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FACTORS AFFECTING THE TOXICITY OF PARAQUAT AND DALAPON TO GRASS SWARDS

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FACTORS AFFECTING THE TOXICITY OF PARAQUAT AND DALAPON TO GRASS SWARDS

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SUMMARY

The influence of different sward and spraying conditions on the effectiveness of sward destruction by paraquat and dalapon was investigated in 4 field experiments. Paraquat caused the greatest reduction in vegetation when sprayed 10 days after cutting. Applications in high volume (562 v. 112 l/ha) increased the effectiveness of both herbicides. When applying paraquat, inclined fan jets were more successful than vertical or opposed inclined fans. The inclusion of a wetting agent increased the overall effect of paraquat applied at high pressure but, at low pressure, spraying without a wetter was more effective. Dalapon at 5.6 kg/ha was more effective than paraquat at 0.28 kg/ha in controlling a range of grass species. However, paraquat was more successful in the control of broad-leaved species.

It was concluded that an enhanced control of vegetation by paraquat and dalapon might be achieved using the techniques described above.

INTRODUCTION

The conventional way to use paraquat for sward destruction has been to treat vegetation that has made 7-15 cm of fresh growth after being cut. The usual technique is to apply the herbicide through vertical jets at a volume rate of between 225 and 450 l/ha and a pressure of 2.07 Bar. The inclusion of a wetting agent is sometimes considered to be beneficial.

However, early work at the Weed Research Organization had suggested that greatest reduction in vegetation could be achieved by treating a frequently defoliated sward with paraquat on the day of cutting (G.P. Allen, unpublished data). Later studies indicated that high volume rates also enhanced the effects of paraquat on a sward (A.K. Oswald, unpublished data). Work on the analysis of foliage distrubution in grassland by point quadrat has shown that an inclined needle makes more contacts with vegetation than a vertical needle (Warren Wilson, 1960). It was thought, therefore, that if spray drops were directed onto the vegetation by an inclined fan there would be greater contact, leading to a more efficient retention.

Four experiments were carried out to ascertain whether these factors might have any influence on the performance of paraquat and dalapon used for sward destruction.

METHOD AND MATERIALS

Details of the experiment sites and methods are shown in table 1. Before spraying, the botanical composition was measured by one of two methods. The first was to count all grass tillers, clover petioles and broad-leaved plants present in 90 turf cores, each 10.8 cm in diameter, taken at random over the experimental area. The second method was to use an inclined point quadrat to record all contacts with vegetation at 250 points over the experiment area (table 2).

Table 1 Details of experiment sites, management and assessments

	EXPERIMENT NO. 1	2	3	4
Location at WRO	Lime Kilns	Lime Kilns	Lime Kilns	The Crossing
Soil type	Sandy loam	Sandy loam	Sandy loam	Silty clay loam
Age of sward	1 year	2 years	2 years	At least 40 years
Pre-spray management	Grazed by beef cattle Silage cut in June	As experiment 1	As experiment 1	As experiment 1
Sward height at spraying (cm)				
0 days after cut	6-10	10-15	7.5-10	2.5
5 " " "	8-13			
10 " " "	11-18		15-20	10
Plot size (m)	Main plots 10.9 x 13.7 Treated plots 10.9 x 2.3	9.15 x 2	9.15 x 2	8 x 2
Number of replicates	3	3	3	3
Date of spraying	27 September, 1971	4 October, 1971	10 October, 1971	20 October, 1972
Method of spraying	Oxford Precision Sprayer (OPS)	OPS mounted on wheels running on metal tracks	As experiment 2	As experiment 1
Assessments				
Visual scores	Weekly from spraying until November, then monthly until late April	As experiment 1	As experiment 1	Weekly from spraying until January, then monthly until June
Point quadrat	23 November, 1971 17 April, 1972	1 December, 1971 8 May, 1972	29 November, 1971 3 May, 1972	22 January, 1973 4 June, 1973

Table 2. Composition of swards used in the experiments just before spraying.

Species		Percentage presence			
	Experiment	1	2	3	4
	Assessment method	90 random turf cores	90 random turf cores	90 random turf cores	250 random point quadrat points
	Date	27.9.71	4.10.71	1.10.71	20.10.72
Holcus lanatus		25	15	9	16
Festuca rubra		24	7	17	47
Lolium perenne		18	18	19	6
Agrostis stolonifera		11	27	26	15
Poa trivialis		11	27	24	0
Other grasses		8	4	3	12
Trifolium repens		3	1	1	0
Other broad-leaved spp.		0	1	1	4

After spraying, treated plots were scored periodically using a scale from 0 (no green material visible) to 9 (no visible effect). On each occasion two people scored independently and the mean of both scores was recorded. An inclined point quadrat was used to measure the relative frequency of the sward constituents on two occasions after treatment.

EXPERIMENT 1. THE INFLUENCE OF SWARD MANAGEMENT AND CUT-SPRAY INTERVAL ON THE SWARD KILLING PROPERTIES OF PARAQUAT AND DALAPON

Method and Materials

Eighteen experimental treatments were compared in three replicates.

Herbicide	Sward management	Cut-spray interval
Paraquat @ 0.28 kg ai/ha	Grazed continuously before spraying	0 days
Dalapon @ 5.6 kg ae/ha	Cut once before spraying	5 days
	Cut three times before spraying	10 days

The herbicides were sprayed in 225 l water/ha with 0.1% Agral 90 surfactant through '00' ceramic fan jets at 2.07 Bar.

Results

Effects of the herbicides on the sward. Mean effects of paraquat developed quickly, reaching a maximum one week after spraying (fig. 1). Thereafter vegetation recovered although reductions of 25% were still visible 30 weeks after spraying. Dalapon was slower to act and maximum effects were not recorded until 20 weeks after spraying. These were maintained for 2-5 weeks. Reductions of 45-55% were still visible 30 weeks after spraying. A greater reduction in vegetation was achieved by applying dalapon than by paraquat, when assessed 8 and 30 weeks after spraying; on the latter occasion, paraquat-treated plots were showing considerable recovery (fig. 5a).

Influence of sward management on herbicide performance. Pre-spraying treatments had no significant effect on the efficacy of either herbicide.

Influence of cut-spray interval on herbicide performance. Paraquat caused most sward damage when sprayed 10 days after cutting (fig. 2b). Dalapon was more effective, initially, when applied on the day of cutting but there was no significant difference in the response of the sward to cut-spray interval when assessed 30 weeks after spraying.

Effects of the herbicides on individual species. Holcus lanatus was more severely checked by paraquat than dalapon 8 weeks after spraying but eventually dalapon achieved the greatest reduction (Table 3). Festuca rubra, Lolium perenne, Agrostis stolonifera, Poa trivialis and Trifolium repens were more susceptible to dalapon than paraquat at all times. Phleum pratense and Dactylis glomerata were damaged equally by both chemicals but recovery after dalapon was significantly less than after paraquat. Ranunculus bulbosus and Plantago spp. were most susceptible to paraquat.

Influence of sward management on individual species. Significant reductions of L. perenne were noted on plots cut frequently before spraying, especially with paraquat. There were no differences in the response of the other species present. (Table 3).

Influence of cut-spray interval on individual species. Paraquat was more damaging to H. lanatus when applied 10 days after cutting. Dalapon was initially most effective when sprayed on the same day as cutting (Table 3). L. perenne was most susceptible to paraquat sprayed 10 days after being cut. P. trivialis was significantly reduced by paraquat sprayed on the same day as cutting and by both herbicides applied 5 days later. T. repens was most effectively controlled by paraquat sprayed 10 days after cutting.

Discussion

The type of management before spraying did not influence the effects of the herbicides on the sward as a whole. There was no significant difference between the effects of the herbicides on swards cut or grazed before spraying. However, L. perenne cut frequently was more susceptible to paraquat.

