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Research Paper

Growth, yield and quality of wheat (*Triticum aestivum*) as influenced by organic sources of nitrogen nutrition

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ABSTRACT

A field experiments were conducted for five years from 2003-04 to 2007-08, during *rabi* seasons at G.B. Pant University of Agriculture & Technology, Pantnagar, on *Mollisols* under the Tarai region of the Uttarakhand, to study the effect of organic sources of nitrogen nutrition on growth, productivity and quality of wheat {*Triticum aestivum* (L.) emend. Fiori & Paol}, 'PBW 343'. Fourteen treatments with three replications were laid out in a randomized block design (fixed plot). Four nitrogen doses i.e. 125, 100, 75 and 50% of the recommended dose of nitrogen (RDN=150 kg/ha) were applied through each of the three organic sources *i.e.* FYM, vermicompost and neemax. Urea as inorganic source for recommended nitrogen and control (no nitrogen) was also tested for comparison of the results. The study showed that RDN through urea gave maximum wheat yield (4.63 t/ha), which was significantly higher than other treatments. Among the organic sources of nitrogen nutrition, FYM @ 125% of RDN gave maximum wheat yield (3.65 t/ha), which was at par with vermicompost and neemax at same rate but significantly higher than FYM @ 50% of RDN. Morphological determinants *viz.* emergence count/m^2, plant height (cm), dry matter accumulation (g/m^2) and yield contributing characters, *i.e.,* spike/m^2, grains/spike[1] and 1,000-grains weight (g) were also significantly higher under N nutrition through urea than others, but FYM, vermicompost and neemax @ 125% of RDN gave significantly higher value of these parameters than their respective nitrogen nutrition @ 50% . Protein content, protein yield, nitrogen uptake and nitrogen use efficiency indicators, which higher under nitrogen nutrition through urea, than those under organic sources of nitrogen. Among the organic sources, vermicompost resulted in maximum value of protein content, protein yield and nitrogen harvest index than others. However, nitrogen use efficiency indicators *i.e.,* physiological, agronomic and recovery efficiency were higher under FYM treated plots. All of the organic treatments except 50% of RDN through neemax and 50% of RDN through vermicompost were highly promising. All the treatments except control maintained a positive balance of nitrogen in soil. High cost involved in procuring large quantity of FYM and vermicompost resulted in negative net returns under these treatments.

Key words: FYM, Neemax, Vermicompost, Wheat

National food security is an important issue and wheat has pivotal role in ensuring food security of the country. Heavy application of chemical fertilizers to wheat in prevailing intensive agriculture has resulted in deterioration of soil health and environmental pollution (Horrigan *et al.* 2002). In addition to this, decreasing factor productivity, global energy crises and price escalation of chemical fertilizers has lead to emphases on supplementation or substitution of chemical fertilizers with low priced nutrient sources such as organics (Kumar and Dhar, 2009). Plant nutrition through organics is a practice adopted by the farmers from antiquity. Organic sources of plant nutrients are effective in enhancing wheat productivity, soil properties and biological activity (Pathak *et al.,* 2005). Organics also increase the efficiency of applied nutrients (Pandey *et al*. 2007). Kumar *et al*. (2009) found that the incorporation of FYM and vermicompost had beneficial effect on wheat. Although nitrogen is an essential macronutrient to be considered for realizing the full yield potential of wheat, but global concern of nitrate pollution demands low input strategy for nitrogen fertilization (Ramesh *et al.* 2005). Considering the above facts, field investigations were undertaken to find out the effect of organic sources of nitrogen nutrition on wheat crop.

