QUANTITATIVE STUDIES ON THE USE OF PARAQUAT FOR PASTURE RENOVATION

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Summary

Trials are described which study the effect of rate of paraquat and fertilizer interactions when this chemical is used for pasture renovation. Spraying in March caused yield in the first winter to be lower but subsequent pasture composition and production were improved. Annual weeds increased at three of the six sites as a result of the March spraying.

INTRODUCTION

PARAQUAT first showed promise as a tool to pasture improvement in the Dannevirke district, but over the last three years its use has extended to most parts of the Dominion. Blackmore (1962, 1965) has observed good grass establishment, stronger clover, and livestock preferences for pastures renovated with paraquat.

Soil fertility differences as well as peculiarities of climate in districts outside of the hill country surrounding Dannevirke have made it necessary to determine quantitatively the exact nature of response of pastures sprayed with paraquat as an aid to introducing improved grasses.

TRIAL DESIGN, TREATMENTS, SITE DESCRIPTION AND MANAGEMENT

The trials discussed in this paper were designed to study:

(a) The effect of rate of paraquat (Trial I).

(b) The effect of rate of fertilizer (phosphate) in association with pasture renovation (Trial II).

Rates of chemical are expressed as active ingredient per acre.

TRIAL I (Two sites—Pukeatua and Wharepuhunga, both near Te Awamutu)

Treatments for Comparison	*Treatments Basic Overall*
1. Paraquat at 2 oz	Volume of water at spraying was 28 gal/acre.
2. Paraquat at 4 oz	Non-ionic wetting agent was added at 0.1% a.i.
3. Paraquat at 6 oz	The initial fertilizer and the seed were broadcast one day after spraying.
4. Paraquat at 8 oz	DDT prills were applied with the seed at 2 lb a.i./acre.
5. Unsprayed control	

Spraying was completed on March 17, 1966, at Pukeatua and March 19, 1966, at Wharepuhunga. The pasture had been short-grazed and allowed to recover for up to one week before spraying.

Fertilizer

Pukeatua: 6 cwt 30% potassic superphosphate initially followed by 2 cwt 15% potassic superphosphate in September, 1966.
Wharepuhunga: 4 cwt 15% potassic superphosphate initially followed by 3 cwt 15% potassic suprephosphate in September, 1966.

Seed

Pukeatua: 'Grasslands Ariki' ryegrass plus 'Grasslands Manawa' ryegrass in the ratio of 3:1, broadcast at 18 lb per acre.
Wharepuhunga: 'Grasslands Ruanui' ryegrass plus Grasslands Manawa ryegrass (3:1) broadcast at 18 lb per acre.

Treatments were replicated five times in a randomized block design. Individual plot size was 30 ft × 10 ft.

The site at Pukeatua was on a highly developed sheep farm which has wintered 8.5 ewe equivalents per acre. At the Wharepuhunga site winter stocking levels are estimated at just on 6 ewe equivalents per acre. Both sites were on soils derived from Maeroa Ash. Fertility Index Ratings (Dale, 1966) estimated at the start of the trial were 8/12 and 8/9 for Pukeatua and Wharepuhunga, respectively. Average annual rainfall at both sites is round 50 in. per annum.

(A third site of this trial was abandoned owing to fertility gradients appearing, as well as heavy grass-grub (*Costelytra zealandica*) infestations.)

TRIAL II (Three sites—Arapuni, Te Poi and Oropi)

Autumn chemical and fertilizer treatments for comparison were:

Chemical	*Fertilizer*	*Treatment Abbreviation*
ARAPUNI—Sprayed April 5, 1966.		
1. Unsprayed	Nil.	CFO
2. Unsprayed	4 cwt 15% potassic superphosphate per acre.	CFN
3. Unsprayed	4 cwt 15% potassic superphosphate + 4 cwt superphosphate per acre.	CFH
4. 4 oz paraquat	Nil.	SFO
5. 4 oz paraquat	As for 2.	SFN
6. 4 oz paraquat	As for 3.	SFH

TE POI, near Matamata—Sprayed March 10, 1966.

