

Long term effects of withholding phosphate application on North Island hill country: Whatawhata Research Centre

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ABSTRACT From June 1984 to May 1988 a large-scale grazing trial at Whatawhata Research Centre evaluated the effects of a halt to previous superphosphate fertiliser application on hill country production. Over the 4-years pasture production, pasture species composition, stock grazing days or Olsen P soil fertility status were little affected as a result of halting topdressing. Pasture production declined most on 'easy' (10-20° slope) slopes after a halt to fertiliser application. The decline was greatest (10-13%) where previous rates of fertiliser had been high. Total production on 'steep' (30-40° slope) slopes did not decline significantly. However, at soil test (Olsen P) levels of less than 10 the pasture moss and dead matter content increased, indicating a deterioration in pasture quality. Legume content did not decline. Within the range of normal topdressing rates to hill country (0-30 kg P/ha/yr) Olsen P tests did not reflect topdressing differences or any effects of a halt to fertiliser application. At higher topdressing rates (50-100 kg P/ha/yr) the effect of continued or discontinued topdressing was reflected predominantly in the 0-3 cm soil depth. A halt to previous topdressing significantly reduced available grazing over the final 3 years. This decline reflected the decline in measured pasture production.

Keywords Phosphate, fertiliser, hill country, residual effects

INTRODUCTION

During 1975-85 fertiliser application to New Zealand hill country peaked at more than 1 m tonnes annually. On most farms this represented the culmination of a long period of pasture development, improvement and stabilisation. In addition land development incentive schemes encouraged the establishment of significant areas of new hill country pasture, especially in the North Island.

The withdrawal of subsidies on fertiliser and other farm inputs in the mid 1980's put severe economic pressure on many hill country farms, and fertiliser use fell drastically. Little research information was available to predict the effects on pasture or animal production of reducing or withholding fertiliser

application. Farmers were therefore not able to make rational decisions as to how or where fertiliser application could initially be reduced with least subsequent effects on production.

At Whatawhata Research Centre a large scale trial which had received a range of superphosphate application rates for 4 years had developed a range of soil phosphate and pasture production levels (Gillingham et al. 1984). This site was used to evaluate the effects of halting topdressing, compared with continued annual application of superphosphate, on pasture production, pasture species composition, animal grazing days, and soil P levels on both easy and steep sloping hill country.

TRIAL SITE

The trial site was at Whatawhata Research Centre, latitude 37° 48's, altitude 200 m, 22 km west of Hamilton in the North Island of New Zealand. The total area was 21.4 ha with a general west-north-west aspect; slopes ranged from flat to very steep (i.e. 40° +). The soil was predominantly a northern yellow-brown earth with some recent volcanic ash on some gentle slopes (Bruce 1976). The pasture had been established for 15-20 years and had been regularly fertilised with superphosphate. The area was subdivided into 25 paddocks such that each contained some slopes ranging from flat to greater than 30°. Because of the variable topography this resulted in paddocks of different size (range 0.243 to 1.223 ha).

TRIAL MANAGEMENT

Superphosphate fertiliser was applied annually in late summer-autumn at rates of 10, 20, 30, 50 or 100 kg total P/ha to 4 replicates. An additional 5 paddocks were each topdressed at 5 different rates and used as preconditioning areas for stock being transferred onto the trial, as indicated below. This programme was followed for 4 years (1980-84) after which fertiliser application to 2 replicates of each treatment was discontinued for a further 4 years (Residual treatments). Fertiliser application was also stopped on the 'preconditioning' paddocks. Fertiliser application to 2 replicates of each fertiliser rate. Rotational grazing was by 5 mobs of about 200 Romney-cross ewes or wethers placed in preconditioning paddocks for 2 days. This was to minimise the effects of different pasture P content on associated dung P return during grazing, before being moved onto the first replicate of the

