PROGRESS MADE WITH PARAQUAT IN RELATION TO PASTURE MANAGEMENT

P. P. Williams and P. C. Palmer Imperial Chemical Industries (N.Z.) Ltd., Hamilton and Palmerston North

Summary

Spraying pasture with paraquat in spring or summer at rates of 1 to 4 oz/acre increased the clover content during the first summer and was followed by strong recovery of ryegrass during the autumn/winter period. Trials have indicated increased dry matter production from treated pasture in late winter/early spring. Lamb growth rates were significantly higher on sprayed pasture, especially during the summer to autumn period. The implications of these effects are discussed in relation to farm management.

INTRODUCTION

WHITE CLOVER (Trifolium repens L.) is the main source of nitrogen in New Zealand pastures. Higher dry matter yields are obtained from the growth of improved grasses, mainly ryegrass, which are able to show marked responses to increased nitrogen availability. This paper examines the use of paraquat to alter the botanical composition of pastures, particularly the clover to grass ratio, and relates the consequent effects on herbage and animal productivity to farm management practices. A broader interpretation is thereby placed on the use of herbicides which, traditionally, are used to remove weeds.

Earlier concepts of using herbicides in this broader role, chemical ploughing and autumn pasture renovation, are seen to have limited application. A research programme to evaluate these applications of chemical on pasture has led to the approach discussed in this paper. There has been a change in chemical, a lowering of rate* from 6 or 8 oz/acre paraquat to 1 or 4 oz/acre, and a change in time of application from autumn to the period of maximum pasture growth, which occurs during spring or summer (Palmer, 1968; Williams, 1968).

^{*}Throughout this paper rates of paraquat will be given in oz active ingredient per acre.

The application of low rates of paraquat is seen as a further tool available to the pasture manager, to be used in association with other factors, all 'of which are manipulated to reach an objective of a balanced ryegrass/clover pasture.

EFFECTS ON PASTURE

The responses of pasture to paraquat applied at rates of from 1 to 4 oz in the spring or summer period are presented as pasture composition and dry matter production effects.

PASTURE COMPOSITION

The responses of the pasture components clover, ryegrass and "other grasses" to paraquat are shown in Fig. 1.

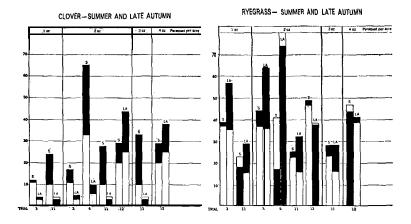
Clover

The immediate effect was an increase in percentage clover on all fourteen trials at all rates (Fig. la). By late autumn the phase of marked clover dominance had passed (Fig. lb) owing to the seasonal reduction in clover growth at this time of the year, and also to the increasing competition from ryegrass.

Ryegrass

Ryegrass showed some tolerance to paraquat as seen in Figs. lc and Id. However, the initial effect was a check; but by late autumn ryegrass had completely recovered, there being no significant reduction in any trial at any rate. There were cases (Fig. ld) of a significant increase in the proportion of ryegrass on sprayed pasture compared with the unsprayed, suggesting a response by ryegrass to the build-up of soil nitrogen following the phase of clover dominance, and reduced competition from other grasses. It has been observed that cocksfoot and timothy follow a similar pattern to ryegrass.

^{*&}quot;Other grasses" includes Yorkshire fog (Holcus langtus L.), sweet vernal (Anthoxanthum odoratum L.), crested dogstail (Cynosurus cristatus L.), Poa spp., Bromis mollis L., browntop (Agrostis tenuis Sibth), and creeping bent (A. stolonifera L.). These species are listed in declining order of susceptibility to paraquat,



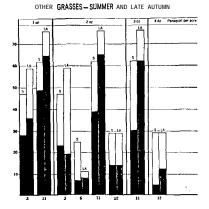


Fig. 1: Effect of paraquat on pasture composition (percentage dry weight). Summer = 2 months after spraying. Late autumn = 4 to 6 months after spraying. Clear column = untreated control. Shaded column = paraquat.

