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PROJECT REPORT No. 131

EFFECTS OF SOIL TYPE, WEATHER AND RESISTANCE ON EFFICACY OF HERBICIDES AGAINST BLACK-GRASS

AUGUST 1996

PRICE £2.00

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by

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This is the final report of a two year project which started in July 1992. The work was funded by a grant of £28,150 from the Home-Grown Cereals Authority (Project No. 0052/1/91).

CONTENTS

Summary

The aim of this of this project was to determine whether soil type, weather effects or genetic differences in resistance to herbicides could explain variability in response to herbicides.

Trays were filled with a standard volume of sandy loam soil from Anstey Hall and seeded with either the local population or the standard susceptible Rothamsted black-grass (*Alopecurus myosuroides*) population. Trays of each population were sunk into field plots at each site and were over-sprayed with either chlorotoluron, isoproturon or fenoxaprop-ethyl. This experiment was repeated in 1992/93 and 1993/94 at each of six locations. The local black-grass population was tested for resistance using the standard glasshouse test but differences in activity in the field were not explained by the results of this test.

Adsorptive capacity of the soil was not a major factor influencing the activity of soil-acting herbicides at the levels recorded at these sites. It was concluded that weather factors had a major effect on the performance of herbicides for the control of black-grass with rainfall before and after spraying probably playing a major role.

The technique used proved difficult particularly in the wet autumn period in 1993. The trays were difficult to sink into the wet field soils in the autumn, particularly on the heavier soils.

Background

Orson (1991) concluded that soil and 'environmental' factors' can have a major influence on the activity of chlorotoluron and isoproturon on black-grass (*Alopecurus myosuroides*). The adsorptive capacity and moisture content of the soil were key factors. At the time resistance was thought to be of less importance on a nation-wide scale than it is now.

Objectives

The objective of this trial series at six sites was to examine the significance in the field of black-grass (*Alopecurus myosuroides*) resistance measured in the standard glasshouse test (Clarke & Moss, 1989). One population (the standard susceptible Rothamsted population) was common to all sites and was grown in trays of a standard soil from ADAS Anstey Hall in Cambridge. At each site there was therefore a comparison between the local population in two soils and between the local and Rothamsted seed populations in the same soil. In addition, there was the comparison between the different geographical locations and between two successive years.

The literature on black-grass resistance was reviewed by Moss & Clarke (1992).

Treatments

Experiments were done in 1992/93 and 1993/94 seasons, hereafter referred to as 1993 and 1994.

A sandy loam soil was collected from Anstey Hall near Cambridge, sieved and sent to all sites. The technique used was the same as that used by S.R. Moss at IACR Rothamsted. Trays (19 by 27 by 10 cm depth) were filled to 2 cm from the top with Anstey soil and 0.8 g seed of either the local (collected earlier in the season) or the standard population was mixed into a small volume of soil and added to the surface of trays to give a seed rate equivalent to 6000/m². The soil types and characteristics are defined in Table 1 along with the date and growth stage at treatment (Tables 2 and 3).

Table 1. Soil type and Kd (measure of adsorption to soil) for chlorotoluron for each soil.

	Site	Soil type	Kd	
			1993	1994
A	Anstey, Cambridge	sandy loam	1.7	1.5
B	Boxworth, Cambridge	clay, Hanslope series	3.1	3.2
C	Bridgets, Winchester	silty loam, Andover/Panhole series	2.3	2.8
D	Morley, Wymondham	chalky loam, Beccles series	2.9	1.9
E	ARC, Winchester	silty loam, Andover series	2.8	2.7
F	E. Hanningfield,Essex	silty clay loam	3.1	3.9
G	Wolverhampton	clay loam, Worcester series	4.4	3.8

Table 2. Spray dates, weed growth stages and soil moisture at treatment in 1993.

Site	Date treated	Soil moisture at treatment		Weed growth stage at treatment
		Tray	Field	
Boxworth	1.2.93	28.9	24.6	GS11-12
Bridgets	30.12.92	30.6	22.3	GS11
Morley	10.12.92	wet	wet	GS11-12
ARC	18.1.93	24.6	20.1	GS11-12
Essex	2.2.93	-	-	GS11-12
Wolverhampton	4.3.93	-	-	GS11-12

Table 3. Spray dates, weed growth stages and soil moisture at treatment in 1994.

Site	Date treated	Soil moisture at treatment		Weed growth stage at treatment
		Tray	Field	
Boxworth	31.1.94	16.4	13.0	GS11-12
Bridgets	7.1.94	21.0	24.5	GS12
Morley	16.1.94	-	-	GS12-13
ARC	31.1.94	27.1	18.7	GS11-21
Essex	31.1.94	-	-	GS11-13
Wolverhampton	2.2.94	-	-	GS13

The local black-grass population was collected during the previous summer from the trial site and the standard susceptible seed was collected from Rothamsted. The samples from the local sites were classified for resistance to chlorotoluron and fenoxaprop-ethyl (Tables 4 and 5) using the ADAS test (Clarke & Moss, 1989).

