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Evaluation of integrated nutrient management in respect to yield, microbial population, nutrient content and uptake by wheat (*Triticum aestivum* L.) under eastern Uttar Pradesh

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Abstract
Field experiment was carried out in randomized block design with three replications and the treatment consisted of T_1- control, T_2- 100% RDF (120:60:40 kg ha^{-1} N: P_2O_5: K_2O); T_3- 75% RDF, T_4- 75 % RDF + 25 % N-FYM, T_5- 75% RDF+ Bio-fertilizer (*Azotobactor*); T_6- 50% RDF + 50 % N-FYM, T_7- (50 % RDF + 50 %N-FYM + PSB) and T_8- 50 % RDF + *Azotobacter* + PSB. The treatment effect was compared based on yield, soil microbial population, nutrient content, protein content and nutrient uptake by wheat crop. The grain and straw yield (q ha^{-1}), soil microbial population, nutrient content, protein content and uptake of nitrogen, phosphorus and potassium were maximum under T_7, which was at par with T_2, T_4 and T_6 and significantly superior over T_1,T_3, T_5 and T_8.
The maximum grain and straw yield of wheat (41.90 & 60.65 q ha^{-1}) was recorded with T_7 which was significantly higher over than T_1 (17.90 & 26.5 q ha^{-1}), T_3 (32.84 & 49.09 q ha^{-1}), T_5 (35.64 & 53.0 q ha^{-1}) and T_8 (34.80 & 51.75 q ha^{-1}) while at par with T_2 (41.60 & 60.33 q ha^{-1}) T_4 (39.55 & 57.0 q ha^{-1}) and T_6 (39.88 & 57.15 q ha^{-1}). Maximum number of bacteria (39.38 X 10^7 g^{-1} soil) was recorded in T_7 (50 % RDF + 50 % N-FYM + PSB) which was statistically at par with value recorded in T_6 (50 % RDF + 50 % N-FYM). Treatment T_7 and T_6 were found significantly higher over rest of treatments while the minimum number (6.21 X 10^7 g^{-1} soil) of bacteria was recorded under treatment T_1 (control). Similar trend also reported in the population of fungi and Actinomycetes in the soil after harvest of wheat crop. The maximum NPK content in grain (1.82, 0.50and 0.54 %) and in straw (0.55, 0.13 and 1.52 %) was observed under treatment T_7 (50 % RDF + 50 % N- FYM + PSB) and minimum NPK content in straw (1.53, 0.43 and 0.50 %) and in straw (0.49, 0.10 and 1.43 %) was observed under treatment T_1 (control). The maximum protein content (11.38 %) was observed in treatment T_7 (50% RDF + 50% N-FYM + PSB) which was statistically at par with treatments T_2, T_4, T_5 and T_6 and significantly superior over treatments T_1 (control), T_3 and T_8 while the minimum protein content (9.56 %) was recorded under treatment T_1 (control). The maximum uptake of N (110.12 kg ha^{-1}), P (28.83 kg ha^{-1}) and K (114.81 kg ha^{-1}) were observed under treatment T_7 (50 % RDF + 50 % N-FYM + PSB), While minimum uptake of N (40.37 kg ha^{-1}), P (10.35 kg ha^{-1}) and K (46.85 kg ha^{-1}) were observed under T_1 (Control).

Keywords: wheat, yield, FYM, PSB, azotobactor and RDF etc

Introduction
Wheat (*Triticum aestivum* L.) is the first important strategic cereal crop for the majority of world's populations. It is the most important staple food of the world. It exceeds in acreage and production every other grain crop (including rice and maize) and is therefore, the most important cereal grain of the world, which is cultivated over a wide range of climatic conditions. India has achieved self-sufficiency in food production at present, but the realistic demand for food has been estimated at 301.08 million tons for 2020, which will reach 330.18 million tons by the year 2030 (Goyal and Singh 2002). About 91% of the total wheat production is contributed by northern states. India is one of the principal wheat producing and consuming country in the world.
Adoption of intensive cropping system will meet the food demands of increasing population, requires high input energy, which are not only responsible for environment degradation but also increased the cost of cultivation. The manufacture of chemical fertilizer is highly cost effective and depends on non-renewable fossil fuel that is in acute shortage. To compensate the supply and recent price hike in inorganic fertilizers,

use of indigenous sources like farm yard manure, Azotobactor and PSB play a vital role in maintaining or improving soil fertility. Therefore, Integrated Nutrient Management favorably affect the physical, chemical and biological environment of soil. Integrated nutrient supply involving conjunctive use of fertilizers and organic source of nutrients (Roy, 1992) [9] assume greater significance.

