PASTURE GROWTH RATE STUDIES IN RELATION TO GRAZING MANAGEMENT

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MOST OF THE MATERIAL presented in this paper has been published elsewhere (1, 2, 3) and for this reason a detailed review of the literature will not be given here.

The work under discussion has been mainly concerned with the effects of variations of environmental factors on the leaf growth of pasture, and in particular with the relationships that exist in the utilization of light energy by the leaf of pasture. An understanding of these factors will obviously influence the production of food for the grazing animal.

It has been established (1) that the rate of regrowth of pasture following defoliation conforms to the exponential (or logarithmic) and Mitscherlich laws of growth—*i.e.*, regrowth with respect to time follows a sigmoid or S-shaped curve. A full treatment of growth as determined by these laws is given by Thomson (4). Typical growth curves of pasture following defoliation are shown in Fig. 1.

Phases of Growth of Pasture

For the convenience of discussion, the curves of growth presented in Fig. 1 are divided into three phases:

Phase 1 in which rate of growth increases exponentially.

Phase 2 in which growth is at a constant maximum rate.

Phase 3 in which growth rate declines at first slowly but then at an increasing rate until increases are negligible; in some cases yields decline.

A number of factors influence growth in these various phases and all except the major climatic factors can be controlled to some extent by management practices.

Some of these factors are discussed below. No attempt has been made to discuss all the factors and the order of presentation is not necessarily the order of importance.

FACTORS INFLUENCING GROWTH IN PHASE 1.

A considerable amount of experimental work has been carried out on the possible role of stored reserves and the remobolization of these following defoliation. An extensive review of this work has been given by Weinmann (5). It is generally considered that a build-up of plant materials occurs in the roots and growing points of the plant during growth

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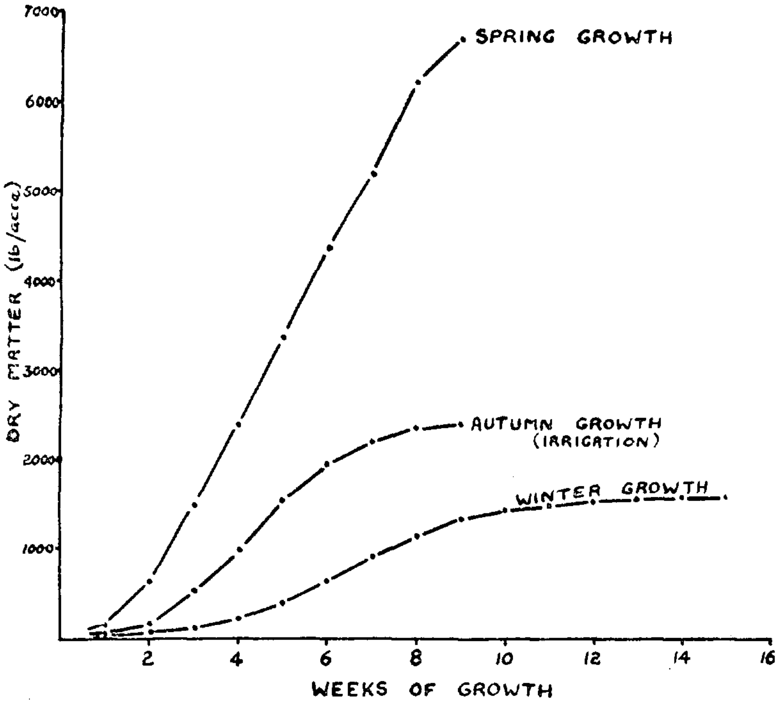

Fig. 1: Typical seasonal growth rate curves of pasture following defoliation.

and that, following defoliation, immediate regrowth is determined by the amount and remobilization of these reserves. However it is considered by a number of workers that the whole question of stored reserves and their role in regrowth warrants review.

A second factor recently observed (6) is that relating to the availability of soil moisture for regrowth. This work suggests that, even when soil moisture is appreciably above wilting point, regrowth following severe defoliation is limited by a water shortage because of the inability of defoliated plants to exert sufficient pressure to counteract the retention pressure of the soil particles on the soil water.

