*Jordan Journal of Agricultural Sciences,* Volume **13**, No.**3** 2017

# Improvement of Soybean Yield by N-fixing Bacteria in Combination with Diammonium Phosphate Fertilizer

***Manochehr Shiri Janagard* [*], *Morteza Kamrani*[*], *Yaser Hoseini*[*]**

## ABSTRACT

To investigate the effect of Biosoy and Barvar-2 bio-fertilizers in combination with nitrogen and phosphorus fertilizers on yield and yield components of soybean, a factorial experiment based on randomized complete block design with three replications was conducted on Research Farm of Moghan College of Agriculture and Natural Resources in 2014. The first factor included biological fertilizers in three levels (control, single inoculation with Biosoy and dual inoculation with Biosoy+Barvar-2) and the second factor included chemical fertilizers in four levels (150 kg/ha urea, 200 kg/ha diammonium phosphate, 150 kg/ha urea + 200 kg/ha diammonium phosphate and control). The results have shown that the highest pod dry weight, shoot dry weight, grain numbers, pod numbers, grain yield and biological yield were achieved when seeds inoculated with Biosoy and/or Biosoy+Barvar-2 and received 200 kg/ha diammonium phosphate. There were no significant differences between inoculation with Biosoy and dual inoculation with Biosoy and Barvar-2 at all chemical fertilizer levels. Application of 150 kg/ha urea + 200 kg/ha diammonium phosphate decreased Crop performance in both single and dual inoculation. Both types of inoculation produced higher nodule dry mass than non-inoculated seeds at all fertilizer levels. Therefore, inoculation of soybean seeds by Biosoy and/or Biosoy+Barvar2 along with application of 200 kg/ha diammonium phosphate produced the highest grain yield and saved the use of urea fertilizer.

**Keywords**: Barvar-2, Biosoy, Diammonium phosphate, Inoculation, Nodule, Soybean, Urea.

## INTRODUCTION

Soybean grain is the main source of protein for animal feed and human diet (Dastmalchi & Dhaubhadel, 2015 and Singh & Singh, 1992). Soybean plant in the tropics is increasingly becoming a commercial crop and is of important nutritional because of the oil, protein and high compatibility (McKevith, 2005). According to FAO (FAOSTAT, 2013) the area under soybean cultivation in Iran was 76 thousand hectares with an average yield of 4.2 tons per hectare and in the world was almost 113 million hectares with an average yield of 5.2 tons per hectare.

Nitrogen is a mobile element that its intake by plants in wet and dry conditions is limited due to leaching and water scarcity. Reduction of phosphorus availability in acidic soils in the presence of iron and aluminum ions and in calcareous soils by calcium ions decreases plant growth (Shen *et al*, 2011). Pseudomonas putida bacteria as phosphate solubilizing bacteria, increases root growth and as a result the availability of elements (Jha *et al*, 2009; Ahemad and Kibret, 2014). Seed coating of phosphate solubilizing bacteria bacillus caused a significant increase in leaf biomass and yield components such as the number of pods per plant, the number of seeds per plant and seed yield per plant compared to the control (Minaxi *et al*,

[*] Moghan College of Agriculture and Natural Resources, University of Mohaghegh Ardabili, Ardabil, Iran.
Received on 9/5/2016 and Accepted for Publication on 4/12/2016.

2011). Dias *et al*. (2008) showed that the beneficial effects of microorganisms on the growth and yield of crops are often not clear and even had a negative effect on crops, especially in the first year. For instance, phosphate solubilizing organisms compete with the plant for uptake phosphorus.

