ORIGINAL ARTICLES

The efficiency of Plant Growth Promoting Rhizobacteria (PGPR) on yield and yield components of two varieties of wheat in salinity condition

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ABSTRACT

In order to investigate the effects of plant growth promoting rhizobacteria on growth yield and yield components of two wheat cultivars under saline conditions, a factorial experiment with three replicates conducted in greenhouse at Khorasan Razavi Agriculture and Natural Resources Center, Mashhad. The first factor was two wheat genotypes (Falat cv. Sensitive to salinity and Bam tolerant). The second factor was four irrigation water salinity levels as (1, 4, 8, and 12 dS/m) and the 3th factor was five biological treatments as (Pseudomonas fluorescens 153, 169, Pseudomonas putida 108, 4 and control treatment without inoculation). Wheat seeds sown after inoculation with desired strains. In this experiment 5 traits including grain yield, shoot dry weight (biologic yield), grain per panicle, 1000-grain weight and tiller number were determined. Results showed that salinity significantly decreased at 5% level. Bacterial inoculation had striking effect on grain yield, 1000 grain weight, interaction effects of salinity and inoculation were significant for grain yield. In general indicated that these strains can be used to overcome salinity stress and improving wheat growth and yield under saline conditions.

Key words: Wheat, Salinity stress, Plant Growth Promoting Rhizobacteria, Yield

The amount of salt that affected land world wide is estimated to be 900 million ha, it’s 6% of the global total land mass (Flowers 2004). Soil salinity limited plant growth and crop production in many parts of the world, particularly in arid and semi-arid areas (Shannon 1984). Stalinizatation can result from the natural phenomena (for example rainfall limited) or human activities (such as unsuitable agricultural functions). Leaching salt downward in to the deeper layer with excess water is the most common method to lower soil salt content in the root zone (Qadir et al. 2003). However, soil leaching is not feasible for locations that are distant from water resources of for those with poor drainage. In these sites, high evaporation also results in

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soil salinity. Soil salinity is defined as the concentration of dissolvable salts extracted from soil by water (Richards 1954). Soil salinity prevents plant growth and development with adverse effects such as osmotic stress, Na⁺ and Cl⁻ toxicity, ethylene production, plasmolysis, nutrient imbalance and interference with photosynthesis (Sairam and Tyagi 2004). Decrease of photosynthetic capacity due to the osmotic stress and partial closure of stomata (Drew et al. 1990). Plant growth promoting rhizobacteria (PGPR) are a group of bacteria that can actively colonize plant roots and increase plant growth (Kloepper and Schroth 1978). PGPR may improve plant growth and yield by direct and indirect mechanisms (Noel et al. 1996). Indirect mechanisms have been observed with most PGPR strains. Direct mechanisms may act on the plant itself and affect growth (Kloepper and Schroth 1978) by means of plant growth regulators, solubilization of minerals and fixation of atmospheric nitrogen. PGPR can inhibit the harmful effects of phytopathogenic organisms and environmental stresses. Woitke (2004) reported that a high salinity treatment with Bacillus subtilis had even a lower yield despite improved vegetative plant growth. PGPR produce plant growth promoting compounds including phytohormones; auxins, cytokinins and gibberellins (Dashit et al. 2000), antibacterial peptides that prevent pathogenic strains (Maurohofer et al. 1992), and enzyme of ACC deaminase, this enzyme enables these microorganisms to utilize ACC as a sole nitrogen source by metabolizing it to ammonia and α-keto butyrate.

Rhizobacteria can attach to the surface of plant roots or seeds and can take up some of the ACC exuded by the plant and degrade it through the action of ACC deaminase (Glick et al. 1998). Ethylene is required for many plants for seed germination but high levels of ethylene can impede plant growth. PGPR that contain ACC deaminase, when bound to the seed coat of a developing seedling, act as a mechanism for ensuring that the ethylene level dose not become raised to the point where root growth is impaired.

The objective in this study was to investigate the effect of PGPR on yield and yield components of two varieties in saline soil.

