2 at the 4-6 leaf stage with visual observations at later stages. At site 1. yields were taken from 10 random quadrats of 1 yd^2 from each treatment.

RESULTS

Details are given in Tables 1 and 2 of assessments of crop stand and couch control (*Agroypon repens* and *Agrostis gigantea*). Counts of *A. fatua* were made at the second assessment. Tables 3 and 4 show the effect of treatment and drilling date on crop population, the control of couch and of *A. fatua*. The results from the trials on spring beans are given in Tables 5 and 6.

Table 1.

First assessment of barley and couch on 23.5.68. Numbers of barley plants and couch shoots expressed as a mean % of the untreated population. Mean vigour scores for growth of barley and couch expressed on a scale of 1 - 10

	Barley						Couch					
Days between application and drilling	Plants as % of untreated			Vigour			Shoots as % of untreated			Vigour		
	10	20	24	10	20	24	10	20	24	10	20	24
1) 2 lb spray	94.8	89.5	110.5	9.5	9.2	9.4	50.0	34.4	23.6	10.0	9.0	9.0
2) 2 x 2 lb spray	19.3	76.7	66.6	4.8	6.8	8.2	36.7	14.0	10.9	9.5	10.0	10.0
3) 4 lb spray	33.0	71.9	88.2	6.5	7.3	7.5	17.3	7.3	6.9	8.0	9.0	9.0
4) 3 lb granule	32.0	90.5	86.2	6.1	8.1	8.0	18.8	14.4	7.4	8.0	9.0	9.0
5) 6 lb granule	5.8	38.9	28.0	3.1	5.3	4.2	13.2	9.0	9.0	5.5	7.0	6.5
6) cultivations	-	-	106.0	-	-	10.0	-	-	37.0	-	-	10.0
7) untreated nos. and vigours	1335	1234	1177	10.0	10.0	10.0	324	299	433	10.0	10.0	10.0

Table 2.

Second assessment of barley, couch and Avena fatua on 24.7.68.
Numbers are expressed as a mean % of the untreated population

Days between application and drilling	Barley tillers as % of untreated 10	20	24	Couch wt (gm) as % of untreated 10	20	24	*A. fatua* tillers as % of untreated 10	20	24
1) 2 lb spray	93.4	76.7	100.4	167.3	171.6	109.6	6.1	7.5	13.7
2) 2 x 2 lb spray	25.7	81.6	109.9	114.4	77.3	55.6	2.1	5.7	5.9
3) 4 lb spray	28.8	78.1	119.2	129.8	70.9	51.7	1.1	2.3	5.9
4) 3 lb granule	25.9	105.0	114.3	157.5	49.6	51.7	1.8	0.6	2.0
5) 6 lb granule	1.9	17.8	9.5	44.2	36.9	44.9	0.4	0.0	0.0
6) cultivations	-	-	152.2	-	-	16.9	-	-	31.4
7) untreated nos.	4,085	4,004	3,455	1,474	1,998	2,523	280	174	51

breakdown of the figures for the second drilling at the second assessment from Table 2, can be found in Table 3 and shows that treatment 4, the 3 lb granule application, was the all round treatment.

Table 3.

The effect of treatment, at the second drilling, on barley population, control of couch and control of A. fatua

	Treatment giving:- (a) no effect on barley stand	(b) more than 50% reduction of couch shoot weight	(c) more than 95% reduction of *A.fatua* tiller numbers
1) 2 lb spray	-*	-	-
2) 2 x 2 lb spray	-	-	-
3) 4 lb spray	-	-	+
4) 3 lb granule	+	+	+
5) 6 lb granule	-	+	+

*reduction in barley stand was probably due to the very high couch infestation rather than treatment effect.

Table 4.

First and second assessments % untreated for barley, couch and Avena fatua, mean values from all drillings for each treatment

assessment	Barley first	Barley second	Couch first	Couch second	*A. fatua* second
1) 2 lb spray	98.3	90.2	36.0	149.5	5.8
2) 2 x 2 lb spray	54.2	72.4	20.5	82.4	4.5
3) 4 lb spray	64.4	75.4	10.6	84.1	3.1
4) 3 lb granule	69.6	81.7	13.5	86.3	1.5
5) 6 lb granule	24.2	9.7	10.4	42.0	0.2
7) untreated	100.0	100.0	100.0	100.0	100.0
L.S.D. at 5%	28.5	45.6	10.8	49.2	3.0
1%	40.5		15.3		4.2
0.1%			22.2		6.1

Table 4 shows that to achieve good control of couch with 6lb granule, crop competition was notimportant, but for all other treatments crop competition was important.