Seed inoculation with Rhizobium increased nodule dry weight (Zuffo *et al*, 2015, Mohamed & Hassan, 2015). Hungria *et al*, (2006) have reported that the amount of fixed nitrogen by soybean was 300 kilograms per hectare that met almost 94% of the soybean need for nitrogen. This fixed nitrogen increase plant growth and yield (Salih *et al*, 2015). A significant increase in growth parameters and grain yield by various researchers (Soe *et al*, 2010, Kala *et al*, 2011) has been reported because of seed inoculation with Bradyrhizobium strains. Rhizobium significantly increased parameters such as plant height, dry weight of nodules, the number of pods per plant, grain yield per plant (Gajera *et al*, 2014), the number of seeds per pod and harvest index (Jaga & Sharma, 2015) and dry weight soybean shoots (Zuffo *et a*., 2015). Mohammed and Hassan (Mohamed & Hassan, 2015) also reported that inoculated pea crops compared with non-inoculated had more dry nodule weight, grain yield, the number of pods and grains number. Salih *et al*. (2015) stated that the growth and grain yield were much more for 100 kg per hectare diammonium phosphate in combination with Bradyrihzobium treatment. The combined application of B. japonicum and low application of nitrogen fertilizer compared to single application of all nitrogen increased soybean yield and growth characteristics and beneficial effect of B. japonicum on total dry weight, stems, pods, and grain yield improved by reducing nitrogen amounts so that the most effectiveness obtained with the least amount of fertilizer (El-Shaarawi *et al*, 2011). Inoculation of common bean with plant growth promoting bacteria along with phosphorous fertilizer significantly increased stem height, nodule dry weight, grain and biological yield not stem biomass (Zafar *et al*, 2011).

The aim of this study was to find a combination of biological and chemical fertilizers in which not only increases the performance of the crop, but also reduces chemical fertilizer consumption in the conventional farming system.

**Materials and Methods**

The study was conducted as factorial based on a randomized complete block design with 12 treatments and three replications in the research field of the Moghan College of Agriculture and Natural Resources, Ardabil, Iran, (Longitude 47 degrees 10 minutes, latitude 39 degrees 42 minutes, mean annual precipitation of 245 mm and a mean annual temperature of 15 °C), in 2015.

Some soil properties are presented in Table 1. The available fraction of Zn, Fe, Cu, Mn, P and K, and total amount of N were shown in it. Micronutrients were extracted by DTPA extraction. In the conventional cropping system in Moghan plain the amount of urea as nitrogen and diammonium phosphate as phosphorous fertilizer for soybean was 150 and 200 kg per hectare, respectively. The first factor included biological fertilizers in three levels (control, inoculation with Biosoy and dual inoculation with Biosoy and Barvar-2,) and the second factor included chemical fertilizers in four levels (150 kg/ha urea, 200 kg/ha diammonium phosphate, 150 kg/ha urea + 200 kg/ha diammonium phosphate and control).

**Table 1. Some characteristics of soil**

| $Zn_{ava.}$ (ppm) | $Fe_{ava.}$ (ppm) | $Cu_{ava.}$ (ppm) | $Mn_{ava.}$ (ppm) | $N_{t.}$ (%) | $P_{ava.}$ (ppm) | texture |
|---|---|---|---|---|---|---|
| 3.62 | 4.58 | 3.80 | 9.67 | 0.09 | 10.5 | Loamy clay |
| $K_{ava.}$ (ppm) | (pH) | Ec (ds/m) | CEC (meq/100 g) | Caco3 (%) | OM (%) | |
| 627 | 7.45 | 1.89 | 18.5 | 15/08 | 0.95 | |

The biofertilizer, Biosoy, which contains Bradyrhizobium japonicum bacteria obtained from Biorum Company and Barvar-2 special for soybean that contains the bacteria Pseudomonas putida s-P13 and Pantoea agglomerans for dissolving phosphate obtained from Green Biotech Company. In both types of bio-fertilizers, there were $10^8$ bacteria per gram of fertilizer. A Pack of Barvar-2 (100g) and a pack of Biosoy (500 cc) were used for inoculation 70 kg of seed. Each plot consisted of five rows with four meters long, spaced 50 centimeters apart. The optimum plant density (50 plants per $m^2$) obtained by extra seed sowing and hand thinning. Soybean (cv Zan) seeds with a distance of 8 cm in rows on both sides of the stack were planted at a depth of 3-4 cm. The distance between the blocks and plots was 3 and 1.5 meters, respectively. Different amounts of urea and diammonium phosphate fertilizers were placed approximately 5 cm under and beside of the place of the seeds at planting. Irrigation was performed immediately after planting and fertilizing so that bacteria do not die of drought. Subsequent irrigation was carried out in accordance with conventional cropping system in which soybean farms were irrigated after 15-20 days from previous irrigation. Weeds controlled manually. The soil around five soybean plants was fully irrigated; next plant roots along with soil particles enclosed were taken by shovel from each plot at the early stage of grain filling (R5). Then the roots were washed, nodules collected and weighed after drying in an oven. After physiological maturity in which all parts of plants were brown, 10 plants randomly harvested and stem height, shoot dry weight, dry weight of pods, biological yield, the number of pods, the number of grains per pod and grain weight was determined. Grain yield was determined by harvesting all plants in one square meter. Pod weight was assayed after the 2 weeks air-drying in the laboratory. Nodules and stems dried at 72 °C for 48 hours in an oven. SAS software and Duncan's multiple range test used to data analysis and mean comparisons.