Rate of regrowth is also related to the intensity of defoliation and its effect on subsequent photosynthetic activity of the pasture. In an experiment carried out at Grasslands (2) the height of defoliation was shown to influence markedly the rate of regrowth. The rate of growth of pasture increased until complete light interception was reached, and thereafter an almost constant maximum rate was sustained. Following defoliation to 5 in., over 95 per cent. of the incident light was intercepted and hence maximum rate of regrowth attained approximately 4 days after cutting, whereas pasture defoliated to 3 in. and 1 in. did not reach the stage of maximum rate of regrowth until 16 and 24 days after defoliation, respectively. The pasture used in the experiment was a mixed sward of short-rotation ryegrass, red and white clover, and the stage of regrowth at which almost complete interception of light was attained corresponded of a leaf area index of 5. Beyond this point the rate of increase of leaf area and the increment in dry matter were maintained at a constant rate. An extension of this work at present being carried out suggests that the leaf area index (of 5) varies with species and season.

The above results are shown graphically in Figs. 2 and 3.

A considerable amount of detailed experimental work is still required before the relative importance of the above three factors in the regrowth of a sward of pasture plants can be determined for different environmental conditions. However, the important feature of all factors is that the most detrimental effects occur following severe defoliation or grazing, and thus the aim in management should be to prevent hard grazings.

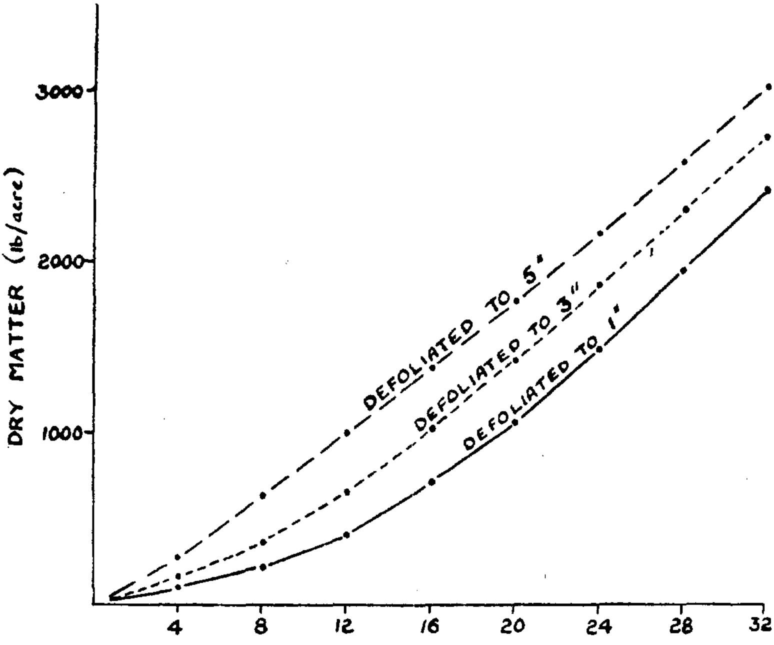

Fig. 2: Rates of pasture regrowth following different heighths of defoliation.

