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EFFECTS OF *Rhizobium phaseoli* STRAINS AND MOLYBDENUM FOLIAR APPLICATION ON GROWTH AND YIELD OF COMMON BEAN (*Phaseolus vulgaris* L.)

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EFFECTS OF *Rhizobium phaseoli* STRAINS AND MOLYBDENUM FOLIAR APPLICATION ON GROWTH AND YIELD OF COMMON BEAN (*Phaseolus vulgaris* L.)

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ABSTRACT

Talebipour N, Aminpanah H, Rabiee M (2015) Effects of *Rhizobium phaseoli* strains and molybdenum foliar application on growth and yield of common bean (*Phaseolus vulgaris* L.). *J. Soil Nature* 8(1), 1-8.

A field experiment was conducted at Rice Research Station of Rasht, northern Iran, to evaluate the effect of molybdenum foliar application on common bean (*Phaseolus vulgaris* L.) growth and yield when inoculated with different *Rhizobium phaseoli* strains. A factorial combination of five strains of *Rhizobium phaseoli* [un-inoculated (control), seed inoculated with strain R122, R133, R136, and R147), and three foliar applications of molybdenum at the rates of [0 (control), 1.5 and 3 g L^{-1} of Sodium Molybdate Dihdrate] consisted the experimental treatments which were arranged in a randomized complete block design with three replicates. Analysis of variance indicated that the main effect of *Rhizobium phaseoli* strain was significant for plant height, pod yield, seed yield, 100-seed weight and biological yield, but not for pod number per plant, seed number per pod and harvest index. The main effect of molybdenum foliar application was significant only for pod yield, seed yield and pod number per plant. At the same time, the interaction between *Rhizobium phaseoli* strain and molybdenum foliar application was significant only for pod yield, seed yield, pod number per plant, and harvest index. Results indicated that *Rhizobium phaseoli* strain had different responses to molybdenum foliar application in regards to seed yield and pod yield. However, in most cases, molybdenum foliar application increased significantly pod and seed yields both in un-inoculated and seed inoculated plants with different *Rhizobium phaseoli* strains. Based on the result of this experiment, seed inoculation with *Rhizobium phaseoli* strains R147 or R136 and molybdenum foliar application at the rate of 1.5 g L^{-1} are recommended for obtaining the highest seed and pod yields in common bean.

***Key words**: Phaseolus vulgaris* L.*, foliar application,* N_2*-fixing bacteria, sodium molybdate dehydrate, symbiosis*

INTRODUCTION

Common bean (*Phaseolus vulgaris* L.) is the world's third most important pulse crop after soybean (*Glycine max* (L.) Merr.) and peanut (*Arachis hypogea* L.) (FAO 2013). Common bean cultivars show a great variation in growing period which enables farmers to cultivate them in a wide range of cropping systems and environments as diverse as the Americas, Africa, the Middle East, China and Europe. This annual legume is a significant contributor to agricultural sustainability through N_2-fixation and as a rotation crop allowing the diversification of agricultural production systems. World wide, bean is produced on 29.2 million ha, with an estimated of total production of 23,100 million tons in 2013 (FAO 2013). In Iran, bean is produced on 98000 ha, with an estimated of total production of 253,000 tons in 2013 (FAO 2013).

