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RESEARCH ARTICLE

Integrated nutrient management with inorganic fertilizers, vermicompost, biofetilizer and zinc sulphate in wheat (*Triticum aestivum*)

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SUMMARY

A field experiment was conducted during *Rabi* 2010-11 and 2011-123 at Kanpur on sandy loam soil to assess the influence of integrated nutrient management on wheat (*triticum aestivum*). Treatments comprised of 12 nutrient levels *viz.*, control, 100% RDF (150 kg N + 60 kg P_2O_5 + 40 kg K_2O through chemicals fertilizers), 75% RDF, 50% RDF, 75% RDF + vermicompost 2.5 t/ha, 50% RDF + vermicompost 5 t/ha, 75% RDF + vermicompost with $ZnSO_4$ 25 kg/ha and/or *Azotobacter*, 50% RDF + vertmicompost with $ZnSO_4$ and/or *Azobacter*. Results revealed that application of 100% RDF recorded the highest productive shoots/m^2, grain weight/spike, grain yield, straw yield, net return and B:C ratio. In grain yield, the pretreatments of 75% RDF + vermicompost with $ZnSO_4$ and/or *Azotobacter* also remained significantly at par with 100% RDF, but in net return and B:C ratio, 100% RDF recorded significantly highest. Any reduction in 100% RDF either alone or in integrated nutrient treatments, yield attributes, yields, net return and B:C ratio showed considerable reduction. Therefore, to attain higher production and profit, the application of 100% RDF through inorganic fertilizers is needed in wheat crop under central Uttar Pradesh condition.

Key Words : Wheat, Fertilizer, Vermicompost, Zinc, *Azotobacter*, Productivity, Economics

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Wheat is the second most important cereal crop in India, after rice, both in terms of area and production. The country has witnessed spectacular progress in wheat production and is the second largest producer of wheat next to China (Kumar and Yadav, 2006). Organic farming often has to deal with a scarcity of readily available nutrients in contrast to inorganic farming which relies widely available on soluble fertilisers. The aim of nutrient management in organic systems is to optimise the use of on-farm resources and minimise losses (Kopke, 1995).

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Wheat is the most important staple food grain crop in Indian diet and main source of protein and calories for a large section of population. By 2020, India will have a population of about 1.3 billion and there will be a substantial pressure on land to produce more food (Jat *et al.*, 2013) Wheat is generally grown in intensive cropping systems which resulted in depletion of soil nutrients and in stagnation of crop yield to a greater extent. Therefore, use of chemical fertilizers is increasing day-by-day to get the same yield which adversely affects the physico-chemical properties of the soil. Integration of various sources of nutrients (organic and inorganic) is more suitable because this reduces the use of chemical fertilizers and improved soil condition, besides being an environment friendly approach. The availability of organic manure like FYM is limited, thus, use of vermicompost may be a better alternative which is richer in plant nutrients than FYM.

Besides, biofertilizers like *Azotobacter* and micronutrient like zinc may also be integrated with chemical fertilizers and vermicompost for better results. In the present investigation, an attempt has been made to evaluate the effect of varying levels of chemical fertilizers and vermicompost alone and in combination with zinc and or *Azotobacter* on the performance of wheat crop.

MATERIAL AND METHODS

A field experiment was conducted at Students Instructional Farm of C.S. Azad university of Agriculture and technology, Kanpur during *Rabi* seasons of 2010-11 and 2011-12. The soil of the experimental field was sandy loam in texture with pH 7.5, 0.44% organic carbon, 170 kg/ha available N, 17.8 kg/ha available P_2O_5, 165.0 kg/ha available K_2O and 0.53 ppm available zinc. The experiment was laid out in Randomized Block Design, comprised twelve treatment combinations *viz.*, T_1 –Control (no fertilizer or manure), T_2 – 100% RDF (150:60:40 kg NPK/ha), T_3 – 75% RDF (112.5:45:30 kg NPK/ha), T_4 – 50 RDF (75:30:20 kg NPK/ha), T_5 – (T_3 + vermicompost 2.5 t/ha), T_6 – (T_5 + $ZnSO_4$ 25 kg/ha), T_7 – (T_5 + *Azotobacter*), T_8 – (T_7 + $ZnSO_4$ 25 kg/ha), T_9 – (T_4 + vermicompost 5 t/ha), T_{10} – (T_9 + $ZnSO_4$ 25 kg/ha), T_{11}- (T_9 + *Azotobacter*) and T_{12} – (T_{11} + $ZnSO_4$ 25 kg/ha) were replicated thrice. Vermicompost was applied 20 days before sowing and well mixed in soil as per treatment plot. Wheat variety 'PBW-343' was sown on 10th and 1st December in 2010 and 2011, respectively. *Azotobacter* was used as seed treatment. Half of the nitrogen as per treatment and full dose of phosphorus, potassium and $ZnSO_4$ were applied at the sowing as basal application and remaining nitrogen as per treatment was top dressed after first irrigation. N,P and K were applied through urea, di-ammonium phosphate and muriate of potash, respectively. The crop received four uniform irrigations during each year. To evaluate the effect of treatments, observations on experimental crop were recorded regarding shoot densities, yield attributes and yields. The economics of different treatments was also worked out.

