
THE PROCEEDINGS OF THE
NEW ZEALAND SOCIETY
OF
ANIMAL PRODUCTION
VOLUME 62 2002

# ANIMAL AND PASTURE PRODUCTION AS INDICES OF FERTILIZER MAINTENANCE REQUIREMENTS

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SUMMARY

Responses to 1 cwt and 3 cwt of superphosphate per acre per annum were measured over a seven-year period by various mowing and grazing techniques. Permanent mowing and clipping-return enclosures were considered unsatisfactory. Mowing enclosures which were shifted annually within paddocks topdressed with either treatment and movable frames using the rate-of-growth techniques were both considered satisfactory. Results indicated that 3 cwt per acre superphosphate applied annually was slightly above maintenance topdressing requirements.

Responses were also measured by animal performance as lamb meat and wool produced per acre from Romney ewes carried on the trial through their productive life. Two stocking rates were included, the highest increasing to 8.2 ewes per acre in 1967–8 to obtain maximum utilization of available feed. Under the high stocking rate, responses to 3 cwt per acre superphosphate became evident over the final two years.

Owing largely to variability in seasonal production, it is concluded from present results that animal production as an index of fertilizer maintenance requirements has little advantage over mowing techniques in the presence of the grazing animal.

THERE is considerable knowledge of the fertilizer and trace element requirements for satisfactory pasture establishment on the majority of New Zealand soils, yet little information exists on the quantity of fertilizer required to maintain pasture production.

Unfortunately, the measurement of maintenance topdressing requirements presents many difficulties. The most desirable information required is that of a quantatitive nature which can be measured according to some economic yardstick,—*e.g.*, animal products.

The simplest and least costly approach is to measure maintenance requirements in terms of pasture response to fertilizer. The low cost of these experiments makes it possible to gain precise information by inclusion of a number of treatments and by replication in space. Should mowing experiments be used, it might be argued that, provided the production, digestibility and nutritive value of the pasture is known, the potential animal production for any maintenance topdressing can be calculated. The objection to this approach is that it does not consider the losses in efficiency of utilization that occur in practice; losses which could reduce substantial increases in pasture production to barely discernible differences in animal production.

Animal treading can exert variable effects on pasture production depending upon soil type (Edmond, 1958; Scott, 1963; Campbell, 1967) and the intensity and frequency of defoliation (Brougham, 1957) can have marked effects. The importance of animal returns of dung and urine in improving pasture has been clearly demonstrated (Sears *et al.*, 1948) and an indication of the uneven nature of these returns has been given by Davies *et al.* (1962).

The measurement of actual yields of available pasture dry matter is not only dependent upon harvesting technique (Elliott and Lynch, 1958), but also on the subtraction of a large amount of decaying and dead plant material. Campbell (1964) has made the distinction between apparent pasture production and net gain of available pasture dry matter—the two of which can differ significantly. He also attempted to assess the percentage utilization of pasture throughout the year—a figure which is only of the order of 20% by the method considered most meaningful by Campbell.

Looking at the animal itself, it is clear that reactions to climatic environment are considerable (Joyce and Blaxter, 1964), and it is unlikely that they will change entirely in sympathy with changes in pasture productivity or quality. Yet another factor invalidating the direct transposition of pasture yield increases to animal producitvity is the variation in maintenance requirements of animals in harvesting pasture at different stocking pressures (Coop, 1965). Finally, the low level of conversion of plant energy into animal products (Hutton, 1963), means that pasture production measurements must over-estimate the size of response obtainable as animal products.

It was with the foregoing factors in mind, some of which have only recently been clearly defined, that the present experiment was commenced in 1961. The purpose of this paper is to outline the main results and to use them to discuss and assess the adequacy of animal grazing trials as a means of measuring fertilizer maintenance requirements.

## EXPERIMENTAL

The trial area was on a hygrous yellow-grey earth which typifies coastal hill country of Otago. The area had been developed from browntop pasture for 10 years and topdressed annually with 2 cwt per acre superphosphate. The sward composition was not good—containing by point analysis 23% sown grasses, 22% clovers and 34% weed grasses.

The trial was a five replicate randomized block design comparing 1 cwt and 3 cwt per acre* superphosphate applied annually at a low and a high level of stocking. The low-rate stocking plots were 1.42 acres in area and the high-stocking plots 0.83 acres.

The trial was stocked with two-tooth Romney ewes and these were culled when full mouth and were replaced by a new line of two-tooth ewes. Ewes were mated to Southdown rams.