Table 5.

First and second assessments % untreated for barley, couch and A. fatua, mean values, from all treatments for each drilling

assessment		Barley first	Barley second	Couch first	Couch second	A. fatua second
Days between	10	47.5	46.0	39.3	118.9	18.6
application	20	77.9	76.5	29.9	84.4	19.4
and drilling	24	79.9	92.2	26.3	68.9	19.6
L.S.D. at 5%		20.2	32.2	7.6	34.8	N.S.
1%		28.7		10.8		

Table 5 shows the effect of crop competition on couch control; the third drilling which received the least chemical check gave the greatest couch suppression but a contributory effect could have been that the third drilling caused disturbance of the couch after commencement of growth, although this was not observed in the field.

Table 6.

Application details and assessments of crop stand and the % reduction in couch shoots, for grower trials on field beans, two months after application

Trial No.	Location	Date appln.	Date drilling	Field beans Nos. as % untreated	Field beans vigour	Couch (A. repens) % reduction in shoot nos.
1)	Hunts.	5.3.68.	5.3.68.	47.0	6.0	87.9
2)	Hunts.	7.3.68.	8.3.68.	118.1	8.6	80.0
3)	Essex	25.4.68.	20.4.68.	104.5	7.0	No A.repens

Table 7.

Breakdown of yield results from site No.1 weights in lb/yd^2

	Total plant wt.	Pod wt.	Stem wt.	Stem No./yd^2	Pod wt./stem
Untreated	4.72	2.13	2.59	20.4	0.104
EPTC wt. as % untreated	100	109.7	110.4	126.5	86.8

At trial 1, the beans were retarded and had signs of EPTC damage such as leaf sticking and a dark shiny appearance. This might be attributable to the rotary cultivation causing loss of seed bed moisture, followed by a prolonged dry period (0.54 in. of rain over 6 weeks) which slowed germination and increased the time of exposure of the bean shoot to the EPTC treated soil. The yield results (Table 7) showed that whilst the reduction in competition increased tillering and allowed increased yield, the actual yield per stem was decreased, perhaps due to delayed flowering or to the presence of a greater number of bean stems per acre.

At trial 2 there was a 73.1% reduction in tillers of A. fatua while at trial 3 there was no A. repens but there was a 90.0% reduction in shoot numbers of Equisetum sp. The farmer at site 3 also made a commercial application of EPTC on 80 acres of spring beans, unfortunately leaving no related untreated areas. The EPTC appeared to retard these crops at first but they later recovered to give a late but flourishing crop.

In addition to the bean trials listed above, a grower trial was conducted in Oxfordshire where drilling was within 24 hours of incprporation. The soil treated was a shallow limestone brash which made incorporation difficult, also the trial area covered the only infestation of Agrostis tenuis in the field. Observations made at this site indicated that high levels of A. tenuis and Polygonum aviculare control were achieved, and although crop height was reduced by 20% no reduction in yield was recorded.

DISCUSSION

The control of couch achieved in the barley trial was unfortunately rather less than usually achieved with EPTC, probably due to insufficient incorporation in the heavy clay soil. The machinery used was that available on the farm, a typical cereal farm in North-East Hertfordshire. Rotary cultivation or cross-discing would possibly have achieved better incorporation than the discing and cross harrowing that was used.

In this experiment drilling date had no effect on the control of A. fatua, and all treatments gave highly effective control, the granule treatments being the best. A further drilling, for instance 30 days after application, would almost certainly not have given any crop check, except possibly by the 6 lb/ac granule treatment.

The latest date for drilling spring barley is probably mid-April; treatment with EPTC would therefore have to be carried out by mid-March to leave 30 days before drilling. No information is at present available regarding the success of applications before mid-March in a cold spring.

It was noticed in an area where there had previously been a fire, that the barley grew sufficiently well to totally overcome any effect of EPTC treatment. An analysis of the burnt area showed high potash and phosphate levels, additions of which could assist crop recovery after a check by EPTC in the future.

Successful crops of spring beans were grown where drilling immediately followed an application of EPTC 4lb/ac but it is considered that less crop check would have resulted if sowing had been delayed for two or more weeks.

