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THE GERMINATION AND GROWTH OF POA ANNUA SOWN MONTHLY IN THE FIELD

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Summary A growth study was made of spaced plants arising from seed sown monthly in 1972. Seed germinated during most months of the year, although climatic conditions influenced both total number and rate of emergence. The growth of the resulting plants followed the same allometric pattern and the relationship was constant for both vegetative and reproductive stages in different climatic conditions and over varying time spans. Tiller number was greatest on earlier-sown plants, one in January attaining 45 cm diameter with an estimated 1000 tillers. There were, however two ecotypes in the seed collection. One was characterised by few secondary tillers (50-175) and 15 month mean life-span, the other by many secondary tillers (250-700) and 19 month mean life-span. The peak time of flowering in 1972 was July-September and in 1973 May-June.

INTRODUCTION

Little was known about the germination and growth of P. annua in the field or about the effects on these of different environmental conditions. Seeds have germinated in the laboratory at constant temperatures from 5°C to 30°C (Koch 1968), but in the field many other factors operate. The growth of several P. annua populations at a range of temperatures has been examined (Calder 1973), but the study was limited to early stages only.

This paper reports an experiment examining germination and emergence, dry weight growth during the season, timing and duration of flowering, seed setting and longevity of Poa annua sown monthly in 1972 in the field. When used, Seed refers to a caryopsis enclosed by lemma and palea and groups of plants are referred to by the month in which they were sown.

METHOD AND MATERIALS

A site measuring 4.8m x 1.3m was selected on a sandy loam soil at the Weed Research Organization, Oxford. The surface 8cm of soil was removed, steam sterilized to kill seed, and replaced on the site. P. annua seeds, collected at Begbroke Hill six years previously and stored at room temperature, were sown monthly throughout 1972, in plots measuring 80cm x 65cm. The same number of seeds were sown on each occasion as periodic tests indicated no change in viability (85%). One hundred and twenty five seeds were sown singly 2mm deep at 2cm spacing in rows 5cm apart. The site was protected from birds by netting.

Seedlings from each sowing date were counted weekly. As each month's seedlings grew, they were progressively thinned to prevent intraspecific competition. At each thinning, several plants were selected randomly and their tiller numbers and shoot and root weights recorded. Thinning and sampling were continued until three well-spaced plants remained in each plot. Counts of tillers and panicles continued on these until most had died.

RESULTS AND DISCUSSION

(i) Germination and emergence. The total number of seedlings emerging and the time taken to reach this number differed for the 12 sowing dates (Fig. 1). These differences reflect the influence of climate on both germination and early growth. The time taken for a seed to germinate and emerge is an indication of the micro-environment in the soil surrounding the seed. For example, seed sown in March reached 50% total emergence in 20 days whilst seed sown in August took 51 days. Moisture and temperature are probably the two most influencial factors controlling germination and emergence and so relevant meteorological data is included in Figure 1 to help interpret the differences. Mean minimum temperatures were chosen in preference to mean daily temperatures because of the effect of low temperature on germination (Koch 1968).

Moisture was readily available, in January and early February, but minimum soil temperatures were low and no emergence occurred until after temperatures rose later in February. Once emergence started, it continued fairly rapidly until most of the sowing had emerged. As temperatures rose in subsequent months and the rain-fall remained adequate, the time to 50% total emergence was reduced to an average of 23 days. The higher temperatures during June and July and the increased evaporation from the soil resulted in short periods of moisture stress which probably explain the smaller number of seedlings from the June and July sowings although the initial rates of emergence were similar to those of previous months.

A long dry period in August and high temperatures during both August and September probably caused the delayed emergence of the August-sown seed, but conditions improved again for seed sown in September and October. Temperatures from mid-November onwards were again low, causing both delays and lower levels of emergence in the November and December-sown seeds. The marked effect of small changes in temperature on emergence suggest that some combination of degree days together with soil-moisture tension might determine the time taken for *P. annua* to emerge.

(ii) Seedling growth. The root and shoot weight data for the spaced plants of each sowing date show typical exponential growth curves (Figure 2). The slopes of these curves indicate that the May - June period of both 1972 and 1973 was the period of maximum growth. Only January, February and March plants, which had emerged by early April, had developed sufficient leaf area by the end of May to make full use of these favourable conditions. Seedlings from the August or later sowing dates overwintered as very small plants and in 1973 resumed active growth even earlier.

Like the January, February and March plants in 1972, the August plants exhibited a faster growth rate during the May - June period of 1973 than those of later sowings. The highest growth rate of all seedlings for the first 10 weeks from mean emergence was found in April plants which had emerged in May. Ten weeks was the longest time span common to the destructive sampling programme of all sowing dates and mean emergence was taken as that date when 50 percent of each month's seedlings had emerged (Fig. 1).

An allometric relationship, $y = bx^k$, where y is the root weight, x is the shoot weight and both b and k are constants (Troughton 1956), was found to exist between

Figure 1. Emergence (per cent of viable seed sown) of P. annua sown each month during 1972 and also rainfall (mm) and weekly mean minimum temperatures (^{o}C) for the duration of the observations.

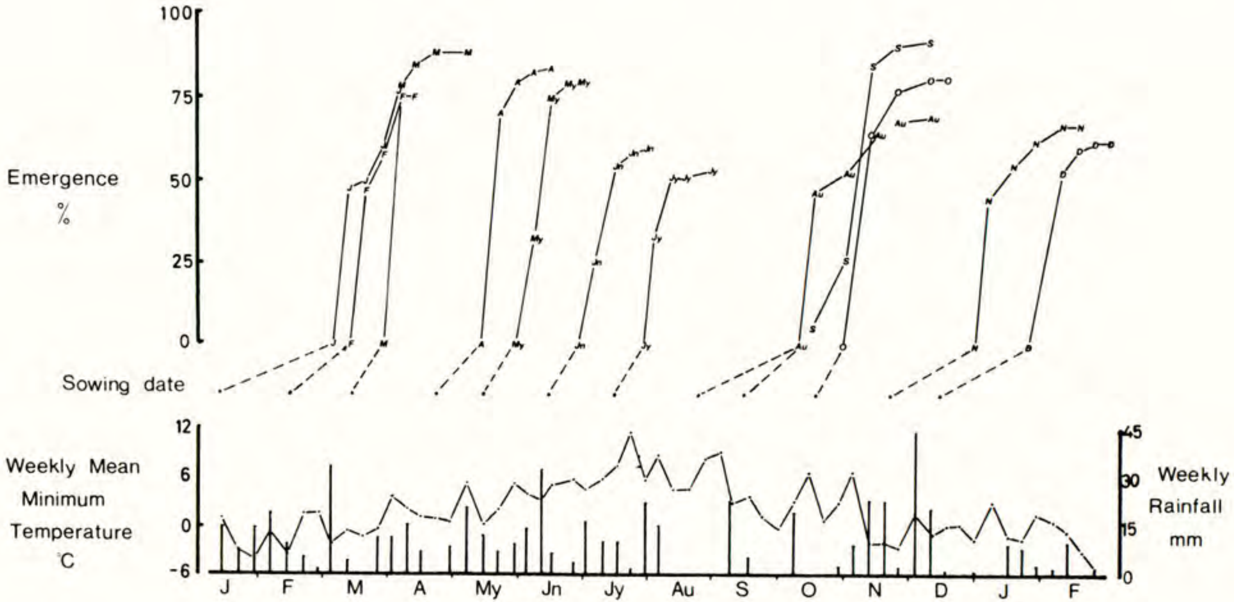
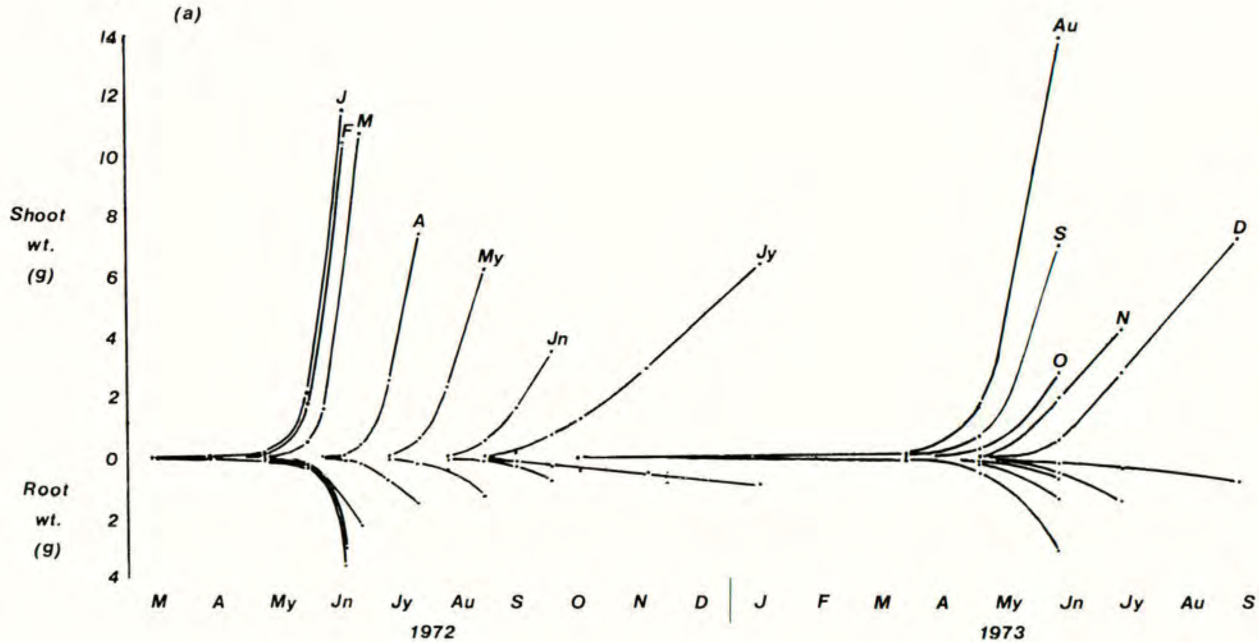


Figure 2. Shoot and root weights per plant of P. annua during the vegetative stage for all sowing dates.



the root and shoot weight data (Figure 3a). Initially, data for the first 10 weeks of growth (vegetative phase) was considered because this kept the growth period constant for all comparisons. This was also a period in which little senescence would have occurred and one in which there would not have been any changes in the value of k owing to the onset of flowering, as Troughton had found in some of his experiments. In addition, only the January to July plants were examined, with the growth data taken at six, eight and 10 weeks after mean emergence as read from the graphs in figure 1. August to December plants had grown very little during this 10 week period because of their overwintering behaviour.

Although the relationships are not strictly linear throughout, and consequently have slightly different k and b values, the lines do not appear to differ significantly from one another because of the experimental errors involved. With very small plants relative growth relationships are particularly sensitive to small changes in either root or shoot weight. For these reasons it is probably more relevant to use one relationship for all the data, namely:

$$\log y = -0.647 + 0.883\ (\pm 0.071)\ \log x \qquad (r = .943) \qquad (1)$$

Shoot and root weight data collected during the reproductive phase of the January to July sowings were then included in the relationship and equation 2 computed (Figure 3b):

$$\log y = -0.626 + 0.920\ (\pm\ 0.050)\ \log x \qquad (r = .965) \quad (2)$$

Equations 1 and 2 should not be compared since much of the data used in their derivation were the same. However, the correlation coefficient (r) for equation 2 is slightly higher than that of equation 1 indicating that the inclusion of the extra data relating to the onset of flowering did not cause any change in the relationship. Similar results were found for both P. trivialis and P. pratensis by Troughton (1956).

The allometric formula was then applied to data from the August to December plants for the longer period of up to 34 weeks after emergence, covering both the overwintering period and the spring growth period of 1973, to see if there was any departure from that described by equation 2. The equation fitting these data was:

$$\log y = -0.676 + 0.925\ (\pm\ 0.061)\ \log x \qquad (r = .972) \qquad (3)$$

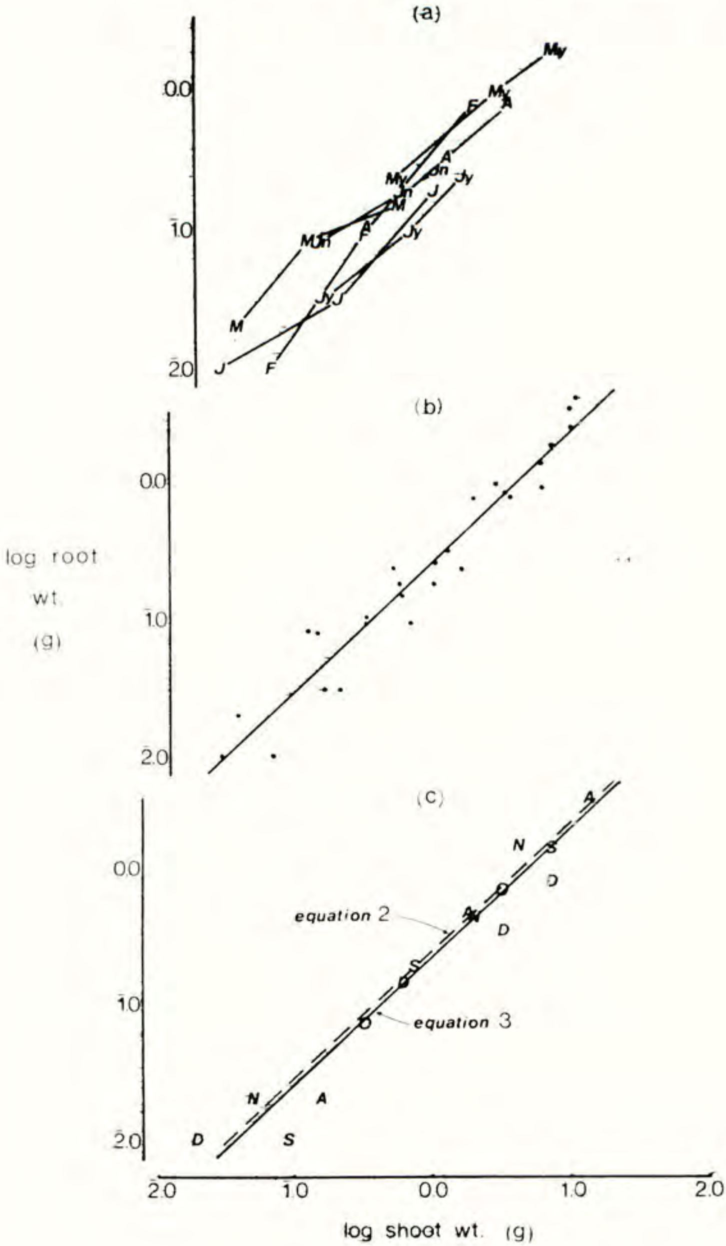
which is plotted in Figure 3c with equation 2 for comparison. Since the regression coefficients are almost identical it is concluded that there is no difference between the two equations.

