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FIELD RESPONSE OF WHEAT CROP TO BACTERIAL INOCULATION: MORPHOLOGY AND YIELD

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Abstract

A field experiment was implemented during the two successive seasons of 2008-09 and 2009-10 at Dayalbagh of district Agra and Saurikh of district Kannauj (U.P.) to evaluate the response of wheat to the application of bacterial inoculants containing three [Azospirillum, Azotobacter, Phosphate solubilizing bacteria (PSB)]was studied under field conditions. The application treatments included control (no fertilizer), chemical fertilizer and biofertilizer. The obtained data reveals that, all plant growth and yield parameters, i.e. plant height, no. of tillers, spike length and yield responded very well with bacterial inoculation.

Key words:

Azospirillum, *Azotobacter*, PSB, inoculants, bacterial inoculation, biofertilizer.

Introduction:

One of the major essential elements for growth of plants is nitrogen. Nitrogen is required in large quantities for plants to grow, since it is the basic constituent of proteins and nucleic acids. Nitrogen is provided in the form of synthetic chemical fertilizer. Such chemical fertilizers dose a health hazard and microbial population problem in soil besides beings quite expensive and making the cost of production high. In such situation the bio-fertilizers play a major role (Tiwary *et al*., 1998). Bio-fertilizers are the formulation of living microorganism, which are able to fix atmospheric nitrogen in the available form for plants either by living freely in the soil or being associated symbiotically with plants (Subba Rao, *et al*., 1979).

It is well known that the continue use and overuse of petrochemical based fertilizers and toxic pesticides have caused a detrimental effect to our soils, water supplies, foods, animals and even people (Jin and Zhang,1996). So, application of biofertilizers became of great necessity to get a yield of high quality and to avoid the environmental pollution as well. Biofertilization technology has taken a part to minimize production costs and at the same time avoid the environmental hazards (Galal *et al*., 2001).

With the introduction of green revolution technologies the modern agriculture is getting more and more dependent upon the steady supply of synthetic inputs (mainly fertilizers), which are products of fossil fuel (coal+ petroleum). Adverse effects are being noticed due to the excessive and imbalanced use of these synthetic inputs. This situation has lead to identifying harmless inputs like biofertilizers. Use of such natural products like biofertilizers in crop cultivation will help in safeguarding the soil health and also the quality of crop products. A number of intellectuals throughout the world started working on the alternatives and found that biofertilizers can help in increasing the yield without causing the damage associated with chemical fertilizers.

In general biofertilizer from associative N_2 fixing bacteria could be used especially for cash crops such as vegetables, fruits, flowers and medicinal or herbal crops. It is a breakthrough technology that promises very significant impact on the country's farmers in terms of increasing farm productivity and income as well saving the country's rupees reserve due to decreased importation of inorganic nitrogenous fertilizers. It is mainly composed of microorganisms that can convert the nitrogen gas into available form to sustain the nitrogen requirement of host plants. These bacteria once associated with roots of some plants can enhance their root development growth and yield. Biological nitrogen fixation is carried out by both symbiotic and free living bacteria and blue green algae. Nitrogen fixing bacteria are very selective in choosing roots of particular legumes species to

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infect, invade form root nodules (Subba rao, *et al*., 1979).

In the present agricultural practices there are number of microbial inoculants used as biofertilizers. They induce *Azospirllum* and *Azotobacter* and phosphor-bacterium, which have been given much attention as they are responsible to plant growth and yield of crops under field inoculation. *Azospirillum* are gram negative, free living, associative symbiotic and non-nodule forming, aerobic bacteria, occurs in the roots of dicots and monocot plants i.e. corn, sorghum, wheat etc. It is easy to culture and identify. *Azospirillum* is found to be very effective in increasing 10-15% yield of cereal crops and fixes N_2 upto 20-40% Kg ha^{-1}. Different A. *brasiliense* strains inoculation in the wheat seed causes increase in seed germination, plant growth, plumule and radicle length.

Azotobacter is the free living aerobic, photoautotrophic, non-symbiotic bacteria. It secretes vitamin-B complex, gibberellins, napthalene, acetic acid and other substances that inhibit certain root pathogens and improves root growth and uptake of plant nutrients. *Azotobacter* naturally fixes atmospheric nitrogen in the rhizosphere. There are different strains of *Azotobacter* each has varied chemical, biological and other characters. However, some strains have higher nitrogen fixing ability than others. *Azotobacter* uses carbon for its metabolism from simple or compound substances of carbonaceous in nature. Besides carbon, *Azotobacter* also requires calcium for nitrogen fixation. Similarly, a medium used for growth of *Azotobacter* is required to have presence of organic nitrogen, micro-nutrients and salt in order to enhance the nitrogen fixing ability of *Azotobacter*.

