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YIELD AND NUTRITIONAL QUALITY OF SNAP BEAN IN TERMS OF BIOFERTILIZATION

[RENDIMIENTO Y CALIDAD NUTRICIONAL DEL FRIJOL EJOTERO EN FUNCIÓN DE LA BIOFERTILIZACIÓN]

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SUMMARY

Snap bean crop responds to nitrogen (N) supply, so in this study a combination of fertilizer and biofertilizer to increase snap bean biomass, yield and nutritional value was tested. The experiment was established in the State of Mexico, under a randomized complete block design with four replications. Treatments were: 0, 100 and 200 kg N ha^{-1}, biofertilizer (mixture of *Rhizobium etli* with *Glomus intraradices*), and the combination of N with biofertilizer. There were no differences in phenology ($P > 0.05$) as a result of fertilizers. Treatment with biofertilizer + 200 kg ha^{-1} N had the highest yield, number of snap beans and percentage of protein (2131 g m^{-2}, 486 snap beans m^{2} and 22 %, respectively), and the lowest values were obtained in the control group (983 g m^{-2}, 278 snap beans m^{-2} and 20.5 %, respectively). Biofertilizer + 200 kg ha^{-1} N resulted in the highest total biomass (649 g m^{-2}), and the control group in the lowest (150 g m^{-2}). The highest harvest index (46 %) was found with the application of biofertilizer + 100 kg ha^{-1} N.

Key words: *Glomus intraradices*; *Phaseolus vulgaris L.; Rhizobium etli.*

RESUMEN

El frijol ejotero es un cultivo que responde al suministro de nitrógeno (N), por lo que en este estudio se determinó la mejor combinación de fertilizante y biofertilizante para aumentar la biomasa, rendimiento y calidad nutricional del frijol ejotero. La siembra se realizó en el Estado de México, bajo un diseño experimental de bloques al azar, con cuatro repeticiones. Los tratamientos fueron: 0, 100 y 200 kg N ha^{-1}, biofertilizante (mezcla de *Rhizobium etli* + *Glomus intraradices*), y la combinación de N + biofertilizante. No hubo diferencias en la fenología ($P > 0.05$) por efecto del fertilizante. El biofertilizante + 200 kg N ha^{-1} produjo el mayor rendimiento, número de ejotes y porcentaje de proteína (2131 g m^{-2}, 486 ejotes m^{2} y 22 %, respectivamente), y el grupo control produjo los más bajos (983 g m^{-2}, 278 ejotes m^{2} y 20.5 %, respectivamente). En biomasa total, los valores más altos fueron para biofertilizante + 200 kg N ha^{-1} p (649 g m^{-2}), y los más bajos (150 g m^{-2}) para el control. El índice de cosecha más alto (46 %) se obtuvo con la aplicación de biofertilizante + 100 kg N ha^{-1}.

Palabras clave: *Glomus intraradices*; *Phaseolus vulgaris* L., *Rhizobium etli*.

INTRODUCTION

Snap bean (*Phaseolus vulgaris* L.) is a crop of world importance, and it is grown in China, India, Indonesia, Turkey, Italy, Thailand, Egypt, Spain, USA, Canada and Mexico (Adsule *et al.*, 2004). In Mexico, biomass production, yield and nutritional quality of snap bean pod are limited by the fertility of the soil where it is planted; thus, it is necessary to carry out agronomic practices such as application of fertilizer and biofertilizer to increase its biomass production, yield and nutritional quality.

Singh *et al.* (2003) mentioned that a low content of nitrogen (N) in the soil (45 kg ha^{-1}) affected growth rate and caused chlorosis in bean leaves. On the other hand, Phillips *et al.* (2002) found that application of 67 kg N ha^{-1} improved yield of fresh snap beans (6.3 ton ha^{-1}), whereas when N was not applied the yield was only 3.8 ton ha^{-1}. Castellanos *et al.* (1998), when adding 80 kg N ha^{-1}, obtained an increase in total bean biomass of 630 kg ha^{-1} with 4 kg N ha^{-1} in the straws. Pick and Mac Donald (1984) evaluated the N content in snap bean pod at 0, 40, 80 and 120 kg N ha^{-1}, and reported the highest N content (19.5 g m^{-2}) with 120 kg N ha^{-1}, and the lowest (15.7 g m^{-2}) in the control group (without N application). These results show that bean responds positively to N fertilization and this response depends on availability of N in the soil.

