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Response of Chemical Fertilizers and INM on Productivity of Wheat (*Triticum aestivum* L.) and Properties of Soil

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ABSTRACT

A field experiment was conducted during rabi season of (2020-21) on wheat at Research Farm of Kulbhaskar Ashram Post Graduate College, Prayagraj (UP), to find out the Response of Chemical Fertilizers and INM on Productivity of Wheat (*Triticum aestivum* L.), and Properties of Soil. The experiment laid out in Randomized Block Design (RBD) with eleven treatments and three replications. The results revealed that the highest plant height was recorded in treatment T_{11} (75% RDF $^{+}$5 t ha^{-1} FYM $^{+}$20 kg ha^{-1} $ZnSO_4$ $^{+}$Azotobacter and PSB), which was significantly superior over treatment T_3, T_4 and T_5. The maximum yield attributing characters (number of spikes per m2, spike length, number of grains per spike and test weight), and yield (grain and straw), were increased with treatment receiving 75% RDF $^{+}$5 t ha^{-1} FYM $^{+}$20 kg ha^{-1} $ZnSO_4$ $^{+}$Azotobacter and PSB (T_{11}). The maximum enhancement in grain and straw yield of wheat was recorded in treatment T_{11} (75% RDF $^{+}$5 t ha^{-1} FYM $^{+}$20 kg ha^{-1} $ZnSO_4$ $^{+}$Azotobacter and PSB), which was significantly superior over T_2, T_3, T_4, T_5, T8 and T_9. The maximum protein content (13.18%), in grain of wheat was found in treatment T_{11} (75% RDF $^{+}$5 t ha-1 FYM $^{+}$20 kg ha^{-1} $ZnSO_4$ $^{+}$Azotobacter and PSB), The application of FYM with Chemical Fertilizers and Bio-fertilizers (Azotobacter and PSB) improved in soil pH and EC and also increased the Soil Organic Carbon and Available N, P & K in soil after the harvest of crop. The treatment (T_{11}). was found best in respect of soil properties.

Keywords: INM, Chemical Fertilizers, FYM, Productivity, Soil Properties, Wheat.

INTRODUCTION

Amongst cereals, wheat (*Triticum aestivum* L.) is the most widely cultivated crop of the world and in India, it is the second important food crop, rice being the first. India, one of the greatest success stories of Green Revolution, is the second largest producer of wheat in the world after China. Wheat is popularly consumed in the form of chapatis, purees, Dalia, upama, pastries, biscuits etc. by human beings and wheat straw by cattle. It is an excellent source of carbohydrates (68%), Protein (8-12%), Fat (2%), and it is also source of dietary fiber, iron, vitamins and minerals. In India, the wheat production is about (107.59), million tons from an area of (31.45), million hectares with a productivity of (3421 kg/ha), [1]. In wheat production, Uttar Pradesh rank first followed by MP, Punjab and Haryana. Uttar Pradesh contributes 9.5-million-hectare area with 32.59 million tones production and (3432 kg/ha), average productivity [1]. Due to intensive agriculture the Indian soils are deficient in nutrients particularly in nitrogen and the soil is degrading day by day with respect to soil fertility and productivity. This may be attributed to the minimum and extra removal of nutrient sources from the soil reservoir than they are replenished, so soil is becoming deficient in available nutrients. Since agriculture becomes more intensive and chemical dependent, therefore, soil toxicities and nutrient imbalance threaten sustainable production. So, we have to think about the cheap and easily available alternate source of nutrients, which not only supply the nutrients to the soil but also improves the physical and chemical properties of the soil. Integrated nutrient management (INM), is the concept of judicious use of organic and inorganic sources of nutrients for sustaining and maintaining soil productivity. Continuous use of indiscriminate and imbalance fertilization has a key role to play in obtaining low productivity, so to achieve optimum crop production management of nutrients through judicious application of organic sources, bio-fertilizers and micronutrients are required. The use of chemical fertilizers in conjunction with organic manures (like compost, FYM, Vermicompost, Green manures etc.), bio-fertilizers (like PSB, *Azotobacter*, *Azospirillum*, *Rhizobium*, *VAM* and potash mobilizing bio-fertilizers) that can supplement a part of NPK fertilizers. Organic manure (FYM), and bio-fertilizers (*Azotobacter* & PSB) amendments are feasible ways to reduce chemical fertilizers application in wheat production without decreasing grain yield. Bio-fertilizers are the live formulation of microorganism which have the ability to mobilized plant nutrients in the soil and cheap, low capital intensive, non-bulk and eco-friendly source to boost productivity [2]. To

