RECOVERY AND GROWTH PATTERNS OF COASTAL BERMUDA GRASS AS INFLUENCED BY NITROGEN LEVEL AND DEFOLIATION FREQUENCY

M. R. Villanueva and E. C. Holt

Former Graduate Assistant, presently Officer In-Charge, Visayas State College of Agriculture, Baybay, Leyte, Philippines, and Professor, Soil and Crop Sciences Department, Texas A & M University, College Station, Texas 77843, U.S.A.

ABSTRACT

The interrelationships among residual leaf area following defoliation, leaf area development patterns and mean crop growth rates of Coastal bermuda grass as influenced by nitrogen levels (20, 50 and 100 kg/ha/mo) and defoliation frequency (2, 4, and 8-week intervals) were evaluated. Residual leaf area index (LAI), dry matter (DM), LAI accumulation at weekly intervals, and mean crop growth rate ($\overline{\text{CGR}}$) were determined.

During the first 2 weeks, DM development was more rapid following more frequent defoliation and at higher N rates. The effect of N on DM accumulation increased after the first 2 weeks and DM did not peak in any of the harvest intervals. Residual LAI was greater with more frequent harvest, but LAI evolution was not significantly influenced by N until the sixth week. Initial regrowth, however, appeared to be related more to N than to residual LAI. Higher N and more frequent defoliation produced denser turf which in turn provided more sites for origin of new leaves and this seems to be more important for rapid regrowth than residual leaves. Mean crop growth rate in all harvest frequencies significantly increased from the first to the second week and was considerably higher with increasing harvest frequencies. Since N was applied at 4-week intervals, these results suggest that N applications more frequent than at 4-week intervals and at rates higher than 100 kg/ha/mo, are required to maximize growth of Coastal bermuda grass.

Ann. Trop. Res. 8:51-59.

KEY WORDS: *Cynodon dactylon* (L.) *Pers.* Leaf area index (LAI). Mean crop growth rate ($\overline{\text{CGR}}$). Dry matter. Nitrogen levels. Defoliation.

INTRODUCTION

Coastal bermuda grass *(Cynodon dactylon* (L.) Pers.) is widely used as a forage plant and has been the subject of extensive studies. The influence of harvest practices on its dry matter (DM) production and nutritive value has been reported numerous times (Clapp et al., 1965; Ethredge et al., 1973; Holt and Lancaster, 1968; and Prine and Burton, 1956).

Leaf area index (LAI) as related to light interception appears to be a useful tool for understanding forage growth (Brown and Blaser, 1968; Donald and Black, 1958). Brougham (1956) suggested that an LAI of approximately 5 is needed to maximize light interception and rate of regrowth in certain grasses. Alexander and McCloud (1962), relating different management systems and LAI of Coastal bermuda grass to CO_2 uptake, reported LAI values ranging from 1 to 20 depending on the system of management.

Lambert (1964) reported that LAI can be increased by N application, but the increase can be restricted by frequent defoliation. Clapp et al. (1965) imposed intensive defoliation systems and obtained LAI values at cutting mainly between 1.5 and 2.2. Dovrat and coworkers (1970, 1971) also pointed out that high rates of N together with long harvest intervals induced slow initial regrowth in rhodesgrass *(Chloris gayana* Kunth.).

Brougham (1956), Davidson and Donald (1958) and Langer (1959) have considered regrowth of forage crops in relation to the residual leaf area following defoliation. Residual LAI following cutting was influenced by both the amount of growth allowed to accumulate prior to cutting and the height of cutting. However, Greub and Wedin (1971) did not find any significant relationship between net DM accumulation and residual leaf area. Further questions on the significance of residual leaves in grass regrowth have been raised by Brown and Blaser (1968).

This paper reports on the effect of nitrogen level and defoliation frequency on rate of dry matter accumulation, LAI evolution and mean crop growth rate of Coastal bermuda grass. Information on the last two parameters is important in relation to fertility and defoliation management particularly for a crop such as Coastal bermuda grass which has the capacity to grow rapidly and to utilize large amounts of N quickly.