RESULTS AND DISCUSSION

The experimental findings obtained from the present study have been discussed in following heads:

Effect on shoot density:

All treatments of nutrient application produced significantly higher number of total shoots per unit area over control treatment (Table 1). Among those, 100% RDF produced maximum shoots, but these were significantly higher only than the shoots produced under 50% RDF, 50% RDF + vermicompost + *Azotobacter* and 75% RDF + vermicompost and zinc. Productive shoots were recorded significantly maximum under the treatment of 100% RDF and significantly minimum in control treatment. All other treatments produced productive shoots significantly at par with each other. Out of total shoots, the percentage of productive shoots was found highest under 100% RDF and lowest under control treatment. In this respect, second position was gained by the treatment 75% RDF + vermicompost + Zn, which produced

Table 1: Effect of nutrient management on shoot density per m^2 of wheat

Treatments	No. of total shoors/m^2		Productive shoors/m^2				Unproductive shoors/m^2			
			Number		Per cent		Number		Per cent	
	I	II	I	II	I	II	I	II	I	II
Control	350.00	353.33	200.00	215.33	57.1	60.9	150.00	138.00	42.9	39.1
100% RDF	356.67	358.67	466.67	469.33	863.8	84.0	90.00	89.34	16.2	16.0
75% RDF	513.00	515.33	396.67	398.67	77.3	77.4	116.33	116.66	22.7	22.6
50% RDF	500.00	505.33	391.67	394.33	78.3	78.0	121.33	111.00	21.7	22.0
75% RDF + verm. 2.5 t/ha	523.33	525.67	403.33	406.67	77.1	77.4	119.67	119.00	22.9	22.6
75% RDF + verm. 2.5 t/ha + Zn	500.00	505.00	411.67	415.33	82.3	82.2	88.33	89.67	17.7	17.8
75% RDF + verm. 2.5 t/ha + *Azo.*	540.00	543.33	419.33	421.67	77.7	77.6	120.67	121.66	22.3	22.4
75% RDF + verm.2.5 t/ha + *Azo*. + Zn	530.00	534.67	423.33	425.33	79.9	79.6	97.67	109.34	20.1	20.4
50% RDF + verm. 5 t/ha	520.00	524.33	383.33	385.67	73.7	73.6	136.67	138.66	26.3	26.4
50% RDF + verm. 5 t/ha + Zn	513.33	515.67	401.67	403.33	78.2	78.2	111.66	112.34	21.8	21.8
50% RDF + verm. 5 t/ha + *Azo.*	506.67	509.33	403.33	406.67	79.6	79.8	103.34	102.66	20.4	20.2
50% RDF + verm. 5 t/ha + *Azo*. + Zn	516.678	518.67	396.67	399.33	76.8	77.0	120.00	119.34	23.2	23.0
S.E.±	21.53	22.37	18.42	20.18	-	-	9.82	2.95	-	-
C.D. (P = 0.05)	44.65	46.39	38.20	41.85	-	-	20.37	6.13	-	-

RDF: 150:60:40 kg NPK/ha; verm- vermicompost, Zn- $ZnSO_4$ 25 kg/ha; *Azo.*- *Azotobacter*; I- 2010-11; II- 2011-2012 just similar per cent of productive shoots to 100% RDF. Both these treatments produced 82-84 per cent productive shoots, while all other treatments produced productive shoots. The number of unproductive shoots in between 73 and 80 per cent of total shoots. The number of unproductive shoots was recorded maximum in control treatment, though the treatment 50% RDF + vermicompost also remained significantly at par with it. The percentage of unproductive shoots out total shoots was lowest under 100% RDF closely followed by 75% RDF + vermicompost + Zn treatment and it was highest in control treatment by the large margin from other all treatments. These results indicate that as the application of chemical fertilizers curtailed from recommended dose, shoot density reduced because of reduced tillering, though application of vermicompost with reduced RDF levels compensated the loss in shoot density up to some extent. The effect of reduced RDF was more pronounced on number of productive tillers which showed that tillers formed in integrated nutrient treatments could not produce earheads in some cases. It was also proved from percentage of productive shoots under different treatments. Superiority of 100% RDF treatment in shoot density might be attributed to more availability of NPK nutrients to crop plants while in integrated nutrient treatment plots, sufficient amount of NPK nutrients was not easily available in soil for exploiting productive tillering potential of crop plants. These results are supported by the findings of Gill and Rathore (2004).

