**Annals of Plant and Soil Research 19(1): 42 - 45 (2017)**

# Response of wheat (*Triticum aestivum*) to Azotobacter inoculation and nitrogen in soils of Vidisha, Madhya Pradesh

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Received: October, 2016; Revised accepted: January, 2017

## ABSTRACT

*A field experiment was conducted during rabi season of 2012-13 and 2013-14 at Masudpur village of Vidisha district (M.P.) to study the effect of nitrogen levels with and without Azotobacter on the yield, quality and uptake of nutrients by wheat (Triticum aestivum L. emend and Fiori Paol). The experiment was laid out in randomized block design with two inoculation levels (no inoculation and Azotobacter inoculation) and three levels of nitrogen (75.0, 112.5 and 150.0 kg ha$^{-1}$) with four replications. The results revealed that seed inoculation with Azotobactet significantly increased the plant height and yield attributes over no inoculation. The yield of wheat grain and straw increased from 4.89 to 5.14t ha$^{-1}$ and from 6.88 to 7.23t ha$^{-1}$, respectively with Azotobacter inoculation. Similar results were also obtained for protein content in grain (12.95 to 13.22 %) and protein yield (632.7 to 678.0 kg ha$^{-1}$) with Azotobacter inoculation. Azotobacter had not effect on the uptake of phosphorus by wheat grain and straw. But nitrogen uptake by the crop and the amount of available nitrogen in post harvest soil increased significantly with Azotobacter inoculation over no inoculation. The wheat crop responded significantly up to 150 kg N ha$^{-1}$ and increased the grain and straw yield by 21.0 and 20.5 %, respectively over control. Application of 150 kg N ha$^{-1}$ proved significantly superior to its lower levels (75 and 112.5 kg ha$^{-1}$) with respect to content and yield of protein. Application of nitrogen significantly increased the uptake of nitrogen and phosphorus by grain and straw of wheat and maximum values of total N (167.9 kg ha$^{-1}$) and P uptake (21.2 kg ha$^{-1}$) were recorded with 150 kg N ha$^{-1}$. The status of available N and P in post harvest soil improved significantly with 150 kg N ha$^{-1}$ over its lowers levels.*

**Keywords:** Azotobacter, nitrogen, quality, nutrient uptake, yield, wheat

## INTRODUCTION

Wheat (*Triticum aestivum L. emend Fiori & Paol.)* is an exhaustive feeder and requires substantial amount of nutrients for higher productivity. Nitrogen plays a role in increasing the food grain production in India. The soils of India are inherently low in soil organic matter and nitrogen, which is the major limiting plant nutrient. Nitrogen is costly input and a major share of it is used for cereal cultivation. The cost of nitrogen fertilizers is increasing day by day. Under such a situation, suitable alternative combinations are to be evaluated. Biofertilizers are low cost and eco-friendly inputs and have tremendous potential for supplying nutrients, which can reduce the chemical fertilizer dose by 25-50% (Vance 1997 and Rana *et al.* 2012). The favorable response of applied nitrogen might be due to the vital role of nitrogen in the growth and metabolism of the plant. Nitragen in the form of protein is major constituent of protoplasm, accelerate the cell division and hence the growth and development of root and shoot. Azotobacter supplied additional nitrogen in an eco friendly manner. Azotobacter has been found to synthesize plant growth promoting substances like auxin, gibberellins, cytokinins and some antibiotics metabolites. It can influence plant growth indirectly by increasing the population of beneficial microorganisms in the rhizosphere. The nitrogen obtained due to nitrogen fixation is in the combined form and not lost by leaching or evaporation. The increase in co-friendly production of wheat can be made possible by wide spread adoption of improved technologies of which fertilizer management particularly that of nitrogen through bio-fertilizers can play a key role. Hence, present investigation was carried out to study the growth, yield and nutrient uptake behavior of wheat to define optimum dose under integrated use of bio-fertilizers and nitrogen.

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## MATERIALS AND METHODS

A field experiment was conducted during rabi seasons of 2012-13 and 2013-14 at farmer's field at Masudpur village of Vidisha district (M.P.).The experimental soil had pH 7.9, organic carbon 3.9 g $kg^{-1}$, available N 162 kg $ha^{-1}$, available P 9.5 kg $ha^{-1}$, available K 146 kg $ha^{-1}$ and available S 19 kg $ha^{-1}$. The experiment was laid out in randomized block design with four replications. The treatments consisted of two inoculation levels (no inoculation and Azotobacter inoculation) and three levels of nitrogen (75.0, 112.5 and 150.0 kg $ha^{-1}$). Nitrogen levels were applied as per treatments through urea. A basal dose of 60 kg $P_2O_5$ and 40 kg $K_2O$ $ha^{-1}$ was applied through triple superphosphate and muriate of potash, respectively. Full dose of P and K were applied at the time of sowing. Wheat seeds were inoculated with Azotobacter culture as per treatments. The wheat variety PBW 343 was sown on 20 November in both the years using 100 kg seeds $ha^{-1}$. Appropriate management practices were adopted to raise the crop. The .crop was harvested at maturity. Growth and yield attributes were recorded at harvest. Grain and straw yields were recorded at harvest of the crop. Grain and straw samples were digested in di-acid mixture of $HNO_3$: $HClO_4$ (10:4) and phosphorus, in di-acid digest was determined by vanadomolybdate yellow colour method, (Jackson 1973). Nitrogen content was estimated by modified Kjeldahl method and protein content was calculated by multiplying with a factor of 6.25. Post harvest soil samples collected were air dried, ground to pass through 2mm sieve and analyzed for available N and P by alkaline permangate method (Subbiah and Asija 1956) and Olsen method (Olsen *et al.* 1954), respectively. The data thus obtained were analyzed statistically using analysis of variance technique for various parameters at 5% level of significance.

