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Potato *(Solanum tuberosum)* seed bio-priming influences tuber yield in new released cultivars

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Abstract

Potato (*Solanum tuberosum*) is a starchy and tuberous crop of the Solanaceae family. In order to study effect of tuber bio-priming on yield of new released potato cultivars a field experiment was conducted at Tabriz, Iran, during 2009. Studied factors were three potato cultivars (Agria, Satina, Kuzima) and three kind of biofeilizers as Azotobacter, Super nitro plus, and Super nitro, a non-inoculated treatment as control. Results revealed that umber of tubers per plant in those seeds inoculated with Azotobacter and Super nitro, was 8.2, while non-inoculated seeds produced 7 tubers per plant. Seed inoculation with biofertilizers caused to reducing of tubers size 34.1%, 38.3% and 25.9%, respectively, when compared to the control. Seeds treated with Azotobacter produced higher tuber yield (18840 kg ha^{-1}), and the lowest from control (15380 kg ha^{-1}). The stepwise regression analysis verified that the tubers with diameter of greater than 40 mm and mean of tuber weight per plant had a marked increasing effect on the seed yield of potato. Seeds inoculation with studied biofertilizers before sowing could be recommended for potato farmers.

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Introduction

Potato (*Solanum tuberosum*) is a starchy and tuberous crop of the Solanaceae family (Bayrami *et al*. (2012). Free living nitrogen fixing bacteria like *Azotobacter chrococcum* and *Azospirillum lipoferum,* not only can fix atmospheric nitrogen but also can release plant hormones such as gibberellins and indole acetic acid to stimulate plant growth (Fayez *et al.,* 1985). Rai *et al*. (1990) reported that when potato cultivars (*Kufri Lalima* and *Kufri Sinduri*) inoculated with *G. mosseice* and *G. fesiculatum*, percent of edible tubers due to improvement of root volume and phosphorous absorption by plants increased.

In a study conducted by bayrami *et al*. (2012) inoculation of potato tubers with *Glomus mosseice* in combination with application of 67% of super phosphate recommended dose resulted in increasing of chlorophyle content up to 78.2. In an-other experiment conducted by Wright *et al*. (1998) inoculation of clover (*Trifolium repens*) seeds with Mycorrhiza increased leaf area due to increasing of chlorophyle content. Kapoor *et al*. (2004) reported that symbiosis of fennel root with two species of mycorrhizal fungi, including *Glomus macrocarpum* and *G. fasiculatum* increased number of umbels in plant and seed weight. Maheshwari *et al*. (1991) showed that using *Azotobacter chrococcum* alone on palmarosa (*Cymbopogon martinii* var. motia), increased yield by 16% and when applied along with 80 kg nitrogen the yield increased 29%. Lewis *et al*. (1995) found that the highest profit was obtained by immersing the cloves in a solution with the bacteria prior to planting followed by soil application.

Badran and Safwat (2004) and El-Ghadban *et al*. (2006) understood that using biofertilizer increased fennel growth. Sharaf (1995) showed that inoculation of datura (*Datura stramonium*) and ammi (*Ammi visnaga*) with a mixture of *Azotobacter* and *Azospirillum* with full doses of rock phosphate and inorganic nitrogen fertilizer, in combination with inoculation with vascular arbuscular mycorrhiza (VAM), improved growth of both plants. There is a little information about interaction between nitrogen biological fixing bacteria with potato. However, Bagyaraj and Menge (1978) recorded a synergistic interaction between *Azotobacter* and vesicular arbuscular mycorrhiza on enhancing dry weight of tomato plants. According to results of Tyagi *et al*. (1999) research application of biofertilizers not only can decrease use of chemical fertilizer by 20% to 50%, but also can simultaneously increase the yield of crop by 10% to 20%. Among the different beneficial soil microbes, *Azospirillum strains* are effective in nitrogen fixing and they also can produce growth promoting substances. Impacts caused by over application of chemical fertilizers, energies, expenses of their production are the reasons for global tendency toward application of biofertilizers (Kannayan, 2002). The objective of this study was to evaluate the effect of bio fertilizers on tuber yield of potato under sustainable production systems.

