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

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ABSTRACT

A field experiment was conducted during 2005-06 and 2006-07 on clay loam soil to assess the effect of integrated nutrient management practices (INM) on growth and yield of wheat (Triticum aestivum L.) The experiment consists of eleven treatments viz., T_1-100% recommended dose of fertilizer (RDF) i.e. 120 : 26.4 : 50 N : P : K kg ha^{-1}, T_2- 100% RDF+Vermicompost @ 1t ha^{-1}, T_3-100% RDF+Vermicompost @ 1t ha^{-1} + Phosphate Solubilizing bacteria (PSB), T_4-100% RDF + PSB, T_5-75% RDF + vermicompost @ 1t ha^{-1}, T_6-75% RDF + vermicompost @ 1t ha^{-1} + PSB, T_7-50% RDF+Vermicompost @ 1t ha^{-1}, T_8-50% RDF+Vermicompost @ 1t ha^{-1} + PSB, T_9-Vermicompost @ 1t ha^{-1} + PSB, T_{10}-Vermicompost @ 1t ha^{-1} and T_{11}-absolute control.The results revealed that the application of 100% recommended dose of fertilizers (RDF) i.e. 120:26:4:50 N:P:K kg ha^{-1}+ vermicompost @1tha^{-1} + phosphate solubilizing bacteria (PSB) and 75% RDF + vermicompost @1tha^{-1}+ PSB produced higher yield attributes and grain yield than the other treatments. The higher yield led to higher NPK uptake by wheat. Further, the available NPK content of soil also increased in above INM treatment over control. The highest benefit : cost ratio (2.73) was obtained from the application of 75% RDF + vermicompost @1tha^{-1}+ PSB.

Key words: Economics, phosphate solubilizing bacteria, vermicompost, wheat

On account of continuing world energy crisis and spiraling price of chemical fertilizer, the use of organic manure as a renewable source of plant nutrients is assuming importance. In this endeavor proper blend of organic and inorganic fertilizer is important not only for increasing yield but also for sustaining soil health (Weber *et al.*, 2007 and Pullicinoa *et al.*, 2009). The vermicomposting is bio-oxidation and stabilization of organic material involving the joint action of earthworm and microorganisms. Although, microbes are responsible for the biological degradation of the organic matter, earthworms are the important drivers of the process, conditioning the substrate and altering biological activity (Aira *et al.*, 2002). Suthar (2008) reported that vermicompost may be potential sources of nutrients for field crops if applied in suitable ratios with synthetic fertilizers. The earlier workers have reported a positive effect of vermicompost application on growth and productivity of cereals and legumes (Suthar, 2006). Phosphate-solubilizing micro-organisms (PSM) involve different character of micro-organisms which turn insoluble organic compound of phosphorus to soluble form (Raju and Reddy, 1999; Sundara *et al.*, 2002). Galal *et al.* (2001) reported that biofertilization technology minimizes production costs and at the same time avoid the environmental hazards.

The demand of wheat in India by 2020 has been projected to be between 105 to 109 m tonnes as against 72 m tonnes production of present day. Wheat is an important cereal crop and requires a good supply of nutrients especially nitrogen for its growth (Mandal *et al.*, 1992) and yield (Krylov and Pavlov, 1989). In view of this the present investigation was carried out to find out the best combination of organic manure and inorganic fertilizer on growth, yield and nutrient uptake by wheat.

MATERIALS AND METHODS

Field experiments were conducted during winter 2005-06 and 2006-07 at the research farm of College of Agriculture, Central Agricultural University, Imphal. The soil was clay loam having organic carbon 0.49 % and 0.50 % with pH 5.2 and 5.4, available N 248 kg ha^{-1}, 252 kg ha^{-1}, available $P_2O_5$16.5 and 17.2 kg ha^{-1} and available K_2O 226 kg ha^{-1} and 230 kg ha^{-1} at the start of the experiment in 0 to 30 cm soil layer during 2005-06 and 2006-07 respectively. The experiment consists of eleven treatments *viz.*, T_1-100% recommended dose of fertilizer (RDF) i.e. 120 : 26.4 : 50 N : P : K kg ha^{-1}, T_2- 100% RDF + Vermicompost @ 1t ha^{-1}, T_3-100% RDF+Vermicompost @ 1t ha^{-1}+ Phosphate Solubilizing bacteria (PSB), T_4-100% RDF + PSB, T_5-75% RDF + vermicompost @ 1t ha^{-1}, T_6-75% RDF + vermicompost @ 1t ha^{-1}+ PSB, T_7-50% RDF+Vermicompost @ 1t ha^{-1}, T_8-50% RDF+Vermicompost @ 1t ha^{-1}+ PSB, T_9-Vermicompost @ 1t ha^{-1}+ PSB, T_{10}-Vermicompost @ 1t ha^{-1}and T_{11}-absolute control. The experiment was laid out in randomized block design with three replications. Vermicompost was applied 15 days before sowing as per treatment. Wheat cultivar HW 2004 was sown in rows 20 cm apart on 2nd November in 2005 and 5th November in 2006 and harvested on 10th March in 2006 and 12th March in 2007 respectively. Half of nitrogen and full dose of phosphorus and potash were applied at the time of sowing as per treatment combination. The remaining nitrogen as per treatment was top dressed after first irrigation. N, P, and K were applied through urea,

