Indian Journal of Agronomy **52** (2) : 124–126 (June 2007)

Integrated nitrogen management in wheat (*Triticum aestivum*)

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Received : March 2007

ABSTRACT

A field experiment was conducted at Bichpuri, Agra during the winter season of 2000–01 and 2001–02 to study the effect of biofertilizers, and organic and chemical nitrogen as well as their combination on growth, yield and uptake of nitrogen by wheat (*Triticum aestivum* L. emend. Fiori & Paol.). The treatments consisted of biofertilizer (*Azotobacter* and *Azospirillum*), organics (FYM @ 5 t/ha) and 3 levels of nitrogen (50, 100 and 150 kg N/ha), and their combinations (i.e. 50 kg N/ha + *Azotobacter*, 50 kg N/ha + *Azospirillum* + FYM @ 5 t/ha); one unfertilized control was also included for comparison. The integrated use of inorganic fertilizer, biofertilizer and organics enhanced the growth and yield of wheat. Higher plant height and yield attributes were recorded in 50 kg N/ha + *Azospirillum* + FYM @ 5 t/ha, followed by 150 kg N/ha. Further, seed and stover yields of wheat enhanced significantly at higher levels of N and integrated use of organic and bio-fertilizers. However, the highest yield attributes were recorded at 150 kg N/ha. The uptake of total nitrogen by wheat was significantly higher at 150 kg N/ha than at 50 kg N/ha + *Azospirillum* + FYM @ 5 t/ha.

Key words : *Azospirillum, Azotobacter,* Biofertilizer, FYM, Integrated fertilizers, Urea, Wheat productivity

The dwarf varieties of wheat have great potential but due to exhaustive nature they require more nutrients and have posed a great threat to long-term sustainability of crop production. Adoption of wheat-maize sequence over a long period results in a decline in soil fertility. Chemical fertilizers will continue to be the main components for meeting the increased crop nutrient needs of the country. However, due to energy crisis their use has become the costliest input, which constitutes 30-40% of the farmer's budget for cereal production. Combined use of organic and inorganic sources of nitrogen increases the production and profitability of field crops and helps in maintaining the fertility status of the soil. Organic manure and biofertilizers are needed along with inorganic fertilizers for better yield and good soil health. It is evident that biofertilizers like *Azotobacter* and *Azospirillum* alone or in combination have great prospect for increasing productivity of wheat (Kumar and Ahlawat, 2004). However, very little information is available regarding the effect of *Azotobacter and Azospirillum* combination with farmyard manure and inorganic nitrogen. The present investigation was, therefore, undertaken to study the integrated nitrogen management in wheat.

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MATERIALS AND METHODS

A field experiment was conducted during winter (*rabi*) season of 2000-01 and 2001-02 at R.B.S. College, Bichpuri, Agra. The soil was sandy loam, alkaline in nature (pH 8.5), medium in organic C (0.45%) and low in available N (152.5 kg/ha), and medium in available P (11.5 kg/ha) and available K (158.5 kg/ha). The treatments comprised 3 combinations of biofertilizers, nitrogen levels and farmyard manure, viz. control, *Azotobacter, Azospirillum,* FYM @ 5 t/ha, 50 kg N/ha, 100 kg N/ha, 150 kg N/ha, 50 kg N/ha, + *Azotobacter*, 50 kg N/ha + *Azospirillum*, 50 kg N/ha + *Azotobacter* + FYM @ 5 t/ha, 50 kg N/ha + *Azospirillum* + FYM @ 5 t/ha. The experiment was laid out in randomized block design with four replications. Nitrogen as per treatment was applied through urea (46% N), half the dose was applied at sowing and the remaining after the first irrigation. A uniform dose of 30.6 kg P and 41.7 kg K/ha through single superphosphate and muriate of potash respectively, was incorporated into the soil before sowing. The FYM at 5 t/ha was incorporated into the soil 21 and 23 days before sowing as per the treatments. The untreated and treated seed of wheat variety 'PBW 343' with biofertilizers (*Azotobacter* and *Azospirillum* as per the treatments) was drilled on 23 November 2000 and 25 November, 2001 respectively, in

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respective years in rows spaced 25 cm apart using hand-plough, and furrows were covered manually. The irrigation and other packages of practices were adopted as per recommendations during the crop-growth period in both the years. The biometric observations were recorded at 30, 60 and 90 days after sowing and at harvest. Yield and yield attributes were recorded at harvest.