The results of this work indicate that paraquat is more effective for sward destruction when sprayed onto grass which has been allowed to make several days' growth after cutting. Dalapon is shown to be as effective when sprayed on the day of cutting as when sprayed after grass growth.

Paraquat was more effective when sprayed 10 days after defoliation. Unfortunately the desirable species, L. perenne and T. repens were affected more than unwanted species.

The use of dalapon was more promising. L. perenne was not damaged any more severely after cutting and spraying on the same day as when it was cut and then treated 10 days later. The more undesirable species, H. lanatus, F. rubra and P. trivialis were all more susceptible when treated immediately after cutting.

This result is relevant to the use of dalapon for selective suppression of indigenous grasses in rye-grass pastures. Low doses could be applied in June/July on swards cut or grazed then treated on the same day, resulting in the removal of unwanted species and the encouragement of rye-grass.

Experiment 1

Fig. 1. Effects on green material.
Scored 0 (no green material visible) to 9 (no visible effect).

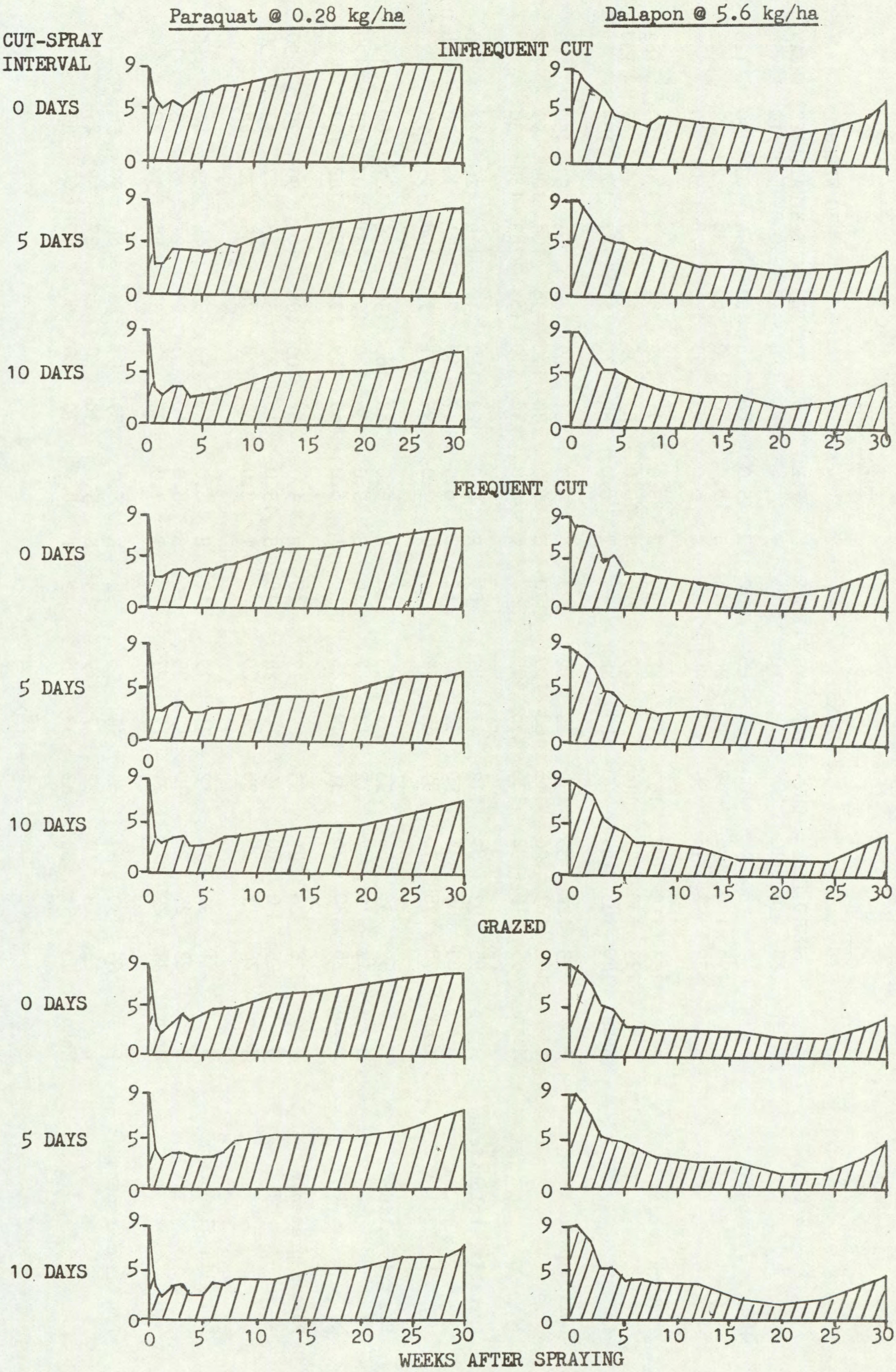


Table 3. Experiment 1. The frequency of the main species present 8 and 30 weeks after spraying in three sward types cut at different times before spraying with paraquat (P) at 0.28 kg/ha and dalapon (D) at 5.6 kg/ha on 27 September 1971. All figures are log values multiplied by 100.

		TREATMENTS																	
		8 WEEKS									30 WEEKS								
SPP		SWARD TYPE			CUT-SPRAY (DAYS)			MEAN		S.E.	SWARD TYPE			CUT-SPRAY (DAYS)			MEAN		S.E.
		FC	G	IC	0	5	10				FC	G	IC	0	5	10			
Holcus lanatus	P	39	78	92	100	64	46	70	H	5.0	86	124	150	154	103	90	126	H	9.0
	D	98	100	136	89	117	128	115	S	14.0	0	0	69	26	22	21	23	S	20.0
	Mean	79	92	118	95	95	104		T	6.0	43	90	126	128	90	70		T	11.0
Festuca rubra	P	153	155	158	157	157	152	155	H	5.0	171	192	183	188	178	180	182	H	6.0
	D	123	130	127	116	135	129	126	S	10.0	141	136	113	125	145	119	130	S	7.0
	Mean	140	143	145	140	146	142		T	6.0	154	172	161	167	164	159		T	7.0
Lolium perenne	P	95	126	139	134	124	102	123	H	5.0	141	149	180	163	157	150	160	H	7.0
	D	104	103	126	116	108	109	110	S	6.0	70	100	136	108	104	95	102	S	13.0
	Mean	95	115	132	126	116	105		T	6.0	118	130	163	143	138	130		T	8.0
Agrostis stolonifera	P	94	93	89	112	77	87	89	H	6.0	122	142	119	134	126	123	128	H	6.0
	D	63	65	31	50	52	57	52	S	6.0	7	15	22	21	13	10	14	S	9.0
	Mean	78	78	70	87	64	72		T	7.0	95	111	95	108	95	95		T	7.0
Poa trivialis	P	59	36	46	53	45	43	46	H	5.0	188	166	150	166	167	180	171	H	3.0
	D	17	9	7	12	13	7	10	S	5.0	136	120	107	131	107	125	120	S	8.0
	Mean	38	20	26	31	29	25		T	6.0	169	149	132	151	142	159		T	4.0
Phleum pratense	P	28	26	41	43	25	17	28	H	5.0	61	100	106	103	90	75	90	H	9.0
	D	25	0	30	13	18	24	18	S	13.0	18	23	32	43	17	13	30	S	13.0
	Mean	26	13	35	28	21	20		T	7.0	48	78	78	85	70	48		T	11.0
Dactylis glomerata	P	11	31	10	12	21	19	17	H	6.0	60	53	53	64	63	40	55	H	6.0
	D	23	27	28	30	13	35	26	S	8.0	10	0	21	21	7	3	10	S	5.0
	Mean	17	29	19	21	17	27		T	7.0	35	20	37	48	30	30		T	8.0
Trifolium repens	P	65	50	57	64	58	50	54	H	6.0	89	53	86	84	90	54	78	H	5.0
	D	24	13	10	22	7	19	15	S	5.0	38	0	18	27	9	27	16	S	13.0
	Mean	44	31	33	43	33	35		T	8.0	70	20	60	60	60	40		T	7.0

Table 3. cont.

