EFFECT OF INM ON GROWTH INDICES, YIELD ATTRIBUTES, YIELD AND ECONOMICS OF WHEAT (*Triticum aestivum* L. emend. Fiori & paol.)

ABSTRACT

The experiment was conducted at farmers field in Haridwar district of Uttarakhand during 2019-20 and 2020-21. The experiment consisted of eleven treatments *viz.* control (T_1), 100 % RDF (T_2), FYM @ 10 t/ha (T_3), VC @ 5t/ha (T_4), 75 % RDF + FYM @ 10t/ha (T_5), 75 % RDF + VC @ 5 t/ha (T_6), 50 % RDF + FYM @ 10 t/ha (T_7), 50 % RDF + VC @ 5 t/ha (T_8), 50 % RDF + FYM @ 10 t/ha + VC @ 5t/ha (T_9), 75 % RDF + FYM @ 10 t/ha+ Azotobacter + PSB (T_{10}), 75 % RDF + VC @ 5 t/ha+ Azotobacter + PSB (T_{11}). The treatments were replicated thrice and were laid out in randomized block design (RBD). Wheat variety used for the experimentation was PBW 343. The net plot size was 5 m × 5 m and crop spacing was 20cm between rows. The results reported that wheat crop with the application of 75 % RDF + VC @ 5 t/ha+ Azotobacter + PSB (T_{11}) performed better in terms of growth parameters and yield under field condition compared to some of the treatments. Significantly higher B: C (2.9) ratio was calculated for 75 % RDF + FYM @ 10 t/ha+ Azotobacter + PSB (T_{11}). Percent increase of 5.5 % and 3.6 % was recorded during 2019-20 and 2020-21, respectively in grain yield with the application of 75 % RDF + VC @ 5 t/ha+ Azotobacter + PSB (T_{11}) over 100 % RDF (T_2). Maximum net returns were estimated in treatment T_{10} (75 % RDF + FYM @ 10 t/ha+ Azotobacter + PSB) of Rs. 97288 and Rs. 102005 followed by treatment T_{11} (75 % RDF + VC@ 5 t/ha+ Azotobacter + PSB) during both the years. Sowing on 20th November with GW 451 produced the highest returns and benefit-cost ratio. These results suggest that combined application of 75 % RDF + vermicompost @ 5 t/ha+ Azospirillum + PSB or 75 % RDF + FYM @ 10 t/ha+ Azotobacter + PSB is effective to get higher yield net return in wheat cultivation, providing valuable insights for farmers and researchers.

KEY WORDS: Wheat, FYM, Vermicompost, yield, INM

INTRPODUCTION

Wheat (*Triticum aestivum* L. emend. Fiori & paol.) belongs to family "*Graminae*" and genus "*Triticum*". "It is primarily grown in temperate region and at higher altitude under tropical climatic areas in winter season. It requires relatively low temperature for satisfactory growth and development. Wheat is the most important staple food crop of the world and emerged as the backbone of India's food security. Wheat grain contains 10-12% protein, which is more than other cereals. Dry and cool weather is most suitable for this crop. The optimum temperature required for ideal germination of the wheat crop ranges from 20 to 25 ºC. It is an important winter cereal contributing about 38% of the total food grain production in India. In the world, wheat was cultivated in an area of about 221.41 million hectares with a total production of 780.29 million tonnes of grains with productivity of 3.52 t/ha (WAP, 2023) during the year 2021-22. In India, total area was 31.13 million hectares with annual production was 109.59 million tonnes of grains during the year 2021-22 with the average productivity of 3.52 t/ha" (WAP, 2023). "India is the second largest wheat producer and consumer after China. In India, the major wheat growing states are Uttar Pradesh, Madhya Pradesh, Punjab, Haryana, Rajasthan, Bihar, Maharashtra and Gujarat. 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 farmyard manure should be encouraged as it supplies plant nutrient, improve the physical, chemical and biological properties of the soil and thereby increase the fertility and productivity of the soil. It has been recognized that Continuous application of organic manures year after year improves physical and chemical conditions by providing a favourable soil structure, enhance soil cation exchange capacity, increase the quantity and availability of plant nutrients, increase humus content, and providing the substrate for microbial activities" (Bohme and Bohme, 2006). "By using organic manure alone lower yield in wheat was observed which shows organic manure alone cannot satisfy the nutrients demands of wheat" (Sheoran et al., 2017).