Other Grasses

The "other grasses" component was significantly reduced during the first summer and to a lesser extent in the late autumn (refer Figs. le and f).

Effect of Rate

Reference to Fig. 1 shows that there was an effect due to rate of chemical. At higher rates there was a greater increase of clover, a more marked suppression of other grasses, but no different effect on ryegrass up to 4 oz.

DRY MATTER PRODUCTION

Yield responses following paraquat application at 4 sites (Fig. 2) indicate an initial suppression of growth relative to the control. Following this, during the clover-dominant phase (Fig. la), dry matter production of the paraquat-treated pastures was about the same as or greater than (Fig. 2b, d) the controls. The recovery of ryegrass in the sprayed pastures during autumn (Fig. 1d) resulted in increased dry matter production during the winterspring period (Table 1).

Confirmation of this effect is the subject of a current series of trials.

Effect of Rate

The initial suppression was in direct relationship to rate (Fig. 2c and d), although the difference between 2 and 4 oz was not great in these trials. There was no consistent effect of rate through the summer to late autumn period. Previous work (Williams, 1967) has suggested that responses can be variable, and sprayed pasture more sensitive to growing conditions immediately following spraying at rates above 4 oz.

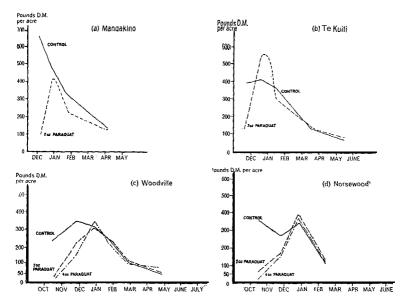


Fig. 2: Pasture growth rate - summer/late autumn.

Factors Affecting Responses to Paraquat

An essential feature of a "satisfactory response" to paraquat is a rapid and vigorous recovery of clover. This affects the interval between spraying and grazing, and the degree of suppression of other grasses. To obtain this "satisfactory response", conditions should be such that the clover component is able to make rapid growth immediately after spraying, to take advantage of the reduced competition.

Besides competition, two other factors important to clover growth are season and soil fertility. Time-of-application trials have demonstrated that optimum results are obtained from spraying during the peak period of pasture growth, spring to summer. Clover recovery should not be limited by inadequate nutrient status of the soil. In general, the higher the fertility the greater the response of clover and therefore of pastures to paraquat.

Oversowing

The characteristic reappearance of ryegrass in the autumn following application of the lower rates of paraquat indicates that in many situations oversowing is unnecessary. There will be occasions where low initial ryegrass content requires some to be oversown, or alternatively there may be a desire to introduce other species. Competition will be lowest immediately after spraying, so to obtain good establishment this is the optimum time for oversowing. In drier districts, the alternative is to oversow in the following autumn, in which case grazing should be managed to aid establishment.

CONSEQUENCES OF PASTURE EFFECTS

The changed pattern of dry matter production brought about by the use of paraquat must be interpreted in terms of farm management.

The fact that paraquat is most effective when applied during the peak period of pasture growth, late spring to summer, tends to minimize the significance of the initial yield suppression. This is because it is a period when pasture supply may exceed demand, and when grazing management can be more easily adjusted to free paddocks for spraying. On the other hand, the indicated increase of yield during the late winter-early spring period following paraquat application (Table 1) is particularly

TABLE 1: FIRST WINTER-SPRING DRY MATTER RESPONSES

| Site | Period of Production | Control | Paraquaf | c v | Response |
|---|--|-----------------------------------|-------------------------------------|-------------------------|---------------------------|
| Te Awamutu Dannevirke Hunterville Pio Pio | 5/8/67 to 20/9/67 13/8/68 to 16/10/68 2/5/69 to 2/9 J69 23/5/68 to 18/10/68 | 1,630 bB 710 b 893 3,790 | 1,900 aA 1,070 a 841 4,300 | 14.3% 18.6% 16.0% | 18% 51% N.S. 14% |

