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Nutrient use Efficiency of Wheat (*Triticum aestivum* L.) under the Influence of Rhizospheric Management at Pantnagar, India

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ABSTRACT: Population relief demanded a rethink of agricultural production practises due to the rising need for food and nutritional security. Increasing cost of fertilizers and declining soil health resulted the lower nutrient use efficiency and crop output. As a result, to reduce the uses of chemical fertilizer, and boosting wheat production and nutrient use efficiency, this research study was conducted at NEB Crop Research Centre, G.B.P.U.A. &T, Pantnagar, India. The experiment used a FRBD design with 6 nutrient management options (100 percent RDF (150:60:40 NPK kg/ha), 75 percent RDF, 75 percent RDF + Vermicompost, 75 percent RDF + Vermicompost + PSB, 75 percent RDF + Poultry manure, and 75 percent RDF + Poultry manure + PSB), 75 percent RDF + Poultry manure, and 75 percent RDF + Poultry manure + PSB. According to research findings, the treatment combination of 75 percent RDF + Vermicompost/ Poultry manure + PSB is equally effective. It might be due to enhanced nutrient uptake and wheat productivity with reduced doses of inorganic fertilisers.

Keywords: Wheat, Nutrient Management, Fertilizer Placement, Nutrient Use Efficiency.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is the second most important staple food crop in the Indian subcontinent, behind rice, which spurred the green revolution. In order to fulfil expanding food demand, India's agriculture and natural resources are being strained by population increase and agricultural land shortages. To overcome this obstacle, farmers began to use excessive amounts of chemical fertilisers and pesticides, damaging the environment. Chemical fertiliser input, which is based on the conventional assumption of 'high input, high output,' has resulted in excessive fertiliser use while ignoring the biotic potential of rhizospheric soil, is now regulating enhanced grain yield (Jiao *et al*., 2016). At the moment, the wheat production system is experiencing a number of issues, including decreasing factor productivity, yield stagnation, numerous nutritional shortages, and climate change. As the world's population expands, so does the strain on natural resources, making it harder to ensure long-term food security. For a long time, food security has necessitated a delicate balance between growing crop productivity, maintaining soil health, and ensuring environmental sustainability. Nutrient management has played a significant influence in India's massive rise in food grain output from 52 million tonnes in 1951-52 to 259 million tonnes in 2014-15 (DES, 2014). However, the application of unbalanced and/or excessive nutrients resulted in declining nutrient-use efficiency, making fertiliser use uneconomical and causing adverse effects on soil microorganisms, soil enzyme activities, and the atmosphere (Aulakh and Adhya, 2005) and groundwater quality (Aulakh *et al*., 2009), posing health risks and contributing to climate change (Aulakh *et al*., 2009). The idea of nutrient utilisation efficiency (NUE) is significant in the evaluation of agricultural production systems. Fertilizer management, as well as soil and plant water management, can have a significant influence. Nutrient utilisation aims to improve cropping systems' overall performance by delivering economically optimal nutrition to the crop while reducing nutrient losses in the field (Fixen *et al*., 2014).