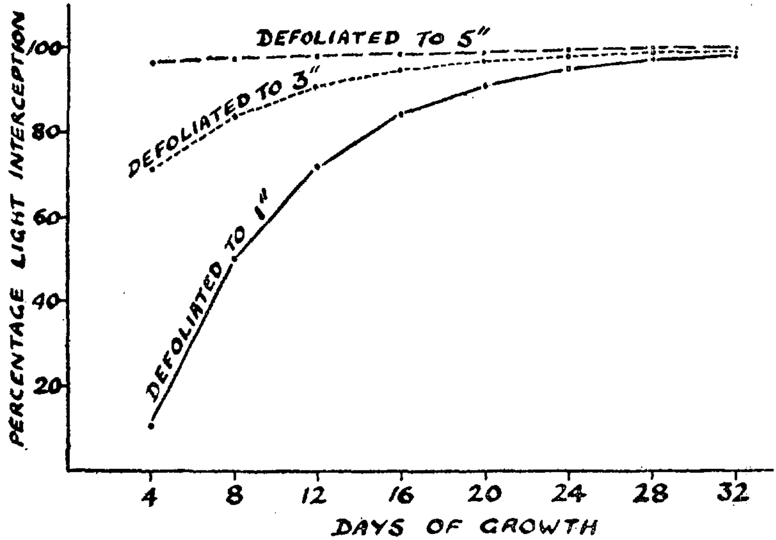

Fig. 3: Relationship between intensity of defoliation and time taken to reach maximum rate of pasture regrowth.

Another factor which is often one of the major causes of slow regrowth of pastures on farms is the high degree of clumping of tillers and the wide dispersion of these clumps. In such pastures, which are frequently seen, there is usually much bare ground showing following grazing. Total regrowth is then slow because of the relatively long time before the ground is completely covered by a canopy of leaf sufficient to intercept almost all the light and hence to give maximum rate of regrowth. These conditions also enable weeds and some of the less productive grasses to germinate and develop. This stresses the need to maintain a uniformly dispersed tiller population of desirable species in the pasture. Resowing or oversowing are the usual courses adopted in practice to build up tiller numbers.

Factors Influencing Growth in Phase 2.

The various factors which influence the rate and duration of the first phase of growth also influence growth to some extent in the second phase. In addition, two other important factors begin to operate.

The first is competition, both inter- and intra-species competition, which commences in the first phase of growth and then increases in intensity and is a major factor after the point of complete light interception. Under normal growing conditions when nutrients are not limiting, competition is mainly for light. The importance of light competition has been dealt with by Donald (7, 8). Under New Zealand conditions, where the ryegrasses and clovers are the dominant components of most pastures, for most of the year the clovers are shaded by the more aggressive growth of the grasses. This results in a reduced growth rate of clover and in some instances a decrease in yield. It is usually during the summer and early autumn that the clovers, because of a better tolerance to high temperatures and lower water supplies, sometimes compete to better advantage than the grasses.

Figure 4 shows the rate of growth of the components of a mixed short-rotation ryegrass/white clover sward during the spring. In this instance, competition for light has resulted in a reduced growth rate of the clover component after the point of complete light interception.

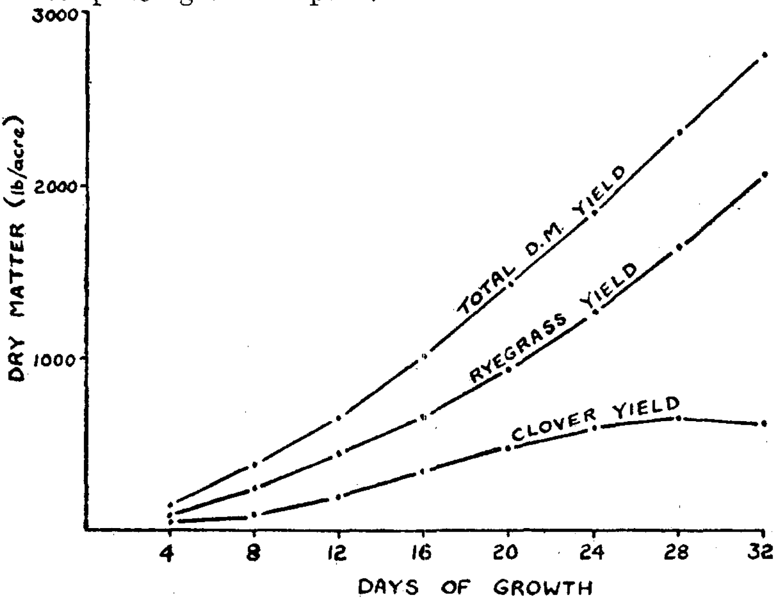

Fig. 4: Rate of growth of ryegrass and clover in a mixed sward during the spring.