**Results and Discussion:**

***Dry weight of nodules:***

Biological and chemical fertilizer interactions affected nodule dry weight (Table 2). In plants from non-inoculated seeds, the nodules dry weight was same at different levels of chemical fertilizer. Inoculation with Biosoy and dual inoculation with Biosoy+Barvar-2 showed significant superiority compared to non-inoculated plants at all levels of chemical fertilizers. At all levels of chemical fertilizers, the difference between inoculation with Biosoy and dual inoculation with Biosoy+Barvar-2 was non-significant. Both sole inoculation with Biosoy and dual inoculation with Biosoy+Barvar-2 produced the highest nodule dry weight when 200 kg/ha diammonium phosphate was applied (Table 3). Application of 200 kg/ha diammonium

phosphate containing 36 kg N and 92 kg $P_2O_5$ equivalent had not a negative impact on the growth of root nodules. Because the right amount, without excess of nitrogen, was placed as a tape under the soil. Sultana *et al*, (2014) showed that the nodule weight for inoculated seeds with Rhizobium has significantly been higher than the control. Fankem *et al*, (2015) reported that soybean seed inoculation with phosphate solubilizing bacteria had lowest nodule weight, where inoculated with nitrogen-fixing bacteria, phosphate solubilizing bacteria, and their combination produced highest amounts. Jaga & Sharma, (2015) also reported similar results.

***Plant height:***

Biological and chemical fertilizer interactions affected Plant height (Table 2). In the case of non-inoculated plants, increased use of chemical fertilizers increased plant height so that control produced the lowest height and the combined use of 150 kg urea and 200 kg/ha diammonium phosphate had the highest height. The difference between inoculation with Biosoy and dual inoculation with Biosoy+Barvar-2 was non-significant at all levels of chemical fertilizer. Application of 200 kg/ha diammonium phosphate for inoculated plants with Biosoy and dually inoculated plants with Biosoy+barvar-2 produced greatest height which, is statistically equal to the application of 200 kg/ha diammonium phosphate + 150 kg/ha urea (table 3). In both single and dual inoculation, application of 200 kg/ha diammonium phosphate compared to other chemical fertilizer levels produced more nodules that fixed more nitrogen caused to greater height. Fankem *et al*, (2015) reported that soybean inoculation with nitrogen fixing and phosphate solubilizing bacteria produced more stem height than control. However, Sultana *et al*. (2014) stated that plant height for inoculated plants with Rhizobium was significantly higher than the control. Begum *et al*. (2015) showed that combined application of nitrogen and phosphorus fertilizers were more effective than the sole application of them.

***Shoot dry weight***

Shoot dry weight was affected by biological and chemical fertilizers (Table 2). For non-inoculated plants, application of chemical fertilizers showed significant superiority compared to control. There were not found significant differences between inoculation with Biosoy and dual inoculation with Biosoy and barvar-2. Inoculated plants with Biosoy and dual inoculation with Biosoy and Barvar-2 along with utilization of 200 kg/ha diammonium phosphate produced more weight, even more than applying of 200 kg/ha diammonium phosphate + 150 kg/ha urea for non-inoculated plants (Table 3). The increase in dry weight of stem was associated with stem height that caused by providing nitrogen to the plant. Fankem *et al*. (2015) reported that inoculated soybean and common bean plants produced more stem dry weight than non-inoculated plants. Also, Elkoca *et al*. (2008) reported that inoculation of pea seeds with nitrogen-fixing bacteria compared to non-inoculated treatments increased significantly shoot dry weight and this increase is equal to or higher than applying of nitrogen, phosphorus, and N + P fertilizers.

