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The Pattern Of Growth Of Individual Pasture Plants

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AN examination of the physiology of growth of pasture plants in relationship to field problems can be grouped under three broad headings. Firstly, quantitative measurement of the efficiency of growth of different pasture plants. Secondly, a study of the influence of different environmental conditions on the habit of growth of these plants. Thirdly, a determination of how far the general course of metabolism, and hence the nutritional value, of the plant is changed by different environmental conditions.

Our approach to the problem is guided by the fact that the terms "more" or "less" are of little use. For any economic assessment it must be known whether "more" represents a 5% or a 15% gain. If such quantitative precision is to be achieved plant physiology work has to cut itself clear of the day to day vagaries in weather conditions. This is done by the development of controlled environment growth cabinets.

The three phases of the problem which I outlined above cover a great deal of ground. In this paper I am limiting myself to an attempt to illustrate the type of situation met in a consideration of each of them.

An experiment carried out last spring by Mr. Waters and myself examined the influence of temperature, light intensity and defoliation on the growth of three pasture species. These were perennial ryegrass, cocksfoot, and paspalum. Table 1 shows how much differences in temperature can affect speed of growth of the plants. Further, there are spectacular differences between the three species. In the comparisons, perennial ryegrass does not show up quite as well as most of us would have expected.

TABLE 1: Percentage Increase Per Week—Weight of Plant.

	Full Light	
	Low Temperature Mean 61° F	High Temperature Mean 80° F
Perennial Ryegrass	114	137
Cocksfoot	219	239
Paspalum	97	308

However, there is much more to it than just a change in rate of growth.

Tables 2 and 3 illustrate how far differences in light intensity and temperature can modify the whole pattern of growth of the plants.

TABLE 2: Perennial Ryegrass.

	Weight of Leaves and "Stems" (mg)	Number of Tillers	Days from Germination
Full Light Low (61° F) Temperature	1960	61.1	53
Shaded 9% Daylight High (80° F) Temperature	587	13.1	56

TABLE 3: Paspalum.

	Weight of Leaves and "Stems" (mg)	Number of Tillers	Days from Germination
Full Light Low (61° F) Temperature	538	16.9	61
Shaded 9% Daylight High (80° F) Temperature	966	4.7	53

Two contrasting sets of conditions have been chosen.

One group was grown at the rather cool temperatures outside and in good light: the other group was in a heated glasshouse throughout but under heavy shading during the second half of the period of growth.

Perennial ryegrass grew more rapidly with cool temperature and good light but the reverse held for paspalum. At the higher temperature it grew much faster despite heavy shading.

However, for both perennial ryegrass and paspalum the shading drastically reduces the number of tillers formed.

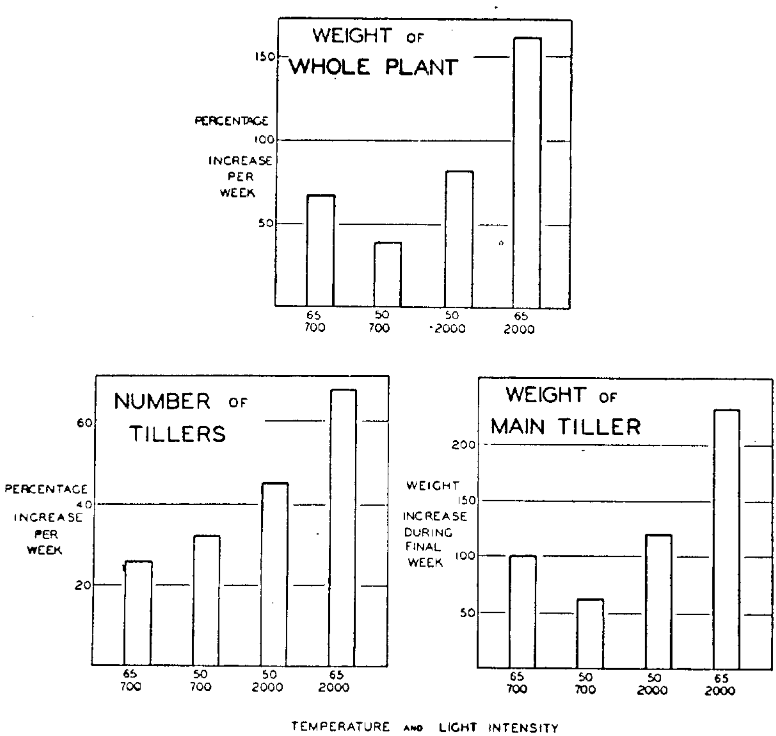

FIGURE 1: A comparison of the influence of two levels of light intensity (700 and 2000 foot candles) and two levels of temperature (50° F and 65° F) on the speed and pattern of growth of perennial ryegrass (S23).