 Clover
 Ryegrass
 Other Grasses

 Control
 ...
 8
 30
 60

Paraquat

HII HII

TABLE 2: PASTURE COMPOSITION, PIO PIO

TABLE 3: PASTURE COMPOSITION, REPOROA
(% dry weight November 14, 1968)

Clover Ryegrass Other Gr

| | Clover | Ryegrass | Other Grasses |
|---------|--------|----------|---------------|
| ontrol | 26 | 50 | 24 |
| araquat | 35 | 61 | 5 |

significant as this is considered to be a critical time in terms of yield deficits.

The enhanced vigour of clover can be considered in relation to the competitive ability of this plant for phosphate and potash in a grass/clover association. The implication is that a pasture in which clover vigour is increased would utilize fertilizer more efficiently, providing a higher nitrogen status for growth of improved grasses.

A series of trials are under way to measure responses to paraquat at a range of rates of superphosphate. Further research work is required to study interactions between phosphate or other elements and pasture composition.

STOCK PRODUCTION EFECTS

The performance of young sheep grazing paraquat-treated pasture has been studied.

The first trial, at Reporoa, is sited on a farm with an average winter stocking rate of 7.25 ewe equivalents per acre. The paddock selected was six years old and regarded as one of the better on the farm.

The second trial, at Pio Pio in the King Country, is on a farm wintering 6.0 ewe equivalents per acre.

Production from both is above their district average,

Prior management on untreated pasture consisted of mob grazing with mature sheep, followed by a three weeks' spell. Stock were drenched monthly with tetramisole during summer and autumn.

At both sites a "satisfactory response" to paraquat was obtained, and grazing commenced one month after treatment.

At Pio Pio, pasture composition two months after spraying is shown in Table 2.

Management at the Reporoa trial reflects the earlier concept of the pastoral use of paraquat which assumed oversowing would be necessary in autumn. On February 28, 1968, stock were moved to facilitate further spraying to aid establishment of direct-drilled ryegrass. Pasture composition for this trial nine months after oversowing is shown in Table 3.

LIVEWEIGHT RESPONSE

For interpretation, liveweight changes are grouped into three periods as shown in Fig. 3.

Summer/Autumn

At both sites, liveweight gain by lambs grazing sprayed pasture was significantly higher (Fig. 3).

At Reporoa, lambs weighing 49 lb at weaning, stocked at 24 per acre, reached 85.7 lb and 75.7 lb in ten weeks to February 28 on the paraquat and untreated pastures, respectively. At Rio Pio, 47 lb lambs stocked at 14 per acre grew to 75.7 and 63.7 lb in the 12 weeks to April 20. This represents an increased liveweight gain on pastures sprayed with paraquat, in both trials, of 1 lb liveweight for each week of grazing in this period.

Autumn/Winter

On both trials, stock lost weight on sprayed and unsprayed pasture during the autumn/winter period. At Reporoa, there was no significant effect due to treatment on liveweight loss. There was, however, a highly significant regression of weight loss from May 9 to July 5 on liveweight at May 9. This regression was of the order of 0.27 lb loss per lamb for each additional pound of initial liveweight.

At Pio Pio, lambs grazing sprayed pasture lost significantly more weight, than those on the untreated control during this period. There is a certain inflexibility in management of live-stock trials which undoubtedly contributed to this loss. Local farmers using paraquat-treated pasture employing different grazing management, which permitted spelling before autumn regrazing, were able to sustain the improved growth of the previous period through May and June.

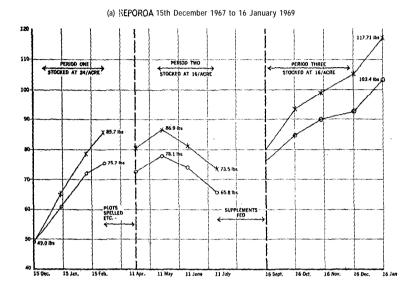
Spring/Summer

At Reporoa during the period September 16 to January 16, there was a highly significant treatment effect of 11 lb liveweight in favour of sprayed pasture (refer Fig. 3a, Period Three).