Therefore, for spaced plants of P. annua it appears that relationship between root growth and shoot growth is constant for both vegetative and reproductive growth and in different climatic conditions and over varying time spans.

(iii) Tiller production. Tiller development of all plants could be grouped into three different patterns consisting of January to March plants, April to July plants and August to December plants (Wells 1974). Although April plants had the fastest relative growth rates for the first 10 weeks after emergence (Fig. 2), it was the January, February and March plants which became the largest. These plants produced many tillers during the favourable growing conditions of May and June and as each plant expanded in area, nodal rooting occurred on most tillers where they touched the soil surface. However, during September, many tillers died and tiller numbers per plant did not increase again until the production of secondary tillers was sufficiently far advanced in October and November. The secondary tillers developed from nodes below the panicle and their subsequent growth increased the plant's diameter still further (at the end of November one January plant was 45cm across, having an estimated 1000 tillers).

The rate of tiller production of the April, May, June and July plants was much lower than that of the earlier sown plants and except for the April plants, they did

Figure 3. Allometric growth in P. annua
(a) January to July plants - emergence to 10 weeks,
(b) January to July plants - emergence to flowering,
(c) August to December plants - emergence to flowering.



not show any decrease during September either. Tiller production ceased during the winter for all plants except those from the July sowing and hence the July plants were the largest at the start of the following season. During the spring of 1973, tillering was quite vigorous in many of these plants but as in the previous season a substantial number of tillers died after flowering though this occurred two months earlier than in 1972.

Plants arising from the August to December sowings, having overwintered as very small seedlings, did not begin tillering actively until spring 1973. They then showed a very similar pattern to that of the plants from the early sowing dates in 1972, and although the post-flowering decline was followed by some secondary tillering, the phase was not as marked as in the previous year. This was most likely a seasonal effect since one might have expected at least the December plants to behave similarly to the January plants. Moisture stress has often been associated with poor growth in P. annua and in both 1972 and 1973, loss of tillers occurred during dry periods.

(iv) Panicle production. The peak time of flowering in 1973 was in May and June, which was slightly earlier than in 1972 (July to September) and more closely approximated the natural flowering period. Most of the plants flowering in 1973 had overwintered after having emerged in the previous season, whereas all those flowering in 1972 had emerged only in that spring. January, February and March plants flowered abundantly in both 1972 and 1973 (up to 300 panicles per plant) and, with the April plants which formed a moderate number of panicles in 1972, were the only ones to have two major flowering peaks before the experiment was terminated. May, June and July plants, which established in the summer, commenced flowering at a younger growth stage than the earlier plants and formed a small number of panicles during autumn and winter but then produced many more during the 1973 peak. It is very likely that August to December plants which formed few panicles in 1973 would overwinter and produce in 1974 a similar flowering peak to that of the earlier plants in 1973. Although there were marked flowering peaks suggesting a strong environmental control mechanism, there always were also a small number of flowering heads present at almost any time of the year once plants had started to flower.

(v) Ecotype differences. During the phase of secondary tillering in both years, morphological differences between plants within most of the sowing date treatments gradually became evident. The differences occurred at random throughout the experiment, having no association with any particular sowing date and so were considered to be of genetic origin. Two main ecotypes were observed. Ecotype A had more robust and erect secondary tillers than ecotype B giving a much more compact plant. It was also characterized by a greater number of secondary tillers (250-700) compared with ecotype B (50-175) (Wells 1974). These differences became even more apparent as the plants grew older, for ecotype B eventually had very few tillers, most of them small and growing at the ends of older tillers. Some of the secondary tillers in both ecotypes were capable of continuing growth independently of the parent plant. They were usually rooted at the originating node and the proximal internodes of the parent tiller often senesced. Of the three plants for each sowing date retained and studied throughout the experiment, all groups except January contained either one or two plants of ecotype B and assessments from June 1973 onwards showed that plants of this ecotype died earlier than those of ecotype A (Table 1).

Table 1

Longevity of ecotypes A and B and tiller number of those still surviving at the end of the growth study

Month sown	Longevity (months)		Month sown	Tiller number as at January 1974	
	Ecotype A	Ecotype B		Ecotype A	Ecotype B
January	19	None	August	235	90
February	19	15	September	210	47
March	19	15	October	145	40
April	17	14	November	115	45
May	18	13	December	205	23
June	19	18			
July	19	17			

Acknowledgement

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EFFECTS OF WEED COMPETITION AND HERBICIDES ON YIELD AND QUALITY OF POTATOES

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Summary Weed competition was most serious beyond the 9th week after planting. Weedy check plots caused a reduction of 58% of the potato tuber yield as compared to all season weed-free conditions. All herbicides tested reduced the oven dry weight of weeds by 55-92% as compared to the unweeded control plots. However, only napropamide at 1.7 and 3.4 kg/ha, and fluchloralin at 3.4 kg/ha gave significantly higher potato tuber yields as compared to weedy check plots. These treatments gave also high numbers of tubers per plant. The average weight per tuber was not affected, except in the case of phytotoxic treatments which included linuron at 3.4 kg/ha and metobromuron at 5.6 kg/ha. The highest specific gravity of tubers was obtained from plots treated with linuron at 3.4 kg/ha, trifluralin at 0.8 and 1.6 kg/ha and weedy check plots.

INTRODUCTION

Potato (Solanum tuberosum) is considered as one of the most abundantly grown food crops in the world, exceeding even cereal crops (Booth & Proctor, 1972). In addition to its high yielding ability, it has a high dietary value. Potatoes are frequently grown under irrigation, and usually receive high amounts of fertilizers. These practices result in giving optimum conditions for the development of the crop as well as the weeds. Since weeds are more efficient than potatoes, they compete with the crop for water, nutrients and light thus reducing the yield and the quality of the potato tubers.

Much has been done on the effect of weed competition on several crops including onions (Shadbolt and Holm, 1956), sugarbeets (Brimhall et al., 1965; Dawson, 1965), beans, (Wilson and Cole, 1966; Kasassian and Seeyave, 1969; Vengris and Sapunkakis, 1971), cotton (Buchanan and Burns, 1970) and other crops (Nieto et al., 1965). However, very little work has been conducted on potatoes. From the limited number

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of reports available in the literature, (Appel, 1965; Wolf, 1969; Dallyn and Sweet, 1970), one can realize that the potato crop is very sensitive to weed competition. Consequently weed control becomes one of the most important cultural practice necessary for the production of a successful crop.

In Lebanon, as well as in other middle eastern countries, few weed competition studies have been made, and very little effort has been put to make use of selective herbicides in potatoes (Singh, 1970; Americanos, 1972). The purpose of this study was to determine to what extent, and at which stage of growth will presence of weeds cause significant losses in the yield and quality of potato tubers. In addition the objective was to evaluate the efficacy of five herbicides, applied at normal rates and twice the recommended rates, for the control of weeds and to study their effects on yield and quality of the tubers.

METHOD AND MATERIALS

The experiment was conducted, in 1973-74, at the Agricultural Research and Education Center of the American University of Beirut, which is located in the northern central Beqa'a Plain of Lebanon, about 80 kms northeast of Beirut. Soil samples collected from the experimental site were analysed and showed the following textural composition: Clay 50.5%, sand 27.8% and silt 21.7%. The soil was classified as clayey, with a cation exchange capacity of 39.5 m.e./100 g of soil, an organic matter content of 2.3%, and a pH of 7.8. In general, 1973 was a very dry year with a rainfall, during the growing period of potato, amounting to 34.1 mm in April, 11.3 mm in May, 1.9 mm in June, and none in July and August. The prevailing temperatures were unusually low, especially during the first two months of the growing season. The average minimum and maximum temperatures in April were 5.8 and 17.9°C, and in May 6.4 and 24.6°C, respectively.

The experimental area was fertilized with 100 kgs of nitrogen and 100 kgs of phosphorous per hectare as a blanket application, followed by shallow disking. Eight weeks after planting, 100 kg of N/ha were applied as a side dressing. Whole potato tubers cv. 'Alpha' were planted with a potato planter. The row spacing was 75 cm, and the distance between plants in the same row was 30 cm. The depth of planting was 15 cm. The plots were arranged in a randomized complete block design with four replications. Plots ($15m^2$) consisted of four rows, each 5 m long. The plots were irrigated weekly by sprinklers for the first eight weeks after planting, and by furrow irrigation thereafter till one week prior to harvesting.

The weed-crop competition study included eight treatments (Table 1): Weed-free plots where hand weeding was done at weekly intervals throughout the whole growing season; weedy plots left undisturbed throughout the whole growing season; hand-weeded weekly for the first 3, 6 and 9 weeks after planting, then the weeds were left to grow undisturbed thereafter; unweeded for the first 6, 9 and 12 weeks after planting, then the weeds were removed weekly thereafter till the time of harvesting.

The most prevalent weed species infesting the experimental plots were dicotyledonous mainly Amaranthus retroflexus and Chenopodium album which represented over 80% of the weed population. Other weeds present in the plots included: Convolvulus arvensis, Cyperus rotundus, Datura stramonium, Diplotaxis erucoides, Heliotropium europeum, Polygonum aviculare, Sinapis arvensis, Solanum nigrum, Sorghum halepense, Tribulus terrestris, Veronica officinalis and Xanthium brasilicum.

The herbicides and rates used are listed in Table 1. All the chemicals were applied as a pre-emergence spray on the day following planting, at a volume of 1000 l/ha. Except for trifluralin, which was incorporated with a rake to a depth of 2 to 3 cm, all other herbicides were incorporated with sprinkler irrigation.

Data recording:

Weed control was determined by measuring the oven dry weight of weeds/m^2 obtained one day prior to potato harvesting. For yield determinations, the tubers were dug out from the two central rows, 130 days after planting, cleaned and weighed. The total number of tubers per 10 plants were counted, and the average number of tubers/plant, and the average weight of tubers were calculated. The percent incidence of sprouting was calculated from tubers collected from 10 plants immediately after harvesting. The specific gravity of the tubers was determined by the method of Ross et al., (1959), the total soluble solids were converted from tables described by the above authors, and the starch content was calculated according to the equation derived by Von Scheele et al., as cited by Schwimmer and Burr (1959). The statistical analysis was done according to the methods described by LeClerg et al., (1962).

RESULTS

Data on the effects of various periods of weed removal and competition, and herbicide application on the dry weight of weeds, tuber yield, average number and weight of tubers, percent sprouting, and specific gravity of potato tubers are presented in Table 1.

Weed yield:

The competition study showed that weed removal for 3 and 6 weeks after planting was not enough to reduce the dry weight of weeds, at the time of potato harvesting, to a significant level equals to that of the weed-free plots; however, hand-weeding for 9 weeks after planting caused a significant reduction in the dry weight of weeds. On the other hand, leaving the weeds to compete with the crop for 6 and 9 weeks did not differ significantly from weed-free conditions. However, competition for 12 weeks produced weed yields equal to 35.0% of the weedy check plots (Table 1). The results indicate that maximum weed competition occurred beyond the 9th week after potato planting.

All herbicide treatments reduced the dry yield of weeds significantly as compared to weedy check plots. Maximum weed control was observed in plots treated with linuron at 1.7 kg/ha, metobromuron at 2.8 kg/ha, and napropamide at 1.7 and 3.4 kg/ha (Table 1).

Tuber yield and number:

The highest potato tuber yield, amounting to 30.2 t/ha was obtained from all season weed-free plots. A reduction of 58% was recorded in the yield of weedy-check plots. Weed removal during the first 3 weeks after planting was not enough to avoid the reduction in the tuber yield which was not significant from weedy-check plots. However, no significant reduction in tuber yield was observed when weeds were removed for 6 and 9 weeks after planting when compared with weed-free conditions. Similarly leaving weeds to compete for 6 or 9 weeks did not cause any significant yield reductions. On the contrary, weed competition for 12 weeks caused a significant reduction of 31.1% in comparison to the yield of weed-free plots.

In the case of herbicides, fluchloralin at 3.4 kg/ha, and napropamide at 1.7 and 3.4 kg/ha, gave a tuber yield equivalent to 75.2%, 86.7%, and 79.4%, respectively,

Table 1

Effects of various periods of weed competition and herbicides on weed yield, tuber yield and quality of potatoes

Treatment	Rate (a.i.) kg per ha	Average weed dry yield t/ha	Tuber yield t/ha	Average number of tubers/plant	Average weight/ tuber (g)	Sprouting %	Specific gravity
Weed-free		0.0 f	30.2 a	14.0 ab	58.6 ab	8.7 abc	1.1018 defg
Weedy check		5.7 a	12.7 de	8.0 de	45.1 bc	0.2 d	1.1101 ab
Hand-weeded 3 weeks		3.7 b	20.0 cd	9.3 cde	59.4 ab	0.5 d	1.1080 bcd
Hand-weeded 6 weeks		1.9 cd	26.5 abc	12.5 abc	62.5 a	3.4 abcd	1.1035 bcdefg
Hand-weeded 9 weeks		0.3 ef	29.1 ab	13.4 abc	58.5 ab	9.8 ab	1.0986 gh
Unweeded 6 weeks		0.3 ef	29.4 a	15.8 a	52.7 abc	10.3 ab	1.0995 fgh
Unweeded 9 weeks		1.2 def	27.7 abc	13.5 abc	55.5 ab	13.5 a	1.0975 gh
Unweeded 12 weeks		2.1 cd	20.8 bcd	10.3 bcde	49.3 abc	10.7 ab	1.0935 h
Fluchloralin	3.4	1.4 cde	22.7 abc	10.7 bcde	55.5 ab	3.8 abcd	1.1083 abcd
	6.8	2.1 cd	19.8 cd	9.5 cde	51.3 abc	4.2 abcd	1.1050 bcdef
Linuron	1.7	1.1 def	20.1 cd	12.5 abc	46.5 abc	7.5 abcd	1.1014 efg
	3.4	2.0 cd	6.1 e	3.3 f	27.2 d	0.8 cd	1.1144 a
Metobromuron	2.8	1.0 def	19.4 cd	11.0 bcde	47.4 abc	3.6 abcd	1.1074 bcde
	5.6	1.7 cde	9.4 e	7.7 ef	36.4 cd	1.9 bcd	1.1080 bcd
Napropamide	1.7	1.0 ef	26.2 abc	13.2 abc	55.8 ab	9.7 abc	1.1024 cdefg
	3.4	0.4 ef	23.9 abc	12.2 abcd	56.4 ab	7.8 abcd	1.1030 cdefg
Trifluralin	0.8	2.4 bc	20.9 bcd	9.5 cde	54.9 ab	0.8 cd	1.1097 ab
	1.6	2.6 bc	19.5 cd	10.9 bcde	54.1 ab	2.8 abcd	1.1086 abc
r Value		-0.57	+0.93			-0.87	

Treatments having the same letter do not differ significantly at 5% level.

as that of the weed-free plots, which did not differ significantly from it. All other herbicide treatments did not differ in their tuber yield from weedy check plots.

