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Effect of integrated nutrient management on soil health, growth and yield of wheat (*Triticum aestivum* L.)

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Abstract

A field experiment was conducted during the *rabi* season 2019-20 to study integrated nutrient management in wheat at the Crop Research Farm of Soil Science Department, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj. The treatments were allocated in Randomized Complete Block Design having nine treatments with three replications. The treatment combination T₉ [50% RDF + 10 t FYM ha⁻¹ + 200 g *Azotobacter* 10 kg⁻¹ seed] gave the best results with respect to growth and yield parameters, viz., plant height (89.70 cm), number of tillers (104.81), fresh weight (19.75 g), dry weight (7.27 g), test weight (59.20 g), biological yield (89.13 q ha⁻¹) and grain yield (45.20 q ha⁻¹). Combined use of inorganic fertilizers, organic manures and biofertilizers resulted in significant enrichment of soil fertility status. Nitrogen in combination with FYM and *Azotobacter* resulted in slight decrease in pH (7.3), electrical conductivity (0.19), organic carbon (0.56%) and available nitrogen (287.34 kg ha⁻¹), phosphorus (29.27 kg ha⁻¹) and potassium (169.53 kg ha⁻¹) in the soil.

Keywords: Wheat, NPK, *Azotobacter*, growth, yield, integrated nutrient management, soil properties

Introduction

The basic concept underlying the principles of integrated nutrient management is the maintenance and possibly improvement of soil fertility for sustaining crop productivity on long term basis. This may be achieved through combined use of all possible sources of nutrients and their scientific management for optimum growth, yield and quality of different crops and cropping systems. Fertilizer is the most indispensable input in crop production. Due to high field to field variability, the possibility of over or under-application of nutrients is very high. Several researchers have highlighted falling productivity and nutrient use efficiency, multi-nutrient deficiencies, high extent of nutrient mining and falling farm income as the consequences of generalized recommendation (Ghosh *et al.*, 2004; Tiwari, 2007) [1, 2]. Use of farmyard manure (FYM) is a means to combat the ill effects of chemical fertilizers to the soil health and crop residues improve the efficiency of applied fertilizer. On the whole, incorporation of organic manures improves the nutrient content and uptake and also improves soil physical properties (Sial *et al.*, 2007) [3]. Among biofertilizers, *Azotobacter* strains play a key role in the nitrogen cycle in nature that binds atmospheric nitrogen inaccessible to plants and releasing it in the form of ammonium ions available to plants in the soil (Dilworth *et al.*, 1988). Uttar Pradesh is the largest producer of wheat in the country and hence it is Uttar Pradesh that can provide sufficient production of wheat to feed the increasing demand of the country. In this light, the present investigation was conducted to study the benefits of integrated nutrient management on wheat.

Materials and Methods

The experiment was conducted at Crop Research Farm, Department of Soil Science and Agricultural Chemistry, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh. The experiment was laid out in randomized block design with nine treatments and three replications (Table 1). The treatments consisted of three levels of RDF levels, i.e. 0%, 25% and 50%, three levels of organic manure, i.e. FYM @ 0 t ha⁻¹, 5 t ha⁻¹ and 10 t ha⁻¹ and three levels of biofertilizer, i.e.

Azotobacter @ 0 g 10 kg⁻¹ seed, 100 g 10 kg⁻¹ seed and 200 g 10 kg⁻¹ seed. The crop variety used was Shriram Super 252, a fast growing variety.

The soil of experimental area belonged to the order inceptisol and had sandy loam texture. It was alkaline in reaction (7.6), had non-saline electrical conductivity (0.18 dSm⁻¹), medium organic carbon content (0.45%), low available nitrogen (271.30 kg ha⁻¹), available phosphorus (24.50 kg ha⁻¹) and available potassium (150.60 kg ha⁻¹). The recommended dose of fertilizers *i.e.* nitrogen, phosphorus and potassium were 120:60:60 kg ha⁻¹.

Well-decomposed farmyard manure was used as organic manure source and was applied a day prior to sowing. Nitrogen was applied through urea (46% N) in two splits, half being applied as basal dose and the other half at tillering stage. Phosphorus was applied through diammonium phosphate (46% P₂O₅) and potassium through muriate of potash (60% K₂O) both at the time of sowing. Seed treatment of *Azotobacter* was used as the biofertilizer source. Integration of all the sources was done as per treatment. Selected growth and yield parameters were observed.

Soil sample analysis was done before sowing and after harvest. The methods used for estimation were digital pH meter (Jackson, 1958) for pH, digital EC meter (Wilcox, 1950) [6] for electrical conductivity, alkaline permanganate method (Subbiah and Asija, 1956) [7] for available nitrogen, rapid titration method (Walkley and Black, 1947) for organic carbon, colorimetric method (Olsen *et al.*, 1954) [9] for phosphorus and flame photometer method (Toth and Prince, 1949) [10] for potassium.

