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Full Length Article

Influence of Organic Nitrogen on the Snap Bean Grown in Sandy Soil

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Abstract

Reverse all the legumes crops, the nitrogen (N) fertilizer requirement of snap bean plant is high, due to it is weak in the fixation of atmospheric N. Using organic fertilizers; chicken manure and biofertilizer, can serve as an alternative to use mineral N fertilizer. Two greenhouse experiments were carried out in factorial randomized complete block design with three replicates. Each experiment included eight treatments; four rates of chicken manure (CM) as a source of organic N; 0 (CM_0), 50 (CM_1), 100 (CM_2) and 200 (CM_3) kg N ha^{-1} applied singly or in combined with biofertilizer (Halex-2). The application of CM_2, significantly, increased the number of leaves and branches, leaf area index and pods number per plant, as well as pods yield, dry mass and N uptake ha^{-1} compared with CM_0. Moreover, inoculating seed of snap bean by biofertilizer significantly increased all studied parameters of snap bean plants. The dry matter and N uptake were mainly distributed in pods, followed by leaves, and stems. The pods yield of snap bean plants was highly positively correlated with the number of branches and leaves, leaf area index, flower clusters number, dry mass, number of green pods, pod weight and N uptake characters, orderly. Generally, the best significant vigorous of the growth and yield traits of snap bean plants, was achieved with the dual treatment of CM_2 (100 kg N ha^{-1}) and inoculate the seed with biofertilizer, which considered as one of the effective agriculture practices in organic farming and environmentally safe procedure.

Keywords: Chicken manure; Biofertilizer; Growth; Yield; Dry mass; N uptake; Correlation

Introduction

Snap bean (*Phaseolus vulgaris* L.) is one of the important legume vegetable crops cultivated in the arid regions for both green pods and dry seeds, considered as a good source of protein.

More attention has been paid to secure high yield and good quality of snap bean through improvement of the factors affecting its productivity. Fertilization with the suitable level of nitrogen (N) had a key role in improving the growth and yield of snap bean plants. Nitrogen is a constituent of all proteins; many metabolic intermediates and nucleic acids (Goh and Haynes, 1986; Salisbury and Ross, 1991). The N fertilizer requirement of snap bean plant is high, due to its weak fixation capacity of atmospheric N compared to other legumes (Piha and Munnus, 1987). Many reports indicate that snap bean plants will not grow well or produce the best yield with low soil N availability (Lynch and White, 1992; Aroujo *et al.,* 1997; Salinas *et al.,* 2011). However, the excessive use of N fertilizers represents the major cost in plant production and creates pollution of agro-ecosystem, as well as deterioration of soil fertility (Fischer and Richter, 1984). Consequently, use of the organic sources of N would be the viable option to meet the snap bean N requirement through use of combination of organic manure and bio-fertilizer considered one of the effective practices in organic farming and environmentally safe procedure.

Using organic fertilizers; chicken manure and bio-fertilizer can serve as an alternative practice to use N mineral fertilizers (Gupta *et al.,* 1988; Wong *et al.,* 1999; Naeem *et al.,* 2006), which play an important role in improving soil physical properties (Dauda *et al.,* 2008). It contributes in increasing the organic soil carbon content and raising soil productivity, through an increase in activity of the useful microorganisms in the soil (El-Gizy, 1994, Suresh *et al.,* 2004; Remesh, 2008). Convert organic nutrient's forms to mineral forms, which become available to plants as the slow-release fertilizers (Kolbe *et al.,* 1995; Marschner, 1995). Moreover, chicken manure contains higher levels of relatively available nutritional elements, especially N, which is essentially required for plant growth (Amanullah *et al.,* 2007).