build ecologically sound and economically viable farming systems, integrated nutrient management (INM), is the only possible approach to sustain soil health and crop production in long run. Combined use of organic, inorganic and biological sources of nutrients plays a vital role in improving the stock of plant nutrients in the soil by increasing the efficiency of plant nutrients, and limiting their losses to the environment. It optimizes the function of the soil biosphere and ultimately sustaining the physical, chemical and biological functioning of soil [3].

Keeping this in view of above facts an attempt was made to study the "Response of Chemical Fertilizers and INM on Productivity of Wheat (*Triticum aestivum* L.), and Properties of Soil" with the following objectives:

1. To study the response of chemical fertilizers and INM on protein content, growth, yield attributing characters and yield of wheat and

2. To study the response of chemical fertilizers and INM on properties of soil

MATERIALS AND METHODS

The field experiment was conducted during *rabi* season of year (2020-21), at the research farm of Kulbhaskar Ashram Post Graduate College, Prayagraj, Uttar Pradesh. Prayagraj (Allahabad), is located between 24°26'N latitudes and 81°56'E longitudes. K.A.P.G. College Prayagraj (U.P.), lies in the southern part of the state in India at an elevation of 98 meter. The climate of Prayagraj is characterized by long and hot summer, a fairly pleasant monsoon and cold seasons. The winter usually extended from mid-November to February and is followed by the summer which continues till about the middle of June. The Rainfall at Prayagraj generally decreases from the South-East to North-West. About (88%), of the annual rainfall is received during the monsoon season. July and August both the month receive maximum rainfall. The annual rainfall of Prayagraj (2020), is 1042 mm and crop duration (Nov-April), total rainfall was 3.56 mm. The maximum and minimum temperature lies 36.62°C and 9.31°C, respectively and the average relative humidity is (71.50%), at during crop duration. The experiment consisted of eleven treatment combinations *viz.*, T_1 (100% RDF), T_2 (75% RDF), T_3 (50% RDF), T_4 (50% RDF $^+$*Azotobacter*), T_5 (50% RDF $^+$20 kg/ha $ZnSO_4$), T_6 (50% RDF $^+$20 kg/ha $ZnSO_4$ $^+$*Azotobacter* $^+$PSB), T_7 (50% RDF $^+$5 t/ha FYM $^+$20 kg/ha $ZnSO_4$ $^+$*Azotobacter* $^+$PSB), T_8 (75% RDF $^+$*Azotobacter*), T_9 (75% RDF $^+$20 kg/ha $ZnSO_4$), T_{10} (75% RDF $^+$20 kg/ha $ZnSO_4$ $^+$*Azotobacter* $^+$PSB), and T_{11} (75% RDF $^+$5 t/ha FYM $^+$20 kg/ha $ZnSO_4$ $^+$*Azotobacter* $^+$PSB), with three replications in a Randomize Block Design (RBD).

The soil of the experimental plot was alluvial with sandy loam in texture. The soil samples were randomly collected from different spots of the experimental field at (0-15), cm soil depths and representative composite sample were subjected to physical and chemical analysis separately. The physical & chemical characteristics of the soil of experimental field are given in (table 1).

