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EARLY GROWTH OF MAKARIKARI AND RHODES GRASSES IN DIFFERENT NITROGEN AND WATER REGIMES

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SUMMARY

In this preliminary pot experiment the Makarikari grass (*Panicum coloratum* var. *makarikariense*) cultivars Pollock and Bambatsi, and Rhodes grass (*Chloris gayana*) cv. Pioneer were subjected to three water and two nitrogen regimes and their dry matter productions were measured after 24 weeks' growth following germination.

The data indicated that early growth of Rhodes grass was very responsive to application of nitrogen fertilizer. The dry matter production of the Makarikari grasses was, however, less responsive to nitrogen fertilizer application and was severely retarded by water-withholding regimes. The role of nitrogen fertilizer application in promoting early growth of the grasses in the field is briefly discussed.

There were no differences measured between the two Makarikari grass cultivars.

I. INTRODUCTION

Makarikari grasses (*Panicum coloratum* L. var. *makarikariense* Goosens) are well adapted to subtropical, sub-humid environments with heavy soils (Lloyd and Scateni 1968) and are recommended for use in perennial pastures on the Darling Downs, Queensland. One major shortcoming is their slow early growth after establishment compared with other subtropical grasses (Lloyd 1971).

The relative performance of grasses in the field, when conditions are often adverse, however, may differ substantially from those measured under optimum conditions. This glasshouse experiment measured the effects of different nitrogen and water regimes on the dry matter production of two cultivars of Makarikari and one of Rhodes grass (*Chloris gayana* Kunth.) in the first 24 weeks after germination.

II. MATERIALS AND METHODS

The experiment measured the effect of withholding water for 5 and 7 weeks (during which the soil reached wilting point for 3 and 5 weeks respectively) on the total and component dry matter productions of three grasses, grown in two nitrogen regimes, during the first 24 weeks after establishment.

Treatments in the fully randomized 3 x 3 x 2 factorial, replicated three times, were:

1. Grasses (G)—
   - G_1: Rhodes grass cv. Pioneer
   - G_2: Makarikari grass cv. Pollock
   - G_3: Makarikari grass cv. Bambatsi
2. Water regimes (W)—Three water regimes are shown diagrammatically in figure 1.

   In water withholding regimes, wilting point was reached after approximately 14 days, irrespective of species or nitrogen treatments.
3. Nitrogen regimes (N)—
   - N_1: No nitrogen fertilizer added.
   - N_2: The equivalent of 450 kg N ha^{-1} applied as urea before planting.

The confounding of pre-stress, stress and recovery periods in water regimes W_2 and W_3 is discussed below, in relation to the objectives of the experiment.

The experiment was carried out in closed cylindrical steel pots (18 cm diameter, 20 cm high) in a glasshouse, using 3·6 kg air-dried (19% moisture) surface soil of a self-mulching Waco clay from the Darling Downs, Queensland (mineral nitrogen concentration 36 ppm and other nutrients not limiting). The moisture contents of the soil at field capacity and wilting point were 55% and 30% respectively. The experiment was conducted for 24 weeks during winter and spring. Mean glasshouse temperatures for the pre-stress, stress and recovery periods for both species in water regimes W_2 and W_3 are presented in table 1.