"The accessibility of the crop to the soil determines the fertilizer requirement of wheat" (Krentos and Orphanos, 1979). "Nutrient use efficiency and water use efficiency are found higher in INM" (Jat et al., 2015). "Production of wheat grain and straw increased by 9 percent with the treatment of INM with municipal solid waste manure in the cotton wheat system" (Akram et al., 2007). "For sustainable crop production the integrated use of chemical and organic fertilizer has been highly beneficial" (Yasin *et al.*, 2015). The main objective of this study was to know about the effect of Integrated Nutrient Management on yield and yield attributing character, total organic carbon, and total organic matter content, nutrient uptake, soil productivity, growth parameter, and the role of INM in reducing environmental impact and controlling the disease.

Therefore, an attempt was made to enhance the productivity through integrated nutrient management in wheat.

METHODS

An investigation was carried out at farmers field of village Telpura in Haridwar district of Uttarakhand to study the effect of integrated nutrient management on growth and productivity of wheat during two consecutive seasons of the years 2019-20 and 2020-21. The soil of the experiment site is silty clay loam in texture and slightly alkaline in reaction. Soil is medium in organic carbon content, low in available nitrogen and phosphorus, potassium. An experiment was conducted in Randomized block design with three replications which included eleven treatments *viz.* control (T_1), 100 % RDF (T_2), FYM @ 10 t/ha (T_3), VC @ 5t/ha (T_4), 75 % RDF + FYM @ 10t/ha (T_5), 75 % RDF + VC @ 5 t/ha (T_6), 50 % RDF + FYM @ 10t/ha (T_7), 50 % RDF + VC @ 5 t/ha (T_8), 50 % RDF + FYM @ 10t/ha + VC @ 5t/ha (T_9) , 75 % RDF + FYM @ 10 t/ha+ Azotobacter + PSB (T_{10}), 75 % RDF + VC @ 5 t/ha+ Azotobacter + PSB (T_{11}). Sowing date of wheat in 2019-20 and 2020-21 was 22-11-2019 and 25-11-2020, respectively. The spacing adopted was 20 cm between rows. Plot size was 5 m x 5 m. Wheat variety used for the experimentation was PBW 343. To supply nitrogen, phosphorus and potassium fertilizers used were urea, DAP and MOP. Full dose of phosphorus and potassium and half dose of nitrogen were applied as basal and remaining half dose of nitrogen was split into two applications one at 30 DAS and another at 60 DAS. Irrigation was applied as and when required. Farm yard manure @ 10 t/ha and vermicompost @ 5t/ha was applied at the time of field preparation as per the treatments. Similarly, seed were primed with Azotobacter @ 20g/kg seeds and PSB (Phosphorus solubilising bacteria) as per the treatments. The data was subjected to statistical analysis following standard procedures (Cochran and Cox, 1967). Benefit accrued was calculated in terms of net returns computed after deducting fixed and variable costs of cultivation.