SPP		TREATMENTS 8 WEEKS SWARD TYPE FC	G	IC	CUT-SPRAY(DAYS) 0	5	10	MEAN		S.E.	30 WEEKS SWARD TYPE FC	G	IC	CUT-SPRAY(DAYS) 0	5	10	MEAN		S.E.
Ranunculus bulbosus	P	25	31	9	21	23	21	22	H	5.0	46	60	49	53	49	53	51	H	6.0
	D	42	42	53	44	42	51	46	S	5.0	77	83	67	79	68	80	70	S	9.0
	Mean	33	36	31	32	32	36		T	6.0	60	70	60	60	60	60		T	8.0
Plantago spp	P	40	55	58	35	58	61	51	H	5.0	32	64	36	37	41	55	48	H	6.0
	D	37	47	55	45	37	57	46	S	5.0	68	82	71	67	78	76	70	S	10.0
	Mean	38	51	56	40	47	59		T	6.0	48	70	48	48	60	70		T	7.0

<u>Key to abbreviations</u> Sward types. FC. Frequent cut, G. Grazed, IC. Infrequent cut.
S.E. H. Herbicide, S. Sward type, T. Tine between cut and spray.

EXPERIMENT 2. THE INFLUENCE OF PRESSURE AND VOLUME RATE ON THE SWARD KILLING PROPERTIES OF PARAQUAT APPLIED WITH OR WITHOUT WETTER

Method and Materials

The herbicide treatment was paraquat @ 0.28 kg ai/ha.

The 12 experiment treatments were laid out in three replicates and are shown, with the relevant spray jets in brackets, as follows:

Volume (l/ha)	Pressure (Bar)		Wetter
	1.4	2.8	Conc. in spray liquid
112	(No 80015)	(No 80067)	0.1% Agral 90
337	(" 8004)	(" 8002)	No wetter
562	(" 8006	(" 8005)	

Results

Effects of the herbicides on the sward. Reductions in green material recorded 24 hr after spraying on all treated plots, ranged from 75 to 100% (fig. 2).

Influence of volume rate on herbicide performance. Applications in a volume of 562 l/ha gave a significantly better sward kill than applications at lower rates (fig. 5c).

Influence of pressure and wetter on herbicide performance. There was no direct influence of pressure or wetter on the effects on the sward. However, when wetter was not added the effects of applications at 337 l/ha were increased by spraying at the lower of the two pressures. At the high pressure the addition of wetter increased the effects of the herbicide sprayed at 337 l/ha. (fig. 5d).

Influence of volume rate on individual species. F. rubra and T. repens was most severely damaged by paraquat sprayed in a volume of 562 l/ha, when assessed 8 weeks after treatment (Table 4). P. trivialis was significantly reduced 30 weeks after spraying in a volume of 562 l/ha.

Influence of pressure on individual species. F. rubra was checked more effectively when spray applications were made at 1.4 Bar rather than at 2.8 Bar (Table 4). None of the other species responded to the direct influence of pressure.

Influence of wetter on individual species. F. rubra was reduced most significantly when wetter was not added to the spray volume of 337 l/ha applied at 2.4 Bar. (Table 4). The presence or absence of wetter made no difference to the effects of the high pressure treatment. Taraxicum officinale was significantly damaged after spraying at 337 l/ha when wetter was added. In the absence of wetter the low pressure was more effective than the high pressure.

Discussion

The effects on the sward were more severe when the high volume rate was used. This implies that vegetation should be adequately covered by chemical spray in order to achieve satisfactory sward destruction, especially from a

Experiment 2

Fig. 2 Effects of paraquat at 0.28 kg/ha on green material. Scored 0(no green material visible) to 9 (no visible effect)

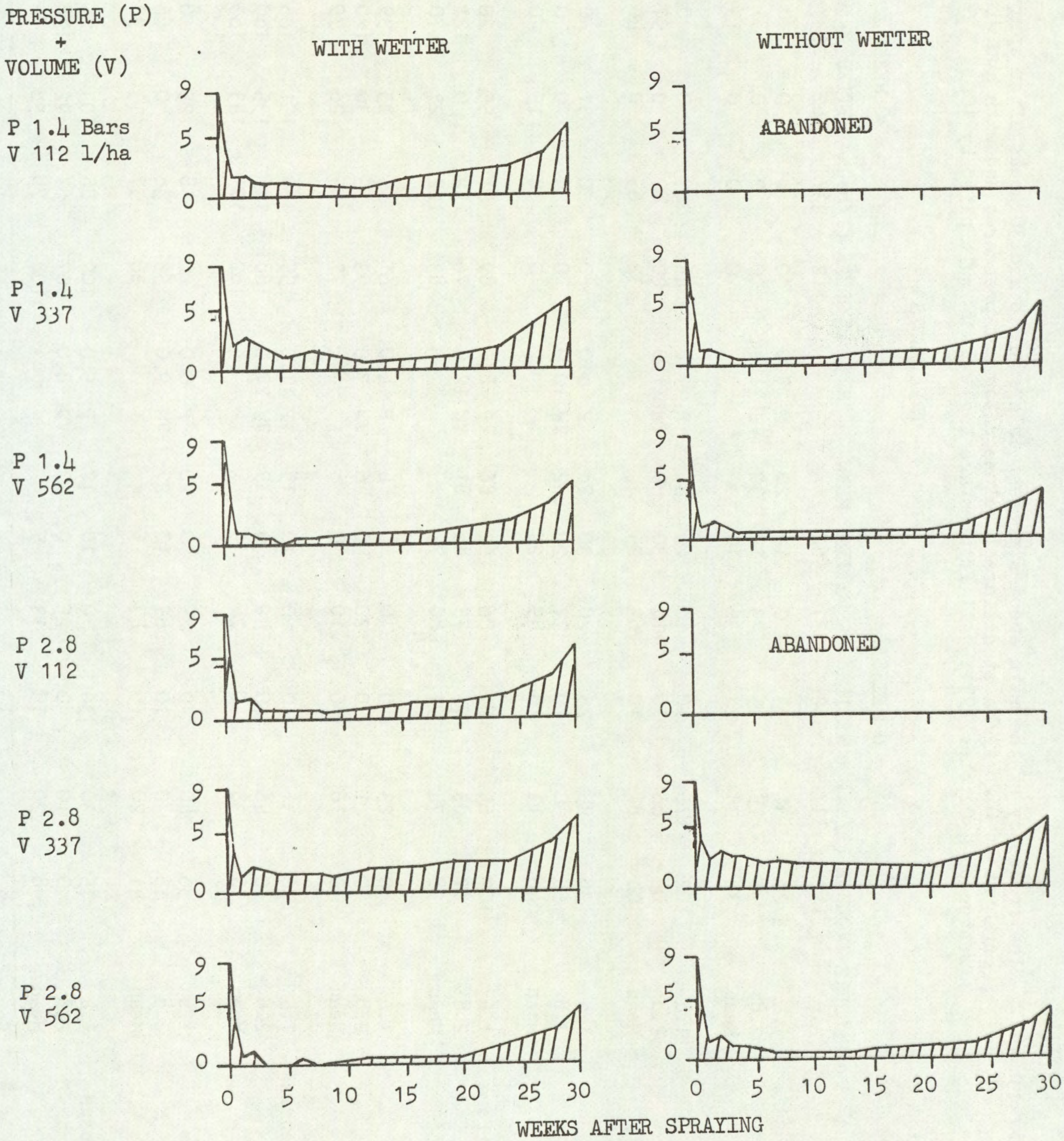


Table 4. Experiment 2. The frequency of the main species present in a sward 8 and 30 weeks after spraying paraquat at 0.28 kg/ha at different volume rates and pressures and with and without wetter on 4 October 1971. All figures are log values multiplied by 100.