MATERIALS AND METHODS

The study was conducted in an established Coastal bermuda grass pasture on an alluvial Miller clay soil at the Texas A & M University Farm near College Station. A split-plot design with four replications was used for the experiment. Harvest intervals (2, 4 and 8-week) were assigned as the main plots. Each of the main plots was divided into three subplots consisting of N rates (20, 50 and 100 kg/ha/mo).

Ammonium nitrate (33.5% N) was used as the source of N and was applied at 4-week intervals. Phosphorus and potassium were applied uniformly on all plots twice during the growing season (April and June) at the rate of 100 kg each of P_2O_5 and K_2O per hectare (44 and 80 kg of P and K/ha). The entire experimental area was mowed twice with a tractor-mounted rotary mower prior to the application of the treatments to allow the development of a uniform stand.

Growth parameter measurements were performed at weekly intervals only for one cycle for each of the harvest frequencies and at all N levels. LAI was determined using leaf area-dry weight relationship with the aid of an automatic area meter (model AAM-5-Hayashi Denko Co.). Dry matter yield was obtained from each plot by harvesting a 0.6 x 1.2 m strip using a flail mower with swinging blades at 5-cm cutting height.

Mean crop growth rate ($\overline{CGR}$) was determined following the procedure and interpretation discussed by Redford (1967) wherein $\overline{CGR}$ expressed in kg/ha/day was calculated as follows:

$$\overline{CGR} = \frac{W_2 - W_1}{t_2 - t_1}$$

where W_1 and W_2 are the total dry weights of plant material (W) per unit area of ground at times t_1 and t_2, respectively.

RESULTS AND DISCUSSION

Cumulative Weekly Dry Matter Production

Growth parameter measurements were made on the fifth harvest of the 2-week harvest frequency and on the second harvest of both the 4 and 8-week frequencies. Weekly DM accumulations during the growth periods are presented in Figure 1. Dry matter production continued to increase in all harvest frequencies until the end of each cycle. In the 2-week frequency, weekly DM accumulation was similar at 50 and 100 kg N/ha and this was significantly higher than that at 20 kg N/ha/mo. In the 4-week frequency, the weekly DM production was similar among N rates during the first 2 weeks but significantly different in the succeeding 2 weeks. Weekly DM accumulation was likewise similar among N rates during the first 3 weeks but significantly different in the succeeding weeks in the 8-week harvest frequency.

Although DM accumulation was initially similar among N rates within harvest frequencies, greater amounts of DM were produced with increasing N beginning from the second or third week. There was generally higher DM accumulation with increasing harvest frequencies during the first 2 weeks of regrowth. This could be attributed to the effect of frequent harvesting on the growth habit of Coastal bermuda grass, i.e. producing stolons which resulted in more rapid regrowth in