RESULTS AND DISCUSSION

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Crop Growth rate

The study of data enumerated in Table 1 revealed that crop growth rate (g/cm$^{2/}$day) was significantly affected at all the crop growth stages under the influence of different sources of nutrients in integrated nutrient management. At 30 DAS the maximum CGR (2.5gm/cm^2 /day and 2.6g/cm^2 /day) in 2019 and 2020, respectively) was observed in 100% RDF which was at par with 75% RDF +FYM @ 10 t/ha + Azo + PSB (2.3g/ cm^2 /day and 2.5 g/cm^2/day/) and 75% RDF +vermicompost @ 5 t/ha + Azo + PSB (2.4g/ cm^2 /day and 2.5g/ cm^2/day) and remarkably higher than rest of the treatments. At 60 DAS the maximum CGR (5.5g/cm^2/day and 5.7g/cm^2/day in 2019 and 2020, respectively) was observed with the application of 75% RDF +Vermicompost @ 5 t/ha + Azo + PSB which is at par with 100% RDF (5.1 g/cm^2/day) and 75% RDF + FYM @ 10 t/ha + Azo + PSB (5.5g/cm^2/day) in 2019 and 100 % RDF (5g/ cm^2 /day), 75% RDF + vermicompost @ 5 t/ha (5.2g/ cm^2/day) and 75% RDF +FYM @ 10 t/ha + Azo + PSB (5.5 g/ cm^2 /day) in 2020 and remarkably higher than rest of the treatments.

Table 1: Crop growth rate (g/cm^2/day) of wheat crop

Treatments	30 DAS		60 DAS		90 DAS	
	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
T_1	1.3	1.3	2.9	2.9	19.6	19.6
T_2	2.5	2.6	5.1	5.0	24.5	24.4
T_3	1.4	1.5	3.2	3.2	20.6	20.6
T_4	1.5	1.6	3.2	3.2	20.9	20.9
T_5	2.0	2.1	4.8	4.9	23.8	23.8
T_6	2.1	2.2	5.2	5.2	24.1	24.1
T_7	1.6	1.6	4.0	4.0	21.1	21.1
T_8	1.9	2.0	4.1	4.1	24.3	24.3
T_9	1.8	1.9	3.9	3.9	23.2	23.3
T_{10}	2.3	2.5	5.5	5.5	24.7	24.7
T_{11}	2.4	2.5	5.5	5.7	25.4	25.5
SEm±	0.1	0.1	0.2	0.2	0.9	0.9
CD at 5 %	0.2	0.2	0.6	0.6	2.5	2.5

At 90 DAS the maximum CGR (25.4g/cm^2/day and 25.5g/cm^2/day in 2019 and 2020, respectively) was observed with the application of 75% RDF + vermicompost @ 10 t/ha + Azo +PSB which was statistically at par with 100 % RDF (24.5g/cm^2/day and 24.4g/cm^2/day), 75% RDF + FYM @ 10 t/ha (23.8g/ cm^2/day and 23.8g/ cm^2/day), 75% RDF + vermicompost @ 5 t/ha (24.1g/cm^2/day and 24.1 g/cm^2/day), 50%RDF + 50% vermicompost (24.3g/ cm^2/day and 24.3 g/ cm^2/day) , 50% RDF + vermicompost @ 5 t/ha +

FYM @ 10 t/ha (23.2g/cm^2/day and 23.3 g/ cm^2/day) and 75% RDF + FYM @ 10 t/ha + Azo + PSB (24.7 g/cm^2 /day and 24.7 g/ cm^2/day) which was remarkably higher then rest of the treatments in both year of experimentation. This might be due to higher microbial population in this treatment. Azotobacter is a heterotrophic bacterium and requires organic carbon as a source of energy which is present in abundance in fields supplied with organic manures **(Narayan and Kehri, 2011).**

Relative Growth Rate

The data presented in Table 2 revealed that relative growth rate (mg/g/day) was significantly affected under the influence of different sources of nutrients in integrated nutrient management. During both the years of the experimentation at 0-30 DAS the maximum value (0.062 mg/g/day and 0.062 mg/g/day in 2019 and 2020, respectively) of RGR was found with the application of 100% RDF and 75 % RDF + vermicompost @ 5 t/ha + Azo + PSB which is at par with 75% RDF + FYM @ 10 t/ha + Azo + PSB. At 30-60 DAS the maximum value (0.74 mg/g/day and 0.74 mg/gm/day in 2019 and 2020, respectively) of RGR was found with the application of 75 % RDF+ FYM @ 10 t/ha + Azo + PSB and 75% RDF+ FYM @ 10 t/ha +Azo + PSB which was statistically at par with 100% RDF (0.73 mg/g/day), 75% RDF + FYM @ 10 t/ha (0.072mg/gm/day) and significantly higher than other treatments.