Furthermore, N is a fertilizer with high solubility and mobility in the soil (Pichardo *et al.*, 2007), as 50 % of the amount applied is used by the crop, and the rest is lost by lixiviation, or goes into the atmosphere in the form of nitrogen oxide (Grageda *et al.*, 2000). An alternative to reduce this loss would be to seek the combination of fertilizers with biofertilizers, such as *Rhizobium etli*, to meet N requirement of snap bean. Tirado *et al.* (1990) indicated that application of N in soybean stimulates the growth of vegetative parts, whereas fixation of atmospheric N increases root growth; thus, when combined, a greater increase in yield and nutritional quality of snap bean can be achieved. Singer *et al.* (2000) found that when *Rhizobium* + 90 kg N were applied, snap bean had greater plant height, number of leaves and branches, fresh weight and dry weight of the biomass. With the combination of *Rhizobium* + 23 kg N, Daba and Haile (2000) found that yield of the bean grain increased by 3 ton ha^{-1}. Irizar *et al.* (2003) observed that in "Flor de Mayo" bean, application of *Rhizobium etli* + *Glomus intraradices* resulted in the highest grain yield (830 kg ha^{-1}), whereas the lowest yield (650 kg ha^{-1}) was in the control group. Also, Grageda *et al.* (2002) found that the best fixation of N occurred at the start of the reproductive development (70 to 77 days after sowing) of grain bean.

The objective of this study was to determine the effect of applying N and biofertilizer (*Rhizobium etli* and *Glomus intraradices*) on the phenology, biomass and yield production of snap bean (*Phaseolus vulgaris* L.) "Hav-14".

MATERIALS AND METHODS

The study was carried out in San Pablo Ixayoc, in the State of Mexico, Mexico (Lat. 19° 33' North, Long. 98° 47' West, at 2600 m altitude), with C(W0)(w) climate, which is temperate sub-humid with summer rainfall, mean annual temperature of 14.7 °C and mean annual rainfall of 609 mm (García, 2005). The soil was clay-sandy loam, with pH 6.3, total N 0.04 %, phosphorus 10.8 mg kg^{-1}, potassium 0.26 cmol kg^{-1} and organic matter 0.6 %.

Treatments consisted on the application of 0, 100 and 200 kg ha^{-1} of mineral N using urea as the source, with and without biofertilizer (mixture of *Rhizobium etli* with *Glomus intraradices*), which generated six combinations of treatments. Nitrogen was applied twice: at sowing (50 %) and at first weeding (50 %). Biofertilizer inoculation was carried out as follows: 2 kg of seed were mixed with adherent (0.013 kg carboxymethyl cellulose, dissolved in 0.150 L water), and allowed to settle for 2 h; then, 0.038 kg RhizoFer (*Rhizobium etli*, 500 million g^{-1}) and 0.100 kg Micorriza Fer (*Glomus intraradices*, 3000 spores kg^{-1}) were applied, allowing to settle for 12 h in the shade; finally, the seeds were sown. The undetermined growth-habit cultivar "Hav-14" was sown in May 26, 2009, at a density of 6.25 plants m^{-2}.

The experimental design was complete randomized blocks, with four replications. Environmental parameters measured during the crop cycle were weekly rainfall (mm), and maximum and minimum weekly mean temperatures (°C). Accumulated heat units (UC, °C) (Snyder, 1985) were calculated along with crop evapotranspiration (ETc, mm) (Doorenbos and Pruitt, 1986). In addition, crop phenology was registered in vegetative stages (V-1 = Emergence, V-2 = First pair of primary leaves, V-3 = First pair of trifoliate leaves, and V-4 = Third pair of trifoliate leaves), and in reproductive stages (R-5 = Pre-flowering, R-6 = Flowering, and R-7 = Pod formation), following the criteria indicated by Escalante and Kohashi (1993).

Harvest of snap beans was made ten times within three-days intervals, when the pod length was > 10 cm, registering fresh weight (g m^{-2}), and number and length (cm) of snap beans. Biomass accumulation (g m^{-2}) and its distribution in leaves, stems and pods were measured through a destructive sampling 90 days after sowing (DAS), taking three plants in each experimental unit (different from those used for fresh pod yield determination). The nutritional quality of the snap beans was determined through a proximal chemical analysis; the percentage of calcium and phosphorus was determined following the method by Sosa (1979), and the moisture percentage in samples was calculated by placing the snap beans in a forced air oven (Model 28, THELCO) at 55 °C, until constant weight was obtained. Furthermore, the harvest index (HI, %), which is the accumulation of dry matter in the organ of agronomic interest with respect to the total (Escalante and Kohashi, 1993) was calculated.