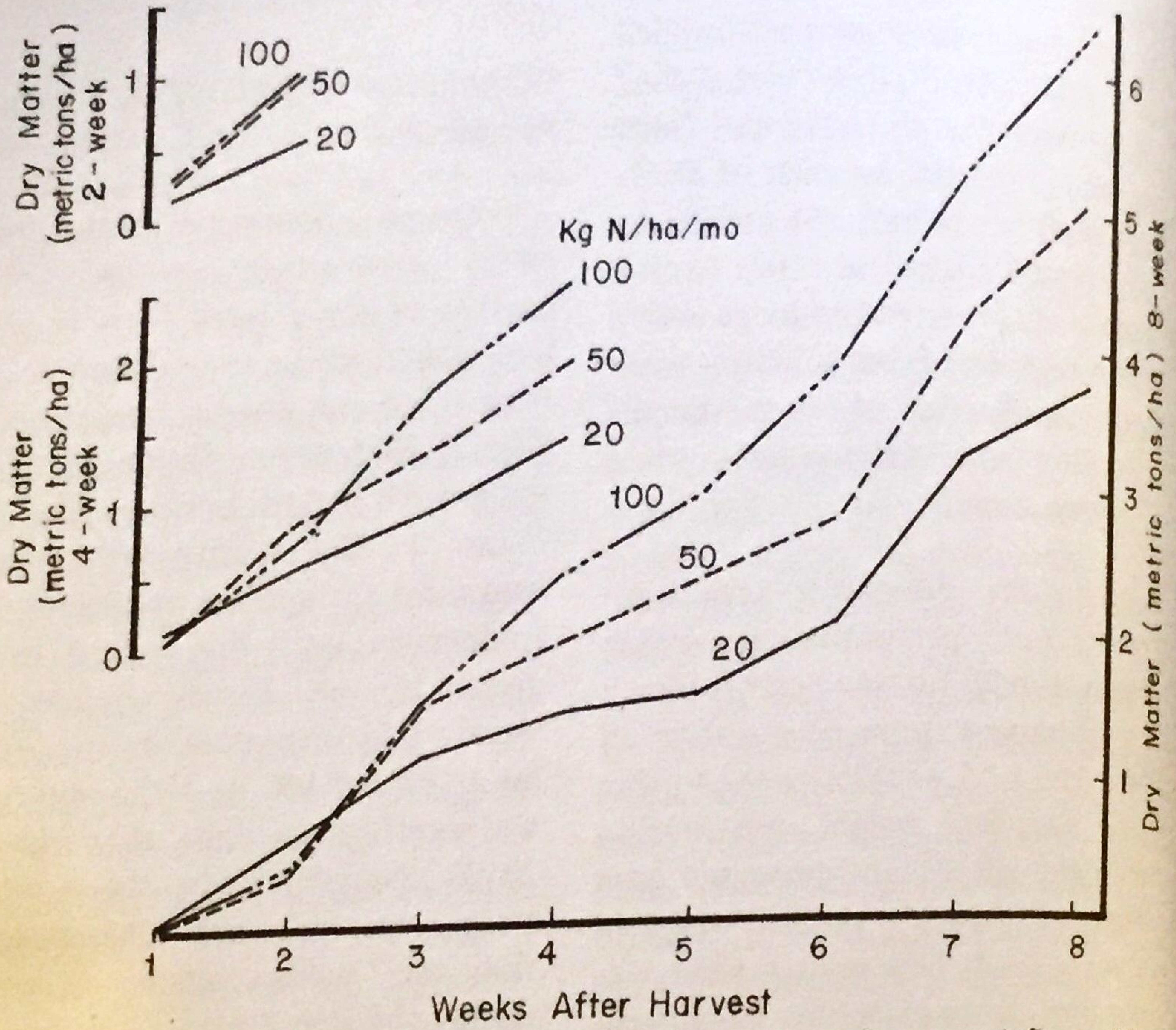

Figure 1. Cumulative dry matter (DM) production of Coastal bermuda grass as influenced by N level and harvest frequency.

the first 2 weeks. The increasing total DM accumulation with increasing N rates and extended growth period is shown in Table 1.

Leaf Area Evolution

Weekly cumulative LAI values are illustrated in Figure 2. Generally, LAI increased with age of the grass but was higher with more frequent harvests during the first 2 weeks of regrowth. Within a given week, LAI values were not significantly different among N rates for both the 2 and 4-week frequencies. In the 8-week frequency, LAI values were not significantly different among N rates until the sixth week, but significantly different during the seventh and eighth weeks. There was a higher rate of increase in LAI at 50 and 100 kg N/ha/mo during the sixth and seventh weeks which later declined after reaching the ceiling values of 3.28 and 5.69, respectively. During the same period, LAI continued to increase but at a lower rate of 20 kg N/ha/mo.

Except for the 50 and 100 kg N/ha/mo levels at the 8-week frequency, the ceiling LAI could not be identified because values were still increasing until the end of the respective cycles. Weekly accumulated DM yield continued to increase in all treatments. Apparently, the

Table 1. Total dry matter yield of Coastal bermuda grass as influenced by N fertilization and harvest frequency.

