THE EFFECT OF INTENSITY OF DEFOLIATION ON ROOT DEVELOPMENT AND PRODUCTION IN SOME PASTURE-GRASS SPECIES.

W. A. JACQUES, MASSEY AGRICULTURAL COLLEGE AND PLANT RESEARCH BUREAU.

INTRODUCTION.

There are many points of approach to a consideration of root development in pasture p&ants, but I wish to confine myself to ths effect on the root system of different rest periods between the removal of leaves and outline the plants reaction to them.

Root studies are most intensively prosecuted in countries where there are regions of low rainfall, low winter temperatures, soils unretentive of moisture or where erosion is a serious menace. Up to the present, very little consecutive study has been directed to root development in countries with a well distributed rainfall and no climatic extremes. This lack of interest is probably due to the fact that climatic conditions are in the main favourable to root growth and the assumption that, this being so, little benefit could accrue from a study of them. That all is not well in these regions will, I 'hope, be apparent later when English and New Zealand trials are dealt with.

Plant study is complicated by the fact that the plant grows and develops in two very dissimilar environments, the air and the soil. Of the two, the more complex is the soil, and anything which will lead to a better understanding of the plant's reaction to it is a step forward in plant ecological studies.

It is only during the last few years that controlled grazing as a means of increasing pasture quality and production has been studied, and an improved method of utilizing the increase has developed. Subsequent work indicates how closely root vigour, health, and yield of leaf are linked together.

THE EFFECT OF DEFOLIATION ON ROOT DEVELOPMENT.

Recent work carried out in New Zealand (2) on establishing plants of certified and uncertified perennial ryegrasses, Italian ryegrass and cocksfoot, indicates the rapidity of root response to the removal of leaf and the consequent effect on the plant as a whole. Only a brief summary of the findings need be given to show this.

Where a weekly cutting to 1" from the ground level was tried against a similar two. and three weekly cutting during the first three months of establishment, the following points were demonstrated.

(1) The number of tillers in uncertified perennial ryegrass, Italian ryegrass and cocksfoot was reduced. Although the early defoliation did not affect the number of tillers of a pedigree strain of Perennial ryegrass, yet it reduced their size and vigour. (This point indicates the inherent vitality of the strain under trial and was in marked contrast to the uncertified line tried).

(2) The number of roots per tiller was 25% less than in the two-weekly cut plants, 35% less than those cut every three weeks, and over 50% less than the uncut controls.

(3) The total number of roots under a system of weekly cuts was the least of any of the treatments.

(4) The weight of roots was reduced, as shown by the fallowing figures, which represent the average of all the species tried.

	No. of cuts.
Average of weekly-cut plants	9
" " 2 " " "	4
" " 3 " " "	3
" uncut controls	0

The rate of increase in root weight was very small under a system of weekly cutting during the time the plant is establishing. If this is apparent with single spaced plants, it is obvious that such treatment would constitute a practice that is inimical to the well-being of a pasture sward, where there is additional retarding effect on growth in the form of inter-plant root competition. A notable exception to the above was found in the Pedigree strain of perennial ryegrass, which alone was able to add appreciably to the weight of its root under this rigorous treatment.

When cut back with two and three-weekly intervals between the cuttings, all the plants under test were able to develop an increasing weight of root.

(5) The more frequent the cutting the smaller was the effective absorbing area,

Although no actual figures can be given for this, the point can be well illustrated by photographs.

(6) The food store of the root was depleted. Roberts and Hunt (4) found that under the conditions prevailing in North Wales, "root growth is checked by all types of leaf cutting, and the amount of the check depends on its severity".

Cutting to 1" from ground level at 10 day intervals led to a gradual decrease in root weight till the plant died after sixteen cuttings, whilst when cut to ground level, the plant survived only seven cuttings at 10-day intervals.

They find that the check on root growth is of three kinds:

(1) A check in weight due to the removal of food reserves from the root to the shoot. This is a normal procedure at flowering time but is abnormal at other seasons. It may be brought about by too frequent or excessive defoliations, which allow insufficient time between cuttings for the replacement of storage food in the root.

(2) A check in actual growth shown by a decreased length of root in perennial ryegrass and decreased length and weight, in Timothy.

(3) A seasonal check in growth rate which is normal even in undefoliated plants.

They found also that the most lenient type of cutting produced the greatest yield of leaf.,

Reference can here be made t- the work of Woodman and others (6) on the nutritive value of unmanured pasture where Varying periods of rest were given between grazings.