Table 1 Effect of fertiliser P rate (easy slope only), slope (easy and steep) and fertiliser withholding policy (Maintenance or Residual) on annual pasture DM production (kg/ha)

| | P rate (kg/ha) | | | | | P. Rate effect Sig. | Slope | | Slope x policy effect Sig. |
|--|----------------|-------|--------------|--------------|--------------|--------------------------|-------|-------|----------------------------|
| | 10 | 20 | 30 | 50 | 100 | | Easy | Steep | |
| Year 1 (1984/85) | | | | | | | | | |
| Easy: Maint. | 10550 | 11800 | 11400 | 13250 | 13150 | *(L)¹ | 12050 | 6350 | ** |
| Resid. | 9650 | 10500 | 10700 | 11700 | 12100 | (474)² | 10900 | 7000 | (369) |
| Year 2 (1985/86) | | | | | | | | | |
| Easy: Maint. | 12550 | 14300 | 13500 | 15300 | 16100 | N S | 14350 | 8700 | NS |
| Resid. | 12500 | 13700 | 12550 | 14150 | 14800 | | 13550 | 7700 | |
| Year 3 (1986/87) | | | | | | | | | |
| Easy: Maint. | 11600 | 13450 | 13150 | 14700 | 15750 | *(L) | 13750 | 8200 | * |
| Resid. | 11250 | 12150 | 11350 | 12300 | 13800 | (748) | 12150 | 8150 | (542) |
| Year 4 (1987/88) | | | | | | | | | |
| Easy: Maint. | 13200 | 14450 | 14100 | 15700 | 16150 | *(L) | 14700 | 10000 | ** |
| Resid. | 12950 | 13200 | 12650 | 13500 | 14450 | (676) | 13350 | 9450 | (499) |
| Mean all years | | | | | | | | | |
| Easy: Maint. | 12000 | 13500 | 13000 | 14750 | | ** | | | |
| Resid. | 11600 | 12400 | 11800 | 12900 | 13800 | (478) | | | |
| Steep: Maint. | | | | | | | | | |
| Resid. | 8150 | 8200 | 7500 | 8500 | 8650 | N S | | | |
| Resid. | 8200 | 7700 | 8700 | 8100 | 8400 | | | | |
| Mean decline with no fertiliser | | | | | | | | | |
| Easy: | 400 | 1100 | 1200 | 1850 | 1500 | | | | |
| steep: | -50 | 500 | -1200 | 400 | 250 | | | | |

¹Only the linear component of the analysis was significant

²Standard Error of the Difference (SED)

Table 2 Effects of fertiliser policy on pasture species composition (% frequency of occurrence). **M=maintenance** of fertiliser application; **R=residual** effects of past topdressing. Significant effects of fertiliser P rate are also shown.

| | | Easy slopes | | | | steep slopes | | | |
|-----------------|------------|-------------|----------------|------------------|------------------|----------------|---------|----------------|---------|
| | | 1984/85 | 1985/86 | 1986/87 | 1987/88 | 1984/85 | 1985/86 | 1986/87 | 1987/88 |
| Ryegrass | M | 57 | 63 | 65 | 66 | 20 | 24 | 18 | 26 |
| | R | 55 | 64 | 57 | 56 | 15 | 23 | 19 | 23 |
| | Sig. (SED) | | | *(3.08) | ** (2.41) | | | | |
| P rate effect | Sig. (SED) | *(4.68) | | ** (4.02) | | | | | |
| | | | | | | | | | |
| Browntop | M | 35 | 28 | 26 | 29 | 32 | 30 | 37 | 31 |
| | R | 32 | 29 | 33 | 36 | 29 | 32 | 28 | 33 |
| | Sig. (SED) | | | *(3.38) | *(2.53) | | | | |
| P rate effect | Sig. (SED) | | *(3.27) | *(5.38) | | | | | |
| | | | | | | | | | |
| White clover | M | 45 | 41 | 33 | 42 | 18 | 19 | 13 | 25 |
| | R | 38 | 40 | 35 | 42 | 16 | 17 | 12 | 17 |
| | Sig. (SED) | | | | | | | | |
| P rate effect | Sig. (SED) | | | | | | | | |
| | | | | | | | | | |
| weeds | M | 27 | 30 | 36 | 37 | 27 | 30 | 43 | 38 |
| | R | 27 | 32 | 40 | 41 | 28 | 27 | 35 | 42 |
| | Sig. (SED) | | | | | | | | |
| P rate effect | Sig. (SED) | | | *(3.17) | ** (3.63) | | | *(4.99) | |
| | | | | | | | | | |
| Moss | M | 28 | 19 | 18 | 25 | 54 | 44 | 53 | 56 |
| | R | 25 | 27 | 23 | 29 | 53 | 51 | 56 | 57 |
| | Sig. (SED) | | *(3.34) | | | | | | |
| P rate effect | Sig. (SED) | | | | | *(9.19) | | *(9.39) | |
| | | | | | | | | | |