Biofertilizer use become an important component in an integrated nutrient supply system and hold a great promise to improve crop yields through better nutrient supplies. *Azotobacter, Azospirillum* and *Klebsiella* are the most important bacteria to the non-symbiotic fixation of atmospheric N. Biofertilizer plays a vital role in restoring the natural soil nutrient cycle by fixing and released plant available N forms to soil (Mahdi *et al.,* 2010), as well as stimulating plant growth through the synthesis of growth

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promoting substances (Frankenberger and Arshad, 1995; Noel *et al*., 1996). Nevertheless, the main mechanism of this beneficial effect is not fully understood. Among the explanations proposed for plant growth promotion by these bacteria is an increased uptake of mineral nutrients (Pacovsky *et al*., 1985; Bashan and Levanony, 1990). Using organic manure and biofertilizer in improving the plant growth, yield, and quality of snap bean plants have reviewed by several authors (Wani and Lee, 1995; Gabr, 2000; El-Bassiony *et al.,* 2010).

However, very little attention have been paid for the combined effect of chicken manure and biofertilizer on snap bean plants grown in sandy soil poor in organic matter under arid regions. Hence, the objective of these experiments was to evaluate response on the growth, dry mass accumulation, N uptake, green pods yield, and pod's quality traits of bean plants to chicken manure rates and Halex-2 biofertilizer.

Materials and Methods

Two greenhouse experiments were carried out during the winter seasons of 2010-2011 and 2011-2012, at the Agricultural Experiment Stations, Hada-Alsham, King Abdulaziz University, Saudi Arabia. Each experiment included eight treatments; four rates of chicken manure (CM) as a source for organic N; 0 (CM_0), 50 (CM_1), 100 (CM_2) and 200 (CM_3) kg N ha^{-1} (CM amounts, ton ha^{-1}, that is equivalent to each of N rates listed in Table 2) applied single, or in combined with Halex-2 biofertilizer. The biofertilizer (Halex-2) is a mixture of non-symbiotic N-fixing bacteria, of genera *Azotobacter*, *Azospirillum* and *Klebsiella*, was prepared in the Biofertilization Unit, Plant Pathology Department, Faculty of Agriculture, Alexandria University, Egypt.

Some important physical and chemical properties of the experimental soil (0-30 cm depth) and the chemical properties for each the chicken manure and irrigation water obtained from a local well, were estimated according to the published procedures (Page *et al.,* 1982) before the start of each trial are given in Tables 1, 2 and 3.

The treatments were set in factorial randomized complete block design with three replicates. Each experimental unit contained two rows; 3 m × 2 m. One week before sowing, chicken manure (CM) was incorporated into the soil of rows at 15 cm depth. Halex-2 biofertilizer was utilized at the rate of 500 g ha^{-1}. The inoculation process was performed by immersing the snap bean seeds in a Halex-2 suspension containing 5% Arabic gum, for 10 minutes just before planting. The inoculation process was repeated three weeks later as a side dressing beside the plants. Seeds of the control treatment were dipped in distilled water containing 5% Arabic gum for the same time. Seed of the snap bean (Super Stryke *cv*.) was sown on October 29, 2010 and October 22, 2011, in four lines on each row. The row spacing was 15 cm between the seeds and 20 cm between the lines.

The actual evapotranspiration of the snap bean crop (ET_c), under greenhouse at Hada-Alsham area conditions, was calculated and adjusted at the beginning of each growth stage. It's calculated by multiplying reference evapotranspiration (ET_0) for different growth stages of snap bean plants (Table 4), throughout the growing season (November–February), by a crop coefficient (K_C); $ET_c=ET_0\times K_c$, as indicated in Allen *et al*. (1998) and Razmi and Ghaemi (2011). The drip irrigation network consisted of lateral's GR of 16 mm in diameter, with emitters at 0.5 m distance, with allocating two laterals for each row. The emitters had a discharge rate 4 l h^{-1}. Irrigation frequency was every alternate day, to maintain soil moisture above 50% soil moisture depletion, according to Qassim and Ashcroft (2002), which is the optimum level of snap bean plants. Other recommended agricultural practices were followed as commonly used in the commercial production of snap bean. The average temperature and relative air humidity inside the greenhouse were 24 ± 2.3°C and 72 ± 3% through snap bean growth stages, respectively.