Table 4. Resistance ratings for chlorotoluron and fenoxaprop-ethyl for samples from the six sites at the start of the experiment in 1993.

Site	Chlorotoluron	Fenoxaprop-ethyl
Boxworth	susceptible	susceptible
Bridgets	susceptible	2-star
Morley	susceptible	2-star
ARC	no germination	no germination
Essex	susceptible	susceptible
Wolverhampton	susceptible	susceptible

Table 5. Resistance ratings for chlorotoluron and fenoxaprop-ethyl for sample from the six sites at the start of the experiment in 1994.

	Chlorotoluron	Fenoxaprop-ethyl
Boxworth	susceptible	susceptible
Bridgets	susceptible	2-star
Morley	susceptible	susceptible
ARC	susceptible	susceptible
Essex	susceptible	susceptible
Wolverhampton	susceptible	susceptible

The trays were sunk into the field plots sown with a winter wheat crop and sprayed along with the plots using a hand-held sprayer fitted with nozzles delivering 200-250 l/ha and operating at 2.1 kPa. Field plot size varied between sites but each tray treatment was replicated four times.

Herbicide treatments in both seasons were;
Chlorotoluron (chloro) at 3.5 kgai/ha as 7.0 l Dicurane/ha
Isoproturon (ipu) at 2.5 kgai/ha as 5.0 l of 500g/l product/ha
Fenoxaprop-ethyl (fenox) at 0.12 kgai/ha as 2.0 l Cheetah-R/ha

Tiller numbers were counted in all boxes and results are expressed as percentage control. Tiller or head numbers were counted in the field at different times and these are detailed in the relevant Tables. Assessments were not always carried out at the same time and hence may not be compared directly (Table 6).

Analysis of data

Data were not statistically analysed because of the high degree of variability in black-grass establishment within and between sites and in response to the various herbicide treatments. These factors result in very high coefficients of variation.

Results and Discussion

Rothamsted black-grass was less well controlled by chlorotoluron at Bridgets and Essex in both years and at Bridgets in 1994 than at the other four sites. Isoproturon performed poorly at the same two sites but also less well at Boxworth (Tables 6 and 7). Fenoxaprop-ethyl only worked consistently at the Morley and ARC sites. It seems likely that these differences for chlorotoluron and isoproturon activity were related to weather rather than soil type since the Wolverhampton soil had the highest Kd and all treatments performed well at this site.

Table 6. Percentage control of Rothamsted (susceptible) black-grass tiller numbers in boxes in 1993.
(date of assessment in brackets)

Treatment	Boxworth	Bridgets	Morley	ARC	Essex	Wolverhampton
	(27/4)	(20/5)	(25/3)	(17/3)	(23/4)	(5/5)
Chloro	99.0	78.1	97.5	100.0	39.5	97.8
Ipu	85.0	43.4	93.7	100.0	72.8	98.5
Fenox	70.0	76.2	98.2	100.0	41.7	100.0

Treatments generally performed similarly in both seasons relative to other treatments although there were small differences in activity of the same treatments between seasons. The most obvious difference was between chlorotoluron activity at the Essex site in both years.

Table 7. Percentage control of Rothamsted (susceptible) black-grass tiller numbers in boxes in 1994.
(date of assessment in brackets)

Treatment	Boxworth	Bridgets	Morley	ARC	Essex	Wolverhampton
	(13/5)	(21/4)	(30/3)	(28/3)	(19/4)	(28/4)
Chloro	100.0	80.0	90.2	100.0	91.5	100.0
Ipu	90.0	68.0	94.3	100.0	61.0	100.0
Fenox	75.0	86.5	95.1	99.4	55.2	75.1

In 1993 there was a considerable range in activity of all herbicides on the local population in trays between sites (Table 8). Chlorotoluron activity was more influenced by site than was isoproturon activity.

Table 8. Percentage control of local (L) and Rothamsted (R) black-grass tillers in boxes in 1993.

Treatment	Boxworth	Bridgets	Morley	ARC	Essex	Wolverhampton
Chloro R	99.0	78.1	97.5	100.0	39.5	97.8
Chloro L	84.7	61.0	66.0	100.0	56.8	62.4
Ipu R	85.0	43.4	93.7	100.0	72.8	98.5
Ipu L	52.0	9.0	85.2	100.0	80.0	91.0
Fenox R	70.0	76.4	98.2	100.0	41.7	100.0
Fenox L	38.3	90.0	94.3	94.0	34.8	84.6

In 1994 chlorotoluron gave excellent control of the local population in trays at three sites and >80% at the other sites (Table 9) and was more consistent than in 1993. Isoproturon also gave >90% control and fenoxaprop-ethyl >89% control at four of the six sites. Isoproturon and fenoxaprop-ethyl both performed less well at Bridgets and the Essex sites than at the other sites.