Chemical	*Fertilizer*	*Treatment Abbreviation*
1. Unsprayed	4 cwt superphosphate per acre.	CFN
2. Unsprayed	8 cwt superphosphate per acre.	CFH
3. 6 oz paraquat	As for 1.	SFN
4. 6 oz paraquat	As for 2.	SFH

OROPI, near Tauranga—Sprayed March 17, 1966.

Chemical	*Fertilizer*	*Treatment Abbreviation*
1. Unsprayed	3 cwt superphosphate per acre.	CFN
2. Unsprayed	6 cwt superphosphate per acre.	CFH
3. 8 oz paraquat	As for 1.	SFN
4. 8 oz paraquat	As for 2.	SFH

Trial design, volume of water, wetting agent and DDT were as for Trial I, different randomized layouts, however, being used at each site. Seed and fertilizer were broadcast one day after spraying. Seed for Te Poi and Oropi were as for Wharepuhunga Trial I and at Arapuni as for Pukeatua Trial 1.

Subsequent treatments involved the re-application of the high rate of fertilizer to CFH and SFH plots in spring.

Arapuni was a sheep/cattle grazing property and Te Poi and Oropi were both mixed dairy/sheep. The Arapuni and Te Poi sites were of similar fertility, both wintering at least 6 ewe equivalents per acre with Fertility Index Ratings of 8/10. The Oropi site was of lower fertility, probably wintering 5 ewe equivalents per acre with a Fertility Index Rating of 8/8. Soils at Arapuni and Te Poi were derived from Tirau Ash and at Oropi from Kaharoa Ash.

Trial management involved taking cuts for dry matter production and measuring pasture composition by point analysis (Radcliffe and Mountier, 1964, 1965). A modified alternate grazing/cutting technique (Lynch, 1960) was used for taking yield measurements. All plots were trimmed initially to mower height, closed as necessary for a production cut, grazed off with up to 200 dry sheep per acre for four to five days and then spelled for a further four to five days before trimming in preparation for the next harvest.

RESULTS

Dry matter production from May to December and pasture composition changes over this period are shown in Tables 1 and 2. Table 3 contains non-analysed dry matter production data for a trial similar to Trial I in Wellington and Horowhenua districts.

In all trials and sites there was an initial depression in dry matter production owing to spraying. This depression continued through the first winter and was in direct proportion to rate of paraquat. The early spring cuts showed a reversal of effect when the sprayed plots out-yielded the control (Pukeatua Trial I and Arapuni and Te Poi Trial II). Late spring cuts at Te Poi maintained this trend, but for Pukeatua and Arapuni yields were more variable, owing possibly to stronger growth of Yorkshire fog (*Holcus lanatus*), in the controls, before it enters its reproductive phase. The final harvest at Pukeatua and Arapuni showed an overwhelming response to spraying in dry matter production and this can be attributed directly to productivity of Grasslands Ariki ryegrass at this period, whereas Grasslands Ruanui (New Zealand perennial) ryegrass was sown at the other sites. Dry matter production at Te Poi should be interpreted with caution as there was a dense infestation of stinking mayweed (*Anthema cotula*) on the sprayed plots. At the fifth harvest botanical dissection analysis was

TABLE 1: DRY MATTER PRODUCTION
(lb D.M. per acre)

TRIAL I — *Pukeatua*

Treatment (oz)	*Harvest (Period)*							
	H1 31/4 to 16/5/66	*H2 25/5 to 1/7*	*H3 12/7 to 18/8*	*H1 + H2 + H3*	*H4 27/8 to 26/9*	*H5 4/10 to 18/10*	*H6 29/10 to 15/11*	*H7 25/11 to 21/12*
2	520	390	440abAB	1350aA	1050aAB	680aA	600	1020aA
4	260	290	430abAB	980abAB	1090aA	580abcAB	540	1010aA
6	170	230	520aA	920abAB	990abAB	540bcAB	530	1050aA
8	130	160	320bB	600bB	1060aAB	590cB	600	1040aA
Control	550	440	360bB	1350aA	840bB	610abAB	550	890bA
CV				14.1%	11.7%	12.5%		