Nitrogen (N) is one of the most essential plant nutrients, becoming a limiting factor in agricultural ecosystems. In developing countries, increased use of N fertilizer to improve crop yield is limited by costs, availability, and potential negative environmental impact (Hinsinger 2001). The symbioses between *Rhizobium* and legumes are a cheaper and usually more effective agronomic practice for ensuring an adequate supply of N for legume based crop production than the application of fertilizer-N (Zahran 1999). The total annual terrestrial inputs of N from biological nitrogen fixation as given range from 139 to 175 million tones of N (Burns and Hardy, 1975). Leguminous crop plants are able to supply their N requirements not only through soil and fertilizer N uptake, but also by forming symbioses with a diverse group of nitrogen-fixing soil bacteria known as rhizobia. The legume–rhizobia association is highly specific, such that each rhizobial strain establishes a symbiosis with only a limited set of host plants and vice versa. The inclusion of the biological N-fixers in production systems significantly reduces the use of inorganic N fertilizer (Gan *et al.* 2009). Leguminous crops residues generally have lower C:N ratios and higher N contents than cereals, and during the mineralization of leguminous materials, up to 50% of the amount of N can be released within two months of incorporation into the soil (Fageria and Baligar, 2005). The amount of N_2 fixation depends on the legume species, population of bacterial symbionts, soil acidity, soil moisture, and soil nitrogen availability. In addition to N_2-fixation in legumes, some rhizobia species such as *rhizobium* and *bradyrhizobium* produce phytohormones (auxins, cytokinins, abscicic acids), lumichrome, rhiboflavin, lipochitooligosaccharides, and vitamins that promote plant growth and yield (Herridge *et al.* 1993; Keating *et al.* 1998; Hayat and Ali, 2004; Kloepper and Beauchamp, 1992; Dakora 2003; Matiru and Dakora, 2004). Other plant growth-promoting rhizobacteria PGPR traits of Rhizobia and Bradyrhizobia include solubilization of inorganic phosphorus and antagonism against plant pathogenic microorganisms (Abd-Alla 1994; Chabot *et al.* 1996). At the same time, some PGPR strains of *Rhizobium meliloti* have been reported to produce siderophores (Plessner *et al.* 1993; Arora *et al.* 2001) in iron stress conditions and thereby added an advantage to exclude the pathogen *Macrophomina phaseolina*, causing charcoal rot of groundnut. In guar (*Cyamopsis tetragonoloba* L. Taub), moth (*Vigna acontifolia*) and mung (*Vigna radiata*), seed inoculated plants produced greater yield (up to 10–25%) than control plants (Rao 2001).

Significant differences among rhizobial strains were observed under growth room, greenhouse, and field conditions for many legume crops (Bremer *et al.* 1990; Matos and Schroder, 1989; Ferreira and Marques, 1992; Somasegaran *et al.* 1988).

Molybdenum (Mo) is one of the essential micronutrients for legumes growth and development, which normally present at average levels up to 2.3 mg kg^{-1} soil (Reddy *et al.* 1997). The early steps of nodule formation and N_2 fixation in legume roots are known to be very sensitive to mineral nutrition such as P and Mo (Streeter 1988). The most important enzyme in symbiotic N_2 fixation by rhizobia baceria in legume roots is nitrogenase which exists in three forms, i.e. molybdenum nitrogenase, vanadium nitrogenase, and iron nitrogenase. Mo-containing nitrogenase is the most widely studied and is the enzyme utilized by *Rhizobium* (Russelle 2008). It has been reported that more Mo is required for legume plants that depend on biological N_2 fixation for their N supply compared to those receiving fertilizer N, because biological N_2 fixation is a very energy-consuming process, and needs more Mo for plant metabolism (Parker and Harris, 1977; Israel 1987). To guarantee the adequate rates of N_2 fixation, nodules act as strong sinks of Mo under limited supply of this nutrient (Brodrick and Giller, 1991; Olivera *et al.* 2004). Although molybdenum is a low mobile element in the plant and this may limit N_2-fixation by restricting the supply of it to the nodules of legumes, Williams *et al.* (2004) showed that foliar-applied molybdate was rapidly distributed throughout the plant, including translocation towards the stem and roots within 24 h. In this regards, Brodrick and Giller (1991) reported that foliar application of Mo increased significantly common bean (*Phaseolus vulgaris* L.) growth under field condition. They found that Mo contents of the nodules and shoots increased by 81% and 56%, respectively after molybdenum foliar application and concluded that when molybdenum is scarce in the plant it is mobile and is translocated from roots and shoots to the nodules. Therefore, Mo fertilization through foliar application can effectively increase Mo content in nodules of legume and improve the activity of nitrogenase enzyme.

There are insufficient data about the molybdenum foliar application on common bean plants growth and yield, especially when it inoculated with the different *Rhizobium phaseoli* strains. Therefore, the aim of this experiment was to assess the effect of molybdenum foliar application on common bean growth and yield when inoculated with different *Rhizobium phaseoli* strains.