Table 1: Mechanical & Chemical analysis of soil

Component	**Percentage**	**Method**
Sand	45.07	Hydrometer method[4]
Silt	31.20	
Clay	23.31	
Texture	Sandy loam	
Parameters	**Value**	**Methods**
pH (1:2.5)	8.18	By pH meter
OC (%)	0.28	Walkley & Black method[5]
EC (dSm)	0.34	By Electrical Conductivity Meter
Available Nitrogen (kg/ha^{-1})	222.10	Alkaline Permanganate method [6]
Available P_2O_5 (kg/ha^{-1})	14.75	0.5M $NaHCO_3$ (pH 8.5) extractable P (Olsen's method)[7]
Available K_2O (kg/ha^{-1})	275.75	1N NH_4OAc extractable K using Flame Photometer[8]

The fertilizers were applied @ 120 kg N, 60 kg P_2O_5, and 40 kg K_2O per ha through urea, di-ammonium phosphate and muriate of potash respectively. Half dose of nitrogen and full dose of phosphorus and potassium were applied as basal dose at the sowing time in all treatments. The remaining half dose of nitrogen was top-dressed after first irrigation of wheat crop. Zn was applied as $ZnSO_4$ in plot as soil application. The PSB was applied in soil at the rate of 12 kg/ha while the *Azotobacter* used as seed treatment at the rate of 200 g per 10 kg of seed. The treatment wise doses of FYM were applied @ 5 t/ha in the field 15 days before sowing of crop. The seed @ 100 kg/ha of wheat variety PBW- 373 was sown at a row distance of 20 cm and 4-5 cm depth in the experimental plots.

Table 2: Chemical Composition of FYM

Particulars	**FYM**
Organic carbon (%)	12.50
N (%)	0.50
P_2O_5 (%)	0.25
K_2O (%)	0.50
Zn (ppm)	13.50

Plants parameters like plant height, no. of spikes/m^2, spike length, number of grains/spikes, yield, soil properties etc., was observed. The protein content was calculated after analyze the N content in grain and value was multiplied with (6.25), The experiment data were analyzed using "Analysis of Variance Techniques" in Randomized Block Design (RBD).

RESULTS AND DISCUSSION

Growth, yield, yield attributes and protein content of wheat

Growth

The highest plant height was recorded in T_{11} (75% RDF $^{+}$5 t/ha FYM $^{+}$20 kg/ha $ZnSO_4$ $^{+}$*Azotobacter* $^{+}$PSB), which was at par with treatments T_1 (100% RDF), T_2 (75% RDF), T_6 (50% RDF $^{+}$20 kg/ha $ZnSO_4$ $^{+}$*Azotobacter* $^{+}$PSB), T_7 (50% RDF $^{+}$5 t/ha FYM $^{+}$20 kg/ha $ZnSO_4$ $^{+}$*Azotobacter* $^{+}$PSB), T_8 (75% RDF $^{+}$*Azotobacter*), T_9 (75% RDF $^{+}$20 kg/ha $ZnSO_4$) & T_{10} (75% RDF $^{+}$20 kg/ha $ZnSO_4$ $^{+}$*Azotobacter* $^{+}$PSB), and significantly superior over T_3 (50% RDF), T_4 (50% RDF $^{+}$*Azotobacter*), & T_5 (50% RDF $^{+}$20 kg/ha $ZnSO_4$), Among all the integrated plots, maximum plant height (102.79 cm), was recorded in treatment T_{11} in which inorganic, organic, bio-fertilizers and micronutrients as sources of nutrients were applied. It may be due to FYM enhance the mineralization of all the nutrients specially nitrogen to stimulate the growth of plants it also increased the humid substances that affected nutrients accumulation and promoted root growth which led to better growth of the plants. The nitrogen has been proved as a constituent of amino acids, proteins and protoplasm which are directly influence the plant growth. The use of bio-fertilizers could be attributed to their multiple action for synthesize growth promoting substances, antifungal and antibiotics which might have been utilized by plants in synthesis of protein, carbohydrates, and other assimilates thereby improving growth of the plants. The results are in confirmation by [9-11].