In each experimental unit, the snap bean plants in the first row was allocated to measure the growth characters; the number of branches and leaves, leaf area index and flowering characters. The dry mass accumulation and the concentrations of N and K were estimated as described in Cottenie (1980). The plants of second row were saved to find the green pods yield and its component characters. Leaf area index (LAI) calculated as the ratio of the leaf surface area to the ground area occupied by a plant stand (Thomas and Winner, 2000).

Leaf Area Index = Leaf area per plant / ground area per plant

In the second season, the uptake of N calculated as the product of the crop biomass (dry weight). The concentration of N in each of the branches, leaves, and pods was estimated as described in Cottenie (1980). The obtained values of N concentration were multiplied with the dry matter content of branches, leaves, and pods; the N uptake ha^{-1} was derived based on plant population.

All obtained data of the present study was subjected to the analysis of variance techniques according to the design used by the MSTATC computer software program (Bricker, 1991). The comparisons among means of the different treatments were carried out by using the revised LSD test at ($P<0.05$). Correlation coefficient (r) among some characters of snap bean plants, as a mean of the two growing seasons of 2010-2011and 2011-2012, was calculated.

Results

Effects on Vegetative Growth

Application of CM_2 (100 kg N ha^{-1}) gave significantly the highest mean values of the number of leaves and

Table 1: Soil physical and chemical properties of the two experimental sites in the 2010 and 2011 seasons

Seasons	Soil Properties									
	Sand (%)	Silt (%)	Clay (%)	Texture	EC. (dS m^{-1})	pH	N (%)	P (mg kg^{-1})	K (mg kg^{-1})	Organic Matter (%)
2010	90.1	7.1	2.8	sandy	3.11	8.1	0.02	7	12	0.11
2011	89.2	7.9	2.9	sandy	3.23	7.9	0.03	9	20	0.08

Table 2: Chicken manure chemical properties and its amounts equivalent to each N rate (t ha^{-1}) in the 2010 and 2011 seasons

Seasons	Chicken manure properties				Chicken manure amount (t ha^{-1}) that equivalent to each the N rate		
	Moisture (%)	N (%)	P (%)	K (%)	50 kg N ha^{-1}	100 kg N ha^{-1}	200 kg N ha^{-1}
2010	5.9	3.2	1.3	1.0	1.654	3.309	6.619
2011	5.7	3.4	1.1	1.2	1.554	3.108	6.216

Table 3: Chemical properties of irrigation water, as average in both seasons

Water Properties						
EC (dS m^{-1})	Na (meq l^{-1})	Mg (meq l^{-1})	Ca (meq l^{-1})	HCO_3 (meq l^{-1})	Cl (meq l^{-1})	SO_4 (meq l^{-1})
2.1	0.39	0.22	5.15	0.48	1.95	5.51

Table 4: Length of the growth stages, crop coefficients (K_c), reference evapotranspiration (ET_0) and water requirements of snap bean crop (ET_c), under the greenhouse conditions

Growth stages	Establishment	Vegetative	Flowering and pods formation
Number of days stage^{-1}	15	25	50
Crop Coefficients (K_C)	0.5	1.05	0.90
Reference evapotranspiration (ET_0) mm day^{-1} on the inside of the greenhouse =73% from outside the greenhouse (Razmi and Ghaemi, 2011)	3.2	4.5	4.9
Water requirements of snap bean crop (ET_c) mm day^{-1}	1.6	4.73	4.41
Total water requirements per growth stage	24.0	118.3	220.5

Table 5: The growth characters of snap bean plants as affected by chicken manure and Halex-2 biofertilizer during seasons of 2010-2011 and 2011-2012

