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Influence of Zinc and Seed Inoculation with Rhizobium Bacteria on Yield and Yield Components of *Triticum aestivum* (Case study: Nurabad, Iran)

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ABSTRACT: In order to investigate the influence of different levels of zinc and seed inoculation with Rhizobium bacteria on yield and yield components of *Triticum aestivum* var: chamran, a Factorial experiment in a completely randomized design with six treatments and three replicates were performed in Mamsani, Nurabad, Fars Province, Iran in 2013-2014. The first factor was zinc fertilizer in the form of zinc sulfate in (0, 0.5, 1%) levels and the second factor was Rhizobium bacteria in two levels (non-use and use). The results of the data mean comparisons showed that interaction of Rhizobium and zinc sulfate factors' had the highest Weight of one Thousand seeds (42.7 kg/ha) and the highest grain yield (kg/ha 4274.8).

Keywords: Rhizobium, wheat, yield, zinc sulfate

INTRODUCTION

Population growths in developing countries, food multifariousness, and its over-consumption in developed countries have raised the global demand for food which is historically unprecedented. This and limited crop cultivation have led to problems in food provision and preparation. Food production in recent decades has taken a strategic perspective, and it is directed to increasing crop yield and adequate utilization of the existing agriculture potentials. Man should increase agricultural production for food security. Increase in production is satisfied by increasing the area under cultivation or by increasing the yield per unit area; the first option is very limited and it has contributed to more attention for increasing the yield per unit area (Moradi and Panahi, 2014).

Wheat is grown more than any plant in the world, and not only is a staple food, but also politically enjoys the same importance as oil or even a superior stand (Behnia, 1994). Wheat is the main crop in the world in terms of production rate, and producing it amounted to about 674 million tons in 2010 (Fao, 2010).

With optimal organic and chemical fertilizers consumption, wheat production can be increased; moreover, protein and micronutrient concentrations in grain and straw can be increased to satisfy the needed calories and a healthy society. One of the most important scientific principles to achieve maximum genetic capacity figures is balanced plant nutrition with fertilizers. Iranian soil is mostly poor in organic matter, so the use of organic matters and biological methods could be a effective conduct to improve the structure, physical, and chemical properties of soil, improve required nutrients' uptake from soil, and increase crop yield to achieve a sustainable agriculture (Moradi & Panahi, 2014).

One reason for the low yield in wheat is nitrogen deficiency, namely the lack of organic matter in soil. The region's soils are low in organic matter and thus soil microorganisms are negligible. Rhizobium are bacteria, around roots of leguminous plant, that cause increased uptake of nutrients such as phosphorus, potassium, calcium, and iron, and this coexistence contributes to the solubility of alkaloids in plants (Saleh Rastin, 1996).

Micronutrients' deficiency in areas under cultivation is spread all over the world, and millions of hectares of arable land in the world are deficient in one or more micronutrient elements. Optimal plant growth, maximum quality achievement, and product quantity require sufficient and balanced amount of macro and micro nutritional elements in soil (Kuchaki and Khalgani, 1995).

If the soil is deficient in nutritional elements, they should be added to the soil as fertilizers. In other words, fertilizer is a compound that can be added directly to the soil to provide the plant with balanced amount of an element or elements. Fertilizer selection and application should be done considering the fate and supply of trace elements in soil, elements interactions, and element requirements of plants (Lin *et al.,* 2003).

Zinc (Zn) is similar to magnesium (Mg) and iron (Fe) in terms of uptake, competing chemically with each other (Neue *et al.,* 1998). Zinc concentration is different in various plant materials and its amount in wheat seed is 170 mg/kg, and it ranges between 25 and 64 mg/kg in dry plant material (Kulaindaivel *et al.,* 2004). The experiments conducted in Turkey on wheat showed, depending on the method used and the experiment sites, 50% increase in yield compared to the control (Cakmak and Marchner, 1998). Research findings suggest that zinc sulfate sprayed onto the foliage have had the most positive effects on yield and yield components of rice, wheat, corn, and soybeans (Abunyewa *et al.,* 2014; Kulaindaivel *et al.,* 2004). Increase in biological nitrogen fixation leads to yield increase and is effective on sustainable agriculture and the conservation of agricultural inputs (Beyranvand Pirvali and Abbasalian, 2007). The amount of fixed nitrogen depends on factors such as plant cultivars and varieties, bacteria, and environmental conditions; Rhizobium family plants such as alfalfa and clover, and soybean can provide their requisite nitrogen through biological fixation up to 90% and 75%, respectively, in suitable conditions (Liu *et al.,* 2009). According to Yusuf et al., utilizing bio-fertilizers containing Azospirillum and Azotobacter in sage herb increased plant height and shoot dry weight and wet weight (Youssef *et al.,* 2004). In another experiment, Leithy et al. mentioned the positive impact of Azotobacter biological fertilizers on rosemary herb essential oils' increase (Leithy *et al.,* 2006) According to research by Hamidi *et al.,* the highest grain yield was observed in inoculated seed treatments with three bacteria; Azotobacter, Azospirillum, and Pseudomonas (Hamidi *et al.,* 2009).

