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ENHANCEMENT OF WHEAT (*Triticum Aestivum* L.) GROWTH AND Zn CONTENT BY ZINC SOLUBILIZING BACTERIA

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Abstract
The influence of biofertilizer inoculation, viz. *Rhizobium, Azospirillum* and *Pseudomonas* in different combinations with recommended dose of chemical fertilizer (NP) on wheat (*Triticumaestivum* L.) crop was tested during year [2011-2012], to explore the possibility of reducing doses of chemical fertilizers, zinc solubilization and uptake. The results revealed significant uptake of zinc by biofertilizers as compared to chemical fertilizers. Highest shoot zinc(47.6 mg kg^{-1}) uptake was recorded with *Azospirillum* + ½ NP, *Pseudomonas* N ½ P. Highest flag leaves zinc uptake was recorded with *Pseudomonas* + N ½ P (34.73 mg kg^{-1}) and *Azospirillum* + N ½ P (1.46 mg kg^{-1}). Maximum zinc content in wheat straw was recorded with *Rhizobium* ½ NP(13.2 mg kg^{-1}), *Pseudomonas* N ½ P(12.26 mg kg^{-1}) and *Azospirillum* + ½ NP(12.6 mg kg^{-1}). In grain highest zinc (32.33 mg kg^{-1}) uptake was recorded with *Rhizobium* ½ N P, *Pseudomonas* N ½ P and *Azospirillum* + ½ NP.

Keywords: *Azospirillum,* biofertilizers, NARC, *Pseudomonas Rhizobium,* Wheat, Zinc.

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INTRODUCTION
Wheat (*Triticumaestivum* L.) belongs to family poaceae. Wheat is the most important staple diet of the people of Pakistan. It contributes 13.7 percent to the value added in agriculture and 3.0 percent to GDP. In [2010], country produced over 23 million tons of wheat to meet its domestic needs [Agricultural Statistics of Pakistan 2011]. By year 2030, county will require over 33 million tons of wheat to meet its domestic needs [Rajaram *et al*. 1998]. Irrigated areas contribute 95 % towards total national wheat production while rain-fed areas make a payment only 5 % [Agricultural Statistics of Pakistan 2011]. The use of N-fertilizer not only spoils the ground water, soil but also have deleterious effects by the emission of harmful gases. The chemical fertilizers should be replaced

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with the natural and organic fertilizers which can play a key role of the conservation of the environment, [Jangral and Lakra 2014]. Biofertilizers used in conjunction with chemical fertilizers improve crop productivity and nutrient use efficiency. Positive effect of azotobacterization on growth and yield of Brinjal also been reported by many workers. There is a positive influence of PSB on the growth and yield attributes of Brinjal-cv. Krishna [Gaikwad and Wani 2001].

MATERIALS AND METHODS

The research experiments were carried out in the Soil Biology & Biochemistry Group (SBB), Land Resources Research Institute (LRRI), National Agricultural Research Centre (NARC) Islamabad in collaboration with Botany department Hazara University Mansehra. Wheat variety Afaq 2000 was sown during winter on [November 15, 2011]. With average minimum temperature of 1 ^{o}C and average maximum temperature of 36 ^{o}C, a total rainfall of 430 mm, relative humidity of 80% and day length ranging from 10-13 h, plant growth in the region is restricted to the period between November and May. The experiment was laid out in completely randomized block design with three replications. Three PGPR inoculants *Rhizobium, Pseudomonas* and *Azospirillum* were cultured in their respective growth media. The cultures were incubated for 2-3 days (according to requirement) till cells population in each inoculum reached 10 x 10^{5-9} ml, maintained by measuring optical density at 550 nm using Spectronic 21. These cultures were shifted to carrier (soil rich in organic matter) of biofertilizers at NARC.

Given treatments were as follow:

T1= ½ NP, 50:80 kg h^{-1}
T2= N ½P,100:40 kg
T4=*Rhizobium*+½NP, 50:80 kg h^{-1}
T5=*Pseudomonas*+ N ½P,100:40 kg h^{-1}
T6= *Azospirilum* + ½NP, 50:80 kg h^{-1}

Both the fertilizers were applied at the time of sowing. Urea and single super phosphate (SSP) were applied as source of N and P respectively. Zinc was determined in simple extract in atomic absorption spectrophotometer. The data obtained in the study were subjected to analysis of variance using STATISTIX, computer software arranged as a randomized complete block (RCBD) and means were compared by LSD test at 5% ($p< 0.05$) level of significance.