Chicken manure	Biofertilizer	Leaves No. per plant	Branches No. per plant	Leaf area index	Leaves No. per plant	Branches No. per plant	Leaf area index
		First year			Second year		
CM_0*		11.2 e	2.9 c	5.21 c	11.7 e	2.9 d	5.70 d
CM_1		15.5 c	4.4 ab	7.26 bc	16.5 c	4.8 b	7.98 bc
CM_2		20.1 a	5.2 a	9.41 a	22.8 a	5.4 a	9.78 a
CM_3		18.0 b	5.1 a	7.49 bc	19.4 b	5.1 ab	7.75 bc
	BF_0	14.2 b	3.9 b	6.73 b	15.0 b	4.1 b	7.19 b
	BF_1	15.4 a	4.2 a	7.39 a	16.6 a	4.3 a	7.70 a
CM_0	BF_0	10.4 g	2.8 e	4.92 i	10.7 f	2.9 e	5.53 i
	BF_1	12.0 efg	3.1 e	5.51 ghi	12.7 de	3.0 e	5.85 hi
CM_1	BF_0	15.5 cd	4.1 c	6.71 de	16.4 c	4.5 bc	7.47 ef
	BF_1	15.5 cd	4.7 b	7.82 bc	16.5 c	5.0 ab	8.48 c
CM_2	BF_0	18.3 b	5.0 ab	9.13 a	20.4 b	5.5 a	9.36 b
	BF_1	22.0 a	5.4 a	9.70 a	25.1 a	5.4 a	10.20 a
CM_3	BF_0	18.1 b	5.0 ab	7.21 cd	19.6 b	5.1 ab	7.54 def
	BF_1	17.8 bc	5.2 ab	7.77 bc	19.3 b	5.2 ab	7.96 cde

* CM: Chicken manure as a source for organic N; CM_0 (0), CM1 (50), CM_2 (100) and CM_3 (200) kg N ha^{-1}, BF_0: non-inoculated (control), BF_1: Inoculated with "biofertilizer Halex-2."

** Values marked with the same letter (s) are statistically similar using LSD test at ($P < 0.05$).

branches, and leaf area index of snap bean plant, in both seasons (Table 5).

Inoculation the seeds of snap bean with Halex-2 biofertilizer (Table 5), significantly, gave the higher magnitudes of all the studied vegetative growth characters than the non-inoculated ones.

Using CM rates in combination with Halex-2 biofertilizer (Table 5), generally, clarified the presence of significant gradual increments number of leaves and branches, leaf area index of snap bean plant, in both seasons. The application of CM_2 (100 kg N ha^{-1}) with the Halex- 2 gave significantly the highest mean values for all

Table 6: The flowering characters of snap bean plants as affected by chicken manure and Halex-2 biofertilizer during seasons of 2010-2011 and 2011-2012

Chicken manure	Biofertilizer	Nods No. to first flower cluster (Earliness)	Flower clusters No per plant	Nods No. to first flower cluster (Earliness)	Flower clusters No per plant
		First year		Second year	
CM_0*		5.65 a**	7.53 e	5.63 a	7.17 e
CM_1		5.70 a	13.75 c	5.50 ab	13.17 c
CM_2		5.12 b	21.17 a	4.70 c	19.60 a
CM_3		5.17 b	17.43 b	4.45 c	16.63 b
	BF_0	5.60 a	12.01 b	5.48 a	11.84 b
	BF_1	5.16 b	15.28 a	4.83 b	14.69 a
CM_0	BF_0	5.97 a	6.73 i	6.50 a	6.37 f
	BF_1	5.33 a	8.33 h	4.77 bcd	7.97 e
CM_1	BF_0	5.67 a	12.40 g	5.73 ab	12.17 d
	BF_1	5.73 a	15.10 e	5.27 bcd	15.17 c
CM_2	BF_0	5.67 a	20.43 b	5.33 bc	18.70 b
	BF_1	4.57 a	21.90 a	4.17 d	20.50 a
CM_3	BF_0	5.47 a	15.70 de	4.67 bcd	15.47 c
	BF_1	4.87 a	19.17 c	4.23 cd	17.80 b

* CM: Chicken manure as a source for organic N; CM_0 (0), CM1 (50), CM_2 (100) and CM_3 (200) kg N ha^{-1}, BF_0: non-inoculated (control), BF_1: Inoculated with "biofertilizer Halex-2."
** Values marked with the same letter (s) are statistically similar using LSD test at ($P < 0.05$).