Data were analyzed with an ANOVA, followed by means comparison (Tukey test, P = 0.05), using the SAS statistical software (SAS, 2000).

RESULTS AND DISCUSSION

Phenology in relation with temperature and rainfall

The snap bean "Hav-14" did not show phenology differences caused by treatments; on average, plants developed during 107 days: sowing to emergence, 8 days; emergence to third trifoliate leaf (V1 to V4), 36 days; pre-flowering to pod formation (R5 to R7), 41 days; and first to tenth harvest, 30 days (Figure 1). In grain bean, Castellanos *et al.* (1998) observed a similar tendency on phenology duration due to application of fertilizers and biofertilizers. In addition, maximum and minimum temperatures had no variation during the crop growth, which probably explained the similarities on phenological stages among treatments; similar tendencies were reported by Salinas *et al.* (2008) in bean "Hav-14".

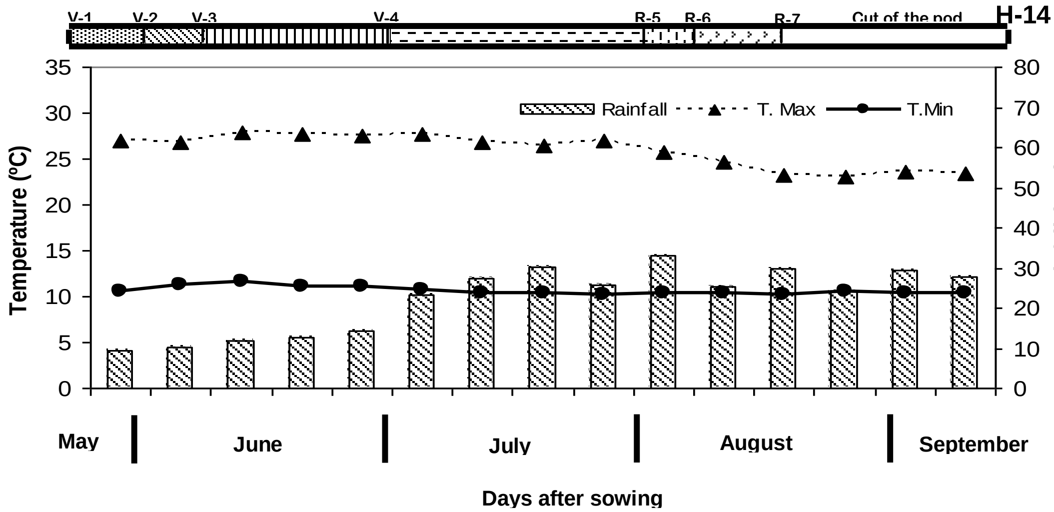

Figure 1. Phenology of snap bean (*Phaseolus vulgaris* L.) cultivar "Hav-14", weekly maximum and minimum mean temperatures, and weekly rainfall. Temperate climate, Summer 2009. San Pablo Ixayoc, Mexico.
Phenological stages: V-1 = Emergence; V-2 = Primary leaves; V-3 = First trifoliate leaf; V-4 = Third trifoliate leaf, R-5 = Pre-flowering; R-6 = Flowering; R-7 = Pod formation.

Yield, number and pod length

Biofertilizer application increased yield and number of pods by 20 and 8.5 %, respectively, compared with the control (Table 1). Similar trends were observed with application of N, obtaining the highest values with 200 kg N ha^{-1} (1876 g m-2 and 467 pods m-2), followed by 100 kg N (1603 g m^{-2} and 387 pods m^{2}), and the lowest values with 0 kg N (1026 g m^{-2} and 299 pods m^{-2}). Pod length showed no differences caused by N, averaging 10.5 cm. Accumulated heat units (758 °C), rainfall received (273 mm) and evapotranspiration of the crop (161 mm) were similar among treatments, in accordance to similar duration of the crop cycle of "Hav-14", not affected by fertilizer regimes.