MATERIALS AND METHODS

Experimental site and design, and crop management

Field experiment was conducted at Rice Research Institute, Rasht (36^o 54' N, 40^o 50' E), Iran, in 2013. Weekly precipitation and temperature during growing period of common bean were presented in Figs. 1 and 2, respectively. Soil properties of the experimental field were 2.1% organic matter content, 34% clay, 45% silt, 21% sand, 0.121% total nitrogen content, 17.7 mg kg^{-1} phosphorus, 264 mg kg^{-1} exchangeable potassium and 7.1 pH. A factorial combination of five strains of *Rhizobium phaseoli* [un-inoculated (control), seed inoculated with strain R122, R133, R136, and R147), and three foliar applications of molybdenum at the rates of [0 (control), 1.5 and 3 g L^{-1} of Sodium Molybdate Dihdrate] consisted the experimental treatments which were arranged in a randomized complete block design with three replicates. Just before final land preparation, each plot received 20 kg ha^{-1} N as urea, 50 kg P ha^{-1} as triple super phosphate. Common bean seeds (Guilan landrace) were inoculated with *Rhizobium phaseoli* strains before planting and dried in sunshade for five hours and were planted on 15 September at the density of 16.6 seeds m^{-2} in rows spaced 30 cm apart. Plot size was 1.8 m by 5 m. To provide the target plant population density, two seeds per hill were planted and plants were thinned to one per hill when the second leaf emerged. The plots were irrigated as necessary throughout the season to avoid water stress. Weeds were hand-weeded on 2 October. Mollusk pests were controlled with niclosamide (0.25 L ha^{-1}) on 3 October. In accordance with the treatments, foliar application of molybdenum was applied twice, i.e. on 30 October and 11 November, using a knapsack hand sprayer until runoff. Control plants were sprayed with tap water. Plants were harvested on 3 December 2013.

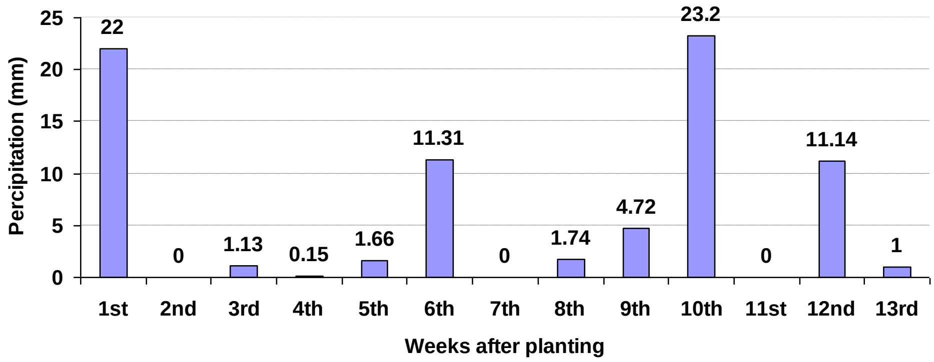

Fig. 1. Weekly precipitation during common bean growing period in experimental site

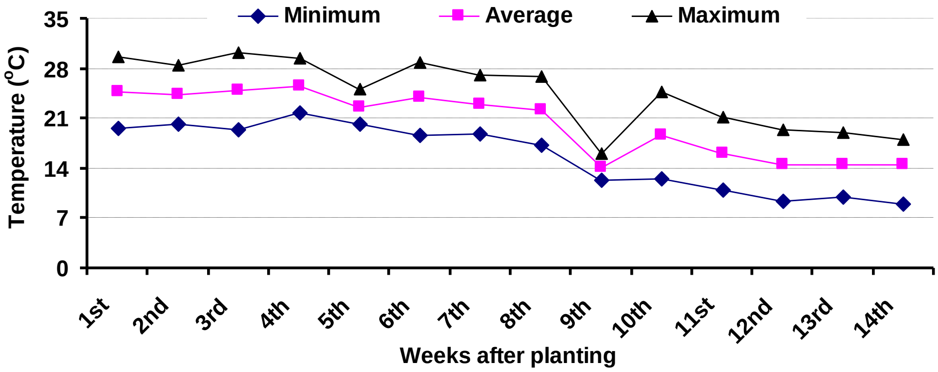

Fig. 2. Weekly temperatures (maximum, minimum and average) during common bean growing period in experimental site