A second factor which begins to influence the growth rate in this phase and is a major factor in the third phase is that of tissue decomposition. This is illustrated in Fig. 5 where the rate of growth of pasture over the winter months is shown to reach a yield ceiling and then remain at this level regardless of the length of spelling.

The pasture illustrated was growing during the latter part of the spelling period but the growth was only sufficient to

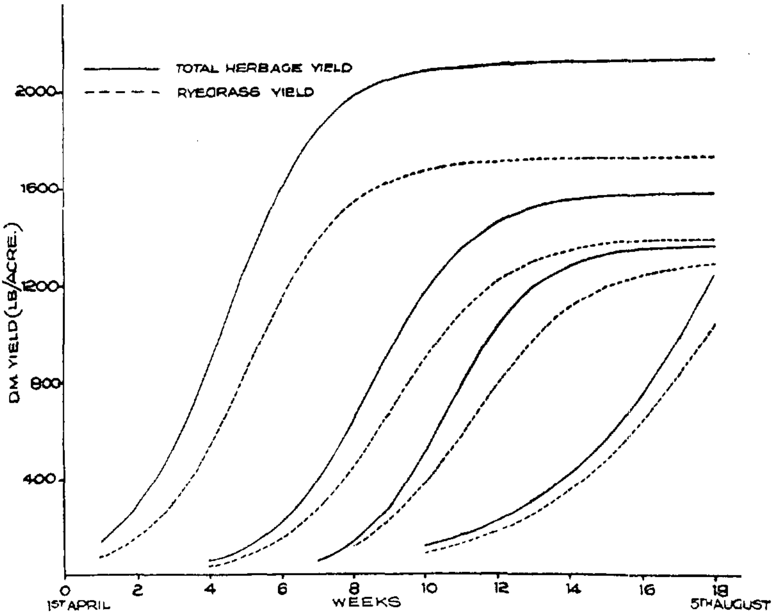

Fig. 5: Effect of tissue decomposition on pasture growth after several weeks spelling.

offset herbage losses due to decomposition. The losses can be attributed to the action of slugs and worms, and to parasitic and saprophytic fungal growths. An additional factor could be loss through the death of leaf, a factor which could be of considerable importance in the growth of clover. The suggestion is therefore made that, under normal farm conditions, winter spelling of pasture to meet feed requirements in the early spring can have a detrimental effect on the number and vigour of plants in the pasture, resulting in poor yields of feed. The length of spelling should not exceed 6 to 8 weeks.

Factors Influencing Growth in Phase 3.

The two factors influencing growth in the second phase obviously operate in the third phase. The only additional one that will be discussed under this heading is the effect of a limiting supply of a plant nutrient on growth rate. As an illustration, the amount of nitrogen contained in a pure stand of ryegrass at a dry matter yield of 3,000 lb. per acre is approximately equivalent to 600 lb. of sulphate of ammonia per acre. This assumes a nitrogen percentage of 4. When it is realized that the average daily growth rate of a pasture of short-rotation ryegrass in the second period of growth ranges from 25 lb. of dry matter per acre in the winter to about 150 lb. of dry matter per acre in the spring, the rapid turnover of this element is readily appreciated. It is possible that, at some times of the year, nitrogen, together with other nutrients, severely limits grass production. Under our grassland economy, the maintenance of a vigorously growing white clover in the pasture is an obvious requirement. While maximum production of feed is a primary concern, the maintenance of a balance of grasses and clovers in the sward is of equal importance.

In the above discussion the various factors were treated separately and grouped under headings in which the major influence occurs. It should be realized that no one factor operates independently of the others and that all make up a dynamic complex.

Effects of Grazing

In an attempt to determine the total effect of some of these factors on growth, an experiment was laid down at the Grasslands Division in which the cumulative effects of various frequencies and intensities of grazing are being determined. The pasture is a mixture of short-rotation ryegrass, red and white clover.

The systems of management are as follows:

(1) Grazings when the herbage reaches a level of 3 to 4 in. down to a level of 1 in.
(2) Grazings when the herbage reaches a level of 7 to 8 in. down to a level of 3 to 4 in.
(3) Grazings when the herbage reaches a level of 9 in. down to a level of 1 in.
(4) Grazings when the herbage reaches a level of 12 in. down to a level of 3 to 4 in.