respective Residual phosphate rate treatments. Grazing of the first replicate usually took 2-3 days before each mob was moved on to graze the second replicate and then moved on to the first and the second replicates of the Maintenance treatments, before being removed from the trial area. Post-grazing pasture height was about 2-3 cm. During early spring each year (i.e. September-October) the total trial was continuously grazed. All stock numbers and grazing durations were recorded. Grazing treatments began in May 1984.

Within each paddock were fixed measurement sites on both easy ($10-20^\circ$ slope) and steep ($30-40^\circ$ slope) strata. These were established as 5 transects distributed representatively over each paddock with each transect consisting of 5 pegs, each indicating a measurement area of about 1-2 m radius as defined by slope. These sites were used for all subsequent pasture and soil measurements.

TRIAL PRODUCTION MEASUREMENT

Mean, post-grazing, pasture dry matter (DM) levels on each transect were visually assessed. A site

representing the mean value was selected, trimmed to about 2 cm height, or just below the mean grazing level, and a 0.2m^3 exclusion cage placed on the site. At the next measurement date, i.e., after grazing, the regrowth pasture was harvested and the cage repositioned. Pasture regrowth interval varied from about 4 to 6 weeks with a total of 9 harvests per year.

PASTURE SPECIES COMPOSITION

Pasture species composition was measured by 2 methods: percentage frequency of occurrence and percentage, by weight, of DM production. The former was recorded in early spring each year, after the pasture had been under **continuous** grazing for at least 2 weeks. On permanently established line transects (adjacent to those used for other measurements) and up to 20 in each paddock, the pasture species observed to be present in a 5 mm diameter ring held 5 cm above ground level were recorded. Measurements were made at 0.5 m intervals along each 20 m transect, **totalled** for each slope category, and expressed as a percentage of the total observation sites.

Table 3 The major components of pasture composition (% by weight) in spring 1984 (Year 1) and 1987 (Year 4) and significant effects of fertiliser policy in other seasons. Associated slope and fertiliser P Rate effects are shown.