SPP	PRESSURE (Bar)	8 WEEKS VOLUME (l/ha) + WETTER 112	337	562	- WETTER 337	562	MEAN	S.E.	30 WEEKS VOLUME (l/ha) + WETTER 112	337	562	- WETTER 337	562	MEAN	S.E.
Holcus lanatus	1.4	28	31	33	0	10	20	P 7.0	0	0	0	0	0	0	P 4.0
	2.8	36	15	15	73	10	30	VW 11.0	0	0	0	31	0	6	VW 7.0
	Mean	32	23	24	36	10			0	0	0	15	0		
Festuca rubra	1.4	102	76	10	10	20	44	P 7.0	44	47	0	0	15	21	P 11.0
	2.8	105	86	10	114	30	69	VW 11.0	20	82	0	97	25	45	VW 17.0
	Mean	104	81	10	62	25			32	65	0	48	20		
Lolium perenne	1.4	38	25	25	20	30	28	P 6.0	0	0	31	0	0	6	P 4.0
	2.8	54	0	10	77	20	32	VW 10.0	0	0	0	0	0	0	VW 7.0
	Mean	46	13	18	49	25			0	0	15	0	0		
Agrostis stolonifera	1.4	109	65	107	86	62	86	P 8.0	89	91	55	20	36	58	P 14.0
	2.8	87	83	75	75	84	81	VW 12.0	76	152	0	121	61	82	VW 22.0
	Mean	98	74	91	80	73			83	122	27	70	48		
Poa trivialis	1.4	0	23	0	0	0	4	P 4.0	61	95	23	39	33	50	P 8.0
	2.8	0	1	0	20	0	6	VW 7.0	93	75	30	120	40	72	VW 13.0
	Mean	0	16	0	10	0			77	85	26	79	36		
Alopecurus pratensis	1.4	36	31	0	0	10	15	P 17.0	155	159	151	166	134	153	P 7.0
	2.8	0	46	0	49	0	19	VW 27.0	168	186	135	160	157	161	VW 12.0
	Mean	18	38	0	24	5			162	173	143	163	145		
Trifolium repens	1.4	36	40	0	25	0	20	P 6.0	20	38	25	0	0	16	P 6.0
	2.8	46	0	10	69	10	27	VW 9.0	53	36	0	66	15	34	VW 10.0
	Mean	41	20	5	47	5			36	37	13	33	8		
Ranunculus bulbosus	1.4	15	30	30	0	10	17	P 5.0	109	88	104	25	56	76	P 9.0
	2.8	0	10	0	25	0	7	VW 8.0	107	67	92	118	85	94	VW 14.0
	Mean	8	20	15	13	5			108	78	98	72	70		

Table 4. cont.

		TREATMENTS														
		8 WEEKS							30 WEEKS							
SPP	PRESSURE (Bar)	VOLUME (l/ha) 112	337	+ WETTER 562	- WETTER 337	562	MEAN	S.E.		VOLUME (l/ha) 112	337	+ WETTER 562	- WETTER 337	562	MEAN	S.E.
Rumex acetosa	1.4	15	25	0	0	10	10	P	5.0	121	108	105	62	116	103	P 8.0
	2.8	20	25	0	15	15	15	VW	8.0	130	86	83	110	111	104	VW 13.0
	Mean	18	25	0	8	13				126	97	94	86	114		
Taraxicum officinale	1.4	25	15	0	10	0	10	P	4.0	112	104	77	46	98	87	P 5.0
	2.8	10	15	10	15	0	10	VW	7.0	115	98	70	113	77	95	VW 9.0
	Mean	18	15	5	13	0				113	101	74	80	88		

<u>Key to S.E. abbreviations</u> P. Pressure, VW. Volume/Wetter interaction

contact herbicide. This applies particularly to fine leaved grasses such as F. rubra where aqueous sprays are not easily retained.

It was suggested, however, that even high volume rates should not be applied at too great a pressure as this can also result in spray running off vegetation.

The addition of a wetting agent can reduce the risk of chemical run-off, otherwise lower rates of volume and pressure are advisable.

EXPERIMENT 3. THE INFLUENCE OF SPRAY NOZZLE TYPE AND CUT-SPRAY INTERVAL ON THE SWARD KILLING PROPERTIES OF PARAQUAT AND DALAPON

Method and Materials

The following 12 treatment combinations were applied in three replicates

Herbicide	Spray nozzle type	Cut-spray interval
Paraquat @ 0.28 kg ai/ha	Vertical fan	0 days
Dalapon @ 5.6 kg ae/ha	Inclined fan	10 days
	Opposed inclined fans	

The herbicides were applied at a pressure of 2.07 Bar and a volume rate of 225 l water/ha containing 0.1% Agral 90 surfactant.

For nozzle types 1 and 2, Tee jets No. 8002 were placed at vertical or inclined forward at 32.5° from vertical on the spray boom. For nozzle type 3, Tee jets No. 80067 were placed in pairs with one nozzle pointing forward and the other backward, each at an angle of 32.5° from vertical. This gave an internal angle of 65°.

Results

Effects of the herbicides on the sward. The effects of both herbicides were as previously recorded (fig. 3).

Influence of spray direction on herbicide performance. The effects of dalapon on the sward were initially greater when the treatment was sprayed in a vertical or inclined fan than an opposed inclined fan (fig 5f). Only the inclined fan was significantly more effective than the opposed inclined fan when spraying paraquat. There was no difference due to spray direction when effects were assessed 30 weeks after spraying.

Influence of cut-spray period on herbicide performance. When assessed 8 weeks after spraying, dalapon was more effective when sprayed on the day of cutting, but this influence was not evident 30 weeks after spraying (fig. 5g). Paraquat was not affected significantly by cut-spray period.

Effect of the herbicide on individual species. Initial control of H. lanatus was more effective after paraquat treatment but greater reduction was recorded 30 weeks after spraying with dalapon (Table 5). The eventual reduction of A. stolonifera was significantly greater after spraying with dalapon. This was also true of A, pratensis and T. repens. Ranunculus bulbosus and Cerastium vulgatum were both significantly reduced by paraquat.

Influence of spray direction on individual species. Spraying dalapon through a vertical fan caused the most effective reduction of F. rubra 8 weeks after spraying (Table 5). Spraying in an inclined fan was significantly more effective

Experiment 3

Fig. 3. Effects on green material.
Scored 0(no green material visible) to 9 (no visible effect).

