

SOME PRELIMINARY OBSERVATIONS ON FERTILIZER PLACEMENT  
IN RELATION TO ROOT GROWTH IN SOME GRASSES.

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The question of the most suitable positional placement of different fertilizers is one which has received much attention in the United States in particular for a number of years past. In Europe too, attention has been given to the importance of the root system in relation to food supply. (5)

The position is made clear from the American viewpoint by Duley (1) who says "The earlier idea seemed to be that if the soil was low in a given fertility element, it could be added by almost any method and satisfactory crops would result. This idea is giving way to the practice of fertilizing each crop by the method that will produce in it the most economical increases. In other words, we are coming more and more to the idea of 'fertilizing the crop' rather than 'fertilizing the soil' .

Sprague (6) , however, summarizes from work with perennial grasses - "That the residual effect on the soil of applying, various fertilizers and soil amendments has come to be recognized as a potent factor influencing plant growth" .

The American method has been worked out extensively for such annual crops as corn (maize), potatoes, wheat, cotton etc. For example, the best results are obtained from maize (2) (9) by placing the fertilizer in a band 2" wide and  $1\frac{1}{2}$ " from the seed on either side and  $\frac{3}{4}$  - 1" below the seed level. This band of manure lies in the direct line the roots will take and is thus available to the roots without them having to search for it. Coe (4) shows that contact of fertilizer with seed maize is harmful to germination and that the location of the fertilizer above the seed with varying intervals of soil separation proved to be worthless in dry seasons, while the location of the fertilizer directly below the seed with varying intervals of soil separation produced quick results. (8) Duley (1) in trials with wheat in Kansas gets the best yields by placing the manure in contact with the seed, rather than broadcasting and discing in. An increase of over 6 bush, per acre was thus obtained.

On the other hand, soil investigations in Iowa (3) show that in certain seasons broadcasting and discing-in seems preferable. It is regarded as a safe method and never leads to germination or growth injury. It involves, however, a separate operation of applying the manure and necessitates discing. Tinnefeld (7) in Europe is of the opinion that "Plowing gave the best practical results in artificial fertilizer distribution, that scarification produced complete uniform distribution of the fertilizer through the seed bed; the best fertilizer distribution and mixing with soil was obtained by cultivating to a depth of 9.5" .

It is thus seen that workers on fertilizer placement are not in agreement as to the most suitable procedure for manuring even annual crops. The position in regard to manuring a perennial crop, a crop that has to occupy the same ground for a number of years is worthy of even greater attention than it has received with annuals. As grass is our main perennial crop in this country it may be profitable to review our methods of manuring it.

It is first necessary to consider the type of root growth developed by the grasses. For this purpose, dogstail and ryegrass have been taken as typical of the erect growing plants recommended for use in seeds mixtures and were sown on March 6th. Soil and manure were placed in 3in. drain pipes placed on end in the ground. The manure was added at the rate of 4 cwt. of superphosphate per acre as shown in Table 1, and seven replications of each treatment were given for both types of seed.

T A B L E 1.

1. No manure.
2. All surface manure.
3. The top 2" of soil mixed with the manure.
4. All manure in a layer 2" from the surface.
5. Half of manure on surface, half mixed in top 2" of soil.
6. " " " " " " in layer 2" deep.
7. The top 4" of soil mixed with the manure.
8. All manure in a layer 4" from the surface.
9. Half of manure on surface, half mixed in top 4" of soil.
10. " " " " " " in layer 4" deep.
11. The top 6" of soil mixed with manure.
12. All manure in a layer, 6" from the surface.
13. Half of manure on surface, half mixed in top 6" of soil.
14. " " " " " " in layer 6" deep.

Dogstail was slower in making its appearance than ryegrass. In the early stages of growth, individual differences in growth rate between the plants was fairly great irrespective of the treatment given, and no correlation between the size of cereal growth and fertilizer treatment could be obtained. On germination, the first appearance of roots in a woolly mass at the base of the seed in under a week after sowing. Roots are thus active before the shoot emerges from the enveloping glumes. The primary roots grow rapidly and penetrate up to 3" into the ground. It is possible that they function for a considerable time (as may occur in wheat) even after the secondary roots are well established. The secondary roots are of two distinct types (a) the "white roots" so called by Brenchley and Jackson (10) and (b) the truly fibrous roots. There is also a type observed in these grasses (c) which can be regarded as being intermediate between these two,

- (a) the "white roots" are easily distinguished in the early stages particularly in perennial ryegrass by their greater diameter, their glossy appearance and by their straight unbranched habit of growth as compared with the wavy, profusely-branched fibrous roots. The "white roots" as in barley (II) have abundant hairs along the length of the root, but, root hairs are only present behind the growing points on the branched or fibrous roots.