| | | Policy | | | Slope | | | P rate effect | | | |
|---------|-----------------|--------|-------|------|-------|-------|------|---------------|-------|------|-------|
| | | Resid | Maint | Sig. | Easy | Steep | Sig. | | | | |
| 1984/85 | | | | | | | | | | | |
| Spring | Ryegrass | 26 | 23 | | 41 | 8 | | (3.0) | NS | | |
| | Browntop | 11 | 12 | | 13 | 11 | | | | | |
| | White clover | 7 | 10 | | 10 | 7 | ** | (0.7) | | | |
| | weeds | 11 | 11 | | 9 | 13 | * | (1.9) | | | |
| | Dead matter | 4 | 7 | * | 3 | 9 | *** | (1.1) | | | |
| | Moss | 4 | 4 | | 0 | 0 | * | (2.1) | | | |
| 1985/86 | | | | | | | | | | | |
| Winter | Moss | 6 | 3 | *** | (0.9) | 0 | 8 | *** | (1.1) | ** | (0.9) |
| Spring | Other grasses | 16 | 12 | * | (1.6) | 3 | 24 | *** | (2.0) | | |
| Summer | Grasses | 60 | 69 | ** | (2.3) | 61 | 68 | | | | |
| | Dead matter | 15 | 11 | * | (1.4) | 12 | 15 | | | | |
| | Moss | 2 | 1 | * | (0.6) | 0 | 3 | *** | (0.6) | | |
| Autumn | Ryegmss | 26 | 32 | ** | (1.6) | 48 | 10 | *** | (2.4) | ** | (2.6) |
| 1986/87 | | | | | | | | | | | |
| Winter | Grass | 67 | 72 | * | (2.2) | 80 | 59 | *** | (1.9) | * | (3.4) |
| | Dead Matter | 13 | 8 | * | (1.7) | 4 | 17 | *** | (1.7) | | |
| 1987/88 | | | | | | | | | | | |
| Spring | Ryegrass | 16 | 25 | ** | (2.2) | 32 | 9 | *** | (2.4) | *(L) | (3.4) |
| | Browntop | 10 | 12 | | | 12 | 10 | | | | |
| | White Clover | 6 | 6 | | | 7 | 6 | | (1.4) | *(L) | (1.4) |
| | weeds | 16 | 13 | | | 13 | 16 | | | | |
| | Dead matter | 5 | 6 | | | 4 | 7 | ** | (0.8) | | |
| | Moss | 2 | 2 | | | 1 | 3 | * | (0.8) | | |
| Summer | Grass | 53 | 61 | * | (3.1) | 58 | 55 | | | * | (5.0) |
| | weeds | 20 | 15 | ** | (1.6) | 22 | 13 | ** | (1.5) | ** | (2.5) |
| Autumn | Grass | 57 | 67 | *** | (1.5) | 72 | 52 | *** | (2.3) | | (2.4) |
| | Dead matter | 14 | 10 | * | (1.3) | 6 | 18 | *** | (1.3) | * | (2.1) |

The latter was measured in each season by subsampling harvested pasture, separating into single or bulked species categories and expressing each as a percentage of the total sample weight.

SOIL PHOSPHATE (OLSEN P)

In late summer/early autumn of each year, soil samples at 0-3, 3-7 and 7-15 cm depths were collected from each pegged site and bulked per depth to form one sample per transect i.e., 5 per stratum per paddock.

Samples were dried, sieved and analysed for phosphate (P) by the MAF Quick test procedure.

ANIMAL GRAZING DAYS

Sheep numbers grazing each paddock and the duration of each grazing period were recorded and summed to give total sheep grazing days per year.

Because paddocks differed in their proportion of easy and steep slopes and consequently in their overall productivity regardless of fertiliser treatment, the percentage easy sloping land in each paddock was measured and used as a covariate when comparing grazing days per treatment.

RESULTS

Pasture DM production

Over the 4-years pasture DM production increased significantly with increasing fertiliser P rate, but on easy slopes only (Table 1). Mean production on easy

slopes ranged from 12 000 kg DM/ha at 10 kg P/ha to 15 300 kg DM/ha at 100 kgP/ha.

The decline in production as a result of halting topdressing, and relying on residual effects compared with maintaining fertiliser application, was also significant only on easy slopes. The difference in annual production between Residual and Maintenance treatments increased with increase in fertiliser P rate. Where only 10 kg P/ha/yr had been previously applied mean annual DM production was only 400 kg/ha (3 %) less than where this topdressing rate continued. Where 100 kg P/ha/year was the previous topdressing rate the mean production decline was 1500 kg DM/ha/year (i.e. 10%).

Seasonal reductions in pasture growth also occurred on Residual treatments in year 1 (Spring and Autumn), year 2 (Winter), year 3 (Spring) and year 4 (all seasons).

Pasture species composition

Climate in early spring is very similar from year to year and therefore provides a useful time to assess the effects of a management change on pasture composition. The halt to fertiliser application had little effect over 4 years on pasture species composition in spring, whether measured by the '% frequency' (Table 2) or by the '% by weight' (Table 3) techniques.

White clover content in spring was unaffected, and on easy slopes a significant decline in ryegrass and increase in browntop content did not occur until year 3 (Table 2). On steep slopes no such effects occurred.

Measurements in other seasons showed isolated but inconsistent responses. The exception was the grass component, which declined, and weeds or dead matter, which increased, when fertiliser was discontinued (Table 3). In all seasons slope was the dominant influence on most components of pasture composition (Table 3).