Data on the average number of tubers per plant show that there is a highly positive correlation (r = + 0.93) between tuber yield and number. Treatments which gave a high tuber yield, such as the weed-free plots, gave also a high average number of tubers per plant and vice versa. A significant decrease in the average number of tubers, and consequently in tuber yield, was recorded from plots treated with high rates of linuron and metobromuron at 3.4 and 5.6 kg/ha, respectively, due to phytotoxicity of the chemicals.

Tuber quality:

The quality characteristics reported in Table 1 include the average weight per tuber, percent incidence of sprouting, and the specific gravity of the tubers. The results show that with the exception of linuron and metobromuron at the high rates used, which reduced significantly the size of the tubers, no statistical differences in the average weight of tubers were observed amongst the other treatments.

Minimum percent sprouting of tubers was observed, at the time of harvest, in plots with maximum interval of weed competition. Only 0.2% sprouting occurred in weedy check plots as compared with 8.7% recorded under weed-free conditions (Table 1). Weed removal for 3 weeks after planting did not significantly increase the percent sprouting of tubers; whereas leaving the weeds to compete with the crop for 12 weeks, where weeds were removed thereafter, increased significantly the percent sprouting. This indicates that weed-free conditions, particularly toward the end of the growth cycle of potatoes, stimulate sprouting of the tubers.

Data in Table 1 show that there is a highly negative correlation (r = - 0.87) between the specific gravity and percent sprouting of tubers. Weedy check plots which gave significantly low percent sprouting showed a significant increase in the specific gravity of the tubers. Similarly, plots treated with linuron at 3.4 kg/ha, which gave a low sprouting percentage, resulted in a higher specific gravity value. The starch and total soluble solid contents of the tubers, which were derived from tables reported by Ross et al. (1959) and Schwimmer and Burr (1959), followed the same trends of significance as the specific gravity values, and as such are not reported in Table 1.

DISCUSSION

It has been noted that leaving the weeds to compete with the crop for 6 or 9 weeks after planting did not significantly reduce the potato tuber yield. This was due to the delayed weed competition which was only obvious after 12 weeks (Table 1), since the prevailing average temperatures during the first 6-7 weeks after planting were low (minimum 5.8°C; maximum 17.9°C).

Although the application of linuron and metobromuron, at both rates tested, resulted in significant weed control; however, the tuber yield as well as the average number of tubers per plant did not differ significantly from weedy check plots. This may be due to herbicide toxicity, particularly at the high rates tested. In addition, it was observed that potato plants, grown in the linuron - treated plots at 1.7 kg/ha, showed necrosis of the foliage after receiving sequential insecticidal sprays of carbaryl 40 w.p. (sevin 1.5 g/l of H_2O), and gusathion 50 e.c. (1 cc/l of H_2O). This herbicide-insecticide interaction may be responsible for the low tuber yield obtained. The possibility of such an interaction is being currently investigated.

The significantly higher percentage of tuber sprouting, observed in treatments with the least weed competition, may be attributed to the physiological stage of maturity which was reached earlier under weed-free conditions, specially towards the end of the growth season. These tubers which were left in the soil beyond the maturity date were provided with favorable moisture and temperature conditions which helped in breaking their dormancy, thus resulting in a higher sprouting percentage. Since sprouting requires a supply of monosaccharides converted from starch, a reduction in the amounts of starch and total soluble solids of the tubers is expected. Since the specific gravity is directly correlated with these two characteristics, a similar reduction in its value was noted with the increase in percent sprouting.

In conclusion, it appears that the maximum period of weed competition occurs beyong the 9th week after planting. The herbicides fluchloralin at 3.4 kg/ha and napropamide at 1.7 and 3.4 kg/ha gave the best selective weed control in potatoes, with no detrimental effects on the quality characteristics of the tubers studied. Further work is being carried out to examine the effects of weed competition and herbicides on the mineral composition of the tubers.

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NOTES

METRIBUZIN USE IN POTATOES ON ORGANIC SOILS

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Summary Three experiments, one on King Edward and two on Maris Piper showed the high tolerance of these maincrop potato varieties to metribuzin. Treatments applied immediately after planting and ridging failed to provide adequate weed control. Applications made just before or at crop emergence provided excellent weed control. Post-emergence applications at 50% crop cover provided adequate weed control but the level of crop damage was unacceptable.

Galium aparine and Agropyron repens were not controlled by metribuzin treatments although some G. aparine plants were stunted and some A. repens shoots that had not passed the two leaf stage were killed. 1.5 kg/ha of metribuzin applied just pre-emergence of the crop or later gave better weed control than an application of 2.24 kg a.i./ha linuron plus 0.28 kg a.i./ha paraquat applied at 20% crop emergence with little or no apparent crop damage.

INTRODUCTION

Metribuzin is a triazinone herbicide which can be active both through the foliage and the soil (Eue et al, 1969). It is moderately persistent in both mineral and organic soils (May, 1971) and Eue et al, 1970, reported that it is relatively well tolerated by potatoes. This crop is important on the organic soils of East Anglia, where many soil acting herbicides are relatively ineffective.

Three experiments with metribuzin on potatoes growing in organic soils are reported in this paper. The first in 1972 was to determine its suitability for weed control in King Edward potatoes and in 1973 two similar experiments examined the possibilities of its use in Maris Piper.

The choice of Maris Piper in 1973 was influenced by two main factors, (1) the resistance of this important maincrop variety in the 'fens' to the golden cyst nematode (Heterodera rostochiensis) and (2) visual symptoms of damage to this variety, growing on mineral soils, which had caused the manufacturers to suspect its tolerance of metribuzin.

METHOD AND MATERIALS

All three experiments were of the same design and the same experimental techniques were used. Treatments of 0.75, 1.5 and 3.0 kg a.i./ha metribuzin (70% w/w w.p.) were applied to the crop at four times (I) post ridging, (II) pre-emergence of the crop, (III) 20% crop emergence and (IV) late post-emergence. A herbicide control of 2.24 kg a.i./ha linuron plus 0.28 kg a.i./ha paraquat applied at time III was used for comparison as well as an untreated control. The 1972 experiment was at Littleport on King Edward potatoes growing in a soil of 30% organic matter content and pH 5.8. The two 1973 experiments were on Maris Piper, at Mepal on a soil of 14% organic matter content and pH 6.0 and at Hilgay on a soil of 29% organic matter content and pH 7.5

All herbicide treatments were applied in water at 340 l/ha through 6503 teejets fitted to an Oxford Precision Sprayer. Treatments were replicated four times and plot size was four rows of 6.1 m length and 76 cm centres. Chitted seed were mechanically planted in the plots; King Edward at 2.26 t/ha and the Maris Piper at 2.76 t/ha.

Weeds were assessed by counting the numbers in ten quadrats of 45.7 cm by 10.2 cm per plot. After assessment all plots were hand weeded and, except at Littleport where a final ridging was carried out, left until harvest. Blight sprays were used from the end of June and at Hilgay and Mepal demeton-S-methyl was used for aphid control. At harvest the potatoes were lifted with a single row digger and picked up by hand. Yields were taken from the centre two plot rows. The tubers were later graded into ware sizes and green tubers.

Table 1 gives the principle dates for each experiment. All treatments were applied under dry conditions except those at time III at Littleport. These were applied after rain and although the foliage was dry the soil was damp. No weeds had emerged before the post-ridging application but at time II approximately half of the final weed population had emerged and plants were in the cotyledon stage. At time III over 80% of the weed population had emerged and growth stages ranged from cotyledon to first true leaves stage. At time IV the crop was approximately 25 cm high and giving approximately 50% ground cover. The majority of weeds were 12 to 18 cm high.

Table 1

			Littleport	Mepal	Hilgay
crop planted			24.3.72	30.4.73	7.4.73
rows ridged			27.3.72	2.5.73	11.4.73
post-ridging application		(I)	29.3.72	8.5.73	11.4.73
pre-emergence	"	(II)	26.4.72	22.5.73	7.5.73
20% emergence	"	(III)	10.5.72	28.5.73	11.5.73
post-emergence	"	(IV)	1.6.72	15.6.73	6.6.73
weeds assessed			16.6.72	28.6.73	21.6.73
crop harvested			5.10.72	3.10.73	9.10.73

The main weed species in order of abundance were Urtica urens, Poa annua and Polygonum persicaria at Littleport, Polygonum aviculare, P. persicaria, Agropyron repens, Chenopodium album and Chenopodium ficifolium at Mepal and U. urens, Galium aparine, C. album and Polygonum convolvulus at Hilgay.

RESULTS

Assessments of weed populations and potato yields for each experiment are given in tables 2, 3 and 4. Logarithmic transformations were used in the statistical analysis of the weed counts. For the weeds total numbers and counts of the two most resistant species on each experiment are presented, and for the crop, yields of total tubers harvested, total green tubers and marketable ware greater than 4.4 cm are given. The trends of all other grades were very similar.

A large number of seedlings emerged after the pre-emergence applications but most of these were killed by the residual action of 1.5 or 3.0 kg a.i./ha metribuzin. The post-emergence applications severely scorched and retarded most weeds although they were not always completely killed. Urtica urens was severely scorched but not completely killed at Littleport. Such scorched but not killed weeds were regarded as alive and counted at the time of assessment. Galium aparine was not controlled by any treatment but a number were severely stunted by treatments applied at times II and III. Some shoots of Agropyron repens up to the two leaf stage were scorched and even killed by metribuzin treatments but overall control was poor and variable.

At time I 0.75 kg a.i./ha metribuzin did not provide adequate weed control although 3.0 kg a.i./ha gave moderate to good control. 0.75 kg a.i./ha at time II gave moderate to good control and 1.5 kg a.i./ha gave good control. 0.75 and 1.5 kg a.i./ha at time III gave moderate to good and 3.0 kg a.i./ha good weed control. Applications at time IV gave the best control except at Littleport where they failed to completely kill Urtica urens. In general applications made pre-emergence or later gave better weed control than linuron plus paraquat.

No visible crop damage was observed from the first three times of application but on all experiments there was scorch and chlorosis from the fully post-emergence treatments (time IV). This damage was slight to moderate on King Edward but severe on Maris Piper. Tuber yields were lower at times I and IV than at II and III. At times II and III the optimum rate of metribuzin was between 0.75 kg a.i./ha and 1.5 kg a.i./ha.

DISCUSSION

Two main factors influenced the potato yields in all three of these experiments, weed competition and herbicide toxicity. Both King Edward and Maris Piper were damaged by late foliar treatments with metribuzin - Maris Piper being the more susceptible. Thus yields from the plots treated just post-ridging were relatively poor due to inadequate weed control but those from the plots treated fully post-emergence were even poorer, in spite of good weed control, due to herbicide toxicity.

The two best times for treatment on the basis of these experiments were either just before (II) or just after crop emergence (III) and there seems to be no reason to treat Maris Piper differently from King Edward.

Acknowledgements

We are grateful to the farmers who provided the sites, the manufacturers for the herbicides, the Statistics Department of Rothamsted Experimental Station for the statistical analysis of the yields, the Joint Statistics Department of WRO and

Table 2

Littleport - King Edward 1972

	Number of weeds/m^2						Tuber Yields - t/ha			
	Urtica urens	$\log_e(x+1)$	Poa annua	$\log_e(x+1)$	Total weeds	$\log_e x$	Total tubers	Total green tubers	Marketable tubers > 4.4 cm	Mean
I applied post-ridging										
0.75 kg a.i./ha metribuzin	187	5.217	10	2.347	318	5.703	37.9	2.2	33.5	
1.5 " "	116	4.587	5	1.557	197	5.077	41.6	2.9	35.7	35.1
3.0 " "	32	3.387	4	1.557	70	4.239	42.2	3.0	36.2	
II applied pre-emergence										
0.75 kg a.i./ha metribuzin	24	2.867	27	3.157	133	4.809	43.3	3.9	36.7	
1.5 " "	12	2.517	17	2.857	56	3.979	49.3	4.4	42.2	39.5
3.0 " "	1	1.037	8	2.107	25	2.905	46.8	4.4	39.7	
III applied 20% emergence										
0.75 kg a.i./ha metribuzin	6	2.107	26	3.127	139	4.655	48.2	4.5	40.4	
1.5 " "	4	1.517	41	3.167	92	4.377	46.8	4.1	39.5	40.1
3.0 " "	0.5	0.937	15	2.527	34	3.432	47.5	4.9	40.5	
IV applied post-emergence										
0.75 kg a.i./ha metribuzin	177	4.417	41	3.477	316	5.447	41.7	2.6	36.3	
1.5 " "	72	4.087	16	2.447	179	5.053	40.5	4.2	33.8	33.7
3.0 " "	93	3.697	21	2.777	173	4.387	36.0	2.6	31.0	
III applied 20% emergence										
2.24 kg a.i./ha linuron + 0.28 " paraquat	88	4.097	82	4.377	327	5.719	46.5	3.7	40.1	
control	234	4.947	25	2.977	369	5.752	29.7	2.0	25.1	
S E		± 0.43		± 0.45		± 0.36	± 8.24	± 1.07	± 7.74	±1.9