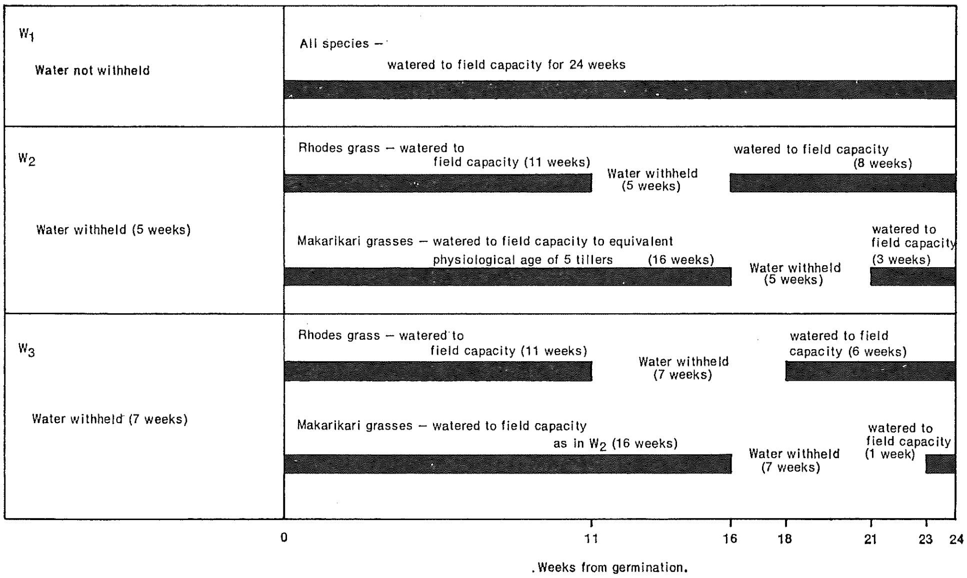

Figure 1.—Diagrammatic presentation of the three water regimes applied.

TABLE 1

MEAN DAILY GLASSHOUSE TEMPERATURES DURING PRE-STRESS, STRESS AND RECOVERY PERIODS FOR BOTH GRASS SPECIES IN WATER REGIMES W_2 AND W_3

Grass Species	Water Regime	Mean Maximum/Minimum Temperatures °C					
		Pre-Stress		Stress		Recovery	
Rhodes	W_2	26·7	8·3	26·7	9·4	30·6	12·8
	W_3	26·7	8·3	27·2	10·0	30·6	14·4
Makarikari	W_2	26·7	8·3	29·4	12·2	31·7	15·0
	W_3	26·7	8·3	30·0	13·3	31·1	15·0

For the field capacity treatment, pots were watered to 55% moisture (by weight) at 5, then 3-day intervals up to 8 weeks after establishment, but daily thereafter as evapotranspiration increased. To provide an even distribution of water through the soil, water was applied to each pot to the soil surface, and also through two plastic tubes inserted 4 and 12 cm deep into the soil. Individual pot weights were recorded to estimate evapotranspiration. Allowance was made for the increasing fresh weight of the growing plants by estimation, based on final dry matter production.

Four plants per pot were grown and harvested 24 weeks after establishment. Plant tops were removed by cutting 1 cm above the soil surface, and tillers were counted and separated into leaf blade and stem (including leaf sheaths). Crown (the plant part remaining after tops and roots were removed) and root material were recovered separately from the soil and the dry weights of all components were recorded after drying at 80°C for 2 days.

III. RESULTS

1. Dry matter production

(a) TOTAL DRY MATTER PRODUCTION (T.D.M.P.)

The T.D.M.P. (figure 2) of Rhodes grass was greater than that of both Makarikaris in comparable treatments. Nitrogen application increased the T.D.M.P. of Rhodes grass more than that of both Makarikaris in all water regimes. Water regimes in which increasing periods of water stress were imposed, decreased the T.D.M.P. of all grasses in conditions of nitrogen sufficiency, but not in conditions of nitrogen deficiency. Thus, the early growth of Rhodes grass was more rapid than that of the Makarikaris and it was more sensitive to nitrogen fertilizer application in conditions of soil nitrogen deficiency. It was proportionately less reduced by the water regimes W_2 and W_3 in conditions where nitrogen was not limiting. In comparison, it is significant that the T.D.M.P. of Rhodes grass grown in the water environment in which water was withheld for almost one-third the growth period, was greater than that of both Makarikaris grown in soil held at field capacity throughout.