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A SYSTEM FOR CONTROLLING PERENNIAL GRASS WEEDS ON A LARGE CEREAL FARM SITUATED ON A CHALK SOIL

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Summary A system is described by which Agropyron repens and Agrostis Gigantea are suppressed within the continuous growing of spring cereals on a large farm. The system employed avoids the use of the mouldboard plough and involves the use of a variety of tined implements in conjunction with Paraquat. Details are given of the approach to cultivation, the ground covered by the various machines and there is a guide to the costs that are involved.

INTRODUCTION

Work that is described has been carried out during the past six years on a 1200 acre farm at Tytherington in West Wiltshire. The soil is lower chalk at altitudes of 300 to 550 ft. The fields on the higher land, which average about 50 acres are of lighter soils with a considerable content of large flints. On the lower land the fields average 20 acres and are composed of a medium to heavy silt loam with fewer flints. The more elevated soils are shallow and there is an area of organic downland. The average annual rainfall is 33 ins. Only about 1000 acres of the farm are considered to be arable and the utilisation in 1968 was 715 acres of cereals, 140 acres of grass seed production and the remainder of the land is in grass. A single suckler herd of 191 cattle is used for beef production and there is a flock of 405 ewes and lambs. The staff consists of a working foreman and five men helped by paid student labour at harvest.

Seven years ago there was an increase of Agropyron repens and Agrostis Gigantea in the cereal crops (mainly spring barley) due to the abandonment of the traditional kale crop in conjunction with a bastard fallow, which had together provided a cleaning break. More than one sixth of the arable acreage had been taken up by this crop and the fallow which were abandoned because they proved uneconomic. A further build up seemed unavoidable under the existing cultural system of winter ploughing and spring cultivation. It was therefore decided to develop a completely new system to combat the weeds.

METHOD AND MATERIALS

The system consists basically of :-

a. immediately after harvest : complete destruction of surface vegetation of all types.

b. early autumn : chisel ploughing at the minimum depth and frequency to provide complete surface disruption of the soil.

c. autumn : surface cultivating to break down the soil and so expose roots and rhizomes to the atmosphere.

d. autumn/winter : spike harrowing to keep the soil moving and kill volunteers, cereals and weeds.

e. spring : a final spike harrowing in front of and behind the combine seed drill.

Experience over the years has provided a fair experience of the ways in which the operations (a - e above) should be carried out. The details of this experience are itemised below.

The destruction of vegetation

The simplest method is to set fire to the straw swathes after the cereal harvest - having created a fire break. This method works admirably when there is a minimum of green growth between the swathes.

When weed growth between the swathes of straw is sufficient to impede burning then the whole area, including the swathes, is sprayed with 0.5 lb/ac paraquat ion with wetter. The green growth is allowed to desiccate, which normally takes about eight days, and the whole area is fired. The removal of the straw by baling makes burning more difficult. Under very dry conditions it may be possible to burn in the absence of straw but often it is not. When it is not possible to burn and there is sufficient green leaf to impede the action of a chisel plough, 0.5 lb/ac paraquat ion with wetter is applied.

When cultivations are likely to be delayed because of demands on labour for other operations or because of inclement weather the stubble is sprayed with 0.5 lb/ac paraquat ion with wetter to stop further development of the rhizomes of the grass weeds. Should a stubble which has been burned without chemical desiccation still contain areas of vegetation these are sprayed and are allowed to desiccate before chisel ploughing.

Chisel Ploughing

The object of the chisel ploughing is to disrupt the whole surface area. The depth of penetration is kept to a maximum of 4 inches on the light soils and 5 to 6 inches for one pass on the heavier soils. Two passes are required on light soils and three on heavier soils.

Subsequent autumn and winter cultivation

A medium sized rigid tined cultivator is used for the first two cultivations after chisel ploughing. These have the effect of shaking the clods so as to free the weed. The final loosening of the weed is produced by a single pass of a spring tined harrow. Spike harrows are used for one or two passes to destroy seedlings as required. Finally, a medium rigid tine harrow is used before the onset of winter to leave the land with a small ridge and furrow appearance.

Spring cultivation

A spring tined harrow is used where the land has become consolidated during winter or a spike harrow is used where this has not occurred. The spring cultivations finish the weedkilling operations. The work is organised so that two men operate the harrows and corn drill in order to sow and harrow in 40 acres per day.

