A DEMOGRAPHIC ANALYSIS OF GROWTH DIFFERENCES BETWEEN NUI AND RUANUI RYEGRASS AT HIGH AND LOW NITROGEN INPUTS

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Abstract

Because of phenotypic differences, monocultures of Nui have tillers that are on average 43% larger but 20% less dense than monocultures of Ruanui. Nui tillers had larger leaves for most of the year and also more leaves per tiller during spring when Nui leaf appearance rates tended to be higher. Nui growth rates were higher in spring when temperature and nutritional limitations were removed. Nui yielded 54% more than Ruanui annually under high nitrogen nutrition.

High nitrogen nutrition increased tiller density and death, tiller and leaf appearance rates, and leaf size and growth rate during the warmer months. Intermittent applications of nitrogen increased temporarily tiller and leaf appearance rates inapparent compensation for preceding lower rates. High nutrition tillers were more severely defoliated and had fewer leaves at the beginning of regrowths.

INTRODUCTION

Although ***Lolium perenne*** L. 'Grasslands Nui' was selected for improved summer growth and persistence (Rumba11 1969, Armstrong 1977), yield advantages over *Lolium perenne* L. 'Grasslands Ruanui'are also apparent in other season (Baars *et. a/.,* 1976, Sheath ***et.*** *al.,* 1976, Hayman 1980). As the physiological reason for Nui's yield advantage under moist conditions is unknown (Chu 1979), we have attempted a demographic analysis to determine why Nui grows faster.

Demographic-type parameters possibly determining the vegetative yield advantage of Nui are tiller density (Sheath et ***al.,*** 1976), as determined by tiller appearance and death, and leaves per tiller, as determined by leaf appearance and death. Cultivar differences in reproductive growth could result from differences in proportions of vernalised tillers, the timing of stem elongation, or in the growth rates of reproductive tillers.

METHODS

Monoculture plots (4 x 4m) of Nui and Ruanui were sown (40 kg/ ha) on a Karapoti brown sandy loam (Cowie 1974) at Grasslands Division, Palmerston North in 1976. Prior to sowing, the area received 500 kg/ ha 30% potassic superphosphate and 100 kg/ ha magnesium sulphate. As animal cycling of nutrients was minimised, soil fertility was kept high with subsequent fertiliser dressings(at the above rates) at approximately six-monthly intervals.

When nutritional treatments were introduced (June 1977), the design consisted of two cultivars, each with high and low nutrition treatments replicated four times and completely randomised. Low nutrition plots received no water above natural rainfall, nor nitrogenabove 65 kg/ ha with the six-monthly dressing. High nutrition plots, designed to remove water and nitrogen limitations to growth, were irrigated to maintain tensiometer readings 30 cm below soil surface at below 0.7 bar soil moisture deficit. Calcium ammonium nitrate was applied weekly at rates twice the expected growth requirement to allow up to 50% loss between applications. The annual application rate averaged 2150 kg N/ha.

Plots were rotationally grazed with sheep that had fasted for 12 hrs. Nitrogen return from sheep excrement was minimised by grazing sheep in small groups for 2 hr shifts. Dung deposited was removed.

Twenty-five tillers were tagged in each plot and examined twice weekly to determine rates of leaf and tiller appearance and death. Dead leaves were collected, dried and weighed. Herbage and litter yields, tiller weight and tiller density were measured from weekly 2.25 dm^2 quadrat harvests per plot cut to ground level. Growth rates were determined from regressions fitted to live ryegrass yield data.

RESULTS AND DISCUSSION

GROWTH RATE

During the establishment year, capacitance probe measurements indicated that Nui outyielded Ruanui during spring and autumn. With nutritional treatments applied, Nui high-nutrition (NH) spring and summer growth rates were higher than Ruanui high-nutrition (RH) in both years of the experimental period (Fig. I), but as NH was superior because of greater tolerance to a severe invasion by Argentine stem weevil in summer 1979 (Hunt and Gaynor in prep), attention will be drawn to the spring superiority of NH in October 1979, and September, October and November 1980, although Nui outyielded Ruanui in other months also. Integrating the growth rates over a year (1979/ 80) indicated a 54% advantage to NH over RH (29,700 compared with 19,200 kg DM/ha).