**Table 2. ANOVA for some growth parameters at different level of chemical and biological fertilizers**

| S.O.V | df | MS | | | | |
|---|---|---|---|---|---|---|
| | | **Nodule biomass** | **plant height** | **Stem dry weight/plant** | **Pod dry weight/plant** | **Biological yield** |
| replication | 2 | 0.013** | 131.2** | 0.017$^{ns}$ | 11.1** | 13.0** |
| Bio-fertilizers (A) | 2 | 0.46** | 243.2* | 1.34** | 8.26** | 15.75** |
| Chemical fertilizers (B) | 3 | 0.018** | 322.9** | 2.54** | 12.14** | 25.53** |
| A× B | 6 | 0.010** | 261.1** | 0.93** | 3.78** | 8.16** |
| Error | 22 | 0.001 | 49.9 | 0.092 | 0.64 | 0.83 |
| C.V.(%) | | 6.7 | 8.85 | 8.22 | 12 | 9.18 |

$^{Ns}$, * and **: Non-significant, Significant at 0.05 and 0.01, respectively

***Pods Dry weight per plant***

The interaction effect of biological and chemical fertilizer has affected pods dry weight per plant (Table 2). In non-inoculated plants, applying of 150 kg/ha urea + 200 kg/ha diammonium phosphate produced significantly higher pod dry weight than non-application of chemical fertilizer. When plants were inoculated with Biosoy and or biosoy+barvar-2, utilization of 200 kg/ha diammonium phosphate produced the highest pod dry weight, which was significantly higher than the pod dry weight of non-inoculated plants when they received 150 kg/ha urea + 200 kg/ha diammonium phosphate (table 3). Application of 200 kg/ha diammonium phosphate along with seed inoculation with Biosoy and Biosoy+barvar-2 had the highest pod dry weight due to increase in nitrogen supply to plants by nitrogen fixing bacteria. However, Rao (2014) reported that the combination of Bradyrhizobium and Pseudomonas bacteria along with 100 percent of nitrogen and phosphorus fertilizers produced the most pod weight.

***Biological yield:***

Biological and chemical fertilizers interaction has affected biological yield (Table 2). In non-inoculated plants, all chemical fertilizers levels increased significantly biological yield compared to the control. When inoculated plants with Biosoy and Biosoy+Barvar-2 fertilized by 200 kg/ha diammonium phosphate the plants produced the highest biological yield, which, was more than applying 150 kg/ha urea+ 200 kg/ha diammonium phosphate for non-inoculated plants (table 3).

Production of the highest biological yield in both types of inoculation along with applying 200 kg/ha diammonium phosphate was due to higher amount of nodules, increase in stem and pod dry weight. El-Shaarawy *et al*. (2011) stated that the most effective of B. japonicum in total dry weight was obtained in the lowest amount of chemical fertilizer. Sankar *et al*. (2015) also reported beneficial effects of plant growth promoting bacteria on dry weight of *phaseolus mungo*.

***Pods per plant***

The number of pods per plant was affected by biological and chemical fertilizer interaction (Table 4). In the case of non-inoculated plants, use of 150 kg/ha urea +

200 kg/ha diammonium phosphate produced the highest amount and non-application of chemical fertilizer produced the lowest number. The non-application of chemical fertilizer for non-inoculated plants had the lowest pod among all combination treatments. Both types of inoculations produced the greatest pod numbers when plants treated with 200 kg/ha diammonium phosphate (table 5). Therefore, the use of 200 kg/ha diammonium phosphate along with seed inoculation by Biosoy or Biosoy+barvar-2 could produce as pod numbers as combined application of urea and diammonium phosphate in non-inoculated plants. That was because Biosoy produced more nodules compared with non-inoculated plants. Increas in the number of pods per plant in inoculated plants by Sankar *et al*. (2015) and Sultana *et al.* (2014) have also been reported. Jaga and Sharma (2015) reported that 75% of chemical fertilizers along with inoculation by phosphate solubilizing and Rhizobium bacteria produced the greatest pods.

