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Nikhil Raghuvansi
Research Scholar, Department of Agronomy, Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya, Uttar Pradesh, India

BN Singh
Assistant Professor, Department of Agronomy, Narendra Deva University of Agricultural and Technology, Kumarganj, Ayodhya, Uttar Pradesh, India

Corresponding Author:
Nikhil Raghuvansi
Research Scholar, Department of Agronomy, Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya, Uttar Pradesh, India

Effects of sowing methods and nutrient management on root phenology and microbial activity in soil under wheat (*Triticum aestivum*)

Nikhil Raghuvansi and BN Singh

Abstract
A field experiment was conducted in split plot design (SPD) with 20 treatment combinations for two years (2017-18 and 2018-19) at Agronomy research farm, Narendra Deva University of Agricultural Sciences, Kumarganj, Ayodhya, Uttar Pradesh during *rabi* seasons. Treatments were consist of four sowing methods *viz.* (A_1) Broadcasting method, (A_2) Line sowing method, (A_3) Furrow Irrigation Ridge Bed (FIRB), (A_4) Criss cross sowing (20× 20 cm) and five nitrogen management treatments, *viz.* (B_1) control, (B_2) 50% N as basal + 25% N after first irrigation + 25% N after second irrigation, (B_3) 50% N as basal + 50% N after first irrigation, (B_4) 25% N as basal + 25% N after second irrigation + 50% through FYM as basal, (B_5) 25% N as basal + 75% through FYM as basal. Results revealed that the root dry weight, root length and microbial population were recorded higher values in A_3 FIRB planting system than A_2 Line sowing method at all growth stages during both the years of investigation. Whereas in case of nitrogen management, root growth parameters of wheat, *viz.* root dry weight and root length were significantly higher with (B_2) 50% N as basal + 25% N after first irrigation + 25% N after second irrigation and microbial population in soil significantly higher at various observational growth stages when crop was supplied with combined application of (B_5) 25% N as basal + 75% through FYM as basal over the other treatment during both years of field study. However, in this study FIRB sowing method with (B_2) 50% N as basal + 25% N after first irrigation + 25% N after second irrigation are best treatment for higher root phenology and (B_5) 25% N as basal + 75% through FYM as basal for soil health.

Keywords: Root, wheat, nitrogen, sowing method, microbial population

Introduction
India is after green revaluation progress in food grains production has slightly been described as the transformation from begging bowl to the bread basket (Swaminathan 1996). Wheat crop is a very important and remunerative cereal crop in North India after rice, grown under diverse agro-climatic conditions and occupied an area of 30.22 m ha with the annual production of 97.00 m tonnes with an average yield of 3.23 tonnes/ha during 2016-17 (Anonymous 2017). Among the modern agriculture management practices sowing method and nutrient management practices are imperative for boosting the growth and production of crops especially under irrigated condition. significant work has been reported on these aspects but efforts are still required for getting maximum yield. Sowing methods has a great role to play in increasing yield of crops. Indian farmers generally use the old broadcast method of sowing that has so many disadvantages, that is, uneven distributions of seeds, depth, and seed lying scattered being picked up by birds. Improved planting method may lead to increased production of maize which will result in attaining self-sufficiency in food and feed Amin *et al.*, (2006) [3]. Roots not just act as a sink for mineral nutrients transported to the root surface by mass flow and diffusion but as well they obtain up also ions or water preferentially which may lead to the depletion or accumulation of ions (Kaur *et al.* 2005 and Mehta 2004) [8, 9]. Root exudates may mobilize mineral nutrients directly and primarily provides the energy for microbial activity in the rhizosphere of plant root (Aggarwal *et al.* 2006) [12]. Integrated nitrogen management along with resource conservation technologies like FIRB sowing method could help in mitigating the problem to some extent. The potential sources of nutrients include chemical fertilizers and bulky organic manures (Ba Bomen *et al.* 2007, Jat *et al.* 2006 and Tulasa Ram and Mir 2006) [4, 7, 15]. Integrated nitrogen management aims and improves the physical, chemical and biological health of soil and enhances the availability of both applied and native soil nutrients to whole crop growing periods. This helps in retarding soil degradation and deterioration of irrigation water and environmental quality by promoting carbon sequestration and checking the losses of nutrients to water bodies and atmosphere (Jat *et al.* 2006) [7]. A scientifically managed system of soil fungus and bacteria plant association

is useful in conserving energy by reducing fertilizer requirement of crops and meeting production targets in nutritionally deficient soils (Sepat *et al.* 2010) [14]. The aims of this study were to examine root system characteristics of wheat genotype under nutrient management and planting systems.