Previously, to meet the problems, aggressive cropping patterns were used, resulting in a decline in soil nitrogen status (Balyan and Idnani, 2000). The indiscriminate application of fertilisers has a negative impact on the soil's physicochemical qualities, resulting in low wheat yields. The diminishing responsiveness to inputs has been identified as a key concern threatening the wheat-based farming system's long-term viability (Mishra, 2006). Through the use of bio-fertilizer, vermicompost, and farmyard manure, significant attempts have been made to reduce the need of fertilisers in field crops. Integration of diverse nutrient sources (organic, inorganic, and biofertilizer) is preferable since it decreases the usage of chemical fertilisers and cultivation costs while also being environmentally beneficial (Ram and Mir, 2006). According to Gupta *et al*., (2006), unbalanced fertiliser usage is a major problem in Indian agriculture, therefore a new alternative is the combined use of organic and inorganic sources of critical nutrients, which boosts field crop productivity and profitability while also helping to preserve soil fertility. To improve production and soil health, organic manure and bio-fertilizers are required in addition to chemical fertilisers. According to research, bio-fertilizers such as Azotobacter and Azospirillum, whether used alone or in combination, have a high chance of enhancing wheat productivity (Kumar and Ahlawat, 2004). As a result, the study's goals were to identify yield and nutrient usage efficiency trends, as well as to evaluate the N, P, and K budget as impacted by the use of NPK fertilisers in conjunction with or without organic manures over time. Fertilizer placement reduces soil nutrient losses and direct fertilizer-seed contact, both of which contribute to inefficient sowing, and improves nutrient availability for plant roots (Nkebiwe *et al*., 2016). Combined NPK fertiliser deposits, on the other hand, have a greater impact on wheat productivity and quality. Wheat productivity is also boosted by the use of P and K fertilisers. Deep fertiliser placement is necessary for optimum root system development, nutrient uptake, and plant yield, according to the findings (Nkebiwe *et al*., 2016). As a result of the analysis of various field research on fertiliser sources and placement, an important question has arisen: "What fertiliser source and placement can be chosen to improve wheat productivity and soil health?" Rhizospheric management allows for improved crop output and soil health while remaining environmentally benign. As a result, rhizospheric management is chosen with the goal of lowering fertiliser inputs and increasing nutrient utilisation efficiency.

MATERIAL AND METHODS

A. Experiment details

A field experiment was carried out in block D-3, N. E. B. Crop Research Centre, Govind Ballabh Pant University of agriculture and technology, Pantnagar, dist. Udham Singh Nagar (Uttarakhand) during year 2017-18 and 2018-19.

The study was laid in FRBD design with 3 fertilizer placement options *viz* Surface application, Deep placement, and Band placement methods and 6 nutrient management options *viz* 100 percent RDF (150:60:40 Kg NPK/ha), 75 percent RDF, 75% RDF+ Vermicompost (2 q), 75% RDF + Vermicompost (2 q) + PSB (10kg/ha), 75% RDF +Poultry manure(2 q), 75% RDF + Poultry manure (2 q) +PSB (10 kg/ha) and replicated thrice. One addition control treatment was also used. All 19 treatment combinations were tested. The experimental soil was clay loam having high OC, medium in available N, high in available P and medium in available K with neutral pH during the *rabi* season, 2017-18 and 2018-19. Sowing of wheat variety (WH-1105) during *rabi* 2017-18 and 2018-19 was done at a row to row spacing of 20 cm on November, 24. 2017 and November, 29. 2018. The experimental details are given in Table 1.

Table 1: Details of experiment laid out.

Location of experiment	D-3 block, wheat agronomy, Norman E. Borlaug Crop Research Centre of G.B. Pant University of Agriculture and Technology, Pantnagar,
Season and year	Rabi seasons of 2017-18 and 2018-19
Crop	Wheat
Variety	WH-1105
Seed rate	100 kg ha^{-1}
Experimental design	Factorial Randomized Block Design (FRBD)
Replications	3
No. of factors	2
Levels of factors	1. Placement methods = 3 2. Nutrient management = 6 3. Absolute control = 1
Total no. of Treatment combinations	3 × 6+1 = 19
Total no. of plots	19 × 3 = 57
Crop geometry	Row to Row distance = 20 cm
Gross Plot size	7.30m x1.8m = 13.14 m^2
Net plot size	6.80 m x 1.4 m = 9.52 m^2

B. Soil properties

Under the prevailing effect of tall vegetation and moderate to good drainage, the Tarai region's soils originated from calcareous, medium to fairly coarse-grained minerals. The soil in the experimental plot was clay loam, which belongs to the Mollisole order (Deshpande *et al*., 1971). Before sowing and two days following harvest, a 0.15 cm deep soil mix sample was obtained. To measure soil fertility status, individual samples were shade dried, processed, and analysed. The soil exhibited a high organic carbon content, moderate nitrogen availability, high phosphorus availability, and moderate potassium availability, as well as a neutral pH.