**Materials and methods**

In this experiment we used two varieties of wheat (T. aestivum ssp. Variety Falat as sensitive genotype and T. aestivum ssp. Variety Bam4 as tolerant genotype). Wheat seeds were sterilized in 2% sodium hypochlorite for 3 min, and then rinsed 4 times with distilled water. Sixteen seeds were sown in each pot (25 cm diameter and 15 cm deep) in a greenhouse under 12000-14000 lux light condition (that created by using sodium and helium lamps), at temperature of 30°C and 20°C in day and night, respectively. After sowing, seedlings numbers in any pots were decreased to ten. Soil samples were collected from farm and then transferred to the greenhouse. The soil used was Entisols. The soil characteristics were pH 7.9, EC 0.9 dS m⁻¹, total nitrogen 0.025 mg kg⁻¹, K 148, P 7.2, Mn 9.84, Zn 0.32, Fe 2.48, and Cu 0.82 mg kg⁻¹. P₂O₅ and K₂O fertilizer was applied according to the soil analysis. The PGPR effect on salinity levels was conducted by using 4 salinity levels (1, 4, 8 and 12 dS m⁻¹). These saline solutions were prepared by NaCl and CaCl₂ and were applied after two leaves step. Before planting, one drop of Arabic gum added to 15 gr seeds for each pot and then inoculation was performed with 1 gr of inoculum. All plants were harvested after many of panicles were reached.

Four strains of rhizobacteria including Pseudomonas fluorescens 153, 169, Pseudomonas putida 108 and 4 were selected from the microbial bank of soil biology research department of khorasan razavi soil and water research institute. Perlit was used as vector for inoculum preparation. Cell density in Pseudomonas fluorescens 153, 169, Pseudomonas putida 108 and 4 were 1.3×10⁹, 1.25×10⁹, 1.2×10⁹ and 1.01×10⁹ per 1 ml, respectively.

After harvesting a total of five traits consist of grain yield, shoot dry weight (biologic yield), grain per panicle, 1000-grain weight and tiller number were evaluated.

The experiment was conducted in completely randomized design (CRD) with split factorial arrangement with 3 replications. The analysis of variance (ANOVA) was performed using the software MSTATC and treatment means were compared by tucky test.

**Results and discussion**

To alleviate the negative effect of soil salinity on wheat yield and yield components were inoculated four strains of PGPR, Pseudomonas fluorescens 153, 169, Pseudomonas putida 108 and 4.

Results of the measurements on yield and yield components are given in table 1 and 2.

All traits were significantly increased by inoculation with PGPR. We observed significantly differences for all traits under non-salinity and salinity stress. Under non-salinity stress, the grain yield, biologic yield, grain per panicle, 1000-grain weight and tiller number was increased by 26, 29.12, 23, 28.6 and 23.9%,
respectively, in comparison to the bacterial control treatment. The grain yield (Fig. 1), biologic yield, grain per panicle, 1000-grain weight (Fig. 2) and tiller number of wheat varieties under salinity stress (EC 12 dS m\(^{-1}\)) was also increased by 126, 138, 127, 76 and 66.9% in the PGPR strain treatments compared to the control condition. Grain yield in treatment containing *Pseudomonas putida* 108 was increased 10.14% compared to the non-salinity stress condition. The reduction of plant yield caused by salinity stress is the most common phenomenon of plants under stress.

Table 1: Variance analysis of tiller number, grain per panicle, 1000-grain weight, grain yield and shoot dry weight (biologic yield)