RESULTS AND DISCUSSION

In this study zinc uptake was significantly affected by bacterial inoculation treatments over chemical fertilizers alone. Inoculation with plant growth promoting bacteria (PGPB) can result a significant change in various plants growth parameters, which may affect crop yield.

Wheat shoot zinc due to the effect of different inoculants at 105 DAE are presented in Fig. 1. The data indicated that shoot zinc is significantly different in all the treatments. Highest shoot zinc was recorded with *Azospirillum*+½ NP (47.60 mg kg^{-1}).

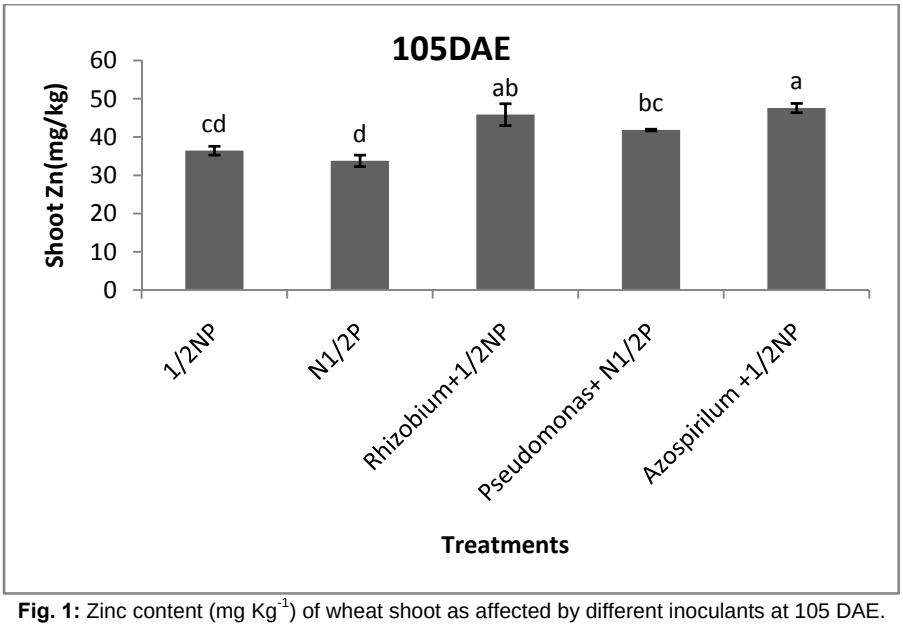

Fig. 1: Zinc content (mg Kg^{-1}) of wheat shoot as affected by different inoculants at 105 DAE.

Comparison of chemical fertilizer ½ NP (36.47 mg kg^{-1}) in shoot zinc with inoculants i.e. *Rhizobium* + ½ NP (45.87 mg kg^{-1}), and *Azospirillum*+½ NP (47.60 mg kg^{-1}), while N ½ P (33.80 mg kg^{-1}) with *Pseudomonas*+ N ½ P is (41.87 mg kg^{-1}). Biari *et al.* [2008] reported that Plants nutrient uptake of N, P, K, Fe, Zn, Mn, and Cu were also significantly influenced by application of *Azospirillum.* Azospirillum spp. Inoculation to improve yields has been extensively discovered in cereal crops [Sivasakthivelan and Saranraj 2013].

Wheat flag leaves zinc due to the effect of different inoculants at 125 DAE are presented in Fig. 2. The data directed that flag leaves zinc is significantly different in all the treatments. Highest flag leaves zinc was

recorded with *Rhizobium* + ½ NP (33.80 mg kg^{-1}), *Pseudomonas*+ N ½ P (34.73 mg kg^{-1}) and *Azospirillum*+½ NP (36.47 mg kg^{-1}).