**Table 3. Mean comparisons for some growth parameters at different level of chemical and biological fertilizers**

| Factor A | Factor B | Nodule dry weight (gr/plant) | plant height (cm) | Stem dry weigh (gr/plant) | Pod dry weight (gr/plant) | Biological yield (gr/plant) |
|---|---|---|---|---|---|---|
| Non-inoculation | 0 | 0.43c | 60.00c | 2.16d | 4.13d | 6.2c |
| | 150 | 0.41c | 74.25bc | 3.27c | 5.13cd | 8.4b |
| | 200 | 0.46c | 79.44ab | 3.55c | 5.72cd | 9.27b |
| | 150+200 | 0.39c | 84.35ab | 4.00bc | 6.70bc | 10.7b |
| Inoculation with Biosoy | 0 | 0.71b | 81.76ab | 3.67c | 5.89cd | 9.56b |
| | 150 | 0.66b | 78.25abc | 3.55c | 5.74cd | 9.29b |
| | 200 | 0.92a | 96.45a | 4.65ab | 8.47ab | 13.13a |
| | 150+200 | 0.66b | 73.33bc | 3.38c | 5.25cd | 8.63b |
| Inoculation with Biosoy and Barcvar2 | 0 | 0.76b | 88.8ab | 3.53c | 6.30c | 9.83b |
| | 150 | 0.69b | 77.5bc | 3.51c | 6.34c | 9.85b |
| | 200 | 0.97a | 90.43ab | 4.92a | 9.78a | 14.71a |
| | 150+200 | 0.69b | 72.58bc | 3.45c | 5.88cd | 9.34b |

0, 150 and 200 are control and amount of urea and diammonium phosphate fertilizers/ ha, respectively. In all columns numbers with same letters have not significant differences from each other at 5% based on Duncan's test.

**Table 4. ANOVA for yield and yield components at different level of chemical and biological fertilizers**

| S.O.V | df | MS | | |
|---|---|---|---|---|
| | | Pod numbers/ plant | Grain numbers/ plant | Grain yield per $m^2$ |
| replication | 2 | 3.71$^{ns}$ | 33.8* | 2** |
| Bio-fertilizers (A) | 2 | 17.45** | 83.2** | 1.7** |
| Chemical fertilizers (B) | 3 | 30.99** | 368** | 3.27** |
| A× B | 6 | 13.94** | 105.5** | 1.01** |
| Error | 22 | 1.91 | 8 | 0.17 |
| C.V. (%) | | 9.53 | 9.07 | 11.8 |

$^{Ns}$, * and **: Non-significant, Significant at 0.05 and 0.01, respectively

***Grains per plant***

The number of seeds per plant was affected by biological and chemical fertilizers interaction (Table 4). In the case of non-inoculated plants, the use of urea produced the lowest while applying urea with diammonium phosphate produced the highest number of seeds per plant. There were no significant difference between inoculation with Biosoy and inoculation with Biosoy+Barvar-2 at all chemical fertilizer levels. Application of 200 kg/ha diammonium phosphate to the inoculated plants by Biosoy and Biosoy+Barvar-2 produced the highest number of seeds even higher than the combined application of nitrogen and phosphorus fertilizers in the non-inoculated plants (Table 5). Sultana *et al*. (2014) stated that the number of seeds per plant increased by inoculation with Rhizobium. Also, Jaga & Sharma, (2015) showed that combined use of phosphate solubilizing and Rhizobium bacteria produced the highest number of seeds when plants have been received 75% nitrogen and phosphorus fertilizers.

**Table 5. Mean comparisons for yield and yield components at different level of chemical and biological fertilizers**

| Factor A | Factor B | Grain yield (kg/ $ha^{-1}$) | Grain numbers / plant | Pod numbers/ plant |
|---|---|---|---|---|
| Non-inoculation | 0 | 118d | 19.7d | 9.90e |
| | 150 | 146cd | 27.6c | 11.85ed |
| | 200 | 159cd | 30.3bc | 14.8bcd |
| | 150+200 | 195bc | 35.6b | 16.45ab |
| Inoculation with Biosoy | 0 | 168cd | 29.1bc | 14.22bcd |
| | 150 | 158cd | 27.3c | 13.31bcd |
| | 200 | 242ab | 44.6a | 18.22a |
| | 150+200 | 159cd | 27.8c | 12.53cde |