The treatments were determined with reference to the curves of pasture growth shown in Fig. 1. It was proposed that treatment 1 would consist of frequent harvests of phase 1 growth, treatment 2 of frequent harvests of phase 2 growth, treatment 3 of relatively long spells made up of phase 1 and

TABLE 1: TOTAL DRY MATTER YIELDS (lb./acre) FOR THE FOUR GRAZING TREATMENTS (No. of grazings shown in parentheses).

Season	Treatment				Std.	*d*
	4in.-1 in.	7 in.-3 in.	9 in.-1 in.	12 in.-3 in.	error	0.05
Summer, 1955-56 (2/12/55-28/2/56)	4,700(5)	6,850(5)	5,700(3)	6,150(4)	±200	650
Autumn, 1956 (1/3/56-1/6/56)	2,230(3)	2,770(3)	2,920(2)	2,400(2)	± 90	280
Winter, 1956 (1/6/56-31/8/56)	2,410(3)	1,530(3)	2,490(2)	1,930(2)	±120	380
Spring, 1956 (31/8/56-27/11/56)	5,060(6)	6,120(7)	6,380(4)	6,920(5)	±170	520
Total (2/12/55-27/11/56)	14,400(17)	17,300(18)	17,500(11)	17,400(13)	±420	1300

some phase 2 growth, and treatment 4 of long spells in which phase 2 and phase 3 growth occurred. Some deviations from the above have occurred but these will be discussed with reference to the results, which are presented in Table 1. They show total dry matter yields for the four treatments obtained during the first year of the experiment.

The results presented in the table show marked seasonal differences between treatments. The salient features are as follows:

(1) COMPARISON OF FREQUENT HARD GRAZINGS WITH FREQUENT LAX GRAZINGS. (i.e., treatment 1 with treatment 2.)

For all seasons except the winter, treatment 2 significantly outyielded treatment 1; during the winter the reverse was the case. The numbers of grazings were equal in all seasons except the spring, when there was one more grazing of treatment 2. Some of the reasons for these differences have been discussed previously. An additional factor during the summer and early autumn was the greater yield of herbage obtained from red clover in treatment 2.

The winter difference in favour of treatment 1 is difficult to explain, although the technique used in grazing may have been a contributing cause. The paddock size was small and to obtain uniform grazings in treatment 2 a relatively high concentration of stock was required. This meant that the time taken to graze individual paddocks was only a few hours and because of the on-and-off system of grazing it is probable that a considerable amount of nutrients was taken from the paddocks to the detriment of subsequent yields. It is also possible that a much smaller area of leaf is required to intercept all available light during the winter when the altitude of the sun never reaches a high level. This coupled with the fact that treatment 1 was grazed at 5 to 6 in. at times during the winter, would suggest that growth from this treatment was not all phase 1 growth.

(2) COMPARISON OF FREQUENT LAX GRAZINGS WITH INFREQUENT HARD GRAZINGS. (i.e., treatment 2 with treatment 3.)

No significant differences were recorded between these treatments during the autumn and spring. However, during the summer, treatment 2 was significantly higher than treatment 3 and the reverse applied during the winter. The same explanation outlined in the preceding comparison applies to the winter difference, and reasons for the summer difference have also been discussed.

(3) COMPARISON OF FREQUENT HARD GRAZINGS WITH INFREQUENT HARD GRAZINGS. (i.e., treatment 1 with treatment 3.)

In all seasons except the winter, treatment 3 yielded significantly higher than treatment 1. These results agree with those recorded previously by Sears (9) and can be explained with reference to the growth curves presented in Fig. 1.

The significant feature of the above results in relation to pasture management on the farm is that high yields of herbage can be obtained from frequent grazings of the pasture, provided hard grazings are avoided.

In addition to the above, measurements of tiller population and dispersal of tillers have been made. The results obtained from the latest determination at the end of September, 1956, are shown in Table 2.

