Indian Journal of Agricultural Sciences 75 (9): 600–2, September 2005

Effect of *Azotobacter chroococcum* on wheat (*Triticum aestivum*) yield and its attributing components*

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Received : 13 July 2004

Key words: Wheats, *Triticum* spp, Biomass, Yield-attributing traits

Wheat (*Triticum aestivum* L. emend. Fiori & Paol.) crops need nitrogenous fertilizers and it is applied to crop as a basal dose and at various growth stages. Nitrogen fixing bacteria have been tried in cereal crop with considerable success. These microorganisms serve as a viable alternative to nitrogenous fertilizers and involve comparatively less cost. Several workers have reported significant increase in yield in various crops through the use of *Azotobacter* (Allison 1947, Cooper 1959, Mishustin 1970, Rangaswami *et al.* 1976).

In present investigation two efficient strains of *Azotobacter* – W-5 (standard culture) and DA-2 (newly identified culture for wheat) were tested on wheat varieties of hexaploid and tetraploid group to study their role for two crop seasons in ascertaining over all impact on yield and yield attributing traits. Six varieties, viz 'HD 2687', 'HD 2733', 'PBW 343', 'HD 2329' of bread wheat (*T. aestivum*) and 'PBW 34' and 'PDW 215' durum wheat (*T. durum* Desf.) were selected for this experiment. These varieties had distinct ploidy level and also represented 2 distinct group, i e with 1B/1R chromosome segment 'HD 2687', 'HD 2733' and 'PBW 343' and without this segment 'HD 2329', 'PBW 34' and 'PDW 215'. The soil was given half of the nitrogen as a basal dose required for successful wheat crop. These strains were applied to seed @ 500 g/100 kg just prior to sowing. A replicated yield trial in split-plot design with W-5, DA-2 and the control was laid out at the research farm of Indian Agricultural Research Institute, New Delhi for two crop seasons, i e 2002–2003 and 2003–2004. Thousand grain weight and germination per cent was taken into consideration before adjusting amount of seed per plot. The gross plot size was kept 6 m × 1.38 m accommodating 6 rows of 6 m length and 23 cm apart. The basal dose of 60 kg N and 60 kg P_2O_5 per hectare were applied and thereafter there was no top dressing of nitrogenous fertilizer. The whole experiments contained 54 plots (18 in each treatment) and were sown with Precision Norwegian Seed drill to ensure proper seed placement and germination. The harvest from 5 m × 1.38 m plot was taken for grain yield. The biomass, sampling yields and harvest index per cent was worked out from the crop of 1 m² of each plot.

The data recorded on various quantitative characters in

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Table 1 Factorial ANOVA of wheat experiments with inoculated (A) varieties (B) and replication of split plot design

Component		Grain yield (g/plot)	Biomass (g/s/m)	Sample yield (g/s/m)	Harvest index (%)	Tillers/m	Grains/ear	1 000-grain weight (g)
Replication	I	2 676	1 257	473	35.7	506	62	43
	II	2 422	1 145	385	36.0	499	60	43
	III	2 483	1 106	483	36.2	497	60	43
Treatment (main plot)	Control	2 600	1 107	431	37.7	502	59	42
	W-5	2104	947	355	32.7	435	61	43
	DA-2	2877	1 455	483	37.5	563	62	43
Varieties (sub plot)	'HD 2687'	2 688	1 203	428	35.7	546	56	42
	'HD 2733'	2 786	1 266	470	35.0	547	61	41
	'PBW 343'	2 477	1 135	417	36.3	500	63	41
	'HD 2329'	2 333	1 177	425	36.4	447	59	42
	'PBW 34'	2461	1 085	386	36.1	490	63	46
	'PDW 215'	2 416	1 151	414	36.4	471	62	46
	CD (P = 0.05)	60.9	72.7	32.9	1.68	19.6	1.6	0.6

two crop seasons indicated that the values showed common trends and with no marked differences. In view of this situation the raw data was averaged over the years to proceed further. The analyzed results indicated that grain yield and its components, replication, varieties (Factor-B) and the treatment (Factor A), viz W-5 and DA-2 and control differ significantly (Table 1) except for the tillers counts of 1 m^2 and 1 000-grain weight.

Wheat poses problem for the establishment of *Azotobacter* in its rhizosphere. The inoculation of crop plants with bacterial preparation is recommended because a selective and compatible strain is supposed to accelerate plant growth (Apte and Shende 1981). These strains provide biologically fixed nitrogen to the inoculated plant and also stimulate plant growth by excreting plant growth promoting substances like auxins, kinetins, vitamins and gibberellins (Pandey and Kumar 1989). In the present investigation the treated varieties of both treatments showed remarkable vegetative growth and ultimately the flowering period was enhanced by 4–6 days depending upon the varieties of different ploidy group. Ploidy level of wheat did not appear to play a very significant role in the plant-microbe interaction. The additional nitrogen in rhizosphere stimulated the build up of plant growth and health.