## Stocking Rates

The stocking rates and lamb-carrying percentages are shown in Table 1.

TABLE 1: EWE AND LAMB CARRYING CAPACITY

| | *Low Stocking* | | *High Stocking* | |
|---|---|---|---|---|
| | *No. Ewes per Acre* | *Lambs/Ewes per Acre (%)* | *No. Ewes per Acre* | *Lambs/Ewes per Acre (%)* |
| 1961–2 | 3.5 | 120 | 6.0 | 120 |
| 1962–3 | 4.2 | 150 | 5.9 | 140 |
| 1963–4 | 4.2 | 150 | 6.0 | 160 |
| 1964–5 | 4.9 | 157 | 7.1 | 150 |
| 1965–6 | 5.0 | 110 | 7.4 | 110 |
| 1966–7 | 6.4 | 145 | 8.0 | 139 |
| 1967–8 | 6.4 | 156 | 8.2 | 129 |

The two stocking rates initially selected were considered to be optimum, and excessively high, respectively. These were subsequently shown to be too low and were increased so that increases cannot be attributed to any improvement in pasture composition or production as a result of heavier stocking. They are the result of decisions to increase stocking to reach a point where animal performance was depressed through heavy stocking.

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*9 cwt per acre was applied to the "3 cwt superphosphate" treatment in 1965.

Lamb-carrying percentages were balanced between fertilizer treatments and because of this the percentages in Table 1 do not indicate lambing percentages accurately.

PASTURE PRODUCTION

Production from each paddock was measured under grazing by the movable frame technique (Lynch, 1947).

Within each of the 20 paddocks, two mowing and clippings-return (Lynch, *loc. cit.*) trials were conducted annually. Both contained plots receiving 0, 1 and 3 cwt per acre superphosphate. One of these trials was a permament enclosure and received annual fertilizer application. The second trial was shifted annually on to a new site within the paddock so as to measure the residual value of previous paddock fertilizer treatments.

MANAGEMENT

Difficult management decisions arose and at times ideal management practices had to be forgone so that treatments could be handled in a comparable manner to permit a valid comparison of results. This meant that management was not at maximum efficiency at some times of the year.

In the first year there was sufficient saved grass to winter all stock on all treatments on grass alone. In the sixth and seventh winters this was also possible on the lightly stocked treatments. For the remaining years swedes or choumollier were fed at between 0.2 and 1.0 acres per 100 ewes. These areas of winter feed were grown outside the trial area but are included in computations of stocking rates.

Immediately prior to lambing until weaning at the first draft, ewes and lambs were set stocked. Over the first five years this practice was continued through to mating in order to avoid changes in pasture composition brought about by different management of replicates. This resulted in inadequate utilization of feed. Over the last two years, when stocking rates were high, ewes were held on one or two replicates and autumn growth of pasture was saved on the remaining replicates.

Lamb-carrying percentage, birth rank and age were balanced between fertilizer replicates with occasional interchange of ewes and lambs between a replacement mob to balance these factors between fertilizer treatments. No attempt was made to balance the factors between stocking rate treatments.

## RESULTS

### LAMBING PERFORMANCE

Lambing percentages are shown in Table 2.

TABLE 2: PERCENTAGES OF LAMBS BORN

| | Low Stocking | | High Stocking | |
|---|---|---|---|---|
| | Annual Superphosphate Treatment | | | |
| | 1 cwt | 3 cwt | 1 cwt | 3 cwt |
| 1961 | 148 | 140 | 120 | 136 |
| 1962 | 133 | 143 | 132 | 144 |
| 1963 | 126 | 157 | 140 | 148 |
| 1964 | 146 | 183 | 129 | 156 |
| 1965 | 122 | 116 | 114 | 116 |
| 1966 | 135 | 154 | 140 | 151 |
| 1967 | 151 | 157 | 122 | 148 |

In 1961 and 1965 two-tooth ewes account for the relatively low lambing percentage, and no treatment difference was expected as the ewes were introduced to the trial at mating. For the other five years the 3 cwt superphosphate treatment resulted in a higher lambing percentage. This was expected under high stocking, but not under low stocking where adequate feed was available and ewe liveweights at mating were comparable. With one exception, lambing percentage was depressed by higher stocking irrespective of fertilizer treatment.

