THE EFFECTS OF DEFOLIATION AND ROOTPRUNING

ON COCKSFOOT AND PERENNIAL RYEGRASS;

AND

THE INFLUENCE OF SOIL MOISTURE

ON ROOT INITIATION

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APPENDIX XIV:

These photographs, which are all on the same scale, illustrate the cumulative effect of the different treatments by the end of the experiment. The plants illustrated are all average or near average for their particular treatments.

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I.

INTRODUCTION.

The world is short of food (1). The population of the world is unequally distributed in relation to the productive ability of the land. Countries, where an extension of the farmed area is possible, are handicapped by a lack of available labour. In general these are the countries where production has not, as yet, reached a maximum level. As labour hinders extension an endeavour must be made to utilise present farm areas in the most efficient manner possible. In this way surpluses of food may be accumulated in these countries, e.g. New Zealand, for despatch to needy areas where the consumption of food is at a low level.

New Zealand produces animal products in quantity. To increase this quantity better use must be made of our chief stock food - grass. By more efficient use of our grasslands the production of our existing herds and flocks will be increased while an increase in our animal population will be inevitable.

For efficient use of our grasslands we must "know" our grasses. It would appear that a grass has an optimum length of leaf, beyond or within which the yield of nutrients decreases. By grazing down to this length the maximum uptake of nutrients should be possible. In nature we cannot consider grass on its own. In farming systems, as we understand them today, there must be a tolerance between plant and animal. If optimum leaf length is maintained then the grazing animal willsuffer a lack of food, at some period of the year. Or, if an animal is to be permitted full expression of its potentialities for production, the plant, at some period, will have to be grazed to less than this optimum length. The maltreatment accorded by one to the other may be such as to prevent subsequent normal growth and production. Consequently a suitable middle course must be taken.

Yet, for the evaluation of our different grasses, both species and strains, we must know their optimum leaf lengths - or more loosely, height of grazing - and their reactions to different degrees of leaf removal.

Our knowledge of root growth and development is pitifully inadequate. We must discover the nature of the interrelation of tops and roots. Top growth is seasonal. Evidence points to the likelihood of root growth being seasonal. For a clear appreciation of grass growth a study of the seasonal root behaviour of grasses is essential.

Soil moisture influences our grasses, possibly their roots in particular. Irrigation of our dry land and drainage of our wet, may not be attended by all possible success without this knowledge.

In this experiment an endeavour was made to discover the reactions of different species and strains of grass, to different severities of leaf removal. An attempt was made to follow the seasonal growth of their root systems by observing the initiation of new roots at the base of the plant.. The effect of soil moisture on root initiation in grasses was also investigated.

The experiment was laid down on an area at Massey College in March 1948.

II.

REVIEW OF LITERATURE.

Blackman 1905 (2) stated "the way of those who set out to evaluate exactly the effects of changes in a single factor upon a multi-conditioned metabolic process is hard." He points out that "the analytical treatment of metabolic phenomena is not made any less certain in its procedure, though it is made more complex by the interaction of those metabolic effects which have been described by their investigators as stimulatory." The growth of grass is just such a multi-conditioned metabolic process. Thus it appears odious to consider different phases of growth without regard for the other phases. Nevertheless for convenience and clarity this review is grouped under various arbitrary headings.

SEASONAL GROWTH OF GRASSES.

Grass grows in a seasonal manner. Conclusive evidence for this has been published by Stapledon and Williams 1922(3) in Britain, and Hudson, Doak and McPherson 1934(4) in New Zealand. This seasonal growth of herbage can be modified by cutting or grazing treatments. Many workers have contributed to our knowledge of this aspect of grass management. Frequency and severity of defoliation have been the factors considered most often.

EFFECTS ON HERBAGE OF DIFFERENT FREQUENCIES AND SEVERITIES OF CUTTING.

Lindhard 1913(5), Stapledon and Beddows 1926(6), Stapledon and Milton 1930(7), Graber 1931(8), Robertson 1933(9), Roberts and Hunt 1936(10), Nedrow 1937(11), Harrison and Hodgson 1939(12) and Schofield 1944(13 and 14) all subscribe to the view that frequent cutting, severe cutting or a combination of both, will lead to decreased yields, whereas light cuttings carried out at long intervals of time will have little effect on yields of herbage. Stapledon and Milton state that continued plucking of inflorescences as they appear favoured root and top development.