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Table 1: Effect of integrated nutrient management on growth and yield attributing characters of wheat

Treatment	Dry matter accumulation at 90 DAS (g m^{-2})			Effective tillers m^{-2}			Grains $spike^{-1}$			Test weight (g)		
	2005-06	2006-07	Pooled	2005-06	2006-07	Pooled	2005-06	2006-07	Pooled	2005-06	2006-07	Pooled
T_1	550.13	579.67	564.90	256	204	230	34.60	37.80	36.20	43.09	42.74	42.92
T_2	589.63	702.00	645.82	280	221	251	44.20	43.07	43.63	43.11	43.30	43.21
T_3	654.93	712.00	683.47	317	288	303	45.97	44.93	45.45	43.14	43.52	43.33
T_4	588.80	540.33	564.57	264	214	239	42.53	40.60	41.57	43.00	42.87	42.94
T_5	623.27	697.00	660.13	281	273	277	43.60	43.47	43.53	43.01	43.33	43.17
T_6	650.60	715.00	682.80	314	292	303	46.37	48.13	47.25	43.20	43.71	43.45
T_7	534.13	657.67	595.90	266	277	272	39.16	38.37	38.76	43.10	43.28	43.19
T_8	542.93	668.67	605.80	281	224	252	40.00	40.40	40.20	42.96	43.42	43.19
T_9	428.87	462.00	445.43	246	217	232	37.13	37.77	37.45	42.75	42.74	42.75
T_{10}	400.03	419.67	409.85	240	183	212	37.10	35.67	36.38	42.51	42.33	42.42
T_{11}	283.23	328.33	305.78	178	104	141	23.17	28.07	25.62	42.60	42.23	42.42
SEm(±)	29.71	18.59	19.31	10.14	5.25	4.73	2.94	2.10	2.33	0.07	0.10	0.06
LSD(0.05)	87.81	54.94	57.09	41.19	15.51	13.97	8.68	6.19	6.87	0.20	0.29	0.18

Note: *T_1-100% recommended dose of fertilizer (RDF) i.e. 120 : 26.4 : 50 N : P : K kg ha^{-1}, T_2- 100% RDF + Vermicompost @ 1t ha^{-1}, T_3-100% RDF+Vermicompost @ 1t ha^{-1}+ Phosphate Solubilizing bacteria (PSB), T_4-100% RDF + PSB, T_5-75% RDF + vermicompost @ 1t ha^{-1}, T_6-75% RDF + vermicompost @ 1t ha^{-1}+ PSB, T_7-50% RDF+Vermicompost @ 1t ha^{-1}, T_8-50% RDF+Vermicompost @ 1t ha^{-1}+ PSB, T_9-Vermicompost @ 1t ha^{-1}+ PSB, T_{10}-Vermicompost @ 1t $ha^{-1}$and T_{11}-absolute control.*