TABLE 3: MEAN LIVEWEIGHTS OF LAMBS AT DRAFTING (LB)

| | Low Stocking | | High Stocking | | |
|---|---|---|---|---|---|
| | Annual Superphosphate Treatment | | | | |
| | 1 cwt | 3 cwt | 1 cwt | 3 cwt | Coeff. of Var. % |
| 1961–2 | 59.5a* | 58.1a | 61.6a | 61.2a | 15.9 |
| 1962–3 | 62.3a | 60.6a | 60.4a | 63.0a | 3.4 |
| 1963–4 | 67.9aA | 71.2aA | 64.3bB | 64.0bB | 4.9 |
| 1964–5 | 60.8aA | 62.7aA | 55.1bB | 58.1bB | 5.5 |
| 1965–6 | 64.0aA | 65.1aA | 54.1bB | 55.8bB | 4.4 |
| 1966–7 | 52.9aA | 51.8aA | 44.0bB | 45.6bB | 6.9 |
| 1967–8 | 56.7aA | 58.9aAB | 49.6bBC | 52.6bC | 4.4 |

*The results of multiple range tests (Duncan, 1955) at the 5% and 1% levels are indicated by small and capital letters after the means, respectively. For each level of significance, means with the same letter do not differ significantly.

## Lamb Liveweights

Table 3 summarizes the liveweights of all lambs at the first drafting (selection for slaughter). For the initial four years nearly all lambs were drafted at the first draft and in subsequent years two drafts disposed of all lambs.

From the third season onwards there were highly significant depressions in per-animal performance owing to high stocking.

No statistically significant differences could be established between lamb liveweights attributable to high fertilizer use, although the data suggest a response under high stocking in that liveweights are higher on the 3 cwt superphosphate treatments under high stocking in five of the seven years.

## Carcass Gradings

Over the first four years, nearly all lambs were drafted for slaughter prime and no clear differences could be detected between treatments.

In 1965–6, there were differences between stocking rates in percentage of lambs drafted and in the last two years of the trial there were differences between all treatments as shown in Table 4. High stocking not only depressed lamb liveweights, but it also decreased the number drafted. Carcass gradings were inferior from high stocking and there was a higher proportion of lighter carcasses than from the two stocking treatments.

In 1966–7, under high stocking, a high proportion of lambs were drafted from the 3 cwt superphosphate treatment. There were insufficient carcasses in each grade to

Table 4: Percentages of Lambs Drafted for Slaughter

| | | *Low Stocking* | | *High Stocking* | |
|---|---|---|---|---|---|
| | | *Annual Superphosphate Treatment* | | | |
| | | *1 cwt* | *3 cwt* | *1 cwt* | *3 cwt* |
| 1965–6 | (at 1 draft) | 87aA* | 87aA | 58bB | 58bB |
| 1966–7 | (at 2 drafts) | 82aA | 82aA | 58bB | 78aA |
| 1967–8 | (at 2 drafts) | 71bBC | 92aA | 60dCD | 80cAB |

*Results of multiple range tests; see Table 3.

permit a statistical test of the distribution of gradings between treatments.

In 1967–8, there was a greater proportion of poorer carcass gradings (YL Grade) on the 1 cwt than on the 3 cwt superphosphate treatment ($P<0.05$). A similar lowering of carcass, gradings followed high stocking ($P<0.05$).

### Lamb Meat per Acre

Results shown in Table 5 have been calculated on the basis of liveweights of all lambs at drafting, assuming the lambs' carcasses were 48% of their fasted liveweight.

Table 5: Lamb Meat per Acre (lb)

| | *Low Stocking* | | *High Stocking* | |
|---|---|---|---|---|
| | *Annual Superphosphate Treatment* | | | |
| | *1 cwt* | *3 cwt* | *1 cwt* | *3 cwt* |
| 1961–2 | 122 | 119 | 216 | 217 |
| 1962–3 | 190 | 182 | 244 | 255 |
| 1963–4 | 206 | 216 | 296 | 286 |
| 1964–5 | 224 | 231 | 282 | 286 |
| 1965–6 | 169 | 176 | 282 | 290 |
| 1966–7 | 265 | 262 | 272 | 297 |
| 1967–8 | 263 | 281 | 263 | 272 |

As results are largely a reflection of the liveweights and percentages of lambs drafted, the apparent differences in lamb meat per acre between fertilizer rates under heavy stocking are not clearly established.

Results show the marked increase in lamb meat produced per acre following heavy stocking apart from the last two years of the trial when there was only a small gain in lamb meat produced per acre from high stocking owing to a depression in per-animal performance. Also, the fact that fewer and lighter lambs were drafted from the high-stocking treatments lends support to the argument that the high-stocking rate is near maximum.