PSB are used as biofertilizer since 1950s (Kudashev, 1956; Krasilinikov, 1957). These microorganisms secrete different types of organic acids e.g.carboxylic acid (Duebel and Merbach, 2005) thus lowering the pH in the rhizosphere (He and Zhu, 1988). *Pseudomonas fluorescens, Bacillus megatherium var. phosphaticum, Pseudomonas striata, Bacillus polymyxa* are the bacteria have phosphate solubilizing ability.

In the present investigation the combination of plant growth promoting bacteria and synthetic fertilizers were used to study the response of wheat crop to bacterial inoculation.

MATERIALS AND METHODS:

A field experiment was carried out at Dayalbagh (Agra) and Saurikh (Kannauj) in India during 2008-09 and 2009-10 to study the field response of wheat crop to bacterial inoculation. Two sources of mineral fertilizer and biofertilizers were used. Two rates of mineral N source were applied at 50% and 100% of recommended doze. Grains were grown without inoculation and inoculated with separate kind of biofertilizers. Coating grains with the gum media carrying the bacteria strain on the same day of sowing.

Random Block Designing (RBD) was adopted with three replications and 6 treatments. Treatments were consisted of $\mathbf{T_0}$ as control (no input), $\mathbf{T_1}$ (Farmer's practice), $\mathbf{T_2}$ (Azs+60 Kg Nha^{-1}), $\mathbf{T_3}$ (PSB+60 Kg Nha^{-1}), $\mathbf{T_4}$ (Azt+60 Kg Nha^{-1}), $\mathbf{T_5}$ (PSB+Azs+Azt+60 Kg Nha^{-1}). The recommended N P K for wheat was 120kg N, 60 kg P and 40 kg per hectare. N was applied as split doze i.e. half of the N at the time of sowing and the remaining half were applied with 1st irrigation. Biofertilizers were applied through seed inoculation just prior to sowing and other major nutrients i.e. P and K were applied in the form of potash and DAP respectively at the time of sowing.

RESULT AND DISCUSSION:

The data regarding to the effect of different treatments on the morphology and yield (parameter viz. plant height, number of tillers, spike length and yield) of wheat are given here -

Tables (1a, 1b and 2a, 2b) clearly show that, the growth and yield attributes of wheat are influenced by the different treatments. It is evident from the data that there was a significant difference in plant height among different treatments during both the years at both sites. The amount of nitrogen significantly affected height. The minimum plant height was recorded in control (where nitrogen was not applied) at both experimental sites during both the years. The data in tables 1 and 2 revealed that at both sites maximum plant height at 120 DAS was observed in treatment T_3 (PSB+60 kg N ha^{-1}). At Dayalbagh plants attained maximum height i.e. 82.64 cm and 86.27 cm during 2008-09 and 2009-10 respectively and at Saurikh 90.08 cm during 08-09 and 90.38 cm during 09-10 respectively.

PSB increased the growth of plants by mechanisms other than P solubilization e.g. production of phytohormones, such as IAA (Arshad and Frankenberger, 1998). Phosphorus is a major growth limiting nutrient and unlike the case for nitrogen, there is no large atmospheric source that can be made biologically available (Ezawa *et al*., 2002). The microorganisms involved in P solubilization can enhance plant growth by increasing the efficiency of biological nitrogen fixation, enhancing the availability of other trace elements and by production of plant growth substances (Gyaneshwar *et al*., 2002). PSB have the ability to increase available phosphorus for plant through production of organic acid (Mehana and Farag, 2000).

The data of table 1 and 2 clearly depicted that the no. of tillers in each treatment, where biofertilizers were applied with 60 kg N ha^{-1} was slightly higher than the uninoculated control. Among different seed treatment maximum no. of tillers were observed in T_2 (Azs+ 60 kg N ha^{-1}) at Dayalbagh and Saurikh site. Increase in no. of tillers due to application of *Azospirillum* was 4.55 and 5.77 at Saurikh and 4.55 and 5.66 at Dayalbagh during 2008-09 and 2009-10 respectively. This might be attributed to the response of *Azospirillum* which has beneficial effects on both plant growth and yield of wheat crop. *Azospirillum* can utilize atmospheric nitrogen and contributed to plant nitrogen nutrition. It also improved the plant nutrient uptake and contributed towards the increase in number of tillers. These results are in line with earlier reports. Albrecht *et al*., 1981; Bashan, 1986, Bouton *et al*., 1979, reported the increase in total plant dry weight, total no. of tillers, fertile tillers and grain weight with *Azospirillum* inoculation in cereals and non cereals species.