MATERIALS AND METHODS

Fixed plot experiments were conducted for this study. Exhaustive maize crop was taken in *kharif* and field ex-

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periments were taken in *rabi* season during 2004-2008 on a silty clay loam soil having pH 7.5, organic carbon 0.67%, medium in available N, P, K and S, at Norman E. Borlague Crop Research Center of G.B Pant University of Agriculture & Technology, Pantnagar. The area is located at 29^{o}N latitude, 79.50^{o}E longitude and at an altitude of 243.8 m above the mean sea level. Climate of the region is humid sub tropical with an average annual rainfall of 1433 mm. Ninety per cent of annual rainfall is received during the south-west monsoon, which sets around third week of June and continues up to September end. For the intended study fourteen treatments were tested under three replications by using randomized block design. Four doses @ 125, 100, 75 and 50% of recommended dose of nitrogen (RDN=150 kg/ha) were applied through three organic sources i.e., FYM, vermicompost and neemax. Urea used as a source for recommended nitrogen and control (no fertilizer) was also part of treatments for the comparison of results. The quantity of organic manure was calculated on dry weight basis, considering the moisture content and nitrogen percentage. The average values of nitrogen content were 0.61% in FYM, 1.36% in vermicompost and 5.2% in neemax. Required organic manure was applied one day before wheat sowing. The P and K were applied @ 26 and 32 kg/ha. The sources of P and K were single super phosphate and muriate of potash. Before wheat, *kharif* maize was taken as exhaustive crop. Wheat 'PBW 343' was sown @ 100 kg/ha in the first week of November during all the years. The sowing was done by the seed drill at a row spacing of 21 cm. Crop was harvested at physiological maturity in first week of April during all the years. Morphological determinants *viz.*, emergence count/m^2, plant height (cm), dry matter accumulation (g/m^2), days taken to flowering and maturity, yield contributing characters and yield were measured. N (%) was analyzed by micro Kjeldhal method and N uptake (kg/ha) was calculated from yield and N content. The nitrogen use efficiency was computed as , agronomic efficiency (AE= Yn – Yo/F_N), physiological efficiency (PE= Yn – Yo)/ Un – Uo and recovery efficiency (RE = Un – Uo/F_N). Where Yn and Yo and Un and Uo were yield and nitrogen uptake in N fertilized and control treatment respectively. F_N is nitrogen applied through fertilizer. Harvest index and nitrogen harvest index were calculated as the ratio of seed to biomass and the seed N to biomass N, protein content (%) was analyzed by multiplying percent nitrogen in grain with conversion factor 5.75 for wheat. The nitrogen balance/gain after the five year of experimentation , under different treatments was calculated by substracting initial available N value (i.e 254 kg/ha) from available N value obtained after the end of experiment. Sustainability index of the different treatments over five years of study was calculated by the formula SYI = $\bar{Y} - \delta / Y\ max$, where, $\bar{Y}$ was average yield of a treatment, δ was treatment standard deviation and Y max was maximum yield in the experiment over years. Economic analysis of adopted treatments was done by using standard method.

RESULTS AND DISCUSSION

Morphological determinants and yield attributes

Five years pooled data analysis revealed that all morphological determinants and yield attributing characters responded significantly to treatments (Table 1). Emergence count/m^2 was affected significantly by the organic sources of nitrogen, but in erratic fashion. However, FYM @ 125 % of RDN gave more emergence/m^2 than others. FYM, vermicompost, and neemax @ 125 % of RDN resulted in the highest plant height, which was significantly higher than 50 % of RDN. FYM, vermicompost and neemax @ 125 % and 100 % of RDN gave at par dry matter accumulation but they were significantly superior to 75 % and 50 % of RDN applied through the same nutrient sources. Organic sources had at par effect on days taken to flowering and maturity, which was significantly more than RDN applied through urea and control. Spikes/m^2 found the highest under RDN applied through urea. Among the organic sources of nitrogen, FYM @ 125% of RDN gave maximum spike/m^2, which was significantly higher than control but significantly lower than RDN applied through urea. Nitrogen doses were found at par in their effect on spike/m^2 irrespective of the nature of the organic source. Maximum number of grains/spike^1 was recorded under RDN applied through urea, which was significantly higher than all organic sources. Nitrogen nutrition @ 125% of RDN from different organic sources showed at par result for grains/spike^1 but had significant difference from their respective 50% of RDN. RDN through urea had maximum 1,000-grain weight followed by FYM, vermicompost and neemax @ 125% of RDN. Among the organic sources of nitrogen, 125% RDN through FYM, vermicompost and neemax had significantly higher 1,000-grain weight than their respective 50% of RDN level. Application of organic sources might have increased the activities of beneficial micro organisms due to increased organic pool in soil, which resulted in production of growth–promoting substances and improved nutrient availability for longer period throughout the crop growth and thus the use of organic sources had the beneficial effect on crop growth (Yadav *et al.* 2008). Twenty five % more nitrogen application through organics may compensate the losses of nitrogen, which occurs during mineralization, might be responsible for good response of