Ellett and Carrier 1915(15) support the above group of writers and, further, claim that the decrease in herbage yield due to harsh cutting treatments may be more than compensated for by the increased protein percentage of the herbage actually produced. Aldous 1930(16) disagreed claiming that the higher protein percentage did not compensate for the loss in total yield caused by cutting. Lander 1942 (17) found for both arguments. The 1939-40 cycle of seasons was a dry one in India, and under the conditions ruling his results agreed with Ellett and Carriers' findings. The following year 1940-41, was wetter and his results confirmed Aldous' argument. Apparently local conditions determine the soundness of either contention. It seems that Aldous' argument would carry more weight in New Zealand.

In Hawaii Wilsie, Akamine and Takahashi 1940 (18) found that Napier Grass responded conventionally to cutting treatments. They found an 8 weekly cutting to 3 inch height above ground level gave greatest yield of palatable herbage. They claimed that this degree of defoliation was just sufficient to maintain food reserves and to permit good top growth of high palatability. More lenient or less lenient treatment yielded less total palatable fodder. Kennedy and Russell 1948(19) with a Kentucky blue grass-white clover pasture found clipping to ½" above ground level each 8 weeks gave, under their conditions, greatest yield of dry matter. As with the Hawaiian workers more lenient or less lenient cutting treatments yielded less. In view of these findings it would seem likely that a particular severity of cutting will give maximum yield of palatable herbage and another particular severity of cutting may give maximum yield of dry matter. Possibly in practice the optimum treatment for grass would be somewhere between the two.

EFFECT OF STAGE OF GROWTH ON NUTRIENTS.

Nutrient content varies with stage of growth. Lander

(17) in accord with other workers found that percentage protein was highest at periods of least growth. This seems to be the general case. Bukey and Weaver 1939(20) noted a marked decrease in carbohydrate content under severe cutting conditions. Sturkie 1930(21) claimed that cutting of tops reduced rootstocks of Johnson grass. Plants entering the growing season with well developed rootstocks yielded at least 50% more dry top weight than those which lacked this initial advantage. McCarty and Price 1942(22) find that the storage of carbohydrate reserves by grasses, is cyclic in nature. Minimum storage coincides with maximum top growth, maximum storage occurring in autumn at the completion of secondary herbage growth. They state that early spring growth is dependent on the presence of adequate reserves of carbohydrate, 75% of these reserves producing only 10% of the herbage actually grown. Subsequent growth is dependent on currently assimilated foods. The amount of foliage present during the normal storage period determines the amount of carbohydrate reserve accumulated in roots and stem bases. Severity of cutting treatment is said to be the major influence on quantity of carbohydrate reserves. Graber 1931(8) claimed that the depletion of food reserves consequent on cutting, implied limited root growth and so lowered capacity to resist adverse conditions.

STIMULATORY EFFECT TO TOP GROWTH OF CUTTING TREATMENTS.

Immediately following initial cuttings or well spaced cuttings a rapid regeneration of top growth may be recognised. Support to this statement is given by Parker and Sampson 1931 (23), Martin G. Jones 1933(24), Hodgson 1942(25), Sullivan and Sprague 1944(26) and Jacques 1948(27). With cocksfoot Jones ascribed the phenomenon to the use of stored food reserves in the white leaf base. Hodgson, with cocksfoot, found this rapid regeneration decreased following subsequent cuttings. Lenient cuttings did not give this regeneration to any marked extent. Sullivan and Sprague claim that the vigour of this regeneration can be correlated with reserve food stores, particularly carbohydrates stored in the roots and remaining tops. With ryegrass they indicate that reserves in the leaf base are used first. Thus, dependent on the presence of reserve food material, an initial burst of top growth closely follows a cutting, the more severe the cutting the greater the burst. This initial rapid regeneration declines in strength following repeated cuttings and soon disappears.

EFFECT OF DEFOLIATION ON ROOT GROWTH.