Materials and Methods

The field experimental work of the investigation was conducted during *rabi* of 2017-18 and 2018-19 at Agronomy research farm, Narendra Deva University of Agricultural Sciences, Kumarganj, Ayodhya, Uttar Pradesh, to know the effect of nitrogen managements in wheat (Halna) under different sowing methods. The experiment was conducted in a split plot design with 20 treatment combinations and replicated thrice, during both the years of experimentation. The field topography was fairly uniform with a gentle slope and field was leveled before sowing of crop. A composite soil sample in zig-zag manner was collected from the experimental field to study the contents of available N, P and K, pH, electric conductivity, organic carbon content and some physical properties of the soil. The soil analysis revealed that the soil was silt-loam in texture, low in organic carbon, available nitrogen and available phosphorus contents while it was medium in available potassium. The soil reaction was moderately alkaline tendency. Data were recorded on root dry weight (g/ plant), root length (m/plant) and microbial population. The wheat variety Halna is a late sown bread wheat variety was tested to this experiments. It has distinguishing characters like semi-erect growth habit, early time of ear emergence, drooping flag leaf attitude, medium ear length, medium shoulder width of lower glume with round shoulder shape, bent peduncle attitude and length of brush hair not prominent.

Result and Discussion

Root length

The root length was observed at 30, 60, and 90 DAS and the data presented in Table. 1 showed that in general root length increased with the growth of wheat plant and was maximum at 90 DAS than reduced due to drying of root heirs. The length of the root accelerated with increasing rate during vegetative stage from 30 to 60 DAS. The root length significantly varied due to different planting methods and nitrogen management.

Table 1: Effect of sowing methods and nitrogen management on root length (cm) of wheat (*Triticum astivum* L.) during 2017-18 and 2018-19

Treatment	30 DAS		60 DAS		90 DAS	
	2018	2019	2018	2019	2018	2019
Sowing methods						
A_1	5.6	5.08	20.87	19.51	21.33	19.99
A_2	6.96	6.28	30.91	30.23	34.59	33.49
A_3	7.92	7.4	33.00	32.02	35.73	35.51
A_4	6.24	5.96	25.27	23.71	26.20	25.18
SEm ±	0.2	0.16	0.73	0.84	1.06	0.82
LSD	0.76	0.52	2.51	2.89	3.66	2.84
Nitrogen management						
B_1	5.92	5.42	18.08	17.57	18.45	17.69
B_2	7.36	6.88	33.74	33.02	37.06	35.38
B_3	7.06	6.65	28.98	27.47	30.92	30.48
B_4	6.76	6.16	32.95	31.51	35.87	34.49
B_5	6.28	5.84	23.80	22.27	25.02	24.69
SEm ±	0.17	0.12	0.77	0.83	0.71	0.68
LSD	0.49	0.44	2.21	2.38	2.05	1.95

The results revealed that the maximum root length of wheat was recorded under FIRB (furrow irrigation and ridge bed) as compared to other planting methods at all the growth stages. At 30 DAS, higher root length statistically found with FIRB (furrow irrigation and ridge bed) followed by line sowing method and criss cross sowing (20× 20 cm). The lowest root length observed with broadcasting method of sowing and same trend was observed in both years of experimentation. At 60 and 90 DAS, Significantly higher root length was noted with FIRB (furrow irrigation and ridge bed) and that was at par with line sowing method. Whereas, criss cross sowing (20× 20 cm) method was third best treatment. The significantly lesser root length was observed with broadcasting method of sowing. The same trend or observed in both years of experimentation. This finding is related to an earlier work by Cicer *et al.*, 2011 [5], Diver and Greer (2001) [6] and Famaye *et al.* (2003) [6] that potted planted techniques provide a favorable condition for root growth.

Under nitrogen management significantly influenced the root length of wheat and the longest roots were recorded under (B_2) 50% N as basal + 25% N after first irrigation + 25% N after second irrigation at all the growth stages during both the years. However, at 30, 60 and 90 DAS, it was found to be at par with (B_4) 25% N as basal + 25% N after second irrigation + 50% through FYM as basal treatments during both the years of experimentation. The third best treatments found (B_3) 50% N as basal + 50% N after first irrigation as basal followed by (B_5) 50%RDN through Urea and 50% through FYM as basal and the lowest root length observed with application of 0 kg N per ha (control) during all stage of observation and both year of experimentation. Ahmad *et al.* (2006) [2] and Kaur *et al.* (2006) [8] were also noticed similar trends.

Root weight (g plant-1)

In general, the root weight was increasing with the age of crops, the data was obsereved at 30, 60, and 90 DAS. The maximum root weight was found under FIRB (furrow irrigation and ridge bed) method of planting at all the stages, which was significantly superior over others. At 30 DAS, FIRB (furrow irrigation and ridge bed) planting method give highest value of dry weight and that was at par with line sowing method during second year of experimentation. At 60 and 90 DAS, root weight under FIRB (furrow irrigation and ridge bed) planting method gave highest performing value and that was at par with line sowing method. The lowest dry weight of root of wheat found under broadcasting method during all stages of growth and both year of experimentation. This result is related to an earlier work done by Diver and Greer (2001) [6] and Famaye *et al.* (2003) [6] that potted planting technique provides a favorable condition for root dry weight.

