INITIAL DEVELOPMENT OF THE 'POTENTIAL GROWTH RATE' CONCEPT FOR ESTIMATING PASTURE GROWTH ON FARMS ACROSS NORTHLAND

[1]G.J. Piggot, [2]J.A. Baars, [1]J.E. Waller and [3]C.A. Farrell

[1]Agricultural Research Division, MAF, [1]Whangarei, [2]Ruakura, [3]Kumeu

ABSTRACT

Pasture growth rate information is used widely in today's pastoral farm management but, at present, growth rates can only be guesstimated using historical records as a guide. The 'potential growth rate' concept aims to provide quantitative, site-specific information by adjusting estimates of potential growth using site parameters, particularly of climate. Cutting trials at 8 sites in Northland in 1983-84 (a climatically favourable year) were used to indicate such potential yields. Pasture growth curves were measured, with and without supplemental irrigation and nitrogen. Maximum growth rates over fortnightly intervals ranged from 130 kg DM/ha/day in spring to 50 kg DM/ha/day in winter. Such data suggest that the potential yield of Northland pastures approaches 30 t DM/ha/year.

Additional Key Words: Growth curve, ryegrass, kikuyu grass, nitrogen, irrigation

INTRODUCTION

Information on pasture growth rate is fundamental to the management of pastoral farms. Most farmers use visual observation as their sole guide to pasture growth but such observations are subjective and dated. Quantitative pasture growth rates are presently extrapolated from historical measurements conducted at a few sites over limited periods and which used artificial defoliation regimes. Such extrapolation is effectively informed guesswork.

The 'potential growth rate' concept has the aim of providing quantitative and daily information on pasture growth for any farm. The steps in the concept involve:

1. The determination of the 'potential' growth rate for pasture in the region. The term 'potential' refers to the best growth rate that could be expected during specified periods of the year from indigenous pastures given conventional management and natural climatic conditions. This 'potential' does not imply impractical or unrealistic use of inputs such as nitrogen fertiliser, irrigation, insecticides, selective herbicides, differential grazing pressures, etc.
2. Site factors are accounted for to adjust regional pasture growth 'potential' to give the site 'potential'. Such factors include pasture composition, soil fertility, fertiliser use, soil drainage, grazing management, pasture density and damage effects, etc.
3. The 'site potential' is further adjusted on a daily basis by accounting for climatic changes, particularly those of rainfall and soil temperture.

The complex adjustments involved can be derived by computer models (Baars, 1980) which allows the farmer to derive daily pasture growth rates by merely recording local climatic parameters. To support this concept, two components are required; the ability to account for permanent on-site factors and the provision of information on 'potential growth rates'. The work described here aimed, in a preliminary way, to provide such information; ie. to measure a range of sites and to 'capture' periods of exceptional pasture growth as a means of assessing the 'potential' growth of standard permanent pastures. The field technique involved monitoring pasture regrowth over prolonged periods on the assumption that regrowth would follow a sigmoid pattern (eg Brougham and Glenday, 1969) and that maximum growth rates during any regrowth period would occur after a lag or exponential growth phase.

Northland pastures under commercial dairy, beef or sheep management are mainly composed of temperate grasses such as ryegrass (*Lolium perenne*), although up to one third have kikuyu grass (*Pennisetum clandestinum*) present. The predominant legume in all well managed pasture is white clover (*Trifolium repens*). Of the 8 sites, across the Northland peninsula, chosen for this work, one was based on kikuyu grass although it was managed so that temperate species would volunteer during the cooler seasons.

MATERIALS AND METHODS

Seven sites were chosen on ryegrass-based pastures adjacent to climatological stations at Kaitaia (on Kaitaia clay soil type), Kerikeri (Rangiora clay), Kaikohe (Wairoro clay loam), Whangarei (Waipapa clay), Dargaville (Te Kopuru sand), Warkworth (Warkworth clay) and Kumeu (Otonga peaty loam), and at Dargaville a kikuyu grass based pasture was also monitored. Only the Kaikohe and Dargaville ryegrass sites contained 'recent' ryegrass cultivars. The Kaikohe site had been cultivated 7 years previously and sown with a 'Grasslands Nui and Pitau' mixture, while the Dargaville ryegrass site had been cultivated 2 years previously and sown with 'Ellett' ryegrass and 'Huia' white clover. All sites were regularly grazed under standard intensive farming systems either by beef cattle (Kaitaia, Kerikeri and Whangarei) or sheep (Kaikohe, Dargaville, Warkworth and Kumeu). All pastures were at least 5 years old except for the Dargaville ryegrass site (2 years since sowing).

