EFFECT OF CHANGES IN ENVIRONMENT AND MANAGEMENT ON GROWTH OF PASTURE SPECIES

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In considering the relationship of light and temperature to the growth of grasses and clovers it is important to know the actual conditions around individual plants in a pasture. Without that information the results of detailed experiments in glasshouse or laboratory conditions cannot be interpreted. For light intensity little comment is needed. It is well known that considerable shading occurs within a long pasture. Shorter plants are overshadowed by tall ones, but even for those taller plants a large proportion of their leaf tissue can be in dense shade. Consequently they will also assume a pattern of growth characteristic of shaded plants.

By general meteorological standards the greater part of the farmed area of New Zealand has a temperate climate free from extremes of heat or cold.

The farmed areas which are under snow or at temperatures below freezing point for any length of time in winter are relatively limited. In summer the mean daily maximum air temperature for January, even at Waipapakauri in the far north, is only 74 degrees F. However, near the soil surface, temperatures may often be very different from air temperatures measured 4ft. 6in. above ground level as for meteorological records. This difference is greatest on a clear day or clear night (1). On a sunny day the extent to which the surface layers of the soil are heated depends on soil type, soil moisture, and pasture cover. Just how much these factors can vary soil temperature is illustrated in Table 1 showing temperature measurements taken about 2 p.m. on a sunny day in January, 1954, at Palmerston North. Maximum air temperature for the day was

77.5 degrees F. On a sandy loam with little pasture cover the soil temperature at ¼in. depth averaged 118.5 degrees F. and even at 3in. depth was 90.5 degrees F. A 3in. cover of pasture reduced ¼in. temperatures of that soil by 30 degrees F.

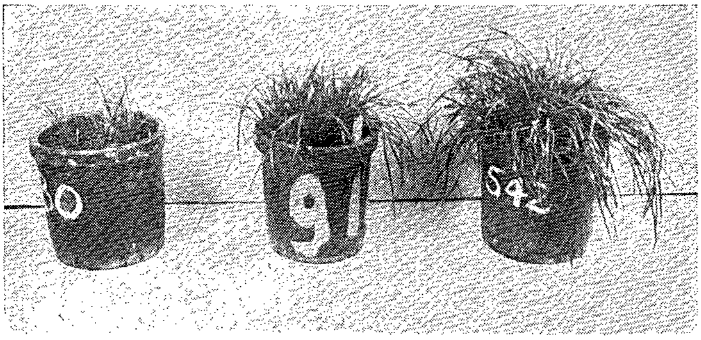
On a silt loam nearby temperatures both in a bare soil and under 4in. pasture cover were 10 to 25 degrees F. lower than on the sandy loam.

Table 1-Soil Temperatures 2 p.m. 28/1/54

Depth	Sandy Loam		Silt Loam	
	Sparse pasture	3in. pasture	¾in. pasture	4in. pasture
¼in.	118.5” F.	88.5°F.	92.0°F.	77.5°F.
3in.	90.5°F.	73.0°F.	77.5°F.	67.0°F.

Maximum air temperature 77.5-F.

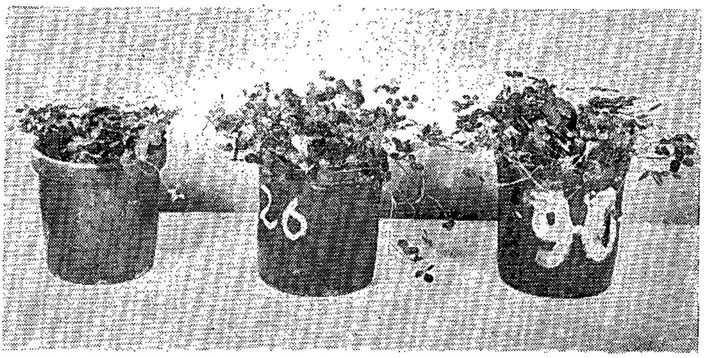
From their form of growth most of our pasture species will be particularly affected by temperatures in those surface layers of the soil. For the grasses and also most of the clovers, the meristematic centres at which the greater part of the herbage is initially formed are placed within ½in. of the surface of the soil. The temperatures of these centres of tissue formation will therefore be largely determined by the temperature, of the soil and air layers close to the soil surface.



Snort Rotation Ryegrass grown at mean temperatures of 90” F. (left), SO” F. (centre), 70” F. (right).

Temperatures of 120 degrees F., which approach lethal level for many species of plants, may occur more frequently in northern districts than is expected.