125% of RDN through organic nutrition. The beneficial effect of organic sources of nutrition on morphological determinants and yield contributing parameters was also noticed by Channabasanagowda *et al.* (2008).

Grain and straw yield

Pooled analysis for five years revealed that different treatments had significant effect on grain and straw yield (Table 2). Nitrogen nutrition through urea had significantly more grain yield than other treatments. FYM @ 125% of RDN gave maximum grain yield, which was at par with FYM @ 100% and 75% of RDN, but significantly higher than 50% of RDN. Similar effect of vermicompost and neemax were found on grain yield. Significantly higher straw yield was recorded under RDN through urea than other treatments. Organic sources @ 50% of RDN had significantly less straw yield than the same sources of nitrogen nutrition at 125% RDN. Individual year analysis revealed that treatments had significant effect on grain yield during all the years. During 2003-04 and 2004-05, highest yield was recorded with FYM @ 125% of RDN, which was significantly lesser

Table1. Effect of organic sources of nitrogen on growth and yield contributing characters (Pooled data over five years)

Treatment	Emergence count/m^2	Plant height (cm)	Dry matter at harvest (g/m^2)	Days taken to flowering	Days taken to maturity	Spikes/m^2	Grains/ Spike	1,000-grains weight (g)
FYM @ 125% of RDN	152.4	94.1	94.1	93.4	140.0	343.8	36.8	40.0
FYM @ 100% of RDN	148.6	92.1	92.1	93.0	140.0	333.0	37.8	39.5
FYM @ 75% of RDN	150.4	90.7	90.6	92.0	138.0	331.2	34.8	39.1
FYM @ 50% of RDN	150.6	89.6	89.6	91.0	137.5	312.0	32.4	38.9
VC @ 125% of RDN	148.6	93.0	93.0	92.4	139.5	336.8	36.2	39.3
VC @ 100% of RDN	151.4	90.9	91.0	92.7	139.0	329.8	35.6	38.6
VC @ 75% of RDN	144.6	89.0	89.3	91.7	137.0	312.6	33.8	38.6
VC @ 50% of RDN	151.2	87.6	87.9	92.0	137.0	309.0	32.4	38.7
Nx @ 125% of RDN	149.2	90.8	90.4	91.4	138.0	336.8	36.2	40.1
Nx @100% of RDN	151.6	90.4	90.3	91.4	138.0	336.8	33.2	39.8
Nx @ 75% of RDN	150.4	86.4	86.5	92.0	137.0	321.8	33.2	39.1
Nx @ 50% of RDN	148.2	84.5	84.9	91.7	136.0	311.4	32.0	38.6
RDN (Urea)	151.8	81.4	93.2	88.8	135.0	386.0	40.0	42.1
Control	144.6	72.6	79.3	76.6	127.4	287.0	26.6	34.0
SEm±	0.63	1.44	0.99	1.12	0.81	5.86	0.82	0.44
CD (P=0.05)	2.08	2.06	2.7	2.84	1.38	19.76	2.74	1.99

RDN: Recommended dose of nitrogen; VC: Vermicompost; Nx: Neemax; FYM: Farm yard manure