CALCULATIONS OF INPUTS

Calculations of the inputs necessary to achieve the cultivations have been made. They have been based on the use of two tractors; the Massey-Ferguson 178 which has a horsepower of 72 and the M.F.165 which has a horsepower of 60.

Table 1

Ground coverage in acres/hour achieved by cultivation implements.

Description of Implement	Working Width (ft.)	Tractor used	Ground Covered (ac/hr)
Chisel Plough	10	178	5
Chisel Plough	8	165	3½
Medium Cultivator (Twose)	12	178	7
Medium Cultivator (Twose)	12	165	6

Description of Implement	Working Width (ft.)	Tractor used	Ground Covered (ac/hr)
Spring Tined Cultivator (Triple K)	18	178	12
" " " "	18	165	9
Exp.Australian Cultivator	17	178	9
Spike Harrow (Parmitter)	27	178	18
Spike Harrow (Parmitter)	27	165	15

The average implement usage per field in 1968 was :-

Chisel plough	-	2.5	passes
medium rigid cultivator	-	3	passes
spring tined cultivator	-	2	passes
spike harrow	-	2	passes

On the basis of the farm accounts it is possible to give a calculated cost of a tractor plus driver of £1. 1s. 3d per hours work.

Chemical Usage

The use of paraquat over the whole 715 acres of cereals was :-

0.16 lb/ac	in	1966
0.16 lb/ac	in	1967
0.23 lb/ac	in	1968

The greater use in 1968 resulted from the very wet and difficult harvest this year.

DISCUSSION

A new system of cleaning has been developed which makes use of the fact that the perennial weed grasses developed their main rhizome system in the top three or four inches of soil. Rhizome found deeper in the soil has generally been placed there by the inversion of the soil by mouldboard ploughing. The object of the new system is to break the rhizomes, shake them free from the soil and keep them exposed to weather on the soil surface throughout the winter. It is believed to be essential to avoid burying the rhizomes deeper than their natural stratum of growth; and therefore the mouldboard plough cannot be used for primary cultivation.

The total labour demand of this technique may be as low as $1\frac{1}{2}$ hours per acre for all mechanical operations including sprayings that are carried out between crops. This comparatively cheap and highly efficient technique allows spring cereals to be regarded as self cleaning in relation to perennial grass weeds.

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A SURVEY OF WEEDS AND THEIR CONTROL IN CEREAL CROPS IN SOUTH EAST ANGLIA DURING 1967

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Summary During 1967 a survey was carried out on 104 fields upon which cereals were growing in S.E. Anglia. Information has been obtained about the crops and weeds associated with particular soils in the area, the farmers' choice of herbicide for broadleaved weed control, the occurrence of annual and perennial grass weeds in the crop and such measures as the farmers undertook to control these weeds. The information with regard to date of harvest, straw disposal and stubble treatment indicated that many farmers paid little or no attention to their stubbles during September and October except where the field was to be sown to autumn cereals.

INTRODUCTION

Following discussions between the Weed Research Organization and the National Association of Corn and Agricultural Merchants in 1966, it was decided to carry out a pilot survey to establish whether the field staffs of member firms of N.A.C.A.M. could assist W.R.O. in the retrieval of information about weeds on the farms of Britain and the methods being used to control them. The survey was carried out in co-operation with Messrs. Frank Pertwee and Sons Ltd. of Colchester during 1967.

SURVEY METHOD

The Weed Research Organization was responsible for planning, co-ordinating and interpreting the information, while F. Pertwee and Sons Ltd., carried out the field work.

A random selection was made of 80 farms on the firm's customer list with the intention that 60 farms would be surveyed and there would be 20 in reserve. In the event, results were obtained from 52 farms. Two fields were selected on each farm by a method of random selection that allowed for there being different numbers of fields on the farms. The farms were located in Essex, Suffolk, East Hertfordshire, South Norfolk and East Cambridgeshire. The survey was concerned with the period March - December 1967, but emphasis was placed on July - November inclusive.

Each field was visited on three occasions: during April/May, just before cereal harvest and at the end of the year. On each occasion information relevant to the time of year was collected. The interviewers were required to fill in a form for each field that would provide a detailed picture of the field, its past and present cropping and everything of relevance that occurred during the period of the survey. Visits to the fields were in accordance with the Company's standard procedure and involved systematic inspection. To avoid confusion in answering the questions relating to soil type and weed presence, categories of reply were provided. The soil categories were limited to: sand, light loam, heavy loam, clay or peat. The weeds present before harvest were described as: dominant, abundant, frequent, occasional or rare. To avoid wrong identification of certain grass weeds, the interviewers were provided with large photographs showing particular characteristics.