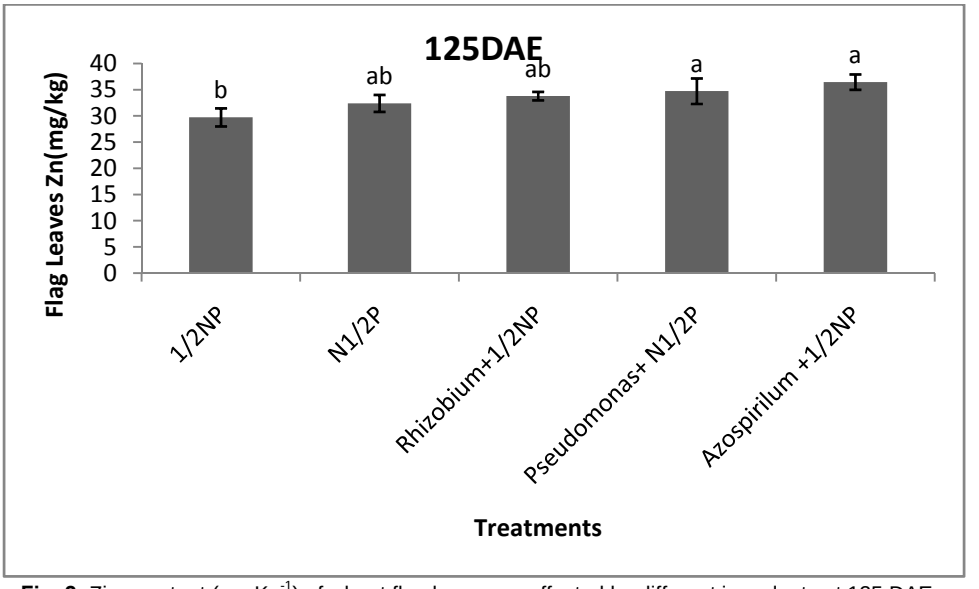

Fig. 2: Zinc content (mg Kg^{-1}) of wheat flag leaves as affected by different inoculants at 125 DAE.

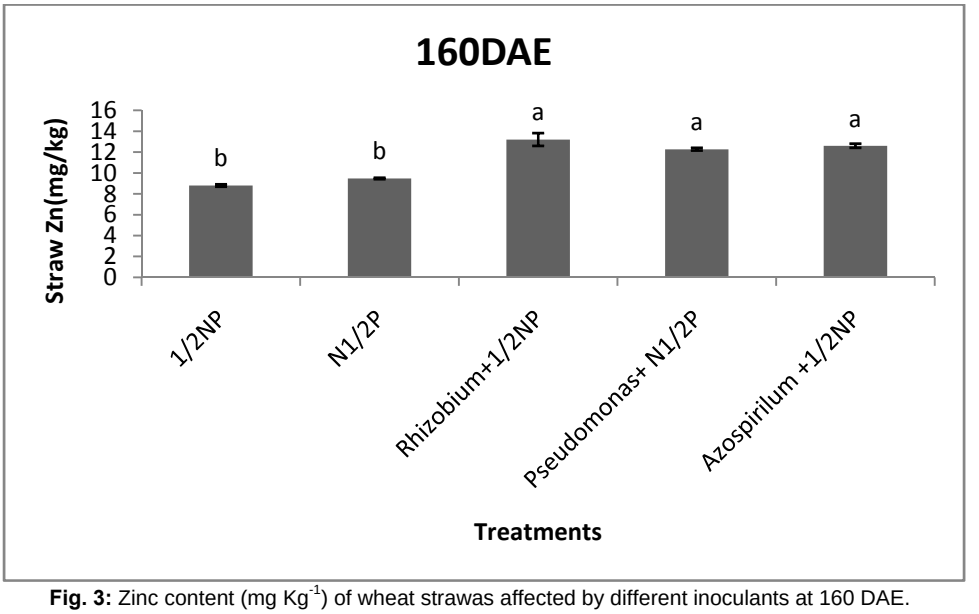

Fig. 3: Zinc content (mg Kg^{-1}) of wheat strawas affected by different inoculants at 160 DAE.

Comparison of chemical fertilizer ½ NP (29.73 mg kg^{-1}) in flag leaves zinc with inoculants i.e. *Rhizobium* + ½ NP and *Azospirillum*+½ NP is (33.80 mg kg^{-1}), and (36.47 mg kg^{-1}) respectively, while N ½ P (32.40 mg kg^{-1})

with *Pseudomonas*+ N ½ P is (34.73mg/ Kg). Maurya *et al. [*2014] and Parewa and Yadav [2014] proposed that a large array of bacteria including species of *Azospirillum*, *Azotobacter*, *Pseudomonas*, *Enterobacter*, *Arthrobacter*, *Burkholderia* and *Bacillus* have reported to enhance plant growth and development. Inoculation of maize and wheat with *Azotobacter* and *Azospirilum* amplified plant growth , nutrient uptake and yield [Dobbelaere *et al.* 2001].

Wheat straw zinc due to the effect of different inoculants at 160 DAE are presented in Fig. 3. The data directed that straw zinc is significantly different in all the treatments. Highest straw zinc was recorded with *Rhizobium* + ½ NP (13.20 mg kg^{-1}), *Azospirillum*+½ NP (12.60 mg kg^{-1}).