At Dayalbagh site highest spike length recorded in treatment T_5 was 11.53 cm during 2008-09 and 14.17 cm during 2009-10.Whereas at Saurikh, highest spike length recorded in treatment T_5 was 11.66 cm during 2008-09 and 15.18 cm during 2009-10.The minimum spike length was observed in uninoculated control (T_0) i.e.7.20 cm and 7.21 cm at Dayalbagh site and 7.38 cm and 8.94 cm at Saurikh site respectively during 2008-09 and 2009-10. The increase in spike length was accompanied by an increase in root biomass and consequently root: shoot ratio. Increase in spike length was highly correlated with root growth. The plant growth promoting rhizobacteria (Azs, Azt, PSB) play an active role in soil through their natural ability to provide important nutrients to the plants. Among the plant nutrients N and P are the key plant nutrients provided by these organisms. It has been reported that the plant PGPR including phosphate-solubilizing microorganisms are able to solubilize the unavailable forms of P in soil by acidification, chelation, and exchange reaction in the soil environment (Maliha *et al*., 2004; Ponmurugan and Gopi, 2006). The importance of additive effects of bacterial inoculants was reported by earlier workers for components tracts like plant height (Katiyar *et al*., 1996), spike length (Walia *et al*., 1991), leaf area (Prodanovic, 1993) and grains per spike (Rosal *et al*., 2005).

Treatment T_2 (Azs+60 kg Nha^{-1}) produced the maximum grain yield. Treatment T_0 produced the minimum grain yield during 2008-09 and 2009-10. The final grain yield is attributed to the cumulative effect of various yield parameters. At Dayalbagh site during 2008-09 and 2009-10, highest grain yield 50.50 q ha-1 and 61.83q ha^{-1} was obtained in T_2 and the lowest was that in control. Similarly, at Saurikh site during 2008-09 and 2009-10, highest grain yield i.e. 51.00q ha^{-1} and 62.33 q ha^{-1} was obtained in T_2 and the lowest was that in control.

The increase in grain yield might be attributed to nitrogen fixing and several hormones producing potential of *Azospirillum*. These results are in close conformity with earlier workers. Bashan (1986) reported that inoculation of wheat with *Azospirillum brasilense* significantly increased plant dry weight, number of tillers per plant, spikelet fertility and grain yield. Also PSB may enhance nutrient uptake by plants through solubilizing insoluble phosphorus (Goldstein, 1987). Plant inoculation with *Azospirillum* promoted greater uptake of No_3, K^+ and H_2PO_4 in corn, sorghum and wheat (Zavalin *et al.* 1998, Saubidet *et al.*, 2000) leading to higher crop yields. Brown (1974) stated that the increase in grain yield and nutrient uptake due to *Azospirillum* inoculation may not be mainly due to nitrogen fixation but may also be due to other factors such as release of growth promoting substances, control of pathogens and proliferation of beneficial organisms in the rhizosphere.

On the basis of the obtained results it could be concluded that field response of wheat crop to bacterial inoculation contributed to increase in growth, yield attributing traits and finally yield.

Growth and yield of wheat during (2008-09) at Dayalbagh site:

Table-1a: Plant height, Number of tillers $plant^{-1}$, Spike length and Yield of wheat

Treatment	Plant height (cm) at 120 DAS	No. of tillers $plant^{-1}$	Spike length (cm)	Yield qha^{-1}
T_0	52.24	1.88	7.20	19.66
T_1	62.98	3.11	11.04	42.50
T_2	66.83	4.55	10.42	50.50
T_3	82.64	4.11	10.21	42.66
T_4	66.18	3.66	10.90	43.50
T_5	70.47	4.00	11.53	46.50

Growth and yield of wheat (2009-10) at Dayalbagh site:

Table-1b: Plant height, Number of tillers $plant^{-1}$, Spike length and Yield of wheat

Treatment	Plant height (cm) at 120 DAS	No. of tillers $plant^{-1}$	Spike length (cm)	Yield qha^{-1}
T_0	59.04	2.22	7.21	20.83
T_1	64.47	3.55	11.98	46.33
T_2	66.37	5.66	13.81	61.83
T_3	86.27	4.33	12.06	48.50
T_4	66.83	3.77	13.31	52.00
T_5	72.11	4.22	14.71	52.16

Growth and yield of wheat (2008-09) at Saurikh site:

Table-2a: Plant height, Number of tillers $plant^{-1}$, Spike length and Yield of wheat

Treatment	Plant height (cm) at 120 DAS	No. of tillers $plant^{-1}$	Spike length (cm)	Yield qha^{-1}
T_0	59.38	2.00	7.38	20.33
T_1	66.09	3.77	10.65	44.16
T_2	70.05	4.55	11.18	51.00
T_3	90.08	4.33	10.41	44.30
T_4	73.15	3.77	11.11	47.66
T_5	72.20	4.22	11.66	48.16

Growth and yield of wheat (2009-10) at Saurikh site:

Table-2b: Plant height, Number of tillers plant^{-1}, Spike length and Yield of wheat

Treatment	Plant height (cm) at 120 DAS	No. of tillers plant^{-1}	Spike length (cm)	Yield qha^{-1}
T_0	60.60	2.33	8.94	22.66
T_1	65.82	3.77	12.70	47.16
T_2	71.66	5.77	14.61	62.33
T_3	90.38	5.66	12.44	50.50
T_4	74.20	4.22	14.39	52.66
T_5	72.43	5.55	15.18	57.66

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