Biofertilizer + N application increased bean yield; biofertilizer + 200 kg N ha^{-1} produced the highest yield (2131 g m^{-2}), followed by biofertilizer + 100 kg N ha^{-1} (1416 g m^{-2}), 200 kg N ha^{-1} (1621 g m^{-2}), 100 kg N ha^{-1} (1402 g m^{-2}), and the lowest values corresponded to biofertilizer + no-N (1069 g m^{-2}), and no-biofertilizer + no-N (983 g m^{-2}) (Figure 2). Singer *et al.* (2000) and Asmaa *et al.* (2010) observed similar trends in the increment of bean yield for the combination of biofertilizer + fertilizer. Probably, a synergistic effect that contributes to increase bean yield was caused by the application of biofertilizer + high N doses (100 and 200 kg N ha^{-1}). Application of biofertilizer stimulates root growth and application of mineral fertilizer favors the growth of the above ground part, thus favoring the absorption of water and nutrients and increasing the elaboration of photosynthates, that will be later translocated to the organ of agronomic interest (snap bean); therefore, if a N source is reduced or lacking, yield and number of beans may decrease considerably.

The number of pods showed similar tendencies than did yield, resulting the highest values with biofertilizer + 200 kg N ha^{-1} (486 beans m^{-2}), and the lowest with no-biofertilizer + no-N (278 beans m^{-2}) (Figure 3). Singer *et al.* (2000) and Bildirici and Yilmaz (2005) found similar results in relation with the greatest number of pods (36 and 21 plant^{-1}) with the application of biofertilizer + N, and the lowest values (20 and 15 pods plant^{-1}) where no fertilizers were used.

Table 1. Yield of snap bean (*Phaseolus vulgaris* L.) (kg m^{-2}), number of pods per m^2, pod length (cm) and environmental indices in relation to fertilization. San Pablo Ixayoc, Mexico. Summer 2009.

Treatments		Yield (g m^{-2})	Number of pods (m^{-2})	Length of the pod (cm)
Bio (Cb)		1668^{a}	401^{a}	10.6^{a}
No-Bio (Sb)		1336^{b}	367^{b}	10.5^{b}
No-Nitrogen (00)		1026^{c}	299^{c}	10.4^{a}
Nitrogen 100		1603^{b}	387^{b}	10.5^{a}
Nitrogen 200		1876^{a}	467^{a}	10.6^{a}
General average		1502	384	10.5
Prob F	Bio	** (10.3)	** (3.69)	** (0.11)
Prob F	Nitrogen	** (12.6)	** (5.49)	NS (0.17)

[a,b,c]Different letters in the same column indicate statistical difference according to the Tukey test ($P \leq 0.05$).
NS = Not significant; Bio = Biofertilizer; Prob F = F probability value.

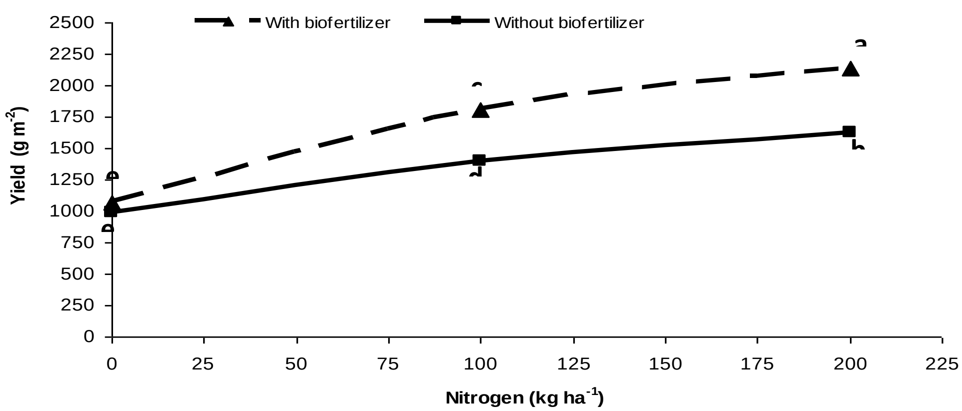

Figure 2. Bean yield (g m^{-2}) in snap bean (*Phaseolus vulgaris* L.) in terms of the combination of biofertilizer and nitrogen. Temperate climate. Summer 2009. San Pablo Ixayoc, Mexico.
[a,b,c,d,e]Different letters on the same curve indicate statistical difference (Tukey, $P \leq 0.01$).