Results and Discussion

The combined application of farmyard manure, NPK fertilizers and *Azotobacter* yielded beneficial results in the optimum combinations. All the treatment combinations showed superiority over the control (Table 2). The plant height was recorded minimum with T₃ (5 t FYM ha⁻¹ + 100 g *Azotobacter* 10 kg⁻¹ seed) and T₅ (10 t FYM ha⁻¹ + 200 g *Azotobacter* 10 kg⁻¹ seed) treatments both of which had 0% RDF incorporated. The highest plant height of 93.24 cm was observed in treatment T₈ (50% RDF + 10 t ha⁻¹ FYM) at maturity and was found to be significant. The increase in plant height may be attributed to increase in the amount of growth substances with increased nitrogen supply. Similar results were reported by Singh *et al.* (2011) [11]. Number of tillers per meter row length also showed similar trends as in plant height with maximum number 106.09 being attained in T₈. Similar findings were reported by Singh *et al.* (2018) [12].

The maximum fresh weight, 19.27 g plant⁻¹ of wheat was recorded with T₉ treatment (50% RDF + 10 t ha⁻¹ FYM + 200 g *Azotobacter* 10⁻¹ kg seed) followed by T₈. The minimum fresh weight, 12.97 g plant⁻¹ was recorded in the control. The results were found to be significant and similar findings were reported by Singh *et al.* (2013) [13]. Similar trends were witnessed in case of test weight (g) of 1000 seeds per

treatment with 59.20 g as maximum found in T₉ treatment. An increased test weight may be attributed to improvement in physical condition of the soil by added organic matter, FYM that helped in optimum translocation of nutrients to the plants. The finding was in line with Desai *et al.* (2015) [14].

The maximum biological yield was found in T₉ treatment which was 89.13 q ha⁻¹. The minimum biological yield of 84.23 q ha⁻¹ was obtained in the control, T₁ and the results were significant. The increase in biological yield may be attributed to the increase in grain and straw yields. Similar findings were reported by Singh *et al.* (2018) [12]. The maximum grain yield was found in T₉ treatment which was 45.20 q ha⁻¹. The grain yield of T₈ treatment was 37.53 q ha⁻¹ and of T₆ (25% RDF + 5 t ha⁻¹ FYM + 100 g *Azotobacter* 10⁻¹ kg seed) treatment was 37.46 q ha⁻¹ which were at par with each other. The minimum grain yield of 34.06 q ha⁻¹ was obtained in the control, T₁ and the results were significant. The increased supply of NPK fertilizers, FYM and *Azotobacter* and increased nutrient uptake improved the grain and straw yields by stimulating the rate of various physiological processes. Similar findings were reported by Singh *et al.* (2011) [11]. The maximum harvest index was recorded in T₉ treatment which was 50.71% and the lowest harvest index 40.13% was obtained in T₇ (50% RDF + 10 t ha⁻¹ FYM) treatment.

In comparison to pre-sowing soil sample, pH value (Table 3) in most of the treatments was reduced. The maximum decrease in soil pH was recorded in T₉ and T₈ treatment which recorded a value of 7.39 and 7.37 respectively. The reduction in soil pH may be attributed to nitrification process in the soil due to ammonium in nitrogenous fertilizers which increases the acidifying potential and reduces pH. Similar trends were observed in electrical conductivity values which recorded a maximum decreased value of 0.19 dSm⁻¹ in T₉ treatment and 0.22 dSm⁻¹ in T₈ treatment. These findings were in close conformity with the findings of Yadav *et al.* (2017).

In comparison to the initial value, the value of available nitrogen in the treatments incorporated with fertilizers was increased. The maximum value of available nitrogen in soil was recorded with integration of 50% RDF + farmyard manure @10 t ha⁻¹ + *Azotobacter* @200 g 10⁻¹ kg seed which recorded a value of 287.34 kg ha⁻¹. The minimum value of available nitrogen among treatments, 260.76 kg ha⁻¹ was recorded in the control. Similar trends were observed in case of available phosphorus and potassium with maximum value of phosphorus increase being 29.27 kg ha⁻¹ and that of potassium being 169.53 kg ha⁻¹. These findings were in close conformity with the findings of Pandey *et al.* (2009) [16]. The integration of 50% RDF + farmyard manure @10 t ha⁻¹ + *Azotobacter* @200 g 10⁻¹ kg seed also improved the organic matter content. The value of organic carbon in soil increased with an increase in the dose of FYM applied as organic matter and its beneficial interaction with inorganic fertilizers and biofertilizers. These findings were in close conformity with the findings of Hemalatha *et al.* (2013) [17].