In listing the weeds present it was found necessary to allow the interviewers to use common names; the botanical names in Table 2 indicate the species to which, in the authors' view, the results refer.

Before the start of the survey, the selected farmers were approached by letter and were given an opportunity of refusing to take part: a very few declined and the remainder were most generously co-operative. An assurance was given that although the results as a whole would be published, individual associations with the survey would be regarded as confidential.

RESULTS

104 fields were surveyed on 52 farms. The total area of the surveyed fields covered 1779 acres with an average field size of 17.1 acres. The fields extended over a range of soil types as indicated in Table 1 with a preponderance of fields in the light and heavy loam categories.

Table 1

Acreages of crops grown on different soil types

Soil Category	Wheat Winter	Wheat Spring	Barley Winter	Barley Spring	Oats Winter	Oats Spring	No. of fields	Total acreage	%
Sand	6	0	0	98	0	0	5	104	5.8
Light loam	57	133	135	299	0	0	30	624	35.1
Heavy loam	192	20	35	566	0	25	50	838	47.1
Clay	70	0	7	124	0	12	19	213	12.0
Peat	0	0	0	0	0	0	0	0	0.0
Total acreage	325	153	177	1087	0	37		1779	
Whole crop	478		1264		37				
% of total acreage	26.8		71.1		2.1				

In Table 2 are shown the weeds found in the young crop on different soil types. Whilst 28 species were mentioned by name, only 9 species occurred in more than 10% of the fields viz: Bindweed, Charlock, Chickweed, Cleavers, Knotgrass, Mayweed, Redshank, Thistle and Wild Oat. With these species there did not appear to be a strong association with soil type. Virtually all nine species occurred on all the soils and the numbers of occurrences on each soil were approximately related to the number of fields in that soil category.

Table 2

Weeds present in the young crops

Surveyors Description	Botanical Name	Number of fields in which weeds were recorded				
		Sand (5)	Light loam (30)	Heavy loam (50)	Clay (19)	Totals
Bindweed[1]	Polygonum convolvulus	3	9	9	4	25
Broadleaved[2]		2	3	2	2	9
Buttercup	Ranunculus spp.	-	1	-	1	2
Charlock	Sinapis arvensis	2	12	25	5	44
Chickweed	Stellaria media	1	15	22	5	43
Chrysanthemum	Chrysanthemum segetum	-	1	-	-	1
Cleavers	Galium aparine	1	4	14	5	24
Dock	Rumex spp.	-	1	1	-	2
Fat hen	Chenopodium album	-	1	3	3	7
Fumitory	Fumaria officinalis	-	1	-	-	1
Knotgrass	Polygonum aviculare	3	12	15	8	38
Mayweed	Tripleurospermum maritimum ssp. inodorum or Matricaria spp.	3	17	17	1	38
Orache	Atriplex patula	-	-	1	-	1
Pansy	Viola spp.	1	2	-	-	3
Parsley piert	Aphanes arvensis	-	-	1	-	1
Polygonum	Polygonum spp.	-	3	2	-	5
Poppy	Papaver rhoeas	3	5	-	-	8
Redshank	Polygonum persicaria	3	3	3	5	14
Shepherd's purse	Capsella bursa-pastoris	-	1	1	-	2
Speedwell	Veronica spp.	1	2	2	-	5
Spurrey	Spergula arvensis	1	-	-	-	1
Thistle	Cirsium arvense	2	1	6	2	11
White campion	Silene alba	-	-	1	-	1
Wild carrot	Daucus carota	-	1	-	-	1
Wild oat	Avena fatua	-	3	10	1	14
Wild radish	Raphanus raphanistrum	-	2	2	-	4

[1]Believed to be mainly black bindweed.

[2]Indicates a general presence of broadleaved weeds

Table 3 shows which herbicides were used to control the weeds present in the young crop and further information on this subject is provided in Table 4. Of the total of 104 fields 11 were not sprayed, 44 were sprayed with a single herbicide (not in a mixture), and 49 received more than one herbicide (in mixture). The herbicides most used on their own against broadleaved weeds were MCPA, mecoprop, 2,4-D and dichlorprop. Wild oat control was carried out on 13 fields by means of barban and tri-allate.