Yield Attributing Characters

Observation on number of spikes/m^2, spike length, number of grains/spike and test weight increased with integrated use of chemical fertilizers with FYM and bio-fertilizers (*Azotobacter* & PSB), and $ZnSO_4$. However, the treatment receiving (75% RDF $^{+}$@5 t/ha FYM $^{+}$@20 kg/ha $ZnSO_4$ $^{+}$*Azotobacter)*, and (PSB), significantly increased the number of spikes/m^2, spike length and number of grains/spikes over the treatments T_2 (75% RDF), T_3 (50% RDF), T_4 (50% RDF $^{+}$*Azotobacter*), T_5 (50% RDF $^{+}$@20 kg/ha $ZnSO_4$), T_8 (75% RDF $^{+}$*Azotobacter*), & T_9 (75% RDF $^{+}$@20 kg/ha $ZnSO_4$), and was at par with rest of the treatments. These findings indicate that integrated use of chemical fertilizers in conjunction with organic manure, *Azotobacter*, PSB and Zinc sulphate increased the yield attributing characters of wheat. The FYM released nutrients in soil through mineralization process slowly from initial to maturity stage of the wheat crop and enhance the physical, chemical and biological properties of soil. The results are in confirmation with the findings of [12, 13].

Yield and Harvest Index

Maximum grain yield of wheat was noticed in treatment T_{11} (75% RDF $^{+}$5 t/ha FYM $^{+}$20 kg/ha $ZnSO_4$ $^{+}$*Azotobacter* $^{+}$PSB), which was significantly superior over the treatments T_2 (75% RDF), T_3 (50% RDF), T_4 (50% RDF $^{+}$*Azotobacter*), T_5 (50% RDF $^{+}$20 kg/ha $ZnSO_4$), T_8 (75% RDF $^{+}$*Azotobacter*), & T_9 (75% RDF $^{+}$20 kg/ha $ZnSO_4$), and at par with the treatments T_1 (100% RDF), T_6 (50% RDF $^{+}$20 kg/ha $ZnSO_4$ $^{+}$*Azotobacter* $^{+}$PSB), T_7 (50% RDF $^{+}$5 t/ha FYM $^{+}$20 kg/ha $ZnSO_4$ $^{+}$*Azotobacter* $^{+}$PSB), and T_{10} (75% RDF $^{+}$20 kg/ha $ZnSO_4$ $^{+}$*Azotobacter* $^{+}$PSB), The maximum enhancement in yield (42.65%), was recorded in T_{11} as compared to treatment T_3 (50% RDF). The plot T_{11} (75% RDF $^{+}$5 t/ha FYM $^{+}$20 kg/ha $ZnSO_4$ $^{+}$*Azotobacter* $^{+}$PSB), produced maximum straw yield (75.72 q/ha), which was significantly superior over the treatments T_2 (75%RDF), T_3 (50%RDF), T_4 (50% RDF $^{+}$*Azotobacter*), T_5 (50% RDF $^{+}$20 kg/ha $ZnSO_4$), T_8 (75% RDF $^{+}$*Azotobacter*), & T_9 (75% RDF $^{+}$20 kg/ha $ZnSO_4$), and was at par with the treatments T_1 (100% RDF), T_6 (50% RDF $^{+}$20 kg/ha $ZnSO_4$ $^{+}$*Azotobacter* $^{+}$PSB), T_7 (50% RDF $^{+}$5 t/ha FYM $^{+}$20 kg/ha $ZnSO_4$ $^{+}$*Azotobacter* $^{+}$PSB), and T_{10} (75% RDF $^{+}$20 kg/ha $ZnSO_4$ $^{+}$*Azotobacter* $^{+}$PSB), All the treated plots produced higher straw yield of wheat as compared to plot receiving (50%), RDF. This may be due to integrated use of chemical fertilizers with organic and bio-fertilizers with zinc not only maintaining soil fertility and productivity of crop but also in providing greater stability in crop production by synergistic effect of FYM on improving efficiency, optimum dose of NPK and corrective deficiency of zinc. Similar observations were observed by [13-15].

Harvest index which denotes the proportion of grain yield to the above ground biomass. The maximum harvest index was noted in treatment T_{11} (75% RDF $^{+}$@5 t/ha FYM $^{+}$@20 kg/ha $ZnSO_4$ $^{+}$*Azotobacter* $^{+}$PSB), It could be due to higher supply of photosynthates to reproductive part as compared to vegetative biomass to sustain higher index. Similar observations were observed by [16, 17].