### Wool Production

Unskirted fleece weights are given in Table 6. Data from two shearings are shown for 1964 because the culled ewes were shorn with eight months' wool at the time of removal from the trial. The results indicate that a large

TABLE 6: MEAN UNSKIRTED FLEECE WEIGHTS (LB)

| | *Low Stocking* | | *High Stocking* | | |
|---|---|---|---|---|---|
| | *Annual Superphosphate Treatment* | | | | *Coeff. of* |
| | *1 cwt* | *3 cwt* | *1 cwt* | *3 cwt* | *Var. %* |
| 1962 | 10.6a* | 10.0a | 10.4a | 10.7a | 11.8 |
| 1963 | 11.3aA | 10.5bB | 10.5bB | 11.5aA | 12.7 |
| 1964 | 9.9bA | 10.4abA | 11.0aA | 10.9aA | 13.7 |
| 1964†‡ | 5.3 | 5.2 | 5.9 | 5.2 | |
| 1965 | 8.6abA | 8.8aA | 8.3bAB | 7.8cB | 10.4 |
| 1966‡ | 10.7 | 10.6 | 10.8 | 10.2 | |
| 1967 | 8.2abA | 8.4aA | 6.9cB | 7.8bA | 15.6 |

*Results of multiple range tests; see Table 3.
†Additional results for 1964 are from culled ewes with 8 months' wool at time of removal from trial.
‡Statistical analysis not available.

response to the quantity of superphosphate occurred only in the last year of the trial and then only at the high stocking rate. Mean fleece weights in 1965 and 1967 were depressed at high stocking; wool production per acre however, was slightly higher than on the low-stocking areas.

Wool characteristics were assessed from 1964 onwards. Consistent differences between treatments for count, style grade, evenness, colour and handle were not apparent.

## PASTURE PRODUCTION

Yields of pasture obtained under grazing for the 3 cwt treatment relative to the 1 cwt treatment are shown in Fig. 1. Yields appear consistently higher on the 3 cwt treatment although the difference due to fertilizer rates did not attain statistical significance until the final year ($P<0.01$).

Results from the annually-shifted mowing enclosures within each paddock are shown in Fig. 2. On paddocks receiving 1 cwt per acre superphosphate annually it is clear that yields declined where topdressing was ceased and that they increased (by approximately 8%) where 3 cwt was applied in place of the paddock dressing of 1 cwt per acre.

On paddocks receiving 3 cwt per acre superphosphate annually, the shifting mowing trials should have included a treatment at a higher rate of topdressing. As results stand, they must be examined for any decline in yield

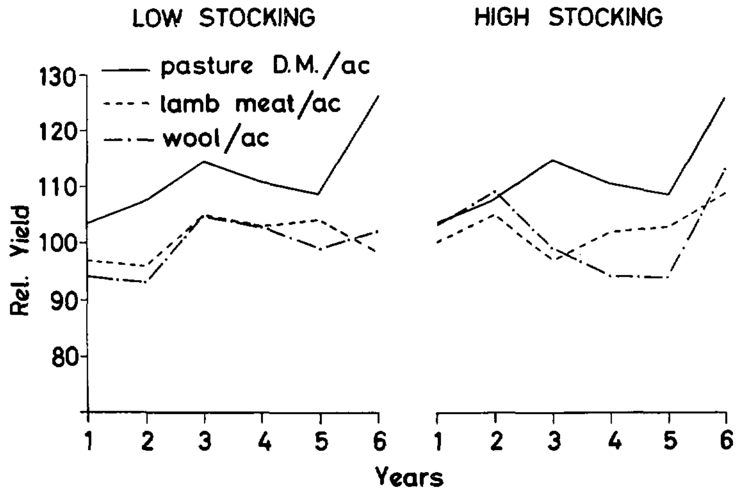


*Fig. 1: Relative yields of pasture dry matter, meat and wool per acre.*

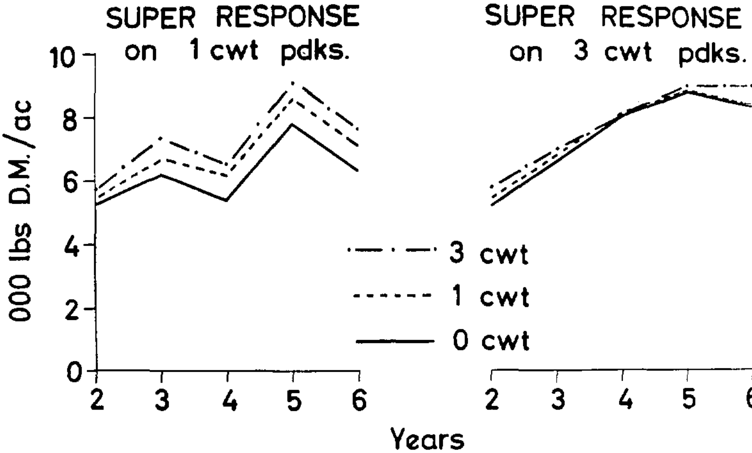


*Fig. 2: Fertilizer responses on annually-shifted mowing enclosures.*

where less than the paddock dressing of 3 cwt per acre superphosphate was applied. There is no evidence to suggest any such decline in yields.