Use of farm yard manure (FYM) should be encouraged availability plant nutrient, improve the physical, chemical and biological properties of the soil and thereby increase the fertility and productivity of the soil. Integrated use of FYM and inorganic N, productivity and monetary returns of wheat can be increased by maintaining or improving soil fertility (Sharma *et al*., 2007) [10].

It has been recognized that the soil contain free living bacteria which are capable of fixing nitrogen non-symbiotically. The beneficial effect of *Azotobacter* on plant is associated not only with the process of nitrogen fixation and improved nutrition of plants but also with synthesis of complex biologically active compounds such as nicotinic acid, pantothenic acid, pyridoxine, biotin, gibberellins and other compounds which stimulate the germination of seeds and accelerate the plant growth under favourable environmental conditions (Mishustin, 1970) [5]. Soil also contain some specific group of soil micro-organisms which increase the availability of phosphate to plants, not only by mineralizing organic phosphorus compounds but also by rendering inorganic phosphorus compounds more available to plant (Arora and Gaur, 1979) [1].

Nitrogen is one of the most important elements as well as expensive input in agricultural production. It is a major component of proteins, hormones, chlorophyll, vitamins and enzymes essential for plant life. Phosphorus is also equally necessary element for seed germination, photosynthesis, protein formation and almost all aspects of growth and metabolism in plants. Potassium plays an important role in sugar translocation, disease and drought resistant in plants. It also helps in quality grain production.

Materials and Methods

A field experiment was conducted during winter season of 2014-15 in silt loam soil at instructional farm of Narendra Deva University of Agriculture and technology Kumarganj, Faizabad (26.470 N and 82.120 E). Initial soil characteristics (0-15cm) of the experimental soil were pH 8.25 (1:2.5 soil and water suspension), electrical conductivity 0.35 dSm^{-1} organic carbon 4.40 g kg^{-1}, available N kg ha^{-1}, available P 12 kg ha^{-1}, available K 240 kg ha^{-1}. The treatment consisted of T_1- control, T_2- 100% RDF (120:60:40 kg ha^{-1} N: P_2O_5: K_2O); T_3- 75% RDF, T_4- 75 % RDF + 25 % N-FYM, T_5- 75% RDF+ Bio-fertilizer (*Azotobactor*); T_6- 50% RDF + 50 % N-FYM, T_7- (50 % RDF + 50 %N-FYM + PSB) and T_8- 50 % RDF + *Azotobacter* + PSB. The experiment was laid out in a randomized block design with 3 replications. FYM was applied as per treatment one week prior to pre-sowing irrigation. Wheat crop (CV NW 2036) was sown at proper moisture on first Dec. 2014 at a row spacing of 20 cm. Half of N and full doses of P and K were added at the time of sowing as per treatments. The remaining dose of N was top dressed in two equal splits after 1st and 2nd irrigation. The sources of N, P_2O_5 and K_2O were urea, single super phosphate and mutate of potash, respectively. Yield and yield attributes were recorded at harvest. Soil samples collected before sowing and after harvest of wheat were analyzed for pH and EC in 1:2.5 soil water suspension; organic carbon, available N, available P and available K.

Results and Discussion

Yield and Harvest index: Yield is the result of cumulative response of yield contributing characters which are determine from the growth and development traits. The data presented in table-1 revealed that the maximum grain yield of wheat (41.90 q ha^{-1}) was obtained under T_7- (50 % RDF + 50 % N-FYM + PSB) treatment which which was statistically at par with T_2 - 100% RDF (46.60 q ha^{-1}) T_6- 50 % RDF + 50 % N-FYM (39.88 q ha^{-1}) and T_4- 75 % RDF + 25 % N-FYM (39.55 q ha^{-1}) and significantly superior over rest of the treatments. The minimum grain yield (17.90 q ha^{-1}) of wheat was found in treatment T_1-control. The maximum straw yield (60.65 q ha^{-1}) of wheat was obtained under the treatment T_7- (50 % RDF + 50 % N-FYM + PSB) which was significantly superior over all the treatments except T_2 - 100% RDF (60.33 q ha^{-1}) T_6- 50 % RDF + 50 % N- FYM (57.15 q ha^{-1}) and T_4- 75 % RDF + 25 % N-FYM (57.00 q ha^{-1}). The minimum straw yield (26.50 q ha^{-1}) of wheat was found in treatment T_1-control.