Table 1: Experimental treatment combinations of integrated nutrient management

Treatment	Treatment combinations
T ₁	Control
T ₂	N ₃₀ P ₁₅ K ₁₅ kg ha ⁻¹
T ₃	5 t FYM ha ⁻¹ + 100 g <i>Azotobacter</i> 10 kg ⁻¹ seed
T ₄	N ₃₀ P ₁₅ K ₁₅ kg ha ⁻¹ + 5 t FYM ha ⁻¹
T ₅	10 t FYM ha ⁻¹ + 200 g <i>Azotobacter</i> 10 kg ⁻¹ seed
T ₆	N ₃₀ P ₁₅ K ₁₅ kg ha ⁻¹ + 5 t FYM ha ⁻¹ + 100 g <i>Azotobacter</i> 10 kg ⁻¹ seed
T ₇	N ₆₀ P ₃₀ K ₃₀ kg ha ⁻¹

T ₈	N ₆₀ P ₃₀ K ₃₀ kg ha ⁻¹ + 10 t FYM ha ⁻¹
T ₉	N ₆₀ P ₃₀ K ₃₀ kg ha ⁻¹ + 10 t FYM ha ⁻¹ + 200 g <i>Azotobacter</i> 10 kg ⁻¹ seed

Table 2: Effect of integrated nutrient management on growth and yield of wheat

Treatments	Plant height (cm)	Number of tillers m ⁻² row length	Fresh weight (g)	Test weight (g)	Biological yield (q ha ⁻¹)	Grain yield (q ha ⁻¹)	Straw yield (q ha ⁻¹)	Harvest index (%)
T ₁	91.92	100.54	12.97	53.53	84.23	34.90	49.33	41.43
T ₂	87.92	99.09	14.17	55.93	85.93	35.98	49.95	41.87
T ₃	92.03	102.00	15.60	54.07	85.07	35.93	49.14	42.23
T ₄	91.23	103.90	19.03	55.13	85.13	36.20	48.93	42.52
T ₅	89.98	102.72	15.80	54.33	84.33	34.33	50.00	40.71
T ₆	92.61	101.63	18.37	55.27	86.27	37.46	48.81	43.42
T ₇	91.82	102.27	18.41	56.20	87.53	35.13	52.40	40.13
T ₈	93.24	106.09	19.27	57.47	87.47	37.53	49.94	42.91
T ₉	89.70	104.81	19.75	59.20	89.13	45.20	43.93	50.71
F-test	S	S	S	S	S	S	S	NS
SEm (±)	2.13	0.17	1.01	1.4	1.4	1.4	1.41	0.45
CD at 5%	6.25	0.49	2.97	4.12	4.12	4.12	4.12	-

Table 3: Effect of integrated nutrient management on soil properties

Treatments	pH	Electrical Conductivity (dSm ⁻¹)	Organic carbon (%)	Available nitrogen (kg ha ⁻¹)	Available phosphorus (kg ha ⁻¹)	Available potassium (kg ha ⁻¹)
T ₁	7.69	0.25	0.51	260.76	24.13	162.60
T ₂	7.66	0.25	0.52	278.29	25.93	164.93
T ₃	7.64	0.24	0.53	260.71	24.07	165.27
T ₄	7.57	0.24	0.53	274.75	25.27	166.06
T ₅	7.44	0.25	0.54	272.22	24.33	165.17
T ₆	7.49	0.24	0.54	279.03	25.67	167.43
T ₇	7.37	0.23	0.53	285.34	26.20	167.73
T ₈	7.37	0.22	0.56	282.41	27.53	169.03
T ₉	7.39	0.19	0.56	287.34	29.27	169.53
F-test	S	S	S	S	S	S
SEm (±)	0.12	0.01	0.03	4.51	1.60	2.71
CD at 5%	0.34	0.04	0.08	13.25	4.71	7.96

Conclusion

Wheat crop supplied with a combined application of N₆₀P₃₀K₃₀ kg ha⁻¹ + 10 t FYM ha⁻¹ + 200 g *Azotobacter* 10 kg⁻¹ seed gave the best results in terms of important growth parameters and yield (45.20 q ha⁻¹). The important physical and chemical properties of soil also improved significantly under this treatment. The benefits of incorporation of integrated nutrient were evident over the control and other treatments without integration. So, it was concluded that wheat crop should be supplied with FYM @10 t ha⁻¹ with soil enrichment of 50% RDF and biofertilizer inoculation of *Azotobacter* @200 g 10 kg⁻¹ seed to achieve high productivity in the alluvial soils of Prayagraj with sandy loam texture.

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