Plant sampling

Plant height was measured from the ground level to the top of the main stem at harvest stage. Ten randomly selected plants were selected from each plot for measuring number of pod per plant, number of seeds per pod, and 100-seed weight. Above ground biomass from 1 m^2 of each plot was oven-dried at 70°C for 72 h, and weighted for biological yield determination. Green pod yield was harvested from the plants grown in half portion of each plot. The rest half of the crop of each plot was kept to allow the pods to get maturity. Then, the matured pods were harvested from the plants grown in the remaining half portion of each plot, hand threshed and weighed. Seed yield was adjusted to 160 g kg^{-1} seed moisture content. To remove border effects, all assessments were done only on four central rows of 4 m (leaving two border rows and 0.5 m on the lengths of each row of the plot).

Statistical analyses

Data were subjected to analysis of variance (ANOVA) using the general linear model (GLM) procedure of SAS (SAS 2004). The analysis was calculated as factorial treatment arranged in a randomized complete-block design. The data for the three doses of molybdenum foliar application were analyzed separately when a significant interaction occurred between factors. When interaction was not significant, main effects were presented. Means separations were conducted using fisher's protected LSD at the 5% probability level.

RESULTS AND DISCUSSION

Plant height

The ANOVA indicates that *Rhizobium phaseoli* strain (Rh) had a significant ($P \leq 0.05$) effect on plant height (Table 1). It was observed that inoculation of *Rhizobium phaseoli* strain R136 and R147 significantly enhanced the plant height by 11% and 9%, respectively, over the control. Application of the other strains, R122 and R133, resulted in plant height at par to that of the control (Table 2). This is similar to the findings of Khatkar *et al.* (2007) and Bhuiyan *et al.* (2008), who reported that seed inoculated plants with rhizobia was significantly taller than un-inoculated plants. Moreover, the main effect of molybdenum foliar application (Mo) and Rh × Mo interaction were not significant (Table 1). In contrast, Kumar and Sharma (2005) reported that plant height of chickpea (*Cicer arietinum* L.) was significantly higher in plants fertilized by molybdenum than control plants. Aghatise and Tayo (1994) reported that Mo application significantly increased plant height of soybean compared to control plants.

Pod yield

There was a significant Rh × Mo interaction ($P \leq 0.05$) for pod yield (Table 1), indicating that *Rhizobium phaseoli* strain had different responses to molybdenum foliar application in terms of pod yield. Foliar applications of 1.5 and 3 g L^{-1} Molybdenum produced 5% and 7% higher pod yield than the control, respectively. In un-inoculated plants, foliar application of Mo at the rate of 1.5 g L^{-1} provided the best benefit to increase the pod yield and increasing the concentration of Mo to 3 g L^{-1} significantly reduced the pod yield (Table 3). For seed inoculated plants with *Rhizobium phaseoli* strain R122, R136, and R147, foliar application of 1.5 and 3 g L^{-1} Mo increased significantly pod yield compared with the control treatment (Table 3). For seed inoculated plants with *Rhizobium phaseoli* strain R136, foliar application of Mo at the rate of 1.5 g L^{-1} gave the best benefit to increase the pod yield (Table 3). Gad (2012) declared that Mo foliar application increased total pod yield in groundnut about 28.8%. It has been reported that Mo is an essential elements for plants, especially for legumes, which increase significantly nodule number per plant and nitrogenase activity, which in turn increase nitrogen fixation and pod yield (Noor *et al.* 1997).