The higher grain yield may be owing to the application of enough nutrients in combination which resulted to greater availability of essential nutrients to plants, improvement of soil environment which facilitate in better root proliferation leading to higher absorption of water and nutrients and ultimately resulting in higher yield. It is also due to more supply of P_2O_5, helps in maintaining better source-sink inter relationship by increasing sink capacity by its role in energy transformation. The results corroborated with observations taken by Devi *et al.*, (2011) [2] and Patel *et al.*, (2014) [7].

The highest harvest index (41.10 %) was calculated with T_6 while minimum harvest index (38.29 %) with control. The respective values of harvest index were calculated with 40.18 %, 40.08 %, 40.96 %, 40.21 %, 41.10 %, 40.85 % and 40.28 % the treatments T_2, T_3, T_4, T_5, T_7 and T_8. In general, the values of harvest index were slightly differs under most of the treatments. Harvest index is a function of economic yield to biological yield (Black and Watson, 1960).

Table 1: Effect of INM on grain yield, straw yield and harvest index of wheat.

Treatments		Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Harvest index (%)
T_1	Control	17.90	26.5	38.288
T_2	100 % RDF	41.60	60.33	40.182
T_3	75 % RDF	32.84	49.09	40.083
T_4	75 % RDF + 25 % N-FYM	39.55	57.00	40.963
T_5	75 % RDF + *Azotobacter*	35.64	53.00	40.219
T_6	50 % RDF + 50 % N-FYM	39.88	57.15	41.101
T_7	50 % RDF + 50 % N-FYM + PSB	41.90	60.65	40.858
T_8	50 % RDF + *Azotobacter* + PSB	34.80	51.75	40.208
SEm±		1.11	2.42	0.61
C.D. (P=0.05)		3.35	7.36	NS

Number of microbial population in soil (g^{-1} soil): The number of microbial population in soil of experimental field after harvesting of wheat crop presented in Table-2 and showed that number of bacteria increased with increasing organic manure in different treatment combination as compared to control. After harvesting of crop, maximum number of bacteria (39.38 X 10^7 g^{-1} soil) was recorded in T_7 (50 % RDF + 50 % N-FYM + PSB) which was statistically at par with value recorded in T_6 (50 % RDF + 50 % N-FYM). Treatment T_7 and T_6 were found significantly higher over rest of treatments while the minimum number (6.21 X 10^7 g^{-1} soil) of bacteria was recorded under treatment T_1 (control). Similar trend also reported in the population of fungi and Actinomycetes in the soil after harvest of wheat crop. It might be due to increase in organic matter in soil resultant microbial population increased. The results corroborated with the finding of Kumar *et al*., (2014) [4].

Table 2: Effect of INM on number of bacteria, fungi, Actinomycetes (g^{-1} soil)

Treatments		No. of bacteria (cfu x 10^7)	No. of fungi (cfu x 10^4)	No. of Actinomycetes (cfu x 10^5)
T_1	Control	6.21	3.18	4.16
T_2	100 % RDF	8.25	4.85	5.32
T_3	75 % RDF	9.14	5.38	6.30
T_4	75 % RDF + 25 % N-FYM	24.65	14.28	16.45
T_5	75 % RDF + *Azotobacter*	11.89	7.06	8.19
T_6	50 % RDF + 50 % N-FYM	38.66	17.60	26.15
T_7	50 % RDF + 50 % N-FYM + PSB	39.38	18.68	27.22
T_8	50 % RDF + *Azotobacter* + PSB	10.12	6.89	8.27
SEm±		0.45	0.24	0.27
C.D. (P=0.05)		1.38	0.7	0.83

Table 3: Effect of INM on N, P, K & Protein (only in grain) content in Wheat grain and straw