Table 9. Percentage control of local (L) and Rothamsted (R) black-grass tillers in boxes. in 1994.

Treatment	Boxworth	Bridgets	Morley	ARC	Essex	Wolverhampton
Chloro R	100.0	80.0	90.2	100.0	91.5	100.0
Chloro L	99.0	89.0	85.0	100.0	80.8	100.0
Ipu R	90.0	68.6	94.3	100.0	61.0	100.0
Ipu L	90.5	23.5	95.2	100.0	82.8	100.0
Fenox R	75.0	86.5	95.1	99.4	55.2	75.1
Fenox L	60.5	89.0	92.3	98.5	37.8	100.0

At the Essex site in 1993 chlorotoluron and isoproturon performed less well on the Rothamsted compared to the local population; this has been observed on occasions previously. At Bridgets, fenoxaprop-ethyl gave higher levels of control of the local compared to the susceptible population. In 1994, chlorotoluron at Bridgets controlled the Rothamsted better than the local population whereas at the Essex site the situation with isoproturon was reversed. Fenoxaprop-ethyl was more active on the local compared to the Rothamsted population at the Wolverhampton site.

The difference between the percentage control of susceptible and the local population in trays is illustrated in Figures 1-3. With one or two exceptions, the degree of control of the Rothamsted population is higher than of the local population. The differences observed were not explained by the resistance measured in the glasshouse tests (Tables 4 and 5).

Figure 1. The difference in % control between susceptible and local populations of black-grass by chlorotoluron in 1993 and 1994 at different sites (details in Table 1).

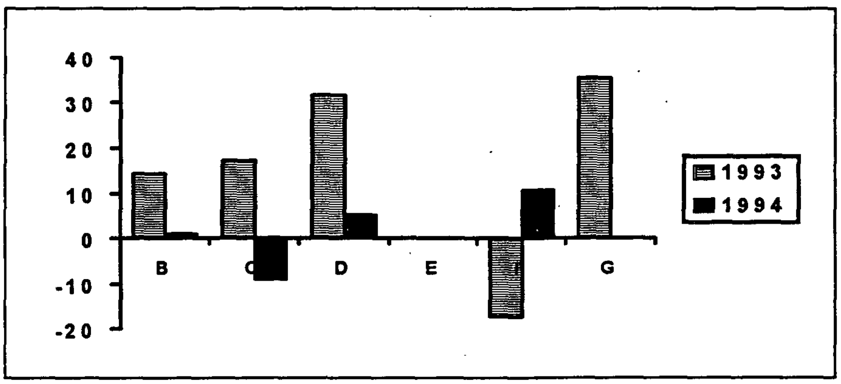


Figure 2. The difference in % control between susceptible and local populations of black-grass by isoproturon in 1993 and 1994 at different sites (details in Table 1).

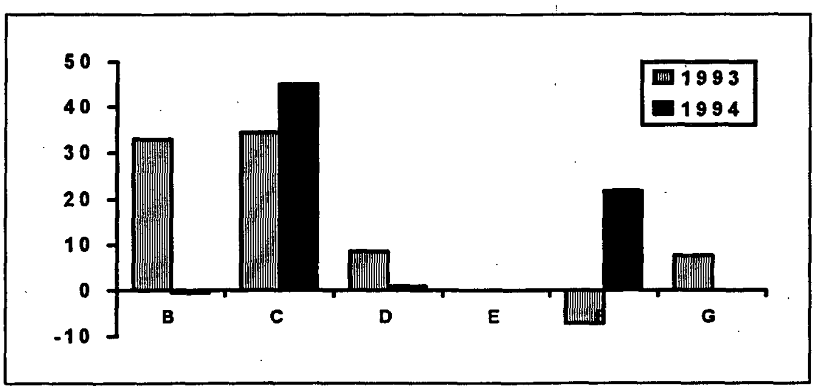
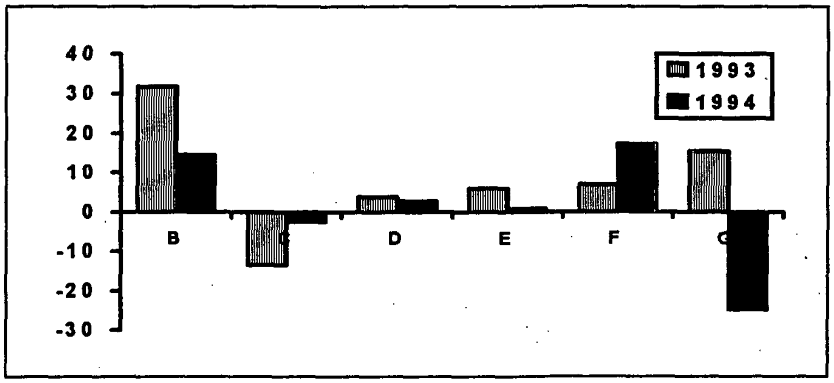