Harvest Frequency (weeks)	Total Dry Matter Yield (metric tons/ha)		
	kg N/ha/mo		
	20	50	100
2	4.07	6.93	13.08
4	8.41	12.78	16.94
8	13.07	15.23	18.28

declining LAI at 50 and 100 kg N/ha was adequate to depress $\overline{CGR}$ (Fig. 3) although DM accumulation continued. The reduction in LAI in these treatments was probably due to the senescence of lower leaves which were not included in the leaf area measurement. The contribution of leaf DM to total DM produced at the point where leaf senescence occurs is relatively less than that at earlier stages as suggested by Prine and Burton (1956). LAI and DM production showed a significant relationship (r = 0.69**) which appeared to become stronger at

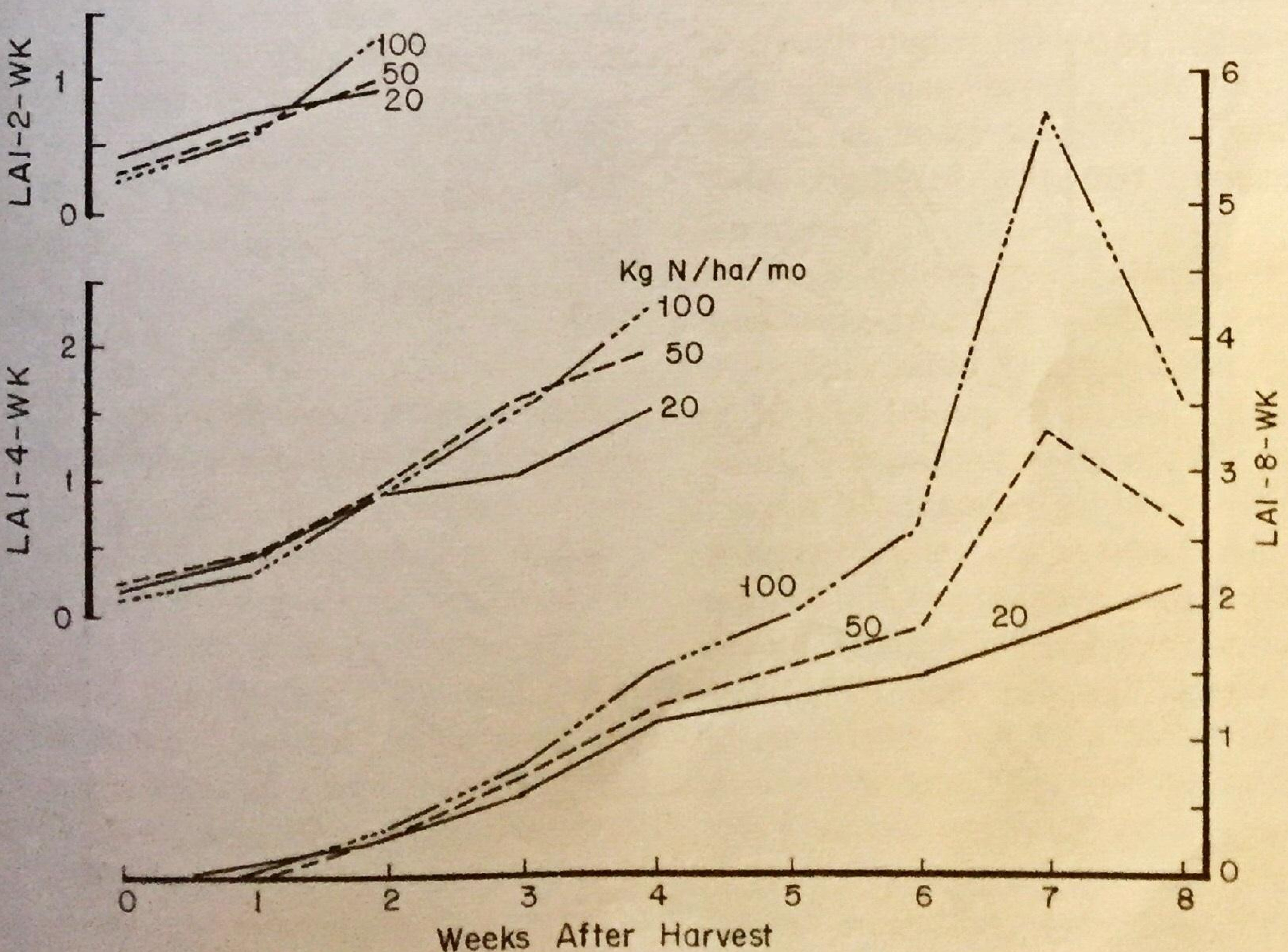

Figure 2. Cumulative weekly leaf area index (LAI) of Coastal bermuda grass as influenced by N level and harvest frequency.

longer harvest intervals.