| Factor A | Factor B | Grain yield (kg/ ha$^{-1}$) | Grain numbers / plant | Pod numbers/ plant |
|---|---|---|---|---|
| Inoculation with Biosoy and Barcvar2 | 0 | 175c | 30.1bc | 16.00abc |
| | 150 | 161cd | 28.6bc | 14.30bcd |
| | 200 | 254a | 46.7a | 18.53a |
| | 150+200 | 178c | 27.9c | 13.76bcd |

0, 150 and 200 are control and amount of urea and diammonium phosphate fertilizers/ha, respectively. In all columns numbers with same letters have not significant differences from each other at 5% based on Duncan's test.

**Grain yield:**

Interaction of chemical × biological fertilizers has affected grain yield (Table 4). Grain yield production from the different treatments; non-application of chemical fertilizer, 150 kg/ha urea, 200 kg/ha diammonium phosphate and 150 kg/ha urea+ 200 kg/ha diammonium phosphate; were

1180, 1460, 1590 and 1950 kg/ha of grain, respectively. Non- inoculation × 150 kg/ha urea was the lowest yield among all treatment combinations. Inoculated plants with Biosoy and/or Biosoy+Barvar-2 along with applying 200 kg/ha diammonium phosphate produced the highest grain yield which was more than the yield of non-inoculated plants received 150 kg/ha urea + 200 kg/ha diammonium phosphate. Application of 200 kg/ha diammonium phosphate containing 92 kg p2o5 equivalent and 36 kg N increase nodules biomass in inoculated plants with Biosoy and/or Biosoy+Barvar-2 which made inoculated plants produced higher yield (Table 5). The combined application of chemical fertilizers along with phosphate solubilizing and rhizobium bacteria produced the highest grain yield (Jaga & Sharma, 2015). Phosphorus fertilizer increases fixed nitrogen and grain yield in plants inoculated with Rhizobium (Ayub *et al*, 2013) because nitrogen fixation needs a lot of phosphorus.

**Conclusion:**

Soybean inoculation with N-fixing bacteria, Biosoy and/or Biosoy+Barvar-2, along with the application of 200 kg/ha diammonium phosphate improved soybean performance such as grain yield compare to seed inoculation along with the application of 150 kg/ha urea+200 kg/ha diammonium phosphate which is used in conventional cropping system in Moghan. Therefore, change in conventional cropping system not only improves the yield and returns to the farmers but also eliminates the use of urea chemical fertilizer.

## REFERENCES

Ahemad, M. and Kibret, M. 2014. Mechanisms and applications of plant growth promoting rhizobacteria: Current perspective. ***J. King Saud. Univ* – Sci**. 26: 1–20.

Ayub, M., Ali, S.A., Tahir, M., Tahir, S., Tanveer, A. and Siddiqui, M.H. 2013. Evaluating the role of phosphorus solubilizing bacterial inoculation and phosphorus application on forage yield and quality of cluster bean (*Cyamopsis tetragonoloba* L.). ***Int. J. Mod. Agric***. 2: 26-33.

Begum, M.A., Islam, M.A., Ahmed, Q.M., Islam, M.A. and Rahman, M.M. 2015. Effect of nitrogen and phosphorus on the growth And yield performance of soybean. ***Res. Agric. Livest. Fish***. 2(1): 35-42.

Dastmalchi, M. and Dhaubhadel, S. 2015. Proteomic insights into synthesis of isoflavonoids in soybean seeds. ***Proteomics***. 15(10): 1646–1657.

Diass, N., Lobo, M.G., Socorro, A.R., Bruckner, U., Heller, J. and Gonzalez, M. 2008. The effect of three organic pre-harvest treatments on Swiss chard (*Beta vulgaris* L. var. *cycla* L.) quality. ***Eur. Food Res. Technol***. 226: 345-353.

Elkoca, E., Kantar, F. and Sahin, F. 2008. Influence of nitrogen fixing and phosphorus solubilizing bacteria on the nodulation, plant growth, and yield of chickpea. ***J. Plant Nutr***. 31: 157–171.