Treatments		N content (%)		P content (%)		K content (%)		Protein (%)
		grain	straw	grain	straw	grain	straw	grain
T_1	Control	1.53	0.49	0.43	0.10	0.50	1.43	9.56
T_2	100 % RDF	1.81	0.55	0.49	0.13	0.53	1.52	11.31
T_3	75 % RDF	1.61	0.52	0.47	0.12	0.52	1.43	10.06
T_4	75 % RDF + 25 % N-FYM	1.80	0.54	0.49	0.13	0.53	1.51	11.25
T_5	75 % RDF + *Azotobacter*	1.67	0.53	0.47	0.12	0.52	1.45	10.44
T_6	50 % RDF + 50 % N-FYM	1.80	0.54	0.49	0.12	0.53	1.50	11.25
T_7	50 % RDF + 50 % N-FYM + PSB	1.82	0.55	0.50	0.13	0.54	1.52	11.38
T_8	50 % RDF + *Azotobacter* + PSB	1.62	0.52	0.49	0.12	0.51	1.43	10.13
SEm±		0.02	0.01	0.01	0.001	0.01	0.03	0.32
C.D. (P=0.05)		0.07	0.03	0.02	0.01	0.02	0.09	0.96

Table 4: Effect of INM on NPK uptake (Kg ha^{-1}) by wheat crop.

Treatments		N uptake (Kg ha^{-1})	P uptake (Kg ha^{-1})	K uptake (Kg ha^{-1})
T_1	Control	40.37	10.35	46.85
T_2	100 % RDF	105.48	28.22	113.79
T_3	75 % RDF	78.40	21.33	87.27
T_4	75 % RDF + 25 % N-FYM	101.97	26.79	107.03
T_5	75 % RDF + *Azotobacter*	87.61	23.11	95.38
T_6	50 % RDF + 50 % N- FYM	102.65	26.40	106.86
T_7	50 % RDF + 50 % N- FYM + PSB	110.12	28.83	114.81
T_8	50 % RDF + *Azotobacter* + PSB	83.29	23.26	91.75
SEm±		2.52	0.66	2.32
C.D. (P=0.05)		7.66	2.00	7.05

N, P, K and Protein content in grain and straw of wheat: The maximum NPK content in grain (1.82, 0.50and 0.54 %) and in straw (0.55, 0.13 and 1.52 %) was observed under treatment T_7 (50 % RDF + 50 % N- FYM + PSB) and minimum NPK content in straw (1.53, 0.43 and 0.50 %) and in straw (0.49, 0.10 and 1.43 %) was observed under treatment T_1 (control).

The maximum protein content (11.38 %) was observed in treatment T_7 (50% RDF + 50% N-FYM + PSB) which was statistically at par with T_2 (100% RDF), T_4 (75% RDF + 25% N-FYM), T_5 (75% RDF + *Azotobacter*) and T_6 (50% RDF + 50% N-FYM) and significantly superior over treatments T_1 (control), T_3 (75 % RDF) and T_8 (50% RDF + *Azotobacter* + PSB), while the minimum protein content (9.56 %) was recorded under treatment T_1 (control). These results are in concordance with Ram *et al*., (2014) [8].

Uptake of N, P and K: The nitrogen is mainly responsible for vegetative growth of plants. In all the three macro nutrients, the uptake of potassium was maximum by crop because it involves in translocation process and in a plant its maximum amount was found in wheat straw than seed. Phosphorus is essential for root growth and seed filling process, so its maximum amount was found in wheat seed than straw. The maximum uptake of N (110.12 kg ha^{-1}), P **(**28.83 kg ha^{-1}) and K (114.81 kg ha^{-1}) were observed under treatment T_7 (50 % RDF + 50 % N-FYM + PSB), While minimum uptake of N (40.37 kg ha^{-1}), P (10.35 kg ha^{-1}) and K (46.85 kg ha^{-1}) were observed under T_1 (Control). The uptake of potassium is more in wheat straw than seed. The phosphorus uptake by crop is less in comparison to other macronutrients due to its low availability in soil. The higher nutrient uptake was mainly due to higher biological (straw +

grain) yield. Pandey *et al.* (2007) [6] and Ram *et al*., (2014) [8] also reported similar findings.

Conclusion

Therefore, based on results obtained in this experiment it can be safely concluded that by use of treatment T_7 (50 % RDF + 50 % N-FYM + PSB) we can get maximum grain and straw yield and check the indiscriminate and imbalanced use of chemical fertilizers. The maximum microbial population, nutrient content, protein content and uptake by crop were achieved under treatment T_7 (50 % RDF + 50 % N-FYM + PSB) fallowed by treatment T_6 (50 % RDF + 50 % N-FYM). The application of organic manures or biofertilizers along with inorganic fertilizers sustaining soil fertility, productivity and improved soil health.

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