Table 2. Relative to relative growth rate (mg/g/day) of wheat crop

Treatments	**0-30 DAS**		**30-60 DAS**		**60-90 DAS**	
	2019-20	**2020-21**	**2019-20**	**2020-21**	**2019-20**	**2020-21**
T_1	0.053	0.053	0.065	0.065	0.092	0.092
T_2	0.062	0.063	0.073	0.073	0.096	0.095
T_3	0.055	0.055	0.066	0.066	0.093	0.093
T_4	0.055	0.056	0.066	0.066	0.093	0.093
T_5	0.059	0.060	0.072	0.072	0.095	0.095
T_6	0.060	0.060	0.073	0.073	0.095	0.095
T_7	0.056	0.056	0.069	0.069	0.093	0.093
T_8	0.058	0.059	0.070	0.070	0.095	0.095
T_9	0.058	0.058	0.069	0.069	0.095	0.095
T_{10}	0.061	0.062	0.074	0.074	0.096	0.096
T_{11}	0.062	0.063	0.074	0.074	0.096	0.096
SEm±	0.000	0.000	0.001	0.001	0.001	0.001
CD at 5 %	0.001	0.001	0.002	0.002	0.002	0.002

At 60-90 DAS the maximum value (0.096 mg/g/day) found with application of 75% RDF+ FYM @ 10 t/ha + Azo+ PSB, 75% RDF+ vermicompost @ 5 t/ha + Azo+ PSB and 100% RDF which is significantly higher than control, vermicompost @ 5 t/ha , FYM @ 10 t/ha and 50% RDF + vermicompost @ 5 t/ha and in second year maximum value (0.096

mg/gm/day) of RGR was found with the application of 75% RDF+ FYM @ 10 t/ha + Azo+ PSB, 75% RDF+ Vermicompost @ 5 t/ha + Azo+ PSB which is statistically higher than control, vermicompost @ 5 t/ha, FYM @ 10 t/ha and 50% RDF +Vermicompost @5 t/ha and significantly at par with rest of the treatments. It might be due to synergistic effect of organic manures, biofertilizers and reduced chemical fertilizers on nutritional environment of soil which have possibly favoured crop growth **(Pathak *et al.*, 2002).**

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Spikes/m^2

The effect of different treatment combinations was found to be significant on number of spikes/m^2 during both the years of the experimentation. During both year of experimentation, the maximum value was obtained (399.5 spike/m^2 and 407.8 spike/m^2 in 2019 and 2020 respectively) with the application of 75% RDF + vermicompost @ 5 t/ha + Azo + significantly surpassed all the treatments except 100%RDF (388.7 spike/m^2 and 393.7 spike/m^2) and 75% RDF + FYM @ 10 t/ha + Azo + PSB (389.9 spike/m^2 and 395.8 spike/m^2), respectively in 2019 and 2020. Application of 75% RDF + vermicompost @ 5 t/ha + Azo + PSB recorded 95.1 % and 97.5% higher number of spikes per m^2 over control, respectively in 2019 and 2020.