Protein content

The maximum protein content in grain of wheat found in treatment T_{11} (75% RDF $^{+}$@5 t/ha FYM $^{+}$@20 kg/ha $ZnSO_4$ $^{+}$*Azotobacter* and PSB), It may be due to application of zinc play an important role in synthesis of protein, nucleic acid and utilization of NPK present in soil. The protein content and protein yield being the function of nitrogen content and its uptake also increased with increase in nitrogen content. These results are in close conformity with the findings of [18, 19].

Soil Properties

Soil pH & EC

Maximum decline in soil pH and EC were recorded with treatment receiving (50% RDF $^{+}$@5 t/ha FYM $^{+}$@20 kg/ha $ZnSO_4$ $^{+}$ *Azotobacter* and PSB (T_7), due to ameliorative nature of organic manures. The soil pH and EC decline slightly in treatment which receiving combination of organic and inorganic sources of nutrients. This may be due to release of various organic acids during decomposition of these organic manures. The results closely corroborate with the finding of [20, 21].

Organic Carbon

Organic carbon in soil increased with the combined application of organic sources of nutrients (FYM), with chemical fertilizers. The maximum organic carbon content in soil was recorded with the application of (75% RDF $^{+}$@5 t/ha FYM $^{+}$@20 kg/ha $ZnSO_4$ $^{+}$*Azotobacter* and PSB), in T_{11} treatment. It was due to the addition of FYM with chemical fertilizers and bio-fertilizers creative environment conducive for formation of humid acid, stimulated the activity of soil microorganism resulted an increase in the organic carbon content of soil. Similar results were reported by [12, 22].

Available Nitrogen (kg/ha)

The treatment T_{11} (75% RDF $^{+}$5 t/ha FYM $^{+}$20 kg/ha $ZnSO_4$ $^{+}$*Azotobacter* $^{+}$PSB), in which all the sources of nutrients was applied recorded highest content of available nitrogen in soil which was at par with T_1 (100% RDF), T_2 (75% RDF), T_7 (50% RDF $^{+}$5 t/ha FYM 20 kg/ha $ZnSO_4$ $^{+}$*Azotobacter* $^{+}$PSB), T_8 (75% RDF $^{+}$*Azotobacter*), and T_{10} (75% RDF $^{+}$20 kg/ha $ZnSO_4$ $^{+}$Azotobacter $^{+}$PSB), and significantly superior over T_3 (50% RDF), T_4 (50% RDF $^{+}$*Azotobacter*), T_5 (50% RDF $^{+}$20 kg/ha $ZnSO_4$), T_6 (50% RDF $^{+}$20 kg/ha $ZnSO_4$ $^{+}$*Azotobacter* $^{+}$PSB), and T_9 (75% RDF $^{+}$20 kg/ha $ZnSO_4$), Increased in available nitrogen could be due to conjunctive use of FYM and bio-fertilizers with chemical fertilizers. The increase in N, P and K status of the soil increased because of the application of

organic manure, and PSB with chemical fertilizers which also enhanced the activity of microbial populations reported by [20-23].

Available Phosphorus (kg/ha)

The maximum available phosphorus content was analyzed in treatment T_{11} (75% RDF $^{+}$5 t/ha FYM $^{+}$20 kg/ha $ZnSO_4$ $^{+}$*Azotobacter* $^{+}$PSB), which was at par with T_1 (100% RDF), T_6 (50% RDF $^{+}$20 kg/ha $ZnSO_4$ $^{+}$*Azotobacter* $^{+}$PSB), T_7 (50% RDF $^{+}$5 t/ha FYM $^{+}$20 kg/ha $ZnSO_4$ $^{+}$*Azotobacter* $^{+}$PSB), T_8 (75% RDF $^{+}$*Azotobacter*), and T_{10} (75% RDF $^{+}$20 kg/ha $ZnSO_4$ $^{+}$*Azotobacter* $^{+}$PSB), and significantly superior over T_2 (75% RDF), T_3 (50% RDF), T_4 (50% RDF $^{+}$*Azotobacter*), T_5 (50% RDF $^{+}$20 kg/ha $ZnSO_4$), and T_9 (75%RDF + 20 kg/ha $ZnSO_4$). The available phosphorus was increased (7.4%), in treatment T_{11} as compared to (100% RDF), It may be due to use of PSB solubilize the native soil phosphorus resulting in increased P availability in soil. This is confirmation with finding of [20, 23, 24].

