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Growth, nutrient uptake and yield of wheat (*Triticum aestivum*) as influenced by biofertilizers and nitrogen

DILEEP KACHROO AND RAVINDER RAZDAN

Division of Agronomy, Sher-e-Kashmir University of Agricultural Sciences and Technology, Main Campus Chatha, Jammu, Jammu and Kashmir 180 009

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ABSTRACT

A field experiment was conducted during the winter season of 1999–2000 and 2000–01 at research farm, Sher-e-Kashmir University of Agricultural Sciences and Technology, R.S. Pura, Jammu, to study the effect of biofertilizers and nitrogen levels on growth, yield attributes, yield and nitroigen-use efficiency of 'PBW 343' wheat (*Triticum aestivum* L. emend. Fiori & Paol). Combined inoculation of *Azotobacter* + *Azospirillum* in 1 : 1 ratio increased the growth, yield attributes and yield significantly. The nitrogen-use efficiency values also were higher. Each unit increase in N level led to significant increase in growth, yield-attributing characters and yield of wheat. The maximum grain yield (53.55 q/ha) was recorded with highest N level. The nitrogen-use efficiency (NUE), apparent N recovery (%), nitrogen-efficiency ratio (NER) and physiological efficiency index of absorbed nitrogen (PEIN) were higher up to 80 kg N/ha and thereafter decreased with increasing N level.

Key words : Wheat, Biofertilizers, Nitrogen, Yield attributes, Nitrogen uptake

For a sustainable agriculture, it is imperative to utilize renewable inputs which can maximize the ecological benefits and minimize the environmental hazards. One possible way of achieving this is to decrease dependence on use of chemical nitrogen fertilizers by harvesting the atmospheric nitrogen through biological processes. An integrated approach for use of biofertilizers with chemical fertilizers is considered as the need of hour, as biofertilizers are not replacement of fertilizers but can supplement their requirement. Therefore, its efficient use in the cultivable crops, mainly to wheat, which is heavy feeder of nitrogen is much more relevant. The increase in eco-friendly production of wheat can be made possible by wide-spread adoption of improved technologies of which fertilizer management particularly that of nitrogen through biofertilizers can play a key role. Hence present investigation was carried out to study the growth and yield behaviour of wheat to define the optimum dose and nutrient-use efficiency under integrated use of biofertilization and inorganic nitrogen fertilization.

MATERIALS AND METHODS

The experiment was carried out at research farm R.S. Pura, Sher-e-Kashmir University of Agricultural Sciences and Technology, Jammu, during the winter season 1999–2000 and 2001–02 in clay loam soil. The available nutrients N, P and K in soil were 251.68, 12.38 and 145.20 kg/ha, respectively, with pH 6.8. The experiment was laid out in randomized block design with 3 replications, comprising 4 nitrogen (0, 40, 80, and 120 kg N/ha) and 4 levels of biofertilizers (uninoculated, *Azotobacter, Azospirillum* and *Azotobacter* + *Azospirillum* in ratio of 1:1). For inoculation, 10% sugar solution was prepared by dissolving 100 g sugar in 1 litre water and heated for 20–25 min. The solution was cooled at room temperature and mixed with cultures treatment-wise. The wheat seeds were inoculated (1 kg + 10 g culture) with the solution and then dried under shade before sowing. Wheat 'PBW 343' was sown on 15 and 17 November of 1999 and 2000, respectively, @ 100 kg/ha between 20 cm apart rows at a depth of 3 cm from the top of the soil in lines using *kera* method of sowing by opening furrows through a liner. The full dose of recommended phosphorus (60 kg P_2O_5/ha), potassium (40 kg K_2O/ha) and half of nitrogen as per treatment at the time of sowing as basal dose and rest of N at 2 equal splits, at crown-root initiation and ear initiation stage. The total rainfall received during the crop season was 87.7 mm and 77 mm during 1999–2000 and 2000–01 respectively. Wheat crop was harvested in the second week of April in both the years.

RESULTS AND DISCUSSION

Biofertilizers

Plant height, tillers/m^2 at harvest, ear length, effective tillers and test weight significantly increased when combined form of *Azotobacter* + *Azospirillum* in the ratio of 1:1 was inoculated compared with uninoculated and alone application of *Azotobacter* and *Azospirillum.* This might be partly owing to their additive effect of nitrogen fixed from the atmosphere and partly owing to synthesis of biologically active substances like vitamins, auxins and gibberellins etc., which in turn might have stimulated the plant growth parameters. These results are akin to the findings of Sushila and Giri (2000).

The grain and straw yield of wheat increased significantly with inoculation of biofertilizers and maximum grain yield was recorded with the combined inoculation of *Azotobacter* + *Azospirillum* in 1:1 ratio was inoculated than uninoculated and alone application of *Azotobacter* and *Azospirillum* (Table 1). The increase was 25.16% over uninoculated. The increase in yield might have resulted from the growth regulating substances produced by combined application of biofertilizers besides fixation of additional nitrogen from atmosphere, thereby, increasing the nitrogen availability in the soil throughout the crop growth. Bhattarai and Hess (1998) also reported the similar findings.

Inoculation of *Azotobacter* + *Azospirillum* in the ratio of 1:1 increased the N uptake by grain, straw and total plant significantly over uninoculated and alone inoculation of *Azotobacter* and *Azospirillum* during both the crop seasons (Table 2), which might be because of better growth and development of the plant and adequate N availability in the soil. However, the higher values (Table 2) of agronomic nitrogen-use efficiency (NUE), apparent N recovery (%), nitrogen-efficiency ratio (NER) and physiological efficiency index of nitrogen (PEIN) were observed when the wheat seed was inoculated with combined form of *Azotobacter* + *Azospirillum* in 1:1 ratio than uninoculated and alone application of *Azotobacter* and *Azospirillum.*

Significantly highest available nitrogen content was recorded in the soil after 2 years (Table 2) when *Azotobacter* + *Azospirillum* in 1:1 ratio was applied as inoculum to wheat seed compared to uninoculated and alone inoculation of *Azotobacter* and *Azospirillum* during both the years. The increase was owing to enhanced nitrogen content in the soil due to inoculation of biofertilizers. However, available P_2O_5 and K_2O contents did not show significant variation due to different treatments.