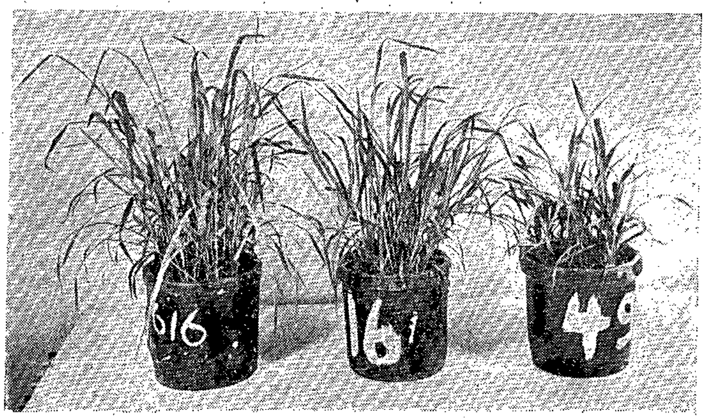
In the controlled environment cabinets plants were grown at mean temperatures of 70 degrees F., 80 degrees F., and 90 degrees F. They received 12 hours of light and 12' hours of darkness. During the light period temperatures were held to 5 degrees F. above the mean level and in the dark 5 degrees below it. For short-rotation and perennial ryegrass, white clover, cocksfoot, and subterranean clover, growth was less at 90 degrees F. than at '70 degrees F. For paspalum there was much more growth at 90 degrees F. than at 70 degrees F. It follows. that where surface



White Clover 'grown at mean temperatures of 90" F. (left), 80" F. (centre), 70° F. (right).

soil temperatures rise to' high levels during summer, growth of the first group of species may be checked by excess temperature.

Further understanding of the potentialities of various species comes from detailed studies- of the



Paspalum grown at mean temperatures of 90" F. (left), 80" F. (centre), 70" F. (right).

changes in their pattern of growth induced by broad differences in light intensity and temperature and by defoliation.

Plants of perennial ryegrass, cocksfoot, and paspalum were grown either in a heated glasshouse, mean temperature 83 degrees F., or outside, mean temperature 59 degrees F. At both levels of temperature one group of plants were grown undefoliated in full light, another defoliated twice to approximately lain., and a third group put under shades which cut off '70 per cent. of the light. The levels of light were adjusted to be the same both in the glasshouse and outside.

In a pasture the individual rooted tiller of a grass is the growth unit. There is no essential difference between a tiller in a pasture 20 years old and a tiller of a plant only a few weeks old. Many features of the growth of that tiller combine to determine the usefulness of a species in different pasture environments. Under all conditions the quantity of tissue being formed by the individual tiller is of prime importance.

It was found in the experiment outlined above that: 1. Where plants were not defoliated and in full light, the amount of tissue formed by a tiller of cocksfoot or perennial ryegrass was broadly similar at both levels of temperature. Actually, the data suggest that tillers of these species may form tissue faster at the lower temperature. With paspalum tissue formation was about four times as fast at 83 degrees F., as at 59 degrees F. and also about four times as fast as for perennial ryegrass or cocksfoot at 83 degrees F.

2. For all three species the growth of an individual tiller was checked for several weeks by defoliation.

3. At 83 degrees F. shading plants to cut off 70 per cent. of daylight reduced the quantity of tissue. formed proportionately more with perennial ryegrass than with cocksfoot or paspalum. The reduction in rate of tissue formation by a tiller of cocksfoot resulting from shading was approximately 20 per cent., with paspalum approximately 30 per cent., and with rye-grass approximately 60 per cent.

The differences in light intensity, temperature and defoliation also induced large changes in general habit of growth, particularly in numbers of tillers formed and in dimensions of the leaves. These features also influence the role a species can play in various types of pasture.

In the spring of 1953 there was a similar experiment to examine the effect of differences in light in--

tensity, temperature, and defoliation on the growth of white clover, subterranean clover, and *Lotus major*. On this occasion the mean temperatures were 72 degrees F. and 53 degrees F. At 72 degrees F. there was a 70 per cent. reduction in light intensity, but at 53 degrees F. only a 50 per cent. reduction.

Clovers have a different pattern of growth from the grass species examined. Accordingly, some different criteria of evaluation are needed: Two which summarise much other data are the amount of tissue formed on a vigorous stem and the rate at which the stems elongate.

As the stems of white and subterranean clover grow 'along the surface of the. soil, it is the leaves rather than the actual stems which provide most of the herbage eaten. Under all conditions of this experiment most leaf tissue was formed by a stem of subterranean clover and least' by *a* stem of *Lotus major*. For subterranean clover this was achieved by the rapid appearance along the stem of relatively large leaves. Both for white clover and *Lotus major* the slower rate of tissue formation by a stem can be offset by a more rapid increase in number of stems growing on each plant.