The few differences in growth rate detected between Nui and Ruanui at low nutrition (NL and RL) were inconsistent with RL greater than NL in December 1978, but NL greater than RL in December 1979. Both cultivars responded to the fertilizer dressings during the spring or summer but little response was apparent during winter. Integrating growth rates over a year indicated a 16% advantage to NL over RL (12,800 compared with 11,000 kg DM/ ha).

The coincidence of the NH spring growth advantage with reproductive growth suggests an association between the two, but the percentage of reproductive tillers showed no difference in the timing of the reproductive

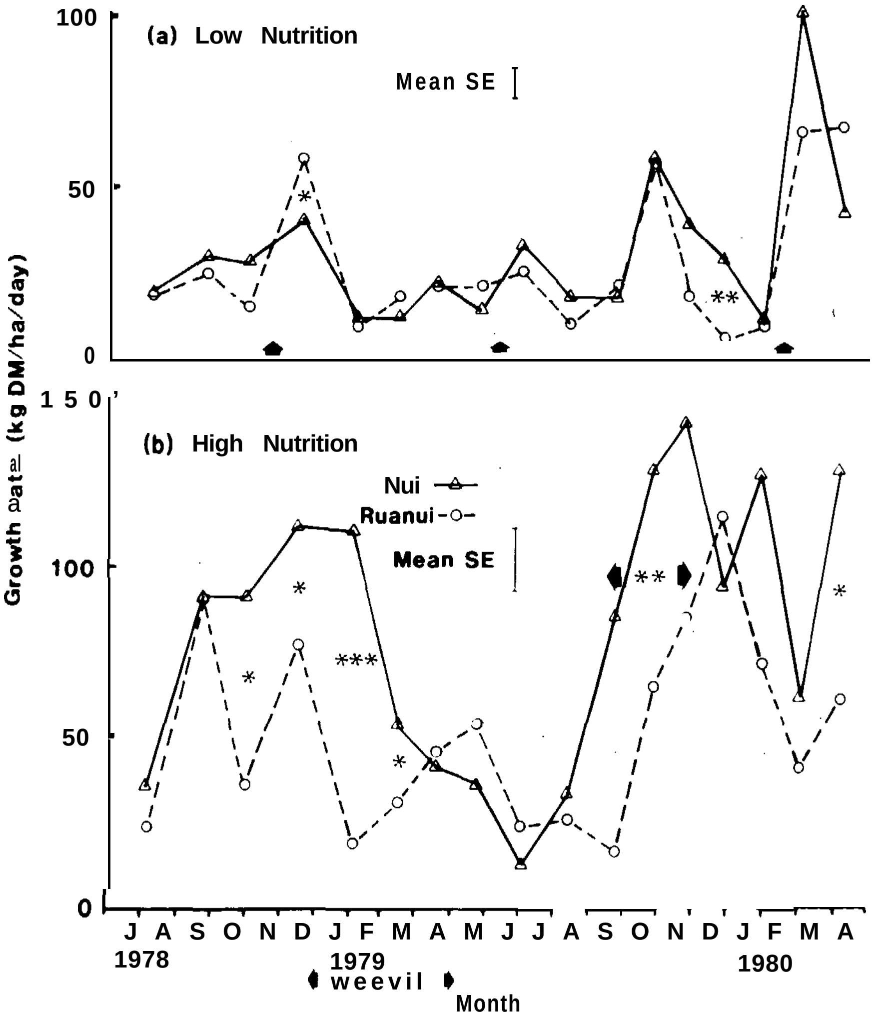

FIG. *1: Growth rates of Nui and Ruanui monocultures at high and low nutrition. Arrows indicate dates when fertiliser was applied to low nutrition plots. Stars indicate significant differences.*

phase, particularly at high nutrition. The proportion of reproductive tillers was highest in late October for both years. There were differences between cultivars (R > N) and nutrition (L > H) in 1978 but there were no treatment effects in 1979 or differences in the timing of reproductive growth in either year, suggesting no association with Nui spring superiority. Differences in stem yields between the two cultivars were also less than differences in leaf yield (Table la). Nui averaged only 14% more stem but 30% more leaf during the September to December period 1979.