(b) Component dry matter production

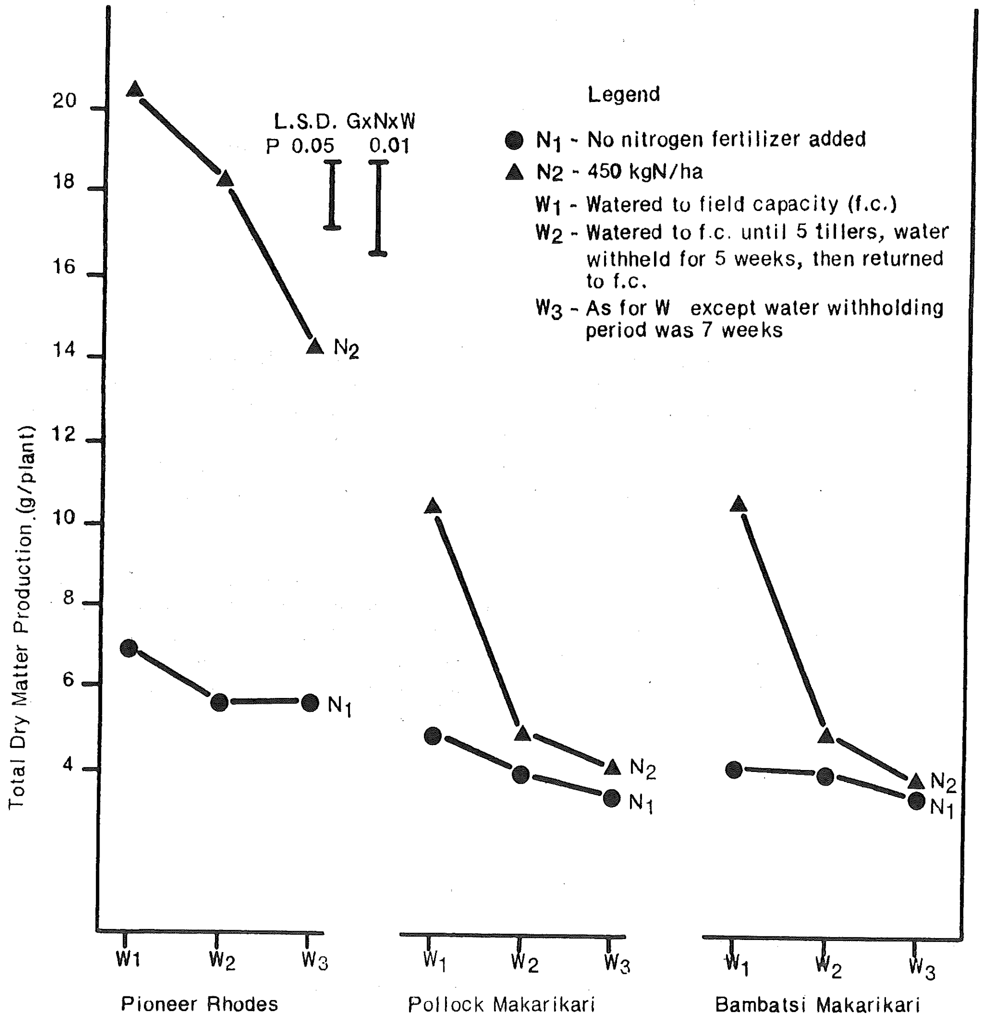

Figure 2.—Total dry matter production of Pioneer Rhodes and Pollock and Bambatsi Makarikari grasses grown in three water and two nitrogen regimes.

Leaf (*L.D.M.P.*). There were no differences in the L.D.M.P. (figure 3) between grasses in any water regime in the low nitrogen treatment. In the high nitrogen regime, the L.D.M.P. of Rhodes grass was greater than that of both Makarikaris in all water regimes and was not affected by watering treatments. The L.D.M.P. of both Makarikari grasses was decreased in both water regimes in which water was withheld.