Fertiliser rate predominantly affected the grass component (Tables 2 and 3), although weeds, moss, dead matter and white clover showed isolated responses.

At certain times of the year both moss and dead matter formed significant amounts of the total DM measured. Consequently these components were measured (% by weight) at all harvests and subtracted from total DM to give a measure of net green growth, the more responsive component of the pasture, and that which is more relevant as a measure of available grazing for animals.

Net green pasture production was lower (results not shown) but showed a similar response to fertiliser P rate and fertiliser withdrawal as did total pasture DM production (Table 1). Slope had a significant effect on the pattern of moss and dead matter accumulation. On easy slopes the annual total was similar (800 to 1250 kg/ha) across all fertiliser rates in both maintenance and residual treatments. On steep slopes, however, moss plus dead matter tended to be highest (2500

Table 4 Effect of fertiliser P rate and policy (M=maintenance; R=residual) on the Olsen P status of the soil (mean of easy and steep).

| P rate (kg/ha) | Depth (cm) | 1984 | | 1985 | | 1986 | | 1987 | | 1988 | | |
|----------------|------------|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| | | M | R | M | R | M | R | M | R | M | R | |
| 10 | 0-3 | 9 | 10 | 9 | 8 | 8 | 8 | 9 | 9 | 9 | 9 | |
| | 3-1 | 1 | 8 | 9 | 8 | 6 | 8 | 5 | 7 | 7 | 7 | |
| | 7-15 | 4 | 6 | 6 | 6 | 3 | 5 | 5 | 5 | 6 | 6 | |
| 20 | 0-3 | 13 | 12 | 14 | 12 | 11 | 17 | 9 | 14 | 12 | 12 | |
| | 3-7 | 8 | 8 | 11 | 9 | 8 | 5 | 6 | 7 | 8 | 8 | |
| | 7-15 | 4 | 1 | 7 | 6 | 6 | 6 | 6 | 6 | 5 | 5 | |
| 30 | 0-3 | 12 | 12 | 11 | 16 | 18 | 13 | 8 | 14 | 9 | 9 | |
| | 3-7 | 7 | 8 | 9 | 10 | 5 | 8 | 6 | 10 | 7 | 7 | |
| | 7-15 | 4 | 7 | 6 | 7 | 6 | 4 | 6 | 6 | 5 | 5 | |
| 50 | 0-3 | 25 | 35 | 17 | 44 | 17 | 47 | 14 | 40 | 15 | 15 | |
| | 3-7 | 10 | 16 | 10 | 15 | 10 | 16 | 8 | 20 | 9 | 9 | |
| | 7-15 | 7 | 11 | 7 | 11 | 7 | 12 | 7 | 12 | 7 | 7 | |
| 100 | 0-3 | 45 | 55 | 33 | 65 | 28 | 74 | 21 | 80 | 21 | 21 | |
| | 3-7 | 15 | 21 | 14 | 22 | 16 | 24 | 12 | 28 | 11 | 11 | |
| | 7-15 | 7 | 13 | 10 | 15 | 10 | 14 | 8 | 16 | 8 | 8 | |
| Policy | 0-3 | ** | (2.0) | | (1.8) | *** | (2.6) | *** | (3.6) | | | |
| | 3-7 | NS | | | (0.9) | *** | (0.7) | *** | (0.6) | | | |
| | 7-15 | *** | (0.3) | *** | (0.4) | ** | (0.5) | ** | (0.6) | | | |
| P Rate | 0-3 | . | ** | (1.6) | *** | (3.2) | *** | (2.9) | *** | (4.1) | *** | (5.7) |
| | 3-7 | *** | (0.8) | . | | (1.4) | . | ** | (1.2) | . | | (0.6) |
| | 7-15 | *** | (0.5) | *** | (0.5) | . | ** | (0.6) | . | ** | (0.7) | *** |

kg/ha) at the low fertiliser rates and declined to 1300 kg/ha at the highest fertiliser rates. This interaction was consistent but not statistically significant. There was some indication that moss plus dead matter content was higher under residual than under maintenance conditions where the fertiliser rates were only 10 or 20 kg P/ha.