Available Potassium (kg/ha)

Maximum potassium content in soil was noticed in treatment T_{11} (75% RDF $^{+}$@5 t/ha FYM $^{+}$@20 kg/ha $ZnSO_4$ $^{+}$*Azotobacter* and PSB), after harvest of wheat crop. The increased in available potassium was under integrated use of organic sources might be due to release more non exchangeable K from the soil. The application of organic manures might have enhanced CEC and caused reduction in K fixation and solubilising action of certain organic acids produces during decomposition and increase capacity to hold K in available form. The increase in K was reported by [12, 21].

Table 2: Response of chemical fertilizers & INM on growth, yield attributes, yield and protein content of wheat

S. No.	Plant height (cm)	Number of spikes m^{-2}	Spike length (cm)	No. of grains $spike^{-1}$	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Test Weight (g)	Harvest Index (%)	Protein content in grain (%)
T_1	100.73	377	12.57	44.27	40.68	67.50	41.88	37.60	12.46
T_2	100.52	346	12.06	39.56	35.42	58.36	38.10	37.76	11.23
T_3	97.60	315	11.52	35.91	32.35	53.17	37.20	37.82	10.26
T_4	98.21	340	11.66	36.92	32.47	54.30	38.94	37.42	10.57
T_5	99.42	348	11.85	38.24	34.12	56.59	40.10	37.61	11.10
T_6	100.91	380	12.77	44.25	41.32	69.80	42.62	37.18	12.46
T_7	101.80	393	13.54	45.80	44.38	74.00	44.14	37.48	12.99
T_8	100.56	363	12.24	40.67	38.46	63.96	41.08	37.55	12.31
T_9	100.65	360	12.36	42.33	39.16	65.70	41.15	37.34	12.32
T_{10}	101.05	378	12.91	44.82	42.48	71.40	43.13	37.30	12.54
T_{11}	102.79	406	13.94	48.03	46.18	75.72	44.65	37.88	13.18
SEm±	0.92	10.16	0.48	1.77	1.93	3.07	1.12	-	0.22
CD at 5%	2.71	29.98	1.42	5.23	5.70	9.08	3.32	-	0.67

Table 3: Response of Chemical Fertilizers and INM on Soil Properties

S. No.	Soil pH (1:2.5)	Soil EC (dSm^{-1})	Organic Carbon (%)	Available N (Kg ha^{-1})	Available P_2O_5 (Kg ha^{-1})	Available K_2O (Kg ha^{-1})
T_1	8.34	0.41	0.47	239.23	18.90	254.34
T_2	8.31	0.39	0.46	234.50	18.42	249.02
T_3	8.27	0.36	0.38	219.04	17.40	238.60
T_4	8.24	0.39	0.41	224.89	17.81	243.00
T_5	8.26	0.36	0.40	226.65	17.68	241.02
T_6	8.27	0.35	0.42	232.45	19.24	245.60
T_7	8.20	0.34	0.49	240.78	19.63	249.00
T_8	8.30	0.39	0.46	235.72	18.47	251.58
T_9	8.32	0.40	0.42	230.05	17.33	252.60
T_{10}	8.29	0.38	0.45	237.50	19.95	252.74
T_{11}	8.21	0.36	0.51	243.60	20.30	257.56
SEm±	0.094	0.015	0.022	3.63	0.62	2.20
CD at 5%	NS	NS	0.065	10.71	1.84	9.44