The internal structure is different, the white roots having a better conducting system than the fibrous roots; but are more liable to damage as they have little strengthening tissue. Most probably their main use is in the plant's nutrient supply; They appear when the plant is beginning to grow vigorously, and consequently, when it is needing a good supply of water and food from the soil. The unbranched roots are so constructed that they are specially adapted to meet such a demand. Their absorptive area is much larger than it is in the branched roots, where absorption can only take place in the parts behind the root tips. The whole root is specially adapted for the rapid passage of water.

The theory that the unbranched roots are chiefly connected with the food and water supply of the plant (as opposed to the theory that they are mainly to support the aerial structure in the cereals), receives further support that (in barley) these roots are only formed during the early stages of the plant's vigorous growth".

In the grasses there is little to suggest their being for any other purpose than purely nutritional. Their complete sequence has not yet been studied; but they are being actively formed throughout the winter when the seed is autumn sown.

In the grasses studied, however, there is no question of them retaining their unbranched habit. After about the 7th. week of growth branch roots had begun to develop from 1" to 3" from ground level, the greater development being in the 3" region rather than the 1". As the roots lengthened the region of the laterals or branch roots extended downwards, the laterals in turn developed further branches until a strongly fibrous system was built up,

- (b) The truly fibrous roots are different at the outset from the white roots, in that they have a smaller diameter, are wavy and become fibrous at an earlier date. They may or may not penetrate to the same depth as the white roots and the upper laterals are more rigid and tend to develop at an angle approximating a right-angle to the root from which they arise. They arise among the white roots and intermingle with them, (This mode of lateral formation is not constant for all grasses,
- (c) There is also the type of root which from external appearance seems to be an intermediate type between (a) and (b). It has a smaller diameter than the white roots but has their appearance and mode of growth, but tends to be somewhat wavy. The thinwhite roots as they can be called, develop quicker than the thick ones and they assume a branched habit at an earlier date. These, together with the fibrous roots, form the bulk of the branched root system before the large white roots assume any activity in this connection. Dogstail has fewer white roots in the early stages they are of smaller diameter than those found in ryegrass and they commence to develop a branched system sooner.

Reviewing the root development during the early stages of growth, the first absorptive roots are developed at the base of the seed about one week after seeding. Thereafter root development progresses rapidly.

The following table gives the air-dried weight of the roots at different dates,.

T A B L E 2,

DOGSTAIL.

Av. of 14	plants	62 days	after sowing	seed	(air-dry weight)	.052	gms.
" "	12	" 83	" "	" "	do	.102	"
" "	10	" 104	" "	" "	" "	.105	"
" "	11	" 125	" "	" "	" "	.186	"

RYEGRASS.

Av. of 14	plants	48 days	after sowing	seed	(air-dry weight)	.044	gms.
" "	14	" 69	" "	" "	" "	.103	"
" "	13	" 90	" "	" "	" "	.320	"
" "	14	" 111	" "	" "	" "	.566	"

THE EFFECT OF FERTILIZER AND OTHER FACTORS ON THE ROOT SYSTEM.