Wharepuhunga

Treatment (oz)	*Wharepuhunga*					
	H1 30/4 to 19/5	*H2 27/5 to 21/7*	*H3 3/8 to 9/9*	*H4 20/9 to 14/10*	*H5 22/10 to 15/11*	*H6 23/11 to 16/12*
2	230bB	110	80	380	1040	850
4	180bB	90	80	410	840	810
6	190 bB	120	70	400	1160	800
8	170bB	100	90	510	1150	800
Control	360aA	200	90	560	1000	810
CV	19.8%					

TRIAL II

Arapuni

Treatment		*Harvest (Period)*					
		H1 *10/5 to 4/6*	*H2* *14/6 to 15/7*	*H3* *26/7 to 18/9*	*H4* *27/9 to 10/10*	*H5* *18/10 to 8/11*	*H6* *18/11 to 13/12*
CFO	....	370	150	700cbBC	640bcAB	800bAB	1000bB
CFN	....	430	140	790bcAB	700abcAB	860abAB	1000bB
CFH	....	420	170	890abA	790aA	970aA	1250aA
SFO	....	90	80	630dC	560cB	600cC	770cC
SFN	....	70	60	850abA	670abcAB	780bB	1220aA
SFH	....	60	50	900aA	760aA	930aAB	1280aA
CV	....			9.5%	14.6%	11.4%	10.5%

Te Poi

Treatment		*Harvest (Period)*					
		H1 *May*	*H2* *5/5 to 12/7*	*H3* *26/7 to 7/9*	*H4* *21/9 to 10/10*	*H5* *18/10 to 12/11*	*H6* *23/11 to 14/12*
CFO	....		—	—	—	—	—
CFN	....	This	120	360	540	700dB	390
CFH	....	harvest	130	340	570	770cB	490
SFO	....	was	—	—	—	—	—
SFN	....	missed	160	560	800	940bA	420
SFH	....		130	600	770	1110aA	530
CV	....					13.7%	

Te Poi Pasture Dissection 12/11/66 (H5)
(lb D.M. per acre)

Treatment	*Lolium* spp.	*Trifolium* spp. (mainly *T. repens*)	*Other Grass*	*Weed*
CFN	282	84	324	14
CFH	354	77	331	8
SFN	610	84	150	94
SFH	786	89	155	78

Oropi

Harvest (Period)

Treatment	*H1* *1/5 to 17/5*	*H2* *28/5 to 26/7*	*H3* *6/8 to 10/9*	*H4* *21/9 to 15/10*	*H5* *24/10 to 12/11*	*H6* *19/11 to 17/12*
CFN	340	290	170	600bB	400bA	1480aA
CFH	350	340	170	710abAB	550abA	1410aA
SFH	180	120	100	800aAB	530abA	1380aA
SFH	210	120	130	690abAB	620aA	1530aA
CV				12.2%	21.2%	14.3%

TABLE 2: PASTURE COMPOSITION BY POINT ANALYSIS

(Cover hits per 50 points)

Treatment	*Ryegrass*	*White Clover*	*Yorkshire Fog*	*Browntop Litter + Bare Ground*	
TRIAL I—Pukeatua, 18/1/67					
Paraquat 2 oz	40aA	17bcAB	Trace	1	2
Paraquat 4 oz	37abA	22aA	Trace	Trace	2
Paraquat 6 oz	34bA	19abAB	Trace	1	4
Paraquat 8 oz	33bA	20abAB	Trace	1	3
Control	33bA	15cB	4	3	2
TRIAL I—Wharepuhunga, 10/1/67					
Paraquat 2 oz	22	16	2	7	7
Paraquat 4 oz	17	19	2	7	9
Paraquat 6 oz	21	17	2	4	8
Paraquat 8 oz	24	16	2	4	8
Control	18	17	4	10	8
TRIAL II—Arapuni, 18/1/67					
CFO	25 } bB	21 } bB	3	4	1
CFN	23 }	25 }	3	3	1
CFH	28 }	28 }	2	3	Trace
SFO	28 } aA	36 } aA	Trace	Trace	1
SFN	29 }	35 }	—	Trace	1
SFH	33 }	37 }	—	Trace	Trace
TRIAL II—Te Poi					
CFN	25bA	30	10		1
CFH	28bA	31	7		Trace
SFN	34aA	34	1		1
SFH	32aA	32	2		1
TRIAL II—Oropi					
CFN	26	17	13	16	1
CFH	32	17	11	9	Trace
SFN	29	22	13	5	—
SFH	36	19	11	3	Trace