TABLE 1: SUMMARY OF SIGNIFICANT DIFFERENCES FOR SUCCESSIVE REGROWTH PERIODS BETWEEN a) CULTIVARS, AND b) NUTRITION LEVEL

		1978 Winter		Spring			Summer			1979 Autumn			Winter			Spring		Summer			1980 Autumn		
		J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M
a) Cultivars: Ruanui (R), Nui (N)																								
Stem yield	NL > RL						+		+															
	NH > RH						+		+	+		+												
Leaf yield	NL > RL																		+					
	NH > RH								+	+								+	+		+			
Tiller density	R > N		+	+	+		+			+	+	+			+	+			+			+	+	
Tiller appearance/tiller	R > N									+	+	+			+									
Tiller death/tiller	R > N								+		–							+			+			
Leaf appearance/tiller	N > R				+				+		--				–									
Leaf death/tiller	R > N		+						+	+		+	+		+						+		+	
Leaf death/area	R > N		+	+			+					+			+						+			
Tiller weight	N > R		+	+	+		+		+	+	+	+	+		+	+	+	+	+		+	+	+	
Leaf weight	N > R			+			+	+	+		+	+	+		+	+		+		+	+	+		
b) Nutrition level: High (H), Low (L)																								
Growth rate	Ruanui			+								+							+					
	Nui			+	+		+		+	+						+		+	+		+		+	
Tiller denrity	H > L			+	+					+						+	+	+	+		+		+	
Tiller appearance/tiller	H > L		+	+	+		+		+	+	+	+	-		+	+	+	+	+		+	–	+	
Tiller death/tiller	H > L						+		+	+	+		+				+		+		+	+	+	
Leaf appearance/tiller	H > L		+	+	+		+		+	+	+	+	-		+	+	+	+	+		+	-	+	
Leaf death/tiller	H > L								+	+	-				-	–					–	+		
Leaf death/area	H > L			+	+		+		+	+	+	+					+	+	+		+	+	+	
Tiller weight	H > L			+	+		+		+	+	+	+			+			+	+		+	+	+	
Leaf weight	H > L			+	+				+	+	+	+	+		+	+		+	+		+	+	+	
						▲	|← Weevil				→|		▲							▲			

▲ Arrows indicate dates when fertiliser was applied to low nutrition plots

CULTIVAR EFFECTS ON DEMOGRAPHIC PARAMETERS

Sheath *et al.,* 1976 suggested that, at a dry site in Otago, Nui was superior to Ruanui because of its greater tiller density and persistence. But in Palmerston North conditions (Fig. 2), Ruanui averaged (over both nutrition levels) 24% more tillers than Nui over the last 12 months of the experiment.

Cultivar differences in tiller densities were not related to tillering, as in the absence of stem weevil invasion in RH there were no differences in tiller appearance rates (Table la). RH plots badly damaged by stem weevil in 1978 recovered by tillering faster, indicating that tillering rate is generally well below potential in ryegrass swards.

Tiller death rate differences between cultivars were inconsistent but generally suggested greater tiller death in Ruanui plots (Table la). Except for RH during stem weevil infestation, tiller death rates (0.003 tillers/ tiller/day over last year) were well below tiller appearance rates (0.025 tillers/ tiller/ day over last year) indicating that the maintenance of stable tiller densities was determined by individual tiller ability to survive grazing rather than inter-tiller competition, i.e., new tillers were unable to recover from severe defoliation