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

Treatment	Grain yield (t ha^{-1})			Biological yield (t ha^{-1})			Net return (₹ha^{-1})			B:C ratio		
	2005-06	2006-07	Pooled	2005-06	2006-07	Pooled	2005-06	2006-07	Pooled	2005-06	2006-07	pooled
T_1	3.49	3.83	3.66	8.92	9.00	8.96	39221	44714	41967	2.37	2.70	2.53
T_2	4.61	4.45	4.53	11.49	10.94	11.21	52258	49634	50946	2.42	2.30	2.36
T_3	5.01	4.74	4.88	12.27	11.76	11.80	58247	53927	56087	2.65	2.46	2.55
T_4	3.38	3.85	3.62	7.95	9.43	8.69	37114	44687	40901	2.19	2.63	2.41
T_5	4.24	4.48	4.36	9.59	10.89	10.24	47301	51194	49247	2.31	2.50	2.40
T_6	4.87	4.90	4.89	11.22	11.52	11.37	56987	57467	57227	2.72	2.74	2.73
T_7	3.68	4.36	4.02	9.49	9.56	9.53	39527	50407	44967	2.04	2.60	2.32
T_8	3.92	4.38	4.15	9.35	10.51	9.93	42867	50121	46494	2.15	2.52	2.34
T_9	3.38	3.25	3.32	7.94	8.25	8.10	31387	29307	30347	1.38	1.29	1.33
T_{10}	3.22	3.13	3.17	7.53	7.97	7.75	29274	27781	28527	1.32	1.25	1.28
T_{11}	1.68	1.69	1.69	3.89	4.60	4.24	14634	14794	14714	1.20	1.21	1.20
SEm(±)	**0.18**	**0.25**	**0.15**	**0.32**	**0.44**	**0.30**	**2802**	**4010**	**2326**	**0.14**	**0.19**	0.11
LSD (0.05)	**0.52**	**0.74**	**0.43**	**0.94**	**1.29**	**0.89**	**8281**	**11851**	**6875**	**0.42**	**0.55**	0.33

*Note: T_1-100% recommended dose of fertilizer (RDF) i.e. 120 : 26.4 : 50 N : P : K kg ha^{-1}, T_2- 100% RDF + Vermicompost @ 1t ha^{-1}, T_3-100% RDF+Vermicompost @ 1t ha^{-1}+ Phosphate Solubilizing bacteria (PSB), T_4-100% RDF + PSB, T_5-75% RDF + vermicompost @ 1t ha^{-1}, T_6-75% RDF + vermicompost @ 1t ha^{-1}+ PSB, T_7-50% RDF+Vermicompost @ 1t ha^{-1}, T_8-50% RDF+Vermicompost @ 1t ha^{-1}+ PSB, T_9-Vermicompost @ 1t ha^{-1}+ PSB, T_{10}-Vermicompost @ 1t $ha^{-1}$and T_{11}-absolute control. *Cost of vermicompost = ₹ 6 kg^{-1} ; Selling price of wheat = ₹ 16 kg^{-1}*

single super phosphate and muriate of potash respectively. The seeds were inoculated with phosphate solubilizing bacteria (PSB) i.e. *Pseudomonas strata* before sowing as per treatments.The crop received three uniform irrigations (at crown root initiation, flowering and milking stages). Organic carbon, pH, available N, P, K of soil and N, P, K content in plant were estimated by standard methods. Nutrient uptake was estimated by multiplying the dry-matter accumulation at maturity in grain and straw of wheat by their respective percentages. Total uptake was calculated by adding uptake of grain and straw. The yield parameters and yields were recorded and analyzed as per Gomez and Gomez (1984). The treatment comparisons were made using t-test at 5% level of significance. The economics was calculated on the basis of prevailing local market price of wheat grains and cost of inputs.

RESULTS AND DISCUSSION

Effect on yield attributes

Integrated use of fertilizers with vermicompost and phosphate solubilizing bacteria increased the dry matter accumulation, number of effective tillers, grains spike^{-1} and the test weight. The enhanced early vegetative growth in terms of higher leaf area, dry matter accumulation and vigorous root system resulted in more spikes which consequently increased the number of spike bearing tillers significantly. Dry matter accumulation produced by the application of 100% RDF along with vermicompost @ 1t ha^{-1} and phosphate solubilizing bacteria (683.47 g m^{-2}) and 75% RDF along with vermicompost @ 1t ha^{-1} and phosphate solubilizing bacteria (682.80 g m^{-2}) were found to be the highest and the lowest from control (305.78 g m^{-2}). It might be due to stimulated vegetative growth of wheat on account of adequate and prolonged supply of essential nutrients.Similarly, the number of effective tillers, grain/spike and test weight produced by the application 100% RDF + vermicompost @ 1t ha^{-1}+ PSBand75% RDF + vermicompost @ 1t ha^{-1}+ PSB were found to be significantly higher than the other treatments and the lowest from the control. Afzal *et al.* (2005) also reported that PSB along with organic manures or with other combinations significantly increased the number of tillers m^{-2}. These results are in line with the findings of Kumar *et al.* (1999) who reported significant increase in number of plants per metre row by inoculation of *Azotobacter chroococcum*.