Comparison of chemical fertilizer ½ NP (8.80 mg kg^{-1}) in straw zinc with inoculants *Rhizobium* + ½ NP and *Azospirillum*+½ NP is (13.20 mg kg^{-1}), and (12.60 mg kg^{-1}) respectively, while N ½ P (9.47 mg kg^{-1}) with *Pseudomonas*+ N ½ P is (12.27 mg kg^{-1}). One such finding of Zahir *et al.* [2004] confirm our findings that the bacteria that are accommodating to plant growth support including *Azotobacter*, *Azospirillum*, *Pseudomonas* and *Rhizobium*. These rhizobacteria mineralized organic element in soil through enzymatic procedures and turn into plant nutritive value as well as plant growth factor. Inoculation of wheat and maize with *Azotobacter* and *Azospirillum* increased plant growth, nutrient uptake and yield were also reported by Dobbelaere *et al.* [2001]. According to the findings of Vyas *et al*. [2009], *Pseudomonas* strains are effective PGPR as they exhibit a wide range of properties *viz.* production of phytohormones like indoleacetic acid (IAA), gibberellic acid and cytokinins; phosphate solubilization and other nutrients. Our present findings are also with the lines of the investigation of Khan and Prakash [2014], who concluded that *Rhizobium* culture significantly increased nitrogen, zinc and molybdenum uptake urd bean.

Wheat grain zinc due to the effect of different inoculants at 160 DAE is presented in Fig. 4. The data publicized that grain zinc is significantly different in all the treatments. Highest grain zinc was recorded with *Azospirillum*+½ NP (37.40 mg kg^{-1}).

Comparison of chemical fertilizer ½ NP (22.53 mg kg^{-1}) in grain zinc with inoculants *Rhizobium* + ½ NP (32.33 mg kg^{-1}), and *Azospirillum*+½ NP is (37.40 mg kg^{-1}), while N ½ P (21.27 mg kg^{-1}) with *Pseudomonas*+ N ½ P is (32.93 mg kg^{-1}). Plant inoculation with *Azospirillumbrasilense* promoted better uptake of nutrients in corn, sorghum and wheat [Saubidet *et al.* 2000]. *Azospirillum* enhances growth and development of plants, such as

phytohormone production and nitrate reduction [Steenhoudt and Leyden 2000].

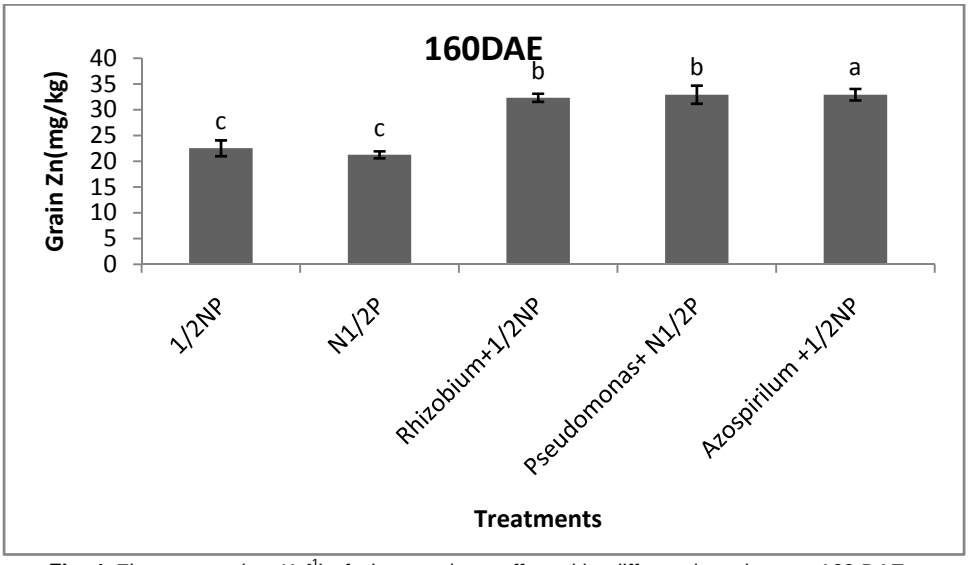

Fig. 4: Zinc content (mg Kg^{-1}) of wheat grain as affected by different inoculants at 160 DAE.