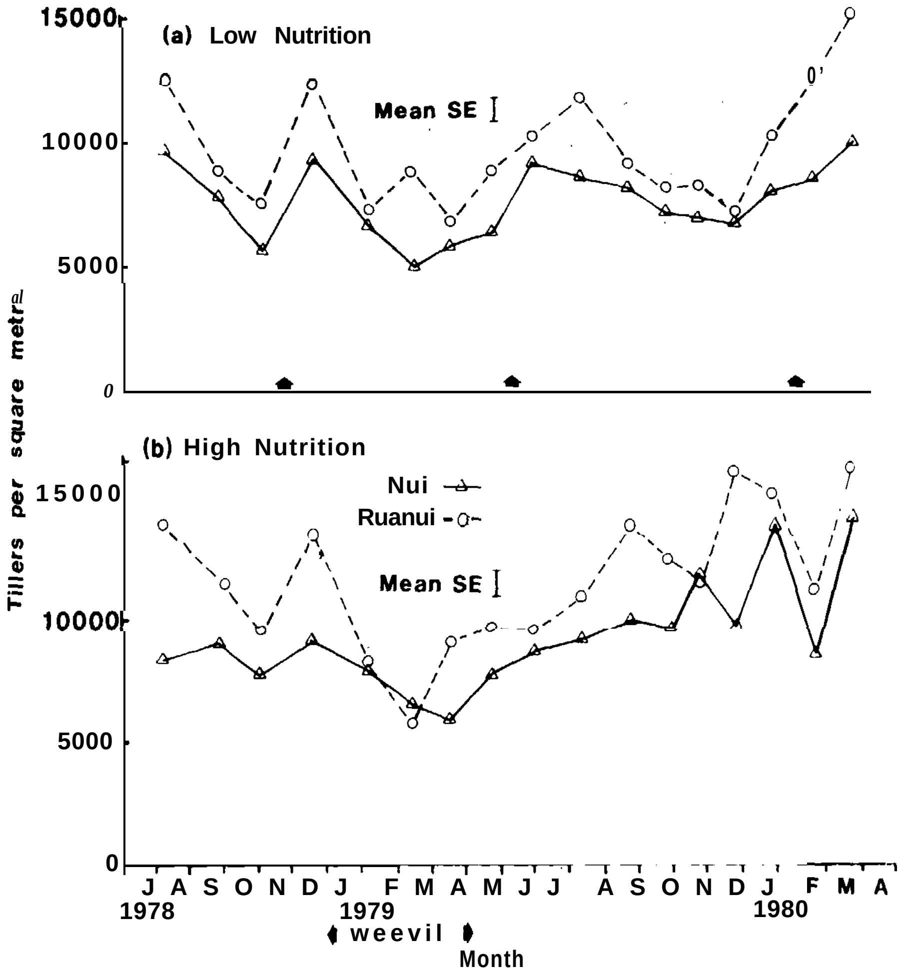

FIG. *2: Seasonal trends in tiller densitiesfor Nui and Ruanui monocultures. Arrows indicate dates when fertiliser was applied to low nutrition plots.*

which occurred frequently enough to pre-empt the lethal inter-tiller competition in undefoliated swards.

Leaf appearance rates per tiller were higher for Nui than for Ruanui in spring 1978 (Table la). Main cultivar effects were not significant in spring 1979, but dates x cultivar x nutrition interactions were significant for leaf appearance (NH > RH on some dates) in October and November, 1979. Nui superiority in spring was therefore associated with higher leaf appearance rates for at least some part of the regrowth periods.

The higher leaf appearance rate resulted in more leaves per Nui tiller during the spring when Nui growth was superior(Fig. 3 b). Nui tillers were often more severely defoliated than Ruanui tillers with fewer leaves per tiller at the beginning of regrowths, but more leaves per Nui tiller by the end of the regrowth.