(1) The chemical composition of three-weekly pasture 'cuts has led to a slight lowering of the percentage of crude:, protein and a slight rise in crude fibre and carbohydrates as compared with one and two-weekly cuts. (Bearing in mind the high protein content of New Zealand pasture herbage this is no drawback).

(2) The digestibility is practically the same.

(3) The nutritive value of pasture cut at three-weekly intervals, while slightly less rich in digestible protein, is nevertheless, equal in respect of total digestible organic matter and of starch equivalent to grass cut at weekly and two-weekly intervals.

(4) The yields of dry matter obtained under a system of weekly, two-weekly and three-weekly cuttings were measured and gave the following results:

Weekly cuts	100
Two-weekly cuts	129
Three-weekly cuts	162

Two interesting points which have a close bearing on the subject matter of the present gaper are raised in this article -

(1) "The depressing influence of drought *on* ths crude protein content of pasture herbage appears to be more pronounced with grass cut at weekly intervals than with grass grown under a system of three-weekly cuts".

(2) "The depression of both digestibility and yield. of pasture herbage, which is the accompaniment of inadequate rainfall, also becomes more pronounced as the system of cutting is intensified".

Stapledon (5) has shown that such reduction in yield is not confined solely to the current season, but that the effect is carried into the subsequent one. The following table (after Hudson (1) quoting Stapledon (5)) illustrates this. .

Treatment in 1922.	Rel. Yield under Uniform cutting in 1923.
20 Fortnightly cuts	100
10 Monthly Cuts	154
1 Hay and 2 Aftermath cuts.	164

Similarly, the yield of root shows the effect of pre-treatment into the second season following (after Stapledon (5))

Treatment 1921	Treatment 1922	Yield of Root (DW) in Spring 1923.	
Cut 17 Times	Cut 8 Times	(5.7)	100
" 10 "	" 8 "	(6.5)	114
" 7 "	" 8 "	(8.9)	156
" 3 "	" 8 "	(8.1)	142

HOW REMOVAL OF LEAVES AFFECTS PASTURE PRODUCTION AND THE ROOT SYSTEM.

Sufficient has been said to show that root extent may be governed by amount and intensity of defoliation, but this does not necessarily account for the increased yield in bulk and feeding units which has been shown to accrue where a lenient system of grazing is practised as against a more vigorous one. To understand this fully it is necessary to switch over for a moment to the physiology of plant growth.

The plant grows in two complementary environments and is dependent on both for its survival. There is an interchange of materials between the parts above and below ground, the root supplying the water and inorganic materials while the leaves supply carbon and synthesise it.

There are, however, two opposing meristematic areas or growing points. Whatever type' of co-operation exists in other parts of the plant it breaks down here. There is definitely an antagonism between these two regions; the leaves on the one hand demand a food supply to produce fresh leaves, the roots on the other want it for root extension. This antagonism results *in* a "balance" being ***set*** up between root and shoot.

The simplest form of expressing it is the "Root/Shoot ratio" where the dried weight of the root and shoot are obtained at periods throughout the season's growth.

Bearing on 'this point, Parker and Sampson (3) (quoting Loeb and Janse) say -

"In a plant having primary and secondary meristems, there. is a continuous competition between the various msristems for materials carried in the conducting tissues. Any factor which favours one growth centre evidently curtails the supply of material available to the others, resulting in retardation of the latter".

After defoliation, the stranger force operating is the demand for a replacement of photo-synthetic tissue, and in consequence the bulk of food materials goes to make new leaf. No matter how effective the root may be in procuring food and water, such cannot be utilized in the absence of green leaves. In consequence of this the root is (temporarily at least) starved, and is unable to continue its normal rate of growth.

The effect of even one defoliation is measurable. If defoliation is continuous then the root is permanently starved and is unable even to maintain itself, so that a decrease in size takes place, the reduction being in proportion to the rate of defoliation. Where the defoliation is severe and continuous the balance between root and shoot is so upset, and the drain of food so strong in the direction of the leaves, that the plant dies.

ITS APPLICATION TO PRACTICE.

When comparing the effect of continuous and close with controlled or rotational grazing the following points stand out:

(a) Rotational Grazing - Though the amount of leafage and nutrients removed per acre is greater than that removed from a similar area where uncontrolled grazing is practiced, yet there i8 a better root system. The reason for this is, that while the balance between root and shoot is upset at grazing, yet the rest period is sufficiently long to allow for recovery and replacement of the shoot and the root is able to extend and collect food reserves.