<table>
<thead>
<tr>
<th>Cultivar (A)</th>
<th>Tiller number</th>
<th>Grain per panicle</th>
<th>1000-grain weight</th>
<th>Grain yield</th>
<th>Biologic yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Error</td>
<td>0.292</td>
<td>2.223</td>
<td>4.732</td>
<td>10.06</td>
<td>72.570</td>
</tr>
<tr>
<td>Salinity (B)</td>
<td>0.879</td>
<td>2116.024</td>
<td>593.750</td>
<td>613.342</td>
<td>7561.716&quot;</td>
</tr>
<tr>
<td>(A*B)</td>
<td>0.003</td>
<td>0.076</td>
<td>0.039</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PGPR (C)</td>
<td>1.350&quot;</td>
<td>855.745&quot;</td>
<td>362.549&quot;</td>
<td>607.629&quot;</td>
<td>5281.731&quot;</td>
</tr>
<tr>
<td>(A*C)</td>
<td>0.003</td>
<td>0.075</td>
<td>0.058</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(B*C)</td>
<td>0.916&quot;</td>
<td>83.562&quot;</td>
<td>35.186&quot;</td>
<td>20.053&quot;</td>
<td>139.875&quot;</td>
</tr>
<tr>
<td>(A<em>B</em>C)</td>
<td>0.003</td>
<td>0.075</td>
<td>0.017</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Error</td>
<td>0.210</td>
<td>9.614</td>
<td>1.976</td>
<td>8.489</td>
<td>80.383</td>
</tr>
</tbody>
</table>

*and** significant at 95% and 99% confidence

Table 2: Measuring results of yield components

<table>
<thead>
<tr>
<th>Traits</th>
<th>Variety</th>
<th>Salinity (dS m(^{-1}))</th>
<th>Bacteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tiller number</td>
<td>Bam</td>
<td>Falat</td>
<td>Control</td>
</tr>
<tr>
<td></td>
<td>1.754</td>
<td>1.754</td>
<td>1.95</td>
</tr>
<tr>
<td></td>
<td>1.845</td>
<td>1.601</td>
<td>1.621</td>
</tr>
<tr>
<td></td>
<td>1.621</td>
<td>1.553</td>
<td>1.519</td>
</tr>
<tr>
<td></td>
<td>1.553</td>
<td>1.519</td>
<td>1.814</td>
</tr>
<tr>
<td></td>
<td>1.814</td>
<td>2.108</td>
<td>1.776</td>
</tr>
<tr>
<td>Grain per panicle</td>
<td>40.473</td>
<td>38.122</td>
<td>50.198</td>
</tr>
<tr>
<td>1000-grain weight</td>
<td>33.072</td>
<td>31.882</td>
<td>37.827</td>
</tr>
<tr>
<td>Grain yield (g plant(^{-1}))</td>
<td>26.947</td>
<td>25.796</td>
<td>31.216</td>
</tr>
<tr>
<td>Biologic yield (g plant(^{-1}))</td>
<td>76.884</td>
<td>77.148</td>
<td>95.14</td>
</tr>
</tbody>
</table>

Discussion

We also observed significant difference between two wheat varieties in bacterial levels for all traits except tiller number. The reduction of yield by salinity stress is the most common reaction of plants under stress condition. This reduction is result of many alterations in physiological activities in the plant. PGPR improved plant yield in saline soils. This promotion effect, however, varied with varieties and soil salinity. The Bam4 variety treated with PGPR had higher yield and yield components than the non-PGPR plants in soil. In this study, inoculation with

Fig. 1: The effect of soil salinity in bacteria on grain yield
The grain yield, biological yield, grain per panicle, 1000-grain weight and tiller number of wheat varieties under salinity stress (EC 12 dS m⁻¹) was also increased and these findings have been reported by others researchers (Hilali et al. 2000; Weller and Cook 1986; Vasudevan et al. 2002; Cheng 2007) for PGPR effects on yield and yield components. Hilali et al (2000) reported that grain yield of wheat inoculated by rhizoctonia leguminosarum bv. Trifolii were increased in comparison to the control treatment. PGPR strains increased yield and yield components of plant in comparison to the non-inoculated control treatment, and the inoculation with PGPR strains under soil salinity conditions improved yield and yield components compared to the non-inoculated control.

In conclusion, PGPR promoted phytoremediation was confirmed to be a feasible and effective remediation technique for soils with moderate salinity.

**Acknowledgments**

We thank the soil and water section of Agriculture and Natural Resource Research Institute in Mashhad for supporting and cooperation in this thesis.

**Reference**


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