An examination of the weeds found in the crop just prior to harvest provided the data for Table 4 and 5 which indicate the presence of the major weeds found at this stage together with their degree of abundance. Although 32 species were mentioned by name, 10 achieved more frequent mention than the others, and only 9 occurred in more than 10 fields. Chief amonst these were the annual and perennial grasses with Agropyron repens the most frequent. Although the surveyors were requested to place

Table 3

Numbers of fields receiving herbicides

	Number of fields where used	
	alone	in mixture
MCPA	24	26
mecoprop	9	15
2,4-D	7	8
dichlorprop	4	6
dicamba	0	15
2,3,6-TBA	0	7
ioxynil	0	3
barban	11*	0
tri-allate	2*	0
no herbicide used	11	

* Usually in association with a broad-leaved weedkiller but not mixed with it.

the weeds found at this stage into one of five categories of abundance; in Table 5 these have been grouped into two categories only. 'Dominant', 'abundant' and 'frequent' have been grouped as 'greater', while occasional, rare and present have been grouped as 'lesser' abundance.

In Table 4 an attempt is made to relate the broadleaved weeds present before spraying to those seen before harvest. This comparison must be treated with caution because there is no guarantee that the weeds seen before harvest were actually present at spraying or vice versa. However, such a comparison might provide an approximate guide to a farmers estimate of the success of a herbicide. The figures in Table 4 indicate a considerable measure of success in terms of weed suppression. Such failure as there might have been appeared to be related to Bindweed, Knotgrass and Mayweed.

A comparison of Tables 2 and 5 shows that, whereas broadleaved weeds were recorded in the young crop, those recorded before harvest were mainly grasses. Couch A. repens was the most commonly recorded species (in 48 fields), while wild oat, meadow grasses, water grass and blackgrass were also very common. The great majority of fields contained grass weeds of some type.

During August and September 1967, the weather provided no serious obstacles to harvesting. The majority of the fields were combine harvested in August and only 1 field had not been harvested by mid-September. As might be expected, harvesting on the heavier soils lagged slightly behind the lighter soils. Straw disposal was spread throughout August and September, the fields on the lighter soils being cleared earlier than those on the heavy soils. The straw had been cleared from 83 of the fields by the end of September.

Of the 103 fields for which information was returned: 55 crops were disposed of by baling, 43 by burning and 5 by chopping.

Following the grain harvest and straw clearance the fields were subject to a variety of activities which can be seen in Table 7. Two fields had been undersown to grass and clover in spring 1967 and received no cultivation after the cereal harvest. Twenty fields were resown to a cereal in autumn 1967 and 82 were not resown,

Table 4

<u>Presence of broadleaved weeds before spraying and before harvest</u>

Principal weeds, grouped according to the herbicide that was applied, indicating their presence before spraying and before harvest. The figure in each case indicates the number of sprayed fields in which the particular weed was present.

Principal weeds present before spraying								Herbicide used	Weeds present before harvest							
Charlock	Chickweed	Cleavers	Bindweed	Knotgrass	Mayweed	Redshank	C. Thistle		Charlock	Chickweed	Cleavers	Bindweed	Knotgrass	Mayweed	Redshank	C. Thistle
19	14	7	5	8	5	1	8	MCPA alone				5	2	2		1
1		1	1	1	2			" + bromoxynil								
					1			" + ioxynil + dichlorprop								
2					1			" + 2,4-D + 2,4-DB								
2	2	1	2	3	2	1		" + dichlorprop						2		
3	5	1	5	5	1	3		" + dicamba				1	1			
	1			2	1			" + fenoprop								
5	10	8	2	5	5	1		Mecoprop alone					1	2		
1			2	1	2	2	1	" + dicamba								
	2			1	2			" + ioxynil								
3	2	4	2	7	6	4	1	2,4-D alone								
3	1	1	4	4	4	1	1	" + mecoprop				1	1	3		
2	3	2		2	3	1		" + dichlorprop								
	1				1	1		" + MCPA + mecoprop + dichlorprop								
1	3	1	2	1	1			Dichlorprop alone				1	1			
3	6	2	3	3	5	1	1	TBA + dicamba + MCPA + mecoprop						4		
	1				2			" + MCPA						1		
					1			2,4-DB + MCPA + benazolin								
					1			Dinoseb amine								

In a number of fields weeds seen before harvest were not recorded as present before spraying.

