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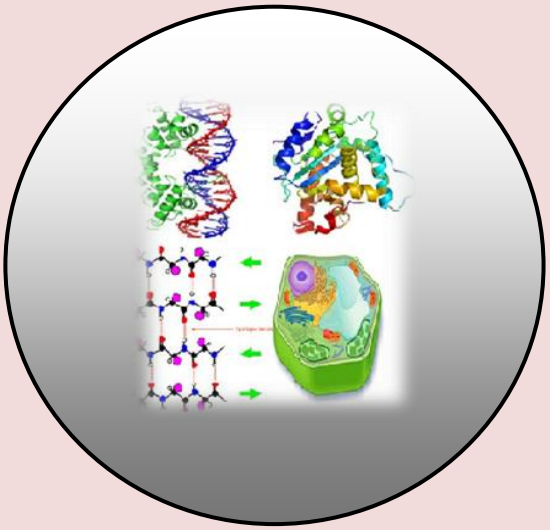

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RESEARCH PAPER

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Improvement of Plant Growth, Nodulation and Yield of Common Bean (*Phaseolus vulgaris* L.) by Microbiological Preparations

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ABSTRACT

Field experiments were conducted to study the effect of microbiological preparations (rhizobium 3, rhizobium 9 and Planta Stim) on plant growth, nodulation and yield of common bean (Phaseolus vulgaris L.). The experiment were carried out in randomized block design with three replications a field experiments of Institute of Genetics and Plant Experimental Biology, Kibray district, Tashkent region, Uzbekistan. Experimental treatments included of uninoculation control, inoculation with rhizobium 3, rhizobium 9 and Planta Stim. Plant growth parameters such as plant height, root length, dry biomass, nodulation and yield components (number of pods plant^{-1}, pods length, weight of pods plant^{-1}, number of grains plant^{-1}, number of grains pod^{-1}, weight of grains plant^{-1} and 1000 grains weight) were measured. The results showed that PlantaStim inoculation increased the number of pods plant^{1} by 23%, number of grains plant^{1} by 8% and weight of grains plant^{-1} by 16 % compared to control. Rhizobium 3 inoculation rose the height of plant by 24%, length of root by 45%, dry weight of root by 31%, number of pods plant^{1} by 34%, number of grains plant^{1} by 48% and weight of grains plant^{-1} by 80%. Inoculation with Rhizobium 9 significantly increased the number of nodules, number of grains plant^{-1}, number of grains pod^{-1}, weight of grains plant^{-1} and 1000 grains weight of bean compared other treatments. It is concluded that a significant positive effect of inoculation with rhizobium 9 on growth, nodulation and yield of common bean plants compared to control and Planta Stim.

Key words: Common bean, Microbiological Preparations, Inoculation, Plant Growth, Nodulation and Yield.

INTRODUCTION

Legumes plants such as common bean, soybean, chickpea, mungbean and lentil are the most important crops in agriculture. Rhizobia-legumes symbiosis play an important role in increasing of crop yields, reducing use of chemical nitrogen fertilizers, increasing soil fertility, decreasing the production cost and reduction of environmental pollution (Herridge et al., 2008).

Rhizobial inoculants improved plant growth, development, nodulation and yield of various leguminous species including bean (Carter et al., 1994; Daba and Haile, 2000), soybean (Zhang et al., 2003; Egamberdiyeva et al., 2004; Dhami and Prasad, 2009; Masciarelli et al., 2014; Jabborova and Davranov, 2015; Mukhtar, 2015; Egamberdieva et al., 2018), chickpea (Sattar et al., 1995; Ben Romdhane et al., 2007) mungbean (Kashem et al., 2000; Hafeez et al., 2001; Sharma, 2001; Anjum et al., 2006; Raza et al., 2004; Jabborova et al., 2018) and

lentil (Namdeo et al., 1996; Sharma and Khurana 1997).

Field conditions showed that inoculation with rhizobia could be a good alternative to nitrogen fertilizers in legume crops (Argaw, 2012; Haque, et al., 2014). Several studies have shown that rhizobial inoculants increased in nodulation, biological nitrogen fixation and nitrogenize activity of nodulated legumes (Daramola et al., 1994; Sattar et al., 1995; Hafeez et al., 2001; Mukhtar, 2015). Zhang et al. (2003) reported that increased nodule number, nodule weight, shoot nitrogen yield, final nitrogen fixed and root system of soybean when inoculated with *B. japonicum* strains. Jabborova et al. (2018) demonstrated that inoculation with Rhizobium significantly increased yield and yield components of mungbean. Daramola et al. (1994) reported that inoculation with *Bradyrhizobium japonicum* strains could increase nodulation, nitrogen fixation and dry matter yield of soybean.