TABLE 2: RYEGRASS TILLER NUMBERS AND PERCENTAGE OF CORES CONTAINING RYEGRASS TILLERS (28/9/56).

	Treatment			
	4"-1"	7"-3"	9"-1"	12"-3"
No. of tillers per sq. ft.	256	236	170	155
Percentage of 2in. dia. cores containing tillers	63.0	58.0	44.5	41.5

At the commencement of the experiment, dispersion and number of tillers were relatively uniform. However, as can be seen from the table, marked differences under the various grazing systems have developed.

In treatments 3 and 4, the number of tillers per square foot and the percentage of a given number of cores (2 in. diameter) containing tillers have decreased markedly. In treatment 3, it is probable that hard grazing following long spelling defoliates individual tillers to such an extent that the growing points are eaten and death occurs. The possible explanation for the low numbers in treatment 4 is a competitive effect, with competition occurring for light at the base of the plants and preventing tiller formation. The thinning out of the pasture in these treatments will affect subsequent yields and later yields should decrease accordingly.

In conclusion, it is felt that the results presented above, when considered in terms of pasture management on the farm, suggest that our knowledge of the growth of pasture plants in a sward under field conditions is far from complete. More work along the lines presented, together with more detailed plant studies by ecologists and plant physiologists working together, is required to supplement present-day knowledge.

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DISCUSSION

Q: : *In this experiment were any observations made on the nutritive value of the dry matter content of the pastures?*

A: : No. Until a more accurate index of nutritive value of pasture is available, I feel that there is not much point in determining things like crude protein or total nitrogen of the herbage, particularly when we know that crude protein levels of high production pastures in New Zealand are never low enough to affect stock adversely.

Q: : *The low production obtained in your treatment 2 during the winter does not agree with the growth rate curves depicted in Fig. 5. Have you any explanation for this apparent anomaly?*

A: : The low production obtained from treatment 2 during the winter can be attributed largely to the grazing and measurement techniques used. Grazings were of short duration during the winter months (6 to 8 hours) and it is possible that fertility (particularly nitrogen) was transferred off these treatments by the grazing animal. Also, these treatments were grazed back to 3 to 4 in. and the measurement technique used takes no account of the amount of material lost through decomposition below this level. This loss would be considerable during the winter period, and this is evident from the amount of decomposition that occurred over the winter once a ceiling yield was reached (Fig. 5).

Q: : *When pastures were at the maximum rate of growth, were they all the same length?*

A: : No. The height at which complete light interception occurs is a function of species and season. Work that is at present in progress shows that in similar swards to those used in these experiments complete light interception is reached at a lower height in the winter than in the summer. The angle of elevation of the sun at local noon in mid-winter is only 27° whereas in mid-summer it is 73° in Palmerston North. For this reason, the amount of leaf required to intercept almost all light would be much lower in winter than in summer.

Q: : *Have any observations been made on the effect of water-logging and pugging of pastures, particularly during the winter? Under practical farming conditions, these may be serious limiting factors.*

A: : Yes. D. B. Edmond at Grasslands Division has commenced a series of investigations on the effect of pugging on pasture growth. One experiment has shown a 50 per cent. reduction in pasture yield from heavy treading during the winter.

Q: : *I take it that the growth rate of pasture plants reached their maximum at different heights for different species. If your work is based on defoliating pastures at different heights, this may bring about changes in species composition. If this is so, your work on pure species may not apply to mixed pastures, and it may be necessary to change the grazing practice according to changes in pasture composition.*

A: : The work reported has been carried out on mixed swards of ryegrass and clover and, as can be seen from the results, marked changes in botanical composition have occurred. However, the treatments where frequent lax grazings were applied have yielded well during all seasons except the winter in one of the experiments. I feel that the same will apply to most of the mixtures used in New Zealand, but it should be realized that hard grazings, and, less frequently, long spellings, are desirable to bring about rapid changes in botanical composition and also to meet livestock feed requirements. The work that is being carried out on pure stands of different species is designed towards obtaining a better understanding of the growth of species when combined in pasture mixtures.