The balance between root and shoot weight is not a fixed one but varies with the season and soil. However, under any

set of environmental oonditibne there is always 'an urge within the plant to revert to the most suitable balance whenever it becomes upset; Thus we find that when the leaf area is reduced the root volume is also reduced. The vigour of the root system is refleoted in the increased vigour of the tops.

(b) Continuous, and Close Grazing - Here there is a continual reduction in photo-synthetic tissue with the possible exception of short periods when the growth gets away from the stock. There is thus little food available and no time between grazings to permit a strong root growth. The balance between root and shoot under these conditions is governed by the reduced shoot area, Furthermore, 'after such treatment has extended over' a period, root food reserves are exhausted and the stunted root is unable to maintain its rate of food supply to the leaves. Thus is set up a vicious circle, firstly of under - nutrition of the roots which is later reflected in a reduced supply of water and salts to the shoot. Both parts of the plants suffer and are unable to produce to their fullest capacity under the existing soil fertility and climatic conditions.

There are many instances in pastoral farming in this country which point to the inability of' the grasses which have been sown to withstand such rigorous grazing, and these have died out to give place to weeds or low production grasses of which Danthonia is the best example. It is a starvation process which has been definitely unprofitable with stock and is equally unprofitable with pastures* The fullest use cannot be made of the soil when plants arc kept with a restricted root system nor is it feasible that (as Woodman and his co-workers have shown) the overgrazed plants will withstand drought oonditions so well as under a more lenient system.

Further trials are needed before it is possible or safe to say which are the mast suitable grazing conditions for the development of the best root growth, but a rotational grazing: system which permits the fullest leaf development consistent with good pasture control would appear to hold out the greatest possibility for an improvement of pasture production.

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DI S CUSS1 ON .

Mr. F.R. Callaghan, Wellington.

Mr. Jacques' paper giving the results of his investigation on the root systems of ryegrass at Massey College, is of considerable importance because of its direct relationship to pasture management .

A few years ago the idea became prevalent that farmer6 were allowing their pasture grasses to grow too long and were failing to get best advantages from them by neglecting. close grazing and rigorous harrowing associated with top dressing. Mr. Jacques' investigations have shown that continued defoliation exerts a serious influence on the root system, destroys its capacity for storage and hence spoils the growth acceleration of a grass recovering after close grazing or other damaging influence.

These studies have been carried out in the Manawatu, a district where the climatic conditions are infinitely more favourable to rapid recovery than those of most of the South Island, where, in addition to grazing, pasture plants have to endure rigorous variations in climatic conditions. Consequently, defoliation in southern districts' is a much more serious matter to the grass and hence pasture permanence must of necessity constitute a more serious problem.

It wsuld be interesting to ascertain whether a grass plant growing in different environments possesses different shoot/root ratios. One would expect that the root system of a ryegrass grown in an Otago dry district would be relatively more extensive than that of one growing in the Manawatu.

Root studies extended in this direction end towards following up seasonal changes in the shoot/root ratio should throw helpful light on problems of pasture management and growth.

It would' be interesting from the farmers point of view if these studies threw some light upon the danger limit to which grazing can proceed. Farmers with guidance in this direction might be able to maintain a greater degree of permanency with their pastures.

In Otago, moreover, a great deal of grazing is provided by cross species indigenous to New Zealand, and which have for generations existed in the absence of grazing animals. Mr. Jacques' has been working that species which has' been developed in association with stock. Can the deductions from ryegrass be applied to native Poas and Fescues?

At the present time soil erosion is a matter of world wide interest. There are districts in New Zealand which are suffering from subtle soil erosion, and against any of the forms of this means of soil depletion grass root systems provide one of the strongest bulwarks.

Ample justification is therefore provided for the continuation of the helpful studies which Mr. Jacques has inaugurated.

T h e Chairman:

I have always felt that it is just as important to know what is happening by various practices to the underground appearance of the plant as to the appearance above-ground. I think, Mr. Jacques, the majority of your work up to the present time has dealt for numerous reasons with what one might term "the initial development of roots". It accurn tely describes

things that happen when certain things are done. The majority of our statements run along the line rather of saying - "what is going to happen if certain things are done" - and frequently what is going to happen arises in the imagination of the person who is making the statement, rather than the problems of the plant that is being examiner?.

I appreciate very much that we have in New Zealand a clan who is prepared to devote his energies and intelligence to work of this nature which is not spectacular - the result coming only from the careful control of the individual ayer the plants he is working on - where the....imagination cannot play a part.