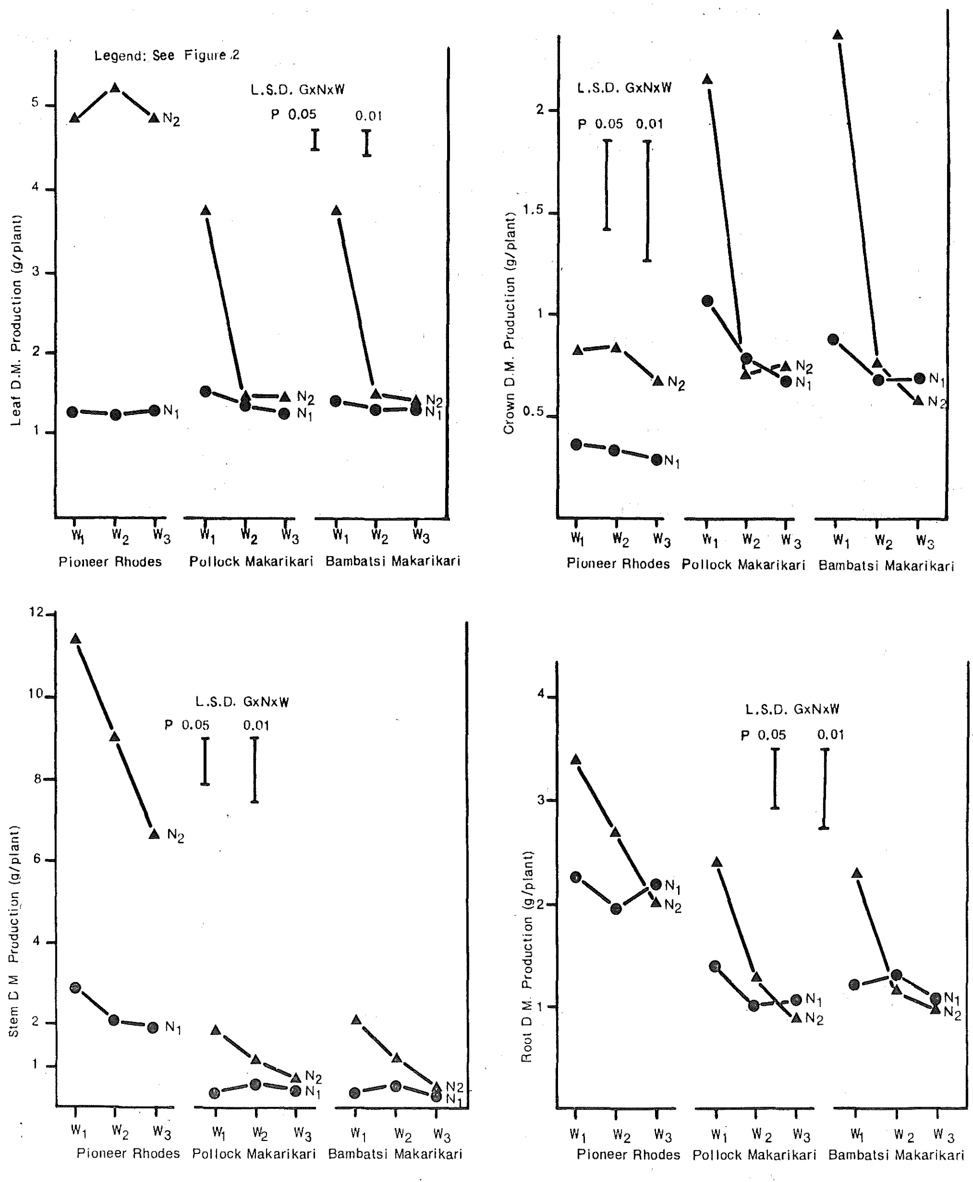

Figure 3.—Component (leaf, stem, crown and root) dry matter productions of Pioneer Rhodes and Pollock and Bambatsi Makarikari grasses grown in three water and two nitrogen regimes.