C. Plant analysis

Nitrogen content: Grain and straw nitrogen levels were calculated separately from the product of five tagged plants to determine yield-attributable traits and yield. The seed and straw samples were ground using a Wiley mill. Kjeldahl method **(Jackson, 1973)**.

Nitrogen uptake: Nitrogen uptake was computed by the following expression:

N uptake (kg/ha) in grain or straw = % N in grain or straw x Grain or straw yield on a dry weight basis (q/ha)

Total uptake of N (kg/ha) = N uptake in grain + N uptake in straw

Nutrient use efficiency: Nutrients use efficiencies (NUE) for N, P and K was calculated in terms of partial factor productivity (PFP) as:

$$\text{PFP for N} = \frac{\text{Grain yield (kg/ha)}}{\text{Amount of N applied (kg/ha)}}$$

$$\text{PFP for P} = \frac{\text{Grain yield (kg/ha)}}{\text{Amount of P applied (kg/ha)}}$$

$$\text{PFP for K} = \frac{\text{Grain yield (kg/ha)}}{\text{Amount of K applied (kg/ha)}}$$

D. Statistical Analysis

The data from various observations were statistically analysed using the factorial randomised block design procedure and standard techniques of Analysis of Variance (ANOVA) as described by Rangaswamy (2006). Wherever the 'F' test was found to be significant, the critical difference at the 5% level of probability was calculated for testing the significance of the difference between any two means. Each net plot received one sample of absolute control. Thus, three samples of absolute control were compared separately with differential fertiliser placement with and without carbon management using the 'student t' test as described by Rangaswamy (2006). The difference between treatments was significant whenever the calculated 'f-value' exceeded the tabulated value (2.028).

RESULT AND DISCUSSION

A. Nitrogen content (%)

The data on nutrient content in percentage at the end of the two seasons are depicted in Table 2.

The placement methods did not affect the nitrogen content in wheat grain and straw significantly. Numerically, deep placement observed higher nitrogen content compared to band placement and surface application during the year 2017-18 and 2018-19. In the case of straw N content, there was not statistically much difference in placement methods during both the year of experimentation.

In terms of nutrient management, nitrogen content had no significant effect on wheat grain and straw content. In terms of control vs. rest, the nitrogen content of the control did not differ from that of the rest of the treatment during the years 2017-18 and 2018-19. The interaction effect on nitrogen content in wheat straw and grain was also found to be non-significant.

B. Nitrogen uptake (kg/ha)

The data on nitrogen uptake by crop at harvest at the end of two seasons is depicted in Table 2.

Fertilizer placement methods influenced the grain and total nitrogen uptake significantly but not the straw nitrogen uptake. Although, deep placement recorded higher total and grain nitrogen uptake over the Surface application and band placement. However, deep placement was at par with band placement and band placement was at par with surface application in grain and total nitrogen uptake during the year 2017-18 and 2018-19. Deep placements recorded numerically the highest straw nitrogen uptake followed by band placement and Surface application. Higher nitrogen uptake was attributed with deep placement due to the higher yield, root density, and nitrogen content compared to band placement and Surface application. Jing *et al*. (2012) discovered that rhizospheric acidification increased root proliferation, shoot dry weight, and nutrient uptake by fertiliser placement. By hastening rhizospheric acidification, fertiliser placement can increase P and N uptake. Wu *et al*. (2017) also suggested that deep nitrogen fertiliser placement had a significant influence on grain N content and straw N content when compared to broadcasting. Hossain *et al*. (2018); Kapoor *et al*. (2008) found that fertiliser broadcasting resulted in higher fertiliser losses and lower fertiliser use efficiency than fertiliser placement. According to Kaleem *et al*. (2009), higher photosynthates accumulation resulted in greater NP fertiliser uptake and yield effects. Chakmakci *et al*., (2017); Chauhan *et al*. (2015); Chen *et al*. (2016) made similar claims.

