Wheat Root length density as affected by nitrogen treatment

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Abstract

Rooting density in the subsoil is one of the important factors in determining nutrient uptake by plants. In order to investigate the effect of different nitrogen treatment on root length 5 nitrogen and two water treatments were carried out with 3 replicates of each treatment. The experiment was designed as a completely randomized block. The root length and root dry weight were measured during the growing season at different depths in the soil. The results show an increase in the root length in the subsoil (60-80 cm depth) and a decrease in root length in the topsoil after anthesis. An important issue, therefore, is whether the uptake of NO_3^--N from subsoil will be limited by root length density.

Key Words

Wheat, root, length, density, nitrogen.

Introduction

A better knowledge of the distribution of roots in soil is necessary to ascertain their effect on water and nutrient uptake by plants. In agriculture, it is usually considered an advantage for crop plants to have deep roots. In many cases, the supply of water under drought conditions may be safeguarded by the uptake of water from the subsoil. But the question also arises as to whether the roots in the deeper layers contribute to the mineral nutrition of the crop to any worthwhile extent. The majority of roots are in top 60-cm layer but in semiarid climates often all the water in this zone is used up by grain filling time and it is roots in the lower layer that facilitate the filling of heads (Hurd and Spratt 1975). In field experiments in South Australia, Schultz (1974) found an average of nearly 50% of the roots in the 0-15 cm layer. The surface soil is normally dry after September in South Australia when wheat is at the heading stage (Large 1954), and the ability of plants to extract water from the subsoil is important for final yield. To fully extract the water from subsoil, Wind (1961) calculated, from the theory of unsaturated water flow, which root density has to be approximately 1 to 2 cm/cm^3. Roots near the surface are prone to desiccate and die; this would retard the ability of these rooting systems to make efficient user of rain from summer thunder storms (Russell 1973).Roots in the subsoil have potential value in feeding the plant, provided plant nutrients are available. Their contribution to plant nutrition will further depend on the fertility of the subsoil layers, the water content of the layers and the amount of roots that have been able to develop in these regions. To explain the relationship between root length density and NO_3-N utilization further experimental efforts concerning different density of roots in the soil profile are necessary.

Methods

The experiment had a randomised complete block design with 3 replications. Factors tested were 5 N treatments, 3 harvest dates and two water regimes arranged in factorial combination. Wheat (cv. Molineux) was used in this experiment. The N treatments were: (N_0) no N; (N_1) 150 mg per pot as KNO_3 placed in the topsoil at sowing; (N_2) 75 mg placed in the topsoil and 75 mg in the subsoil at sowing; (N_3) 150 mg placed in the subsoil at sowing and; (N_4) 75 mg placed in the topsoil at sowing and 75 mg placed in the subsoil on week after anthesis. The topsoil applications were applied to the surface of the soil which was then lightly cultivated. The plants were harvested at tillering, anthesis and maturity. The plants that did not receive N (N0) were harvested only at maturity. The two water treatments, introduced when the wheat was at anthesis, were surface irrigation sufficient to keep water stress low in the plants (W_1), and no surface water, but subsoil irrigation at 60 cm depth (W_2). The soil from each pot was separated into depths of 0-10, 10-20, 20-40, 40-60, 60-80 and 80-100 cm. A sub sample of soil was taken from each layer to determine water content and NO_3-N concentration by the method of Best (1976). Roots were separated from the remaining soil sample by flotation and root lengths and root dry weight were measured. The total length of root in each sample was estimated by the line intercept method of Tenant (1975).

Results

Roots grew slowly until tillering, then root length density increased sharply from tillering to anthesis, especially in the surface layers. At maturity the root length in the topsoil decreased while it increased in the subsoil. This agrees with the observation by Campbell etal. (1977), who reported that there was a decrease in root length in the topsoil sometimes after anthesis and before the dough stage (Table 1). Neither the addition of N nor its placement affected root length density. The results presented by Lotfollahi (1996) imply that growth and distribution of roots in the subsoil have major roles in the post-anthesis N economy of plants because substantial uptake of NO_3-N did not occur until there was an increase in root length density.

Table 1. Root length density and root dry weight in the soil profile.[A]

Depth (cm)	Harvest		
	Tillering	Anthesis	Maturity
	Root length density (cm/cm^3)		
0-10	7.10	14.49	9.46
10-20	4.50	12.43	8.55
20-40	3.37	6.85	6.34
40-60	1.98	4.65	3.92
60-80	0.21	1.52	2.31
80-100	0.05	1.16	2.30
l.s.d. (P=0.05)		1.36	
	Root dry weight (g)		
0-10	0.63	1.75	1.38
10-20	0.36	0.92	0.88
20-40	0.51	1.41	1.20
40-60	0.39	0.99	0.89
60-80	0.08	0.42	0.57
80-100	0.01	0.30	0.67
l.s.d. (P=0.05)		0.15	

[A] Values have been averaged over all N treatments because the effect of N was not significant.
l.s.d applies to the interaction between depth and harvest.

Root dry weight increased until anthesis, then decreased sharply in the top 10 cm of soil (Table 1). However root dry weight in the 60 to 100 cm depth increase up to maturity. The root dry weight of the plants treated with no N (N_0) or with 75 mg in the topsoil and 75 mg in the subsoil at sowing (N_2) under the subsoil irrigation regime was slightly lower at maturity compared with the plants under surface irrigation (Table 2).

Table 2. The effect of nitrogen and water treatments on toot dry weight (g) at maturity.

Water treatment	Nitrogen treatment				
	N_0[A]	N_1	N_2	N_3	N_4
Surface irrigation	0.87	0.93	1.07	0.83	0.91
Subsoil irrigation	0.67	0.95	0.87	0.93	02.95
l.s.d. (P= 0.05)			0.16		

[A] N_0= no N, N_1= 150 mg N topsoil at sowing, N_2= 75mg N topsoil and 75 mg N subsoil (60cm) at sowing, N_3= 150 mg N subsoil at sowing, N_4= 75 mg N topsoil sowing and 75 mg N subsoil after anthesis.

Conclusion

The root length density in the topsoil decreased at maturity compared with anthesis while it increased in the subsoil. Root in the subsoil has potential value in feeding the plant especially in the late season that the top soil is dry.

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