Now there are a number of specialised terms used to describe the various parts of a grass plant and this word tillers is one of them. All the grass leaves seen in the average pasture arise from small stems. These stems are termed tillers. Actually they are very much shortened branches and arise in the same manner as a branch. Any branch on a tree originates either from the original trunk or from an older branch. Despite the very tufted appearance of a grass plant the position is just the same for its tillers.

However, these tillers, which are naturally very close to the ground have one important difference from a branch on a tree. They are each capable of sending out their own roots. Therefore, they can live as virtually independent units. It is generally the individual tillers rather than the plant as a whole, which are the operative units in a pasture. These facts have an important influence on the course of development of a pasture and on the method that can be used to study it. They make it possible to consider applying to pastures the excellent techniques and methods of thinking which have been developed to study the ebb and flow of animal populations.

In large measure the status of an animal population can be characterized by the rate of growth of individual animals and their rate of reproduction.

With grasses one is concerned with the rate of growth of individual tillers and with the speed with which the number of tillers increases. Taken together these determine the total production of a grass plant.

It will be seen from Figure 1 that conditions which will accelerate the growth of an individual tiller do not always accelerate its rate of reproduction.

When both light intensity and temperature are low, the overall growth of a perennial ryegrass plant (an English strain S23) is slowest. It is speeded up by raising temperature or light and is fastest when both are raised together.

The plants then increase in weight by 162% per week. For the growth of the individual tiller the position is very similar. However, when the rate of reproduction of tillers is examined it is found that while giving the plant more light gives an increase in rate of reproduction, raising temperatures without any corresponding improvement in light causes a decrease.

The rate of tiller multiplication is of considerable importance in determining the ability of a pasture species to recover from a set-back, or to become dominant when general fertility conditions change in its favour.

Now, in an established and stable pasture the number of tillers remains relatively constant over the years. Deaths from all causes are roughly balanced by production of new tillers. The rate of growth of the individual tiller then becomes of prime importance in determining the production of the pasture as a whole.

For the growth of a tiller there are considerable differences between species and between strains. For instance, a tiller of Short Rotation ryegrass responds to changes in light or temperature differently from a tiller of Perennial ryegrass (Fig. 2). If light and temperature conditions are poor there is little difference in the amount of growth. But, a tiller of Short Rotation can give a far greater increase in growth when there is an improvement in either temperature alone or light intensity alone. Yet when both light and temperature are satisfactory both tillers are once again growing at the same rate.

By taking appropriate measurements every day or two days it is possible to record the amount of tissue formed each day by a tiller. This varies so greatly according to weather conditions that the data has to be smoothed before it is possible to present a clear picture of the broad trends. In young plants growing in full light there is a

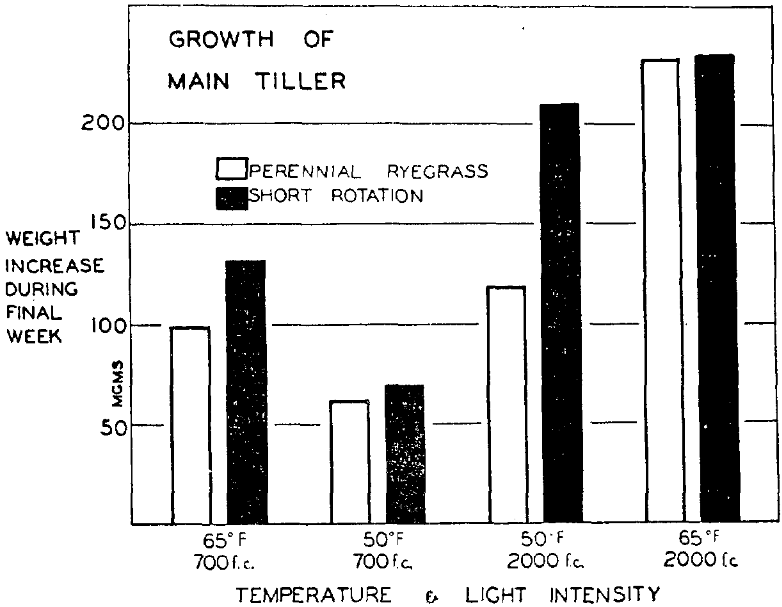

FIGURE 2: The influence of two levels of light intensity and temperature on the growth of a tiller of Short Rotation and Perennial (S23) Ryegrass.