Seed yield

The main effects of *Rhizobium phaseoli* strain (Rh) and molybdenum foliar application (Mo) were significant ($P \leq 0.01$) for seed yield. Moreover, statistically significant Rh × Mo interaction ($P \leq 0.05$) was found for seed yield (Table 1). This indicates that the strains of *Rhizobium phaseoli* showed different responses to molybdenum foliar application in regards to seed yield. In un-inoculated plants, the greatest seed yields were recorded when Mo was sprayed at the rate of 1.5 g L^{-1} (Table 3) and increasing the concentration of Mo to 3 g L^{-1} significantly reduced the seed yield. For seed inoculated plants with *Rhizobium phaseoli* strain R122, the highest seed yield was recorded when Mo was sprayed at the rate of 1.5 g L^{-1} (Table 3). For seed inoculated plants with *Rhizobium phaseoli* strain R133 and R147, foliar application of Mo at the rate of 3 g L^{-1} produced the highest seed yield, with increases of 13% and 25%, respectively compared to control treatment. For seed inoculated plants with *Rhizobium phaseoli* strain R136, foliar application of 1.5 and 3 g L^{-1} molybdenum produced 10% and 25% higher seed yield than the control, respectively. Differences among strains of common bean rhizobia in their nitrogen-fixing performance were also reported by Mostasso *et al.* (2002). Bremer *et al.* (1990) reported that among different strains of *Rhizoblum leguminosarum*, the highest grain yield was observed with lentil inoculated with strain I-ICAR-SYR-Le20. Similarly, yield increases in mungbean following *Rhizobium* inoculation have been reported by Satter and Ahmed (1992). It has been demonstrated that rhizobia species can increase seed and pod yield of legume crops through N_2-fixation, phytohormones (auxin, cytokinin, abscicic acid) lumichrome, rhiboflavin, vitamins, and siderophores production (Arora *et al.* 2001; Dakora 2003; Hayat and Ali, 2004; Matiru and Dakora, 2004). At the same time, some rhizobia species increase P supply for plants through the solubilization of inorganic phosphorus and protect plants plant pathogenic microorganisms (Abd-Alla 1994; Chabot *et al*. 1996). Moreover, Singh *et al.* (2008) found that application of molybdenum significantly increased grain yield in black gram (*Vigna mungo* L.). At the same time, Mo application can play a vital role in N_2 fixation by *Rhizobium*, and it is responsible for the formation of nodule tissue (Sharma *et al*. 1988).

Pod number per plant

According to the Table 1, the main effect of molybdenum foliar application (Mo) and the interaction between Rh and Mo were significant for pod number per plant. Pod number per plant was significantly higher when plants were sprayed with molybdenum compared to untreated plants. For un-inoculated plants and seed inoculated plants with *Rhizobium phaseoli* strain R122, R133, and 147, foliar application of molybdenum at the rates of 1.5 and 3 g L^{-1} produced significantly higher pod number per plant than the control treatment. For seed inoculated plants with *Rhizobium phaseoli* strain R136, foliar application of molybdenum at the rate of 3 g L^{-1} produced the greatest pod number per plant. In groundnut, Gad (2012) observed that Mo-treated plants had significantly higher pod number per plants compared to control plants.

Seed number per pod

The ANOVA indicates that seed number per plant was significantly affected neither by *Rhizobium phaseoli* strain nor by molybdenum foliar application. Moreover, the interaction between Rh and Mo was not significant (Tables 1 & 2).

Hundred seed weight

The main effect of *Rhizobium phaseoli* strain (Rh) was significant for 100- seed weight (Table 1). Regardless of molybdenum foliar application, the highest 100-seed weight was recorded for plants raised from inoculated seed with *Rhizobium phaseoli* strain R133, while the lowest one was recorded for un-inoculated plants. Seed inoculation with there *Rhizobium phaseoli* strains, *viz*. R122, R133, and R136, significantly enhanced seed mass by 9%, 11%, and 16%, respectively than the control (un-inuculated) (Table 2). In contrast, plants raised from inoculated seed with *Rhizobium phaseoli* strain R147 resulted in 100-seed weight at par to that of the control. In contrast, the main effect of molybdenum foliar application (Mo) and Rh × Mo interaction effect were not significant (Table 1). This is contrary to the findings of Gad (2012), who reported that seed weight of groundnut was significantly higher in Mo-treated pants compared to control plants. This result could be attributed the positive effect of Mo on photosynthesis rate (Liu *et al.* 2005) during seed filling period and, therefore, increases in assimilate translocation to the seed.