Table 3

Mepal - Maris Piper 1973

	Number of weeds/m^2						Tuber Yields - t/ha			
	Agropyron repens	$log_{10}(x+1)$	Polygonum aviculare	$log_{10}(x+1)$	Total weeds	$log_{10}x$	Total tubers	Total green tubers	Marketable tubers > 4.4 cm	
I applied post ridging										Mean
0.75 kg a.i./ha metribuzin	124	1.817	40	1.473	224	2.154	35.1	1.0	28.3	
1.5 " "	52	1.234	47	1.505	170	2.036	38.8	0.7	33.4	32.4
3.0 " "	62	1.369	19	1.010	123	1.914	41.5	0.8	35.4	
II applied pre-emergence										
0.75 kg a.i./ha metribuzin	102	1.361	25	1.253	153	1.928	45.2	0.7	39.3	
1.5 " "	38	1.396	8	0.736	53	1.537	39.6	1.0	31.9	34.7
3.0 " "	34	1.291	3	0.485	43	1.383	39.3	0.9	32.8	
III applied 20% emergence										
0.75 kg a.i./ha metribuzin	23	1.129	45	1.494	120	1.928	44.9	1.1	37.8	
1.5 " "	87	1.540	42	1.484	140	1.881	43.7	0.9	37.5	36.7
3.0 " "	31	1.109	3	0.434	42	1.405	42.1	0.6	34.7	
IV applied post-emergence										
0.75 kg a.i./ha metribuzin	65	1.552	36	1.378	120	1.904	36.5	0.8	29.5	
1.5 " "	32	1.181	12	0.847	56	1.513	37.3	0.6	29.5	29.9
3.0 " "	27	1.263	4	0.553	32	1.321	37.4	0.7	30.7	
III applied 20% emergence										
2.24 kg a.i./ha linuron + 0.28 " paraquat	79	1.527	25	1.033	155	1.963	46.3	1.1	38.7	
control	35	1.330	93	1.818	325	2.357	36.7	0.8	30.0	
S E		± 0.23		± 0.174		± 0.105	± 2.87	± 0.31	± 2.60	±1.7

Table 4

Hilgay - Maris Piper 1973

	Number of weeds/m²						Total Yields - t/ha			
	Galium aparine	$\log_{10}x$	Polygonum convolvulus	$\log_{10}(x+1)$	Total weeds	$\log_{10}x$	Total tubers	Total green tubers	Marketable tubers > 4.4 cm	Mean
I applied post-ridging										
0.75 kg a.i./ha metribuzin	49	1.462	20	1.154	112	1.885	42.8	3.4	36.5	
1.5 " "	52	1.522	18	1.093	99	1.795	38.3	2.2	32.5	34.0
3.0 " "	47	1.496	15	1.022	76	1.709	39.7	3.4	33.0	
II applied pre-emergence										
0.75 kg a.i./ha metribuzin	54	1.531	19	1.073	118	1.900	44.5	3.5	37.3	
1.5 " "	38	1.323	9	0.789	63	1.628	44.4	2.9	38.9	37.8
3.0 " "	23	1.180	7	0.740	34	1.339	42.6	1.7	37.3	
III applied 20% emergence										
0.75 kg a.i./ha metribuzin	48	1.525	12	0.949	88	1.788	47.6	3.8	40.4	
1.5 " "	38	1.386	9	0.768	65	1.642	45.8	2.4	40.6	39.7
3.0 " "	41	1.433	12	0.927	69	1.595	43.9	3.0	38.1	
IV applied post-emergence										
0.75 kg a.i./ha metribuzin	42	1.438	10	0.828	58	1.611	40.3	1.7	36.2	
1.5 " "	35	1.282	2	0.379	38	1.349	33.0	1.9	28.6	31.0
3.0 " "	30	1.214	1	0.303	32	1.282	32.8	1.8	28.3	
III applied 20% emergence										
2.24 kg a.i./ha linuron + 0.28 " paraquat	43	1.444	17	1.066	99	1.827	43.8	3.1	38.6	
control	50	1.529	29	1.257	270	2.264	40.9	2.3	35.9	
S E		± 0.076		± 0.136		± 0.062	± 3.97	± 0.70	± 3.60	± 1.3

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NOTES

Proceedings 12th British Weed Control Conference (1974)

A FARMER USAGE SURVEY AND EXTENSION TRIALS WITH METRIBUZIN FOR WEED CONTROL IN U.K. POTATO CROPS

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Summary In 1973 a Farmer Usage Survey demonstrated the effectiveness of metribuzin as a pre-emergence herbicide in early potatoes and as a pre- and post-emergence herbicide in maincrops on over 300 crops of potatoes. Good crop safety was demonstrated at rates up to 1.05 kg/ha and at timings up to a crop height of six inches, combined with a high level of overall weed control. Metribuzin was also shown to be effective in trials on organic soils. The optimum timing for control of *Polygonum convolvulus*, *Galium aparine*, *Polygonum aviculare*, *Solanum nigrum*, *Avena fatua*, *Cirsium arvense*, and *Agropyron repens* was also investigated. The outstanding feature revealed by the survey was the large number of applications made post-crop emergence, sometimes way beyond the recommended timing.

INTRODUCTION

Metribuzin is one of a new group of organic compounds showing herbicidal activity discovered by Bayer A.G. and known as the triazinones. It is the first member of the group to be developed and marketed. A report on the chemistry and potential uses of the triazinones was published by Eue et al (1969). Initial trials work in Germany showed that metribuzin is active pre- and post-emergence of weeds and could be applied pre- and post potato crop emergence (Eue and Tietz 1970).

The triazinones are strong photosynthesis inhibitors, the site of inhibition being the second light reaction (Büchel 1972). A 50% inhibition of the Hill reaction in isolated chloroplasts is achieved with concentrations of approximately 10^{-7} molar. Draber et al (1972) have reported on the structure - activity correlation of triazinones, and Fedtke (1972) reported on the influence of triazinones, in particular metribuzin, on the metabolism of crop plants.

Further mode of action work and the development of metribuzin in the U.K. for weed control in potatoes was reported by Mannall et al (1972); similar development work in the U.S.A. and Canada has been described by Cohink (1973). The U.K. development programme was carried out with a 70% W.P. formulation of metribuzin coded Bayer 6159 and this formulation was marketed in 1973. This report describes extension trials on organic soils and certain specific weed problems, and also a farmer usage survey which was carried out to monitor metribuzin in its first year of commercial usage.

METHODS AND MATERIALS

1. Farmer Usage Survey 1973.

Following successful small plot replicated and farmer usage trials, ACAS approval was obtained for the use of metribuzin pre- and post-crop emergence on potatoes. The material was marketed on a limited scale in 1973 and it was decided that Bayer field staff would monitor farmer usage to confirm the suitability of the recommendations under field conditions.

The following details were recorded:-

1.1 Soil type, rate of application and volume of water used per acre.

1.2 Crop stage at Application. The degree of emergence and average height of the crop were recorded.

1.3 Weed Stage at Application. The principal weeds, and their leaf stage and height were recorded.

1.4 Effect on Crop. Visits were made post-application and any effects of the herbicide on the vigour and appearance of the crop foliage were noted, according to the following grades:-

Nil = No visible éffect. Slight = Transient yellowing of foliage. Moderate = Yellowing and some interveinal necrosis. Severe = Yellowing, necrosis and stunting of haulm.

1.5 Effects on Weeds. The degree of overall weed control was recorded using the following scale:- 1 = 100%: 2 = 97.5 - 100%: 3 = 95 - 97.5%: 4 = 90 - 95%: 5 = 85 - 90%: 6 = 75 - 85%: 7 = 65 - 75%: 8 = 32.5 - 65%: 9 = Nil. Also effects on individual species were noted, using the same scale, where appropriate.

1.6 Following Crops. The effect of metribuzin on crops sown after treated potatoes had been lifted was also recorded, chiefly in Eastern England.

All applications of metribuzin were made using the 70% W.P. formulated as Bayer 6159. All applications were made by growers, using their own machinery. The recommended rates of 1.05 kg/ha metribuzin on maincrop potatoes on medium, heavy and organic soils and 0.70 kg/ha on light soils were used. On early potatoes 0.70 kg/ha was used on heavy soils and 0.50 kg/ha on light soils.

2. Extension Trials

2.1 Trials on Organic Soils. Four small plot replicated trials were carried out in Eastern England by Bayer U.K. Limited in 1973, materials being applied by knapsack sprayer at medium volume on soils of above 65% organic matter, using four replicates. Metribuzin was applied at 1.05 and 2.1 kg/ha. A further double treatment of 1.05 kg/ha followed by 0.70 kg/ha was also applied in two of the trials.

2.2 Control of Galium aparine and Solanum nigrum. A small plot replicated trial was carried out at Elm Farm Trials Station, Bury St Edmunds, applying metribuzin at 0.7 and 1.05 kg/ha to known high populations of Galium aparine and Solanum nigrum at three timings: weed pre-emergence, cotyledon, and two leaf stages.

RESULTS

1. Farmer Usage Survey.

Details of metribuzin usage on 56 crops of early potatoes and 247 crops of maincrop potatoes were recorded.

1.2 Distribution of Sites. The distribution of sites is indicated by the acreage covered in each of the Bayer regions, and is as follows: Eastern 1361 acres, Southern 315 acres, Midland 302 acres, Western 600 acres, Northern 535 acres and Scottish 300 acres, making a total of 3413 acres surveyed.

1.3 Timing of Application. Table 1 summarises the timing of all applications in early and maincrop potatoes.

Table 1

Proportion of crops treated at each timing expressed as % of total

Timing	Early	Maincrop
Pre-emergence - 5%	34	21
5% emergence - 6in high	66	62
6in high and above		17
Totals	100	100

Metribuzin is recommended pre-crop emergence only in early potatoes, but 66% of crops were treated post-emergence, chiefly due to growers regarding Maris Peer as a maincrop potato and treating it post-emergence.

On maincrop potatoes, metribuzin is recommended for application pre- or post-emergence up to a crop height of 6 inches. 79% of all applications on maincrop potatoes were made post crop emergence, showing the need for a herbicide which can be applied to potato crops in this manner. 17% of applications were made beyond a crop height of 6 inches (outside label recommendations).

1.4 Effects on Crop. Crop damage was recorded as shown in Tables 2 and 3.

Table 2

Effect on early potato varieties

Variety	No. of applications: Inside Recs	No. of applications: Outside Recs	No. of damaged crops (Slight - Moderate - Severe): Inside Recs	No. of damaged crops (Slight - Moderate - Severe): Outside Recs		
Maris Peer	4	11	-	0	1	2
Epicure	7	4	-	1	0	0
Craigs Alliance	3	4	-	0	0	1
Home Guard	2	3	-		-	
Red Craigs Royal	1	4	-		-	
Ulster Prince	0	4	-	0	2	0
Maris Page	2	1	-		-	
Ulster Classic	0	2	-		-	
Arran Pilot	0	2	-		-	
Others	0	2	-		-	
Totals	19	37		1	3	3 = 7

None of the nineteen early potato crops treated within recommendations were adversely affected by application of metribuzin.

Seven of the 37 crops (approximately 20%) treated post-emergence were adversely affected by metribuzin. Ulster Prince was the most sensitive early potato variety treated, with two of the four crops treated (50%) showing adverse symptoms. However, both these affected crops were treated outside recommendations.

Table 3

Effect on maincrop potato varieties

Variety	No. of applications: Inside Recs	No. of applications: Outside Recs	No. of damaged crops (Slight - Moderate - Severe): Inside Recs			No. of damaged crops (Slight - Moderate - Severe): Outside Recs		
Pentland Crown	64	10	3	0	0	0	2	1
King Edward	30	6	1	0	0	4	1	0
Pentland Dell	23	3	1	0	0	0	0	1
Majestic	25	2	1	0	0	0	1	0
Desiree	21	4	1	0	1	1	1	0
Pentland Ivory	12	7	1	0	0	0	1	2
Record	16	1		-			-	
Maris Piper	7	3	1	0	0	0	0	2
Bintge	6	2		-			-	
Others	1	4		-			-	
Totals	205	42	9	0	1	5	6	6

Only ten (5%) of the 205 maincrops treated inside recommendations were adversely affected by metribuzin; in nine of these, symptoms were slight. Seventeen of the 42 maincrops (40%) treated outside recommendations were adversely affected.

Of the maincrop varieties covered in the survey the most sensitive to metribuzin application were Pentland Ivory, with 20% of crops treated affected and Maris Piper, with 30% of treated crops affected.

1.5 Overall Weed Control. The percentage occurrence of the grading 1,2,3 and 4-9 for overall weed control on crops treated at each of the four main growth stages was assessed as shown in Table 4.

Table 4

Percentage occurrence of four grades of weed control following different spray timings

Crop Stage	Grade				Totals
	1	2	3	4-9	
Pre-5% emergence	16%	55%	19%	10%	100%
5-50% emergence	24%	52%	17%	7%	100%
50%-6in high	9%	61%	24%	6%	100%
6in high or more	6%	48%	24%	22%	100%

The grading of 2 remained relatively constant at all timings of application. The greatest percentage of grade 1 recordings was at the crop 5-50% emergence stage. Conversely grades 3 and 4^+ were recorded least of all at this timing.

The average overall weed control score for all applications at each crop timing are as follows; Pre-emergence 2.14; 5-50% crop emergence 2.11; 50%-6in crop height 2.29; 6in and above 2.63. Clearly the best overall weed control was achieved with applications up to 50% crop emergence, the ideal timing being from 5% to 50% crop emergence.

1.6 Individual Weed Control. During the pre-marketing development of metribuzin several weeds proved variable in their response to the herbicide. The effect on the weeds was especially noted during the survey and results are shown in Table 5 showing the number of sites where the individual weeds were recorded at each of four levels of control.

Table 5

Individual weed control

Weed	Level of control by weed score			
	1,2	3,4	5	6+
Polygonum convolvulus	6	-	10	4
Galium aparine	2	-	5	6
Polygonum aviculare	26	4	13	1
Solanum nigrum	-	-	5	-
Cirsium arvense	7	1	5	3
Avena fatua	10	6	5	3
Agropyron repens	11	8	9	4

Polygonum convolvulus was best controlled in the early seedling stage. It tended to grow through when metribuzin was applied pre-weed emergence.

Galium aparine. Some control was achieved at the cotyledon to two leaf whorl stage, but the weed is best regarded as being resistant.