Nutrient management had a significant impact on nitrogen uptake for grain and total uptake. However, under nutrient management, 75 percent RDF + vermicompost + PSB had significantly higher nitrogen uptake of grain and total. Because increased root growth from the addition of organic manure improved water and nutrient availability, as well as soil health (Singh *et al*., 2009; Wilhelm *et al*., 2007). Optimal nutrition may have played an important role in maximising wheat yield potential by influencing nutrient supply and soil properties (Chesti *et al*., 2013). Bahadur *et al*. (2013) reported an increase in total N, P, and K uptake in plants as a result of the wheat crop's improved geo-biophysical rhizospheric environment.

In terms of control vs. rest, the control plot had significantly lower grain, straw, and total nitrogen uptake compared to the other treatment combinations during 2017-18 and 2018-19. The interaction effect of fertiliser placement methods and nutrient management on grain, straw, and total nitrogen uptake was found to be non-significant.

C. Nutrient use efficiency

Table 3 shows that deep placement resulted in higher crop nutrient use efficiency in terms of grain yield produced per unit use of these inputs compared to band placement and surface application methods during the years 2017-18 and 2018-19, respectively. Similarly, deep placement had the highest partial factor productivity (PFP) in the case of N, P, and K, followed by band placement and Surface application method in 2017-18 and 2018-19, respectively.

Table 2: Effect of rhizospheric management on N content and uptake in wheat.

Treatment	N content (%)				N uptake (kg/ha)					
	Grain		Straw		Grain		Straw		Total	
	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
Placement methods										
Deep placement	1.68	1.68	0.56	0.57	79.2	79.6	40.0	41.2	119.2	120.9
Surface application	1.67	1.66	0.56	0.57	73.1	74.2	37.7	38.6	110.9	112.8
Band placement	1.67	1.66	0.57	0.57	76.2	76.7	39.0	39.8	115.3	116.5
SE.m. ±	0.01	0.01	0.01	0.01	1.1	1.3	1.3	1.0	2.0	1.8
CD (P=0.05)	NS	NS	NS	NS	3.3	3.7	NS	NS	5.7	5.2
Nutrient management										
100% RDF	1.67	1.68	0.54	0.56	74.4	75.7	38.3	39.9	112.8	115.6
75% RDF	1.67	1.65	0.58	0.58	70.5	70.9	36.6	37.5	107.1	108.3
75% RDF + VC	1.68	1.68	0.56	0.56	78.1	78.9	38.4	39.5	116.5	118.4
75% RDF + VC + PSB	1.67	1.66	0.58	0.57	82.9	81.2	41.7	42.4	124.6	123.6
75% RDF + PM	1.66	1.67	0.56	0.57	72.7	75.8	38.6	39.1	111.3	114.9
75% RDF + PM + PSB	1.68	1.67	0.57	0.57	78.6	78.6	39.9	40.8	118.4	119.4
SE.m. ±	0.01	0.01	0.02	0.02	1.6	1.8	1.9	1.4	2.8	2.6
CD (P=0.05)	NS	NS	NS	NS	4.7	5.2	NS	NS	8.1	7.4
Interaction										
SE.m. ±	0.02	0.02	0.03	0.03	2.8	3.1	3.2	2.4	4.9	4.5
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Control vs rest										
Control	1.66	1.68	0.55	0.57	50.2	47.9	27.4	25.0	77.5	72.9
Rest	1.67	1.67	0.56	0.57	76.2	76.8	38.9	39.9	115.1	116.7
SE.m. ±	0.01	0.01	0.03	0.02	2.0	2.3	2.3	1.8	3.5	3.2
CD (P=0.05)	NS	NS	NS	NS	5.9	6.5	6.7	5.1	10.2	9.3
C.V. (%)					6.5	7.2	14.6	10.8	7.5	6.8

Table 3: Effect of rhizospheric management on partial factor productivity in wheat.

