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# PASTURE INVESTIGATIONS IN THE SANDY FOREST COUNTRY OF NORTH-WEST QUEENSLAND
## 1. Nutritional Requirements

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**SUMMARY**

**The effects of several nutrients on Townsville stylo (*Stylosanthes humilis*) were assessed in two field experiments near Normanton in north-west Queensland. In the first experiment, the response to three rates of phosphorus in the presence and absence of potassium, sulphur, molybdenum, zinc, magnesium-plus-manganese and copper-plus-boron was examined on a sandy yellow earth soil of the Mayvale land system. In the second experiment, on a mottled grey earth soil, four rates of phosphorus and zinc and two rates of potassium were compared.**

**In the first experiment, phosphorus, potassium and zinc were the most important elements necessary for successful growth of Townsville stylo. Molybdenum and sulphur deficiencies were also indicated. Copper-plus-boron was associated with yield depression while magnesium-plus-manganese in the presence of the high phosphorus rate was associated with population depression.**

**In the second experiment rates of 48, 96 and 192 kg ha$^{-1}$ of phosphorus resulted in significant yield increases of Townsville stylo over the 24 kg ha$^{-1}$ rate.**

## I. INTRODUCTION

On the basis of a mean pasture growing period of at least 15 weeks, 6 578 000 ha of Queensland's eastern Gulf country (Leichhardt–Gilbert area) are suitable for Townsville stylo (*Stylosanthes humilis*) growth (Begg 1972). The sandy forest country occupies most of this area (Perry 1964; Bishop 1973).

The climate is monsoonal and Normanton receives 88% of its mean annual rainfall of 915 mm during the 4 summer months of December to March. Topography is flat to gently undulating with total elevation below 90 m and local amplitude less than 6 m. All soils are of a sandy nature and very low in plant nutrients. The vegetation is low woodland dominated by *Melaleuca* spp. with a grass understorey of *Aristida* spp., *Sorghum* spp. and *Chrysopogon fallax*. Both yield and quality of the native pasture are low and major deficiencies of energy and protein in the animals' diet occur for 8 months each year with a year-round deficiency in dietary phosphorus. A detailed description of the region is given by Perry (1964) and Bishop (1973).

If productivity of the region is to be increased, then animal nutrition must be greatly improved. Since improved pasture species offered possibilities for achieving this, a field experimental programme was initiated in 1966 to examine the main facets. No critical investigations into the nutrient status of these soils had previously been done, but observations had indicated large responses by Townsville stylo to phosphorus. This paper reports the results of two fertilizer experiments laid down to assess the response of Townsville stylo to applied nutrients. Papers 2 and 3 deal with species testing and establishment methods respectively.

## II. MATERIALS AND METHODS

There were two experimental sites, designated A and B, both on Glenore Station.

Site A was located 40 km south-east of Normanton. The soil is classified in the Gum Creek Association by Webb, Beeston and Hall (1974) and is a sandy yellow earth with texture grading from sand at the surface to sandy clay loam at depth. The surface 0 to 10 cm contains 8% clay and silt and 92% fine and coarse sand while at 80 to 90 cm the corresponding figures are 23% and 77%. Consistence grades from slightly hard to hard and the soil is massive throughout, earthy and highly porous.

Site B was located 24 km south-east of Normanton and is in the Blackbull Association (Webb, Beeston and Hall 1974). The soil is a mottled grey earth grading in texture from loamy sand to sandy clay loam at depth. The surface 0 to 10 cm contains 10% clay and silt and 89% fine and coarse sand, while at 80 to 90 cm the levels are 34% and 66% respectively. The surface is hard-setting and consistence grades from hard to extremely hard. Soil is massive and earthy throughout and ironstone concretions form a prominent layer at about 50 cm.

At both sites soil reaction is acid ranging from pH 5·5 to 5·9 and available P, total N, and exchangeable cations are low to very low throughout the profile (Webb, Beeston and Hall 1974).