It is concluded from the shifting mowing trials that maintenance topdressing lies between 1 and 3 cwt per acre superphosphate applied annually and probably near to 3 cwt per acre.

## DISCUSSION

The marked increases in carrying capacity obtained on this trial confirm a finding that has become obvious in many parts of New Zealand, *i.e.*, that stocking rates can be raised to a level which previously had been considered far above optimum. There is little doubt that still higher carrying capacity could be obtained in this trial if experimental procedures gave greater freedom of management.

The main objective of this experiment was to assess a technique of measuring fertilizer maintenance requirements. Figure 1 shows the yields of pasture dry matter from mowing under grazing, and the animal production as meat per acre, and wool per acre. Yields of each measure of production are shown as relative yields from the 3 cwt treatment with the 1 cwt treatment = 100.

Clearly, the results show a pasture response to 3 cwt superphosphate, the mean for six years being 11% higher than the mean of the 1 cwt superphosphate plots. For animal production (both lamb meat and wool per acre) under low stocking, there is no clear increase that can be attributed to the higher rate of superphosphate. Under high stocking, which was only moderately high over the initial three years, there is evidence to suggest a response in lamb-meat and wool produced which can be attributed to the higher rate of superphosphate topdressing. The overall response of both, resulting from the higher rate of fertilizer under high stocking, was 3%. Such an assessment needs qualification to the extent that it does not take into account advantages in better lamb-drafting and grading performance on high superphosphate treatments.

The lower level of animal response to the higher rate of superphosphate topdressing compared with potentially available pasture production is in accord with the general assumption made at the commencement of the trial. Losses in conversion of potentially-available pasture production to animal products is of the order of 8% in this experiment. It would be tempting to conclude, therefore, that, for the person who is to use the results of this experiment, the animal production data would be more meaningful for a cost/benefit analysis than the pasture data.

Looked at another way, however, an adviser using these results would presumably wish to narrow advice down below a choice of either 1 cwt or 3 cwt of superphosphate per acre. Owing to variation in response to treatment, probably arising largely through seasonal production variations, no more accurate conclusion can be reached from the animal data than that a topdressing maintenance level of close to 3 cwt per acre is necessary.

Should variability have been less and permitted a more accurate prediction of maintenance topdressing based on animal data, results would still apply only at the stocking rates used in the experiment. Lambourne and Reardon (1963), Coop (*loc. cit.*) and Morley (1966) have produced differing kinds of evidence all of which make it reasonable to assume that animal performance and stocking rate do not bear a linear relationship. For this reason, it appears that at least three stocking rate treatments would be necessary to obtain a measure of the true relationship.

Conclusions at this point would be that pasture-mowing data from the shifting plot trial within each paddock, and the movable frame pasture yields, would both have given about the same conclusion as would the animal data. Permanent mowing plots proved unsatisfactory for such a long-term trial owing to sward deterioration. This has been noted elsewhere (Scott *et al.*, 1963).

In view of the conclusions drawn from the present experiment, it appears that the very high expenditure on animal experimentation as a means of measuring fertilizer maintenance is of rather doubtful value. By using pasture-mowing techniques, a greater number of fertilizer treatments and more replications in space can be achieved to give added precision. Conversion of pasture yields to likely animal performance for purposes of economic appraisal may be sufficiently accurate if based on field established feeding standards.

Conclusions regarding the suitability of animal grazing experiments as a means of measuring fertilizer maintenance topdressing should not detract from the considerable value of this type of experiment in demonstrating the importance of increased stocking and in placing stocking rate and fertilizer requirements in true perspective.

## ACKNOWLEDGEMENTS

The author wishes to acknowledge the considerable assistance of staff at Invermay Agricultural Research Centre and particularly of the late T. Caldwell, O. Booth and A. J. Crawford. The assistance of N. Mountier, Lincoln College, and G. Arnold, Biometrics Section, Department of Agriculture, is also gratefully acknowledged.


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