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New Zealand Climatic Production Potentials of Pasture Plants

By K. J. MITCHELL, Grasslands Division, D.S.I.R., Palmerston North

THREE major features of the programme of work in the field of environmental physiology are:—

Firstly measurement of the effects of different levels of light and temperature on the growth of nine species of pasture plants. This has been carried out in the controlled climate cabinets, with species chosen according to their estimated importance as producers of feed for livestock in New Zealand. The group includes browntop and Yorkshire fog as well as the ryegrasses.

Secondly, measurement of the actual micro-climatic conditions met by plants in a pasture. This is indispensible information for relating results from controlled climate studies to field conditions. It has of course many other uses as well. Last season nine stations at five different regional sites were in operation. By this winter there should be about 25 units in operation at 15 sites throughout the country. That will give a coverage of the country in which there will be few major gaps.

Thirdly, a simple technique has been developed, for the botanical analysis of pastures in use throughout the country which will tell us not only what species are present but also their tiller density per unit area and their evenness of distribution through a paddock. The latter features are regarded as being of particular importance.

Considerable effort was required to develop methods and equipment suited to New Zealand pasture requirements. It is only recently that a volume of results have been coming forward. In the brief time this morning it is intended to illustrate the type of information being obtained and the manner in which results from the three fields of work outlined above can be integrated.

Fig. 1.

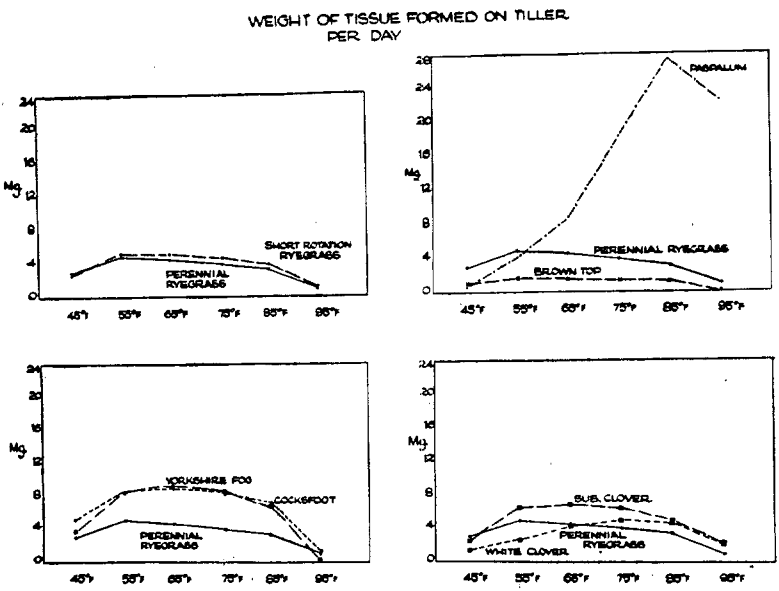


Fig. 1 shows that the effects of different levels of temperature on the growth of the individual tiller or stem may be different from the effects on a whole plant (1). Not only is the optimum temperature for tiller growth of the "English" grasses low, often below 60°F. but also there is a considerable range of temperatures over which the changes in rate of growth of the individual tiller are comparatively small. For these species a rapid decline in growth from the individual tiller does not occur until temperatures are above 85°F. or below 55°F. On the other hand white clover and paspalum show a considerably higher temperature optimum for the growth of the individual tiller.

Fig. 2.

