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GROWTH AND YIELD RESPONSES OF WHEAT CULTIVARS TO INOCULATION WITH N_2-FIXING BACTERIA UNDER FIELD CONDITIONS

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ABSTRACT

The growth and yield responses of eight wheat cultivars, NI 747-19, NI 5439, NI 5643, belonging to *Triticum aestivum* (L.), and HD 2189, CC 464, UP 215, Malvika and Sonalika, belonging to *Triticum durum* (desf.), to *Azotobacter chroococcum* and *Azospirillum brasilense* inoculations were studied in a field experiment (medium black soil). Both the cultures significantly increased the number of fertile tillers, plant dry matter, grain yield and nitrogen status of of grain, straw and soil at the harvest. *Azospirillum* increased the grain yield by 18 to 25% and *Azotobacter* by 13 to 18%. The cultivar Sonalika recorded the highest response to both the inoculations for grain yield. Although a differential response of wheat cultivars to inoculations was observed, yet the interaction between cuitivars×inoculations was not significant for all the parameters of wheat crop studied.

The use of N_2-fixing bacterial cultures, especially *Azospirillum* inoculation, has been extensively evaluated (Anonymous, 1987; Pandey and Kumar, 1989). Inoculation with *Azotobacter* is an established fact for enhanciug N_2-fixation since Beijerinck (1901) isolated and described it as a N_2-fixing bacterium. The recently released wheat cultivars are becoming popular amongst Indian farmers because of their higher potential for grain production and their higher response to nitrogen application. Here an effort has been made to see the growth responses of eight commercial wheat cultivars to two bacterial inoculations, *Azospirillum* and *Azotobacter* under normal agronomic practices.

MATERIAL AND METHODS

Soil, Inoculum und Experimental Design

A field, where sorghum, pearl millet and maize were grown in the previous season, was selected. Its medium black surface soil (0-15 cm) with clay loam texture (Vertic ustropepts) contained: organic C 0.51%, available P 10, total N 510, NO_3-N 14, NH_4-N 6.5 (all in mg/kg) EC 0.43 mmhos/cm, pH (1 : 2.5) 7.2 and most probable number (MPN) of hetero-

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trophic bacteria 11 X 10^7 cells/g on air dry soil basis at sowing. Farm yard manure was applied before sowing @ 10 t/ha. It contained 97 kg organic C/t of manure. The field was fertilized with N, P_2O_5, K_2O @ 120 : 60 : 50 kg/ha through urea, single superphosphate and muriate of potash, respectively. Half of N and entire P and K were applied before sowing and the remaining half of N after 25 days of sowing as top dressing. The lignite based composite strain inoculant of *Azospirillum brasilense* (18 × 10^9 cfu/g) was prepared in the lab with isolate nos. 13, 16 and 19 (Zambre and Konde, 1985) with N_2-fixing capacity 31.2, 30.8 and 34.7 mg N/g of malate, respectively. The *Azotobacter chroococcum* (15 × 10^9 cfu/g lignite) was obtained from the Biological Nitrogen Fixation Scheme, College of Agriculture, Pune-411 005, M.S., India. The seeds of wheat cultivars were treated with inoculants @ 2 kg/100 kg seeds using jaggery as an adhesive. Uninoculated lignite was used for control seeds. After drying under shade the seeds were sown by hand dibbling (22.5 × 2.5 cm) in the pre-irrigated field and after sowing the normal irrigation schedule was followed. The seeds had a count of 10^5-10^6 cfu/seed while sown. The experiment was conducted as a split plot design with cultivars as the main plot treatments and the inoculations as the sub-plot treatments consisting of three replications. Significance between treatment means was determined by Duncans Multiple Range test (Gomez and Gomez, 1984).

Wheat Cultivars, Parameters and Chemical Analysis

The eight high yielding, nitrogen responsive and commercially popular amongst farmers throughout India, cultivars of wheat were selected. They were NI 747-19, NI 5439, NI 5643 from *Triticum aestivum* (L.) and HD 2189, CC 464, UP 215, Malvika, Sonalika from *Triticum durum* (desf.). All the cultivars required 105-130 days for maturity. At harvest, three plants from each plot were randomly taken out and used for recording the observations on dry matter/plant, fertile tillers/plant and N content in the plant. The grain yield was recorded from a net plot area of 2 M^2 at 8% moisture content. The N content was determined (Jackson, 1976) by grinding the samples (20 mesh) of grain and straw separately. The protein content in the grain was calculated by multiplying the N content by 5.83 (Anonymous, 1980). At harvest, three spots were randomly selected in each plot for collection of 1 kg soil from each spot (0-15 cm) and from these three samples one pooled sample was prepared to determine total N content of the soil (Jackson, 1976).