Table 3: Yield attributes of wheat crop

Treatments	Spikes/m^2		Spike length (cm)		Grains/ spikes	
	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
T_1	204.8	206.5	7.4	7.7	34.7	35.0
T_2	388.7	393.7	16.6	17.2	48.4	49.1
T_3	214.5	215.7	8.9	8.6	36.5	37.2
T_4	224.3	226.0	10.7	10.9	39.5	40.0
T_5	371.0	374.9	15.7	16.3	44.4	46.2
T_6	380.6	384.9	16.3	16.7	47.0	48.2
T_7	288.7	290.5	12.4	12.6	41.6	42.3
T_8	351.1	354.4	15.2	15.7	43.8	44.2
T_9	323.1	325.6	14.7	14.9	41.8	42.5
T_{10}	389.9	395.8	16.8	17.9	48.6	51.4
T_{11}	399.5	407.8	17.5	18.7	50.5	54.4
SEm±	10.0	10.0	0.4	0.4	1.2	1.3
CD at 5 %	29.4	29.4	1.2	1.2	3.4	3.9

It might be possibly due to enhanced mineralization and uptake of nutrients. Increased microbial population in rhizosphere positively affects rooting pattern of crop, mineralization of nutrients and increases nutrient uptake by the crop **(Grayndler, 2000).**

Spike length (cm)

The perusal of data presented in Table 3 showed that spike length was significantly affected during both years of the study. During first year maximum spike length was observed in 75% RDF + vermicompost @ 5 t/ha +Azo + PSB (17.5cm) which is at par with 100% RDF (16.6cm), 75% RDF + vermicompost @ 5 t/ha (16.3cm) and 75% RDF + FYM @ 10 t/ha +Azo + PSB (16.8cm) and remarkably higher than rest of the treatment whereas during the second year the maximum spike length was observed in 75% RDF + vermicompost @ 5 t/ha +Azo+ PSB (18.7cm) i.e. 75% RDF + Vermicompost @ 5 t/ha Azo + PSB which is remarkably higher than all treatments except 75% RDF + FYM @ 10 t/ha +Azo + PSB (17.9cm).

Number of grains/ spikes

The data summarized in Table 3 showed that the number of grains/spikes during both the year. Significantly higher number of grains/spike (50.5/spike in 2019 and 54.4/spike 2020) were obtained with the application of 75% RDF + vermicompost @ 5 t/ha + Azo + PSB. It was statistically at par with 100 % RDF (48.4/spike) and 75% RDF + FYM @ 10 t/ha + Azo + PSB (48.6/spike) during 2019 and 75% RDF + FYM @ 10 t/ha + Azo + PSB (51.4/spike) during 2020 and significantly higher than the remaining treatments. This might be due to additive effect of vermicompost+ Azotobacter + PSB and chemical fertilizer in supplying optimum nutrients to the crop and increased synthesis of biologically active substances *viz.* vitamins gibberellins, auxins etc. the results are in conformity with **Singh *et al.* (2013).**

Grain yield

The observed data presented in Table 4 showed that grain yield was significantly affected during both years of the study. The maximum grain yield (51.4 q/ha and 54.4 q/ha in year 2019 and 2020, respectively) was obtained with the application of 75% RDF + vermicompost @ 5 t/ha + Azo + PSB) which is at par with the 100% RDF (48.7 q/ha), 75% RDF + vermicompost @ 5 t/ha (47.8 q/ha) and 75% RDF + FYM @ 10 t/ha + Azo +PSB (50.9 q/ha) in 2019 and 100 % RDF (50.8 q/ha) 75% RDF + FYM @ 10 t/ha + Azo + PSB (52.4) in 2020 and statistically higher than rest of the treatments. It may be attributed to higher yield attributes in this treatment. Similar results were obtained by **Datta *et al.* (2009)** and they reported that highest seed yield of wheat crop was obtained with application of *Azophos*, organic manures and reduced chemical fertilizers. **Parewa *et al.* (2018)** reported 10-30 % yield increment with application of biofertilizers.