Soil phosphate (Olsen P)

Soil tests were similar on both easy and steep slopes in each treatment and therefore the mean values only are shown in Table 4.

In 1984, after a range of fertiliser application rates had been applied for the previous 4 years, a corresponding range in soil P tests had developed (Table 4). Over the range of topdressing rates from 10 to 30 kg P/ha/yr, soil tests were very similar. At 50 and 100 kg P/ha Olsen P soil tests were significantly higher. At these higher rates and greatest rise in soil test was in the surface soil (0-3 cm depth). There was little movement of phosphate into the 7-15 cm soil depth by 1984.

During the next 4 years and over the topdressing range 10 to 30 kg P/ha/yr the effect of either continuing or halting fertiliser application had little effect on soil P tests.

At the higher topdressing rates the effect of fertiliser policy was more significant. Continued fertiliser application raised soil P test levels at all depths. Halting topdressing caused a gradual fall in soil P tests in the surface soil of the 50 kg P/ha treatment, and in both the 0-3 cm and 3-7 cm depths of the 100 kg P/ha treatment.

Subsoil (7-15 cm) P tests were not affected by halting topdressing.

Although the soil sampling pattern was very intensive and from fixed sites each year, fluctuation in Olsen P test values from year to year was still unexplained, especially when levels were lower than 10.

Animal grazing days

In 1983/84, the year just before the study period, animal grazing days generally increased with increasing fertiliser rate (Table 5) but not significantly. Similarly, the total animal grazing days allocated to M and R treatments did not differ significantly, i.e. 4510 and 4357 respectively.

The apparent relative decline in grazing days without fertiliser was 11.3, 13.6, 17.1 and 15.5% in years 1, 2, 3 and 4 respectively (Table 5). In the final 3 years of the trial these differences were significant.

DISCUSSION

Annual application of superphosphate for 4 years increased average pasture growth on gentle slopes (10-20%) only. Similarly, ceasing topdressing, after a previous history of regular application, significantly reduced annual pasture growth on easy slopes only.

The overall drop in production without fertiliser tended to be greater (not significantly) with higher previous topdressing rates. At the highest previous rate (100 kg P/ha) the mean decline in annual production on easy slopes without topdressing was about 10%, compared with only about 3% reduction with 10 kg P/ha.

In line with the DM response pattern there were greater changes in pasture species composition as a result of increasing fertiliser rate (not all responses were presented) than were caused by a halt in topdressing. Considering the small fall in pasture DM production resulting from a halt to topdressing, it would be surprising if changes in pasture species were major.

A halt to topdressing is generally considered to initially affect the legume content of pasture. This did not occur and the grass component, especially ryegrass, was the more sensitive pasture component.

Perhaps the most responsive components of the pasture to differences in fertiliser input were moss and

Table 5 Effects of fertiliser P Rate and policy (M=maintenance; R=residual effects of past application) on total stock grazing days/ha/year (corrected for slope differences between paddocks).

| | Fertiliser P rate (Kg/ha) | | | | | Policy | | | | % Difference | % change from Year 1 | |
|--------------------|---------------------------|------|------|------|------|--------------|------|------|--------------|--------------|----------------------|--|
| | 10 | 20 | 30 | 50 | 100 | Sig | M | R | Sig | | | |
| | | | | | | * | | | | | | |
| 1984/85 Year 1) | 3632 | 4443 | 3867 | 5012 | 5229 | (412.8) | 4704 | 4170 | NS | 11.3 | | |
| 1985/86 | 3708 | 4613 | 3507 | 4824 | 5010 | (38f8.2) | 4650 | 4015 | (24; .2) | 13.6 | 2.3 | |
| 1986/87 | 3298 | 3781 | 3228 | 4567 | 4716 | * (399.1) | 4283 | 3552 | 248t.7) | 17.1 | 5.8 | |
| 1987/88 | 3449 | 3804 | 3507 | 4559 | 4454 | (36ts.5) | 4286 | 3623 | * (229.6) | 15.5 | 4.2 | |