The mean performances of varieties in different treatment (W-5 and DA-2) are presented in Table 2. The mean of varieties in treated plots showed poor and best performance for all the seven quantitative traits as compared to control. It was observed that for grain yield, all varieties in (W-5 and DA-2) were significantly superior even to the best performing control variety. For biomass, all varieties in (W-5 and DA-2) were significantly superior over the low yielding check. In comparison to best performer 'HD 2733' the biomass of 'PBW 343' and 'PBW 34' was higher while the other varieties yielded as good as the best performers.

Sampling of grain yield data indicated superiority of varieties in both (W-5 and DA-2) compared to low yielding check except 'PBW 343'. In comparison to best performer all varieties in (W-5 and DA-2) yielded higher except 'PBW 343' and 'PDW 215' of W-5 treatment. For harvest index, varieties of W-5 treatment yielded significantly higher over the low performer check. In comparison to best performers harvest index of 'PDW 215', there was no variety showing superiority in either of the treatments. Their yield was as good as the untreated plots. The increase in grain yield and biomass over the untreated plots due to inoculation ranged from 11.7 to 14.6 and 11.3 to 18.3%, respectively in comparison to low yielding check, which was significantly superior. This finding is in accordance with the study carried out in potted plants by Apte and Shende (1981). Thus, there was enhancement of wheat yield with part combination of nitrogenous fertilizer and nitrogen fixing microorganism which is a significant achievement.

The tillers produced in inoculated treatment (W-5 and DA-2), over the low tillered check were significantly higher

Table 2 Effect of *A. chroococcum* inoculation on Wheat Yield and its component

Variety	Grain yield (g/plot)			Biomass (g/plot)			Sample yield (g/plot)			Harvest index (%)			Tillers/m^2			Grains/ear			1 000-grain weight (g)		
	W-5	DA-2	Control	W-5	DA-2	Control	W-5	DA-2	Control	W-5	DA-2	Control	W-5	DA-2	Control	W-5	DA-2	Control	W-5	DA-2	Control
'HD 2687'	2 933	3 100	2 083	1183	1533	893	442	520	323	37.3	33.8	36.2	557	603	480	55	58	55	41	42	42
'HD 2733'	2 933	3 250	2 226	1 160	1 587	1 052	487	533	310	37.5	30.6	37.1	607	610	427	60	62	61	41	42	41
'PBW 343'	2 533	2 720	2 183	973	1 463	970	410	477	367	38.8	32.5	37.6	484	564	453	62	65	63	41	42	41
'HD 2329'	2 350	2 650	2 000	1150	1 500	883	437	503	337	37.8	33.6	38.0	429	508	405	58	59	60	41	42	41
'PBW 34'	2 516	2 816	2 050	1 060	1 330	867	318	437	325	37.6	32.8	37.7	485	565	421	61	66	63	44	46	46
'PDW 215'	2 433	2 733	2 083	1117	1 317	1 020	417	433	393	37.2	33.2	39.0	455	530	430	60	63	62	46	45	47
CD (P = 0.05)	61.5	46.2	27.6	0.8	28.3	2.7	0.7														

but when compared with highly tillered check there was no superior varieties except 'HD 2733' evaluated in DA-2 treatment. These varieties in inoculated treatment produced higher number of grains over the low performer check but as good as the best performer. In *T. aestivum,* the 1 000-grain weight in inoculated treatments was comparable with their respective control varieties. *T. durum* showed higher 1 000-grain weight than the *aestivum* wheats. For this character there was no marked difference in all the three treatments.

The higher yield of inoculated varieties was due to the tillers production and grain/ear which were higher or at par with the low performer or best performing check variety. There was no difference in either of the treatment for the grain size. The 1 000-grain weight as obvious was higher in *durum* varieties than the *aestivum* wheats. From these findings, it is evident that in inoculated plots there was a build up of nitrogenous material in the root system that stimulated the plant to produce more tillers with added length of spike. The inoculated treatments served as a biological ramp for nitrogen fixing microorganism. Identification of crop specific strains and their use in improving productivity of the crop is very important in the present scenario. The application of nitrogenous fertilizer can be minimized through application of these efficient *Azotobacter* cultures.

SUMMARY

The efficiency of W-5 and DA-2 strains of *Azotobacter chroococcum* with 6 wheat *Triticum aestivum* L. emend. Fiori & Paol. varieties belonging to bread and durum group were undertaken in replicated yield trial. The data on grain yield, biomass, grain yield of 1 m^2, harvest index, 1 000-grain weight, grains/ear and tillers/m^2 were generated from 2 crop seasons, i e 2002–2003 and 2003–2004. The grain yield, its attributing traits, varieties and the treatments (W-5 and DA-2) differed significantly, indicating diversity in varieties and the inoculant used in the experiment. The inoculant enhanced grain yield and biomass significantly over the control. The grain yield of the inoculated plots was increased due to increase in tillering capacity and the ear size producing higher number of grains.

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