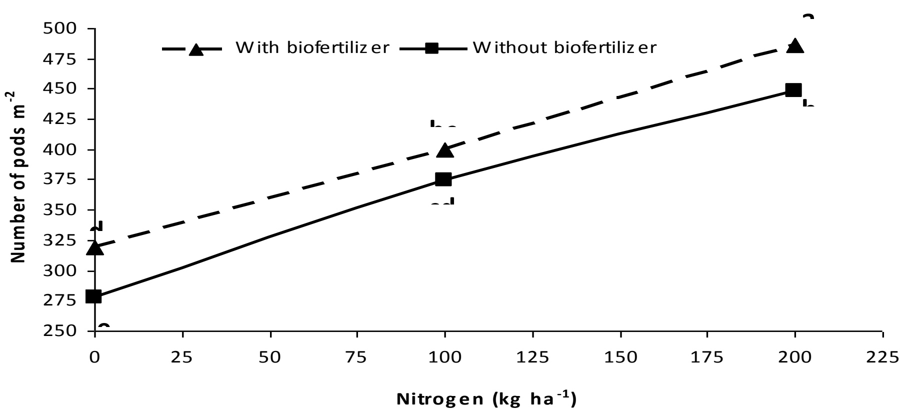

Figure 3. Number of pods per m^2 in snap bean (*Phaseolus vulgaris* L.) in terms of biofertilizer and N. Temperate climate. Summer 2009. San Pablo Ixayoc, Mexico.
[a,b,c,d,e]Different letters on the same curve indicate statistical difference (Tukey, $P \leq 0.01$).

Biomass production

Table 2 shows that application of biofertilizer increased by 32 % total biomass production, derived from a greater accumulation of dry matter in stems, leaves and pods, compared with the control. Mean dry matter distribution was higher in pods (136 g m^{-2}), followed by leaves (115 g m^{-2}), and stems (85 g m^{-2}). These findings are related with those found by Tirado *et al.* (1990), Tancogne *et al.* (1991), and Castro and Laguna (1992), who mention that N fixed by root nodules (ureides) is preferably used in the formation and growth of bean pods and grains, which explains this behavior. Nitrogen application caused significant changes in biomass. Thus, 200 kg N ha^{-1} resulted in the highest biomass (534 g m^{-2}), and the lowest (179 g m^{-2}) was in the control group. Similar tendencies were reported by Gutiérrez *et al.* (2004) for the cultivar "Flor de Durazno". On the other hand, the maximum biomass using fertilizer (534 g m^{-2}) exceeded the one where biofertilizer was applied (403 g m^{-2}), probably because biofertilizer application requires a high expenditure of energy (16 mols of ATP) to fix one mol of N (Olalde *et al.*, 1994; Urzúa, 2005), and the application of fertilizer does not requires this expenditure, and as a result, most of the energy produced is used for biomass production.

Table 2. Distribution and harvest index (HI) of snap bean (*Phaseolus vulgaris* L.) "Hav-14" biomass production (g m^{-2}), in terms of fertilization. San Pablo Ixayoc, Mexico. Summer 2009.

Treatments	Dry weight of leaf (g m^{-2})	Dry weight of stem (g m^{-2})	Dry weight of pod (g m^{-2})	Total biomass (g m^{-2})	Harvest index (%)
Bio (Cb)	131^{a}	101^{a}	171^{a}	403^{a}	42
No-Bio (Sb)	99^{b}	69^{b}	101^{b}	269^{b}	38
No-Nitrogen (00)	77^{c}	37^{c}	65^{c}	179^{c}	36
Nitrogen 100	104^{b}	69^{b}	122^{b}	295^{b}	41
Nitrogen 200	165^{a}	149^{a}	220^{a}	534^{a}	41
General average	115	85	136	336	39
Prob F Bio	** (1.12)	** (1.96)	** (1.67)	** (8.23)	UAD
Prob F Nitrogen	** (2.94)	** (1.57)	** (2.48)	** (12.24)	UAD

^{a,b,c}Different letters in the same column indicate statistical difference (Tukey, $P \leq 0.05$).
Cb and Sb = Average date of three means; NS = Not significant; Bio = Biofertilizer; UAD = Unanalyzed data.