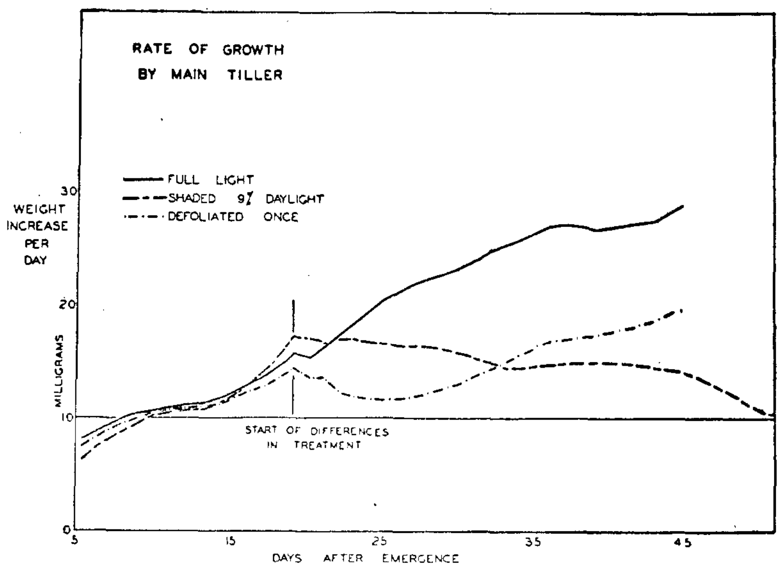

FIGURE 3: The effect of shading and defoliation on the quantity of tissue formed **per day** by tillers of New Zealand Perennial Ryegrass.

steady increase in the amount of tissue formed each day by each individual tiller.

This rate of tissue formation is slowed down temporarily if the tiller is defoliated and slowed down more or less permanently if the plant is shaded (Fig. 3).

The whole pattern of growth of a plant can be changed within a week or less by an alteration in light or temperature conditions. These external changes indicate large changes in the relationships between the root, the stem, and the leaf.

More important they can only result from big alterations in the course of metabolism, and the paths of synthesis which are used for the formation of tissue. Consequently there can be large differences in the nature of the various intermediate substances which arise in the course of forming mature tissue. Evidence from many sources indicates that the constituents of this pool of tissue precursors can play a role in animal nutrition far greater than a mere estimation of the quantity present would indicate.

This point is being emphasised because the conventional methods of assessing the value of grass as feed for livestock take relatively little notice of this group of compounds. To measure the feed value of grass, crude chemical techniques are used to portion the grass to protein, fibre, and an undefined residue. This is rather like trying to find out the cause of milk-fever in a cow by boiling up her whole body in a large pot and then measuring the amount of protein and bone which can be ladled out.

Despite its ability to make great changes in its form and appearance, as environmental conditions alter, the plant still has to remain an integrated whole. The cell walls and the protoplasm still have to be formed and to work in harmony. Thus there is an inherent tendency toward stability in the relative proportions of cell wall and protoplasmic material present in plants of an individual species.

This situation is illustrated by the preliminary results from chemical examination of material grown under contrasting light and temperature conditions (Table 4). This work was carried out by Mr. Bathurst and I have to thank him for agreeing that a sample of the results should be presented before the chemical work is completed.

Table 4: Perennial Ryegrass—Partitioning of Tissue Contents of Leaves (% Dry Weight).

	Cell Wall	Cell Content		
		Pigments and Lipids	Labile Carbo-hydrate	Crude Protein
Full Light Low (61°F) Temperature	35.9	7.3	38.7	18.1
Full Light High (80°F) Temperature	40.9	8.5	29.0	21.6
Shaded 9% Daylight Low (61°F) Temperature	38.0	9.7	26.6	25.1
Shaded 9% Daylight High (80°F) Temperature	41.9	10.5	27.8	19.8

Table 4 shows the broad division of perennial ryegrass leaves into a chemical grouping related to the general functioning of the plant. Although there are considerable variations, the picture which emerges is not one of change, but of relative stability despite the large differences in growing conditions and in the appearance of the plants.

The analyses can be taken a stage further to examine the group of substances which can be roughly termed the protein precursors (Table 5).