Nitrogen

Increasing levels of N up to 80 kg N/ha applied to wheat increased its growth and yield-attributing characters significantly over the control and 40 kg N/ha, but were significantly at par with 120 kg N/ha during both the years (Table 1). The increase was owing to higher amount of N, which increased the nutritional environment and henceforth resulted in more nutrient uptake and increased the meristematic activity of the plant. Singh *et al.* (1996) also observed the similar results.

Increasing levels of N applied in wheat increased grain and straw yields significantly. Application of 80 kg N/ha though at par with 120 N/ha significantly influenced the grain and straw yields of wheat compared with the control and 40 kg N/ha. The average per cent increase in terms of grain yield was 58.89 and 30.23 over the control and 40 kg N/ha respectively. As the grain yield is a prod-

Table 1. Growth and yield attributes and grain yield of wheat as influenced by biofertilizers and nitrogen levels (pooled data of 2 years)

Treatment	Plant height (cm)	Dry-matter accumulation at harvest (g/ha)	Number of tillers/ m^2 at harvest	Ear length (cm)	No. of effective tillers	Test weight (g)	Grain yield (q/ha)	Straw yield (q/ha)
Biofertilizer								
Uninoculated	71.7	68.7	46.1	11.7	215.3	38.8	33.2	53.8
Azotobacter	76.9	89.9	53.3	12.9	249.4	39.1	40.6	64.7
Azospirillum	78.0	93.2	53.8	13.3	151.8	38.5	41.3	66.6
Azotobactor + Azospirillum (1:1)	80.3	100.5	59.6	14.5	279.5	40.2	44.3	72.8
CD (P=0.05)	0.8	5.2	0.6	0.7	15.1	NS	2.7	5.4
Nitrogen (kg/ha)								
0	70.1	47.2	49.5	10.3	231.6	37.8	20.9	33.1
40	73.2	85.2	51.4	12.9	240.5	39.0	34.9	57.1
80	81.6	107.9	55.8	14.2	269.5	39.4	50.6	81.7
120	82.1	112.2	56.0	14.6	281.8	40.5	53.1	85.9
CD (P=0.05)	0.8	5.1	0.6	0.7	15.1	NS	2.7	5.4

Table 2. Nitrogen uptake, final nutrient status of soil and efficiencies of nitrogen of wheat as influenced by biofertilizers and N levels

Treatment	Avarage N putake (kg/ha)*			Final available soil nutrient status (kg/ha)			Average NUE (kg/grain/ (kg N)*	Average apparent N recovery (%)*	Average nitrogen efficiency ratio*	Average physio-logical index of N*
	Grain	Straw	Total	N	P	K				
Biofertilizer										
Uninoculated	53.3	30.6	83.3	245.1	11.7	140.6	16.4	19.1	96.4	39.8
Azotobactor	57.9	31.4	89.4	251.3	11.7	141.3	25.7	20.1	117.8	45.4
Azospirillum	57.9	32.4	90.5	256.8	11.9	141.8	26.6	19.8	119.3	45.7
Azotobactor + *Azospirillum* (1:1)	60.1	33.7	94.2	274.4	12.1	142.1	30.2	22.2	124.2	47.1
CD (P=0.05)	3.0	1.2	4.0	16.8	NS	NS				
Nitrogen (kg/ha)										
0	46.5	26.7	73.6	247.0	11.6	140.1			73.3	28.4
40	53.4	28.7	82.1	250.4	11.7	141.5	34.9	22.3	112.1	42.5
80	63.0	35.4	98.5	259.1	12.0	142.2	30.1	31.4	134.3	51.4
120	66.3	37.4	103.7	271.2	12.1	142.1	26.8	25.4	134.1	51.2
CD (P=0.05)	3.0	1.2	4.0	16.8	NS	NS				

*Average data of 1992–2000 and 2000–01

uct of yield-attributing characters, increase in their values resulted in the increased grain yield. Similar results were also obtained by Reddy and Bhardwaj (1984).

Maximum N uptake was associated with the highest (120 kg N/ha) dose of nitrogen applied to wheat. The N uptake by wheat noted at 120 kg N/ha was however comparable with that recorded at 80 kg N/ha, but was significantly superior to those recorded with the application of 0 and 40 kg N/ha. The increased biomass and its higher N content in the crop by N application, thereby activating greater absorption of nitrogen from soil, resulted in higher N uptake. The results confirm the findings of Verma *et al.* (2000). The graded levels of N had positively influenced the nitrogen efficiencies (Table 2) and the highest value of NUE, apparent N recovery (%), NER and PEIN was found when 80 kg N/ha was applied. The drop in the ANR, NUE, NER and PEIN with increasing N levels at 120 kg N/ha may be due to increase in the denominator (N levels) with less proportionate increase in the numerator.

Similarly, at higher doses of nitrogen fertilization the N content in the soil (Table 2) was observed to be higher than unfertilized and lower does of nitrogen application, which might be due to considerable gain of nitrogen content in the soil than controlled plots. The P_2O_5 and K_2O content in the soil was not influenced by the varying nitrogen doses but its residual available content values were slightly lesser than the initial values mainly due to more removal by the crop.

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