Weinmann 1948(28) under the title of "Underground development and reserves of grasses" has reviewedmost of the literature pertinent to his subject. Nedrow (11) claimed that little had been done on directly restricting root extent or production. Weinmann confirms this statement, claiming as the object of his review, the stimulation of further research into root-top relationships. That there is such a relationship, and a close one, is made clear by Parker and Sampson 1930(29), Jones (24), Sprague 1933(30), Robertson (9), Roberts and Hunt (10), Jacques 1937(31), Nedrow (11), Whyte 1944 (32), Schofield (13) and Nelson 1945(33) in their various works. They agree, and others concur, that frequent clipping of top growth results in poor root growth. Parker and Sampson and Nelson found that severedefoliation caused reductions in root diameters, root ducts and root length. Jones emphasises that restriction of root growth gives an effect lasting through beyond the present season. Jacques emphasises the inhibiting effect on root development of defoliation of very young plants, preventing the establishment of adequate root systems. He shows that as numbers of "crown roots" increases so total root weight increases. Roberts and Hunt claimed checks, to root growth following cutting of tops, were due to removal of stored reserves from root to tops especially at flowering time. They mention that perennial ryegrass has its main storage of reserves in the root system, offering a possible explanation for the generally accepted fact that ryegrass stands severe defoliation better than do cocksfoot or timothy. Whyte sums up simply - "it is probably correct to say that grazing and mowing practices have the greatest effect upon the root systems of herbage species. Evidence is great that lenient cutting treatments are best for roots."

SEASONAL GROWTH OF ROOTS.

It is fairly definite that root growth is seasonal. Weinmann (28) summarises confirmatory material. At Rhode Island, Stuckey 1941 (34) found root growth was at a minimum in late summer - autumn, with a maximum in early spring falling away again through the summer. She classified plants into annual and perennial groupings according to rooting ability. Perennial ryegrass is classified as "annual" and cocksfoot as "perennial". Yen 1947 (35) found that root growth was seasonal but tended to disagree with Stuckey's classification of perennial ryegrass. He believes that the root system of perennial ryegrass persists for longer than a year. Martin 1934 (36) found roots had special growth periods and that removal of tops during these periods inhibited subsequent growth. Removal at other periods had little detrimental effect. This special growth period is said to vary locally.

EFFECT OF INHIBITION OF ROOTS ON TOP GROWTH.

As the preceding material indicates, any pruning or direct inhibition of root growth will be reflected almost immediately in top growth. Robertson (9) tells of a decrease in tiller numbers and tiller size concurrent with restriction of root growth. Jacques (31) found similar indications.

Gericke 1923 (37) found that root pruning of wheat decreased tiller numbers in proportion to the severity of the pruning. Nedrow with root pruning of grasses to 5 inch depth found decreases in top yields up to 50%. Spencer 1941(38) with maize found the same result. Rogers 1939(39) with apple trees claimed that root growth preceded top growth and continued after top growth ceased. He found that constant exposure of roots to light hastened suberisation. Jacques 1944(40) says that from the point of view of increased herbage yields "no advantage is to be looked for as a result of root pruning."

DIFFERENCES BETWEEN SPECIES.

Species react differently to different intensities of defoliation. Stapledon and Beddows (6), Parker and Sampson (23), Robertson (9), Harrison and Hodgson (12), and Lander (17) produce evidence in support of this view. Stapledon and Beddows found strain differences in cocksfoot. Similar differences due to root inhibition seem probable. Weinmann's review seems to imply this.

INFLUENCE OF SOIL MOISTURE ON ROOT GROWTH.

Various factors have an influence on root growth. Soil moisture is one of the more important ones. While soil moisture affects plants so too can plants affect soil moisture content. Veihmeyer and Conrad 1929(41), Hendrickson and Veihmeyer 1931(42) and Bosman 1936(43) stress the fact that actively growing plants cause moisture gradients in the soil, making it impossible to obtain an even soil moisture content. The first named workers emphasise the necessity for taking many samples in an endeavour to obtain a reliable result. Hendrickson and Veihmeyer found that roots would not penetrate a soil of 11% moisture content. Bosman quotes Veihmeyer as saying that the optimum conditions for root growth cover the range from soil field capacity to soil wilting point. Boxman, however, found definite variation of growth within this range. Nedrow (11) suggests a figure of 34% moisture content as being about the optimum.

The Wheat Research Institute in New Zealand (44) suggest 20% as being optimum for wheat, with the field capacity of the soil concerned being 27%. Thus an optimum soil moisture content for each individual soil seems likely. Webb 1936(45) also with wheat found differences between species in their ability to produce roots under the same dry conditions. Probably grass responds in this way.

CONCLUSIONS.

From the literature we see that grass growth, both of tops and of roots, is seasonal in nature. Cutting of tops produces inhibitions in root growth while pruning of roots restricts top growth - the degree of restriction depending on the severity or leniency of the treatment. Top yields fall as cutting treatments become less lenient and rise as they become more lenient. An initial stimulus of growth results from severe cutting treatments, this stimulus increasing in strength with increasing severity of treatment and decreasing in strength with repetition of the treatment. Root growth proceeds in moist soils. For each soil an optimum soil moisture content may exist, at which root growth is greatest.