Polygonum aviculare germinated early in the growing season and was thus often too big to be controlled well by late applications.

Solanum nigrum was controlled well in the early seedling stage, but sometimes germinated late and then grew away.

Cirsium arvense. Though a good kill of top growth was often achieved, regrowth sometimes occurred from the rhizome.

Avena fatua. Pre-emergence control of surface germinating seed and post-emergence control up to the three leaf stage was achieved, but seedlings germinating from depth and larger plants were not controlled.

Agropyron repens. Results were variable. Where rhizomes were near the soil surface, or infestation was light, good suppression was recorded. With severe infestations or deep rhizomes, control was poor.

1.7 Crop Yields. No adverse effects on potato crop yields were reported by growers co-operating in the survey.

1.8 Following Crops. It is recommended that only ryegrass, cereals and winter beans are planted following metribuzin usage in the same season, provided that at least sixteen weeks have elapsed since application. The results of planting 28 fields following metribuzin usage are given in Table 6.

Table 6

Effect of metribuzin on following crops

Crop	No. surveyed	Time since application <16 weeks	>16 weeks	Adverse effects
Winter wheat	14		14	Nil
Spring barley	4		4	Nil
Sugar beet	2		2	Nil
Peas	2		2	Nil
Italian ryegrass	2	2		Nil
Rape	2	2		crop death
Cauliflower	2	2		crop death
Savoy cabbage	1	1		Severe stunting

Brassica crops planted after early potatoes treated with metribuzin were very severely affected. Ryegrass and winter cereals planted in the season of metribuzin usage and crops planted the following spring were not affected.

2. Extension Trials

2.1 Trials on organic soils. In the replicated trials carried out by Bayer, no crop damage was apparent from pre-emergence applications, and any damage from post-emergence applications was transient and slight, even on Maris Piper which was known to be sensitive to metribuzin. The best weed control was achieved at weed cotyledon to 2 leaf stage. Little information was obtained about double applications as in two trials the first dose gave sufficient persistence to render the second dose unnecessary. Where the follow-up dose was used, weed control was improved due to the killing of late germinating weeds.

2.2 Control of Galium aparine. Poor control of Galium aparine was obtained, though some control was achieved at the cotyledon stage. Some reduction in vigour was observed.

2.3 Control of Solanum nigrum. Good control of Solanum nigrum was achieved post-emergence up to the three leaf stage, but this effect was masked by further germination of the species after spraying, metribuzin being not very effective when applied pre-emergence.

DISCUSSION

The Farmer Usage Survey carried out during 1973 generally confirmed the conclusions drawn from the development programme carried out between 1969 and 1972. Metribuzin proved to be safe to early potatoes when applied pre-emergence, and safe to maincrop potatoes pre- and post-emergence up to a crop height of 6 inches. When the herbicide was applied beyond these limits, the chances of crop damage were greatly increased. Of the early potato varieties surveyed, Ulster Prince was the most sensitive to metribuzin, while of the maincrop varieties Pentland Ivory and Maris Piper showed up as being sensitive.

As a result of the survey, the recommendations were changed to include the use of metribuzin on Maris Piper and Pentland Ivory, but pre-emergence only.

The best overall weed control was achieved when metribuzin was applied pre- and post-emergence up to 50% crop emergence, the ideal timing being between 5% and 50% crop emergence. At this timing most weeds had emerged and were at the cotyledon to first true leaf stage.

Polygonum convolvulus, Solanum nigrum and Avena fatua were best controlled when treated at the early seedling stage. They tended to be resistant to pre-emergence applications, and to treatment after the two to three leaf stage. Polygonum aviculare needed treatment at an early stage of crop growth to ensure adequate control of early germinating plants. Galium aparine is best regarded as being resistant to metribuzin and control of Cirsium arvense and Agropyron repens varied with the depth of rhizome and the severity of the infestation. Six growers reported reduced weed populations in crops, (5 winter wheat, 1 sugar beet) sown following metribuzin usage on potatoes.

Used at recommended rates and timings, metribuzin had no adverse effect on crop yields. Ryegrass and winter wheat planted after potato lifting in the season of metribuzin usage were unaffected by the herbicide. Brassica crops following treated early potatoes were severely damaged. Crops planted in the spring of the year following metribuzin usage were unaffected.

Trials carried out on organic soils have shown that metribuzin gives good contact kill of emerged weeds and reasonable persistence to control weeds germinating after application.

Further work on organic soils has been carried out at Arthur Rickwood E.H.F. (May and Smith 1974) using metribuzin at 0.7, 1.4 and 2.8 kg/ha at four timings from just after planting through to 50% crop cover. Best results were obtained from the 1.4 kg/ha rate applied just before or at crop emergence. The principal weeds were Urtica urens, Polygonum persicaria and Poa annua, all of which were well controlled. With regard to effect on crop, it was considered that doses of below 1.4 kg/ha would be required for Maris Piper, though King Edward may be tolerant of a somewhat higher rate.

The outstanding feature of the Usage Survey was the very high proportion of applications made after the crop had emerged, often at very advanced stages of growth and with relatively high levels of crop safety. The reasons for these late applications were the failure of cultivations to control weeds, lack of suitable weather conditions to allow earlier herbicide applications, and sometimes the failure of earlier herbicidal treatments. Further features were the broad spectrum of weeds controlled and the long persistence of metribuzin, even on organic soils.

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POTATO HAULM DESICCATION: A NEW FORMULATION OF DIQUAT TO REDUCE STEM END ROT

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Summary In pot experiments the addition of low doses of diuron to diquat delayed the initial speed of potato haulm desiccation and markedly reduced the incidence of stem-end rot of tubers when plants were under conditions of soil moisture stress and high atmospheric humidity. An out-of-season field trial abroad confirmed these results. Field trials in the U.K. in 1973 showed the delayed haulm kill to be only transitory. Moreover the addition of diuron had no effect on the growth of seed tubers or on the quality of ware potatoes. However the conditions were not such as to induce stem-end rot. Doses of up to 1kg/ha of diuron incorporated into soil had no effect on winter wheat drilled soon after application. An extensive programme of further trials is in progress during the current season to evaluate diquat/diuron mixtures for potato haulm desiccation.

Résumé Dans des expériences en pots, l'addition de doses faibles de diuron au diquat, retardait la vitesse initiale du dessèchement des fanes de pommes de terre et réduisait nettement l'apparition de la maladie sclérotique des tubercules, en cas de forte humidité atmosphérique et de secheresse du sol.

Une expérience effectuée à l'etranger, hors saison, confirma ces résultats. Des expériences effectuées en Grande-Bretagne, en 1973, montrerent que le dessèchement retarde des fanes n'etait que transitoire. De plus, l'addition de diuron n'a aucun effet sur la croissance des tubercules et sur la qualité des pommes de terre de consommation. Cependant, les conditions m'étaient pas favorables à l'apparition de la maladie sclérotique.

Des doses, atteignant 1kg/ha de diuron, incorporées au sol, n'eurent aucun effet sur le blé d'hiver seme peu après le traitement. Un programme important d'autres expériences se poursuit actuellement pour évaluer les mélanges diquat/ diuron dans la lutte contre le dessèchement des fanes de pommes de terre.

INTRODUCTION

The widespread useage of diquat since 1960 has shown it to be an efficient potato haulm desiccant which is convenient and safe to the user. The major constraint to more extensive application in the U.K. is the risk of stem-end rot of tubers in dry seasons. The symptoms of damage and the inductive environmental conditions have been described by Headford and Douglas (1967). The warning system by which meteorological data is used to recommend farmers not to spray under drought conditions has also been described by Headford and Low (1969). This system which has operated since 1968 has proved successful in avoiding damage. However a succession of very dry maincrop spraying seasons in recent years has prevented many farmers from using diquat. Accordingly research aimed at discovery of a safer formulation for potato haulm desiccation was commenced in 1973. A possible solution to the problem was indicated by an earlier pot experiment in which potato plants were sprayed with diquat under inductive conditions (i.e. soil moisture stress combined with high atmospheric humidity) and maintained either in darkness for 24 hours or in the light. Stem-end rot developed only on tubers from plants which had received light immediately after spraying. The effect of the dark period was to delay foliage kill and, thereby, it is suggested, to prevent the very rapid reverse xylem flow of diquat which is associated with tuber damage. Photosynthetic inhibitors were therefore examined as additives for diquat to delay desiccation, that is to chemically simulate the effect of a dark period. A series of such compounds were tested and diuron emerged as the most promising. The present paper summarises the work to date with diquat/diuron mixtures.

METHODS AND MATERIALS

1. Pot tests, 1973

Potato plants var. Arran Pilot were grown to maturity in 10 inch pots of John Innes No. 1 compost for 14 weeks during the period April-July. At the first sign of foliage senescence water was withheld to induce drought stress. Plants showed a moderate general wilt of the leaves after 4 days. At this stage they were sprayed with diquat or diquat/diuron mixtures applied in a fine spray to run-off (approx. 1,000 l/ha). 5 replicates were used. Plants were transferred immediately to a controlled environment room at 90% r.h., a day temp. of 25°C, a night temp. of 20°C and a day length of 16 h. and maintained under these conditions for 1 week. After rewatering to field capacity pots were returned to outside conditions for a further 2 weeks. Haulm kill was assessed at intervals for 3 weeks after spraying and then the tubers were harvested. The numbers of tubers with stem-end rot were recorded and samples analysed for chemical residues.

2. Pot tests, 1974

Methods were similar to those in 1973 except that var. Home Guard was used and grown in 6 inch pots. The growth period was 10 weeks and plants took only 2 days to wilt.

3. Field trials, 1973, U.K.

Five trials were carried out, 1 at Jealott's Hill, the others in East Anglia. The main crop varieties Majestic, King Edward, Pentland Crown and Pentland Ivory were sprayed with diquat and diquat/diuron mixtures at the onset of senescence in mid September following a period of prolonged dry weather. Plot size was 2 rows x 3 m. 4 replicates were used in a randomised block design. Chemicals were applied in 500 l/ha using an Oxford precision sprayer. Leaf and stem kill were assessed for 3 weeks after spraying and at 3-4 weeks tubers harvested. Samples were retained for residue analysis and storage. Stored tubers were maintained in the light at approx. 5°C until mid April 1974. Sprout growth of 50 tubers per treatment from each trial was then measured in terms of numbers of sprouts >0·5 cm long and fresh weight.

A further 50 tubers were planted in 5 replicated plots of 10 tubers randomised in blocks. Assessments of % emergence were made at 3 times, and after the last time, a measurement of plant height taken. An additional 6 trials were carried out by Field Trials Section in Essex on the varieties Majestic and Pentland Crown. Methods were similar to those above except that plot size was 2 rows x 5 m. At harvest tuber samples were analysed for residues and others, after 3 months in dark barn storage, submitted for taint testing to the Campden Food Preservation Research Association.

4. Field trial, 1974, Canary Islands

A trial on early King Edward potatoes was carried out in Tenerife in February. Methods were similar to 3. except that plants were visibly wilting at the time of spraying. In addition a high humidity around the foliage was induced with water applied by mistblower during a 4 h. period commencing 2 h. after spraying until dusk. 3 replicates were used.

5. Field trial, 1973 - Diuron persistence

A trial was carried out at Jealott's Hill on a sandy loam soil (3•5% o.m., p.H. 7.3). Rounded potato ridges were set up in August, sprayed with diuron 4th Sept. at 0•5 - 2•0 kg/ha and the ridges spun out 3 weeks later. A seed bed was prepared and winter wheat var. Maris Ranger drilled. Seed beds were prepared and wheat drilled also at 6 and 9 weeks after spraying. Plot size was 3•5 m (2 m. drilled) x 6 m. 6 replicates were used. Assessments of % crop damage relative to unsprayed controls were made during October - May.

Throughout the work described diquat was used in the form of Reglone containing 14% w/v diquat as the dibromide salt. In the first pot test diuron was used in the form of Karmex, a dispersible powder containing 80% w/w a.i. and in other experiments as a col. formulation containing 64% w/w a.i..

RESULTS

1. Haulm kill and tuber damage

i. Pot tests

The results of 3 growth room tests (1 in 1973, 2 in 1974) are summarised in Table 1.

Table 1

Effect of diquat/diuron mixtures on haulm kill, stem-end rot and tuber residues (trans = arc sin transformed)

Expt.	Dose (kg/ha) diquat	diuron	% foliage kill at days after spraying 1	(trans)	3	7	% tubers with stem end rot	(trans)	residues (ppm) diquat	diuron
1	1	-	60	(51•0)	95	99	41	(39•2)	0•13	-
	1	0•5	24	(28•9)	82	96	0	(0•0)	0•09	N.D.
	1	1	44	(41•3)	93	94	2	(3•1)	0•10	N.D.
	1	2	31	(33•7)	90	94	7	(7•4)	0•08	-
	LSD)P=0•05)			(8•3)				(20•8)		
2	0•8	-	62	(52•0)	78	100	16	(19•5)	-	-
	0•8	0•2	48	(43•8)	70	100	4	(8•3)	-	-
	0•8	0•4	46	(42•7)	87	100	0	(0•0)	-	-
	0•8	0•8	50	(46•2)	81	100	0	(0•0)	-	-
	LSD(P=0•05)			(3•9)				(13•4)		
3	0•8	-	51		91	100	13		-	-
	0•8	0•025	34		86	100	0		-	-
	0•8	0•05	34		90	100	0		-	-
	0•8	0•1	30		88	100	0		-	-
	0•8	0•2	30		92	100	3		-	-
	0•8	0•4	36		92	100	6		-	-
	0•8	0•8	30		96	100	7		-	-

The addition of diuron to diquat significantly reduced the extent of foliage desiccation 1 day after spraying. There was no obvious effect of dose of diuron on the magnitude of this initial reduction which averaged 35% over the 3 tests. By 3 days the effect had almost disappeared. The addition of diuron also caused a marked reduction in the percentage of damaged tubers. There was similarly no consistent effect of dose of diuron on the extent of this reduction although in 2 tests there was an indication that the highest rates of diuron were less effective. For some treatments no stem-end rot was recorded. The overall effect was a reduction in damage from a mean of 23% with diquat alone to a mean of 2% with diquat/diuron mixtures i.e. a reduction of 90%. Only limited residue data are yet available. These indicate insignificant amounts of diuron in the tubers (<0•02 ppm, the limit of detection) and rather lower residues of diquat when applied in mixture (mean 0•09 ppm) compared to application alone (0•13 ppm).

ii. Field trials

The effect of diuron on the haulm kill achieved by diquat on main crop varieties sprayed in the U.K. autumn 1973 is summarised in Table 2.