Effect on yield

Addition of vermicompostwith or without PSB together with different fertilizer levels produced significantly higher grain and biological yields than the application of fertilizers alone (Table 2). Maximum grain yield and biological yield were obtained with the application of 100% RDF+ vermicompost @ 1t ha^{-1}+ PSB and 75% RDF+ vermicompost @ 1t ha^{-1}+ PSB (4.89 t ha^{-1}). The lowest grain yield (1.69 t ha^{-1}) and biological yield (4.24 t ha^{-1}) were recorded from control. The increase in grain and biological yield might be due to adequate quantities and balanced proportions of plant nutrients supplied to the crop as per need during the growth period resulting in favourable increase in yield attributing characters which ultimately led towards an increase in economic yield. Improved physico-chemical properties of the soil through the application of organic manure might be the other possible reason for higher productivity. Rao *et al.*, (1996) also reported that the combination of organic and inorganic N sources resulted in comparable rice yield to the application of inorganic nitrogen alone. Saad and Hamimad (1998) also reported that the greatest grain yield of wheat was found with inoculation of bacteria. Afzal *et al.* (2005) also reported that phosphate solubilizing micro-organism (PSM) in combination with phosphorus fertilizer and organic manure significantly improved grain and biological yield of wheat.

Table 3: Effect of integrated nutrient management on nutrient uptake of crop and soil nutrient status (Pooled data of two years)

Treatment	Nutrient uptake (kg ha^{-1})			Available nutrient of soil (kg ha^{-1})		
	N	P	K	N	P	K
T_1	92.89	11.43	91.89	127.90	11.07	168.63
T_2	120.44	15.91	121.43	143.56	12.22	160.11
T_3	124.42	16.39	128.54	147.01	12.33	171.72
T_4	90.48	11.57	89.98	141.36	12.17	171.49
T_5	110.86	14.59	115.06	144.75	12.11	158.25
T_6	124.43	17.34	131.09	163.12	14.32	175.41
T_7	99.17	11.68	104.23	122.73	11.17	143.86
T_8	103.98	12.91	104.06	127.87	11.24	146.69
T_9	80.67	9.61	87.64	110.85	8.31	113.99
T_{10}	77.21	8.24	82.47	106.85	8.15	110.49
T_{11}	38.41	3.90	29.94	87.62	7.62	100.34
SEm(±)	**4.49**	**0.48**	**7.16**	**0.32**	**0.15**	**0.65**
LSD (0.05)	**13.29**	**1.42**	**21.17**	**0.95**	**0.46**	**1.91**

Economics

Net return and benefit: cost ratio increased with supplementation of recommended dose of fertilizer with vermicompost and phosphate solubilizing bacteria. Highest net return (`57227 ha^{-1}) and benefit cost ratio (2.73) was obtained with the application of 75% +vermicompost @1t ha^{-1}+ PSB than fertilizer alone. The additional cost of organic manures and bio-fertilizer was compensated by the additional yield of wheat. Suthar (2006) reported that integrated application of NPK fertilizers along with vermicompost in field crops not only influences growth and production of plant but at the same time also reduces the production budget.

Effect on nutrient uptake

Application of vermicompost and PSB with fertilizer levels significantly increased the NPK uptake by the crop than the application of fertilizers alone or vermicompost alone. Maximum NPK uptake by the crop was recorded from 75% RDF + vermicompost @ 1tha^{-1} + PSB and 100% RDF + vermicompost @ 1tha^{-1}+ PSB (Table 3). The decrease in available NPK status of soil was recorded in control where no fertilizer was applied to the crop. The increased uptake of the nutrients was due to added supply of nutrient and well developed root system resulting in better absorption of water and nutrient. These results are in agreement with the findings of Datta *et al.* (2003).

Effect on soil nutrient status

Application of vermicompost + PSB along with fertilizer levels significantly increased the available nitrogen, phosphorus and potash status of the soil (Table 3). Available NPK of soil after the harvest of wheat were found to be maximum with the application of 100% RDF + vermicompost @ 1 t ha^{-1} + PSB and 75% RDF + vermicompost @ 1 t ha^{-1} + PSB and the lowest from control.It might be due to the application of vermicompost and PSB which enhances the activity ofsome microbial populations and there was a high level of total N in experimental plot.Pandey*etal*., (2009) also reported that addition of organic manure (10t FYM) with fertilizer levels significantly increased the nutrient uptake by wheat, improved the organic carbon content N, P and K status as compare to chemical fertilizer alone.

From the above study it can be concluded that application of 75% RDF (120:26:4:50 N:P:K kg ha^{-1}) along with vermicompost @ 1t ha^{-1}and PSB produced higher growth and yield of wheat, higher NPK uptake, better residual fertility and more remuneration than recommended fertilizer or organic fertilizer alone.

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