In these trials no Positive data. have been obtained as to the precise effect of superphosphate on root development. Individual differences between the plants were too marked to attempt to measure fine variations due to fertilizer treatment, though at the outset this was intended. Without attempting to review the literature on the subject it is possible to select divergent opinions on the effect of manuring on root growth. Lawes in one of his earliest Papers on "Turnip Culture" in 1847, writes " - - it is certainly true that it (superphosphate) causes a much enhanced development of the underground collective apparatus of the plant especially of lateral and fibrous roots". Erenchley and Jackson (10), using pot cultures with wheat and barley find that super seemed to bring about a considerable development of laterals, particularly in the early stages of growth, and similar results were obtained by Watt with wheat in Australia (28). Hall (25) states that on the grass Plots at Rothamsted, -- the characteristic grasses on the plots receiving ammonium salts possess a shallow rooted habit, while the nitrate of soda. has favoured deeply rooting grasses. Actual examination of the subsoil show the roots have penetrated much deeper on the nitrate of soda plots, they have followed the soluble nitrate down into the soil in the one case, whereas in the other they remain near the surface where the nitrogenous material has been accumulated! Von Seelhorst (24) found that when liberally fertilized, plants have a larger and deeper root system and Weaver (12) that roots branched and developed more abundantly where they came in contact with a fertilized layer. Sprague (6) however says "the effect of available phosphorus supply may be wholly masked by the reaction factor. It is necessary to investigate possible, differences in soil reaction as the explanation for greater root abundance -- before concluding that increased phosphorous supply has enhanced root growth. There is some evidence that nitrogen in a readily available form tends to restrict root growth as compared with applications of nitrogen in a slowly available form. Root abundance was not positively correlated with either the supply of available phosphorous or the organic carbon content". From my own observations with two grasses during establishment, no marked differences from the addition of superphosphate have been seen apparent when the soil used was a fertile one there may have been sufficient phosphate present to make such development. The generally held opinion, however, is contrary to the last two findings.

Other factors too are concerned with abundance and development of the roots such as temperature (18), nutritive conditions of the seed (14) soil moisture (15) (46) aeration (17) (21) (22) soil density (20) soil type (23) organic carbon content of the soil (26) and toxins (23).

### THE IMPORTANCE OF ROOT DEPTH.

The depth to which the root develops is an important feature particularly where summers are dry. Weaver (12) points out that in arid regions the subsoil is not unproductive, and that in them roots make good growth, but in humid regions the unproductiveness of the subsoil has long been recognized. Grass roots are periodically regenerated and entirely adventitious. Most of the new roots are formed in spring (6) and fully half of them (in Colonial bent and *por pratensis*) is generated each spring. The fertility of the soil at this season of regeneration and the amount of grazing is going to affect the occupation of the soil by roots for the entire growing season. Practices that permit more extensive root development will allow the plant to draw on larger volumes of soil for nutrients and moisture and consequently produce greater yields, or resist more unfavourable weather than would otherwise be possible. The case of a developing sward is more important still, for the foundation of the whole of the absorbing system is being laid during the first winter and spring. Therefore any mal-practices at this time are bound to be reflected in the entire season's production. Stapledon et al. (27) have pointed out clearly how the ills of mis-management are transmitted from one season to the next and this viewpoint can be emphasised still more strongly after a study of root development. It would appear too, that in districts which have a mild winter, the root formation and regeneration process is actively progressing throughout the winter. It is considered also that the root forms an additional criterion for selection of varieties for dry conditions (16).

### THE METHOD OF PASTURE MANURING IN NEW ZEALAND:

It is the practice in New Zealand to 'add relatively small dressings of superphosphate to the surface inch or so at the time of sowing the seed. The manure becomes fixed in the layer to which it is applied and can only be assimilated from there. Thus if the root system is such that the fullest use is not made of this area then response to manuring is bound to be limited.

As has been seen previously the early growth of root hairs is developed in the region where the manure had been placed, thus giving a fillip to growth. But the secondary root system is developed in the main at a point much below this. The white roots, clothed all the way down with root-hairs are in a position to utilize nutrients over a considerably wider field and are prevented from doing so effectively by the position of the fertilizer. This is more particularly the case in land which is not essentially fertile and the growth development is dependent on added fertilizer. Furthermore, the development of root hairs at or just below ground level though continuous during the period of initiation of the white roots ceases when the white roots are not being formed. The region of the vigorous formation of fibrous roots during initial development is somewhat below the level of the added fertilizer, if also, as we are led to believe, the fibrous root development is encouraged by phosphate more particularly in regions where the manure is most concentrated, then this method of manuring is leading towards the formation of a superficial fibrous rooted system, which is certainly not the most satisfactory for summer production.

### SUGGESTED VARIATION OF PRACTICE.

It is difficult to see how, when once the pasture is down in permanent grass, the added manure can be incorporated in the lower soil, but during the time the land is being prepared for pasture the incorporation of the manure with the lower soil is a relatively easy matter. It can be ploughed in or disced and cultivated in after ploughing or placed in the bottom of the furrow during the ploughing operation. The problem is one which is worthy of further study and one which is probably of even more

importance on the soils of Canterbury than in the moister North Island districts,

This survey is essentially only a preliminary one, but further work in connection with root development in pasture plants is under way .

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