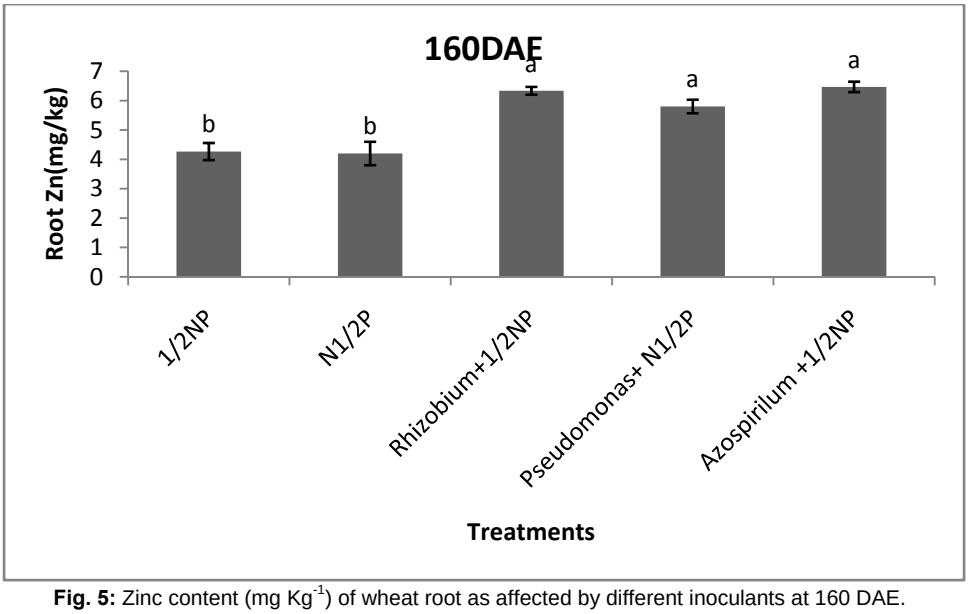

Fig. 5: Zinc content (mg Kg^{-1}) of wheat root as affected by different inoculants at 160 DAE.

The effect of different inoculants on wheat root zinc at 160 DAE are presented in Fig. 5. The data indicated that root zinc is significantly

different in all the treatments. Highest root zinc was recorded with *Rhizobium* + ½NP (6.33 mg kg^{-1}), *Pseudomonas* + N ½P is (5.80 mg kg^{-1}) and *Azospirillum* + ½ NP (6.47 mg kg^{-1}). Comparison of chemical fertilizer ½ NP (4.27 mg kg^{-1}) in root zinc with is *Rhizobium* + ½ NP (6.33 mg kg^{-1}), and *Azospirillum*+ ½ NP is (6.47 mg kg^{-1}), while N ½ P (4.20 mg kg^{-1}) with *Pseudomonas* + N ½ P is (5.80 mg kg^{-1}). Moutia [2010] concluded that *Azospirillum* impacts growth and development of several crops by producing phytohormones such as auxins which have a vital influence on root development. An improved root system leads to better water and nutrient uptake that in turn may influence yield positively. Aniya *et al.,* [2004] studied that *Azorhizobiumcaulinodans* has been shown to colonize wheat roots through crack access of the lateral roots. Tahere *et al.* [2010] reported that the positive effects of *Azospirillum* and *Pseudomonas* symbiosis with barley root and increased the root parameters which influence and increase water and nutrition absorption causing better plant growth.

CONCLUSIONS

The effect of biofertilizers inoculation, viz. *Rhizobium, Azospirillum* and *Pseudomonas* in different combinations with recommended dose of chemical fertilizers (NP) on wheat (*Triticumaestivum* L.) crop was examined during years 2011-2012, to explore the possibility of reducing doses of chemical fertilizers, zinc solubilization and uptake. The results revealed significant uptake of zinc by biofertilizers as compared to chemical fertilizers. Highest shoot zinc(47.6 mg kg^{-1}) uptake was recorded with *Azospirillum* + ½ NP, *Pseudomonas* N ½ P. Highest flag leaves zinc uptake was recorded with *Pseudomonas* + N ½ P (34.73 mg kg^{-1}) and *Azospirillum* + N ½ P (1.46 mg kg^{-1}). Maximum zinc content in wheat straw was recorded with *Rhizobium* ½ NP(13.2 mg kg^{-1}), *Pseudomonas* N ½ P(12.26 mg kg^{-1}) and *Azospirillum* + ½ NP(12.6 mg kg^{-1}). In grain highest zinc (32.33 mg kg^{-1}) uptake was recorded with *Rhizobium* ½ N P, *Pseudomonas* N ½ P and *Azospirillum* + ½.

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