The nutrient management significantly influenced root weight. The results showed that the availability of nutrients increased root weight and the significantly maximum root weight was found under (B_2) 50% N as basal + 25% N after first irrigation + 25% N after second irrigation treatment and that was at par with (B_4) 25% N as basal + 25% N after second irrigation + 50% through FYM as basal at all the stages of crop growth during

Table 2: Effect of sowing methods and nitrogen management on dry weight of roots (g) of wheat (*Triticum aestivum* L.) during 2017-18 and 2018-19.

Treatment	30 DAS		60 DAS		90 DAS		At harvest	
	2018	2019	2018	2019	2018	2019	2018	2019
Sowing methods								
A_1	0.054	0.067	1.40	1.669	1.440	1.742	1.372	1.731
A_2	0.067	0.081	1.81	2.032	1.819	2.138	1.783	2.038
A_3	0.076	0.087	1.98	2.185	1.941	2.249	1.933	2.184
A_4	0.060	0.068	1.56	1.710	1.618	1.751	1.594	1.735
SEm ±	0.0021	0.0045	0.06	0.1114	0.0517	0.1150	0.052	0.100
LSD	0.007	0.015	0.21	0.386	0.179	0.398	0.180	0.347
Nitrogen management								
B_1	0.057	0.062	1.48	1.546	1.535	1.605	1.514	1.606
B_2	0.071	0.093	1.88	2.332	1.880	2.393	1.835	2.309
B_3	0.068	0.084	1.71	1.863	1.716	1.912	1.683	1.849
B_4	0.065	0.075	1.80	2.106	1.802	2.195	1.751	2.133
B_5	0.060	0.066	1.57	1.647	1.590	1.743	1.570	1.712
SEm ±	0.002	0.004	0.05	0.102	0.047	0.093	0.045	0.097
LSD	0.005	0.012	0.14	0.293	0.134	0.267	0.129	0.281

Treatment	Dehydrogenases activity µg TPF g^{-1} soil		Bacteria $10^5 g^{-1}$ soil		Fungi $10^5 g^{-1}$ soil	
	2018	2019	2018	2019	2018	2019
Sowing methods						
A_1	4.550	4.738	25.556	26.058	18.647	19.688
A_2	5.293	5.379	27.986	28.551	20.402	21.521
A_3	5.459	5.544	30.178	30.581	22.008	23.060
A_4	4.698	4.781	27.535	27.535	20.101	20.853
SEm ±	0.092	0.110	0.529	0.699	0.391	0.506
LSD	0.317	0.380	1.830	2.418	1.352	1.750
Nitrogen management						
B_1	4.854	4.865	23.633	24.171	17.223	18.250
B_2	4.882	5.019	27.859	28.380	20.317	21.399
B_3	4.806	4.995	26.738	27.055	19.517	20.443
B_4	5.200	5.294	29.537	29.701	21.552	22.434
B_5	5.258	5.351	31.302	31.599	22.838	23.876
SEm ±	0.073	0.077	0.439	0.450	0.327	0.346
LSD	0.210	0.222	1.264	1.297	0.942	0.998

both the years. Sepat *et al.* (2010) [14] and Jat *et al.* (2006) [7] were also reported identical findings.

Soil microbial activity

Soil dehydrogenase (DH) and microbial population involved in oxidative phosphorylation, and is an important indicator of microbial activity in the soil which has been found to increase significantly increase with sowing methods and nitrogen management. Whereas the highest deydrogenase activity DH and microbial population found with FIRB (furrow irrigation and ridge bed) followed by line sowing method. Under nitrogen management the highest DH and microbial population in soils observed under applied in combination of B_5 25% N as basal + 75% through FYM as basal followed by B_4 25% N as basal + 25% N after second irrigation + 50% through FYM as basal. This might be due to increased microbial activity and MBC in the same treatment. Incorporation of bulky sources of potential beneficial microbes may provide microbial diversity and activity of microorganisms accompanied by better DH activity Nath *et al.*, (2015) [12]. Nayak *et al.*, (2007) [13] also described a generalized short to medium term increase in DH activity following organic matter addition. The results illustrated that the greater part of the favorable effects of elevated and reasonably stabilized specific populations of fungi and bacteria were related to the added microorganisms as well as the application of organic manure for a longer period Nath *et al.*, (2012) [11]. The availability of carbonaceous materials and substrates such as sugar, ami organic acids to the soil from the decomposing organic materials and decay of roots under the plant canopy are important for supplying energy for microbial population Mohammmad *et al*, (2017) [10]. As a consequence, organic inputs generally enhanced the development of microflora and increased the global activity of soil.

Conclusion

The root growth parameters like root dry weight and root length was favorably affected by sowing methods and nitrogen management treatments at all the growth stages. However, higher values of these parameters were observed with FIRB (furrow irrigation and ridge bed) sowing method and when nitrogen applied in split. This might have resulted from the better availability of nutrients to the growing roots.

For soil health, it can be concluded that addition of good quality organic matter along with balanced fertilizer helped in increasing soil biological properties which has been considered as a good indicator of high-quality soil. These inorganic fertilizers along with organic manures provide a good amount of nutrients and growth substances which is essential for good growth and development of crops. The present study concluded that the scientific sowing methods with integrated nitrogen application in split are improving the productivity of wheat as well soil.

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