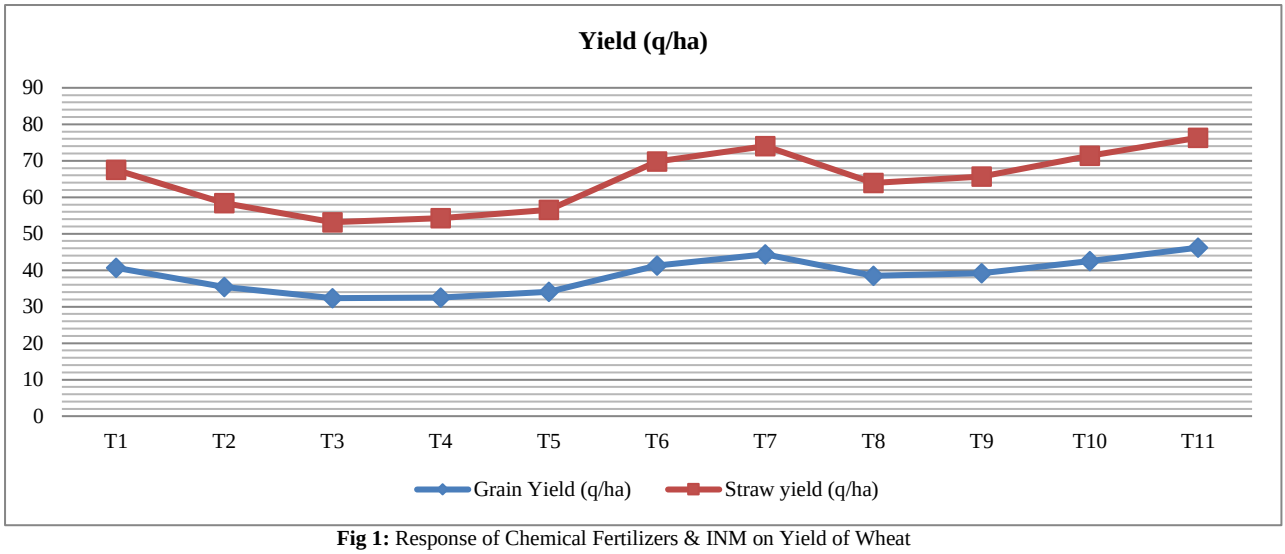

Fig 1: Response of Chemical Fertilizers & INM on Yield of Wheat

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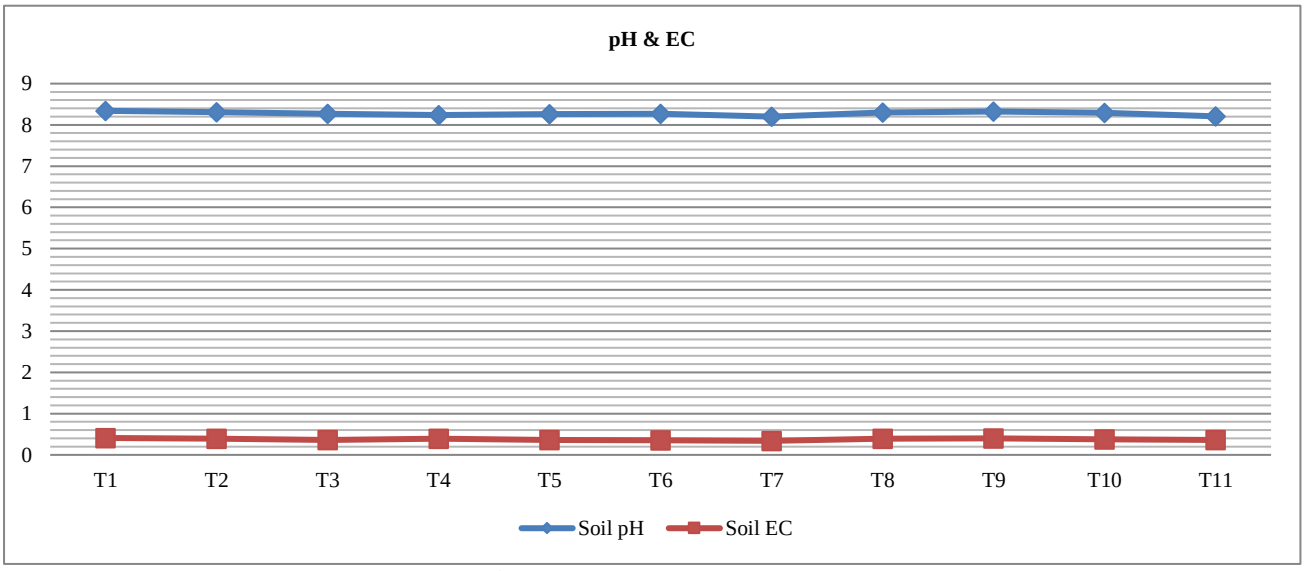