The pasture growth measurements were conducted by monitoring of growth curves over 5 periods of the year. Nitrogen and irrigation were applied in factorial combination so that 4 growth curves were measured per site in each period. The growth curves were measured from caged areas and started during the weeks of 12-16 September 1983, 7-11 November 1983, 16-20 January 1984, 26-30 March 1984, and 18-22 June 1984. Cages were generally sited on undisturbed pasture but if the pasture was too long it was trimmed with a rotary lawnmower. One cut was taken from each cage at siting and then fortnightly, until the end of the measurement period. Nitrogen was applied to the relevant caged area, at siting, at 100 kg N/ha as urea, with 50 kg N/ha supplied for the November and January starts. The site was irrigated at the discretion of the site manager. With a few isolated exceptions, water was only applied during the second and third growth periods using a trickle system applying between 5-10 l/m^2 within the relevant caged area at each application. Both nitrogen and irrigation treatments were intended as supplemental treatments and were not designed to completely relieve nitrogen or moisture stress.

Samples were cut from a standardised 0.25 m^2 quadrat to the height of the quadrat edges using hand shears. This was generally within 3 cm of ground level. Stubble samples were cut to the level of the ryegrass crowns or clover stolons at Whangarei, Kumeu and at both Dargaville sites, and these samples were washed prior to drying and weighing. On one occasion (25-29 March 1984) all sites were assessed for stubble yield. With few exceptions, each operator conducted all cuts at each site.

Soil tests at all sites indicated adequate initial soil pH, phosphorus, and potassium status although all sites received an initial dressing of 0.5 t/ha of 30% potassic superphosphate fortified with trace copper and molybdenum. Pest control consisted of an application of fensulfothion (4 kg ai/ha) in November and an application of maldison-based cricket bait (20 kg/ha) in early February. Soil cores (0-15 cm) were removed from each cage fortnightly for moisture analysis. A herbage sample was taken once, about the mid-point of each period from all cages, for assessment of botanical composition by dissection.

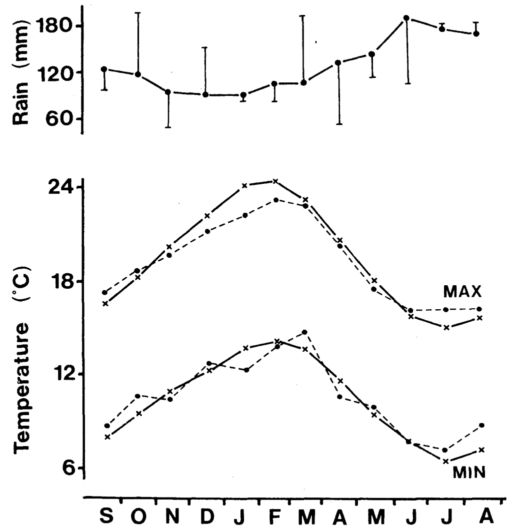

Figure 1: Monthly rainfall and mean daily maximum and minimum temperatures averaged from long term records for 7 sites across Northland. Rainfall and temperatures for the 1983-84 seaason at these sites are indicated by histogram positions and dashed curves respectively.

A summary of climatic data is presented in Figure 1. At most sites, the summer and early autumn rainfall was well above average while it was below average for the late autumn and early winter. Mean daily maximum temperatures were below average for most of the year.

RESULTS

The principal pasture species were perennial ryegrass (Table 1) except at the kikuyu grass site. Seasonal changes

TABLE 1: Botanical composition of pastures (as a % of DM) at eight sites averaged over 5 samplings throughout the trial year.