RESULTS AND DISCUSSION

Biofertilizers

Both biofertilizers (*Azospirillum* and *Azotobacter*) significantly increased plant height, tillers/m^2, length of spike, grain weight/spike, test weight and yields of grain and straw over uninoculated control (Table 1). Singh *et al.* (2000) reported improvement in grain yield of wheat with bio-fertilizer application. The total uptake of N in grain and straw of wheat with biofertilizers was significantly increased over the uninoculated control. However, the differences were not marked for uptake between *Azospirillum* and *Azotobacter*. The increase in N uptake by bio-fertilizers was due to increase in dry-matter yield as well as higher N concentration in the plant. Fertilizer-use efficiency, i.e. agronomic efficiency, apparent N recovery and physiological efficiency, were significantly improved with the application of biofertilizer over control. Both the fertilizers (organic and inorganic) remained at par in respect of fertilizer-use efficiency in both the years. These results are in conformity with those reported by Kumar and Ahlawat (2004).

Farmyard manure and nitrogen

Application of FYM to wheat induced better growth of plant, which resulted in taller plant, more tillers/m^2, length of spike, grain weight/spike, test weight, yield of grain and straw over the control. Increase in plant height, higher number of tillers/m^2 and increased yield of wheat with the application of farmyard manure were also reported by Kumar and Ahlawat (2004). The N uptake in grain and straw of wheat increased significantly with the farmyard manure over the control in both the years. Keshwa and Singh (1998) also reported increase in N uptake due to FYM in wheat. Inorganic, organic and biofertilizer combinations significantly increased the agronomic efficiency, apparent N recovery and physiological efficiency because it was proved from the result that low levels of nitrogen increased these characters. The observation is in conformity with the findings of Prasad *et al.* (2000). The agronomic efficiency, apparent N recovery and physiological efficiency were reduced with the higher level of N. The increasing level of nitrogen up to 150 kg/ha increased the plant height, tillers/m^2, length of spike, grain weight/spike, test weight, and grain and straw yields. All the nitrogen levels significantly increased the growth, yield attributes, yield and N uptake in wheat grain and straw over the control. Similar increase in grain yield of wheat by N application was also observed by Kumar and Ahlawat (2004).

Combined nitrogen and biofertilizers

Combined application of *Azospirillum* or *Azotobacter* with 50 kg N/ha increased the plant height, tillers/m^2, length of spike, grain weight/spike, test weight and yield of wheat over individual biofertilizer or N applied and the control, *Azospirillum* or *Azotobacter* in combination with 50 kg N/ha significantly increased the grain yield of wheat

Table 1. Effect of biofertilizers, farmyard manure and nitrogen on plant height, number of tillers/m^2, length of spike, number of grains/spike and test weight

Treatment	Plant height (cm)		Tillers/ m^2		Length of spike (cm)		Grains/ spike		Test weight (g)	
	2000–01	2001–02	2000–01	2001–02	2000–01	2001–02	2000–01	2001–02	2000–01	2001–02
Control	64.00	67.55	191.70	195.90	7.13	7.75	31.06	32.40	33.15	33.06
Azotobacter	83.00	82.49	262.20	268.20	9.57	9.81	36.13	36.23	36.73	37.63
Azospirillum	83.75	82.42	264.60	270.90	9.73	9.97	36.57	36.67	36.55	37.45
FYM @ 5 t/ha	84.15	83.18	266.70	273.00	9.37	10.00	37.80	37.82	37.37	37.29
50 kg N/ha	84.38	84.29	270.90	274.50	9.83	10.45	36.88	37.08	38.46	38.49
100 kg N/ha	89.38	91.68	307.20	308.10	10.82	11.34	39.36	40.53	41.50	42.40
150 kg N/ha	93.00	96.33	324.90	325.20	11.69	12.13	40.71	41.88	42.52	43.42
50 kg N/ha + Azotobacter	89.50	94.43	301.20	297.90	10.75	10.63	39.48	40.87	41.79	42.22
50 kg N/ha + *Azospirillum*	89.90	93.92	305.10	302.70	10.83	11.03	39.59	41.08	41.83	42.77
50 kg N/ha + *Azotobacter* + FYM @ 5 t/ha	91.83	96.78	329.40	335.10	11.48	11.80	41.31	41.27	42.81	43.71
50 kg N/ha + *Azospirillum*+ FYM @ 5 t/ha	92.00	99.30	330.60	338.40	12.16	12.22	41.42	41.27	42.68	43.10
SEm ±	1.92	1.84	6.43	6.45	0.23	0.23	0.60	0.91	0.68	0.73
CD (P=0.05)	5.67	5.43	18.97	19.03	0.68	0.68	2.36	2.29	2.01	2.15