Effect on yield attributes:

Spike length and number of grains per spike were not

Table 2: Effect of nutrient management on yield attributes of wheat

Treatments	Spike length (cm)		No. of grains per spike		Weight per spike (g)		Grain weight/spike (g)		Test weight (g)	
	I	II	I	II	I	II	I	II	I	II
Control	7.43	7.35	43.00	41.15	3.05	2.97	2.17	2.65	38.00	37.97
100% RDF	8.17	8.05	46.33	45.40	5.00	4.99	4.17	4.46	42.67	42.75
75% RDF	7.67	7.55	45.33	44.40	4.08	3.95	3.17	3.53	41.00	40.97
50% RDF	7.50	7.41	45.00	44.25	3.92	3.88	2.92	3.46	42.00	41.96
75% RDF + verm. 2.5 t/ha	7.83	7.78	45.00	44.40	4.62	4.50	3.75	4.01	42.33	42.25
75% RDF + verm. 2.5 t/ha + Zn	7.87	7.82	45.33	44.30	4.83	4.75	3.83	4.24	41.67	41.60
75% RDF + verm. 2.5 t/ha + *Azo.*	8.00	7.95	45.33	44.33	4.83	4.73	3.92	4.22	41.33	41.25
75% RDF + verm.2.5 t/ha + *Azo.* + Zn	8.10	8.01	45.67	44.71	4.83	4.74	4.10	4.23	41.67	41.50
50% RDF + verm. 5 t/ha	7.67	7.61	45.00	44.20	4.0	3.95	3.10	3.53	39.67	39.51
50% RDF + verm. 5 t/ha + Zn	7.83	7.79	45.00	44.15	4.25	4.15	3.18	3.71	40.33	39.45
50% RDF + verm. 5 t/ha + *Azo.*	7.83	7.80	45.00	44.00	4.17	4.10	3.03	3.66	40.67	39.75
50% RDF + verm. 5 t/ha + *Azo.* + Zn	7.83	7.79	45.00	43.95	4.33	3.96	3.40	3.54	41.67	40.35
S.E.±	0.40	0.32	1.85	1.01	0.39	0.36	0.37	0.34	1.63	1.03
C.D. (P = 0.05)	NS	0.66	NS	2.09	0.81	0.75	0.78	0.71	NS	2.14

RDF: 150:60:40 kg NPK/ha; verm- vermicompost, Zn- $ZnSO_4$ 25 kg/ha*; Azo.- Azotobacter*; I- 2010-11; II- 2011-2012, NS=Non-significat

Table 3: Effect of nutrient management on yield and economics of wheat

Treatments	Grain yield (q/ha)		Straw yield (q/ha)		Harvest index (%)		Net return (Rs./ha)		B:C ratio	
	I	II	I	II	I	II	I	II	I	II
Control	24.35	23.25	31.41	31.00	43.66	42.86	17543	18718	0.73	0.75
100% RDF	56.72	51.73	68.90	63.75	45.37	46.87	66954	71493	2.34	2.52
75% RDF	47.11	44.45	61.49	57.45	43.35	43.62	53581	37463	1.97	2.11
50% RDF	43.80	40.35	53.95	52.10	44.41	43.64	47652	51137	1.82	1.95
75% RDF + verm. 2.5 t/ha	49.99	45.15	60.58	58.34	45.21	43.63	53795	57761	1.79	1.92
75% RDF + verm. 2.5 t/ha + Zn	50.62	48.35	63.78	62.45	43.27	43.64	55074	59256	1.79	1.93
75% RDF + verm. 2.5 t/ha + *Azo.*	53.20	48.30	66.36	62.40	45.47	43.61	59736	64105	1.98	2.12
75% RDF + verm.2.5 t/ha + *Azo.* + Zn	55.09	49.40	68.27	58.62	44.64	43.66	61889	66418	1.99	2.14
50% RDF + verm. 5 t/ha	43.90	42.90	60.59	55.55	42.01	43.58	33787	36919	1.06	1.16
50% RDF + verm. 5 t/ha + Zn	43.47	43.60	64.03	56.30	40.43	43.64	24841	48458	0.76	1.48
50% RDF + verm. 5 t/ha + *Azo.*	45.94	42.60	59.82	55.05	43.43	43.63	56647	60881	1.77	1.89
50% RDF + verm. 5 t/ha + *Azo.* + Zn	47.75	45.05	62.82	58.20	43.18	43.63	51551	55517	1.57	1.68
S.E.±	1.71	2.18	4.57	4.43	1.22	1.32	1505	1469	0.10	0.12
C.D. (P = 0.05)	3.54	4.52	9.49	9.19	2.54	2.74	3122	3047	0.21	0.25