Given the strategic nature of wheat and examining zinc sulfate fertilizer and Rhizobium effective in increasing the wheat yield, this research was conducted. In this study, the effect of different levels of zinc sulfate and seed inoculation with Rhizobium bacteria on Chamran wheat yield (*Triticum aestivum*) in Nurabad was rigorously examined and analyzed.

MATERIAL AND METHODS

The study was conducted in Fahlilan Bridge region, Mamsani, Nurabad, Iran in 2013-2014 crop years. Mamasani is located in north latitude 29° 33′ to 29° 2′; eastern longitude of 50° 58′ and 52° 7′. The capital city is "Nurabad", 30′ and 51° east longitude and latitude 30° 5′. Average temperature in Nurabad is 21°C and average frost days are 2.3 days. Temperature difference between the warm and cold seasons is high. The temperature is also different in every region (north, center, and south of the city). After conducting the soil test, the bed was prepared by semi-deep mold board plowing (about 30 cm) and then its leveling was done, afterward, different levels of Bor fertilizer in the form of solution was added to the plots; the plots sized 3 × 4 m, the distances between the plots and between the blocks were 0.5m and 1m, respectively.

At the beginning of the growing season, thinning was done and to control weed plants, hand weeding was done three times. During this phase, necessary tasks and note takings were done to perform the required measurements on the treatments until the harvest time; the harvest traits, plant height, spike length, grain yield, Weight of one Thousand seeds and seed number per square meter were studied.

Factorial design experiment was conducted as a randomized complete block design with three replications. Treatment variables consisted of three levels of zinc (0, 0.5, and 1%) and Rhizobium bacteria in two levels (non-use and use), and the experiment was done in an interactive way. Data obtained were analyzed by SAS software and Duncan's test was used to compare treatment means. Curves were plotted using Excel software.

RESULTS AND DISCUSSION

A. Plant height

According to the obtained results of the ANOVA Rhizobium bacteria on plant height was significant at ($P \leq 0.01$); also zinc sulfate had no significant effect on plant height of wheat plants lonely. Analysis of variance showed that interaction of Rhizobium and zinc sulfat had significant effect on wheat plant height at ($P \leq 0.05$) (Table 1). Based on the results of the data mean comparison, the maximum height (74.8 cm) was observed in R_1Zn_2 treatments; and minimum height (57.4 cm) was recorded in control treatment R_0 Zn_0 (Table 2).

Table 1: Analysis of variance of mean squares of different levels of Rhizobium bacteria and zinc sulfate on wheat.

Source of variations	Grain yield	Weight of one Thousand seeds	The number of grains per spike	Straw weight	The number of tillers	Spike length	Plant Height	Degree of freedom
Replications	230784.25ns	19.10 ns	5940.3*	3936.7**	11.48 ns	2.66 ns	21.05 ns	3
Rhizobium bacteria	635260*	330.17**	89527.6*	4860.2*	94.69**	130.15**	333.38**	1
Zinc sulfate	2535957.2*	31.79*	31924.2*	3632.9*	21.81*	4.62^{ns}	57.2^{ns}	2
Interaction of the bacteria and zinc sulfate	836435.2^{ns}	5.052^{ns}	24395.13^{ns}	175762.4^{ns}	1.09^{ns}	1.78^{ns}	240.38*	4
Error	18.70	16.17	16.82	14.97	8.85	4.164	22.8	33
Coefficient of Variation	12.9	10.43	13.21	8.7	6.39	22.25	11.62	

**Significant at 1% level, *significant at 5% and ns, not significant

Table 2: The mean interaction comparison in different levels of zinc sulfate and Rhizobium bacteria on wheat.