Biological yield

Biological yield was significantly ($P \leq 0.01$) affected only by *Rhizobium phaseoli* strain (Table 1). As evident from the results (Table 2), seed inoculated plants with *Rhizobium phaseoli* strain R136 produced the greatest biological yield (3753 kg ha^{-1}), followed by those inoculated with *Rhizobium phaseoli* strain R147 (3688 kg ha^{-1}), and then by those inoculated with *Rhizobium phaseoli* strain R133 (3501 kg ha^{-1}); the lowest biomass was recorded for control (un-inoculated) treatment (3207 kg ha^{-1}) with a value statistically similar to those inoculated with *Rhizobium phaseoli* strain R122 (3433 kg ha^{-1}). These results are similar to those of Hatice *et al.* (2008), who reported that among the 21 strains of *Rhizobium leguminosarum* subsp. *ciceri*, 7 strains demonstrated a good performance on chickpea in terms of their high shoot dry matter yields. Similarly, for lentil, Bremer *et al.*

(1990) found that depending on site and growing conditions, strains 99A1 and I-ICAR-SYR-Le20 appeared to be superior to the other strains tested in terms of total dry matter production. Mahmud *et al.* (1997) and Solaiman (1999) reported that shoot dry weight was remarkably higher in inoculated lentil and mungbean plants, respectively, over control. ANOVA also indicated that Molybdenum foliar application had no significant effect on biological yield (Table 2). Contrary to this result, Brodrick and Giller (1991) reported that foliar application of Mo increased significantly common bean (*Phaseolus vulgaris* L.) growth under field condition. Moreover, Hristozkova *et al.* (2006) stated that molybdenum improved plant growth such as root and shoot biomass in pea (*Pisum sativum* L.) plants.

Harvest index

A significant Rh × Mo interaction effect ($P \leq 0.05$) was found for harvest index (Table 1), while the main effects of *Rhizobium phaseoli* strain (Rh) and molybdenum foliar application (Mo) were not significant. Without inoculation and for seed inoculated plants with *Rhizobium phaseoli* strain R147, the highest harvest indices were recorded for foliar Mo-treated plants. For seed inoculated plants with *Rhizobium phaseoli* strain R122 and R133, no significant differences in harvest index were observed between foliar Mo-treated and control plants. For seed inoculated plants with *Rhizobium phaseoli* strain R136, foliar application of molybdenum at the rate of 3 g L^{-1} produced the highest harvest index. In lentil, Bremer *et al.* (1990) reported that no significant differences in HI were found among different strains of *Rhizoblum leguminosarum.*

Table 1. Mean squares of ANOVA for plant height (H), pod yield (PY), seed yield (Y), pod number per plant (PN), seed number per pod (SN), 100-seed weight (SW), biological yield (BY), and harvest index (HI) as affected by strains of *Rhizobium phaseoli* and molybdenum foliar application

Source of variation	df	H	PY	SY	PN	SN	SW	BY	HI
R	2	14.0 ^{ns}	1229 ^{ns}	7268^{ns}	0.05^{ns}	0.19^{ns}	5.22^{ns}	122780^{ns}	7.6 ^{ns}
Strains of *Rhizobium phaseoli* (Rh)	4	14.5*	14898**	15631*	0.05^{ns}	0.18^{ns}	42.17**	422603**	23.5^{ns}
Molybdenum foliar application (Mo)	2	3.5 ^{ns}	37002**	48034**	0.64**	0.35^{ns}	4.01^{ns}	102695^{ns}	14.1^{ns}
Rh × Mo	8	7.2 ^{ns}	9250 *	16116 *	0.27**	0.17^{ns}	13.18^{ns}	163931^{ns}	8.8 *
Error	28	5.6	4013	6220	0.09	0.13	7.68	81778	9.9
CV (%)	-	7.5	4.2	7.2	9.3	10.4	7.0	8.1	10.1