Stem (S.D.M.P.). The S.D.M.P. (figure 3) of Rhodes grass was markedly higher than that of both Makarikaris in all water and nitrogen regimes and was the component contributing most to the difference in T.D.M.P. between species. The S.D.M.P. of all three grasses was reduced by water regime W_3 in which plants were not watered for about one-third the total growth period, relative to W_1, when nitrogen was adequately supplied.

Crown (*C.D.M.P.*). Both Makarikari grasses produced larger crowns than Rhodes grass in the low nitrogen regime (figure 3). Nitrogen fertilizer application increased the C.D.M.P. of all grasses when water was not limiting. The C.D.M.P. of both Makarikari grasses was reduced in the water regimes W_2 and W_3, but in general, the C.D.M.P. of the Makarikari grasses was a more significant proportion of their T.D.M.P. than with Rhodes grass.

Root (*R.D.M.P.*). The R.D.M.P. of Rhodes grass was generally greater than that of both Makarikaris (figure 3). Conditions of nitrogen sufficiency increased the R.D.M.P. of all grasses when water was not limiting; and water-withholding regimes reduced their R.D.M.P. in the high, but not the low nitrogen regime.

(c) RELATIONSHIP BETWEEN COMPONENT AND TOTAL DRY MATTER PRODUCTION

In the low nitrogen regime, the slightly higher T.D.M.P. of Rhodes grass compared with the Makarikaris was due to higher stem and root production. There was no difference in leaf production and the crown production of the Makarikari grasses was greater than that of Rhodes. Different water regimes had a negligible effect on the production of the components of all species in the low nitrogen treatment.

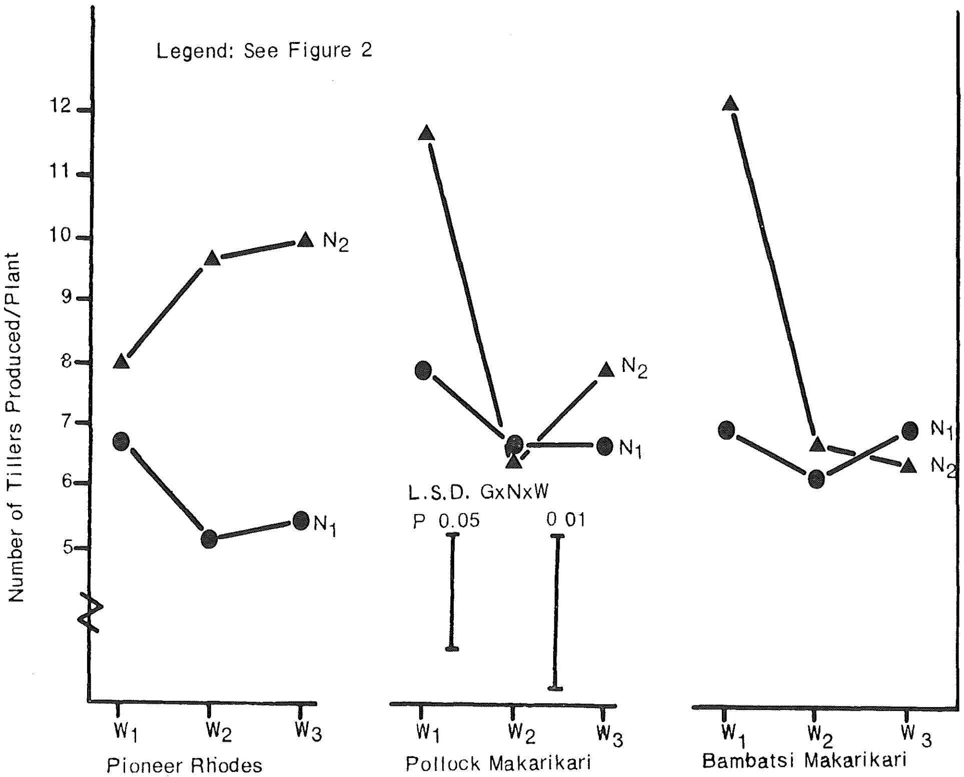

Figure 4.—Number of tillers produced by Pioneer Rhodes and Pollock and Bambatsi Makarikari grasses grown in three water and two nitrogen regimes.