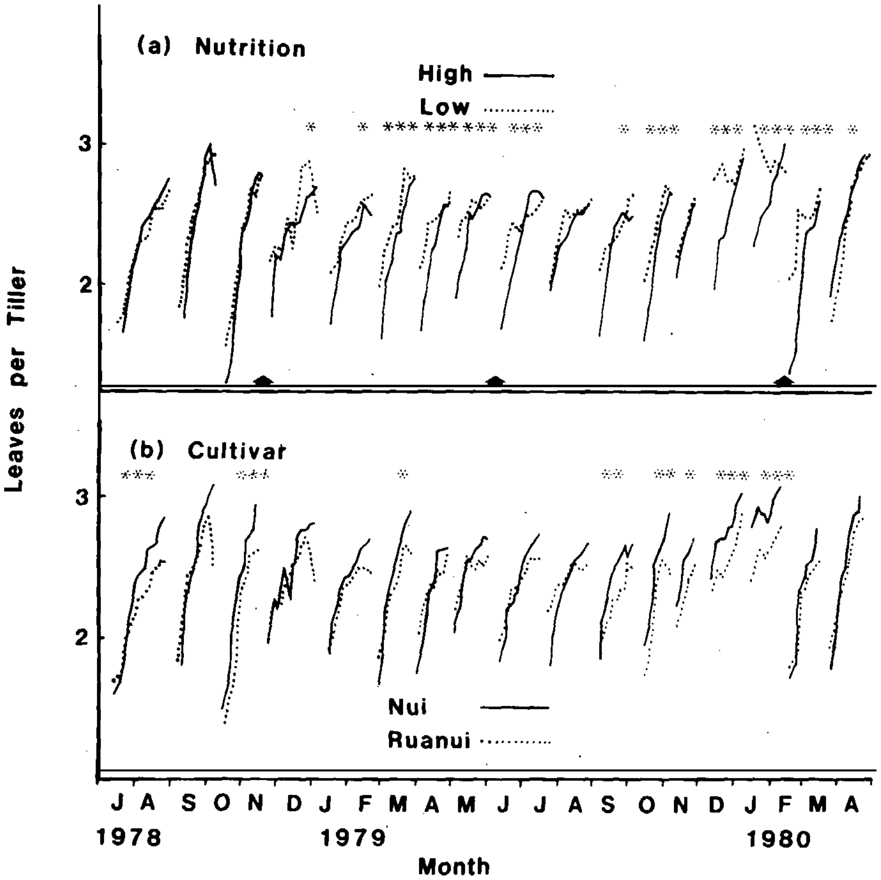

FIG. 3: Ratio of leaves per tiller for Nui and Ruanui ryegrass at high and low nutrition. Arrows indicate dates when fertiliser was applied to low nutrition plots. Stars indicate significant differences.

Leaf death per tiller was higher for Ruanui during stem weevil infestation, and during winter. While no cultivar effects on leaf death were detected during spring, the lower leaf death per Nui tiller may have contributed to the higher leaves per Nui tiller then and at other times.

Nui tillers were on average 43% larger than Ruanui tillers during the last year of the experiment (Table la) but differences in leaf size were less easily detected during the spring.

NUTRITIONAL EFFECTS ON DEMOGRAPHIC-TYPE PARAMETERS

Nutritional effects on growth rates were seasonal (Table 1). No differences were detected for winter months and responses were precluded in RH during stem weevil infestation. Otherwise, high nutrition increased growth rate particularly for Nui. Periodic fertiliser application of low nutrition plots obscured some nutritional responses.

High nutrition in the absence of stem weevil also increased tiller density during the warmer months. High tiller death rates resulting from stem weevil attack in RH were countered by high nutrition which increased tiller appearance (Table 1 b). Periodic applications of nitrogen to low nutrition plots consistently caused large rapid increases in tillering so that tiller appearance in low nutrition plots temporarily surpassed that in high nutrition plots, an effect detected in October-November 1978 as a nutrition x date interaction. The compensatory increase in tillering was consistently short-lived.

High nutrition increased tiller death rate probably because increases in tiller size and tiller density intensified inter-tiller competition. Effects of high nutrition on tiller death rate were therefore least in winter-spring (Table lb), when nutritional effects on tiller size and density were also least.

Nutritional effects on leaf appearance (Table 1 b) were similar to those on tillering, including the temporary compensation in low nutrition plots after periodic fertiliser applications.

Nutritional effects on leaf death show that while leaf death per tiller' was mostly the same or lower at high than at low nutrition (disregarding the stem weevil season) the increase in tiller density by high nutrition often resulted in more leaf death per unit area in high nutrition plots (Table 1 b).

High nutrition increased tiller weight by an average of 30% over the last year of the experiment (Table 1 b), but effects were least during the coldest months (July 1978, 1979) and for the flowering period (October-November 1979). As tiller weight increased so did leaf size. The larger high nutrition tillers were often more severely defoliated than low nutrition tillers particularly in the summer, resulting in fewer leaves on high nutrition tillers Fig. 3a).

CONCLUSIONS

The data presented show that Nui has greater yield potential than Ruanui and should be the preferred cultivar not only for drought prone districts but also where fertility and moisture favour rapid growth. Nui fits the description of a high fertility grass even better than Ruanui, being potentially highly productive, and able to out-produce Ruanui and respond to nitrogen at an earlier stage in the spring. The demographic-type analysis has shown the spring superiority of Nui over Ruanui to be associated with more leaves per Nui tiller, resulting at least in part from higher leaf appearance rates. Nui has the added advantage under high nutrition conditions of being more resistant than Ruanui to Argentine stem weevil. Management factors (water and mineral nutrients) limit the productivity of Nui in the field during the warmer months.

Leaf and tiller appearance rates are sensitive to nitrogen and, to some extent, leaf and tiller appearance are limited more by nitrogen stress than leaf and tiller initiation. Nitrogen increases the size and number of tillers but in doing so increases the inter-tiller stress. Larger tillers (Nui and high nutrition plots) have fewer leaves per tillers following grazing indicating better utilization. Unless utilized, the increased production from nitrogen fertiliser will eventually be realized as increased leaf and tiller death.

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