Table 2

Effect of diquat/diuron mixtures on % haulm kill of U.K. main crops at intervals (days) after spraying (mean 5 trials, 4 varieties)

Dose (kg/ha)		1	3	7	
diquat	diuron	leaves	leaves	leaves	stems
1	-	52	89	99	76
1	0·25	44	81	98	76
1	0·5	40	85	99	72
1	1	42	84	98	72
1	2	41	83	99	74

As in the preceeding pot tests, diuron caused a significant reduction (mean 19%) in the foliage kill by diquat at 1 day, again regardless of the dose of diuron. By 3 days the reduction (mean 7%) was only just observable and not significant and by 1 week negligible. A further 6 trials in Essex showed similar results. Although soil mositure deficits in excess of 100 mm were recorded in most of these trials no stem-end rot occurred, even with diquat alone, due, it is believed, to low ambient atmospheric humidities. However, an out-of-season field trial in the Canary Islands in which a high humidity was intentionally provided yielded positive results on this aspect. These data are shown in Table 3.

Table 3

Effect of diquat/diuron mixtures on haulm kill and tuber damage of King Edward potatoes in Tenerife (trans = arc sin transformed)

Dose (kg/ha)		% haulm kill (days)						% stem-end rot (trans)	
diquat	diuron	1	(trans)	3	(trans)	7	14		
1	-	51	(46·0)	80	(63·9)	95	100	48	(44·0)
1	0·125	16	(24·0)	43	(41·1)	90	100	13)	
1	0·25	35	(36·2)	55	(47·9)	85	100	8)	(13·2)
1	0·5	28	(32·0)	43	(41·1)	86	100	10)	
1	1	23	(28·9)	33	(35·2)	86	100	6)	
LSD(P=0·05)			(8·4)		(10·9)	N.S.			(22·5)

In this case diuron gave a larger reduction in initial top kill (mean 49% at 1 day) than in the U.K. and this persisted rather longer but haulm kill differences were not statistically significant at 7 days. As in all previous experiments all doses of added diuron were effective and all markedly reduced tuber damage from 48% with diquat alone to a mean of 9% with diuron mixtures i.e. a reduction of 81%.

2. Sprout growth and seed performance

No significant effects of haulm desiccation treatments were recorded on sprout growth during storage of seed tubers from the main crop trials or on their emergence and early growth when planted in the field the following year. These data are summarised in Table 4.

Table 4

Effect of diquat/diuron mixtures on the sprouting and early field growth of seed potatoes (mean 5 trials, 4 varieties)

Dose (kg/ha) diquat	diuron	No. sprouts per tuber	Fresh wt. per sprout (g)	Total fresh wt. per tuber (g)	% emergence 23.5	29.5	10.6	Plant height (cm) 14·6
1	-	1·49	0·54	0·81	26	74	98	19
1	0·25	1·60	0·66	1·05	22	78	99	19
1	0·5	1·55	0·65	1·01	32	80	99	20
1	1	1·78	0·57	1·02	32	79	98	19
1	2	1·45	0·66	0·96	29	67	98	18
-	-	1·60	0·56	0·89	27	72	99	19
LSD(P=0·05)		0·37	0·14	0·29	N.S.	N.S.	-	-

3. Residues and taint

Samples from the 11 1973 main crop trials of treatments comprising the standard dose of diquat (0·8-1·0 kg/ha) either alone or in mixture with 1 kg/ha diuron were analysed for tuber residues. In all cases diquat residues were very low (0·03 ppm) to non detectable (<0·01 ppm); diuron residues were also very low being beyond the limit of detection (<0·02 ppm). In addition samples from 3 of the trials of treatments comprising the standard dose of diquat in mixture with either 0·5, 1 or 2 kg/ha diuron were tested for taste quality. Processed in either the fresh or frozen form the tubers showed no detectable taint.

4. Following crops

Effects of soil incorporated diuron on a following crop of Maris Ranger winter wheat are shown in Table 5. Damage at the highest dose of diuron took the form of initial chlorosis and later slightly stunted growth.

Table 5

Effect of diuron on % damage relative to unsprayed controls of wheat drilled at intervals of 3, 6 or 9 weeks assessed at dates shown

Dose (kg/ha)	10 Oct. 3	6	9	2 Nov. 3	6	9	27 Nov. 3	6	9	23 Jan. 3	6	9	21 Mar. 3	6	9	2 May 3	6	9	29 May 3	6	9
0·5	0	-	-	0	-	-	0	0	-	0	0	0	0	0	0	(1)	0	(1)	0	0	(1)
1	0	-	-	0	-	-	0	0	-	0	0	0	(2)	0	0	(1)	0	0	(1)	(1)	0
2	0	-	-	12	-	-	0	0	-	0	0	0	22	7	8	21	14	9	15	8	13

(values in brackets are not significantly different from zero)

There was no significant effect of diuron at rates of 1 kg/ha or less.

DISCUSSION

In all the experiments described (3 pot tests and 12 field trials) the addition of diuron consistently produced an initial delay in the desiccation of potato haulm given by diquat. Diuron is known to be a very potent inhibitor of the Hill reaction of photosynthesis, the process normally required for diquat to manifest its herbicidal action. Evidently the inhibition is of limited duration since after 3-7 days there was little observable difference between the haulm kill achieved by mixtures compared to diquat alone.

In all pot tests and in the Tenerife field trial in which stem-end rot inductive conditions were provided this transitory inhibition of leaf kill was associated with a marked reduction in the extent of tuber damage.

Earlier unpublished experiments strongly indicate diquat induced stem-end rot to be due to a high concentration of chemical being received at the basal end of the tuber very rapidly as a consequence of reverse xylem flow during the early stages of leaf kill. Although the speed of movement of diquat to the tubers under conditions of reverse xylem flow (i.e. dry soil and wet air) in the presence of diuron has not yet been measured it is most likely to be significantly slower in view of the observably slower initial desiccation of the leaves. Residue data from one of the pot experiments described showed that the effect of diuron was to reduce the concentration of diquat in the whole tuber by 30%. Of more particular significance however is the effect that diuron may have on the time course of diquat accumulation in tissue immediately adjacent to the point of stolon attachment; if appreciably slower than with diquat alone the lower initial concentrations may permit dilution in a larger bulk of tissue. Residues of diuron itself in tubers even under inductive conditions appear to be negligable.

Somewhat surprising was the lack of a detectable effect of dose of diuron on the magnitude of either the initial delay in haulm kill or the reduction of stem-end rot. In the third pot test the lowest dose of only 1/40 kg/ha diuron was effective. This may be explicable in terms of the very low aqueous solubility of diuron (42 ppm at 25°C). Applications were made to run off. Assuming a volume rate of 1,000 l/ha, 1/40 kg/ha is equivalent to 25 ppm which is close to the solubility level. A further experiment is in progress to test even lower doses of diuron.

The field evidence presented for diquat/diuron mixtures from 11 U.K. trials of efficient haulm desiccation, low residue levels and lack of taint or affect on seed value are encouraging although further field data are needed for early varieties and in general for crops sprayed under conditions where higher tuber residues (and damage) with standard diquat would normally be obtained. The present information on possible hazards to the next crop as a consequence of using diuron in the formulation is also encouraging. In the U.K. (and Europe and North America) winter wheat accounts for a vast proportion of the succeeding crop. In the trial described no adverse effects were seen on winter wheat when drilled very soon after spraying doses of 1 kg/ha or less of diuron and this with application to a bare soil surface rather than to potato foliage which would in practice intercept an appreciable amount of the compound. In a further trial conducted during the same season on a clay loam soil in Berkshire even 2 kg/ha diuron applied after drilling caused no visible damage to winter wheat, barley or oats (pers. comm., G. Douglas, Jealott's Hill). Diuron is adsorbed mainly by organic matter (Hance, 1965) and degraded principally by soil microorganisms (Kearney and Kaufman, 1969). Most work on the residual phytotoxicity of diuron to arable crops has been carried out in the U.S.A. in view of the useage of the compound as a cotton herbicide. Upchurch et al. (1969) reported damage to winter wheat following cotton in which 1·6–2·2 kg/ha diuron had been applied to sandy loam soils very low in organic matter (0·6–1·2%) although in further trials on the same soils two years later these treatments showed no significant effects. At somewhat lower doses (0·8–1·6 kg/ha) diuron is in fact currently recommended for pre-emergence weed control in winter wheat, oats and barley in the U.S.A. (Hepworth and Fine, 1971) and at 0·3–1·4 kg/ha early post-emergence in wheat and barley in Australia (Catt, 1974); also at 0·2–0·4 kg/ha (in mixture with chlorpropham) pre-emergence in beans in the U.K. (Fryer and Makepeace, 1972). From an extensive series of field trials in the U.S.A., Hill et al. (1955) concluded that diuron used at doses of 1-2 kg/ha is degraded within 4-8 months and that there is no significant soil accumulation from repeated annual applications.

It seems very unlikely therefore that the proposed use of low doses (probably in the region of 0·25 kg/ha) of diuron with diquat for potato haulm desiccation will present any practical hazard to winter cereals. Further information is required on the tolerance of minor crops (principally oil seed rape and transplanted brassicae) which might follow soon after potatoes. During the current season an extensive programme of field work has been arranged. This includes trials on early and main crop varieties over a wide area with additional experiments under polythene covers as an insurance against wet weather preventing the possibility of stem-end rot conditions. Haulm kill efficiency will be assessed and numerous tuber samples examined for damage, residues, seed performance and ware quality. In addition any possible effects on following crops will be recorded.

If successful it is hoped that the present drought warning system for diquat could be abandoned or at least appreciably relaxed when the new formulation becomes available.

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ORYZALIN AND ORYZALIN COMBINATIONS FOR WEED CONTROL IN OIL SEED RAPE

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Summary Oryzalin, 3,5-dinitro-N^4,N^4-dipropylsulfanilamide, has shown excellent selectivity in oil seed rape when pre-emergence surface applied at 1.0 - 1.5 kg a.i./ha. The wide spectrum of weeds controlled by this herbicide at these dosages includes the following important broadleaf species: Chenopodium album, Matricaria spp., Polygonum aviculare, P. convolvulus, Stellaria media and Veronica arvensis. Additionally, oryzalin provided good to excellent control of most annual grasses, including Alopecurus spp., Apera spica-venti and Poa annua. Methods to increase initial activity against annual grass weeds are discussed.

INTRODUCTION

Oryzalin, 3,5-dinitro-N^4,N^4-dipropylsulfanilamide, is a new pre-emergence surface applied herbicide. This product was previously known under the code EL-119.

The toxicological, chemical and physical properties of oryzalin are discussed in detail by Snel et. al. (1974). These workers also discussed the leaching properties of oryzalin and arrived at the conclusion that a minimum amount of precipitation (rainfall or sprinkler irrigation) of 1.25 cm. is needed to "activate" the compound. A list of the weed species susceptible to oryzalin at the recommended rate is published elsewhere (Snel et. al. 1974).

When oryzalin was applied at rates of 1.12 - 1.5 kg a.i./ha pre-emergence in winter rapeseed in Sweden, this herbicide provided a very effective season-long control of the major weeds occurring in this crop under Swedish climatic and soil conditions, i.e. Matricaria spp., and Stellaria media (Snel et. al. 1974). Oryzalin displayed a high crop selectivity when applied to the Swedish low erucic acid variety "Simis" and significant yield increases were measured in treated plots. Early season control of annual grasses with oryzalin was occasionally less than optimal, especially when "activation" of the compound by rainfall was delayed for more than 7 days.

This less than optimal initial weed control could present potential problems under the conditions encountered in the Dutch and German winter rapeseed areas where annual grass weeds play a very important role in the weed spectrum.

Methods to improve the early season activity of oryzalin against grasses have therefore been investigated and are reported here.

METHOD AND MATERIALS

Oryzalin was applied pre-emergence to the soil surface after seeding winter rapeseed. The compound and the reference products were applied with Azo gasplot sprayers with a 2 metre spray boom fitted with Birchmeyer J60 nozzles. The spray volume ranged between 400 and 600 litres/ha. In all instances, the experiments were laid out in a randomized block design with 25-50 m^2 plots and 4-5 replications.

Trifluralin (treatments 6 and 7, tables 1, 2 and 3) was soil incorporated before sowing with a tractor mounted rotary cultivator or spring tooth harrow to a depth of 5-8 cm. In treatment 7, the trifluralin application was followed after seeding the crop with a pre-emergence surface application of oryzalin at 375 g a.i./ha. The entire experimental site was cultivated with the soil implement used for incorporation of trifluralin, since plots which receive different soil preparation treatments frequently have a slightly altered weed spectrum.

A total of 24 experiments in winter rapeseed has been conducted in Germany and the Netherlands since August, 1971. Soil types varied from sandy loam (for assessing possible phytotoxicity) to heavy clay soils with heavy infestations of Alopecurus. The experiments conducted in the Netherlands during the 1973/74 season are discussed in detail. Two trials were located in Zeeuws - Vlaanderen on sandy clay soils and three in the province of Groningen (one trial on sandy loam and two on clay-loam soils).

The herbicidal efficacy was assessed by weed counts, and/or weed control ratings. Crop selectivity was determined by crop stand counts, crop emergence and yield measurements.

The data from all experiments have been analyzed statistically using the Duncan's Multiple Range Test. In view of great differences in weed spectra, weed infestations, soil types and climatic conditions, it was decided not to carry out a pooled statistical analysis of all winter rapeseed experiments.

RESULTS

Oryzalin when applied at 1.12 kg a.i./ha in combination with 9.0 kg a.i./ha of TCA gave excellent season-long control of Alopecurus myosuroides (table 1). Oryzalin alone compared favourably with the soil incorporated herbicide trifluralin which had a better initial herbicidal efficacy (table 2) against Alopecurus myosuroides. The effect of TCA and TCA + Simazine against this grass weed was disappointing in the spring following the late summer application, notwithstanding good activity of TCA + Simazine observed in the autumn.