Nutrients tested and fertilizer forms and rates used are shown in Table 1. In experiment 1 (at site A) the 96 treatments (3 P x ($\frac{1}{2}$ x $2^6$)) were arranged in four blocks. Experiment 2 (at site B) was a 2 K x 4 P x 4 Zn randomized block design with three replications. The test plant was Townsville stylo, Einasleigh strain in experiment 1 and Greenvale strain in experiment 2, both planted at 22 kg $ha^{-1}$ of seed pods. Basal nitrogen was applied to ensure seedling vigour because uninoculated seed was planted and effective natural nodulation had not been confirmed.

At both sites, standing timber was cut down and removed, and the inter-stump spaces were cultivated with a rotary hoe. Seed (uninoculated) and fertilizers were hand broadcast separately onto the prepared surface and the 5 m x 5 m plots were then hand raked. Trace elements were applied dry by mixing with sandy soil from the plots or in solution with a watering can. Experiment 1 was established on 29 December 1966 and experiment 2 on 2 December 1969. Plant counts from four 0·1 $m^2$ quadrats per plot were recorded on 23 February 1967 and 8 February 1968 for experiment 1 and 8 January 1970 for experiment 2. Yield samples were taken on 16 May 1967 for experiment 1 and 14 April 1970 for experiment 2 by cutting four 0·4 $m^2$ quadrats, at a height of 2 cm, from each plot. The harvested material was subsequently dried in an oven. Neither experiment was grazed by animals at any stage.

**TABLE 1**

RATES OF ELEMENT AND COMPOUND USED IN EXPERIMENTS 1 AND 2

| Element | Experiment 1 | | | |
|---|---|---|---|---|
| | kg Element $ha^{-1}$ | | kg Compound $ha^{-1}$ | |
| Phosphorus | $P_0$ | 0 | Trisodium phosphate | 0 |
| Phosphorus | $P_1$ | 24 | Trisodium phosphate | 292 |
| Phosphorus | $P_2$ | 48 | Trisodium phosphate | 584 |
| Potassium | $K_0$ | 0 | Muriate of potash | 0 |
| Potassium | $K_1$ | 92 | Muriate of potash | 176 |
| Sulphur | $S_0$ | 0 | Hyd. sodium sulphate | 0 |
| Sulphur | $S_1$ | 18 | Hyd. sodium sulphate | 176 |
| Molybdenum | $Mo_0$ | 0 | Ammonium molybdate | 0 |
| Molybdenum | $Mo_1$ | 3·3 | Ammonium molybdate | 0·6 |
| Zinc | $Zn_0$ | 0 | Zinc chloride | 0 |
| Zinc | $Zn_1$ | 7 | Zinc chloride | 14 |
| Magnesium plus Manganese | $(Mg+Mn)_0$ | 0 + 0 | Light magnesium carbonate +hyd. manganese chloride | 0+ 0 |
| | $(Mg+Mn)_1$ | 5·5+12 | | 22+44 |
| Copper plus Boron | $(Cu+B)_0$ | 0+ 0 | Cupric chloride (hyd.) + borax | 0+ 0 |
| | $(Cu+B)_1$ | 5+11 | Cupric chloride (hyd.) + borax | 14+22 |
| Nitrogen | *N | 31 | Urea | 67 |

| Element | Experiment 2 | | | |
|---|---|---|---|---|
| | kg Element $ha^{-1}$ | | kg Compound $ha^{-1}$ | |
| | $P_1$ | 24 | Aerophos (Ca) | 96 |
| | $P_2$ | 48 | Aerophos | 193 |
| | $P_3$ | 96 | Aerophos | 384 |
| | $P_4$ | 192 | Aerophos | 768 |
| | $K_1$ | 128 | Muriate of potash | 246 |
| | $K_2$ | 256 | Muriate of potash | 492 |
| | $Zn_1$ | 4 | Zinc chloride | 8 |
| | $Zn_2$ | 7 | Zinc chloride | 14 |
| | $Zn_3$ | 14 | Zinc chloride | 28 |
| | $Zn_4$ | 20 | Zinc chloride | 41 |
| | * S | 18 | Gypsum | 94 |
| | * Mo | 3·3 | Ammonium molybdate | 0·6 |
| | * N | 31 | Urea | 67 |

* Basal treatment.