Table 2. Effect of organic sources of nitrogen on grain and straw yield of wheat

Treatment	Grain yield (t/ha)						Straw yield (t/ha)					
	2003-04	2004-05	2005-06	2006-07	2007-08	Mean	2003-04	2004-05	2005-06	2006-07	2007-08	Mean
FYM @ 125% of RDN	3.59	3.42	3.00	4.04	4.22	3.65	3.58	3.77	4.75	5.92	6.27	4.86
FYM@ 100% of RDN	3.47	3.16	2.96	3.83	3.95	3.47	3.48	3.64	3.82	5.78	6.01	4.54
FYM @ 75% of RDN	3.31	3.06	2.90	3.63	3.78	3.35	3.41	3.69	3.65	5.21	5.78	4.55
FYM @ 50% of RDN	3.14	3.05	2.81	3.11	3.36	3.09	3.10	3.36	3.15	4.72	5.24	3.92
VC @ 125% of RDN	3.53	3.43	2.90	3.81	3.98	3.53	3.58	3.57	4.08	5.92	5.97	4.62
VC @ 100% of RDN	3.33	3.25	2.90	3.60	3.76	3.37	3.21	3.37	4.12	5.34	5.74	4.56
VC @ 75% of RDN	3.09	3.00	2.83	3.23	3.52	3.13	3.15	3.25	3.35	5.21	5.35	4.06
VC @ 50% of RDN	2.79	2.72	2.80	3.09	3.34	2.95	3.17	3.34	3.62	4.87	5.29	4.06
Nx @ 125% of RDN	3.13	2.84	3.16	4.05	4.03	3.44	3.70	3.41	4.38	5.81	6.15	4.50
Nx @100% of RDN	3.09	2.88	3.10	3.93	4.10	3.41	3.10	3.39	4.05	5.92	6.17	4.53
Nx @ 75% of RDN	2.92	2.65	3.07	3.64	3.89	3.23	2.89	3.16	4.05	5.04	6.07	4.24
Nx @ 50% of RDN	2.55	2.32	3.00	3.07	3.40	2.87	2.20	2.49	3.72	4.35	5.32	3.62
RDN (Urea)	3.90	3.55	4.95	5.28	5.45	4.63	5.49	5.66	5.68	7.26	8.18	6.45
Control	2.88	2.17	2.35	2.23	2.92	2.50	2.99	3.31	2.7	2.56	2.94	4.26
SEm±	0.09	0.10	0.15	0.18	0.15	0.12	0.16	0.18	0.19	0.27	0.18	0.17
CD (P=0.05)	0.39	0.33	0.47	0.62	0.54	0.32	0.48	0.53	0.62	0.89	0.54	0.60

RDN: Recommended dose of nitrogen; VC: Vermicompost; Nx: Neemax than RDN through urea, but with par with vermicompost @ 125% of RDN and significantly higher than neemax @ 125% of RDN. Grain yield was significantly less under FYM, vermicompost and neemax @ 50% of RDN than 125% of RDN during 2005-06, 2006-07 and 2007-08. Straw yield was also affected significantly due to treatments during all the years. Pooled analysis revealed that straw yield was the highest under recommended nitrogen applied through urea (Table 2), which was significantly higher than other treatments. FYM, vermicompost and neemax gave at par straw yield at 125% of RDN, which was significantly higher than 50% of RDN applied through neemax during 2003-04 and 2004-05. However, during 2005-06, 2006-07 and 2007-08 FYM, vermicompost and neemax at 125% of RDN gave significantly higher straw yield than at 50% of RDN. Nitrogen availability rate and mineralization losses might be responsible for variation in grain yield under different organic sources. However, compensation and deficit of nitrogen from recommended nitrogen doses may caused yield variation. Concentration variation in FYM, vermicompost and neemax produced variation in yield. Beneficial microorganism responsible for mineralization might be killed under neemax treated plot, which hamper the mineralization, might be responsible for lowest wheat yield in this treatment. Kumar and Dhar (2009) also agreed with these findings.