Treatments	Grain yield(Kg/He)	Weight of one Thousand seeds (Kg/He)	The number of grains per spike	Straw weight (Kg/He)	The number of tillers	Spike length (Cm)	Plant Height (Cm)
R_0Zn_0	31575.5^{f}	35^{d}	748^{f}	1054^{f}	4.8^{e}	48.43^{f}	57.4^{f}
R_0Zn_1	3200^{e}	37.4^{c}	752.5^{e}	1274^{e}	5.2^{e}	49^{e}	59^{e}
R_0Zn_2	33574^{d}	39.5^{bc}	784^{d}	1395^{d}	7^{d}	52^{d}	62.8^{d}
R_1Zn_0	3740.2^{c}	35.5^{d}	912^{c}	1572.5^{c}	8.5^{c}	57^{c}	68.4^{c}
R_1Zn_1	3974^{b}	40^{b}	928.5^{b}	1728.4^{b}	10.7^{b}	62^{b}	70^{b}
R_1Zn_2	4274.8^{a}	42.7^{a}	952^{a}	1845^{a}	11.2^{a}	68^{a}	74.8^{a}

Means that contain at least one letter in common are not significantly different.

B. The number of seeds per square meter

Analysis of variance showed the effects of Rhizobium bacteria and zinc sulfate levels had significant effects on the number of seeds per square meter (P≤0.05) (Table 1). On the other hand, interaction of Rhizobium bacteria and zinc sulfate levels' had no significant effect on the number of wheat grains per square meter. Comparing the data, the highest number of seeds per square meter (952) was recorded in the treatment of R_1Zn_2 and the minimum seeds number per square meter (748) in the control treatment R_0 Zn_0 (Table 2).

C. Weight of one Thousand seeds

Analysis of variance showed Rhizobium bacteria had significant effect on Weight of one Thousand seeds at (P≤0.01); also Zinc sulfate had significant effect on the Weight of one Thousand seeds (P≤0.05) lonely. Interaction of Rhizobium bacteria and zinc sulfate had no significant effect on grain weight (Table 1).

Mean comparisons showed the maximum Weight of one Thousand seeds (42.7 kg/ha) was observed in the interaction of Rhizobium bacteria and zinc sulfate R_1Zn_2 while it's minimum (32.5 kg/ha) seen in the control treatment R_0 Zn_0 (table 2).

D. Spike length

According to the obtained results of the ANOVA showed Rhizobium bacteria had significant effects on spike length at ($P \leq 0.01$), also interaction of zinc sulfate and Rhizobium bacteria had no significant effect on spike length (Table 1). The maximum spike length (68 cm) was observed in the treatment of R_1Zn_2 while it's minimum (48.43 cm) seen in the control treatment R_0 Zn_0 (Table 2).

E. Grain yield

Analysis of variance showed Rhizobium bacteria and zinc sulfate had significant effects on grain yield at ($P \leq 0.05$). Interaction of Rhizobium bacteria and zinc sulfate had no significant effect on grain yield (Table 1). Results from comparing the mean of data showed that the interaction of zinc sulfate and Rhizobium bacteria had significant effect on grain yield, The highest grain yield per spike (4274.8 kg/ha) was observed in the R_1Zn_2 and the lowest grain yield (3157.5 kg/ha) seen in the control treatment R_0 Zn_0 (table 2).

CONCLUSION

Based on the results of the data analysis, the effect of Rhizobium bacteria on plant height, spike length, and Weight of one Thousand seeds was significant at 1%, and it was significant on the traits of the number of seeds per square meter and grain yield at 5%. Different levels of zinc sulfate factor were significant on the number of seeds per square meter, Weight of one Thousand seeds, and grain yield at 5%.

Different levels of zinc sulfate had no significant effect on plant height and spike length. The results showed that the Rhizobium and zinc sulfate factors' interaction had significant effect on plant height at 5%, but had no significant effect on other traits.

The interaction of Rhizobium and zinc sulfate factors with their highest Weight of one Thousand seeds (42.7 kg/ha) and the highest grain yield (4274.8 kg/ha) are recommended for wheat cultivation in areas with similar climatic conditions to Mamasani

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