Other species present in small numbers included sweet vernal, *Poa* species, crested dogstail, cocksfoot and paspalum.

done (see Table 1), and the increase in dry matter production on the sprayed plots was due mainly to more vigorous ryegrass. Wharepuhunga (Trial I) and Oropi (Trial II) did not respond in dry matter production to spraying to the same degree as the other sites and it will be recalled that these sites were of lower fertility than the others.

In Wellington/Horowhenua trials (Table 3), dry matter production changes were basically similar to the trend shown by the Waikato trials.

TABLE 3: DRY MATTER PRODUCTION, WELLINGTON/HOROWHENUA TRIALS (lb D.M. per acre)

	Mangaroa (Wellington)		*Te Horo (Horowhenua)*	
Date of cut:	*2/7/66*	*24/11/66*	*17/6/66*	*2/12/66*
Treatment (period)	*7/4/66 to 2/7/66*	*17/10/66 to 24/11/66*	*29/4/66 to 17/6/66*	*21/10/66 to 2/12/66*
Paraquat 2 oz	700	1,690	570	2,040
Paraquat 4 oz	440	1,640	440	2,040
Paraquat 6 oz	240	1,790	440	2,050
Paraquat 8 oz	300	1,740	1,830	1,890
Control	930	1,380		

In order to assess fertilizer/spraying interactions the sprayed/normal maintenance fertilizer treatment (SFN) should be studied in Trial II. There is a hint that interactions do in fact occur where SFN compares favourably with CFH (control high fertilizer, up to four times normal rate per annum).

Table 2 shows pasture composition assessments in January, 1967. These results do not show the effect of spraying in autumn on annual flat-weed populations the following spring. It was necessary to spray for Scotch thistle (*Cirsium lanceolatum*) at Pukeatua and Arapuni and for stinking mayweed at Te Poi in September, 1966. Point analysis in January showed ryegrass and clover contents on sprayed plots to be at least equal to and higher than (Pukeatua and Trial II sites) the corresponding control. In Trial I certain of the original ryegrass would have survived treatment at the lower rates (in particular 2 oz) but at the higher rates ryegrass content in Table 2 can be attributed entirely to better establishment of the sown varieties after spraying. Unpalatable and low-producing grasses as a group (the perennials—Yorkshire fog, browntop and sweet vernal) were reduced by spraying at all sites. In Trial II the fertilizer factor had a slight effect on pasture composition, but negligible when compared with the effect of spraying.

DISCUSSION

The main effects of spraying with paraquat in autumn for pasture renovation shown in these trials were:

(1) Better ryegrass/clover content.

(2) Less unpalatable and low producing grasses.

(3) Increased annual flat-weeds in the first spring (occurred on three sites).

(4) Depressed production in the first winter. This effect was in direct proportion to rate of paraquat.

(5) Increased subsequent production in line with the inherent productivity of species present.

(6) Possibility of more efficient utilization of maintenance fertilizer dressings by renovated pastures.

With the object of avoiding the short-term drawbacks of increased annual flat-weeds and reduced production in the first winter, the 1967 trials were laid down a month earlier.

In districts subject to summer droughts, it may be necessary to move to the other end of the scale and make treatment in late spring. Drilling of seed on tractor country could have advantages over broadcasting. Plant nutrients in the form of fertilizer phosphate and nitrogen cannot be omitted in the search for a "quick start" factor. The rate of paraquat should exceed 4 oz only in extreme circumstances, such as very dense browntop.

Apart from being used as a convenient way to get rid of surplus growth and return nutrients to the plots, livestock were not included in these trials. In order to obtain a thorough understanding of pasture renovation, the grazing animal must be brought into the trials not merely as a management tool, but as a factor of quantitative study.

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