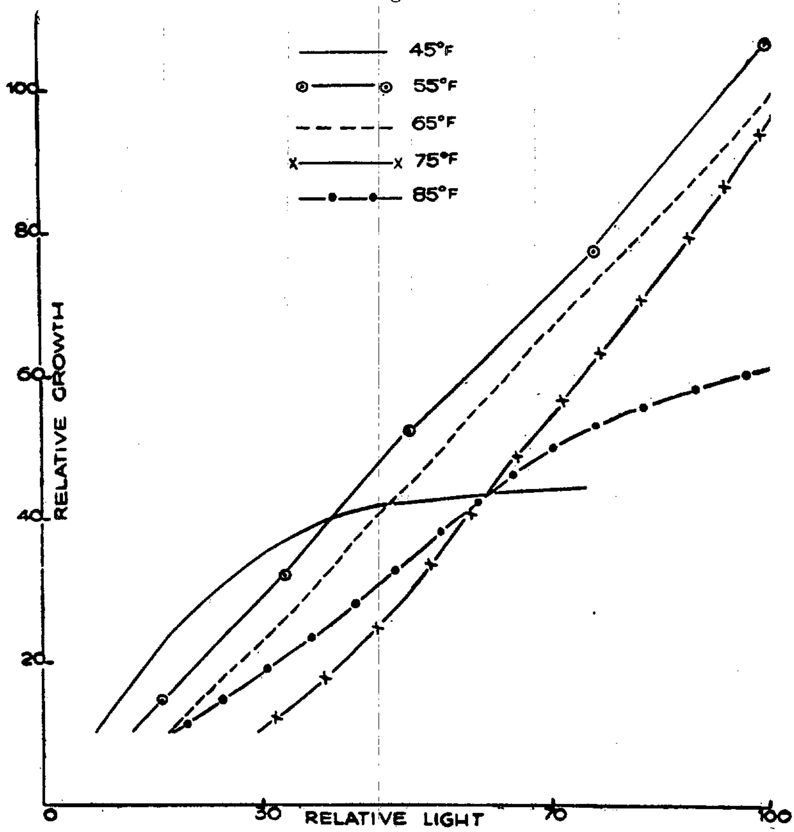
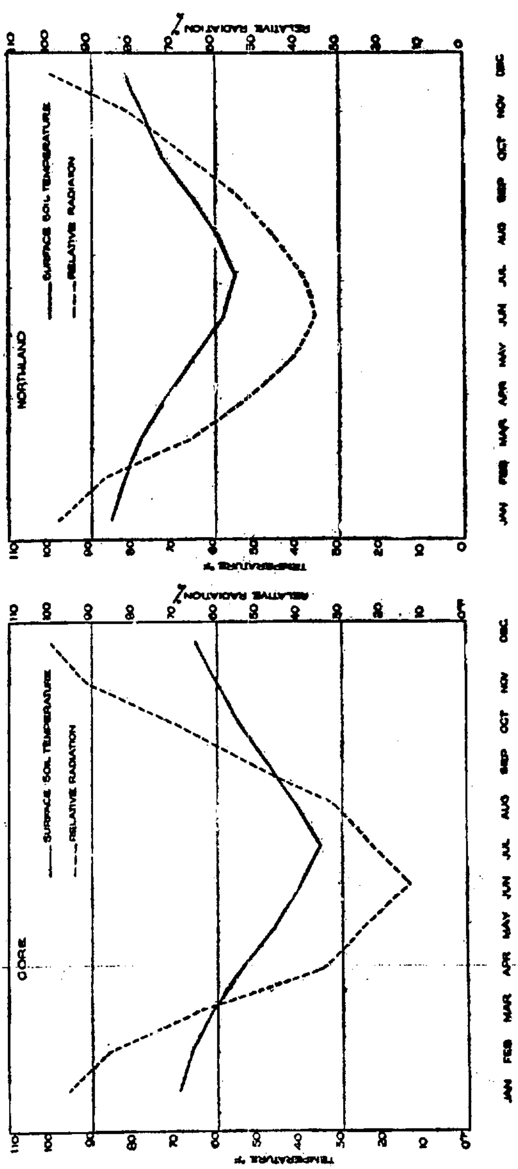


Fig. 2 illustrates the changes in rate of growth of an individual tiller of ryegrass resulting from differences in quantity of light available to the plant. At temperatures of 55°F. to 75°F. an increase in quantity of light gives a large increase in the growth of the individual tiller. However above and below these levels an increase in quantity of light gives a much smaller increase in the growth of the individual tiller. Excess or insufficient temperature becomes the major limiting factor for growth.

The microclimate observations seek to assess the actual climate in which plants live in pastures throughout New Zealand. Fig. 3 illustrates the light and temperature conditions at the two extremes of the country, a warm area in Northland, and the climate of Gore in the South.

Fig. 3.


NORTHLAND
CORE
SURFACE SOIL TEMPERATURE
RELATIVE RADIATION
TEMPERATURE °F
RELATIVE RADIATION %
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

The quantity of light received per day is similar in mid-summer in Southland and in the North. In mid-winter it declines in the North to about 35 per cent of the summer maximum and in the south to about 15 per cent of the summer maximum. In both cases this decline is sufficient to make shortage of light a major limiting factor for growth during the winter.

The temperatures shown in Fig. 3 are the means for the surface half inch of soil. These are considered the best single measurement to describe effective growing temperatures. Such soil temperatures are generally higher in summer than the corresponding mean air temperatures.

With this climatic information, the results from the controlled climate cabinets where growth has been measured at different controlled levels of both light and temperature, can be used to predict the potential seasonal growth curves of the various species. The picture for perennial ryegrass, white clover, cocksfoot and paspalum are shown in Figs. 4 and 5.

For perennial ryegrass a feature of major interest is the small difference in potential production during the late autumn, winter and early spring between Northland, Ruakura and Grasslands. The data indicates that as far as perennial ryegrass is concerned the winterless North is a myth and is likely to remain so.