	Kaitaia	Kerikeri	Kaikohe	Whangarei	Dargaville	Warkworth	Kumeu	Kikuyu
Lolium perenne	62	36	52	39	43	41	31	23
Poa spp.	18	8	12	13	24	27	19	7
Holcus lanatus		23		9	3	18	1	
Agrostis spp.		1	18	8	2	6	3	
Pennisetum clandestinum	1							47
Other grasses[1]		1		3	1	4	3	2
Trifolium repens	12	20	10	12	20	9	11	8
Other legumes[2]			1					5
Weed and dead	7	11	7	15	7	9	15	7

[1]Other grasses = *Anoxanthum odoratum, Bromis* spp., *Paspalum dilatatum*
[2]Other legumes = *Lotus* spp. and *Trifolium pratense*

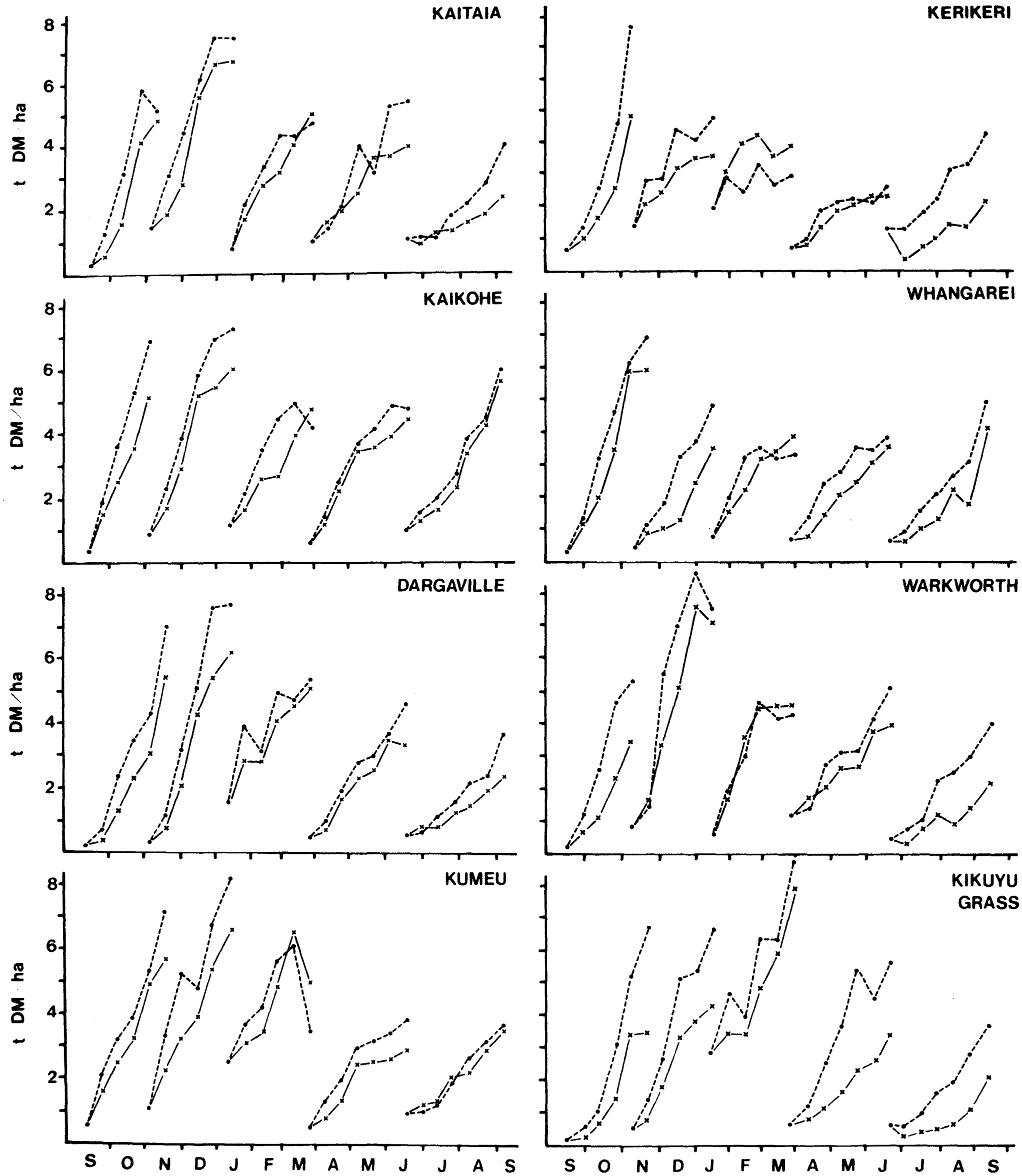

Figure 2: Pasture growth curves from eight sites during 1983-84. The dotted curves are from pasture fertilised with nitrogen.

in botanical composition occurred and are available on request. Nitrogen and irrigation treatments had little effect on composition. Clover content was relatively high during Jan-March (growth curve 3); the average for each site was 21% of DM.