This trial therefore followed the growth of Romney-ewe lambs weighing 49 lb at weaning on December 15, 1967, to two-tooth ewes of 103.4 lb (control) and 117.7 lb (treated pasture), at January 16, 1969,

WOOL PRODUCTION

Wool weights recorded on the Reporoa trial in November showed a significant difference between the two groups (Table 4).



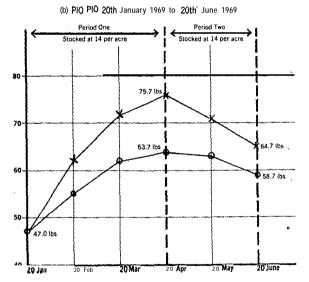


Fig. 3: Growth rate of Romney ewe lambs to two-tooth ewes on paraquat and untreated pasture.

TABLE 5: NET RETURN OF LAMB GROWTH EFFECT (EX PIO PIO TRIAL)

| | Liveweight at Weaning/Purchase (lb) | Liveweight in 12 weeks (lb) | Estimated Carcass (1b) | Approx. Carcass Value (at 14c/lb) | Value/acre |
|---------------------|---|-----------------------------------|------------------------------|--------------------------------------|---------------------------------------|
| Control Paraquat | 47 47 | 64 ` 76 | 29 35 | \$4.06 \$4.90 | \$56.84 \$68.60 |
| | | | | Additional return: | \$11.76 |
| | | Total appl | | spraying \$0.50 to \$1.50 | \$1.50 to \$2.50 \$9.26 to \$10.26 |

TABLE 4: WOOL WEIGHTS, REPOROA GRAZING TRIAL (lb greasy wool/lamb)

| Control | | | | 1111 | 8.5 aA | | |
|---------------|--|--|--|------|---------------|--|--|
| Paraquat | | | | | 9.4 bA | | |
| SE = 0.24 lb | | | | | | | |
| | | | | | | | |

CONSEQUENCES OF STOCK EFFECTS

On many farms, it is normal practice to wean lambs on to pasture which has been previously prepared with mobs of older sheep or cattle. In both of the trials reported, the comparison was between a paraquat-treated pasture, and one prepared for lambs by mob stocking of ewes. The benefit of 1 lb liveweight per week of grazing in summer is therefore a potential improvement over a commonly used management practice.

In dryland districts, rape may be grown as a lamb fattening crop., Taylor and Arnst (1968), in work at Rakaia, demonstrated similar growth rates of lambs fed rape, to those grazing sprayed pasture.

The actual consequence of this effect of paraquat as a cash return to the sheep farm will depend upon the type of stock to which these pastures are fed and the overall policy of the enterprise. To assess the impact that this management practice may have on a sheep farm, three farming systems may be considered.

The first is a breeding unit where lambs are sold in store, forward store or fat condition. Ewe lambs are retained through the winter, for selection as flock replacements.

The second enterprise is an intensive fattening unit which at the absolute extreme may breed no stock, purchasing lambs in store condition for fattening over the sumer period.

The third situation is in dryland districts where lambs must be sold before pastures become unpalatable in summer, or a crop of rape is grown specifically for lambs.

These in turn can be called the "breeding" unit, the "fattening" unit and the "dryland" farm.

On both "breeding" and "fattening" units, the effect of paraquat on the lamb account can be assessed on the basis of growth rates in the lamb trials during summer to autumn (e.g., the Pio Pio trial, Table 5).

This assessment, whilst'it is directly applicable to the "fattening" unit, leaves the "breeding" unit with several alternative ways of utilizing improved lamb. growth rates. All lambs may be

sold fat where previously this was not possible, lambs may be finished earlier, or sold at higher weights.