Common bean (*Phaseolus vulgaris* L.) is one of the most important legume for human nutrition and a major protein. Common bean contain about 65% of total protein, 32% of energy and micronutrients such as iron, zinc, thiamin and folic acid (Broughton et al., 2003). Common bean in symbiosis with effective rhizobium can fix nitrogen on agricultural conditions.

The present work was conducted to evaluate microbiological preparations improve plant growth, nodulation and yield of bean in field conditions.

MATERIAL AND METHODS

Plant and microbial preparations

Common bean (*Phaseolus vulgaris* L.) seed was used for field experiments. *Rhizobium* 3 and *Rhizobium* 9 preparations were obtained from the culture collection of the Department of Microbiology and Biotechnology, National University of Uzbekistan. Planta Stim (trichodermin) was obtained from private company of AnGuzal Agroservis, Uzbekistan.

Determination of soil properties

Soil samples were collected from a research field of Institute of Genetics and Plant Experimental Biology, Kibray district, Tashkent province. In order to determination the soil properties before performing experiment, soil samples took from 0-10, 0-20 and 0-30 cm depth of soil. The total nitrogen content was determined by Kjeldahl method. The phosphorus content by Machigin, the potassium content by Machigin-Protasov and organic matter by Tyurin methods were analyzed.

Field experiments

A field experiment was conducted to study effect of *Rhizobium* 3, *Rhizobium* 9 and Planta Stim on plant growth, nodulation and yield of common bean (*Phaseolus vulgaris* L.). The experiment were carried out in randomized block design with three replications a field experiments at the Institute of Genetics and Plant Experimental Biology, Kibray, Tashkent region, Uzbekistan. Experimental treatments included of uninoculation control, inoculation with *Rhizobium* 3, *Rhizobium* 9 and Planta Stim. Seeds were sown on 13 and 14 April for the year of 2018. A plot size of 10 m^2 with row spacing 30 cm and plant spacing of 10 cm were used. Harvesting was performed on 19 and 20 July 2018. After 95 and 96 days plant height, length of roots and pods, dry weight of roots, dry weight of stems, dry weight of pods, dry weight of grains, number of pods and grains per plant, number of grains per pod, 1000 grains weight were determined.

Experimental data were analyzed with the Stat View Software using ANOVA.

RESULTS AND DISCUSSION

Analysis of soil properties is shown in Table 1. At 10-15 cm depth of soil samples showed better results compared to 11-20 cm and 21-30 cm The soil of the field experimental area is shown a total of 0.076% nitrogen, 30.5 mg/kg phosphorus, 227 mg/kg potassium and 1.34% organic matter in 10-15 cm depth of soil. The lowest nitrogen, phosphorus, and potassium an organic matter was shown in 21-30 cm depth of soil.

Table 1. Soil properties of field experiments.

Soil properties	Total nitrogen (N), %	Phosphorus (P_2O_5), mg/kg	Potassium (K_2O), mg/kg	Organic matter, %
0-10 см	0.076	30.5	227	1.34
11-20 см	0.062	26.6	208.41	0.847
21-30 см	0.056	15.9	190.4	0.52

The results showed that effect of inoculation of common bean seed with *Rhizobium* 3, *Rhizobium* 9 and Planta Stim preparations on plant growth, nodulation and yield were conducted in field conditions. The results showed that Planta Stim inoculation increased height of plant by 7 %, length of root by 4%, dry weight of root by 11 % and dry weight of shoot by 8 % compared to control. The *rhizobium* 3 and *rhizobium* 9 showed better results compared to control and Planta Stim. *Rhizobium* 3 inoculation significantly increased the height of plant by 24%, length of root by 45 %, dry weight of root by 31 % and dry weight of shoot by 37% compared to control. Data regarding root length and dry weight of root showed that *Rhizobium* 9 inoculation increased root length by 62 % and dry weight of root by 34 % compared to control (Table 2).