Growth rates at the eight sites were higher in spring and summer than in autumn and winter (Fig. 2). There was a significant advantage to applying nitrogen except during growth curve 3 (Table 2). (The average growth rate is calculated as the average across the whole period of each growth curve measurement). The effect of nitrogen on the maximum growth rates was not as pronounced as on the average growth rates. Irrigation responses had no significant effect on the average or maximum growth rates

TABLE 2: The average growth rate (kg DM/ha/day) for each growth curve or the maximum growth rate in a fortnight about the middle of each growth curve period of pastures at 8 sites.

	Growth curve				
	1	2	3	4	5
Average growth rate					
−N	72	68	50	34	26
+N	96	87	47	45	41
Signif.	***	*	NS	***	***
−I		75	49		
+I		80	48		
Signif.		NS	NS		
SED	5	11	10	3	3
NI interaction	NS	NS	NS	NS	NS
Maximum growth rate					
−N	127	113	84	65	31
+N	126	158	105	88	51
Signif.	NS	*	NS	NS	*
−I		129	93		
+I		143	96		
Signif.		NS	NS		
SED	18	29	20	21	6
NI interaction	NS	NS	NS	NS	NS

when averaged over all sites (Table 2). However, irrigation had strong effects on site responses. At Kaitaia and Whangarei for Nov-Jan (curve 2) and Kumeu for Jan-March (curve 3), irrigation reduced the average daily growth rate from a mean of 71 to 49 kg DM/ha/day, while at Kaikohe and the kikuyu grass site for both growth curves, and Kumeu for curve 2 and Warkworth for curve 3, irrigation increased the mean of the average daily growth rate from 57 to 80 kg DM/ha/day. Similar variation occurred to a lesser degree in maximum growth rates at different sites.

Stubble yields varied within 1 t DM/ha over the year (Fig. 3) on the ryegrass pastures. The kikuyu grass site reached an autumn maximum of over 7 t DM/ha of stubble, which was predominantly kikuyu grass stolon.

DISCUSSION

The climate during 1983-84 was generally favourable for pasture growth at all sites with the possible exception of the east coast sites at Kerikeri and Whangarei which had a lower summer rainfall than the other sites. Summer temperatures may also have been too low for maximum kikuyu grass growth. This favourable weather, assisted us in estimating potential pasture growth rates. High rates of pasture growth, such as those exceeding 150 kg DM/ha/day, were measured from many fortnightly periods throughout the year except for July and August, particularly on the +N growth curves. The average growth rates (Table 2) are similar to those quoted by Brougham (Brougham, 1959; Brougham and Glenday, 1969). The mid-winter growth rates differ — our results being more than double those of Brougham's — but temperature differences alone may explain any differences. Maximum growth rates were higher than Brougham's results, although differences between sites, years, techniques, grazing methods, etc, could have contributed to this.

Two challenges to future pasture research arise from these values for potential growth rate. The first is to find why the growth rates were so high so that such rates could be predicted or influenced by management. The second is to

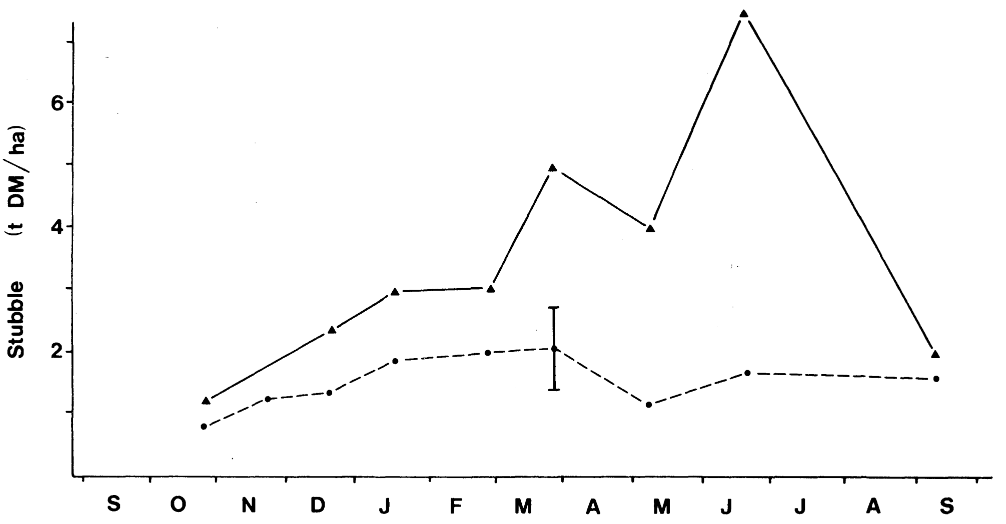

Figure 3: Annual pattern of stubble yield for 7 ryegrass (● ········ ●), and 1 kikuyu grass (▲———▲), sites. On ryegrass pastures, 3 sites were averaged except in March were a SE for 7 sites is presented.