RDF: 150:60:40 kg NPK/ha; verm- vermicompost, Zn- $ZnSO_4$ 25 kg/ha; *Azo.- Azotobacter*; I- 2010-11; II- 2011-2012 much influenced by different treatments (Table 2). However, maximum values of both were recorded under 100% RDF treatment but those were significantly higher only over control and that too only during the year 2011-12. other all nutrient management could not increase spike length significantly even over control treatment, but number of grains/spike was found significantly higher under all nutrient treatments over control. It might be attributed to fertility of spikelets which may improve due to proper uptake of plant nutrients under nutrients application treatments. Spike weight was recorded highest under 100% RDF treatment and significantly lowest in control treatment. The treatment of 75% RDF alone or in integration with other sources recorded spike weight significantly at par with that of 100% RDF, but treatments of 50% RDF failed to do so. It might be attributed to number of grains/spike which also behaved similarly under different treatments. Grain weight/spike was also recorded highest under 100% RDF treatment, but it was found at par with all the treatments of 75% RDF and significantly higher than 50% RDF treatments. Control treatment recorded significantly lowest grain weight/spike. These effects might be attributed to number of grains/spike and spike weight (Table 2). Test weight of grains was significantly influenced by treatments only during second year of study, but trend was similar during first year also. It was recorded highest under 100% RDF treatment and lowest in control. However, all treatments of 75% RDF and the treatment of 50% RDF alone recorded test weight at par with 100% RDF treatment. Integrated nutrient treatments with 50% RDF reduced test weight significantly compared to 100% RDF perhaps because of the reason that being almost similar number of grains/spike in 50% RDF treatments, those could not develop properly due to lesser availability of nutrients in general and that of phosphorus and potash in particular. The better performance of yield attributes of wheat under the treatments of 100% RDF and integrated nutrient treatments with 75% RDF may be explained due to sufficient availability of plant nutrients in soil and their proper uptake by crop which produced more crop canopy thereby production, accumulation and translocation of more photosynthates from source to sink. These results are in agreement to the findings of Gill and Rathore (2004) and Rather and Sharma (2009).

Behera *et al.* (2007) reported that the application of available organic sources, particularly FYM and poultry mature along with the full recommended dose of mineral fertilisers to wheat was essential for improving productivity of wheat-soybean system. Thakur and Patel (1998), Tripathi and Gehlot (1999), Singh and Agarwal (2004) also reported a beneficial effect of FYM on wheat.

Effect on yield:

The treatment 100% RDF being at par with the treatments 75% RDF + vermicompost with zinc or *Azotobacter* or zinc + *Azotobacter*, produced significantly higher grain yield than all other treatments (Table 3). The integration of vermicompost alone with 75% RDF could not compete in grain yield with 100% RDF. The integration of Zn +*Azotobacter* with reduced RDF levels and vermicompost though increased grain yield over RDF + vermicompost but margin of increase was not found significant in any case. However, control treatment reduced significantly lowest grain yield. Such higher grain yield under 100% of RDF and other integrated nutrients treatments might be attributed to more number of productive tillers per unit area and improved yield attributes particularly the grain weight/ spike. Singh *et al.* (2003) also observed that any reduction in NP even with integration of 5 t/ha FYM caused significant reduction in grain yield of wheat. It may thus, be inferred from grain yield results that to get higher grain yield the use of 100% RDF is necessary. Organic like vermicompost may be applied in addition to improve the soil condition or 25% RDF may be substituted from 2.5 t FYM/ha with 25 kg $ZnSO_4$/ha and seed treatment of *Azotobacter.* Such integration of nutrient may compensate the yield loss due to 25 per cent reduced RDF up to considerable extent. The trend of straw yield was also found similar to grain yield under different treatments, however, significance of treatments varied. Straw yield seems to be attributed to total shoot density per unit area and the trend may be supported by the findings of Singh *et al.* (2003). Kumar *et al.* (2007) and Rather and Sharma (2009) also worked on the same topic and their results are in confirmity with the results of the present study.

Effect on economics:

Net return was obtained significantly highest from 100% RDF application by large margin of more than Rs. 5000/ha from next best treatment 75% RDF+ vermicompost + *Azotobacter* + $ZnSO_4$ (Table 3). However, the treatment 75% RDF + vermicompost + *Azotobacter* was also found at par with the treatment 75% RDF + vermicompost + *Azotobacter* + $ZnSO_4$. Remaining all treatments reduced net return significantly. However, control treatment earned significantly lowest net return. B:C ratio showed the same trend of net return under different treatments. These results corroborate with the findings of Singh *et al.* (2003).

The results of present study may be concluded that the application of 100% RDF through chemical fertilizers is needed to get the higher production and profit from wheat cultivation. However, any organic as per availability may be applied in addition to maintain and improve soil health for long term sustainable production.

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