Materials and methods

Field experiment was conducted at the Agricultural Research Station of Islamic Azad University of Tabriz, Iran, during growing season of 2009. Tabriz located in the north-west of Iran, and the climate is semi-arid and cold and average annual precipitation is 256 mm. The soil was sandy-loam with EC of 0.76 ds m^{-1} and pH of 7.3-7.6 ds m^{-1}. Total nitrogen content of the soil was 0.12%; phosphorous and potassium contents of 29 mg kg^{-1} and 333 mg kg^{-1}. The experimental field had been in a wheat-bean rotation cycle for the last two years. The experimental area was ploughed in the fall and manured with 14 t ha^{-1}. Field was cultivated, disked, furrowed, and then plotted in spring before sowing the seeds. Fertilizers used, in spring before sowing, were 50 and 35 kg ha^{-1} of ammonium phosphate and potassium sulfate, respectively, based on soil analysis. The size of plots was 4 by 3 m. Each plot consisted of five potato rows spaced 75 cm apart. Factorial experiment was arranged based on randomized complete block design with three replications.

Studied factors were three new released potato cultivars (Agria, Satina, Kuzima) and three nitrogen fixating biofeilizers as Azotobacter, Super nitro plus,

and Super nitro, a non-inoculated treatment as control. All plots were hand removed for other weed species in growing season. Plots were irrigated immediately after sowing to assure uniform emergence. No herbicide, neither before nor after sowing, was used to control weeds. At harvesting stages, the middle three potato rows of each plot were hand harvested.

All data were analyzed using the MSTAT-C software. Treatment means were separated using Fischer's Protected LSD at P= 0.05 level. Regression analysis was performed to describe the relationship between tuber yield and duration of redroot pigweed interference using the REG PROCEDURE of SAS 2000.

To formulate the relationship between three independent growth variables measured in our experiment with a dependent variable, multiple regression analysis was carried out for the tuber number per plant (X_1), tubers with diameter of lower than 40 mm (X_2), tubers with diameter of greater than 40 mm (X_3), and mean of tuber weight per plant (X_4) as independent variables and tuber yield as a dependent variable. The multiple regression equation is shown as follows.

Tuber yield (tones ha^{-1}) = 0.400 + 0.0907 (X_1) + 0.0007 (X_2) + 0.0919 (X_3) + 0.0888 (X_4)

Furthermore, the stepwise regression analysis was also carried out for the data obtained to test the significance of the independent variables affecting the tuber yield as a dependent variable. The resulted stepwise regression equation is shown as follows.

Tuber yield = 1.58 + 0.1011 (X_3) + 0.3201 (X_4);
R^2 = 90.9

Results and discussion

Based on the variance analysis of data obtained from the study, effect of potato cultivar on tubers with diameter of lower than 40 mm, tubers with diameter of greater than 40 mm, mean of tuber weight per plant and tuber yield were significant at 1% probability level. Also, effect of biofertilizer application on all studied variables were significant at 1% probability level. While, only interaction of factors on tubers with diameter of greater than 40 mm and tuber yield were significant at 5% probability level (Table 1).

Table 1. Variance analysis for the effects of biofertilizers on studied traits in potato cultivars.

SV	df	Tuber number per plant	Tubers with <40 mm diameter	Tubers with >40 mm diameter	Mean of tuber weightper plant	Tuber yield
Replicate	2	0.333	0.028	0.250	11.083	41.103
Cultivar (C)	2	0.083^{ns}	113.44**	46.33**	50.08**	109176.98**
Biofertilizer (B)	3	1.296**	2057.66**	319.778**	45.56**	197841.79**
C × B	6	0.046^{ns}	8.63^{ns}	0.778*	3.083^{ns}	3589.39*
E	22	0.188	29.844	0.770	6.306	235.76
CV (%)	-	15.82	9.03	10.84	15.11	18.89

**, * and ns: significant difference at 1% and 5% of probability levels and non-significant, respectively.

Mean comparisons revealed that when the potato tubers were inoculated with Azotobacter and Super nitro, number of tubers per plant as a major yield component of potato was 8.2, while non-inoculated seeds produced 7 tubers per plant (Fig. 1). Rice *et al.* (2007) in a study conducted on late ripening potato cultivars in warm conditions emphasized on positive effect of seed biofertilization with *Azospirillum* on number and size of tubers and reported that there is a significant correlation between number of tubers per plant and economical yield.

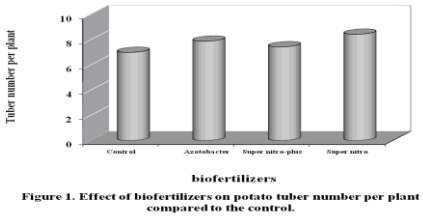

Figure 1. Effect of biofertilizers on potato tuber number per plant compared to the control.

Biofertilizers

Fig. 1. Effect of biofertilizers on potato tuber number per plant compared to the control.