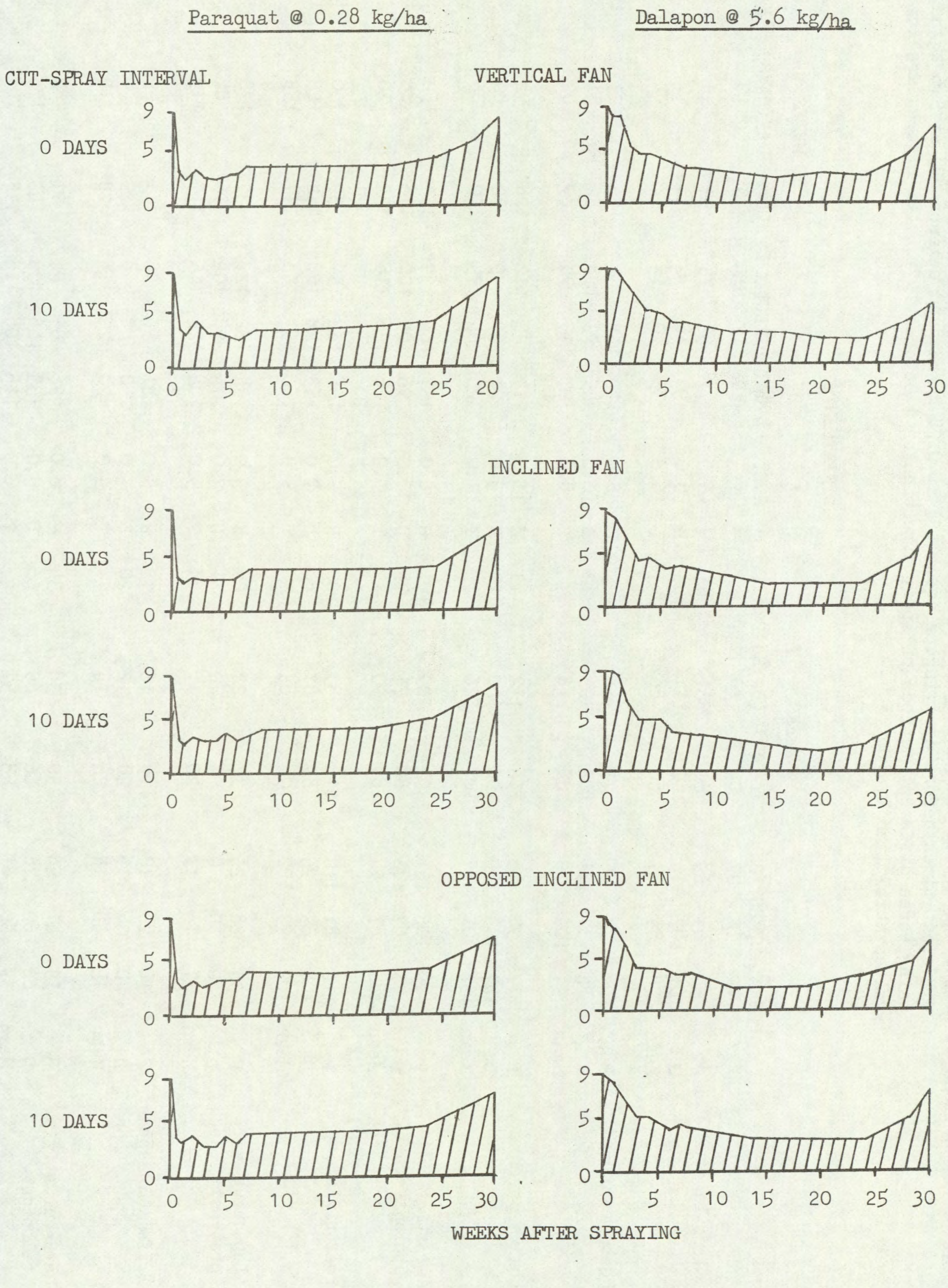


Table 5. Experiment 3. The frequency of the main species present 8 and 30 weeks after spraying in a sward cut at different times before spraying paraquat (P) at 0.28 kg/ha, and dalapon (D) at 5.6 kg/ha, using three different methods of spray direction on 1 October 1971. All figures are log values multiplied by 100.

		TREATMENTS															
		8 WEEKS								30 WEEKS							
		SPRAY DIRECTION			CUT-SPRAY(DAYS)		MEAN	S.E.		SPRAY DIRECTION			CUT-SPRAY(DAYS)		MEAN	S.E.	
		VF	IF	OF	0	10				VF	IF	OF	0	10			
Holcus lanatus	P	54	63	65	61	61	61	H	6.0	71	62	73	92	45	68	H	8.0
	D	101	107	110	100	111	106	D	8.0	0	18	0	12	0	6	D	10.0
	Mean	78	85	87	80	86		T	6.0	35	40	36	52	22		T	8.0
Festuca rubra	P	108	77	95	73	114	93	H	8.0	110	138	81	96	123	109	H	12.0
	D	74	132	131	102	123	112	D	10.0	45	93	108	82	81	82	D	15.0
	Mean	91	105	113	88	118		T	8.0	77	115	94	89	102		T	12.0
Lolium perenne	P	117	98	124	114	112	113	H	11.0	119	98	112	128	92	110	H	12.0
	D	147	103	110	100	140	120	D	13.0	121	29	79	72	80	76	D	15.0
	Mean	132	101	117	107	126		T	11.0	120	64	95	100	86		T	12.0
Agrostis stolonifera	P	95	106	101	94	109	101	H	8.0	157	164	137	153	152	152	H	8.0
	D	73	67	86	80	71	75	D	10.0	96	109	100	116	88	102	D	10.0
	Mean	84	87	94	87	90		T	9.0	126	136	118	134	120		T	8.0
Poa trivialis	P	110	81	110	118	83	100	H	5.0	166	154	159	159	160	160	H	5.0
	D	106	65	94	89	87	88	D	7.0	153	148	148	154	145	150	D	6.0
	Mean	109	73	102	104	85		T	5.0	160	151	153	157	153		T	5.0
Alopecurus pratensis	P	34	28	25	37	22	29	H	5.0	134	152	127	137	138	138	H	11.0
	D	0	5	0	3	0	1	D	7.0	74	98	102	96	87	92	D	14.0
	Mean	17	16	13	20	11		T	5.0	104	125	115	117	113		T	11.0
Trifolium repens	P	18	25	10	19	16	17	H	5.0	41	50	28	51	29	40	H	4.0
	D	10	34	18	28	12	20	D	7.0	0	0	8	5	0	2	D	5.0
	Mean	14	30	14	24	14		T	5.0	20	25	18	28	14		T	4.0
Ranunculus bulbosus	P	15	41	46	30	38	34	H	8.0	96	69	94	91	82	87	H	8.0
	D	62	60	76	66	65	66	D	9.0	135	146	133	143	134	138	D	10.0
	Mean	39	50	61	48	52		T	8.0	116	108	114	117	108		T	8.0

Table 5. cont.

SPP		8 WEEKS SPRAY DIRECTION VF	IF	OF	CUT-SPRAY (DAYS) 0	10	MEAN	S.E.	30 WEEKS SPRAY DIRECTION VF	IF	OF	CUT-SPRAY (DAYS) 0	10	MEAN	S.E.
Taraxicum officinale	P	68	40	64	80	25	57	H 6.0	118	101	128	137	95	116	H 4.0
	D	64	67	74	74	63	68	D 7.0	141	114	129	128	128	128	D 5.0
	Mean	66	53	69	77	49		T 6.0	130	108	129	132	111		T 4.0
Cerastium vulgatum	P	8	10	21	16	10	13	H 6.0	10	15	20	17	13	15	H 6.0
	D	47	28	43	40	38	39	D 7.0	48	67	37	63	38	51	D 8.0
	Mean	27	19	32	28	24		T 6.0	29	41	28	40	26		T 6.0

Key to abbreviations

Spray direction: VF. Vertical fan, IF. Inclined fan, OF. Opposed inclined fan.
S.E. H. Herbicide, D. Spray direction, T. Time between cut and spray.

in reducing P. trivialis than other spray directions when vegetation was assessed 8 weeks after spraying. T. officinale was also greatly reduced 30 weeks after treatments sprayed in an inclined fan.

Influence of cut-spray period on individual species. F. rubra. Most effectively reduced 8 weeks after spraying on the day of cutting (Table 5). P. trivialis and T. officinale. Initial reductions were greatest after spraying 10 days after cutting.

Discussion

The effects of spraying paraquat or dalapon through vertical or inclined fan nozzles were similar. There was an indication, however, that paraquat was more effective when applied in an inclined fan. Of the individual species, P. trivialis and T. officinale were more effectively controlled after spraying with an inclined fan nozzle. This suggests that more work needs doing on the response of different species to directional spraying.

Dalapon provided better sward destruction when applied on the day of cutting, as indicated in experiment 1. Paraquat was not influenced by cut-spray interval.