With high nitrogen, the much greater T.D.M.P. of Rhodes grass compared with the Makarikaris was due particularly to a larger response to nitrogen in production of stem, and to a lesser but significant extent in the production of leaf.

2. Number of tillers produced (T.N.)

In the low nitrogen regime there were no significant (P = 0·05) differences in the T.N. by each grass (figure 4). In the high nitrogen regime, the T.N. by both Makarikari grasses was greater than that of Rhodes where water was not limiting; in both water-withholding regimes, the T.N. by the Makarikari grasses was reduced whereas that of Rhodes was not. Stem elongation was thus largely responsible for the markedly greater S.D.M.P. of Rhodes grass.

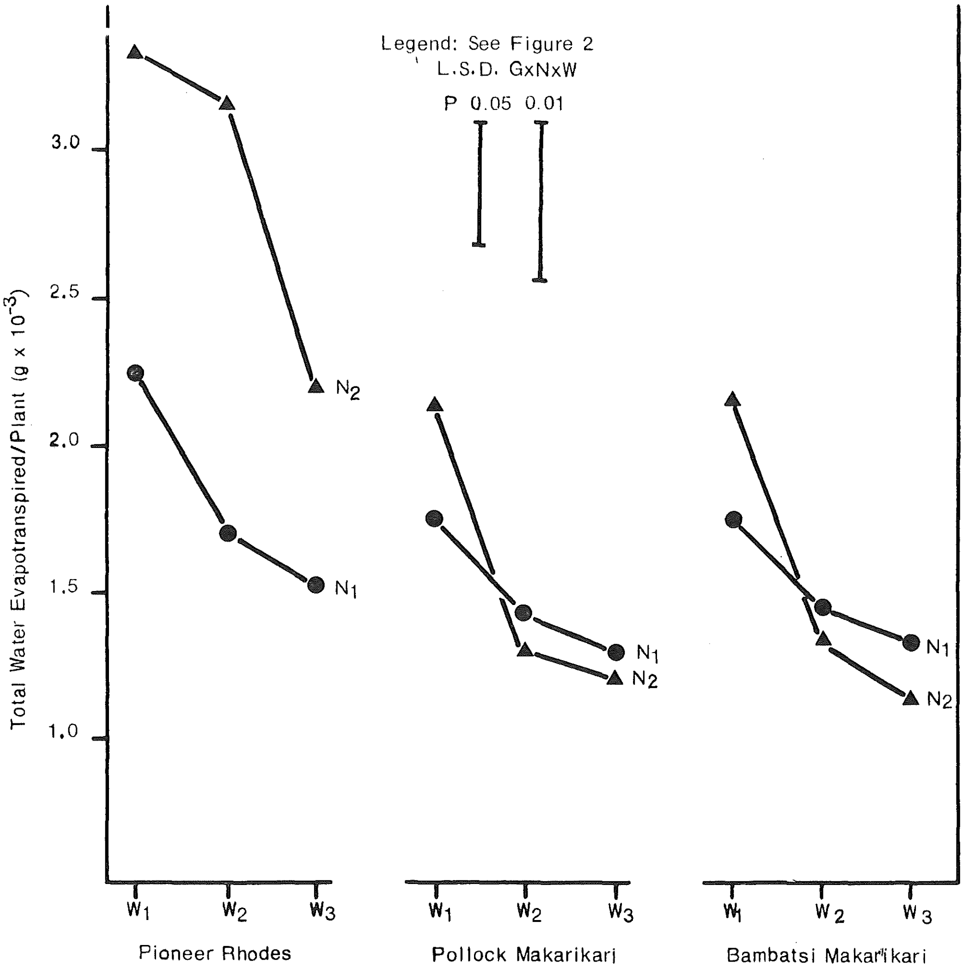

Figure 5.—Water use by Pioneer Rhodes and Pollock Bambatsi Makarikari grasses grown in three water and two nitrogen regimes.