Rhizobium biological fixes atmospheric N_2 by legumes-Rhizobium symbiosis, enriches nitrogen status of soil and improvement of growth, development, nodulation and yield of legumes. Inoculation with *Rhizobium* strains indicated increase in the height of plant, length of root, dry weight of root and dry weight of shoot of bean compared to control. There are several studies which showed that seed inoculation with *Rhizobium* bacteria increase the height of plant, length of root, dry weight of root and dry weight of shoot of legumes plants (Bremer et al., 1990; Carter et al., 1994; Sattar et al., 1995; Thakur and Panwar, 1995; Sharma, 2001; Jabborova et al., 2014; Jabborova, 2015; Jabborova and Davranov, 2015; Mukhtar, 2015; Egamberdieva et al., 2014, 2016, 2017, 2018; Jabborova et al., 2018). Raza et al. (2004) reported that inoculation with *Rhizobium* increase in plant height by 12 %, root length by 29 % and dry weight by 11% of mung bean over control. Haque et al. (2014) reported that the *Rhizobium* strain BINA L4 inoculated gave highest plants height of lentil (18.03 cm) and percent increases over control at 60 days of sowing. Similar results were obtained by Mukhtar (2015) in soybean.

Table 2. Effect of *microbiological* peparations on plant height, root length and plant weight of common bean (*Phaseolus vulgaris* L.).

Treatments	Plant height (cm)	Root length (cm)	Shoot dry weight (g)	Root dry weight (g)
Control	32.20±2.43	13.80±1.44	3.92±0.60	0.35±0.01
PlantaStim	34.60±1.80	14.40±0.71	4.26±0.12	0.39±0.01*
Rhizobium 3	40.20±1.14*	20.00±1.64*	5.39±0.74*	0.46±0.03*
Rhizobium 9	37.40±1.18*	22.40±0.78*	4.90±0.34*	0.47±0.01*

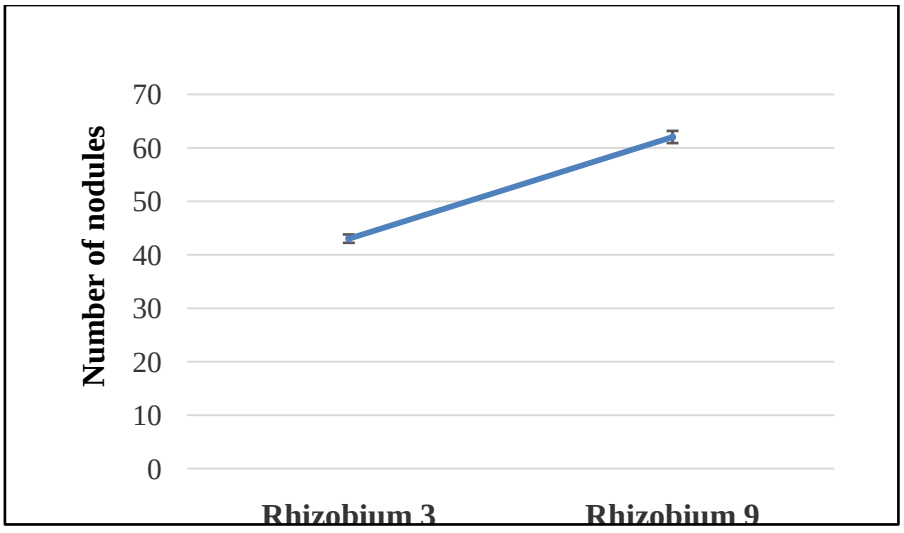

Figure 1. Effect of rhizobial inoculation on number of nodules of common bean.

Number of nodules of bean increased in both the *Rhizobium* 3 and Rhizobium 9 inoculation. Rhizobium 9 had a positive significant effect on the number of nodules per plant that the maximum the number of nodules per plant was obtained from inoculation with Rhizobium 9 treatment by 62 nodules that the number of nodules per plant increased by 44% as compared with Rhizobium 3 treatment (Figure).

The rhizobial inoculation with its considerable positive effects showed increases the number of nodules per plant. Similar findings were reported for bean (Carter et al., 1994; Daba and Haile, 2000), soybean (Daramola et al., 1994; Dhami and Prasad, 2009; Jabborova and Davranov 2015; Mukhtar, 2015; Egamberdieva et al., 2018), munbean (Hafeez et al., 2001; Raza et al., 2004; Jabborova et al., 2018), chickpea (Ben Romdhane et al., 2007; Egamberdieva et al., 2014), lentil (Namdeo et al., 1996). According to the results of some authors, B. *japonicum* USDA 30 and 31 improved soybean nodulation and increased nitrogen fixation (Zhang et al., 2003). Masciarelli et al. (2014) reported that inoculation of soybean plants with *B. japonicum* increased nodule number. Sattar et al. (1995) reported on chickpea when inoculated with *Bradyrhizobium* strain increased the number of nodules of chickpea.