Leaf area development was increased by N primarily during the sixth to eighth weeks of growth. The increasing contribution of stems, more than leaves, to total growth as N was increased probably accounts for the limited leaf area response.

Residual Leaf Area and Rate of Regrowth

Residual leaf area after clipping decreased with less frequent clipping and with increased N rate within frequencies. Residual leaf area was 0 in all N treatments at the 8-week harvest interval.

First week regrowth showed a significant but not close relationship ($r = 0.404^*$, d.f. $= 34$) with residual leaf area. Regrowth during the first week after cutting was greater with more frequent cutting which indicates a residual leaf area effect. However within frequencies, regrowth increased with increased N

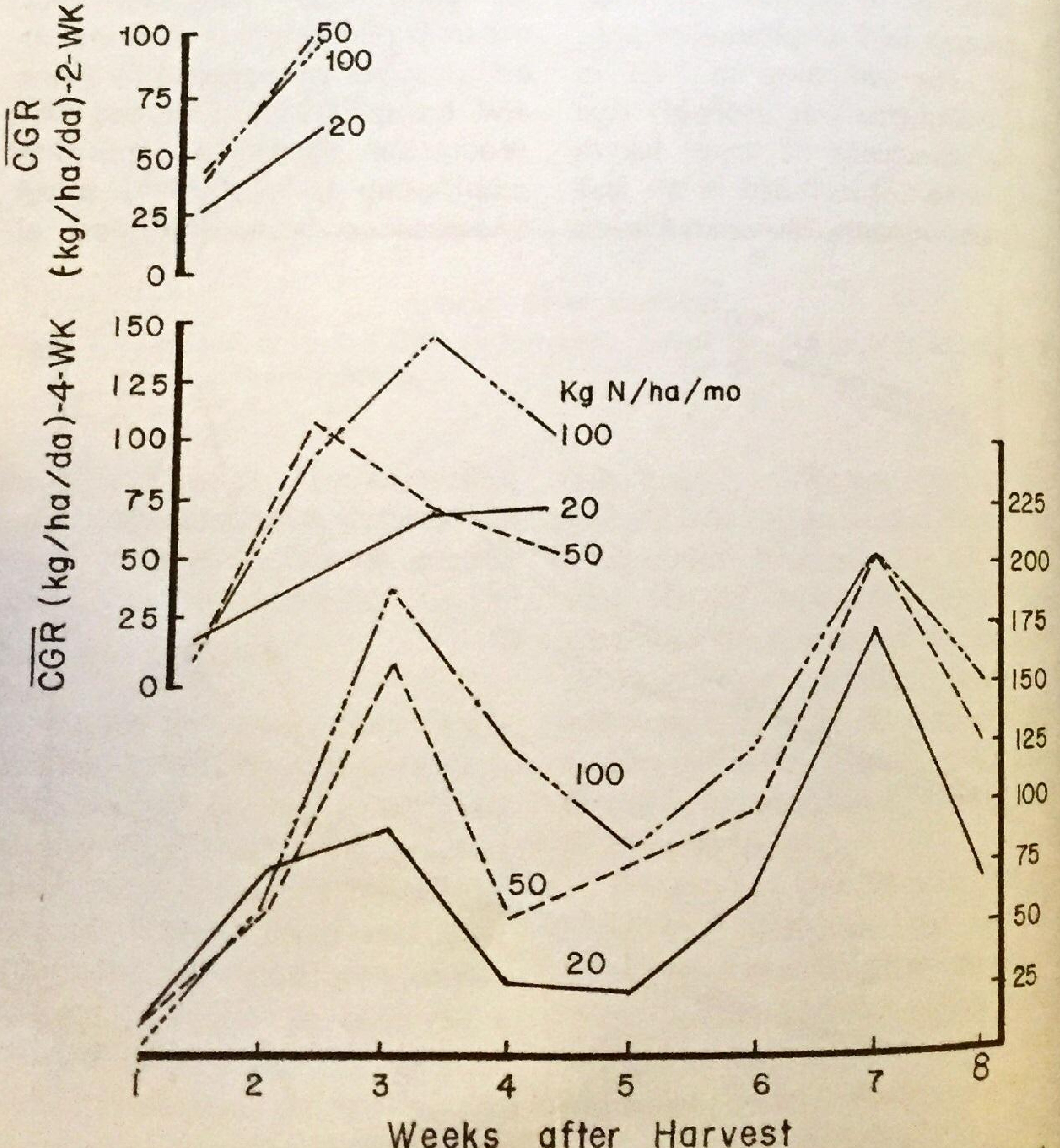

Figure 3. Mean crop growth rate ($\overline{CGR}$) of Coastal bermuda grass as influenced by N level and harvest frequency.

while residual leaf area showed the opposite pattern. By the third week, accumulated regrowth was greater in less frequently harvested plots. These results suggest that N is more important than residual leaf area in promoting regrowth and that the rate of regrowth of all new leaves may exceed that of some old leaves within the first 3 weeks after cutting. Ethredge et al. (1973) reported greater yields with 3-week clipping frequency at 0 height than at any greater height. Obviously, all residual leaves were removed and new growth was produced from new leaves. Hart and Lee (1971) concluded that age of leaves is more important than LAI in influencing CO_2 exchange, young Coastal leaves being highly efficient. Clapp et al. (1965) reported that Coastal cut back to 2 cm when it reached 5 cm produced 15 to 31% more forage than that cut back to 8 cm each time it reached 15 cm. LAI of the latter treatment averaged 47% higher than the former but the leaves were older.