Table 2. Effect of biofertilizers, farmyard manure and nitrogen on wheat grain and straw yield, total nitrogen uptake, agronomic efficiency, apparent N recovery and physiological efficiency

Treatment	Grain yield (t/ha)		Straw yield (t/ha)		Total N uptake (kg/ha)		Agronomic efficiency (kg grain/kg N)		Apparent N recovery (%)		Physiological efficiency (kg grain/kg N uptake)	
	2000-01	2001-02	2000-01	2001-02	2000-01	2001-02	2000-01	2001-02	2000-01	2001-02	2000-01	2001-02
Control	2.65	2.77	4.59	4.61	58.49	60.15	-	-	-	-	-	-
Azotobacter	3.46	3.53	5.58	5.71	78.51	81.55	12.94	15.26	26.06	30.08	57.32	55.03
Azospirillum	3.59	3.60	5.64	5.81	83.63	88.27	13.68	14.08	28.30	29.74	55.58	53.06
FYM @ 5 t/ha	3.53	3.79	5.68	5.82	82.69	85.24	8.00	5.68	23.36	22.00	52.81	54.49
50 kg N/ha	3.75	3.82	5.89	5.95	95.02	96.27	22.00	21.00	54.68	51.40	40.23	40.76
100 kg N/ha	4.67	4.74	6.52	6.71	120.73	124.53	20.21	19.71	48.22	48.35	41.91	40.86
150 kg N/ha	4.88	4.95	6.73	6.79	128.86	132.22	14.86	14.53	36.40	36.21	40.82	40.11
50 kg N/ha + *Azotobacter*	4.40	4.58	6.42	6.55	109.88	114.14	34.94	36.26	80.74	81.14	43.27	44.50
50 kg N/ha + *Azospirillum*	4.44	4.52	6.44	6.59	109.64	114.84	35.68	35.08	82.98	81.48	43.00	43.23
50 kg N/ha + *Azotobacter* + FYM @ 5 t/ha	4.80	4.86	6.68	6.76	125.43	128.15	42.94	41.94	104.10	103.48	41.25	40.53
50 kg N/ha + *Azospirillum* + FYM @ 5 t/ha	4.82	4.88	6.79	6.79	127.43	130.45	43.28	42.28	106.68	105.12	41.05	40.22
SEm ±	0.09	0.10	0.14	0.17	2.15	2.33	0.68	0.67	1.38	1.46	0.93	1.24
CD (P=0.05)	0.28	0.31	0.41	0.50	6.50	6.93	2.00	1.99	4.00	4.31	2.73	3.66

over uninoculated control by increasing the length of spike, grain weight/spike, test weight. Enhanced yield with bio-fertilizers and nitrogen might be owing to increased supply of plant hormones by micro-organism and nitrogen, which improved the vegetative growth and resulted in higher yield. Similar findings were reported by Aly *et al.* (1999). The higher values of yield-attributing characters and finally the yield due to *Azospirillum* inoculation with 50 kg N/ha was superior to *Azotobacter* with same combination. Seed inoculation with *Azospirillum/Azotobacter* and 50 kg N/ha application also enhanced nitrogen uptake.

Combined effect of nitrogen, bio-fertilizers and FYM was significant in both the years for various characters. Grain and straw yields obtained with the application of above combination were those similar to those obtained at 150 kg N/ha. Combination of 50 kg N/ha, *Azotobacter* or *Azospirillum* and 5 t/ha FYM significantly increased plant height, tillers/m^2 and other yield-attributing traits. The highest values of these traits were recorded with 50 kg N/ha + *Azospirillum* + FYM (5 t/ha). Among the biofertilizers, *Azospirillum* proved superior to *Azotobacter*. *Azospirillum*, a micro-aerophic N fixer is second only to blue-green algae and it could be used to replace some of the N fertilizer requirement. Increase in N uptake, grain and straw yields of wheat was observed due to combined application of 50 kg N/ha + *Azotobacter/Azospirillum* and FYM (5 t/ha). This combination increased the availability of total N to plant, which ultimately resulted in higher plant height and other yield-contributing characters. The more pronounced effect of *Azospirillum* with FYM and nitrogen was because of their combined application to seed, soil and roots. Similar results were reported by Keshwa and Singh (1998).

Inorganic, organic and bio-fertilizer combinations significantly increased the agronomic efficiency and apparent N recovery because it was proved that the low levels of nitrogen increased the agronomic efficiency and apparent N recovery. However, same combination had low value for physiological efficiency than other treatments under investigation. Prasad *et al.* (2000) also reported similar results.

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