In this study the highest tubers with diameter of lower than 40 mm (36.5 tubers) obtained from Kuzima cultivar. While, Satina with lower rate of tubers with lower than 40 mm diameter was a suitable variety, because this size of tubers has lower marketable. Seed inoculation with biofertilizers (Azotobacter, Super nitro plus, and Super nitro) caused to reducing of this size tubers up to 34.1%, 38.3% and 25.9%, when compared to the control (Fig. 2). Number of tubers smaller than 30 g reduced when potato seeds were inoculated with *Glomus intraradics* or *G. mosseice* and applied lower dose of super phosphate recommended dose (Bayrami *et al.* (2012).

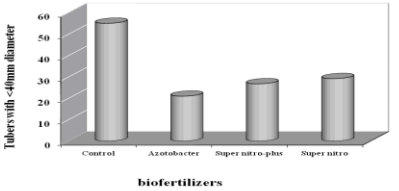

Figure 2. Effect of biofertilizers on tubers with <40 diameter compared to the control.

Biofertilizers

Fig. 2. Effect of biofertilizers on tubers with 40 diameter compared to the control.

Treatment with higher tubers number per plant (super nitro inoculated seeds with 8.4 tubers) had lower mean of tuber weight per plant (70.2 g) after control (Fig. 1 and 3). These results were supported by findings of Hossein *et al.* (2009), and it was concluded that Azotobacter and Super nitro plus had higher effect on tuber size than tuber number. While, we observed reverse trend when seeds inoculated with Super nitro.

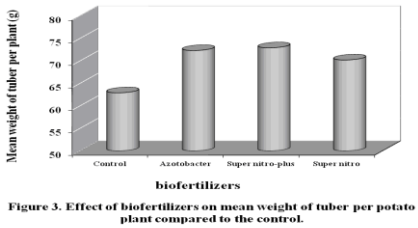

Figure 3. Effect of biofertilizers on mean weight of tuber per potato plant compared to the control.

Biofertilizers

Fig. 3. Effect of biofertilizers on mean weight of tuber per potato plant compared to the control.

Seeds treated with Azotobacter produced higher tuber yield (18840 kg ha^{-1}), and the lowest from control (15380 kg ha^{-1}). With consideration of effect of yield components on total yield as Martin *et al.* (1999) emphasized on it, in the present study higher yield was obtained from those treatments with higher yield components. Complementary findings of this study revealed that in all potato cultivars tuber yield value in non-inoculated seeds were significantly difference from those seeds treated with the biofertilizers, which is in good agreement with those reported by Hossein *et al.* (2009) and Rai *et al.* (1990).

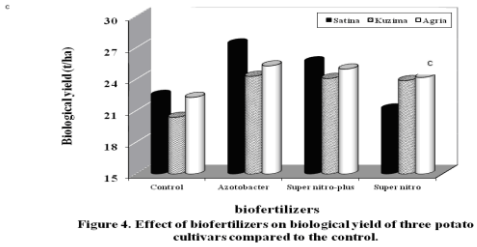

Figure 4. Effect of biofertilizers on biological yield of three potato cultivars compared to the control.

Biofertilizers

Fig. 4. Effect of biofertilizers on Biological yeild of three potato cultivars compared to the control.

Tuber yield of potato cv. Agria can be affected by interaction of biofertilizer and fertilizer (Bayrami *et al.* 2012). In another experiment conducted by Al-Karaki *et al.* (1998) on tomato (*Lycopersicum esculentum*) and Gupta *et al.* (2002) on peppermint (*Mentha piperita*) plants treated with biofertilizers had higher colonization in rhizosphere and greater nutrient absorption and yield. Also, symbiotic relationship between Arbuscular Mycorrhiza and wheat in different phosphorous levels resulted in higher phosphorous translocation from root to above-ground parts of crop plant, which caused to improvement of quantity and quality of wheat. Bayrami *et al.* (2012) study concluded that seed inoculation with mycorrhiza can play a major role in reducing of chemical phosphorus fertilization rate in sustainable production systems of potato. According to investigation results of Das and Saha (2007) revealed that inoculation of *Azotobacter* and *Azospirillum* on rice in presence of partial application of nitrogen fertilizer and farm yard manure increased seed yield. The stepwise regression analysis verified that the tubers with diameter of greater than 40 mm and mean of tuber weight per plant had a marked increasing effect on the seed yield of cumin.

Conclusion

Seeds inoculation with studied biofertilizers before sowing could be recommended for potato farmers.

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