Coastal bermuda grass tended to form denser and more lateral growth below the cutting height when harvested more frequently. Similarly, denser growth was produced at higher than at lower N rates at the same frequency of cutting. This response provided more sites for new shoot and leaf growth which likely caused more rapid regrowth with frequent cutting and higher N rather than residual leaf area being the cause.

Mean Crop Growth Rate ($\overline{CGR}$)

Mean crop growth rate ($\overline{CGR}$) data are graphically illustrated in Figure 3. $\overline{CGR}$ increased significantly in all harvest frequencies from the first to the second week and was significantly higher with increasing harvest frequencies. After the second week, there were only slight increases in the 4-week frequency. In the 8-week frequency, $\overline{CGR}$ declined after the third week, increased after the fifth week, peaked in the seventh week and then declined. The relatively high $\overline{CGR}$'s (approximately 100 kg/ha/day) attained in the second week with LAI's in the range of 1.0 are indicative of the photosynthetic efficiency of young Coastal leaves. These data explain why it is possible to obtain higher yields of Coastal with frequent severe defoliation though at some sacrifice in total yield compared with less frequent harvesting.

$\overline{CGR}$ generally increased with increasing rates of N fertilization with more rapid increase occurring at 50 and 100 kg N/ha/mo. Maximum $\overline{CGR}$ was never attained in the 2-week frequency. In the 4-week frequency, the time at which maximum $\overline{CGR}$ was reached varied with N rate. Maximum $\overline{CGR}$ was reached by the 20 and 100 kg N/ha/mo levels (71 and 145 kg DM/ha/day) during the third week and by the 50 kg N/ha/mo level (111 kg DM/ha/day) during the second week. In the 8-week frequency, maximum $\overline{CGR}$ was attained by all N levels during the same week. Despite the twin peaks of $\overline{CGR}$, the second peaks (172, 206 and 205 kg DM/ha/day at 20, 50 and 100 kg N/ha/mo. respectively) were generally higher than the first.