Interaction of biofertilizer + N on biomass production

Figure 4 shows that the highest total biomass production (649 g m^{-2}) was obtained with the combination of biofertilizer + 200 kg ha^{-1} of N, followed by no-biofertilizer + 200 kg ha^{-1} of N (240 g m^{-2}), biofertilizer + no-N (203 g m^{-2}), and the lowest (150 g m^{-2}) in the control group. On the other hand, treatments inoculated with biofertilizer increased the dry matter by 24 % in leaf, 32 % in stem and 40 % in pod, compared to those fertilized only with urea. Results suggest that inoculation with *Glomus intraradices* increased the surface of root absorption, which caused higher absorption of N and increased biomass production (Escalante *et al.*, 1998).

Harvest index (HI)

The harvest index had significant differences among treatments, the highest (46 %) being achieved with biofertilizer + 100 kg N, and the lowest (29 %) with no-biofertilizer and no-N (control) (Figure 5). Thus, N application increases production of total dry matter, but it does not increase the harvest index (organ of agronomic interest); farmers of limited resources might use only biofertilizer to reduce production costs in snap bean, where yield is not affected by lack of N application.

Nutritional quality of snap bean

The ANOVA showed significant changes due to biofertilizer, N and the interaction biofertilizer*N (Table 3). Biofertilizer application increased content of calcium (16.1 %), phosphorus (0.53 %), neutral detergent fiber (22.2 %), hemicellulose (6.7 5), protein (21.6 %), and ether extract (1.8 %), compared with the control. On the contrary, the highest content of soluble carbohydrates (43.4 %) was found in the control group.

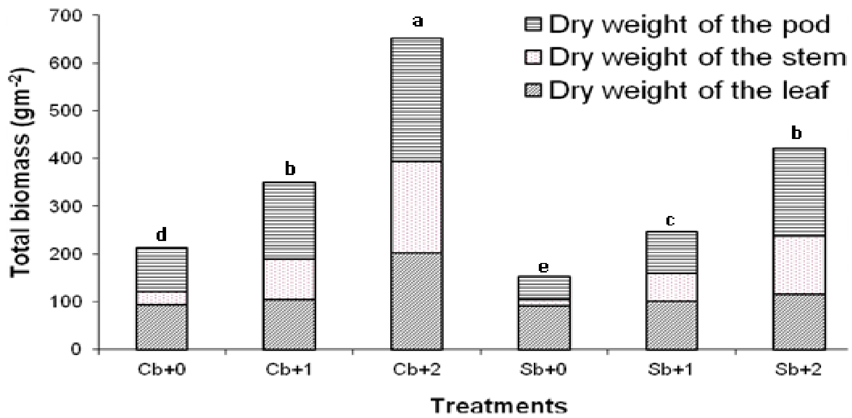

Figure 4. Biomass production (g m^{-2}) in snap bean (*Phaseolus vulgaris* L.) in terms of biofertilizer and nitrogen (N). Temperate climate. Summer 2009. San Pablo Ixayoc, Mexico.
[a,b,c,d,e]Different letters within the figure indicate statistical difference (Tukey, $P \leq 0.01$).
Cb + 0 = Biofertilizer and no-N; Cb + 1 = Biofertilizer + 100 kg N ha^{-1}; Cb + 2 = Biofertilizer + 200 kg N ha^{-1}; Sb + 0 = No-biofertilizer and No-N; Sb + 1 = No-biofertilizer + 100 kg N ha^{-1}; Sb + 2 = No-biofertilizer + 200 kg N ha^{-1}.