*, ** indicate significance at 0.05 and 0.01probability level, respectively
ns: not significant

Table 2. Plant height (H), pod yield (PY), seed yield (Y), pod number per plant (PN), seed number per pod (SN), 100-seed weight (SW), biological yield (BY), and harvest index (HI) response to strains of *Rhizobium phaseoli* and molybdenum foliar application

Traits / **Factors**	H (cm)	PY (kg ha^{-1})	SY (kg ha^{-1})	PN $plant^{-1}$	SN pod^{-1}	SW (g)	BY (kg ha^{-1})	HI (%)
Strains of *Rhizobium phaseoli*								
Un-inoculated (Control)	29.7	1430	1047	10.4	3.3	36.2	3207	30.0
R122	30.7	1473	1050	10.5	3.3	39.5*	3433	30.7
R133	31.6	1472	1083	11.1	3.4	42.0*	3501*	34.0
R136	32.9*	1499*	1141*	11.0	3.6	40.1*	3753*	30.40
R147	32.3*	1541*	1119*	12.0*	3.6	38.1	3688*	30.5
LSD (0.05)	2.2	61	76	1.5	0.4	2.6	276	4.2
Molybdenum foliar application (g L^{-1})								
0 (control)	31.2	1414	1023	9.5	3.30	39.8	3427	30.1
1.5	31.3	1532*	1111*	11.6*	3.50	38.9	3590	31.2
3	30.9	1520*	1129*	12.2*	3.6*	38.8	3532	32.0
LSD (0.05)	2.1	47	58	1.1	0.27	2.0	213	2.3

* indicates significant difference over control

Table 3. *Rhizobium phaseoli* strain (Rh) × foliar application of molybdenum (Mo) interaction effect on pod yield (PY), seed yield (SY), pod number per plant (PN) and harvest index (HI)

Rh strains	Mo (g L^{-1})	PY (kg ha^{-1})	SY (kg ha^{-1})	PN No. $plant^{-1}$	HI (%)
	0.0	1356 ± 17	974 ± 29	9.1 ± 0.7	28.3 ± 0.2
control	1.5	1536 ± 31	1168 ± 62	11.0 ± 0.7	30.9 ± 1.2
	3.0	1398 ± 26	998 ± 35	11.3 ± 0.8	30.8 ± 3.3
	0.0	1376 ± 14	1020 ± 26	7.9 ± 0.8	30.7 ± 1.1
R122	1.5	1533 ± 68	1098 ± 26	11.7 ± 0.5	29.5 ± 0.2
	3.0	1510 ± 20	1033 ± 23	11.5 ± 0.3	31.9 ± 1.9
	0.0	1416 ± 26	1027 ± 26	9.4 ± 0.3	34.8 ± 2.3
R133	1.5	1526 ± 14	1058 ± 25	12.1 ± 1.1	34.9 ± 2.6
	3.0	1474 ± 72	1163 ± 103	11.8 ± 0.8	32.2 ± 1.8
	0.0	1438 ± 6	1021 ± 25	10.3 ± 1.5	28.0 ± 0.9
R136	1.5	1519 ± 36	1121 ± 28	10.7 ± 1.3	29.7 ± 0.5
	3.0	1540 ± 20	1281 ± 13	13.5 ± 1.2	33.4 ± 0.5
	0.0	1486 ± 14	1074 ± 16	10.5 ± 0.8	28.6 ± 1.5
R147	1.5	1546 ± 31	1111 ± 23	12.5 ± 0.2	31.1 ± 3.3
	3.0	1591 ± 50	1171 ± 95	13.1 ± 0.5	31.8 ± 1.5

CONCLUSION

This experiment illustrated that molybdenum foliar application increased significantly pod and seed yields both in un-inoculated and seed inoculated plants with different *Rhizobium phaseoli* strains. Based on the result of this experiment, seed inoculation with *Rhizobium phaseoli* strains R147 or R136 and molybdenum foliar application at the rate of 1.5 g L^{-1} are recommended for obtaining the highest seed and pod yields in common bean.

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