RAINFALL. Rainfall recorded at Glenore homestead, 19 km from experiment 1 and 3 km from experiment 2, for the 4 wet-season months for the years 1966–67, 1967–68 and 1969–70 is shown in table 2.

**TABLE 2**

RAINFALL (mm) AT GLENORE FOR THE MONTHS DECEMBER TO MARCH FOR THREE SEASONS AND (IN PARENTHESIS) NORMANTON RECORDINGS AND LONG TERM AVERAGES

| Month | 1966–67 | 1967–68 | 1969–70 | Normanton average* (95 years) |
|---|---|---|---|---|
| December .. .. .. | 98 ( 31) | 76 ( 47) | 217 (221) | (143) |
| January .. .. .. .. | 112 (105) | 225 (298) | 94 ( 51) | (259) |
| February .. .. .. .. | 138 (168) | 145 (195) | 76 ( 93) | (254) |
| March .. .. .. .. | 144 (138) | 43 ( 56) | 111 (174) | (157) |

* Commonwealth Bureau of Meteorology

## III. RESULTS

**Experiment 1.** Significant main effects and first order interactions for the four parameters measured are given in table 3. A number of second order interactions were recorded but are regarded as not important in the interpretation of responses.

**TABLE 3**

SIGNIFICANCE OF F VALUES FOR MAIN EFFECTS AND FIRST ORDER INTERACTIONS IN THE ANALYSIS OF VARIANCE FOR POPULATION, YIELD AND CHEMICAL COMPOSITION IN EXPERIMENT 1

| Population | | Yield | Chemical Composition | |
|---|---|---|---|---|
| 23 Feb 67 | 8 Feb 68 | 16 Jan 67 | %N | %P |
| –P** | K* | P** | P** | P** |
| Mo** | P x Zn* | Zn** | –Zn** | –Zn** |
| P x K** | | K* | P x S* | P x K* |
| S x Mo* | | P x Zn** | P x K* | –Zn x P** |
| –P x (Mg+Mn)** | | Zn x K* | –Zn x P* | |
| | | –(Cu+B)** | –Zn x S* | |
| | | –(Cu+B) x P** | | |
| | | –(Cu+B) x Zn* | | |

– decreased pasture component measured; all other responses were increases
* $P < 0{\cdot}05$ ** $P < 0{\cdot}01$

POPULATION. $P_2$ in the absence of K reduced stylo population compared with all other treatment combinations (table 4). The presence of S in the absence of Mo proved inferior to all other treatment combinations of Mo and S. Stylo population was reduced when (Mg + Mn) was present at the high rate of P. In the second year, residual K increased population and there was a positive P x Zn interaction.

YIELD. $P_1$ in the presence of Zn significantly outyielded all other P x Zn combinations and $P_2$ with Zn increased yield over the remaining combinations (table 5). Zn with K outyielded other treatments while Zn in the absence of K significantly increased yield over treatments with no Zn application.

**TABLE 4**

INTERACTIONS FOR P AND K, AND MO AND S IN YEAR 1 AND MAIN EFFECT FOR K IN YEAR 2 FOR TOWNSVILLE STYLO POPULATION (EXPERIMENT 1)

| Element rate | Population (plants $m^{-2}$) | | L.S.D. 5% | L.S.D. 1% |
|---|---|---|---|---|
| *Year* 1 (1967) | $K_0$ | $K_1$ | | |
| $P_0$ | 145 | 118 | 33 | 45 |
| $P_1$ | 117 | 126 | | |
| $P_2$ | 59 | 124 | | |
| | $S_0$ | $S_1$ | | |
| $Mo_0$ | 112 | 87 | 27 | 36 |
| $Mo_1$ | 121 | 139 | | |
| *Year* 2 (1968) | *Mean K levels* | | | |
| $K_0$ | 89 | | 51 | 69 |
| $K_1$ | 143 | | | |