Table 5

Number of fields on which major weeds were present before harvest

Soil type	Number of fields	Category of abundance	couch (A. repens)	Wild oat	Meadow grasses	Mayweed	Bindweed	Water grass (Agrostis stolonifera)	Blackgrass	Knotgrass	Couch (Agrostis gigantea)	Thistle
SAND	5	greater	1	0	0	0	1	0	1	0	2	0
		lesser	3	1	3	1	0	1	0	1	1	0
		Total	4	1	3	1	1	1	1	1	3	0
LIGHT LOAM	30	greater	8	5	6	4	2	3	5	3	3	0
		lesser	6	4	4	7	3	2	1	4	0	1
		Total	14	9	10	11	5	5	6	7	3	1
HEAVY LOAM	50	greater	7	14	6	3	3	8	3	4	1	3
		lesser	9	9	7	9	10	7	4	5	5	5
		Total	16	23	13	12	13	15	7	9	6	8
CLAY	19	greater	8	6	5	4	1	3	4	1	2	3
		lesser	6	4	3	2	1	1	2	1	0	1
		Total	14	10	8	6	2	4	6	2	2	4
TOTAL	104	greater	24	25	17	11	7	14	13	8	8	6
		lesser	24	18	17	19	14	11	7	11	6	7
		Total	48	43	34	30	21	25	20	19	14	13

Table 6

Numbers of fields harvested or on which the straw was cleared during each period of half a month

Date	Sand (5)	Light loam (30)	Heavy loam (50)	Clay (19)	Total
Combine Harvesting					
July late		1		1	2
Aug. early	2	17	16	4	39
Aug. late	3	10	23	6	42
Sept. early		2	10	6	18
Sept. late				1	1
Not given				1	1
Straw Clearance		≠			
July late				1	1
Aug. early	1	4	6	1	12
Aug. late	4	11	16	6	37
Sept. early		3	15	7	25
Sept. late		2	2	3	7
Oct. early			2		2
Not given		9	8	1	18

≠ 1 field had not been cleared by the end of the year

Table 7

Activities on the fields after harvest 1967
(the figures refer to the number of fields on which the operation occurred)

Activity	Sand (5)	Light loam (30)	Heavy loam (50)	Clay (19)	Total (104)
Nil (already undersown)	-	1	-	1	2
Resown to autumn cereal	1	4	12	3	20
Prepared for planting in spring 1968	4	25	38	15	82
<u>Time of ploughing for autumn cereal</u>					
August	-	-	1	-	1
September	1	2	5	1	9
October	-	2	5	2	9
November	-	-	1	-	1
<u>Time of ploughing for spring sowing*</u>					
August	-	1	1	-	2
September	-	4	6	2	12
October	-	3	6	4	13
November	1	7	10	5	23
December	1	3	9	1	14
After December	2	1	4	3	10
<u>Activities after straw clearance and before ploughing on fields to be resown in spring 1968</u>					
>1 cultivation	1	6	10	-	17
1 cultivation	1	11	13	5	30
No cultivation	-	7	11	7	25
Application of farmyard manure	1	-	4	3	8
Application of herbicide	-	1+	1+	3	5

* No information was received in respect of 8 fields
\+ In conjunction with cultivation

presumably to await sowing in spring 1968. All the fields that were resown in the autumn were ploughed, mostly in September and October. The ploughing of the fields for spring sowing extended over quite a long period from September to the new year with November as the peak month. More than half of the fields were not ploughed until after the end of October.

The period from straw clearance to ploughing which amounted to 2 months or more in many fields was not widely used as an opportunity for carrying out measures of weed control. Of the fields to be sown in spring only 5 were treated with a herbicide in the autumn and 55 fields received one cultivation or none at all. The overall impression is of much of the land standing for a long period in the autumn with no crop growing on it and little being done to it.

CONCLUSIONS

1. The experience of the survey indicates that it is feasible for W.R.O. and an interested firm of agricultural merchants to co-operate successfully in obtaining information from farmers.

2. If approached in the right way, the farmers are prepared to collaborate.

3. The survey has produced a great deal of valuable information about methods of cereal production, about the weeds that occur and the methods that are used to control them.

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