RESULTS AND DISCUSSION

The results in Tables 1,2 and 3 show that, in general, the treatment means for the cultivars differed significantly from one another for all the parameters studied except the tiller number. Similarly, treatment means for inoculations also differed significantly from one another. However, the cultivar × inoculation interactions were found non-significant for

TABLE 1

Number of tillers, plant dry matter and grain yield in wheat cultivars as influeuced by inoculations

Inoculation	Cultivars								
	NI 747-19	NI 5439	NI 5643	HD 2189	CC464	UP 215	Malvika	Sonalika	Mean
				Tillers/plant					
Uninoculated control	2.8	3.2	2.9	2.7	3.1	2.7	3.0	2.7	2.7
A. chroococcum	3.2	3.6	3.6	3.4	4.0	3.3	4.0	3.4	3.5
A. brasilense	3.7	4.0	3.8	3.9	4.7	3.7	4.4	4.0	4.0
LSD (<0.05)				NS					
Mean	3.2	3.6	3.4	3.3	3.9	3.2	3.7	3.4	0.3
LSD (<0.05)				NS					
CV %				12.6					
				Plant dry matter (g/plant)					
Uninoculated control	10.7	12.6	10.4	11.9	13.0	11.9	11.2	12.5	11.8
A. chroococcum	12.0	13.8	11.6	13.5	14.6	13.2	12.7	14.4	13.2
A. brasilense	12.4	14.7	12.2	14.1	15.0	13.6	13.1	14.8	13.7
LSD (<0.05)				NS					
Mean	11.7	13.7	11.4	13.1	14.2	12.9	12.3	13.9	0.31
LSD (<0.05)				0.60					
CV (%)				4.1					
				Grain yield (q/ha)					
Uninoculated control	33.1	34.8	30.9	33.8	32.9	31.2	33.9	35.1	33.2
A. chroococcum	37.5	41.2	35.0	39.6	38.2	35.7	39.8	41.5	38.5
	(13)[a]	(18)	(13)	(18)	(16)	(14)	(18)	(18)	
A. brasilense	39.3	43.4	36.4	41.5	39.8	37.1	42.0	44.0	40.4
	(19)	(25)	(18)	(23)	(21)	(19)	(24)	(25)	
LSD (<0.05)				NS					1.1
Mean	36.6	39.8	34.1	38·3	37.0	34.6	38.5	40.2	
LSD (<0.05)				1.8					
CV %				13.3					

NS=Non Significant.

Per cent increase over uninoculated control.

TABLE 2

Protein content in grain and N content in straw of wheat cultivars as influenced by inoculation

Inoculation	Cultivars								
	NI 747-19	NI 5439	NI 5643	HD 2189	CC 464	UP 215	Malvika	Sonalika	Mean
Grain protein (%)									
Uninoculated control	11.2	13.5	11.2	11.1	13.2	12.2	12.5	13.2	12.5
A. chroococcum	11.4	13.7	11.6	13.4	13.6	12.5	12.9	13.6	12.8
A. brasilense	11.6	13.9	11.7	13.6	13.8	12.6	13.1	13.8	13.0
LSD (<0.05)				NS					0.18
Mean	11.4	13.7	11.5	13.4	13.5	12.5	12.8	13.5	
LSD (<0.05)				0.32					
CV %				7.4					
N content in straw (%)									
Uninoculated control	0.56	0.57	0.58	0.54	0.53	0.48	0.55	0.60	0.55
A. chroococcum	0.60	0.64	0.62	0.60	0.58	0.52	0.61	0.66	0.60
A. brasilense	0.61	0.66	0.63	0.62	0.61	0.54	0.62	0.68	0.62
LSD (<0.5)				NS					0.02
Mean	0.59	0.62	0.61	0.58	0.57	0.51	0.59	0.64	
LSD (<0.05)				0.02					
CV %				10.0					

NS—Non Significant.