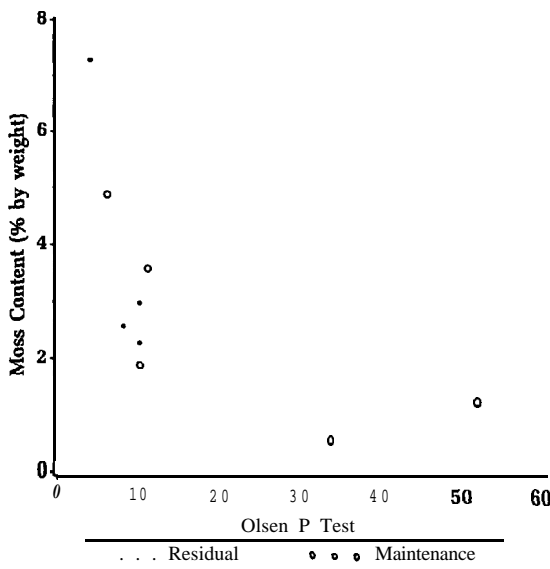


Figure 1 Pasture moss content in 1987/88 (mean all harvests) relative to soil Olsen P test (0-7 cm February 1988) — Steep slopes only.

dead matter, especially on steep slopes where moss content increased sharply at soil test (Olsen) levels of less than 10 (Figure 1). This effect did not occur on easy slopes at the same low soil test levels, presumably because other growth-related soil characteristics still produced more than 11000 kg DM/ha/yr. At lower production levels moss was more competitive and, with dead matter, substituted for other species in the pasture. The presence of both of these components provides a useful indication of slow growth and lower pasture utilisation than under higher fertility conditions.

The soil tests showed a number of interesting features. Samples were taken at both 0-3 and 3-7 cm depths whereas the usual advisory samples are taken as a single sample to 7.5 cm depth. Results showed that as topdressing rate increased most of the rise in soil P status was in the surface soil. With a halt to topdressing almost all of the decline in soil P test also occurred in the 0-3 cm depth of soil.

At fertiliser rates of 30 kg P/ha or less soil P test was affected little. This indicates that the extra P supplied by 30 kg P/ha, compared with 10 kg P/ha, contributed largely to extra P uptake by pasture and some increase in production (Table 1), with more P being transferred away by stock compared with the 10 kg P/ha topdressing rate. Only at fertiliser rates of 50 kg P/ha or more was this equilibrium overcome and excess P accumulated in the soil. The results suggest that Olsen P tests will not clearly identify differences in topdressing policy over a 4-year period

when annual fertiliser rates are in the range 0-30 kg P/ha.

Animal grazing days in the first year without fertiliser differed markedly in the Residual compared with Maintenance treatments (Table 5), i.e. a differences of 11.3% compared with only 3.5% estimated for the same paddocks in the year just before the study commenced. There was no similar change in pasture production (Table 1) or species composition (Table 2 and 3) which could have contributed to such a rapid change in stock grazing days. The result may therefore be largely an effect of the change in grazing system with the start of this study. Because animals grazed the residual treatments before the maintenance treatments, stock had possibly lost appetite in the latter half of the rotation and were taking longer to graze out each paddock. This would have inflated estimated stock grazing days for the maintenance treatments.

A more useful comparison, therefore, is to examine the change occurring after year 1. This shows that grazing days on residual treatments declined a further 2.3, 5.8 and 4.2% in years 2, 3 and 4 respectively. These changes reflect the pasture production measurements on easy slopes in particular. In any paddock with an equal distribution of easy and steep slopes, most of the pasture growth will occur on easy slopes. It is, therefore, not surprising that stock grazing records should align with pasture production results from easy slopes, and in this trial conform that overall production declined only slightly over 4 years as a result of halting topdressing.

Measurements of pasture production, pasture species composition and stock grazing days all indicate that over the range of most fertiliser application rates to hill country (i.e., 10-30 kg P/ha) the effect of stopping, compared with continuing, topdressing, had little effect over a 4 year period. The most significant effect on steep slopes in this region was that the moss and dead matter components of the pasture tended to increase markedly at soil P tests of less than 10. Consequently these components would be expected to become more widespread, with more significant effects on production, over longer periods without fertiliser.

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