Table 4: Effect of INM on yield and test weight of wheat crop

Treatments	Grain yield (q/h)		Straw yield (q/ha)		Test weight (g)	
	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
T_1	27.5	28.0	39.7	42.2	38.8	38.9
T_2	48.7	50.8	69.9	72.5	41.1	41.4
T_3	31.8	32.5	50.1	51.0	40.1	40.4
T_4	36.8	37.9	60.3	61.5	40.1	40.3
T_5	46.5	47.9	66.6	68.8	40.5	40.8
T_6	47.8	49.1	69.6	71.4	40.8	41.1
T_7	43.4	44.6	62.3	63.5	40.1	40.2
T_8	45.7	46.8	65.6	67.4	40.3	40.5
T_9	44.5	45.7	63.9	65.9	40.2	40.4
T_{10}	50.9	52.4	73.0	75.3	41.5	41.7
T_{11}	51.4	54.4	73.1	77.3	41.6	41.8
SEm±	1.3	1.2	1.8	1.9	0.6	0.6
CD at 5 %	3.8	3.6	5.2	5.6	1.7	1.7

Straw yield

The data summarized in Table 4 showed that the number of straw yields during both the year was significantly affected under the influence of different sources of nutrients. Maximum straw yield was obtained from the 75% RDF + vermicompost @ 5 t/ha + Azo +PSB (73.1 q/ha and 77.3 q/ha in 2019 and 2020 respectively) which is at par with 100% RDF (69.9), T_6 (69.6) and 75% RDF+ FYM @ 10 t/ha + Azo + PSB (73 q/ha) in 2019 and 100% RDF (72.5 q/ha) and 75% RDF + vermicompost @ 5 t/ha + Azo + PSB (75.3 q/ha) in 2020 and statistically higher than rest of the treatments. **Gayatri *et al.* (2021)** reported that application of biofertilizers enhanced grain and straw yield significantly.

Test weight

The data set in table 4 reveals that the applications of various sources of nutrients failed to show any significant effect on the test weight of the crop during both the years of the study. However, numerically highest value (41.6g and 41.8g, respectively in 2019 and 2020) was obtained with the application of 75 %RDF +VERMICOMPOST @ 5 t/ha +Azo + PSB and lowest (38.8g and 38.9g, respectively in 2019 and 2020) with control during both year of experimentation.

Economics

The economics of different treatments are given in the Table5. Data show that maximum net returns were estimated in treatment T_{10} (75 % RDF + FYM @ 10 t/ha+ Azotobacter + PSB) followed by treatment T_{11} (75 % RDF + VC@ 5 t/ha+ Azotobacter + PSB). Treatment control (T_1) secured lowest net return. Similar trend was also observed in case of benefit cost ratio. It was highest in treatment T_{10} followed by treatment T_5. Similar results were reported by **Devi *et al.* (2011)** that with the supplementation of NPK fertilizers with PSB and vermicompost @ 1t/ha increased net return of wheat crop production. **Kumar *et al.* (2016)** also reported that application of 75 % RDF + FYM @ 5t/ha + ZnSO4 @ 20 kg/ha + Azotobacter recorded higher B: C ratio.

Table 5 : Effect of INM on economics of wheat crop

Treat-ments	Cost of cultivation		Gross return		Net return		B:C ratio	
	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
T_1	28875	33975	72117	74253	43242	40278	1.5	1.2
T_2	36475	41575	127497	132787	91022	91212	2.5	2.2
T_3	29875	29175	85390	87203	55515	58028	1.9	2.0
T_4	37375	36675	100070	102713	62695	66038	1.7	1.8
T_5	35575	34875	121633	125427	86058	90552	2.4	2.6
T_6	43075	42375	125557	129070	82482	86695	1.9	2.0
T_7	33675	32975	113657	116443	79982	83468	2.4	2.5
T_8	41175	40475	119677	122557	78502	82082	1.9	2.0
T_9	37425	36725	116483	119797	79058	83072	2.1	2.3
T_{10}	35905	35205	133193	137210	97288	102005	2.7	2.9
T_{11}	43405	42705	134193	142027	90788	99322	2.1	2.3

CONCLUSION:

From the above results, it can be concluded that combined application of 75 % RDF + vermicompost @ 5 t/ha+ Azospirillum + PSB or 75 % RDF + FYM @ 10 t/ha+ Azotobacter + PSB is effective to get higher yield net return.

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