Extreme winter cold reduces growth of ryegrass to about nil in a Southland winter and in summer high temperature levels in the North cause the potential growth of ryegrass to be well below that further South.

White clover shows a pronounced seasonal growth curve at all sites, with a general advantage in growth from the higher temperature levels.

Cocksfoot shows a severe winter check to growth both at Gore and at Grasslands. Its highest summer growth is at Gore and the lowest in Northland. In Northland the estimated potential growth is lower than at Ruakura at all times of the year except in the early spring.

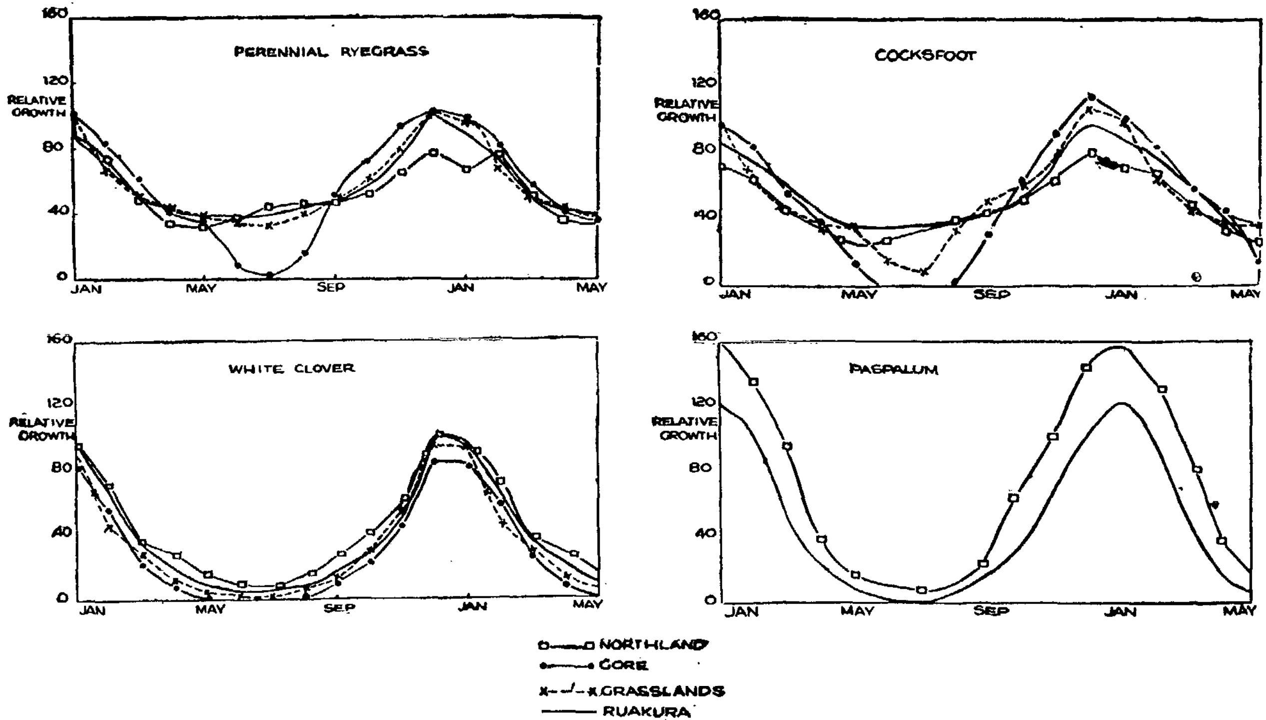
Paspalum is so sensitive to low temperatures that its potential winter production remains low even in the warm North.

From data such as that shown in these curves an estimate can be made of the potential annual production of various pastures throughout the country. The results for three pastures will be presented. These are a paspalum dairy pasture from the North, a good dairy pasture from Ruakura (assessed both for Ruakura and Palmerston North), and a good ryegrass sheep pasture from Marton.

The assumption is made that the density and species composition found in the sampling made in the spring can be maintained throughout the year. This will not be completely correct and present work is aimed to determine how much there will be seasonal changes in density which cannot be ironed out by management.

The reduction factor is an estimate of the ratio by which the rate of growth of a tiller as it occurs in the controlled climate cabinets, must be reduced to allow for field grazing conditions. The greater part of the reduction is due to a specific effect of defoliation in checking the growth of an individual tiller. This has little to do with root reserves or root starvation or carbohydrate shortage. Our present evidence indicates clearly it is due to shortage of a growth factor synthesised in mature leaves. If these mature leaves are constantly being nipped off, this causes a reduction in growth which can persist for some weeks. It would be of major importance to gain an understanding of the nature of this growth factor mechanism.