Fig 2: Response of Chemical Fertilizers & INM on Soil pH & ECe

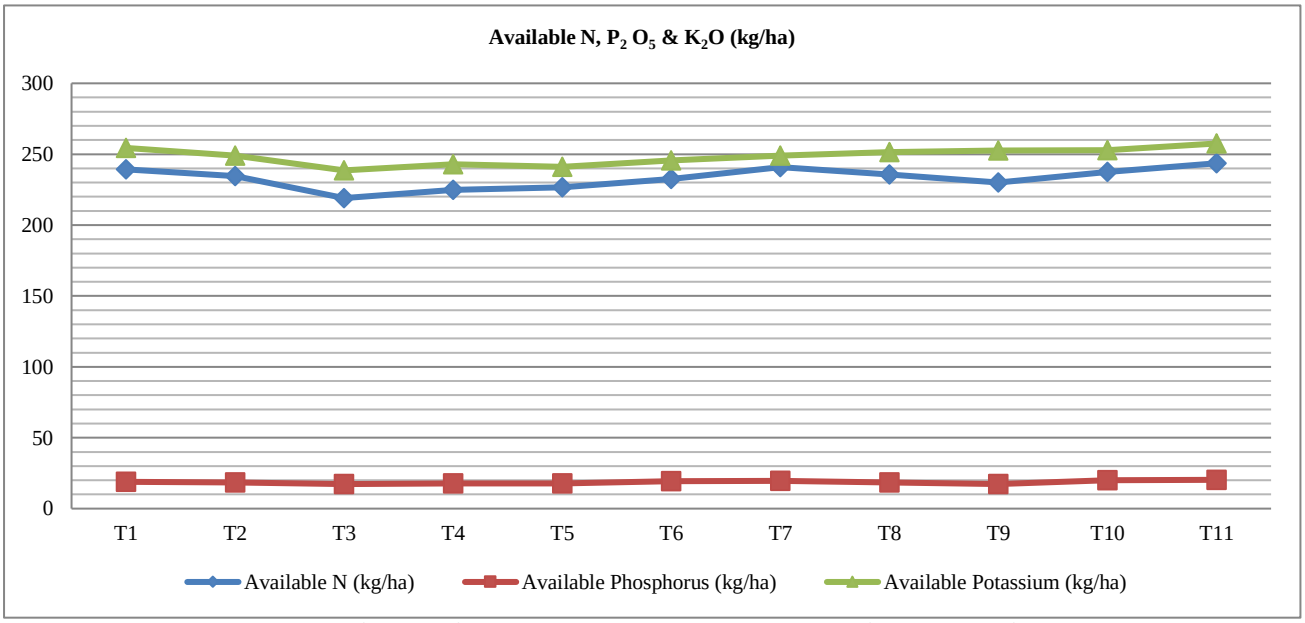

Fig 3: Response of chemical fertilizers & INM on available N, P_2O_5 & K_2O after the harvest of cro

CONCLUSION

On the basis of experimental findings following conclusion could be drawn:

1. Integrated use of chemical fertilizers, FYM, *Azotobacter*, PSB and $ZnSO_4$ increased the growth, yield attributing characters and yield of wheat and also increased the protein content in wheat grain as compared to chemical fertilizers alone.
2. Combined use of chemical fertilizers, FYM, *Azotobacter*, PSB and $ZnSO_4$ as a source of nutrients improved the properties of soil in respect to soil pH & EC, of organic carbon and available nitrogen, phosphorus and potassium in the soil.
3. Finally, the treatment T_{11} (75% RDF $^{+}$@5 t/ha FYM $^{+}$@20 kg/ha $ZnSO_4$ $^{+}$*Azotobacter* $^{+}$PSB), proved better for increasing wheat yield and improved properties of soil and it may be recommend to the farmers.

Conflict of Interest

None declared.

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