The second interpretation which applies to the breeding unit is in connection with ewe lambs, which in twelve months will join the breeding flock. Ewe hoggets which reach -75 lb liveweight in the oestrous season show oestrous behaviour (G. K. Hight, pers. comm.). The philosophy that "the ewe hogget is one of the few classes of stock with potential to appreciate in value and farmer experiences and trial results suggests that continuous setreproduce at the same time" (J. R. Barton, Farm Management Consultant, Te Kuiti, pers. comm.) could be more successfully applied to increase sheep farm profitability. Furthermore, there is information available to show a correlation between occurrence of oestrous cycling in hoggets and two-tooth fertility (Hight, 1968).

(Hight, 1968).

The "dryland" farmer can regard the clover-dominant pasture as a crop, cheaper to grow and more flexible in grazing requirements than rape. In this case, spraying would be done in spring before dry conditions prevail, the objective being to retain palatable pasture during summer on which high liveweight gains can be sustained.

Further information is required to determine the grazing system that will enable the best use to be made of sprayed pasture over the autumn/winter period. The observed difference between stocking may not be the best grazing management in autumn.

The improved performance of stock grazing sprayed pasture during the spring to summer period will benefit all three farming systems.

It has been observed that stock show preference for sprayed pastures as soon as these have recovered, This aspect, whilst it probably contributes to the improved growth rate of lambs, can present a management problem on paddocks which contain steeper sidlings.

CONCLUSIONS

The property of paraquat to enhance the proportion of clover in a grass/clover association is viewed as a further tool available to the New Zealand pasture manager. Its function cannot be properly interpreted in isolation from other factors which affect the growth and returns from. ryegrass/white clover pastures, but must be fully integrated into the farm management systems as these exist.

Research and experience indicate that 2 oz of paraquat applied in spring or summer provides the most consistent effect over a wide range of conditions. Flexibility in both rate and time of application should be maintained to suit specific situations.

Dry matter production in late winter and early spring determines the carrying capacity and thereby productive potential of many farms. The response by ryegrass to the summer phase of clover dominance has contributed additional dry matter during this critical period. The effect of paraquat-treated pasture on lamb growth rates, coupled with this dry matter response, can directly contribute to sheep farming profitability.

Agricultural research has two functions. The first is to establish biological specifications, and the second to assess farm management implications of these. Any innovations should be appraised on both bases. There is a need for further research on the biological effects of paraquat on pasture, in particular the significance of pasture composition changes in relation to fertilizer efficiency. Farm management research must be applied to assess the impact of paraquat as a tool of pasture management.

ACKNOWLEDGEMENTS

Thanks to farmers who have provided sites for trials, to farm advisers and scientists for discussions and to Mrs J. G. Tattersfield (Miss J. G. Miller) for statistical analyses.

REFERENCES

Hight, G. K., 1968: Proc. Ruakura Fmrs' Conf. Week: 4.4.64.
Palmer, P. C., 1968: Proc. 21st N.Z. Weed & Pest Control Conf.: 120-7.
Taylor, R.; Arnst, R. N., 1968: Proc. 21st N.Z. Weed & Pest Control Conf.: 114-9.

DISCUSSION

Rates of water applied with paraquat were 28 to 30 gal per acre. No experimental evidence was available for rates of less than 1 oz per acre. Asked whether the results obtained would be applicable to hill country, Williams replied that little aerial work had been carried out. Cost of application and efficiency at low rates would heed to be considered. It could perhaps be used in isolated areas or for a specific purpose. Responses were best on high-fertility areas. As far as trees were 'concerned, there would be only a temporary scorching of leaves.

Paraquat could be used for the introduction of ryegrass on hills, but best establishment came after drilling. Blackmore commented that a number of hill pastures had been established by air, with good strikes of grass. Many of the unwanted grasses were resistant to p'araquat but not to dalapon. However, the latter suppressed clovers. A chemical was needed which would deal specifically with low-fertility species. Williams stated that at present such a chemical was not available and he emphasized the fact that paraquat was most useful on high-fertility pastures.