El-Shaarawi, A.I., Sabh, A.Z., Abou-Taleb, S.M. and Ghoniem, A.E. 2011. Effect of inorganic nitrogen and *Bradyrhizobium japonicum* inoculation on growth and yield of soybean. ***Aust. J. Basic Appl. Sci***. 5(10): 436-447.

Fankem, H., Tchakounte, G.V.T., Nkot, L.N., Mafokoua, H.L., Dondjou, D.T., Simo, C., Nwaga, D. and Etoa, F.X. 2015. Common bean (*Phaseolus vulgaris* L.) and soya bean (*Glycine max*) growth and nodulation as influenced by rock phosphate solubilising bacteria under pot grown conditions. ***Int. J. Agric. Policy Res***. 3(5): 242-250.

Food and Agriculture Organization of the United Nations. 2013. FAOSTAT-Crops. Rome, Italy.

Gajera, R.J., Khafi, H.R., Raj, A.D., Yadav, V. and Lad, A.N. 2014. Effect of phosphorus and bio-fertilizers on growth yield and economics of summer green gram [*Vigna radiata* (L.) Wilczek]. ***Agric. Update***. 9(1): 98-102.

Hungria, M., Francini, J.C., Crispino, C.C., Moraes, J.Z., Sibaldelli, R.N.R. and Arihara, J. 2006. Nitrogen nutrition of soybean in Brazil: Contributions of biological N2 fixation and N fertilizer to grain yield. ***Can. J. Plant Sci***. 86(4): 927-939.

Jaga, P.K. and Sharma, S. 2015. Effect of bio-fertilizer and fertilizers on productivity of soybean. ***Ann. plant soil* Res**. 17(2): 171-174.

Jha, B.K., Pragash, M.G., Cletus, J., Raman, G. and Sakthivel, N. 2009. Simultaneous phosphate solubilization potential and antifungal activity of new *Fluorescent pseudomonad* strains, *Pseudomonas aeruginosa*, *P. plecoglossicida* and *P. mosselii*. ***World J. Microbiol. Biotechnol***. 25: 573–581.

Kala, T.C., Christi, R.M. and Bai, N.R. 2011. Effect of *Rhizobium* inoculation on growth and yield of horsegram (Dolichos biflorus L.). ***Plant Arch***. 11(1): 97-99.

McKevith, B. 2005. Nutritional aspects of oilseeds. ***Nutr. Bull***. 30: 13-26.

Minaxi, L.N., Yadav, R.C. and Saxena, J. 2011. Characterization of multifaceted *Bacillus* sp. RM-2 for its use as plant growth promoting bioinoculant for crops grown in semi-arid deserts. ***Appl. Soil Ecol***. 59: 124–135.

Mohamed, A.A. and Hassan, M.A. 2015. Evaluation of two chickpea (*Cicer arietinum* l.) cultivars in response to three *Rhizobium* strains at River Nile State, Sudan. ***Merit Res. J. Agric. Sci. Soil Sci***. 3(5): 062-069.

Rao, D.L.N. 2014. Recent advances in biological nitrogen fixation in agricultural systems. ***Proc. Indian Natn. Sci. Acad***. 80(2): 359-378.

Salih, S.H., Hamd, S.A.M. and Dagash, Y.M.I. 2015. The Effects of *Rhizobium*, mycorrhizal inoculations and diammonium phosphate (DAP) on nodulation, growth, and yield of soybean. ***Universal J. Agric. Res***. 3(1): 11-14.

Sankar, A.M., Prabakaran, G., Murali, M. and Anandakumar, D. 2015. Growth, nodulation and yield response to biofertilizers and organic manures of *phaseolus mungo*.(l). ***Int. J. Adv. Interdiscipl. Res***. 2(2) 22-28

Shen, J.B., Yuan, L.X., Zhang, J.L., Li, H.G., Bai, Z.H., Chen, X.P., Zhang, W.F. and Zhang, F.S. 2011. Phosphorus dynamics: from soil to plant. ***Plant Physiol***. 156:997–1005.

Singh, U. and Singh, B. 1992. Tropical grain legumes as important human foods. ***Econ. Bot***. 46: 310-321.