TABLE 3

Total nitrogen content of soil at harvest as influenced by inoculation and wheat cultivars

Inoculation	Cultivars								Mean
	NI 747-19	NI 5439	NI 5643	HD 2189	CC 464	UP 215	Malvika	Sonalika	
				Total N (mg/kg soil)					
Uninoculated control	742	728	739	722	710	750	700	691	722
A. chroococcum	762	754	757	746	732	772	728	721	746
B. brasilense	765	762	761	757	742	776	737	729	753
LSD (<0.05)				NS					3.3
Mean	756	748	752	741	728	766	722	714	
LSD (⩽0.05)				5.0					
CV %				30					

Presowing total N = 510 mg/kg soil

all the parameters suggesting that there was no effect of inoculation on any particular cultivar. Table 1 showed that across the inoculations the plant dry matter and fertile tillers were maximum in the cultivar CC 464 (14.2 g/plant and 3.9/plant, respectively), while the grain yield was maximum in Sonalika (4.02 t/ha) followed by NI 5439 (3.98 t/ha) and HD 2189 (3.83 t/ha). Across the cultivars, the maximum number of tillers and plant dry matter were recorded with *Azospirillum* followed by *Azotobacter* and the uninoculated control. Similar observations were made for protein % in grain and for N content in straw about inoculations across the cultivars. NI 5439 yielded maximum protein (13.5%) followed by Sonalika (13.5%). In these cultivars, a similar trend was found for N content in the straw. The total N content in the soil after harvest was the highest in the cultivar UP 215 (766 mg/kg soil) across the inoculations as well as across the cultivars. *Azospirillum* inoculation gave more (753 mg/kg soil) than *Azotobacter* (746 mg/kg soil) and the uninoculated control (691 mg/kg soil). The pre-sowing total N content was 510 mg/kg soil. The cultivars Sonalika, Malvika and NI 5439 gave the maximum per cent increase (18% with *Azotobacter* and 25% with *Azospirillum*) over the control for grain yield (Table 1). The quality of grains in terms of protein content was almost similar with all inoculations in all the cultivars. However, HD 2189 showed a comparatively better response to inoculation. For all the parameters a parallelism between the number of tillers, plant dry matter, grain yield, protein in grains and N content in straw was obtained (Tables 1,2, and 3).

The purpose of this study was to evaluate the effect of inoculations on the growth of wheat cultivars in order to find out the cultivar specific response. Von Bulow and Dobereiner (1975) showed significant differences in the growth of different maize cultivars inoculated with *Azospirillum*. However, on the contrary our results suggest that *Azospirillum brasilense* and *Azotobacter chroococcum* could significantly increase the growth of wheat cultivars but are not specific for any cultivar. Several explanations have been put forward for a cultivar specific response. It has been reported that cultivars which release more organic compounds in their rhizosphere may be selected for maximum utilization of the potentialities of *Azospirillum* (Rao, 1987). Therefore, for our results one of the possible explanations for no cultivar specific response could be that all the wheat cultivars used here might have secreted more or less a similar amount of root exudates in their rhizosphere. For a general beneficial effect several explanations have been given. Many workers suggest that benefits observed with such inoculations are not solely due to N_2-fixation. The other properties of these bacteria like the secretion of growth promoting substances helps in root proliferations (Okon, 1985), the presence of siderophores produced by these bacteria in rhizosphere plays an important role in Fe uptake by plant (Barton *et al.*, 1986), and also the increased NO_3 reductase activity in leaf in turn enhances more N assimilation in plants with inoculation (Ferreira *et al.*, 1987; Wani *et al.*, 1988). The increased phosphate and potassium uptake have also been reported due to inoculations (Kapulnik *et al.*, 1987). Our results are in conformity with those of Ishac (1987), Ferreira *et al.*, (1987), Warenmbourg *et al.* (1987), Kapulnik *et al.* (1987), Baldani *et al.* (1987), Reynders and Vlassak (1982), Jagtap and Shingte (1982) and Shende (1982) who also observed an increase in dry matter, fertile tillers, N content and grain yield due to inoculations. The highest total soil N content at harvest in case of cultivar UP 215 (Table 3) suggests it to be more efficient for soil N incorporation. However, this kind of N at harvest could be from all N_2-fixing bacteria other than *Azospirillum* and *Azotobacter*.

In conclusion, it was observed that there was no generalized relationship between inoculations and cultivars. However, amongst all the eight wheat cultivars Sonalika, Malvika and NI 5439 appeared to be comparatively more efficient utilizer of inoculation benefits for grain yield and HD 2189 for protein content. In terms of response by wheat, *Azospirillum* inoculation proved to be better than *Azotobacter* (Zambre *et al.*, 1984). However, it is suggested that studies with additional cultivars on other locations and for longer periods could provide better understanding of the problems and potentials associated with *Azospirillum* & *Azotobacter* inoculations.

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