## RESULTS AND DISCUSSION

### Growth and yield attributes

Plant height and number of tillers/meter at harvest were significantly increased with Azotobacter inoculation over no inoculation (Table 1). This might be partly owing to its additive effect of nitrogen fixed from the atmosphere and partly owing to synthesis of biologically active substances like vitamins, auxin and gibberellins etc, which in turn might have stimulated the plant growth parameters. These results are akin to the findings of Singh *et al.* (2013).Application of nitrogen significantly increased the growth parameters. Application of 150 kg N $ha^{-1}$ produced significantly taller plants, more number of tillers and dry matter than all other levels of nitrogen. Similar results were reported by Singh and Yadav (2006). The yield attributes, *viz*. grain weight/plant and 1 000-grains weight was significantly increased with inoculation of *Azotobacter* over no inoculation (Table 1). Similar results were reported by Kachroo and Razdan (2006). Application of 150 kg N $ha^{-1}$ produced 35.6 and 93.8% more grain weight/plant and 26.2 and 11.9% more 1 000-grains weight than that of 112.5 kg and 75 kg N $ha^{-1}$, respectively. Higher level of N improved the fertility level of soil and created congenial condition for better growth and development of plants, and thus improved the yield attributes. These results are in conformity with those reported by Singh and Yadav (2006).

### Yield

Data showed that the grain and straw yields of wheat increased significantly with inoculation of bio-fertilizers and maximum yield was recorded with *Azotobacter* inoculation (Table1). The increases in grain and straw yields due to Azotobacter inoculation were 250 and 350 kg $ha^{-1}$ over no inoculation, respectively. The increase in yield might have resulted from the growth regulating substances produced by biofertilizers besides fixation of additional nitrogen from atmosphere thereby increasing nitrogen availability in the soil throughout the crop growth. Kachroo and Razdan (2006) also reported similar results. Application of 150 kg N $ha^{-1}$ produced significantly higher grain and straw yield over that of 75 and 112.5 kg N $ha^{-1}$. The highest grain yield of 5.49 t $ha^{-1}$ was produced with 150 kg N $ha^{-1}$, showing an N increase of 21.0 % over 75 kg N $ha^{-1}$. Application of 150 kg N $ha^{-1}$ gave straw yield of 7.66 t $ha^{-1}$, registering an increase of 20.5% compared with those of 75 kg N $ha^{-1}$. The increase in grain and straw yields due to increase in level of N might be due to the fact that nitrogen fertilizer pushed up the removal

Table 1: Effect of Azotobacter inoculation and nitrogen on growth, yield and quality of wheat (mean of 2 years)

| Treatment | Plant height (cm) | Tillers/$m^3$ | Test weight (g) | Yield (t $ha^{-1}$) | | Protein (%) | | Protein yield (kg $ha^{-1}$) |
|---|---|---|---|---|---|---|---|---|
| | | | | Grain | Straw | Grain | Straw | |
| Azotobacter | | | | | | | | |
| Un inoculated | 84.2 | 114.6 | 49.8 | 4.89 | 6.88 | 12.95 | 3.59 | 632.7 |
| Inoculated | 86.2 | 118.0 | 51.0 | 5.14 | 7.23 | 13.22 | 3.83 | 678.0 |
| SEm± | 0.30 | 0.89 | 0.11 | 0.05 | 0.12 | 0.06 | 0.05 | 7.0 |
| CD (P=0.05) | 0.88 | 2.46 | 0.33 | 0.15 | 0.37 | 0.19 | 0.15 | 21.0 |
| Nitrogen (kg $ha^{-1}$) | | | | | | | | |
| 75.0 | 81.3 | 106.0 | 44.6 | 4..54 | 6.35 | 12.55 | 3.35 | 570.0 |
| 112.5 | 85.6 | 116.0 | 50.3 | 5.09 | 7.18 | 13.12 | 3.69 | 667.1 |
| 150.0 | 89.0 | 124.0 | 56.3 | 5.49 | 7.66 | 13.58 | 4.10 | 745.4 |
| SEm± | 0.39 | 1.12 | 0.14 | 0.06 | 0.15 | 0.05 | 0.06 | 9.0 |
| CD (P=0.05) | 1.10 | 3.68 | 0.41 | 0.19 | 0.46 | 0.24 | 0.19 | 26.0 |

of nutrients and water enhanced the photosynthesis and translocation of assimilates from source to sink. Singh and Yadav (2006) and Chauhan *et al.* (2014) also reported an increase in grain and straw yields due to N application.