Seeding rates for clovers are relatively low. For the three species considered here the subsequent spread through a pasture depends largely on the growth of stems along the ground. Where these root at the nodes this can give, in effect, an increase in the total number of plants in the pasture.

From measurements of the daily increase in length of stems it was found that plants of both *Lotus major* and white clover could increase the diameter of the area covered by their stems by nearly 6in. in a fortnight, given a mean temperature of 72 degrees F. and full light. At 53 degrees F. mean temperature the spread of white clover was as fast in 50 per cent. shade as in full li'ght, and with *Lotus major* it was faster in the shade. Where white clover was shaded at the higher temperature level there was little stem elongation. ,

With subterranean clover there was little stem elongation by these vegetative plants, except where they were shaded at low temperatures. Accordingly, it is omitted from Table 2.

There is a further point to be considered. If light and temperature conditions in a pasture differ considerably from those under which a strain was selected, there may be a considerable increase in the variability between individual plants. Some can adapt themselves better to the changed environment. Considerable death of plants may result.

Table 2—Influence of temperature on weight of tissue produced by primary tiller of plants undefoliated and in full light. Period of 15 days (milligrams of dry matter).

Mean Temperature	Perennial Ryegrass	Cocksfoot	Paspalum
83°F.	71.0	72.0	265.6
59°F.	77.4	75.6	44.1

Table 3—Proportionate influence of Defoliation and Shading on Weight of tissue produced in 15 days after treatments commenced.

Treatment	Temperature	Perennial Ryegrass	Cocksfoot	Paspalum
Full Light Not Defoliated	83°F.	100%	100%	100%
	59°F.	100%	100%	100%
Full Light Defoliated	83°F.	39%	29%	24%
	59°F.	88%	20%	37%
Shaded Not Defoliated	83°F.	39%	73%	68%
	59°F.	32%	47%	47%

Table 4—Diameter covered by elongating stems in 14 days.

Treatment	Temperature	White clover (in.)	*Lotus* (in.)
Full light	72°F.	5.5	5.8
	53°F.	4.1	2.0
Defoliated	72°F.	3.2	2.6
	53°F.	1.5	1.3
Shaded	72°F.	0.8	4.3
	53°F.	4.3	3.3

This increased variability may at times be responsible for disappointing results from a strain of pasture plants.

In conclusion, it appears that for many districts of New Zealand temperatures of the surface layers of the soil may rise to 90 degrees F. or considerably higher on sunny days. This rise in soil temperature will become greater with a drying of the surface layers of the soil and with increase in the altitude of the sun.

These levels of temperature are above the optimum for growth of many species used in New Zealand pastures. A few inches of pasture cover can substantially reduce the temperature of the soil surface.

For perennial ryegrass, high soil temperatures, as much or more than the effect of flowering, may be responsible) for the decline in production during a warm summer. If the surface layer of soil dries out and heats up, a decline in growth would be expected, even if reasonable supplies of soil moisture are available from the soil layers below.

The evidence suggests that under warm conditions a tiller of cocksfoot will not grow any better than perennial ryegrass if in relatively short pastures, but where a pasture is long enough to give mutual shading between plants, growth of cocksfoot will be better than from perennial ryegrass.

The spectacular increase in growth of paspalum with the rise in temperature to 80 to 90 degrees F. suggests that even in the warmest parts of New Zealand temperatures may still be below the optimum for its growth. Higher effective temperatures could come from keeping a pasture closely grazed, but their benefit would then be offset by the check to growth from close defoliation. For white clover the measurements of daily stem elongation suggest that'its spread within a pasture will be limited most by close defoliation at low temperatures or'overshading at high temperatures.

Although a large weight of leaf was produced by individual stems of -vegetative plants of subterranean clover, there was little elongation of these stems, except where the plants were shaded at low temperatures. 'This emphasises the importance of an extensive spread of seeding stolons for achieving a good stand in a pasture.

From the criteria examined the growth of *Lotus major* was found to be relatively fast at warm temperatures, but slow under cool conditions.

REFERENCE

(1) Geiger, "The Climate Near the Ground." Harvard Univ. Press.

DISCUSSION

Q. For how long do soil temperatures stay at a high level during the day?

A. Near the soil surface, for 4 to 5 hours on a sunny day.

Q. Have there been any experiments on the apparent cooling benefit of irrigation?

A. Measurements have not yet been made. The benefit from a moist soil surface in reducing surface temperatures comes not so much when there is adequate foliage cover as when the pasture is defoliated and the sun's rays beat directly on the soil surface. If the surface of a closely grazed pasture is dry it will heat up more and there mill be a far greater death of tillers. At Grasslands close defoliation gave over a 50 per cent. reduction in number of tillers present.