Table 7: Effect of Chicken manure and biofertilizer on dry mass and leaf mineral contents of snap bean plants during seasons of 2010-2011 and 2011-2012

Chicken manure	Biofertilizer	Dry mass per plant (g)	N (%)	K (%)	Dry mass per plant (g)	N (%)	K (%)
			First year			Second year	
CM_0*		27.52 f	3.72 b	1.74 cd	29.17 e	3.72 d	1.68 d
CM_1		36.35 d	4.16 a	1.89 a	37.31 c	4.01 b	1.92 c
CM_2		43.48 a	4.16 a	1.98 a	45.04 a	4.16 a	2.08 a
CM_3		39.76 b	3.70 b	1.62 d	39.00 b	3.85 c	1.69 d
	BF_0	32.93 b	3.69 b	1.70 b	33.97 b	3.77 b	1.73 b
	BF_1	37.82 a	4.13 a	1.97 a	38.31 a	3.96 a	2.02 a
CM_0	BF_0	24.54 g	3.39 f	1.47 b	26.47 g	3.42 g	1.37 h
	BF_1	30.49 h	4.05 bc	2.02 a	31.86 f	4.01 cd	1.98 bcd
CM_1	BF_0	33.51 e	4.05 bc	1.79 cd	34.82 e	3.99 cde	1.82 def
	BF_1	39.20 c	4.26 ab	1.99 ab	39.79 c	4.03 cd	2.01 abc
CM_2	BF_0	40.28 c	4.07 bc	1.92 abc	42.15 b	4.10 bc	1.99 bcd
	BF_1	46.66 a	4.24 ab	2.04 a	47.94 a	4.22 a	2.17 a
CM_3	BF_0	37.28 d	3.41 f	1.28 f	37.85 d	3.55 g	1.49 gh
	BF_1	42.21 b	4.04 bc	1.96 abc	40.16 c	4.15 bc	1.89 cde

* CM: Chicken manure as a source for organic N; CM_0 (0), CM1 (50), CM_2 (100) and CM_3 (200) kg N ha^{-1}, BF_0: non-inoculated (control), BF_1: Inoculated with "biofertilizer Halex-2".
** Values marked with the same letter (s) are statistically similar using LSD test at ($P < 0.05$).

the vegetative growth characters of snap bean plants, in both seasons. The increments of the above-mentioned characters were 126.4, 92.9 and 102.3% over control as an average of the two seasons, orderly.

Effects on Flowering Characters

Soil application of CM_2 and CM_3 (100 and 200 kg N ha^{-1}) produced snap bean plants earlier in flowering followed by CM_1 and CM_0, respectively, in both the seasons (Table 6). Moreover, the application of CM_2 (100 kg N ha^{-1}) gave significantly the highest flower clusters number per plant of snap bean plants (182 and 174% in both seasons, respectively) compared with CM_0. This result was due to chicken manure positive effect on increased vegetative growth traits of snap bean (Table 5).