Protein content and yield and NUE

Pooled analysis of protein content, protein yield, nitrogen uptake and nitrogen use efficiency (NUE) indices showed that treatments had a significant effect on these parameters (Table 3). Highest protein content (%) was observed at RDN through urea followed by 125% of nitrogen from vermicompost. Reduction in nitrogen doses significantly reduced the protein content in all of the organic sources. Vermicompost and FYM treated plots had significantly higher protein content than Neemax treated plots. This is the fact that organics provided readily available plant nutrients, growth-enhancing substances and number of beneficial organism, like N_2-fixing and P-solublizing and cellulose decomposing organisms (Barik and Gulati, 2009). However, neemax may kill the beneficial microorganism, which resulted nitrogen supply to the plant in slower pace, which may caused the lower protein content. Protein yield was maximum under RDN applied through urea, which was significantly higher than other treatments. Among organic sources of nitrogen nutrition, vermicompost treated plots gave significantly higher protein yield than FYM and neemax treated plots. Protein yield reduced with reducing doses of nitrogen in all the organic sources. FYM, vermicompost and neemax @ 125% of RDN gave significantly higher protein yield than 50% of RDN. Grain nitrogen uptake was highest under RDN applied through urea. Among the organic sources, FYM resulted in significantly higher nitrogen uptake than vermicompost and neemax. Differences between 125% of RDN and 50% of RDN were also found significant in all the organic sources of nitrogen nutrition. The total nitrogen uptake was highest under recommended nitrogen applied through urea and was found significantly higher than other treatments. Vermicompost @ 125% of RDN resulted in highest nitrogen uptake, which was significantly higher than all the other doses of RDN applied through vermicompost. Similar results were noticed under treatments, where nitrogen was applied through FYM and neemax. Nitrogen harvest index was found maximum in RDN applied through urea. Nitrogen applied through vermicompost had significantly high nitrogen harvest index than FYM and neemax. Nitrogen use efficiency was measured in term of physiological efficiency, agronomic efficiency and recovery efficiency. Physiological efficiency was higher under nitrogen nutrition through neemax, followed by urea and than FYM. However agronomic efficiency was highest for urea, followed by FYM and vermicompost. Apparent recovery efficiency also responded in same way as agronomic efficiency. Nitrogen doses through organics upto 125% of RDN increased the agronomic efficiency and recovery efficiency. Physiological efficiency get decreased at 125% of RDN though organics might be due to higher N uptake by the crop. Singh *et al.* (2009) reported similar results.

Available nitrogen balance

Under all the treatments, available nitrogen balance was positive and ranged from 12.9 kg/ha (50% of RDN through FYM) to 101.6 kg/ha (125% of RDN through neemax). The maximum positive nitrogen balance under the treatment receiving 125% of recommended nitrogen through neemax, can be attributed to the fact that the nitrogen uptake under this treatment was lower as compared to that under 125% of recommended dose of nitrogen through FYM and vermicompost. The negative nitrogen balance (-30.39 kg/ha) was found under control only. FYM and vermicompost improve the available nitrogen, seems to be due to complete water solubility of both the sources.

Sustainability index

The treatment where recommended dose of nitrogen was applied through urea was found to be the most sustainable with sustainable index (SI) of 0.72. This may be due to fact that during all the five years of study, maximum grain yield was obtained under this treatment. Although

Table 3. Effect of organic sources of nitrogen on protein content and yield, nitrogen uptake and nitrogen use efficiency indices (Pooled data over five years)