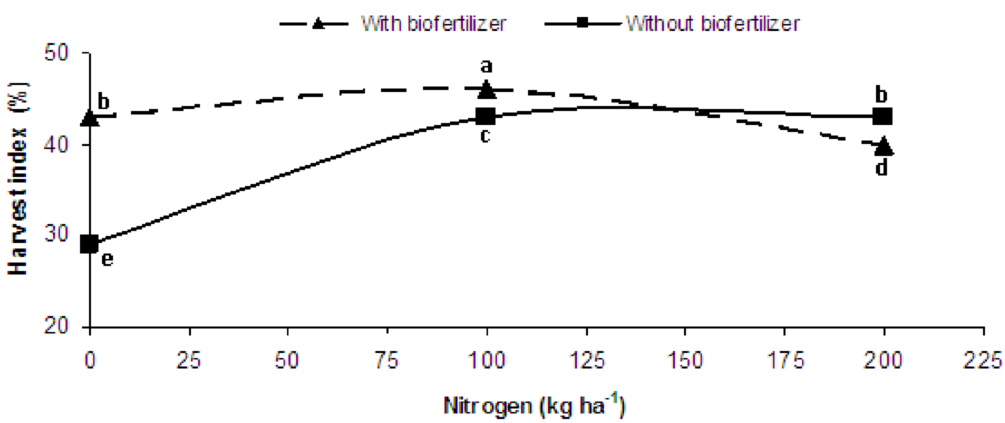

Figure 5. Harvest index of snap bean (*Phaseolus vulgaris* L.) “Hav-14” in terms of biofertilizer and N. Temperate climate. Summer 2009. San Pablo Ixayoc Mexico.
[a,b,c,d,e]Different letters on the same curve indicate significant differences (Tukey, $P \leq 0.01$).

The highest nutritional quality found in the treatment with biofertilizer can be partially related to N fixation (*Rhizobium etli*) and to root system growth (*Glomus intraradices*). Possibly, this was caused by the increment in nutrient absorption and transport toward the pod. In addition, Urzúa (2005) and Castro and Laguna (1992) mentioned that the highest N fixation in bean is coincident with flowering stages and pod formation (R5 and R6); this likely caused the increment of N in the pod. Furthermore, reduction in the content of soluble carbohydrates was possibly related to a high expenditure of energy (ATP) used in N fixation.

On the other hand, application of 200 kg N ha^{-1} resulted in the highest content of minerals (7.2 %), phosphorus (0.53 %), protein (21.8 %) and ether extract (1.8 %), and the lowest corresponded to the control group (6.9, 0.50, 20.7 and 1.7 %, respectively). Similar results on protein content were reported by El-Tohamy *et al.* (2009), who evaluated 60, 120, 180, 240 and 300 kg N ha^{-1} in snap bean, and obtained the highest content of protein (19 %) with 300 kg N ha^{-1}, and the lowest (13.5 %) with 60 kg N ha^{-1}. When biofertilizer and N were applied, an increment in the content of nutrients was obtained. With 200 kg N ha^{-1}, the bean had the highest content of minerals (7.4 %), phosphorus (0.54 %) and ether extract (1.9 %), and the lowest (6.6, 0.47, and 1.7 %, respectively) was obtained in the control group. However, the highest percentage of protein (22 %) was found when biofertilizer + 200 kg N ha^{-1} were used, followed by biofertilizer + 100 kg N ha^{-1} (21.9 5), no-biofertilizer + 200 kg N ha^{-1} (21.5 %), no-biofertilizer + 100 kg N ha^{-1} (21.1 5), biofertilizer (21.1 %), and the lowest (20.5 %) in the control group.

Asmaa *et al.* (2010) found a similar tendency in the effect of combination of fertilizers in the nutritional quality, where the combination of biofertilizer (2 kg ha^{-1}) + 280 kg N ha^{-1} resulted in the highest content of protein (20.1 %), phosphorus (0.38 %) and carbohydrates (45 %), and the combination no-biofertilizer + 200 kg N ha^{-1} had the lowest values (16.8, 0.27, and 40.3 %, respectively). Thus, accumulation of protein in snap bean is increased by the combination of biofertilizers + N.

The application of biofertilizer and fertilizer in snap bean "Hav-14" did not produce changes in the duration of its phenology (107 days). Thus, the accumulation of heat units (758 °C), precipitation (273 mm) and ETc (161 mm) were the same for all treatments. However, differences among treatments were observed in total dry matter accumulation, yield and number of snap beans, with the highest values (649 g m^{-2}, 2131 g m^{-2} and 486 snap beans m^{-2}, respectively) being obtained with biofertilizer + 200 kg N ha^{-1} and the lowest (150 g m^{-2}, 983 g m^{-2} and 278 snap beans m^{-2}) in the control group. Percentage of dry matter accumulated in the organ of agronomic interest (harvest index) also showed differences, with the highest harvest index (46 %) obtained with biofertilizer + 100 kg N ha^{-1}, and the lowest (29 %) in the control group.

Snap bean nutritional content also presented differences by treatment; the highest percentage of protein (22 %), neutral detergent fiber (30 %), hemicellulose (8.5 %) and calcium (18 %) were obtained with the combination of biofertilizer + N, and the lowest (21.5 %, 26 %, 3 % and 11 %, respectively) were obtained with the application of N. Combined application of biofertilizer with N promotes root growth and chlorophyll formation in leaves, thus causing higher production of photosynthates that increase biomass production, yield and nutritional quality of snap bean.

