EFFECT OF SOIL MOISTURE AND METHOD OF N APPLICATION ON ROOT GROWTH OF WHEAT

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INTRODUCTION

In a field experiment carried out by Dr. Verma in India there was an indication that splitting the N fertilizer application increased yield in a humid year but not in a dry year. The availability of some large weighing lysimeters at the Swift Current Research Station prompted us into setting up this study. Objectives were to determine (a) the relative efficiency of plant uptake of N applied in split applications, and to roots vs leaves and (b) how this might be influenced by soil moisture.

MATERIALS AND METHODS

Manitou wheat was grown on Wood Mountain clay loam (Mitchell et al., 1944) in weighing lysimeters (150 cm deep x 40 cm diameter). Four N treatments were combined factorially with three soil moisture regimes. Nitrogen treatments were (a) No N applied; (b) all N applied 2.5 cm below the seed (basal); (c) 1/2 the N applied basal and 1/2 applied by foliar spray at tillering; and (d) 1/2 basal + 1/2 the N top-dressed at tillering. The moisture regimes were (a) rainfall only (dry treatment), (b) water added to adjust moisture to field capacity whenever depletion reached 10% of available moisture (medium wet), and (c) moisture adjusted to field capacity whenever depletion reached 70% of available moisture (wet). The growing season rainfall in 1973 was 5.0 cm which was much below the long time average of 16.57 cm. There were three replicates per treatment; one of each replicate lysimeter was sacrificed for root determination at the end of the experiment. The N was applied in the form of urea at rates of 25 kg/ha for the dry treatment and 100 kg/ha where water was added. Phosphorus was applied at a rate of 100 kg/ha P_2O_5 to all treatments. Forty seeds of wheat were planted per tank and these thinned to 20 plants per tank after germination.

The number of heads, the weight and N content of straw and roots were determined. (Because of grasshopper damage to grain only straw and root data were obtained). Roots were determined at maturity by cutting the cylinders lengthwise then sectioning the soil crosswise at 30 cm intervals. The soil was ground, a subsample taken for moisture determination and the remainder soaked overnight in a Na_2CO_3 solution to disperse it. The soil suspension was then washed through a nest of sieves and the roots collected and ovendried.

RESULTS AND DISCUSSION

The number of heads had been counted before the grasshopper damage occurred. The number of heads was increased to the same extent by the medium-wet and wet-treatments [compare to dry treatment (Table 1)]. Under dry conditions there was no effect of N application on the number of heads irrespective of the method of application. When water was added application of N increased the number of heads but there was no difference between method of N application.

Table 1. Effect of soil moisture & method of N application on No. of heads/lysimeter

Treatment	Rainfall only (dry)	10 to 100% field capacity (medium wet)	70 to 100% field capacity (wet)
Whole N basal	27	82	79
1/2 N basal + 1/2 foliar†	24	78	76
1/2 N basal + 1/2 top dressed†	25	80	80
No N applied	24	41	37

†Top dressing & foliar spray applied at tillering

As expected, straw weight was directly proportional to moisture content (Table 2). However, root weight of the dry treatment was surprisingly greater than that of the medium-wet and as great as that of the wet treatment. Furthermore, in three of the four dry treatments, root weight was twice as great as straw weight (grain excluded). Some workers have reported greatest root growth under dry conditions while others report the opposite (Gardner, 1960). Hurd (1974) suggests that one reason why root growth in dry soils may appear better than growth in wet soils might be because of poor aeration associated with wet soils. Although this was possible in our study it is not consistent with our results since the wettest treatment outyielded the medium-wet treatment with respect to root weight.

Table 2. Effect of soil moisture and method of N application on yield of straw & roots & on the straw/root ratio

Treatments	Rainfall only			10 to 100% field capacity			70 to 100% field capacity		
	Straw (g/lysimeter)	Roots	Straw* root ratio	Straw (g/lysimeter)	Roots	Straw* root ratio	Straw (g/lysimeter)	Roots	Straw* root ratio
Whole N basal	9	22	0.50	66	15	4.2	85	24	3.3
1/2 N basal + 1/2 foliar†	11	21	0.43	64	17	3.6	80	22	3.7
1/2 N basal + 1/2 top dressed†	11	12	0.98	64	10	5.9	82	10	8.5
No N applied	6	14	0.49	26	10	2.3	32	10	3.7

*Data based on only one replicate & straw wt. does not include grain

†Top dressing & foliar spray applied at tillering

Straw weight was increased by the addition of N but there was no difference between methods of application (Table 2). The same was generally true for root weight except where N was added 1/2 basal + 1/2 top dressed. These findings are not in keeping with those reported by others (Hurd, 1974) that split applications of N gave best yields and the most roots. The straw to root ratio was less than one in dry treatments and greater than one in wetter treatments. This indicates that under the dry conditions roots made more efficient use of the energy available to the plant than did the shoots. Similar observations have been made by others (Hurd, 1974). Generally, there was no consistent effect of N or method of N application on straw/root ratio.

Under dry conditions the roots were, in general, distributed evenly throughout the top 90 cm of the profile with a significant proportion located below this depth (Figure 1). In the two wetter treatments, the major proportion of the roots were located in the top 60 cm of the profile. Typical soil moisture distribution associated with the three moisture treatments are shown in Figure 2. Wiersum (1967) found that roots grew best where soil water suction was low. Singh (1952) reported that deeper roots are an advantage under conditions of high suction. The pattern of distribution observed in this study are therefore in keeping with the findings of Wiersum, 1967 and Singh, 1952. It was also in keeping with the fact that roots initially take water from surface layers but as suction increases in these layers they tend to take water from progressively deeper layers where suction is lower (Hurd, 1974).