**TABLE 5**

INTERACTIONS OF P AND Zn, AND K AND Zn ON DRY MATTER YIELD OF TOWNSVILLE STYLO (EXPERIMENT 1)

| Rate | Yield (kg $ha^{-1}$) | | L.S.D. | |
|---|---|---|---|---|
| | $Zn_0$ | $Zn_1$ | 5% | 1% |
| $P_0$ | 373 | 334 | | |
| $P_1$ | 739 | 1 793 | 359 | 489 |
| $P_2$ | 400 | 1 259 | | |
| $K_0$ | 497 | 863 | 293 | 400 |
| $K_1$ | 511 | 1 394 | | |

CHEMICAL COMPOSITION. In the absence of Zn each successive level of P increased plant N percentages (1.47, 1.76, 2.06) and plant P percentages (0.05, 0.10, 0.17). The presence of Zn reduced the N percentages from 1.76 to 1.54 at $P_1$ and from 2.06 to 1.70 at $P_2$ while P percentages were reduced from 0.10 to 0.08 and from 0.17 to 0.10 respectively. The presence of K at $P_2$ increased N percentages from 1.79 to 1.96 and P percentages from 0.12 to 0.15. The presence of S increased N percentages from 1.55 to 1.74 at $P_1$ and from 1.79 to 1.97 at $P_2$.

**Experiment 2.** The only significant response was in dry matter yield to rates of P (table 6). Plant N and P concentrations were not recorded and population differences were not significant.

**TABLE 6**

YIELD RESPONSES TO RATES OF P IN EXPERIMENT 2

| Rate | Yield (kg ha$^{-1}$) |
|---|---|
| $P_1$ | 2 324 |
| $P_2$ | 2 755 |
| $P_3$ | 3 132 |
| $P_4$ | 3 236 |
| L.S.D. 5% | 387 |
| 1% | 514 |

## IV. DISCUSSION

Chemically there is very little difference between the two sites with both being very low in plant nutrients. The subsoil at site B has a higher clay content below 30 to 40 cm than at site A, and concurrent work (Bishop 1974) has shown superior growth of introduced species at site B.

The overall yield at site A was quite low with a maximum plot yield of 1 793 kg ha$^{-1}$ with most treatments yielding below 1 000 kg ha$^{-1}$. Although higher yields were obtained at site B they can still be regarded as low for the levels of P used. Rainfall during the 1966–67 wet season was considerably below average and in 1969–70 the January–February rainfall was far below average. This could be a major factor contributing to the low dry matter yields.

In the absence of Zn, the high P level was less effective than the low P level and gave only a marginal yield increase over the nil level. In view of the possibility that Zn and K were limiting yield at the $P_2$ level, higher rates of Zn and K were applied in the second experiment at site B. However, these had no significant effect and yields from $P_3$ and $P_4$ were not significantly different. The reduced yield at the $P_2$ level in experiment 1 is not understood but one possibility is that the high levels of sodium applied (due to the form of fertilizer used in this experiment) had an adverse effect on Townsville stylo growth.

Phosphorus increased N% and P% of Townsville stylo plants and the figures for whole plant analysis (harvested in May at the haying-off stage) compare satisfactorily with figures from Katherine, N.T., where whole plant figures for May were 1.6% to 1.8% for N and 0.04% and 0.08% for P (Fisher 1970). The reduced N and P percentages in the presence of Zn are regarded as dilution effects due to the higher yields.

Yield appeared to be increased by Mo and S but neither increase was significant. Mo gave a population increase but this occurred only after a S depression. Both Mo and S responses could have been masked by the basal nitrogen application.

The dry matter depression in the presence of (Cu + B) is thought to be a toxic effect from the high level of borax used.

Although it is not possible to select an optimum P application rate from these results, they do indicate a very high P requirement for maximum yield and high N and P percentages. Potassium and the trace element Zn are also necessary. Further investigation of the Mo and S requirements of Townsville stylo on these soils is indicated.

## V. ACKNOWLEDGEMENTS

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