3. Water use (E_t)

The E_t by Rhodes grass was greater than by both Makarikaris in all treatments (figure 5), and it was increased by the application of nitrogen whereas that by the Makarikari grasses was statistically ($P = 0 \cdot 05$) unchanged. The $E_t^{\prime}$ of all grasses was reduced by the water regime W_3, compared with W_1; and more severely in the high than in the low nitrogen treatment.

IV. DISCUSSION

The relative growth of species with different growth rhythms is confounded in an experiment such as this and can only be fully interpreted by detailed growth analyses in which changes in growth parameters during pre-stress, stress and recovery periods are measured separately. In this study, the Makarikari grasses received water to soil field capacity for 5 weeks longer than Rhodes grass in the pre-stress phase; Rhodes grass was supplied with water at soil field capacity for the same additional time during the recovery phase. It is emphasized that the objective of this study was not to measure the effects of water stress on plant growth, but the inter-related effects of the different water treatments during the first 24-weeks' growth, and it seems reasonable in this preliminary study, to discuss differences between species. It is perhaps significant that with Makarikari grass at least, the growth performance was not sensitive to differences in the duration of the recovery period.

The early growth of Rhodes grass is not only greater than that of Makarikari grass in optimum field conditions (Lloyd 1971), but also in the environmental conditions specified in this study. In the low nitrogen treatment, the differences were relatively small and unaffected by water regime, which suggests that nitrogen was more limiting for growth than water. The application of nitrogen fertilizer increased the dry matter production of Rhodes grass (all plant parts except crowns) more than that of both Makarikaris. Even where Rhodes grass was deprived of water at soil field capacity for about one-third of the growth period, its dry matter production exceeded ($P = 0 \cdot 01$) that of the Makarikaris watered to field capacity throughout. Water-withholding regimes markedly reduced the dry matter productions of both Makarikari grasses in the high nitrogen treatment. These findings suggest an advantage in providing a 'high nitrogen' environment for the early growth of Rhodes grasses in all weed-free field conditions. They also demonstrate that the slow inherent rates of development of the Makarikari grasses are accentuated by moisture conditions often encountered in field environments to which the grass is suited, where irrigation is not practised. It is unlikely that the use of nitrogen fertilizer to promote the early growth of non-irrigated stands would be recommended.

The data also explain why grazing stands of Makarikari grass pastures are rarely developed within 6 months of establishment, and why low-lying areas receiving runoff from adjacent slopes particularly favour Makarikari grass.

Lloyd (1971) measured a faster rate of tiller production by Rhodes grass in the first 23 days after emergence compared with Makarikaris, which was associated with its more rapid early growth. He indicated the Makarikari grasses continued the production of primary tillers for longer than other species studies. In this experiment, the differences in early growth between species were not related to the number of primary tillers present after 24-weeks' growth, but to tiller elongation (measured as S.D.M.P.), and to leaf production in the high nitrogen regime. This is compatible with Lloyd's (1971) findings.

Mature Makarikari grasses are extremely drought resistant (Bryant 1966) and even as seedlings they have been observed to survive prolonged drought in experiments on the Darling Downs. Their very low dry-matter production and low water use in water withholding regimes, relative both to their production in non-limiting water environments and to Rhodes grass, could represent or reflect a drought escaping mechanism of the species.

There were no significant differences in the total or component early growth between the two Makarikari grass cultivars Pollock and Bambatsi in the conditions imposed in this experiment.

V. ACKNOWLEDGEMENTS

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