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Effect of different levels of nitrogen and biofertilizers on growth and yield of barley (*Hordeum vulgare* L.)

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ABSTRACT : Nitrogen at different levels and biofertilizers effects were studied on growth and yield of barley. An experiment was conducted in a factorial Randomized Block Design with three replications. Treatments included 3 levels of nitrogen (40, 60 and 80 kg ha^{-1}) and bio-fertilizers on four levels (not inoculation, *Azotobacter, Azospirillum* and *Azotobacter + Azospirillum*). The results revealed that fertilizer N @ 80 kg/ha with both (*Azotobacter + Azospirillum*) inoculations was found to be the most responsive, with significantly increased in the growth parameters *viz.*, plant height, maximum number of tillers and grain yield of barley. *Azospirillum* inoculation, *Azotobacter* inoculation and uninoculated control significantly differed between each other.

Key Words : *Azotobacter, Azospirillum*, Inoculations, Biofertilizers

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Barley (*Hordeum vulgare* L.) is the world's fourth most important cereal after wheat, rice and maize. The major use of barley is in brewing industries for manufacturing malt. Both barley grains and straw are highly digestible compared to wheat because they do not contain gluten. Barley ranks next to wheat both in acreage and production among *Rabi* cereals in India. In order to find out some alternative for fertilizer nitrogen economy, the use of diazotrophic bacteria has been evaluated. *Azotobacter* is a well known free-living heterotrophic bacterium which plays a beneficial role in crop production. Studies on biological nitrogen fixation have mainly emphasized the role of *Rhizobium* and *Azotobacter*. However, with the discovery of free-living N_2-fixing bacterium *Spirillum lipoferum* (now *Azospirillum brasilense)* form associative symbiosis with wheat. It has been suggested that the plant growth response may be attributed to the hormone production by these bacteria or to an increased nutrient uptake by inoculated roots. Generally the yield increases in different crops have been obtained in soils rich in organic matter. However, the increased cost of organic matter and fertilizer nitrogen prevents its use at higher levels by small and marginal farmers in India. It was, therefore, felt essential to find out the correct and compatible level of fertilizer nitrogen with these inoculations in barley production.

RESEARCH PROCEDURE

Field experiment was conducted during *Rabi* season of 2010 at central research farm, Sam Higginbottom Institute of Agriculture, Technology and Sciences, Allahabad. The soil of the experimental site was sandy loam with pH (7.7) and medium in organic carbon (0.4%). The initial status of available N, P_2O_5 and K_2O of the experimental site was 220.0, 18.8 and 250.0 kg ha^{-1}, respectively. The experiment was laid out in a factorial Randomized Block Design with twelve treatments replicated thrice. The treatments included 3 levels of nitrogen (40, 60 and 80 kg ha-1) and bio-fertilizers on four levels (not inoculation, *Azotobacter, Azospirillum* and *Azotobacter + Azospirillum*). Observations were recorded for various growth and yield attributes.

RESEARCH ANALYSIS AND REASONING

The results of the present study as well as relevant discussions have been presented under following sub heads:

Growth attributes :

The different growth indices like plant height, number of tillers, crop growth rate and relative growth rate of barley was significantly influenced by various treatments (Table 1).

Significantly higher plant height was recorded with the application of 80 kg N ha^{-1} + inoculation with *Azotobacter* + *Azospirillum*. Minimum plant height was recorded without seed inoculation + 40 kg N. It might be due to increased availability of nitrogen leading to better nutritional environment in the root zone for growth and development. As nitrogen is one of the major essential plant nutrients required for growth and its uptake by plants might have enhanced rapid cell division, cell enlargement and cell multiplication leading to better vertical growth. Similar findings were reported by Singh *et al.* (2000). Significantly maximum number of tillers/hill was recorded with the treatment inoculation with *Azotobacter* + *Azospirillum* + 80 kg nitrogen, Minimum number of tillers/hill was recorded without seed inoculation + 40 kg N. Among the biofertilizers, maximum crop growth rate was recorded at throughout the crop growth stages in the treatment in which the seed was inoculated with azotobacter as well as *Azospirillum*. Minimum crop growth rate was measured in the treatment in which uninoculated seed was sown. Inoculation with *Azotobacter* + *Azospirillum* was found statistically at par with the treatment inoculation with *Azotobacter*. Among the nitrogen levels application of 80 kg N recorded crop growth rate as compared to 40 and 60 kg N ha^{-1}. It was found to be statistically significant. Whereas crop growth rate was found non-significant in treatment 60 kg N/ ha, was found to be statistically at par with 80 kg N / ha. Among the biofertilizers, highest crop growth rate was recorded in treatment inoculated with *Azotobacter* + *Azospirillum* and treatment uninoculated, as compared to rest

Table 1: Effect of different biofertilizers and nitrogen levels on plant height and number of tillers of barley