Figs. 4 & 5.


PERENNIAL RYEGRASS
COCKSFOOT
WHITE CLOVER
PASPALUM
RELATIVE GROWTH
0
40
80
120
160
JAN
MAY
SEP
JAN
MAY
NORTHLAND
CORE
GRASSLANDS
RUAKURA

The sheep pasture has received a greater reduction ratio for each tiller because its grazing is generally shorter, and hence the check from the growth factor shortage is greater. On the other hand the continual short grazing of the sheep pasture has allowed a much higher number of tillers per square foot to be established.

The highest estimated production is from the paspalum pasture which can make very rapid growth under warm conditions and the lowest, 19,000lb. of dry matter, for the Ruakura pasture. That the estimate for the Ruakura pasture should be considerably lower than that for the Manawatu sheep pasture emphasises the importance of high tiller number per square foot, i.e., density, for reliably good levels of production throughout the year.

At the same time the similarity of the temperature response curves for the species of English grasses emphasises that in pasture similar production per unit area should be obtained from many small tillers or fewer large tillers. A dense cover of small tillers can come from species which produce small tillers, e,g., browntop, or from close defoliation and hence reduction in tiller size of species able to produce large tillers, e.g., cocksfoot.

It follows that there is no single optimum height of defoliation suitable for all species and all types of grazing management. The denser the pasture and the smaller the individual tillers the lower will be the optimum height of grazing which will give maximum sustained yield from a pasture.

ESTIMATED POTENTIAL PRODUCTION OF PASTURES.

PASTURE	COMPOSITION TILLERS + STEMS PER SQ. FT.	REDUCTION FACTOR	POTENTIAL ANNUAL PRODUCTION (LBS DM. PER ACR.)	RATIO OF BEST MONTH, TO WORST MONTH.
DAIRY NORTHLAND	PASPALUM 261 BROWN TOP 79 WHITE CLOVER 324	0·20	37200	16·7
DAIRY RUAKURA	PERENNIAL RYEGRASS 344 POA spp. 197 WHITE CLOVER 183	0·20	18,500	3·8
SHEEP MARTON	PERENNIAL RYEGRASS 1531 WHITE CLOVER 258	0·10	24,900	3·6

Discussion

MR. CLARKE: Why is the increase in winter production of short rotation as compared with perennial ryegras greater in the field than is suggested by differences in tiller growth shown in Figure 1?

DR. MITCHELL: Evidence from earlier experiments suggest short rotation ryegrass is better able to respond to short periods of favourable light or temperature conditions.

MR. V. WILLIAMS: Is it likely that the amount of moisture present in autumn flush grass is very much greater than that present in spring flush grass?

DR. MITCHELL: The dry matter percentage of the spring flush grass will probably be less.

MR. ROSS: Has there been any control of humidity?

DR. MITCHELL: Relative humidity was held at approximately 70%.

PROFESSOR COOP: We have come to the conclusion that the most important single pasture plant for parts of the South Island is lucerne. There are a whole host of strains of lucerne. Would your technique offer any short-cut to the difficult process of deciding which of the different strains is the best for a particular environment?

DR. MITCHELL: Work in the California "phytotron" has shown this can be done quickly and successfully.

MR. SINCLAIR: Is there any difference in the ability of perennial ryegrass and short rotation ryegrass to withstand high temperatures under conditions of adequate moisture or is our management at fault because we have difficulty in promoting growth in short rotation under irrigation?

DR. MITCHELL: At temperatures of 95 degrees Fahrenheit in the cabinets where plants are grown with adequate moisture neither type of ryegrass give much growth, but many more plants of short rotation actually die.

DR. HAMILTON: Would Dr. Mitchell explain a little more clearly how he arrived at his figure of 37,000lb. of dry matter per acre for a Northland pasture?

DR. MITCHELL: We had data from the controlled climate cabinets for tiller growth at different levels of temperature and light. Data stating the temperature and light conditions of the North were obtained from meteorological and micro-climate records. The two sets of data were integrated to give estimates of the production each month from the pasture specified.

MR. LYNCH: Has Dr. Mitchell studied seasonal changes in tiller density?

DR. MITCHELL: That work is being carried out now. Unless trampling in winter or drought in summer open up a pasture, these should not be large.

MR. LYNCH: Are there any changes in dry matter percentage with leaves of different ages?

DR. MITCHELL: The upper parts of a growing leaf of grass very soon reach maturity for all new tissue is formed from the basal intercalory meristem. Once mature, dry matter percentage should be relatively constant until senescence commences.

MR. LYNCH: How did Dr. Mitchell get these tiller density figures?

DR. MITCHELL: From plug sample pasture analyses procedure which was mentioned. Representative good pastures were sampled in various districts.