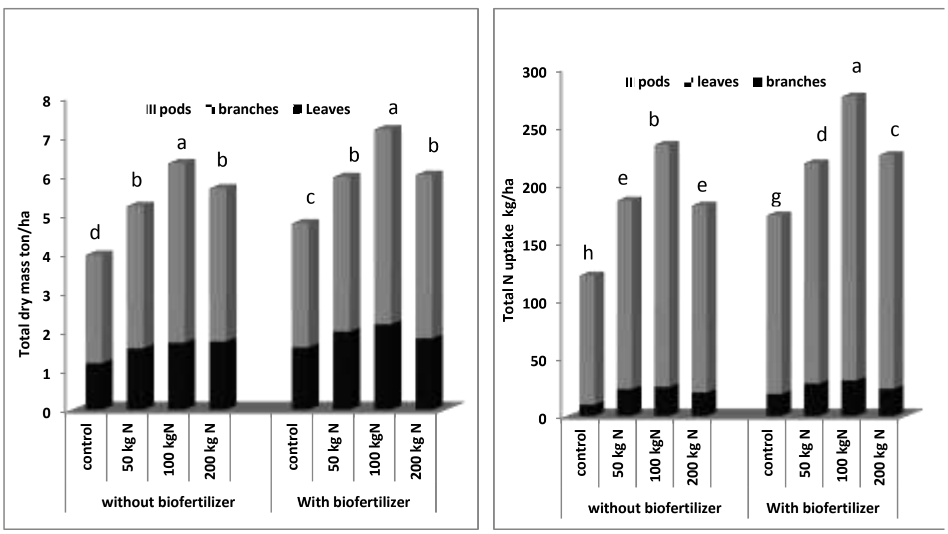
The results showed that inoculation the seed of snap bean with the biofertilizer Halex-2 was able to improve the flowering characters of snap bean plants, which lead to earliness of flowering and increase the number of flower clusters per plant (25.1 and 23.8% in both seasons, respectively) compared with non-inoculated seeds (Table 6).

Comparisons between the mean values of the different treatment combinations indicated that, at any CM rate, inoculation the seeds with Halex-2 recorded the highest mean values of the number of flower clusters per plant compared to the non-inoculated ones, in the two seasons (Table 6). The highest mean value of the number of flower clusters per plant and earliness characters were recorded with the application of CM_2 (100 kg N ha^{-1}) coupled with Halex-2. The increases of the aforementioned traits were

Table 8: The green pods yield and its components characters of snap bean plants as affected by chicken manure and Halex-2 biofertilizer during seasons of 2010-2011 and 2011-2012

Chicken manure	Biofertilizer	Pods yield ($t\ ha^{-1}$)	Pods No. per plant	Pod weight	Pod thickness (mm)	Pods yield ($t\ ha^{-1}$)	Pods No. per plant	Pod weight	Pod thickness (mm)
		First year				Second year			
CM_0*		10.7 d	12.6 f	4.9 a	7.0 a	10.3 d	13.7 f	5.0 a	6.9 a
CM_1		15.1 c	19.7 d	4.1 c	6.2 c	14.3 c	19.6 d	4.3 cd	6.3 c
CM_2		20.7 a	26.5 a	4.2 bc	6.3 c	20.4 a	27.0 a	4.2 d	6.4 bc
CM_3		18.6 b	24.5 b	4.2 bc	6.3 c	18.5 b	25.1 b	4.3 cd	6.4 bc
	BF_0	15.3 b	17.2 b	4.6 a	6.7 a	15.1 b	18.1 b	4.6 a	6.6 a
	BF_1	17.2 a	21.0 a	4.2 b	6.3 b	16.7 a	21.3 a	4.3 b	6.4 b
CM_0	BF_0	9.8 e	11.3 g	5.2 a	7.7 a	9.4 f	12.0 h	5.4 a	7.2 a
	BF_1	11.6 e	13.8 f	4.5 a	6.3 a	11.1 e	15.3 g	4.6 a	6.5 a
CM_1	BF_0	14.5 d	18.4 d	4.2 a	6.3 a	13.7 d	18.5 def	4.3 a	6.3 a
	BF_1	15.6 cd	21.1 c	4.0 a	6.3 a	14.9 d	20.7 d	4.2 a	6.2 a
CM_2	BF_0	19.6 b	24.8 b	4.3 a	6.3 a	19.6 b	26.3 ab	4.2 a	6.6 a
	BF_1	21.7 a	28.2 a	4.2 a	6.3 a	21.2 a	27.8 a	4.3 a	6.3 a
CM_3	BF_0	17.2 c	22.6 c	4.3 a	6.6 a	17.5 c	23.5 c	4.4 a	6.4 a
	BF_1	19.9 b	26.4 b	4.2 a	6.0 a	19.5 b	26.9 ab	4.2 a	6.3 a