**Quality**

The protein content in wheat grain and straw increased significantly with Azotobacter inoculation over no inoculation. This may be attributed to nitrogen fixation by Azotobacter. Protein yield in grain also increased significantly with Azotobacter inoculation which ranged from 632.7 kg $ha^{-1}$ at no inoculation to 678.0 kg $ha^{-1}$ with Azotobacter inoculation. This increase in protein yield may be attributed to increased grain yield and protein content in grain with Azotobacter inoculation (Katiyar *et al.* 2011). The protein content in wheat grain and straw increased significantly with nitrogen application and maximum value of protein content in grain (13.58%) and strae (4.10%) was recorded with 150 kg N $ha^{-1}$. This may be due to the fact that the plants accumulated more nitrogen with increasing levels of nitrogen and ultimately showing more protein content. Since, N is an important constituent of plant protein which plays an important role in protein synthesis, higher protein content could be expected at increased doses of nitrogen. Similar results were reported by Singh *et al.* (2014). There was a consistent and significant increase in protein yield of wheat grain with increasing levels of N and maximum value (745.4 kg $ha^{-1}$) was recorded at 150 kg N $ha^{-1}$.These increase in protein yield due to N levels may be attributed to increased yield and protein content in wheat grain Chauhan *et al.* (2014) also reported similar results.

Table 2: Effect of Azotobacter inoculation and nitrogen on uptake of nutrients by wheat and available N in post harvest soil

| Treatment | Nitrogen (kg $ha^{-1}$) | | | Phosphorus (kg $ha^{-1}$) | | | Available nitrogen (kg $ha^{-1}$) | Available P (kg $ha^{-1}$) |
|---|---|---|---|---|---|---|---|---|
| | Grain | Straw | Total | Grain | Straw | Total | | |
| Azotobacter | | | | | | | | |
| Un inoculated | 101.0 | 39.1 | 140.1 | 9.8 | 6.8 | 16.6 | 160.0 | 10.9 |
| Inoculated | 108.5 | 44.6 | 156.1 | 10.4 | 7.5 | 18.9 | 169.8 | 11.2 |
| SEm± | 1.19 | 0.49 | 1.71 | 0.26 | 0.32 | 0.77 | 1.27 | 0.14 |
| CD (P=0.05) | 3.59 | 1.36 | 5.11 | NS | NS | NS | 3.85 | NS |
| Nitrogen (kg $ha^{-1}$) | | | | | | | | |
| 75.0 | 91.0 | 34.0 | 125.0 | 8.1 | 5.4 | 13.5 | 144.0 | 9.1 |
| 112.5 | 106.2 | 42.3 | 148.5 | 10.2 | 7.0 | 18.0 | 168.5 | 10.9 |
| 150.0 | 117.8 | 50.1 | 167.9 | 11.5 | 9.7 | 21.2 | 182.0 | 13.0 |
| SEm± | 1.46 | 0.54 | 2.15 | 0.32 | 0.39 | 0.97 | 1.57 | 0.18 |
| CD (P=0.05) | 4.41 | 1.61 | 6.46 | 0.97 | 1.19 | 2.92 | 4.72 | 0.51 |

**Uptake of nutrients**

Inoculation of bio-fertilizers increased the N uptake by grain and straw significantly over no inoculation treatment, which might be because of better growth and development of the plant and adequate N availability in the soil (Table 2). Application of 150 kg N $ha^{-1}$ recorded maximum nitrogen uptake by grain and straw, which increased by 29.4 and 47.3%, respectively over 75 kg N $ha^{-1}$.The total uptake of N by wheat crop (grain + straw) increased from 125 kg $ha^{-1}$ to 167.5 kg $ha^{-1}$. It might be because nitrogen uptake is directly correlated with yield. Increased yield ultimately resulted in higher N uptake. The P uptake by grain and straw increased significantly with N application. The P uptake by grain and straw increased by 42.0% and 79.6% with 150 kg N $ha^{-1}$over 75 kg N $ha^{-1}$, respectively. The corresponding increases in total P uptake by wheat crop 57.0%. Improvement in P uptake with N levels was due to the increase in grain and straw yield and P and K content. Singh and Agrawal (2004) also observed an increase in N, P and K uptake by N application.

**Soil fertility**

Significantly higher available nitrogen content was recorded in the post harvest soil when bio-fertilizers were applied as culture to wheat seed compared to no inoculation treatment. The increase was owing to enhanced nitrogen content in soil inoculation of bio-fertilizers. However, available P content did not show significant variation due to bio-fertilizers. At higher doses of nitrogen application, the available N content in the soil was observed to be higher than lower dose of nitrogen, which might be due to considerable gain of nitrogen content in the soil with its addition. The available P content in the soil was influenced significantly by the varying nitrogen doses. The maximum value of available was noted at 150 kg N $ha^{-1}$ indicating beneficial effect of N on P availability. Singh *et al.* (2013) also reported similar results.

On the basis of the experimental findings, it is concluded that application of Azotobacter and nitrogen, besides augmenting the crop yield, also improve the quality and uptake of nutrients in wheat.

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