Table 3. Chemical analysis of snap bean (*Phaseolus vulgaris* L.) cultivar "Hav-14" in terms of fertilization. Summer 2009. San Pablo Ixayoc, Mexico.

		Nutrients									
Treatments		Min	Ca	P	SC	ADF	Lignin	NDF	Hem	Prot	EE
Bio (Cb)		7.1^{a}	16.1^{a}	0.53^{a}	40.9^{b}	22.2^{a}	0.6^{b}	28.8^{a}	6.7^{a}	21.6^{a}	1.8^{a}
No-Bio (Sb)		7.0^{a}	13.3^{b}	0.50^{b}	43.4^{a}	22.1^{a}	2.1^{a}	26.5^{b}	4.4^{b}	21.0^{b}	1.7^{b}
No-Nitrogen 00		6.9^{b}	14.5^{b}	0.50^{b}	42.5^{a}	21.9^{a}	2.8^{a}	28.1^{a}	6.1^{a}	20.7^{b}	1.7^{b}
Nitrogen 100		6.9^{b}	16.5^{a}	0.51^{b}	41.2^{a}	21.9^{a}	0.6^{b}	28.7^{a}	6.7^{a}	21.5^{a}	1.8^{a}
Nitrogen 200		7.2^{a}	13.1^{c}	0.53^{a}	42.8^{a}	22.4^{a}	0.6^{b}	26.2^{b}	3.7^{b}	21.8^{a}	1.8^{a}
Cb x 00		7.2^{b}	15.3^{b}	0.54^{ab}	39.7^{d}	21.9^{a}	0.7^{b}	30.4^{a}	8.5^{a}	21.1^{cd}	1.7^{cd}
Cb x 100		6.8^{d}	18.1^{a}	0.51^{c}	40.4^{cd}	22.4^{a}	0.6^{b}	29.4^{ab}	7.0^{ab}	21.9^{ab}	1.8^{bc}
Cb x 200		7.0^{c}	14.8^{c}	0.55^{a}	42.7^{b}	22.2^{a}	0.6^{b}	26.7^{cd}	4.5^{bcd}	22.0^{a}	1.6^{d}
Sb x 00		6.6^{e}	13.7^{d}	0.47^{d}	45.4^{a}	22.0^{a}	4.9^{a}	25.8^{d}	3.8^{cd}	20.5^{d}	1.7^{cd}
Sb x 100		7.0^{c}	14.9^{c}	0.52^{c}	42.0^{b}	21.5^{a}	0.6^{b}	28.0^{bc}	6.4^{abc}	21.1^{bcd}	1.9^{ab}
Sb x 200		7.4^{a}	11.4^{e}	0.53^{bc}	42.9^{b}	22.7^{a}	0.6^{b}	25.7^{d}	3.0^{d}	21.5^{abc}	1.9^{a}
General average		7.03	14.7	0.51	42.1	22.1	1.4	27.7	5.6	21.3	1.8
Prob F	Bio	NS(0.89)	*(0.14)	NS(0.09)	*(1.34)	NS(0.91)	*(0.10)	*(1.13)	*(1.78)	*(0.46)	*(0.06)
	N	*(0.08)	*(0.18)	*(0.01)	*(1.64)	NS(1.11)	*(0.13)	*(1.39)	*(2.19)	*(0.57)	*(0.07)
	Bio x N	*(0.11)	*(0.29)	*(0.01)	*(2.12)	NS(1.57)	*(0.17)	*(1.77)	*(2.91)	*(0.77)	*(0.10)

Different letters in the same column indicate significant differences (Tukey, $P \leq 0.01$). NS = Not significant; Bio = Biofertilizer; Min = Minerals; N = Nitrogen; Ca = Calcium; P = Phosphorus; SC = Soluble carbohydrates; ADF = Acid detergent fiber; NDF = Neutral detergent fiber; Hem = Hemicellulose; Prot = Protein; EE = Ether extract; ; Prob F *( ) = F probability value.

CONCLUSION

Yield, biomass production and nutritional quality of snap bean depend on the use of biofertilizer and the dose of N applied. The highest yield, biomass production and percentage of protein were obtained with the combination of biofertilizer + 200 kg of N ha^{-1}, and the lowest with no-biofertilizer + no-N. The highest harvest index was obtained with the combination of biofertilizer + 100 kg ha^{-1} of N.

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