Soe, K.M., Bhromsiri, A. and Karladee, D. 2010: Effects of selected endophytic actinomycetes (*Streptomyces* sp.) and bradyrhizobia from Myanmar on growth, nodulation, nitrogen fixation and yield of different soybean varieties. ***CMU. J. Nat. Sci***. 9: 95–109.

Sultana, M.M., Haque, M.A., Reza, M.S.A. and Chowdhury, M.M.H. 2014. Performance of rhizobia and nitrogen on nodulation yield and N uptake by soybean in salin soil. ***J. Environ. Scie. Nat. Resour***. 7(1): 215-226.

Zafar, M., Abbasi, M.K., Rahim, N., Khaliq, A., Shaheen, A., Jamil, M. and Shahid, M. 2011. Influence of integrated phosphorus supply and plant growth promoting rhizobacteria on growth, nodulation, yield and nutrient uptake in *Phaseolus vulgaris*. ***Afr. J. Biotechnol***. 10: 16793-16807.

Zuffo, A.M., Rezende, P.M., Bruzi, A.T., Oliveira, N.T., Soares, I.O., Neto, G.F.G., Cardillo, B.E.S. and Silva. L.O. 2015. Co-inoculation of *Bradyrhizobium japonicum* and *Azospirillum brasilense* in the soybean crop. ***Revista de Ciências Agrárias***. 38(1): 87-93.

# تحسين انتاج فول الصويا باستخدام البكتيريا المثبتة للنيتروجين مع سماد ثنائي فوسفات الأمونيوم

**مانوشهي جانا جارد*، مرتضى كامراني*، ياسر حُسيني**

## ملخص

للتحقق من اثر استخدام السماديين الحيويين البيوسوي والبارفار–2 عند خلطهما مع الاسمدة النايتروجينية والفسفورية على انتاجية وخصائص انتاج فول الصويا، فان تجربة عاملية باستخدام تصميم القطاعات الكاملة العشوائية مع ثلاث مكررات قد تم اجراؤها في مزرعة ابحاث واقعة في كلية موهان للزراعة والموارد الطبيعية في عام 2014. تضمن العامل الاول ثلاثة مستويات من السماد الحيوي (المرجع، وتلقيح واحد من البيوسوي، وتلقيح مزدوج من السماديين الحيويين البيوسوي والبارفار–2) واما العامل الثاني فشمل أربعة مستويات من الأسمدة (150 كجم/هكتار يوريا، و 200 كجم/هكتار ثنائي فوسفات الأمونيوم، 150 كجم/ هكتار يوريا + 200 كجم/هكتار ثنائي فوسفات الأمونيوم، والمرجع). وقد أظهرت النتائج أن أعلى وزن جاف للجراب والساق، وعدد الحبوب، وعدد الجراب، ومحصول الحبوب والمحصول البيولوجي كانت عندما استخدمت البذور الملقحة مع البيوسوي و/ أو البيوسوي والبارفار–2 مع 200 كجم/هكتار من ثنائي فوسفات الأمونيوم. ولم تكن هناك اي فروق ذات دلالة إحصائية بين التلقيح ب البيوسوي والتلقيح المزدوج ب البيوسوي والبارفار–2 مع جميع مستويات الأسمدة. ان اضافة 150 كجم/هكتار يوريا + 200 كجم/هكتار ثنائي فوسفات الأمونيوم ادى الى انخفاض أداء فول الصويا عند التلقيح لمرة واحدة او التلقيح مرتين. أنتجت كلا النوعين من التلقيح أعلى كتلة جافة من عقيدات البذور غير الملقحة مع جميع مستويات الأسمدة. لذلك، فان تلقيح بذور فول الصويا ب البيوسوي و/ أو البيوسوي والبارفار–2 مع اضافة فوسفات 200 كجم/هكتار ثنائي الأمونيوم يعطي أعلى إنتاج من الحبوب ويقلل استخدام سماد اليوريا.

**الكلمات الدالة:** ثنائي فوسفات الامونيوم، سماد اليوريا.

*جامعة موهاغيغ اردابيلي، ايران.

تاريخ استلام البحث 2016/5/9 وتاريخ قبوله 2016/12/4.