Treatment	Partial factor productivity (kg/kg nutrient applied)					
	Nitrogen		Phosphorus		Potassium	
	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
Placement methods						
Deep placement	44.8	45.1	114.1	114.9	170.1	171.2
Surface application	41.8	42.4	106.4	108.0	158.6	161.0
Band placement	43.5	43.9	110.9	111.9	165.4	166.8
SE.m. ±	0.6	0.7	1.6	1.8	2.3	2.6
CD (P=0.05)	1.8	2.0	4.5	5.1	6.7	7.6
Nutrient management						
100% RDF	34.4	34.7	86.1	86.7	129.1	130.1
75% RDF	43.4	44.1	108.5	110.2	162.8	165.3
75% RDF + VC	45.6	46.2	116.4	117.9	173.1	175.4
75% RDF + VC + PSB	49.0	48.3	125.1	123.3	186.1	183.4
75% RDF + PM	42.4	43.9	109.7	113.5	163.1	168.7
75% RDF + PM + PSB	45.2	45.5	117.0	117.8	173.9	175.0
SE.m. ±	0.9	1.0	2.2	2.5	3.3	3.7
CD (P=0.05)	2.5	2.8	6.3	7.2	9.4	10.7
Interaction						
SE.m. ±	1.5	1.7	3.8	4.3	5.7	6.5
CD (P=0.05)	NS	NS	NS	NS	NS	NS
Control vs rest						
Control	0.0	0.0	0.0	0.0	0.0	0.0
Rest	43.3	43.8	110.5	111.6	164.7	166.3
SE.m. ±	1.1	1.2	2.8	3.2	4.1	4.7
CD (P=0.05)	3.1	3.5	7.9	9.0	11.8	13.5

Deep placement, on the other hand, was comparable to band placement in terms of partial factor productivity of N, P, and K. The efficient management of rhizospheric processes and the root system has accelerated crop genotype efficiency, microbial interactions, and nutrient use efficiency through localised nutrient use (Shen *et al*., 2012; Cakmakci *et al*., 2014). Because of localised fertiliser application, root and root-mediated rhizosphere processes are modifying root exudation and intensifying rhizospheric interactions (Zhang *et al*., 2010; Jiao *et al*., 2016).

Among the nutrient management treatments, the integrated use of 75% RDF + vermicompost + PSB produced the highest crop nutrient use efficiency and PFP for N, P, and K, followed by the use of other nutrient management options. All of these parameters were found to be the lowest when RDF was used without the addition of organic manure or PSB. Manure application influenced nutrient mobilisation, availability, and uptake, resulting in higher nutrient use efficiency (Ram *et al*., 2020). Wheat production capacity increases with each kg of organic manure added due to improved nutrient availability (Kumar *et al*., 2017). The use of inorganic fertiliser in conjunction with organic manure increased agronomic efficiency. Furthermore, the decomposition of organic manure provides nutrients to crops and creates favourable conditions for plant growth (Kakraliya *et al*., 2017).

During the years 2017-18 and 2018-19, the interaction effects of fertiliser placement and nutrient management were found to be non-significant.

CONCLUSION

Based on the findings, it can be concluded that rhizospheric management using fertiliser placement methods and nutrient management was effective in reducing fertiliser application. Deep placement and 75 percent RDF (112.5:60:40 NPK Kg/ha) + Vermicompost/ poultry manure (2q/ha) + PSB (10 kg/ha) proved effective for improving wheat nutrient use efficiency under rhizospheric management. It could be because of improved nutrient availability and a more favourable soil environment created by the combination of inorganic fertilisers and organic manures. The reduction of chemical fertilizers help us to motivates toward uplifting farmers income, improved nutritional food security and soil fertility due to reduction of cost of production and use of organic manures.

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Conflict of Interest. None.

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