* CM: Chicken manure as a source for organic N; CM_0 (0), CM1 (50), CM_2 (100) and CM_3 (200) kg N ha^{-1}, BF_0: non-inoculated (control), BF_1: Inoculated with "biofertilizer Halex-2"
** Values marked with the same letter (s) are statistically similar using LSD test at ($P < 0.05$)



LSD:1.163 (A) LSD:4.360 (B)

Fig. 1: Effect of chicken manure and Halex-2 biofertilizer on (A) dry mass ($t\ ha^{-1}$) and (B) N uptake ($kg\ ha^{-1}$) accumulation in the varied organs of snap bean plant during season 2011-2012

124.3% and 29.65% over the non-inoculated ones, as an average of the two seasons, orderly. However, the earliness character did not significantly respond to the interaction effect of the two studied factors, in the first season.

Effects on Dry Mass and the Contents of N and K of Leaves

The soil application of CM_2 (100 kg N ha^{-1}) resulted in the highest significant mean values of the total dry mass per plant and leaves contents of N and K, in the two seasons (Table 7).

Inoculation the seed with Halex-2, significantly, increased the dry mass per plant and the leave's contents of N and K compared to the non-inoculated ones, in both seasons (Table 7).

Interaction effects between organic and bio-fertilizer treatments on a dry mass and leaf contents of N and K traits of snap bean plants (Table 7) exhibited significant differences. Comparisons between the mean values of the different treatment combinations indicated that, at any CM rate, inoculation the seeds with Halex-2 achieved the highest values of dry mass per plant and leaves contents of N and K, but with different values, compared to the non-inoculated ones. The application of CM2 (100 kg N ha^{-1}) coupled with Halex-2 was the best treatment.

Table 9: Correlation coefficients (r) among the green pods yield and some characters of snap bean plant, as a mean of the two seasons of 2010-2011 and 2011-2012

Characters	Green pods yield
No. branches	0.780**
No. leaves	0.839**
Leaf area index	0.870**
Flower clusters number	0.732**
Dry mass	0.738**
No. green pods	0.788**
Pod weight	0.912**
N uptake	0.847**

** Correlation coefficient (r) is significant at (P< 0.01).

Effects on Dry Mass Accumulation and N Uptake

Chicken manure application had marked and significant effect on dry mass accumulation and N uptake of different organs of snap bean plants. Increasing the soil application of CM up to 100 kg N ha^{-1} was associated with corresponding and significant increments in dry mass and N uptake of the stem, leaves, and pods, as well as total dry mass ha^{-1} and N uptake ha^{-1}. Dry matter and N uptake were mainly distributed in pods, followed by leaves, and stems (Fig. 1A and B).

Inoculation the seeds with the biofertilizer Halex-2 significantly increased dry moss and N uptake of the stems, leaves, and pods as well as total dry mass ha^{-1} and N uptake ha^{-1} compared to the non-inoculated treatment. Generally, the soil application of CM_2 (100 kg N ha^{-1}) with the inoculation the seeds by the Halex-2 recorded the highest mean values of dry mass accumulation and N uptake of the branches, leaves and pods as well as a total dry mass and N uptake of snap bean plants compared to the other treatments (Fig. 1A and B).

Effects on Green Pods Yield and its Components

The application of CM appeared to effects on the yield traits of snap bean plants (Table 8). The application of CM_2 (100 kg N ha^{-1}) led to significant increments in pods green yield ha^{-1} (96.3%) and the number of pods per plant (100.2%) over the control treatment, as an average of the two seasons. However, weight and thickness pod^{-1} showed significantly decreased with application of CM.

Inoculation of the seed with the biofertilizer Halex-2 caused significant increases of the total yield ha^{-1} and the number of pods per plant (Table 8). The increments of the above-mentioned characters were 11.5% and 19.9% over the non-inoculated ones, as an average of the two seasons, orderly.