EXPERIMENT 4. THE INFLUENCE OF SPRAYING TECHNIQUE ON THE SWARD KILLING PROPERTIES OF DALAPON

Method and Materials

Earlier, unpublished work including experiments 1 to 3 had indicated the influence of certain factors on the efficacy of dalapon sprayed for sward destruction. It was therefore decided to compare the traditional method of applying dalapon with an experimental technique which combined the relevant factors, to see whether a more effective treatment could be achieved.

The herbicide doses and spraying techniques were applied in the following 8 treatment combinations laid out in 3 replicates:

	Spray technique	
Dalapon dose	Traditional	Experimental
13.5 kg ae/ha 9.0 " 4.5 " 0 "	Sward cut 10 days before spraying (Erect sward, 10 cm high. Spray pressure 2.07 Bar. Spray volume 225 l/ha. Spray nozzle, vertical fan)	Sward cut on day of spraying (Prostrate sward, 2.5 cm high. Spray pressure 2.8 Bar. Spray volume 562 l/ha. Spray nozzle, inclined fan)

Tee jets No. 8002 were used for the traditional technique and No. 8005, pointed forward at 32.5° from vertical, were used for the experimental technique. The spray solution contained 0.1% Agral 90.

Results

Effects of the herbicide on the sward. The appearance of the effects of the 13.5 kg/ha dose was recorded three days after spraying. Effects of the 9.0 and 4.5 kg/ha doses were not noted until 4 days later (fig. 4). Maximum effects were recorded 15 weeks after spraying at high and medium doses and 20 weeks after the low dose. Sward recovery began after 20 weeks but was not complete 32 weeks after spraying. All dalapon doses significantly reduced the frequency of live vegetation when compared to the unsprayed control, although recovery of the sward was taking place 32 weeks after spraying (fig. 5h).

Influence of spray technique on herbicide performance. Reductions in vegetation were greater on plots where dalapon had been applied using the experimental spraying technique (fig. 5j).

Effects of the herbicide on individual species. F. rubra was reduced significantly by all doses, although some recovery was recorded after 32 weeks (Table 6). There was little effect on Deschampsia caespitosa 13 weeks after spraying but eventually all doses caused significant reductions. H. lanatus, A. stolonifera and P. trivialis had all been eradicated when effects were assessed 13 weeks after spraying. The three species had made some recovery by 32 weeks but frequency of H. lanatus and A. stolonifera was still significantly lower on treated plots than on unsprayed controls. There were no treatment effects on P. trivialis at this time. No statistical analysis of the effects on L. perenne was possible. Eradication was recorded even 32 weeks after spraying all doses. There was no effect on any of the broad-leaved species when assessed 13 weeks after spraying. R. bulbosus, Rumex acetosa, and C. vulgatum were more abundant on treated plots 32 weeks after spraying.

Influence of spray technique on individual species. The effects on T. officinale were greater when treatments were applied using the experimental technique (Table 6). There was no individual reaction from any of the other species.

Discussion

The experimental technique of applying dalapon for sward destruction was more successful than the traditional method. Initial sward kill was more severe while ultimate recovery was significantly less.

It is not possible to say from this experiment which of the factors in the new technique were most influential. It may be that some did not influence herbicide effects at all while others caused the differences that were recorded. Alternatively, the combination of all four factors have been the reason for the success of the technique.

The delay in sward recovery is of special importance in an autumn sward destruction treatment where spring re-seeding follows. The less indigenous vegetation there is present before sowing, the more successful will be the new crop. Competition will be reduced and the need to re-spray with a quick-acting non-residual herbicide will not arise.

Before the experimental technique can be recommended however, more detailed work is required. The contribution of the individual factors, alone and when combined in the experimental technique, needs to be determined.

CONCLUSION

These results indicate that there is scope for improvement in the control of vegetation by paraquat or dalapon. For example, paraquat applied at high rates of spray volume and pressure through inclined fan nozzles onto vegetation cut 10 days before might improve the degree of sward kill achieved at present.

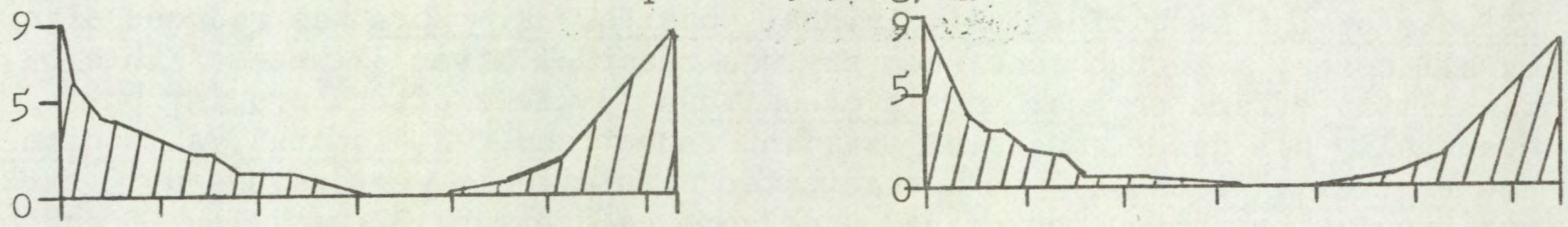
Dalapon could also be made more effective if used in a similar way except that spraying should occur on the day of sward defoliation.

Experiment 4

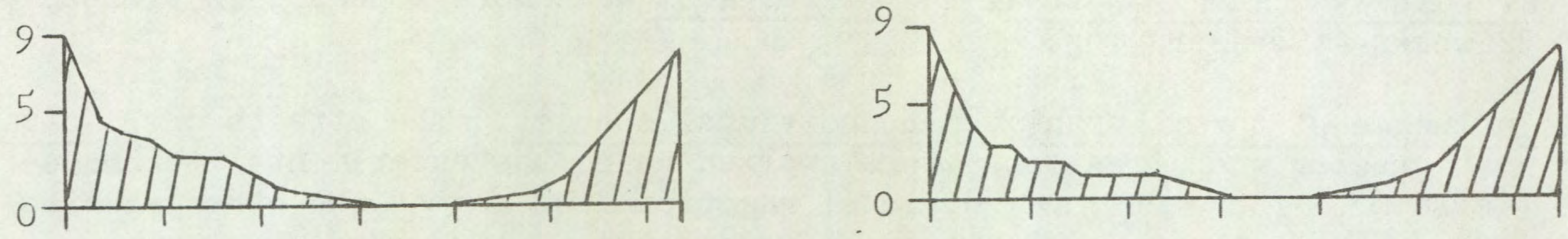
Fig. 4. Effects on green material
Scored 0(no green material visible) to 9 (no visible effect)

TRADITIONAL TECHNIQUE   EXPERIMENTAL TECHNIQUE

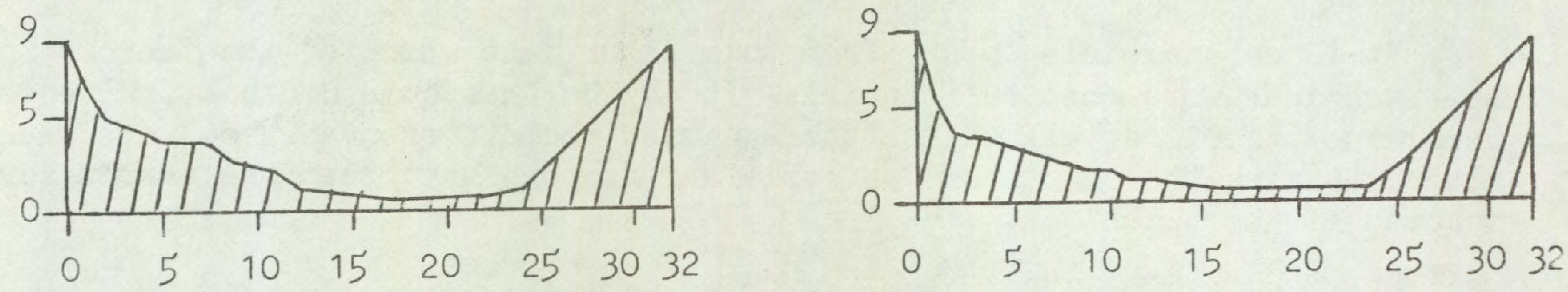
Dalapon @ 13.5 kg/ha



Dalapon @ 9.0 kg/ha



Dalapon @ 4.5 kg/ha



WEEKS AFTER SPRAYING

Table 6. Experiment 4. The frequency of the main species present in a sward 8 and 32 weeks after dalapon applied using traditional (T) and experimental (E) techniques on 20 October 1972. All figures are log values multiplied by 100.