Figure 3. The difference in % control between susceptible and local populations of black-grass by fenoxaprop-ethyl in 1993 and 1994 at different sites (details in Table 1).



It was only possible to make direct comparisons between counts made in March/April in trays and in the field at three sites in 1993 (Table 10). At Boxworth both chlorotoluron and fenoxaprop-ethyl were more active on black-grass in boxes than in the field but there was no difference in response to isoproturon. All treatments worked equally well in both the field and trays at the ARC site. At Wolverhampton, both chlorotoluron and isoproturon perfomed better on black-grass in trays compared to the field whereas with fenoxaprop-ethyl, the situation was reversed. The Anstey soil in trays has a lower Kd than all other soils which could contribute to the greater activity of soil-acting herbicides in this soil.

Table 10. Percentage control black-grass tiller numbers of local population in tray and in the field at three sites in 1993.

Treatment	Boxworth	Boxworth	ARC	ARC	Wolv.	Wolverhampton
	Tray	Field	Tray	Field	Tray	Field
Chloro	84.7	26.4	100.0	100.0	62.4	32.5
Ipu	52.0	52.4	100.0	100.0	91.0	47.9
Fenox	38.3	12.3	94.0	92.9	84.6	98.7

In 1994 (Table 11) comparisons were possible at four sites. Where there were differences, herbicide treatments were more damaging to the black-grass in trays compared to the field plots but the differences were less than in 1993. This suggests that the range of adsorption levels at these sites was not a major factor in the activity of these herbicides.

Table 11. Percentage control of black-grass tillers of the local population in trays and in the field at 6 sites in 1994.

Treatment	Boxworth	Bridgets	Morley	ARC	Essex.	Wolverhampton
	Tray	Tray	Tray	Tray	Tray	Tray
Chloro	99.0	89.0	85.0	100.0	80.8	100.0
Ipu	90.5	23.5	95.2	100.0	82.8	100.0
Fenox	60.5	89.0	92.3	98.5	37.8	100.0
	Field	Field	Field	Field	Field	Field
Chloro	89.0	-	98.7	100.0	79.4	-
Ipu	98.0	-	98.7	100.0	55.7	-
Fenox	79.0	-	99.7	100.0	53.6	-

The cumulative rainfall for 1992/93 and 1993/1994 is presented in Tables 12 and 13 respectively and shows the difference in rainfall between sites in the four-week period post spraying. This may explain some of the differences in black-grass response between sites.

Table 12. Cumulative rainfall (mm) in the four week period post-spraying in 1993.

	Boxworth	Bridgets	Morley	ARC	Essex	Wolverhampton
Days						
7	0.8	6.5	7.0	26.0	6.4	0.8
14	1.8	51.9	12.0	26.0	9.5	1.3
21	2.6	81.4	12.0	55.0	17.2	7.0
28	9.4	100.3	28.5	128.0	34.3	12.5

Table 13. Cumulative rainfall (mm) in the four week period post-spraying in 1994.

	Boxworth	Bridgets	Morley	ARC	Essex	Wolverhampton
Days						
7	11.6	50.3	15.0	28.0	18.7	19.0
14	12.9	67.3	34.0	44.0	21.1	26.8
21	15.0	85.9	36.0	48.0	21.3	35.7
28	28.7	89.1	37.5	69.0	36.8	59.3

Conclusions

- The technique used proved difficult particularly in the wet autumn period in 1993. The trays were difficult to sink into the wet field soils in the autumn, particularly on the heavier soils. It might be better to line the holes with sand prior to locating the trays to ensure that they were level and less likely to sink

- There was a very high degree of variability in the establishment of the populations in boxes in both years. Although the seed samples sown were cleaned, it is difficult to estimate subsequent germination under all weather conditions. The soil in the trays can dry out more quickly than the surrounding field soil or alternatively become very wet due the slightly impeded drainage though the base of the trays.

- It has not been possible to explain the variation between the treatments and sites on the basis of the glasshouse resistance test, Kd or rainfall after application. However, soil acting herbicides are likely to work best when applied to actively growing plants in moist soils with a low adsorption capacity and with rainfall subsequent to spraying.

References

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