Oryzalin, alone or in combination showed very good crop selectivity in the Dutch winter rapeseed cultivars "Marcus" and "Rapol", as well as in some of the new German varieties with low erucic acid contents. The vigour of Alopecurus plants in the oryzalin treated plots was less than in the TCA, TCA + Simazine or

TABLE 1

Weed control in winter rapeseed in the Netherlands with oryzalin, oryzalin + trifluralin and oryzalin + TCA (average from 5 experiments conducted in 1973/74) 1/

Compound	Rate g a.i./ha	% control of *Alopecurus myosuroides*	% control of *Matricaria inodora*	% control of *Stellaria media*
Oryzalin	1125	77	90	81
Oryzalin + TCA	562 + 9000	80	84	63
Oryzalin + TCA	750 + 9000	85	93	69
Oryzalin + TCA	1125 + 9000	90	96	83
TCA	900	46	6	0
Trifluralin	960	73	32	69
Trifluralin + oryzalin	960 + 375	84	93	85
TCA + Simazine	9000 + 250	52	75	30
Untreated control	-	0 (71) 2/	0 (85) 2/	0 (38) 2/

1/ Weed control ratings carried out during the first week of April, 1974. Applications were made during the last week of August or the first week of September, 1973.

2/ Average number of plants/m^2 in untreated control plots.

trifluralin plots, which resulted in reduced tillering. It was observed in German trials that oryzalin severely injured the root systems of escaped volunteer winter wheat and winter barley plant. TCA aided the activity of oryzalin against volunteer cereals in winter rapeseed, but due to relatively low infestations, no accurate assessment of the oryzalin activity was carried out.

The effect of delayed activity of oryzalin against Poa annua is shown in table 2. Seven weeks after application, oryzalin was significantly less active against Poa annua than any of the oryzalin + TCA combinations, however, the activity of the compound alone was significantly superior to TCA alone. In the spring, however, control in the plots treated with 1.12 kg a.i./ha of oryzalin has improved greatly, and was equal to that observed in the plots treated with oryzalin + TCA.

Control of Matricaria inodora in the oryzalin, oryzalin + TCA applications, and trifluralin + oryzalin split application was not significantly different from the reference treatment either in the autumn or in the spring. The split trifluralin + oryzalin treatment gave significantly better control of Matricaria inodora than the trifluralin treatment, especially in the spring.

Slow initial activity of oryzalin against Alopecurus myosuroides is shown in table 3. Trifluralin when applied pre-plant incorporated either alone or followed by a pre-emergence surface application of oryzalin (0.375 kg a.i./ha) displayed a significantly greater activity against this weed than the oryzalin, oryzalin + TCA treatments three weeks after application. No significant difference was noted in activity against Alopecurus myosuroides between the trifluralin and TCA + Simazine. The additive effect of TCA on the control of Alopecurus with oryzalin became evident 7 weeks after application (treatments 3 and 4). In the spring, oryzalin (1.12 kg a.i./ha), trifluralin + oryzalin (0.96 + 0.37 kg a.i./ha), oryzalin + TCA (1.12 + 9.0 kg a.i./ha), and trifluralin (0.96 kg a.i./ha) all gave statistically similar control of Alopecurus myosuroides which indicates that control of Alopecurus myosuroides increased in plots treated with oryzalin applied at 1.12 kg a.i./ha either alone or in combination with TCA. This increased control was not observed at the lower rates of application of oryzalin in combination with TCA, (0.56 or 0.75 kg a.i./ha oryzalin + 9.0 kg a.i./ha TCA).

The activity against Alopecurus myosuroides decreased significantly with time in the TCA + Simazine treatment, and equalled that obtained with TCA alone at the time of the spring assessments (table 3, treatment 7 versus treatment 5). Similar patterns of weed control with oryzalin were observed in our German experiments.

DISCUSSION

Two methods were studied to combine the excellent season-long activity of oryzalin against dicotyledonous weeds in winter rapeseed (Snel et. al., 1974) with good initial activity against annual grass weeds occurring in this crop (especially against Alopecurus myosuroides). These methods were based on combining oryzalin treatments with those of herbicides used for control of annual grasses in winter rapeseed, trifluralin and TCA.

TABLE 2

Control of Poa annua and Matricaria inodora in winter rapeseed with oryzalin, oryzalin + trifluralin and oryzalin + TCA in the Netherlands: Experiment NL 73-202, St. Kruis Z.VL

Compound	Rate g a.i./ha	% control of Poa annua 22 Oct. 73	% control of Poa annua 22 Mar. 74	% control of Matricaria 22 Oct. 73	% control of Matricaria 12 Apr. 74
Oryzalin	1125 1/	78 a	100 a 4/	100 a 4/	98 a 4/
Oryzalin + TCA	562 + 9000 1/	90 a	100 a	98 a	93 a
Oryzalin + TCA	750 + 9000 1/	95 a	100 a	95 a	98 a
Oryzalin + TCA	1125 + 9000	95 a	100 a	100 a	100 a
TCA	9000 1/	58 c	43 c	20 c	10 c
Trifluralin	960 2/	97 a	100 a	84 b	45 b
Trifluralin + oryzalin	960 + 375 3/	99 a	100 a	100 a	98 a
TCA + Simazine	9000 + 250 1/	80 b	68 b	100 a	90 a
Untreated control	0	0	0	0	0
		(62) d 5/	(48) d 5/	(106) d 5/	(164) d 5/

1/ Pre-emergence surface application carried out on 31st August, 1973. Soil contained 16% clay and 1.6% organic matter.
2/ Pre-sowing incorporated carried out on 31st August, 1973.
3/ Trifluralin applied pre-sowing incorporated followed by a pre-emergence surface application of oryzalin.
4/ Figures followed by the same letter are not significantly different (P = 0.05)
5/ Figures in brackets indicate the mean number of weeds m^2 in the untreated control.

TABLE 3

Control of Alopecurus myosuroides in winter rapeseed in the Netherlands 1/
Experiment NL 73-201, Aardenberg, Z.VL

Compound	Rate g a.i./ha	Date of Observation		
		1 Oct. 73	31 Oct. 73	22 March 74
Oryzalin	1125	50 cd 2/	45 cd	74 abc
Oryzalin + TCA	562 + 9000	53 cd	53 cd	54 c
Oryzalin + TCA	750 + 9000	60 cd	60 cd	61 bc
Oryzalin + TCA	1125 + 9000	60 cd	58 bcd	80 ab
TCA	9000	45 d	43 d	59 bc
Trifluralin	960	80 ab	75 ab	74 abc
Trifluralin + oryzalin	960 + 375	88 a	88 a	87 a
TCA + Simazine	9000 + 250	65 bc	65 bc	53 c
Untreated control	0	0 e	0 e (66) 3/	0 d

1/ Date of application 6th September, 1973. Soil contained 26% clay and 2.0% organic matter.

2/ Figures followed by the same letter are not significantly different ($P = 0.05$)

3/ The figure in brackets indicates the number of plants/m^2 in untreated control plots.

First the results obtained by combining oryzalin and TCA as a pre-emergence surface application will be discussed.

In tables 2 and 3, it is shown that oryzalin alone always gave better initial activity against annual grass weeds than TCA alone, while tank-mix applications of oryzalin + TCA always surpassed the activity of oryzalin alone. Although a dosage related increase in activity against Alopecurus myosuroides with increasing oryzalin concentrations in the oryzalin TCA tank-mix pre-emergence applications was difficult to demonstrate in the early autumn, this response could be noted very clearly in the spring (table 3). It appeared that the most efficacious dosage was 1.12 kg a.i./ha of oryzalin combined with 9.0 kg a.i./ha of TCA as borne out in table 1, in which the season-long activity of all treatments obtained in 5 experiments is reviewed (see also table 3, treatments 2, 3, 4, observation date 22 March, 1974). A dose related response could also be demonstrated for control of Stellaria media and Matricaria inodora with oryzalin and TCA combinations (tables 1 and 2, treatments 2, 3 and 4). As anticipated, TCA contributed nothing towards the activity of oryzalin against these dicotyledonous weeds (table 1, treatment 5). The most desirable control of Stellaria media by oryzalin was obtained at 1.12 kg a.i./ha. Snel and co-workers (1974) reported that a similar application rate of oryzalin was required for control of these weeds under Swedish conditions.

The second method of improving the initial activity of oryzalin against Alopecurus myosuroides always proved significantly better than that of the tank-mix combinations of oryzalin and TCA, as shown for one particular experiment in table 3, treatment 7. The season-long activity of the split application against annual grasses was statistically comparable to that of oryzalin + TCA (1.12 + 9.0 kg a.i./ha), oryzalin alone (1.12 kg a.i./ha), tables 1 and 3) or trifluralin (0.96 kg a.i./ha), although the trend exists in our opinion that the split application is slightly better than any of these treatments.

A most remarkable feature of the split application was the activity against Matricaria inodora and Stellaria media. Namely, in the split application technique, only 0.375 kg a.i./ha of oryzalin was required to obtain the same season-long control of these dicotyledonous weeds as that obtained with 1.12 kg a.i./ha of oryzalin alone, i.e. (tables 1 and 2, compare treatments 1, 4 and 7). Trifluralin is only moderately active against Matricaria species (tables 1 and 2) especially in the spring, which would suggest that a higher concentration of oryzalin should be required for good control of this species. Apparently, however, this particular weed is very sensitive to oryzalin since an average control of 84% could be obtained in the spring with 0.56 kg a.i./ha in the 1973/74 trial programme in the Netherlands (table 1). Therefore, presumably trifluralin provided a small additive effect when oryzalin was applied at 0.375 kg a.i./ha. Stellaria media appeared less sensitive to oryzalin than Matricaria, however, trifluralin applied alone exhibited good activity against Stellaria which complemented the low application rate of oryzalin.

In summary, when soil type and cultural techniques make soil incorporation of trifluralin feasible, the addition of oryzalin as a pre-emergence treatment at a very low rate of 0.375 kg a.i./ha provided excellent control of both annual grass and broadleaf weeds, surpassing the herbicidal efficacy of established treatments such as TCA, TCA + simazine and trifluralin (Table 1).

When oryzalin was applied pre-plant incorporated as a tank-mix with trifluralin, the activity against Matricaria species was greatly decreased (Brandes and Snel, unpublished data), necessitating a split application technique.

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CONTROL OF ANNUAL GRASSES AND BROAD-LEAVED WEEDS IN WINTER OILSEED RAPE WITH PROPYZAMIDE

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Summary The results of experiments carried out over two years with post-crop emergence applications of propyzamide to winter oilseed rape are reported. Comparisons were made with 3.3 lb a.i./acre dalapon and 1.87 lb a.i./acre carbetamide.

0.5 lb a.i./acre propyzamide gave excellent control of volunteer cereals, Avena fatua and Alopecurus myosuroides but the slightly higher rate of 0.63 lb a.i./acre was required to give consistently good control of Stellaria media and Veronica persica. October applications resulted in lower weed population levels during the crop establishment period from January to April than did later applications.

Yields from propyzamide plots were consistently higher than those from dalapon plots. Dalapon gave poor or no control of broad-leaved weeds and retarded flowering by 7-10 days. Carbetamide gave inferior weed control in comparison with propyzamide.

Résumé Les résultats de deux années d'expériences sur des applications post-levées de propyzamide au colza d'hiver sont exposés. On a établit des comparaisons avec des doses de 3 lb/acre de matière active (m.a.) de dalapon et de 1.87 lb/acre m.a. de carbetamide.

On a obtenu un excellent contrôle des céréales adventices, Avena fatua et Alopecurus myosuroides, avec 0.5 lb/acre m.a. de propyzamide, mais il a fallu la dose légèrement plus élevée de 0.63 lb/acre m.a. pour obtenir un contrôle régulièrement efficace de Stellaria media et Veronica persica. Des applications effectuées en Octobre, comparées à des applications plus tardives, ont eu pour résultat de réduire la population des plantes adventices pendant la période d'établissement de la culture de Janvier à Avril.

Les parcelles traitées à la propyzamide ont produit des rendements régulièrement plus élevés que ceux des parcelles traitées au dalapon. Le dalapon n'a eu que peu on pas d'effet sur les plantes adventices feuillues et a retardé la floraison de 7 à 10 jours. Le contrôle des plantes adventices par le carbetamide s'est révélé inférieur à celui obtenu avec la propyzamide.

INTRODUCTION

Oilseed rape is playing an increasingly important part in supplying the world with oil and protein. The crop is well suited to UK climatical conditions and is now a very attractive break crop, there being an estimated 50,000 acres harvested in 1974 and a forecast of 100 - 125,000 acres for 1975. This increased interest has led to a demand for a herbicide to control annual grass and broad-leaved weeds.

In the later stages of growth the crop is most effective in smothering weeds but it can suffer severely from competition during its establishment period. The weed species which are most commonly found in winter rape were listed by Hughes (1973) as being volunteer cereals (especially winter barley), Stellaria media, Avena fatua, Alopecurus myosuroides, other broad-leaved weeds (mainly annuals which grow faster than dormant rape, such as Veronica spp) and rhizomatous grasses.

Propyzamide, as the 50% w.p. commercial formulation Kerb 50W, was found to be effective at 0.6 lb a.i./acre for controlling problem weeds in winter rape in France (Sumpter, 1973). The material was subsequently test marketed in 1972 and given full commercial clearance in 1973. The first United Kingdom evaluations carried out by Bryant (1973) in the 1972/73 season showed that post-crop emergence applications of 0.5 and 0.75 lb a.i./acre propyzamide controlled Stellaria media and Veronica persica and checked the growth of Sinapis arvensis.

METHODS AND MATERIALS

Five replicated experiments were carried out on commercial crops, three in East Anglia and two in Wiltshire. The experimental design was three replicates in randomised blocks. The plots at the East Anglian sites, designed for yields to be taken, were 8 yd x 25 yd in size. Treatments were applied with an Oxford Precision Sprayer fitted with Allman '00' jets. The volume rate was 20 gal/acre and the pressure 30 lb/in^2. Plot size at the Wiltshire sites was 5 yd x 10 yd. Treatments were applied with a Van der Weij sprayer at 50 gal/acre and 30 lb/in^2 pressure. All treatments were applied post-crop emergence. The rates of use and times of applications are given in Tables 1, 2 and 3. Propyzamide treatments were compared with either 3.3 lb/acre dalapon (4 lb/acre product) or 1.87 lb a.i./acre carbetamide (2.75 lb/acre product). Other site details are given in Table 1. Assessments were made of treatment effect on crop growth and on weeds. Yields were taken at three sites by taking one or two combine swaths down the length of each plot.