The $\overline{CGR}$ pattern tends to emphasize the importance of N and the frequency and time of its application on Coastal bermuda grass. In the 8-week harvest frequency, the plots received two applications of N during the harvest cycle. The first was applied following the previous defoliation and the second at the end of the fourth week. The reduction in $\overline{CGR}$ after the third week may have been due to N deficiency, although there were no distinct visual deficiency symptoms. This is supported by the increasing trend in $\overline{CGR}$ following the second application of N. Inasmuch as moisture was not limiting and this part of the study was conducted between the later part of June and the early part of August, it is less likely that other environmental factors strongly influenced the trend in $\overline{CGR}$. The decline in $\overline{CGR}$ in the 4 and 8-week frequencies, after an initial increasing trend, is more likely due to exhaustion of soil N.

Results also show that Coastal can utilize N in large amounts even at increasing maturity of the grass. It is suggested that N be applied in excess of 100 kg/ha and more frequently than at 4-week intervals to attain further increases in DM yield.

LITERATURE CITED

ALEXANDER, C.W. and McCLOUD, D.E. 1962. CO_2 uptake (net photosynthesis) as influenced by light intensity of isolated bermuda grass leaves contrasted to that of swards under various clipping regimes. Crop Sci. 2:133-135.

BROUGHAM, R.W. 1956. Effect of intensity of defoliation on regrowth of pasture. Australian J. Agric. Res. 7:377-387.

BROWN, R.H. and BLASER, R.E. 1968. Leaf area in pasture growth. Herb. Asb. 38:1-9.

CLAPP, J.G., JR., CHAMBLEE, D.S. and GROSS, H.D. 1965. Interrelationships between defoliation systems, morphological characteristics and growth of Coastal bermuda grass. Crop. Sci. 5:468-471.

DAVIDSON, J.L. and DONALD, C.M. 1958. The growth of subterranean clover with particular reference to leaf area. Australian J. Agric. Res. 9:53-72.

DONALD, C.M. and BLACK, J.N. 1958. The significance of leaf area in pasture growth. Herb. Asb. 28:1-6.

DOVRAT, A. and COHEN, Y. 1970. Regrowth potential of Rhodesgrass (*Chloris gayana* Kunth.) as affected by nitrogen and defoliation. Proc. 11th Int. Grassland Congr. pp. 552-554.

DOVRAT, A., DIRVEN, G.P. and DEINUM, B. 1971. The influence of defoliation and nitrogen on the regrowth of Rhodesgrass (*Chloris gayana* Kunth). 1. Dry matter production and tillering. Neth. J. Agric. Sci. 19:94-101.

ETHREDGE, J., BEATY, E.R. and LAWRENCE, R.M. 1973. Effects of clipping height, clipping frequency, and rates of nitrogen on yield and energy content of Coastal bermuda grass. Agron. J. 65:717-719.

GREUB, L.J. and WEDIN, W.F. 1971. Leaf area, dry matter production, and carbohydrate reserve levels of birdsfoot trefoil as influenced by cutting height. Crop. Sci. 11:734-738.

HART, R.L. and LEE, D.R. 1971. Age versus net CO_2 exchange rate of leaves of Coastal bermuda grass. Crop. Sci. 11:598-599.

HOLT, E.C. and LANCASTER, J.A. 1968. Yield and stand survival of Coastal bermuda grass as influenced by management practices. Agron. J. 60:7-10.

LAMBERT, D.A. 1964. The effect of level of nitrogen and cutting treatment on leaf area in swards of S48 timothy (*Phleum pratense* L.). J. Brit. Grassland Soc. 19:396-402.

LANGER, R.H.M. 1959. A study of growth in swards of timothy and meadow fescue. 2. The effects of cutting treatments. J. Agric. Sci. (Camb.) 52:273-281.

PRINE, G.M. and BURTON, G.W. 1956. The effect of nitrogen rate and clipping frequency upon the yield, protein content and certain morphological characteristics of Coastal bermuda grass (*Cynodon dactylon* (L.) Pers.). Agron. J. 48:296-301.

RADFORD, P.J. 1967. Growth analysis formulae — their use and abuse. Crop. Sci. 7:171-175.