Treatments	Plant height (cm)	Number of tillers/ hill	CGR (g m^{-2} day^{-1})	RGR (g g^{-1} day^{-1})
T_1- *Uninoculated* + 40 kg N	71.72	3.336	72.50	0.0392
T_2- *Uninoculated* + 60 kg N	75.42	3.80	80.00	0.0391
T_3- *Uninoculated* + 80 kg N	78.04	4.46	142.50	0.0511
T_4- *Azotobacter* + 40 kg N	76.12	4.26	134.17	0.0516
T_5- *Azotobacter* + 60 kg N	84.04	4.60	145.83	0.0496
T_6- *Azotobacter* + 80 kg N	89.79	5.20	190.00	0.0564
T_7- *Azosprilium* + 40 kg N	75.45	3.93	80.00	0.0384
T_8- *Azosprillum* + 60 kg N	78.59	4.60	145.00	0.0507
T_9- *Azosprillum* + 80 kg N	89.34	4.93	170.83	0.0541
T_{10}- *Azotobacter* + *Azosprillum* + 40 kg N	76.42	4.20	131.67	0.0490
T_{11}- *Azotobacter* + *Azosprillium* + 60 kg N	86.63	4.73	167.50	0.0538
T_{12}- *Azotobacter* + *Azosprillum* + 80 kg N	91.57	5.80	231.67	0.0627
S.E.±	0.32	0.06	1.92	0.0007
C.D. (P=0.05)	0.66	0.13	3.98	0.0014

Table 2 : Effect of different biofertilizers and nitrogen levels on grains/spike, grain yield and harvest index of barley

Treatments	Grains/spike (No.)	Grain yield (q/ha)	Harvest index (%)
T_1- *Uninoculated* + 40 kg N	52.80	32.13	0.452
T_2- *Uninoculated* + 60 kg N	54.40	32.71	0.456
T_3- *Uninoculated* + 80 kg N	58.00	35.46	0.435
T_4- *Azotobacter* + 40 kg N	56.07	35.00	0.461
T_5- *Azotobacter* + 60 kg N	60.60	39.21	0.451
T_6- *Azotobacter* + 80 kg N	62.87	43.54	0.457
T_7- *Azosprillum* + 40 kg N	54.93	34.96	0.471
T_8- *Azosprillum* + 60 kg N	59.20	36.88	0.439
T_9- *Azosprillum* + 80 kg N	61.33	40.21	0.446
T_{10}- *Azotobacter* + *Azosprillum* + 40 kg N	57.00	35.17	0.455
T_{11}- *Azotobacter* + *Azosprillum* + 60 kg N	61.13	39.46	0.451
T_{12}- *Azotobacter* + *Azosprilium* + 80 kg N	64.33	45.04	0.464
S.E. (±)	0.29	0.14	0.24
C.D. (P=0.05)	0.60	0.29	0.50

of inoculated treatment. Among the nitrogen levels, application of 80 kg N recorded highest relative growth rate as compared to 40 and 60 kg N ha^{-1}. It was found to be statistically significant. Similar observations were also reported by Singh *et al*. (2000). Minimum plant height was recorded with no application N fertilizer throughout crop growth stages. The development of leaf area is an important factor that could affect crop response to added nitrogen. Larger leaf area development aided in more interception of light leading to higher dry matter production (Vijayalakshmi and Nagarajan, 1994). The obtained results revealed that significant effects might be attributed to better development of inoculation plants compared to uninoculated ones creating a more favourable environment, in terms of natural and concentration of root exudates, for cell growth and metabolic activities of rihizospheric microorganisms (Prikryl and Vancura, 1980) or due to production of growth promoting substances such as indole acetic and gibberellic acids which positively affect plant growth. Many investigators reported the positive effect of biofertilization on these characters.

Yield attributes :

The different yield indices like grains/spike, grain yield and harvest index of barley was significantly influenced by various treatments (Table 2). Significantly more number of grains/spike was recorded with the treatment inoculation with *Azotobacter* + *Azospirillum* + 80 kg nitrogen. It was closely followed by the treatments *Azotobacter* + 80 kg nitrogen. Minimum number of grains/spike was recorded without seed inoculation + 40 kg N. The higher number of grains/spike Nitrogen and inoculation with *Azotobacter* + *Azospirillum* might be due to the better partitioning of carbohydrates from leaf to reproductive parts resulting in increased number of grains/spike, Bhakher *et al*. (2000) also reported similar results.

Grain yield among the biofertilizers, maximum grain yield was recorded in the treatment in which the seed was inoculated with *Azotobacter* as well as *Azospirillum*. It was found to be statistically significant as compare to these culture applied alone as well as uninoculated treatment. Maximum grain yield was recorded with the treatment inoculation with *Azotobacter* + *Azospirillum* + 80 kg nitrogen. It was closely followed by the treatments *Azotobacter* + 80 kg nitrogen. Minimum number of grain yield was recorded without seed inoculation + 40 kg N. Increase in the grain yield due to nitrogen and inoculation with *Azotobacter* + *Azospirillum* application on the yield of barley may be attributed to its role in various enzymatic reactions, growth processes hormone production and protein synthesis. The results are in accordance with those of Zahir *et al.* (1996).

Harvest index among the biofertilizers, maximum harvest index was recorded in the treatment in which the seed was inoculated with *Azotobacter* as well as *Azospirillum*. It was found to be statistically significant as compare to these culture applied alone as well as uninoculated treatment. Maximum harvest index was recorded with the treatment inoculation with *Azospirillum* + 40 kg nitrogen. It was at par with the treatments *Azotobacter* + *Azospirillum* + 80 kg nitrogen. Minimum harvest index was recorded without seed inoculation + 80 kg N.

Conclusion :

On the basis of above findings, it may be concluded that combined inoculation of *Azotobacter* and *Azospirillum* with nitrogen at 80 along with recommended doses of phosphorus and potash (both were at 30 kg /ha) recorded maximum grain yield.

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