Table 1

Site Details

Trial Reference	A	B	C	D	E
Location	Royston, Herts.	Attleborough, Norfolk.	Chelmsford, Essex.	Downton, Wiltshire.	Standlynch, Wiltshire.
Soil type	Chalky silty clay loam	Loamy sand	Silty clay loam	Stony medium loam over chalk	Light to medium loam over chalk
Crop variety	Lesira	Lesira	Janetzkis	Hector	Hector
Spraying dates	1) 24.10.73 2) 28.11.73 3) 21. 1.74	1) 1.10.73	1) 22.10.73 2) 24.11.73 3) 14. 2.74	1) Propyzamide - 29.10.73 2) Carbetamide - 28.11.73	1) Propyzamide - 29.10.73 2) Carbetamide - 28.11.73
Crop stage (no. of true leaves) at spraying	1) 4 2) 6 3) 6	1) 7	1) 3-4 2) 5-7 3) 5-7	1) 3 2) 4	1) 4 2) 5
Drilling date	4th week August 1973	4th week August 1973	4th week August 1973	3 September 1973	4th week August 1973
Seed bed preparation	Ploughed	Minimum cultivation	Discs followed by reciprocating power harrow	Direct drilled	Direct drilled
Weeds present at spraying	Volunteer barley, Af, Vp, Sm, Tm, Fo.	Agr, Cbp, Sm, Vp.	Volunteer barley, Sm	Volunteer barley, Af, Sm, Vp.	Volunteer wheat, Af, Sm, Vp, Agr.
Date of harvest	29 July 1974	25 July 1974	26 July 1974	-	-

Af = Avena fatua, Vp = Veronica persica, Sm = Stellaria media, Tm = Tripleurospermum maritimum, Fo = Fumaria officinalis, Agr = Agropyron repens, Cbp = Capsella bursa-pastoris.

RESULTS

Weed control

Details of the weed control assessments are given in Tables 2 and 3.

October/November applications of both propyzamide at 0.38 - 1.0 lb a.i./acre and dalapon at 3.3 lb/acre gave excellent control of germinating and established annual grass weeds such as volunteer wheat and barley, Avena fatua and Alopecurus myosuroides. Carbetamide at 1.87 lb a.i./acre gave only moderate control of these species when applied at the recommended time (November). Later applications of propyzamide made in January/February generally gave equally good grass control where moderate infestations were present. At site C, however, where there was a severe infestation of volunteer barley, February applications of propyzamide resulted in poor control.

Growth of Agropyron repens (site E) was suppressed 20% and 40% by 0.5 and 1.0 lb propyzamide/acre respectively when applied in October.

Consistently good control of germinating and established Stellaria media and of Veronica persica (up to seedling stage) was achieved by 0.63 - 1.0 lb/acre propyzamide; lower rates of 0.38 and 0.5 lb/acre were not quite so effective. Dalapon and carbetamide gave only poor control of these species. The addition of 0.1 lb/acre diuron to 0.5 lb/acre propyzamide improved the control of Capsella bursa-pastoris significantly, this species being normally only moderately susceptible to propyzamide alone. There were insufficient numbers of Compositae spp. present at the sites where propyzamide/diuron was applied to be able to confidently conclude that the addition of diuron had adequately controlled members of this group (more or less resistant to propyzamide alone).

At sites D and E, assessments of % weed cover of each treatment were made on seven occasions from application (29 October 1973) until 26 July 1974. The mean results are given in Table 2.

Table 2

% weed cover (means of sites D and E)

	Assessment Date						
	1973		1974				
Treatment	29/10*	28/11**	4/1	7/3	30/4	24/5	26/7
Untreated control	7.5	7.5	15	77.5	100	100	100
0.5 lb/acre propyzamide	10	10	12.5	10	22.5	20	22.5
0.75 " "	7.5	10	12.5	12.5	10	10	10
1.0 " "	7.5	7.5	10	10	7.5	7.5	10
1.87 " carbetamide	7.5	7.5	12.5	67.5	87.5	100	100

* Date of application of propyzamide ** Date of application of carbetamide.

The data in Table 2 shows that there was sufficient propyzamide remaining in the soil up until the period when the rape crop met in the row and could thereafter compete successfully with any newly germinating weeds. Carbetamide was not persistent enough to keep the crop clean up until this period. 0.75 lb/acre propyzamide generally gave better weed control than did 0.5 lb/acre propyzamide.

At all sites dalapon was farmer-applied at 2.5 - 3.3 lb/acre to the remainder of the field. Control of annual grass weeds was good but there was little or no control of Stellaria media and Veronica persica which dominated the annual broad-leaved weed spectrum.

Effect on crop

Details of the effect of treatment on oilseed rape are given in Table 4. None of the propyzamide treatments affected crop growth. After January/February the rape in the control plots began to be affected by weed competition and the plants grew less vigorously than in the propyzamide plots.

Table 3

Effect of treatments on weeds

(0-10 scale; 0 = no control, 10 = complete control)

Chemical		Date applied		lb a.i. per acre											
Propyzamide		October '73	Untreated control*	-	-	0.38	0.5	0.63	0.75	1.0	0.5	-	-	-	-
"		November '73		-	-	-	-	-	-	-	-	0.5	1.0	-	-
"		Jan/Feb '73		-	-	-	-	-	-	-	-	-	-	0.5	1.0
Diuron		October '73		-	-	-	-	-	-	-	0.1	-	-	-	-
Dalapon		" '73		3.3	-	-	-	-	-	-	-	-	-	-	-
Carbetamide		November '73		-	1.87	-	-	-	-	-	-	-	-	-	-
Weed	**Trial ref.**	**Assessment date (1974)**													
Volunteer barley	A	20 March	0(M)	10	-	10	10	10	10	10	10	10	10	10	10
	C	21 March	0(H)	10	-	9.3	8.7	10	9.3	10	10	9.3	8.7	4	3
	D	24 May	0	-	7	-	10	-	10	10	-	-	-	-	-
Volunteer wheat	E	7 March	0	-	5	-	9	-	10	10	-	-	-	-	-
Avena fatua	A	20 March	0(L)	10	-	10	10	10	10	10	10	10	10	10	10
	D	24 May	0	-	7	-	10	-	10	10	-	-	-	-	-
	E	24 May	0	-	7	-	9.5	-	10	10	-	-	-	-	-
Alopecurus myosuroides	A	20 March	0(L)	10	-	10	10	10	10	10	10	10	10	10	10
Stellaria media	A	20 March	0(M)	4	-	10	8	10	10	10	10	10	10	8	7
	B	22 January	0(L)	5	-	7	9	9	9	9	8	-	-	-	-
	C	23 January	0(M)	2	-	8	9	9	10	10	10	5	8	4	5
	D	7 March	0	-	3	-	8	-	9	9	-	-	-	-	-
	E	7 March	0	-	2	-	8	-	10	10	-	-	-	-	-
Veronica persica	A	20 March	0(M)	3	-	9	9	10	10	10	9	4	8	7	7
	B	22 January	0(M)	5	-	7	9	9	9	9	8	-	-	-	-
	D	24 May	0	-	2	-	7	-	9	10	-	-	-	-	-
	E	24 May	0	-	1	-	8	-	8	9.5	-	-	-	-	-

* L = light infestation, M = moderate, H = heavy.

Table 4

Effect of treatments on oilseed rape

Chemical		Date applied	Untreated control	lb a.i. per acre												L.S.D. (3)	S.E. (±)
Propyzamide		October '73		-	-	0.38	0.5	0.63	0.75	1.0	0.5	-	-	-	-		
"		November '73		-	-	-	-	-	-	-	-	0.5	1.0	-	-		
"		Jan/Feb '73		-	-	-	-	-	-	-	-	-	-	0.5	1.0		
Diuron		October '73		-	-	-	-	-	-	-	0.1	-	-	-	-		
Dalapon		October '73		3.3	-	-	-	-	-	-	-	-	-	-	-		
Carbetamide		November '73		-	1.87	-	-	-	-	-	-	-	-	-	-		
Trial ref.	**Parameter**	**Assessment date**															
A	Vigour[1]	21.1.74	6.3	9.3	-	5.7	5.7	6.7	6.7	6.0	7.0	7.0	7.0	7.7	6.7		
		20.3.74	6.3	8.3	-	6.3	6.3	7.0	6.8	6.3	7.8	7.0	6.3	7.3	7.3		
	Yield change over control (cwt/ac)		(22.3)	+2.0	-	+1.9	+4.2	+4.4	+3.3	+3.2	+3.1	+1.5	+4.1	+0.8	+3.7	N.S.*	6.0
B	Plant height[2] (% change over control)	4.4.74	(68.4 cm)	-13.5	-	+4.7	-1.6	-0.3	-1.9	+1.2	-5.3	-	-	-	-	7.9***	1.9
	Yield change over control (cwt/ac)		(22.4)	-3.8	-	-1.1	-0.7	-2.9	-1.4	-0.4	-1.9	-	-	-	-	N.S.*	6.4
C	Vigour	23.1.74	10	8	-	10	10	9.3	10	8	8	10	10	-	-		
		21.3.74	6	9	-	9	10	10	10	9.3	10	10	10	10	9		
	Yield change over control (cwt/ac)		(19.5)	+9.3	-	+9.7	+12.3	+10.5	+10.2	+8.9	+7.5	+9.4	+9.0	+9.2	+7.9	5.9*	2.8
D	Vigour	4.1.74	10	-	9	-	9	-	9.5	9	-	-	-	-	-		
		26.7.74	4	-	6	-	9	-	10	10	-	-	-	-	-		
E	Vigour	4.1.74	9	-	7	-	7.5	-	8	7	-	-	-	-	-		
		26.7.74	4	-	5.5	-	10	-	10	9.5	-	-	-	-	-		

(1) Vigour: 0-10 scale; 0 = dead, 10 = healthy.

(2) 30 plants measured/treatment.

(3) * = p at 0.05, *** = p at 0.001.

Where moderate to heavy weed infestations were present (sites A and C) propyzamide treatments resulted in yield increases (significant at p = 0.05 at site C) in the order of 3-4 cwt/acre at site A and 9 - 12 cwt/acre at site C. 3.3 lb/acre dalapon also increased yields at both these sites but not to the same extent as did October applications of propyzamide. All treatments reduced yields slightly at site B (not significant, p = 0.05) but increases were not expected as the weed population was low initially and the majority of the weeds were removed in February when the field was virtually inter-row hoed by liquid ammonia injection equipment. As at sites A and C, lower yields were recorded on the dalapon plots than on the propyzamide plots. Plant height was reduced 13.5% (significant at p = 0.001) by dalapon at this site (pigeon damage was negligible) and the date of flowering was retarded by 7 to 10 days at all 5 sites.

Sites A, D and E suffered heavy overall pigeon damage in January and February except where dalapon was used. Dalapon residues on plant foliage are known to repel birds.

Table 5 shows how crop vigour of plants treated with propyzamide or carbetamide compared with plants treated with dalapon in the remainder of the field (farmer's treatment), in relation to pigeon damage and weed control.

Table 5

The effect of pigeon damage and weed control on crop vigour under different treatment regimes (means of sites D and E)

(0 - 10 scale; 0 = dead, 10 = healthy)

	Assessment Date						
	1973		1974				
Treatment	29/10	28/11	4/1	7/3	30/4	24/5	26/7
Untreated control	10	10	9.5	3.3	4.5	4.5	4
0.5 lb/acre propyzamide	10	10	8.3	3	6.5	9.3	9.5
0.75 " "	10	10	8.8	2.8	6.8	8.3	10
1.0 " "	10	10	8	3.3	7	9.3	9.8
1.87 " carbetamide	-	10	8	3	5.8	6	5.8
3.3 " dalapon (farmer's treatment)	10	10	10	9.5	9	8	8

Pigeons effected damage between January and March in the propyzamide and carbetamide plots at sites D and E, whereas the non-trial area which was treated with dalapon suffered little damage. Despite this, the plants in the propyzamide plots recovered quickly during April and May because of the excellent weed control achieved and crop vigour was eventually better than that of dalapon treated plants. The lack of broad-leaved weed control by dalapon resulted in a reduction of crop vigour from March onwards. Plants in the carbetamide and untreated control plots never recovered from the pigeon damage because of weed competition.

DISCUSSION

The recent increase in the popularity of winter oilseed rape has resulted in the evaluation of a number of herbicides for this crop. Dalapon has been the main material used commercially until recently but only gives control of annual grass weeds and a temporary check to some broad-leaf weeds. Hence there has been a need for a herbicide which controls both grass and broad-leaved weeds as both groups usually occur together. The data presented in this paper confirms the French work in which it was found that 0.63 lb a.i./acre propyzamide applied post-crop emergence in October after the 3 leaf stage controlled all the important weeds of winter rape.

Carbetamide gave inferior weed control to propyzamide and although yields were not recorded, crop vigour assessments at the end of July showed that plants in the propyzamide plots were much healthier than those in the carbetamide plots.

Crop vigour and control of grass weeds was not affected by the date of application of propyzamide but it appears that at some sites the best control of chickweed and speedwells and the best increase in yield was achieved from the earlier applications. The benefits from the earlier application probably arise from the suppression of weeds prior to the important crop establishment period of January to April. Propyzamide breaks down fairly rapidly when the soil starts to warm up in April, but there was no further need for chemical weed control in the propyzamide plots as the crop by this stage could compete successfully with germinating weeds.

Populations of weeds which are moderately susceptible or resistant to propyzamide were unfortunately too low to be able to draw firm conclusions on whether the addition of diuron to propyzamide improved their control. Indications were promising, however, and warrant further evaluations. A mixture of the two herbicides is already marketed in France.

Taking chemical costs into account, yield assessments showed that where moderate to heavy grass weed or grass/broad-leaved weeds were present, propyzamide gave better nett returns than did dalapon. Although dalapon had the advantage of repelling pigeons, the improved broad-leaved weed control and absence of crop damage from propyzamide resulted in higher overall beneficial effects.

As a result of this work, commercial recommendations will be made in the U.K. for winter (October-January) applications of propyzamide at 0.63 lb a.i./acre to control annual grass and broad-leaved weeds in oilseed rape.

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