Table 5: Composition of Protein Precursors (Expressed as mg % of N)

	Total Protein Precursors	Peptides	Amino Acids
Full Light Low (61°F) Temperature	188	35	66
Full Light High (80°F) Temperature	320	62	100
Shaded 9% Daylight Low (61°F) Temperature	357	53	173
Shaded 9% Daylight High (80°F) Temperature	332	30	181

Within this general grouping Mr. Bathurst has separated out the peptides which are the half formed proteins, and the free amino acids which are the basic units from which proteins are built. For all groups, treatments have caused much bigger differences than were seen in the previous table (Table 4).

By microbiological assays the quantities of the individual amino acids can be measured. Of these, aspartic acid is of particular interest for it appears to be a basic type through which most of the others are formed (Table 6).

Table 6: Content of Aspartic Acid and Asparagine (Expressed as mg. % N)

Full Light Low Temperature 61°F	9.2
Full Light High Temperature 80°F	24.3
Shaded 9% Daylight Low Temperature 61°F	63.4
Shaded 9% Daylight High Temperature 80°F	76.3

Where there is good light and low temperature the quantity present is low. Under these conditions the amount of energy available inside the plant for tissue formation is expected to be highest. Hence there is no delay in using up the supplies of these preliminary building materials for protein formation, etc. A rise in temperature, and particularly a fall in light intensity are expected to reduce the size of the pool of energy substances in the plant. As this energy pool falls so does the quantity of aspartic acid accumulate.

It is believed that differences such as are shown for this acid are only samples of the many changes which can occur in constituents present in the metabolic pool, and further that many of these changes can be of importance to animal nutrition.

Discussion

MR. E. A. CLARKE: What is meant by shading to 9%?

DR. MITCHELL: Shades made of scrim, which allow through only 9% of the external light, are placed over the plants. Therefore, irrespective of the variations in daylight intensity, shaded plants at all times are getting 9% the amount of light of those in full daylight.

Mr. J. J. HANCOCK: It is understood that clover plants absorb the greatest amount of the nitrogen fixed in the nodules in the form of asparagine. Is that correct and why do you quote the figures for asparagine in this work?

DR. MITCHELL: It is understood that work by Finnish investigators has shown absorption of the nitrogen as asparagine does occur. In this paper figures for asparagine and aspartic acid have been quoted as this amino acid and its amide represent a basic type of amino compound from which very many of the other amino acids, which are eventually incorporated in the protein, can be formed. It is therefore an indication of the available store of amino compounds.

DR. WALLACE: Is the rate of growth found in the growth cabinets where plants are receiving only about one-third of the light intensity of sunlight comparable with that of plants grown under normal daylight?

DR. MITCHELL: Our experience so far indicates that the two are quite similar although with higher levels of light intensity than were used in the growth cabinet it is expected there will be higher rates of growth.

DR. McMEEKAN: Is there a fundamental difference between plant and animal? For animals too much light will upset the whole of its physiology.

DR. MITCHELL: There is an optimum light intensity for growth of plants. The position of that optimum varies with different species. When light becomes too intense, such as at mid-day on a sunny day the rate of photosynthesis may be actually decreased in leaves which are receiving direct sunlight. However, in any crop which has any length at all a great number of the leaves are shaded by foliage around about and it is probably true that as a generalisation, for all except very short pasture, the more light the more growth. Although the upper leaves may be receiving too much light the lower shaded leaves will be benefiting from the extra light intensity.

MR. GERRING: Is the speaker aware of any relationship between rate of growth and facial eczema? Is the rate of growth higher in the autumn than in the spring?

DR. MITCHELL: The relationship between rate of growth and facial eczema has not been studied in this work. As a generalisation it can be said that provided light is satisfactory, the warmer the temperatures the faster the growth.

MR. D. McFARLANE: As far as I am aware there is no evidence from field trials that there is more pasture growth in the autumn than in the spring, and the implication of the above answer that plants grow faster in the autumn than in the spring is queried.

DR. MITCHELL: Rate of growth of plants is determined by a combination of light intensity and temperature conditions for both of which there are optimum levels. As these optimum levels are not yet known a direct answer to Mr. McFarlane's question cannot yet be given.

DR. HAMILTON: It is to be expected that the potential rate of growth of plants will be greater in the autumn provided all other conditions are satisfactory but in practice moisture is often a limiting factor for growth in the autumn.

DR. MELVILLE: This work is only in its initial stages and it will be a few years yet before we have sufficient quantitative information to give precise answers to questions such as the above.