Treatment	Grain protein content (%)	Protein yield (kg/ha)	N uptake (kg/ha)			N harvest index (%)	Physiological efficiency (%)	Agronomic Efficiency (%)	Apparent N Recovery (%)	*Available N gain (kg/ha)	Sustainability index	Net returns (× 10³/ha)
			Grain	Straw	Total							
FYM @ 125% of RDN	8.6	313.1	52.1	16.6	68.8	75.8	35.7	7.6	21.5	87.41	0.59	-29.0
FYM@ 100% of RDN	8.2	283.3	48.2	15.5	63.7	75.7	35.7	6.5	18.1	62.51	0.56	-20.9
FYM @ 75% of RDN	7.9	265.8	45.0	15.5	60.6	74.3	35.4	5.6	16.0	35.61	0.54	-12.0
FYM @ 50% of RDN	7.5	232.9	40.5	12.7	53.3	76.2	35.3	3.9	11.1	12.91	0.51	-3.5
VC @ 125% of RDN	9.6	338.6	44.2	15.2	69.3	78.1	31.4	6.8	21.8	86.91	0.57	-17.5
VC @ 100% of RDN	9.2	309.8	48.7	14.7	63.5	76.7	31.9	5.8	17.9	62.71	0.53	-12.5
VC @ 75% of RDN	9.1	285.1	44.9	12.8	57.7	77.8	29.8	4.2	14.1	38.51	0.51	-6.6
VC @ 50% of RDN	8.2	242.5	36.7	11.3	48.0	76.4	39.4	3.0	7.6	18.21	0.48	-0.9
Nx @ 125% of RDN	8.3	285.3	41.9	12.7	54.6	76.7	52.2	6.2	11.3	101.61	0.54	2.6
Nx @100% of RDN	7.8	265.5	40.5	12.9	53.5	75.8	53.8	6.0	11.3	72.71	0.54	5.6
Nx @ 75% of RDN	7.6	245.1	37.0	11.9	48.9	75.6	59.3	4.8	8.2	47.31	0.51	7.0
Nx @ 50% of RDN	7.6	217.3	32.6	8.6	41.2	79.2	80.4	2.4	3.0	25.01	0.45	7.1
RDN (Urea)	9.2	426.8	68.4	18.4	86.8	78.8	42.4	14.2	33.5	39.41	0.72	6.1
Control	7.9	249.9	45.0	13.2	36.6	77.3				-30.39	0.36	13.7
SEm±	0.25	13.74	1.21	0.23	1.97	0.35						
CD (P=0.05)	0.67	33.37	2.89	0.79	3.28	1.32						

RDN: Recommended dose of nitrogen; VC: Vermicompost; Nx: Neemax; FYM: Farm yard manure
*Initial value of available N was 254 kg/ha

the SI of the treatments where nitrogen was applied through organic sources was lower, but all of the organic treatments except 50% of RDN through neemax and 50% of RDN through vermicompost can be defined as highly promising as per the criteria outlined by Singh *et al*. (1990). Out of the organic treatments, 125% of RDN through FYM was found to be most sustainable with SI of 0.59.

Economic analysis

The highest net returns (₹13,722) obtained from control due to least cost of cultivation. High cost involved in procuring large quantity of FYM and vermicompost required to supply the nitrogen to wheat crop at different percentages of recommended dose, resulted in negative net returns under these treatments. However, the treatments where neemax was used as the source of nitrogen, net returns was better as compared to FYM and vermicompost. The negative returns, as low as ₹ 29,012 under 125% of RDN through FYM suggest the essentiality of the on farm availability of the organic sources of nutrients. Similar results were reported by Singh *et al*. (2010).

It is concluded from the experiment that, the yield and the morphological parameters responded from RDN *i.e.* (150 kg N/ha) through urea, was at par with FYM and vermicompost @ 125% of RDN. Higher value of protein yield, nitrogen uptake and nitrogen use efficiency indices were noticed under FYM and vermicompost than neemax. The sustainability index of the treatments was lower when nitrogen was applied through organic sources; however, all the organic sources except 50% of RDN through neemax and 50% of RDN through vermicompost were highly promising. Nitrogen balance was positive in all the treatments except control. Negative net returns obtained with FYM and vermicompost due to high procurement cost and volume, which appeal to develop FYM and vermicompost on farm.

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