The application of CM in combined with Halex-2 appeared to have clearly different effects on the productivity traits of snap bean plant (Table 8). The maximum green pods yield ha^{-1} and the number of pods per plant were achieved in CM_2 (100 kg N ha^{-1}) + Halex-2 treatment and the lowest in control. The increases of the above-mentioned traits were 118.9 and 140.7% over the control treatment, as an average of both seasons, orderly. However, weight and thickness pod^{-1} showed insignificantly decreased with application of CM in combined with Halex-2.

Correlation Coefficients

The significant increases in green pods yield of snap bean plant with application of CM and inoculation the seed with Halex-2 was attributed to significant positive correlation between each of them and some growth characters (Table 9). The green pods yield of snap bean plants was highly positively correlated with the number of branches and leaves, leaf area index, the number of flower clusters, dry mass, number of green pods, pod weight and N uptake characters, orderly.

Discussion

The increment in vegetative, flowering, total dry mass per plant and leaves contents of N and K characters of snap bean plants by adding CM_2 (100 kg N ha^{-1}) may be due improved the soil physical and chemical properties by presence of higher levels of nutrient elements of chicken manure (Amanullah *et al*., 2007). These elements are essentially required for plant growth and contributed to increase the meristematic activity of the plant tissues and in building protein molecules (Marschner, 1995). This could encourage the growth of snap bean plants through prompt in the plants to generate leaves and increasing the elaboration of photosynthates. These results are in harmony with those reported by Soliman *et al*. (1991) and Gabr (2000). The superiority in the number of pods per plant and yield ha^{-1} resulted from CM application (Table 8) owes directly to the increase in the vegetative growth characters (Table 5) and leaf contents of N and K (Table 7) to go forward and accelerate the photosynthetic rate, consequently, increased pods yield. Where, the yield of snap bean plants was highly positively correlated with the number of branches and leaves, leaf area index, the number of flower clusters, dry mass, number of green pods, pod weight and N uptake characters, orderly (Table 9). These results are in line with those reported by (Santos *et al*., 2001; Hassan *et al*., 2012).

The promoting effects of Halex-2 biofertilizer on the growth traits, dry mass per plant and leaf contents of N and K of snap bean plant may be related to the role of the non-symbiotic N_2-fixing bacteria, on improving the availability of nutrients and to the modification growth, morphology, and physiology of the root (Carletti *et al.,* 1996). Biofertilizers produce auxin and auxin-like compounds in plants rhizosphere (Noel *et al*., 1996; Jagnow *et al*., 1991; Frankenberger and Arshad, 1995), which help in transport of minerals and water to plant (Sarig *et al*., 1988) and all might together cause promotion of vegetative growth characters, which reflected positively to the yield. These results are in harmony with those reported by (Choudhary *et al*., 1984; Awad *et al.*, 2002) on the garden pea and potato crops, respectively.

The positive effects of CM and Halex-2 interaction may be attributed to CM activated many species of living organisms, which release phytohormones and may stimulate the plant growth and absorption of nutrients (Arisha *et al*., 2003). Such organisms need nitrogen and organic carbon for multiplication which is provided by the CM. This is a plausible that use of CM with biofertilizer showed a beneficial effect on vegetative growth characters of snap bean plants. Moreover, this interaction in improving nutrient availability in the root zone and accordingly reflected in increasing the vegetative growth, and pods yield characteristics of snap bean. These results appeared to be in close agreement with previous results reported (El-Gamal, 1996; Hammad and Abdel-Ati, 1998; Salinas *et al*., 2011).

It is concluded that application of chicken manure using 100 kg N ha^{-1} and inoculation the seed of snap bean with biofertilizer Halex-2 was leading to increase the growth, the number of flower clusters, dry mass, N uptake, pods yield and its components. Therefore, the combination of chicken manure and biofertilizer have the potential to be used to increase the productivity of snap bean grown in sandy soil poor in organic matter under arid regions condition, as a low input, safe, environmentally friendly agricultural practices.

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