develop pasture types and management regimes capable of maintaining maximum growth rates throughout the year, which could provide the yields of up to 30 t DM/ha/year which Table 2 suggests are possible.

The slope of the growth curves did not strongly follow the expected sigmoid shape (Fig. 2), particularly during spring and summer. The expected exponential phase at the bottom of the curve may have been missed because some areas of pasture used for measurement of growth curves were caged at a starting base which was too high or the fortnightly sampling interval may have been too long. The lack of a marked exponential growth phase in these trials may mean its agricultural significance may be over-rated in Northland. More information is needed concerning regrowth from pastures cut to low levels as such information is widely applicable to the rotational grazing systems used in current pastoral farming.

Most of the growth curves had a linear phase of growth which was maintained until high herbage mass accumulated. The development of 'ceiling' yields was not strongly indicated during the 8-12 week periods the growth curves were measured in this study. Very large quantities of herbage needed to accumulate before any ceiling yield or maximum herbage mass was reached. Further, since ceiling yield is a function of the decomposition of dead matter, it is sensitive to warmth and moisture, particularly in the humid climate of Northland, and is thus not seasonally constant. Therefore, it is doubtful whether ceiling yield is of agricultural significance in Northland, since it varies and occurs at such very high herbage masses. Decomposition also probably influenced the variable response to irrigation. Irrigation, at some sites, may well have stimulated decomposition more than herbage production; irrigation cages tended to have lower percentages of dead matter (unpubl. data). By implication, the effect of summer rainfall on pasture yield could be similar and a more sensitive measurement technique would be needed if irrigation effects were to be studied further.

More detailed measurements of the stubble may have aided the interpretation of these results, particularly for the kikuyu grass pasture. Since yields of kikuyu grass stubble showed such a strong seasonal pattern and reached such high levels in autumn (Fig. 3), some doubt is cast on the true picture of seasonal pasture growth as depicted from sampling where stubble is not measured. While the large stubble values may have no nutritive significance, they do indicate a wasted potential for animal production which grazing management or plant breeding could influence.

The responses of the swards to nitrogen (Fig. 2, Table 2) support Ball and Field's (1982) conclusion that "swards are under some degree of nitrogen stress for most of the time". Reproductive growth in October may have masked the effect of nitrogen on maximum growth rate in the first growth curve (Table 2), while the lack of a nitrogen response in the third growth curve was partly caused by the relatively high levels of clover in the pastures during this summer.

In summary, pasture growth curves in Northland appear to conform to the expectations indicated by data recorded in the Manawatu; although special allowance must be made for pastures containing subtropical grasses, such as kikuyu grass, which has poorer winter and spring growth. The results reported here suggest that over the range of herbage masses which are of agricultural importance, regrowth throughout the year is almost linear in Northland. Work is currently in progress to confirm this.

ACKNOWLEDGEMENTS

The owners of the sites are thanked for their co-operation, and the field assistance of S.J. Carbines, D.G. Fraser, M.H. Ward, H.M. Morgan, W.B. McMeikan and T.E. Dawson is gratefully appreciated.

REFERENCES

Baars, J.A. 1980. Development of a stimulation model for pasture growth. *Proceedings Agronomy Society of NZ 10:* 103-106.

Ball, P.R., Field, T.R.O. 1982. Responses to nitrogen as affected by pasture characteristics, season and grazing management. *In* 'Nitrogen Fertilisers in New Zealand Agriculture' *ed.* P.B. Lynch. New Zealand Institute of Agricultural Science. pp 45-64.

Brougham, R.W. 1959. The effects of season and weather on the growth rate of a ryegrass and clover pasture. *New Zealand Journal of Agricultural Research 2:* 283-296.

Brougham, R.W., Glenday, A.C. 1969. Weather fluctuations and the daily rate of growth of pure stands of three grass species. *New Zealand Journal of Agricultural Research 12:* 125-136.