Number of pods, number of grains and weight of grains per plant of common bean, inoculation with Planta Stim treatment showed increased number of pods by 23%, number of grains by 8% and weight of grains by 16 % compared to control (Table 3). The results showed that *Rhizobium* 3 and *Rhizobium* 9 had a positive significant effect on the number of pods per plant that the maximum the number of pods per plant was obtained from inoculation with Rhizobium 3 treatment by 12.40 pods that the number of pods per plant increased by 34% as compared with control treatment (Table 3). *Rhizobium* 3 inoculation significantly increased the weight of pods per plant by 54%, number of grains plant^{1} by 48% and weight of grains plant^{-1} by 80% compared to control. Inoculation with *Rhizobium* 9 significantly increased the weight of pods per plant and the weight of grains per plant compared other treatments. The maximum the weight of pods and ^{the} weight of grains per plant was obtained from inoculation with *Rhizobium* 9 treatment of by 19.17 pods weight and by 16.71 grains weight that the weight of pods and the weight of grains per plant by 54 %- 90 % compared to control treatment. Data in Table 3 shown that PlantaStim inoculation increased 1000 grains weight by 8%, compared to control. Maximum increase in weight of 1000 grains was recorded when *Rhizobium* 3 and *Rhizobium* were inoculated. Inoculation with *Rhizobium* 3 significantly increased 1000 grains weight by 20% compared to uninoculated control but inoculation with *Rhizobium* 9 caused 24 and 14% increase over control and Planta Stim treatments.

Our field experiments demonstrated that common bean was clearly improved when inoculation with *Rhizobium* 3 and *Rhizobium* 9 treatments (Table 3). *Rhizobium* 3 and *Rhizobium* 9 preparations used in this study have improved yield compounds of common bean in field conditions. *Rhizobium* sp. improved the number of pods, the number of grains, the weight of pods, the weight of grains, 100 and 1000 grains weight of several legumes such as, beans (Carter et al., 1994), soybean (Egamberdiyeva et al., 2004; Dhami and Prasad, 2009; Egamberdieva et al., 2013; Masciarelli et al., 2014; Mukhtar, 2015), chickpea (Sattar et al., 1995) mungbean (Thakur and Panwar, 1995; Kashem et al., 2000; Sharma, 2001; Raza et al., 2004; Jabborova et al., 2018), lentil (Namdeo et al., 1996; Sharma and Khurana, 1997). Egamberdieva et al. (2014) reported that *Mezorhizobium ciceri* IC53 significantly increased pod numbers by 28% and yield by 23% of chickpea. Adreshna et al. (1993) reported that the *Rhizobium* inoculation increased the grain yield of mungbean in field conditions. Haque et al. (2014) observed that significant positive effect of *Rhizobium* inoculation on seed yield of lentil over non inoculation. Raza et al. (2004) suggested that *Rhizobium* inoculation increased grain weight per plant by 64% over uninoculated control. Similar results were observed by Anjum et al. (2006).

Table 3. Effect of *microbiological* peparations on components of yield of common bean (*Phaseolus vulgaris* L.).

Treatments	Pods plant^{-1}(no.)	Pod length (cm)	Pods weight plant^{-1}(g)	Grains plant^{-1}(no.)	Grains pod^{-1}(no.)	Grains weight plant^{-1}(g)	1000 grains weight (g)
Control	9.20±0.15	7.80±0.73	12.38±1.67	20.60±1.20	2.36±0.57	8.78±0.46	427±12.17
Planta Stim	11.40±1.33	8.02±0.56	14.71±1.28	22.20±1.87	1.98±0.37	10.25±1.15	462±14.56
Rhizobium 3	12.40±1.30	8.86±0.36*	19.12±2,03*	30.60±0.89*	2.48±0.26	15.86±2.66*	515±16.10
Rhizobium 9	12.00±0.88*	8.84±0.37*	19.17±2.44*	32.00±1.64*	2.68±0.20	16.71±2.38*	528±18.20*

CONCLUSION

This study showed that inoculation with *Rhizobium* 9 resulted in higher number of nodules, number of grains per pod, number of grains per plant, weight of grains and weight of 1000 grains of common bean. *Rhizobium* 9 preparations could be recommended as beneficial microbiological fertilizer for common bean in field conditions.

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