SPP	SPRAY TECHNIQUE	TREATMENTS 8 WEEKS DALAPON DOSE (kg/ha) 13.5	9.0	4.5	0	MEAN	S.E.	32 WEEKS DALAPON DOSE (kg/ha) 13.5	9.0	4.5	0	MEAN	S.E.
Holcus lanatus	T	Not present						10	10	0	199	55	4.0
	E							0	15	10	202	57	
Festuca rubra	T	109	108	139	200	139	6.0	155	170	164	205	174	4.0
	E	64	89	124	204	120		177	153	179	217	181	
Agrostis stolonifera	T	Not present						62	47	40	143	73	6.0
	E							56	70	69	132	81	
Poa trivialis	T	Not present						97	135	86	86	101	12.0
	E							49	77	103	93	80	
Alopecurus pratensis	T	Not present						119	101	131	153	126	9.0
	E							109	109	84	133	109	
Deschampsia caespitosa	T	88	73	41	82	71	9.0	0	20	10	116	36	6.0
	E	36	78	63	99	69		0	23	20	109	38	
Trifolium repens	T	36	20	46	71	43	6.0	60	65	92	99	79	16.0
	E	20	31	56	36	36		59	63	127	70	80	
Ranunculus bulbosus	T	59	46	79	40	56	8.0	175	153	160	100	147	4.0
	E	36	58	93	51	60		152	146	172	89	140	
Rumex acetosa	T	10	41	56	60	42	6.0	169	178	145	73	141	6.0
	E	20	25	25	24	24		147	184	169	55	138	
Taraxicum officinale	T	Not present						105	101	94	51	88	10.0
	E							45	79	79	15	55	
Cerastium vulgatum	T	10	28	25	20	21	8.0	51	83	97	15	62	8.0
	E	0	10	30	20	15		49	60	108	20	59	

These results indicate the need for further work. The contribution of each of these factors should be identified together with the reasons for their effect.

ACKNOWLEDGEMENTS

I thank P. Ayres and C.M. Ellis for assistance in the field and laboratory, C.J. Marshall for analysis of results and J.G. Elliott and R.J. Haggar for helpful criticism of the paper.

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Fig. 5. Frequency of green herbage after treatment with paraquat (P) at 0.28 kg/ha or dalapon (D) at 4.5 kg/ha.

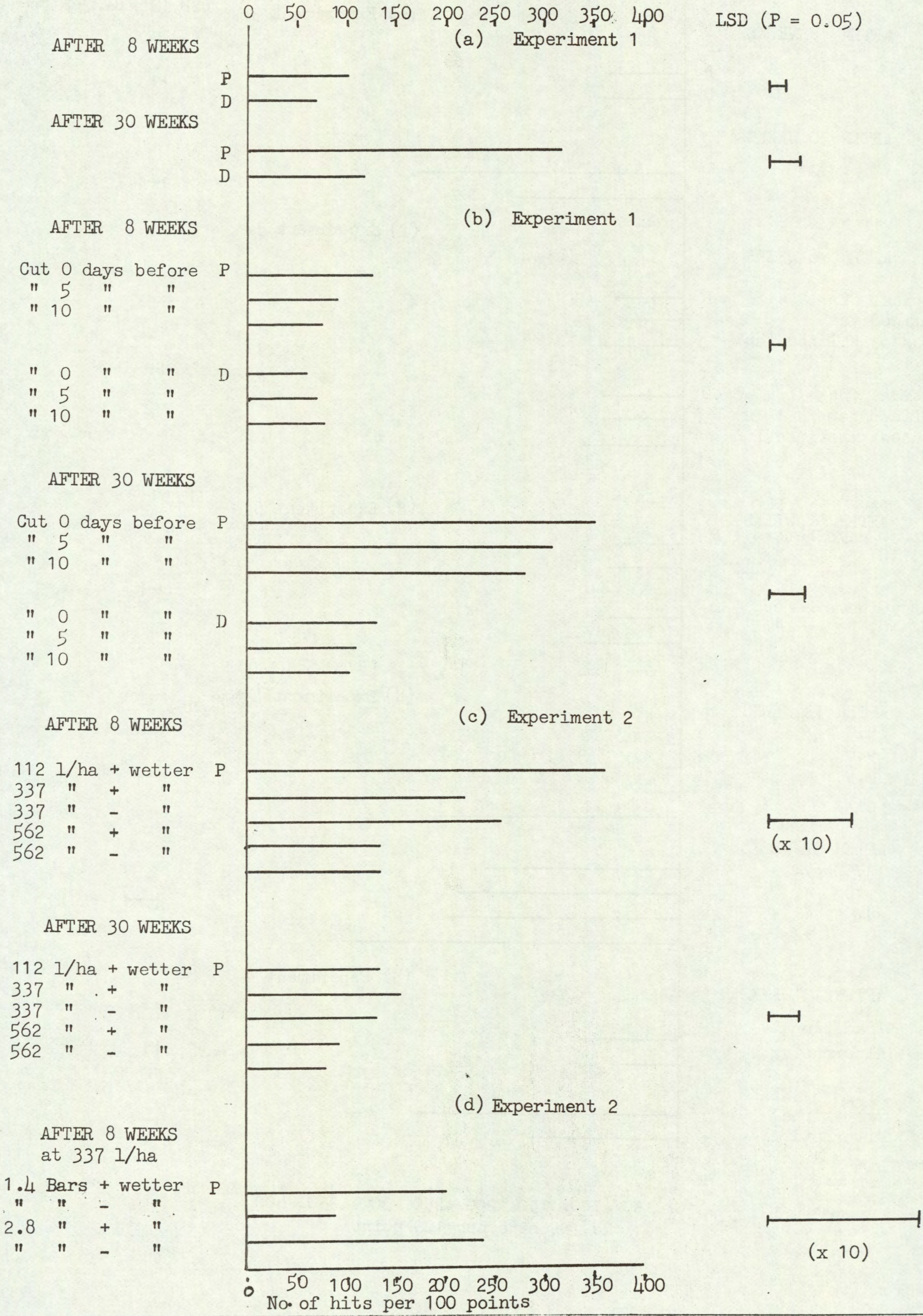
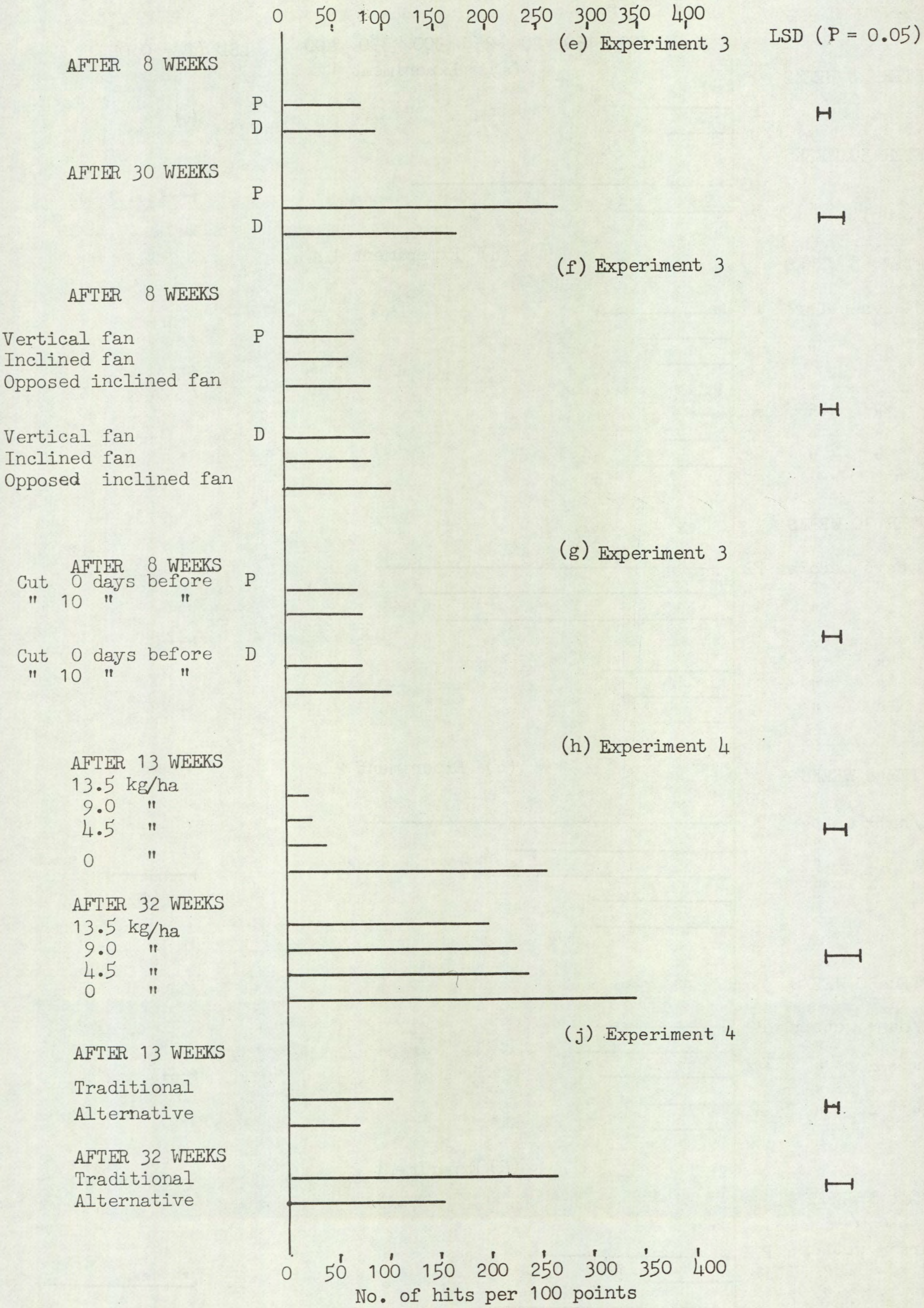