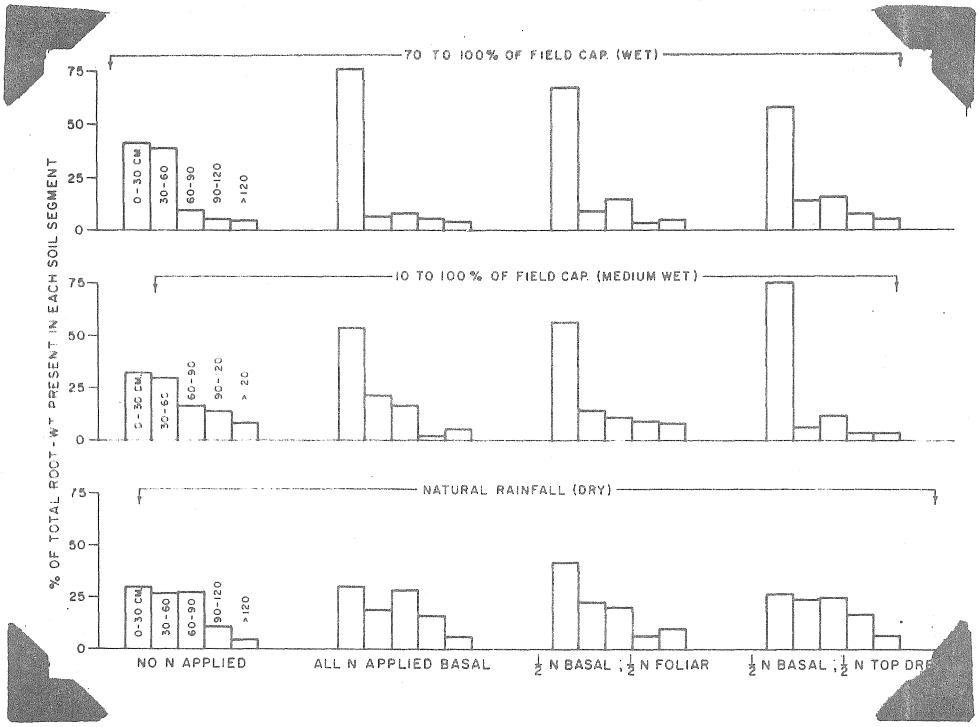

Figure 1 - Effect of method of N application and soil moisture on root distributions of Manitou grown in lysimeters

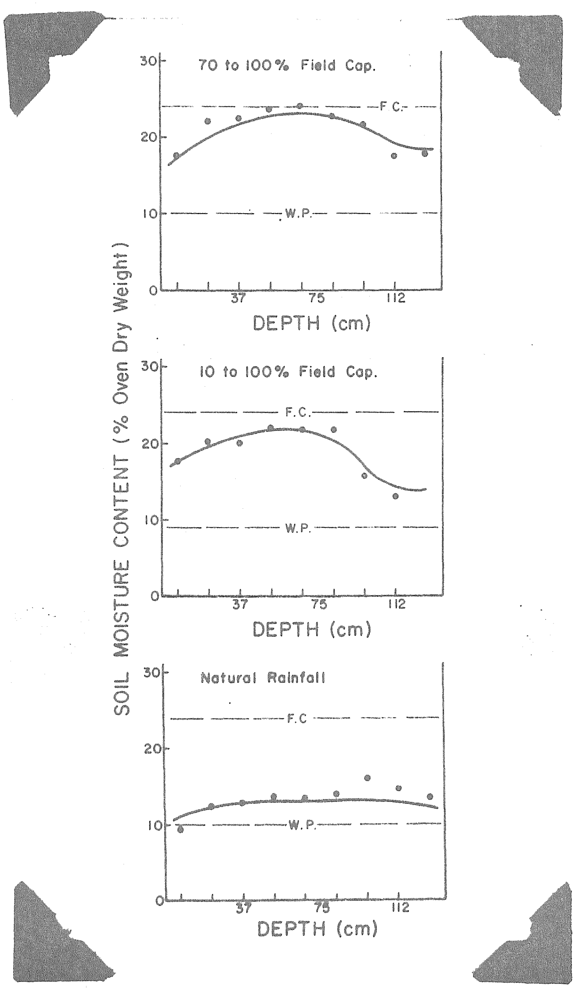

Figure 2 - Soil moisture distribution

When both water and N were added the tendency was for over 50% of the roots to congregate in the top 30 cm of the profile (Figure 1), but there was no differential effect of method of N application on root distribution. Bosemark (1954) has reported that increasing the N in soil caused increased root growth in the surface layers at the expense of depth of penetration.

Percent N in straw and roots generally decreased with increasing soil wetness (data not shown). In general the addition of N tended to increase straw and root N but the method of N application had no differential effect.

In conclusion, it would appear that under the conditions of this study the three methods of N application had no differential effect on top or root growth, although all three methods generally increased growth compared to when no N was applied.

Secondly, it was surprising to find that root growth under dry conditions was greater than under some of the more favourable moisture regimes and also that under dry conditions root weight was greater than straw weight. These findings would appear to require further verification.

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Comment: Concern was expressed over the method of split nitrogen applications as to whether this allowed the nitrogen enough time to be fully utilized by the crop.