Fig. 5 contd.


0 50 100 150 200 250 300 350 400
(e) Experiment 3
LSD (P = 0.05)
AFTER 8 WEEKS
P
D
AFTER 30 WEEKS
P
D
(f) Experiment 3
AFTER 8 WEEKS
Vertical fan P
Inclined fan
Opposed inclined fan
Vertical fan D
Inclined fan
Opposed inclined fan
(g) Experiment 3
AFTER 8 WEEKS
Cut 0 days before P
" 10 " "
Cut 0 days before D
" 10 " "
(h) Experiment 4
AFTER 13 WEEKS
13.5 kg/ha
9.0 "
4.5 "
0 "
AFTER 32 WEEKS
13.5 kg/ha
9.0 "
4.5 "
0 "
(j) Experiment 4
AFTER 13 WEEKS
Traditional
Alternative
AFTER 32 WEEKS
Traditional
Alternative
0 50 100 150 200 250 300 350 400
No. of hits per 100 points

ABBREVIATIONS

ångström	Å
Abstract	Abs.
acid equivalent*	a.e.
acre	ac
active ingredient*	a.i.
approximately equal to*	≃
aqueous concentrate	a.c.
bibliography	bibl.
boiling point	b.p.
bushel	bu
centigrade	C
centimetre*	cm
concentrated	concd
concentration	concn
concentration x time product	ct
concentration required to kill 50% test animals	LC50
cubic centimetre*	cm^3
cubic foot*	ft^3
cubic inch*	in^3
cubic metre*	m^3
cubic yard*	yd^3
cultivar(s)	cv.
curie*	Ci
degree Celsius*	^{o}C
degree centigrade	^{o}C
degree Fahrenheit*	^{o}F
diameter	diam.
diameter at breast height	d.b.h.
divided by*	÷ or /
dry matter	d.m.
emulsifiable concentrate	e.c.
equal to*	=
fluid	fl.
foot	ft

freezing point	f.p.
from summary	F.s.
gallon	gal
gallons per hour	gal/h
gallons per acre	gal/ac
gas liquid chromatography	GLC
gramme	g
hectare	ha
hectokilogram	hkg
high volume	HV
horse power	hp
hour	h
hundredweight*	cwt
hydrogen ion concentration*	pH
inch	in.
infra red	i.r.
kilogramme	kg
kilo (x10^3)	k
less than	<
litre	l.
low volume	LV
maximum	max.
median lethal dose	LD50
medium volume	MV
melting point	m.p.
metre	m
micro (x10^{-6})	μ
microgramme*	μg
micromicro (pico: x10^{-12})*	μμ
micrometre (micron)*	μm (or μ)
micron (micrometre)*†	μm (or μ)
miles per hour*	mile/h
milli (x10^{-3})	m
milliequivalent*	m.equiv.
milligramme	mg
millilitre	ml

† The name micrometre is preferred to micron and μm is preferred to μ.

millimetre*	mm
millimicro* (nano: $x10^{-9}$)	n or mµ
minimum	min.
minus	-
minute	min
molar concentration*	M (small cap)
molecule, molecular	mol.
more than	>
multiplied by*	x
normal concentration*	N (small cap)
not dated	n.d.
oil miscible concentrate	o.m.c. (tables only)
organic matter	o.m.
ounce	oz
ounces per gallon	oz/gal
page	p.
pages	pp.
parts per million	ppm
parts per million by volume	ppmv
parts per million by weight	ppmw
percent(age)	%
pico (micromicro: $x10^{-12}$)	p or µµ
pint	pint
pints per acre	pints/ac
plus or minus*	±
post-emergence	post-em
pound	lb
pound per acre*	lb/ac
pounds per minute	lb/min
pound per square inch*	lb/in^2
powder for dry application	p. (tables only)
power take off	p.t.o.
precipitate (noun)	ppt.

pre-emergence	pre-em.
quart	quart
relative humidity	r.h.
revolution per minute*	rev/min
second	s
soluble concentrate	s.c.
soluble powder	s.p.
solution	soln
species (singular)	sp.
species (plural)	spp.
specific gravity	sp. gr.
square foot*	ft^2
square inch	in^2
square metre*	m^2
square root of*	$\sqrt{\ }$
sub-species*	ssp.
summary	s.
temperature	temp.
ton	ton
tonne	t
ultra-low volume	ULV
ultra violet	u.v.
vapour density	v.d.
vapour pressure	v.p.
varietas	var.
volt	V
volume	vol.
volume per volume	v/v
water soluble powder	w.s.p. (tables only)
watt	W
weight	wt
weight per volume*	w/v
weight per weight*	w/w
wettable powder	w.p.
yard	yd
yards per minute	yd/min

* Those marked * should normally be used in the text as well as in tables etc.

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