Pak. J. Agri. Sci., Vol. 51(3), 548-554; 2014
ISSN (Print) 0552-9034, ISSN (Online) 2076-0906
http://www.pakjas.com.pk

IMPROVING PRODUCTIVITY, NPK UPTAKE AND WATER USE EFFICIENCY OF SNAP BEAN IN SANDY SOIL

Zohair Mahmoud Mirdad

Department of Arid Land Agriculture, Faculty of Meteorology, Environment, and Arid Land Agriculture
King Abdulaziz University, Saudi Arabia
Correspondence author's e-mail: zmirdad1@yahoo.com ;zmirdad@kau.edu.sa

The responses of dry mass accumulation, NPK uptake, water use efficiency, and green pods yield characters of snap bean plants to biofertilizer Halex-2 under four varying humic acid (HA) rates; 0 (HA_0), 0.3 (HA_1), 0.6 (HA_2) and 1.2 (HA_3) ton ha^{-1}, were studied. Two field experiments were conducted, during the season of 2011 and 2012, at the Agricultural Experiment Stations, Hada-Alsham, King Abdulaziz University, Saudi Arabia. Increasing HA rate up to 1.0 t ha^{-1} (HA_2) led to significant increments in the dry mass accumulation, uptake of N, P and K, green pods yield, the number of pods and water use efficiency characters. Moreover, the results showed that inoculation of snap bean seeds by biofertilizer Halex-2 significantly increased all studied parameters of snap bean plants. Generally, the combination treatment of 1.0 t HA ha^{-1} + Halex-2 was the most beneficial treatment which gave significantly higher mean value for total green pods yield ha^{-1}, number of pods $plant^{-1}$ and water use efficiency.
Keywords: Humic acid, biofertilizer, greenhouse, dry mass, pods yield

INTRODUCTION

Snap bean (*Phaseolus vulgaris* L.) plants are relatively sensitive to environmental stresses that may occur in the field (Abdel-Hakim *et al*., 2012), especially under the sandy soil in arid regions, which negatively affects its growth, yield, and quality of the pods. The characteristics of sandy soil play an important role in the plant's ability to extract water and nutrients. Therefore, the use of organic soil conditioners is a promising way to improve the physiochemical conditions of sandy soils.

Using organic soil amendments such as humic substances, can play an important role in improving soil physical properties (Dauda *et al*., 2008), increasing the organic soil carbon content and raising soil productivity (Remesh, 2008) through promoting the activity of the useful micro-organisms (microbial biomass) in the soil (El-Gizy, 1994; Suresh *et al.*, 2004). Humic substances classified into three general categories like humic acid, fulvic acid and humin (Solange and Rezende, 2008). Humic acid (HA) is commercial product that contains many functional groups situated at the carbon chain (e.g. carboxylic acid, phenol, amine, alcohol, aldehyde, ketone, ether, ester and amide). HA has a beneficial effect on the soil properties or plant growth (Patil *et al.*, 2011). Humic acid is also a source of plant nutrients essential for the plant growth (Yildirim, 2007), enhanced nutrient availability through the chelation of nutrients by the functional groups of HA (Varanini and Pinton, 1995). Moreover, HA has promoted the conversion of insoluble nutrients into forms available to plants and retains water soluble fertilizers in the root zones and releases them to plants when needed. The uptake of HA in plant tissue results in various biochemical effects through increasing in nutrient uptake, maintaining vitamins and amino acids level in plant tissues which in turn stimulates the growth of roots and whole plant (Nardi *et al.*, 202). Because of multiple roles of HA, it can greatly benefit plant growth (Knicker *et al.*, 1993; Tan, 1998; Friedel and Scheller, 2002).

Nitrogen nutrition of snap bean, in particular, presents a complex and somewhat paradoxical problem and has questioned for a long time because of the belief that snap bean fix N to provide the plants with some or all of its N requirements. Actually, snap bean is poor N fixers compared to other legumes (Feleafel and EL-Araby, 2001). Therefore, the use of biological N_2 fixation technology, through application the biofertilizer, can decrease N fertilizer application, and reduce environmental risks (Raimam *et al.*, 2007). This process can contribute as much as 75 kg N ha^{-1} per crop cycle (Irissarri and Reinhold-Hurek, 2001). Biofertilizer Hallex-2 (mixture of non-symbiotic N_2 fixing bacteria, of genera *Azotobacter*, *Azospirillum* and *Klebsiella*) plays a vital role in restoring the natural soil nutrient cycle by fixing and releasing plant available N forms to soil (Mahdi *et al*., 2010), as well as stimulating plant growth through the synthesis of growth promoting substances such as IAA (Frankenberger and Arshad, 1995; Noel *et al*., 1996). Using biofertilizer in improving the plant growth, yield, and quality of snap bean plants have reviewed by several authors (Wani and Lee, 1995; El-Bassiony *et al.*, 2010).

The present study was conducted to investigate the effect of biofertilizer under varying levels of organic soil amendment;

humic acid, on dry mass accumulation, NPK uptake, water use efficiency, and green pods yield characteristics of snap bean plants growing in sandy soil under greenhouse conditions.

MATERIALS AND METHODS

Two greenhouse experiments in sandy soil were conducted at the Agricultural Experiment Stations, Hada-Alsham, King Abdulaziz University, Saudi Arabia, during the summer season of 2011 and 2012, to find out the response of snap bean plants cv. "Super Stryke" to the inoculation with Halex-2 biofertilizer under varying organic soil conditioner rates. Each experiment included eight treatments; four rates of organic soil conditioner (Perlhumus) as a source of humic acid (HA); 0 (HA_0), 0.3 (HA_1), 0.6 (HA_2) and 1.2 (HA_3) ton humic acid ha^{-1} applied single, or in combined with Halex-2 biofertilizer. Perlhumus is granulated humic acid for soil and plant, was produced by Humin Tech Co. Germany. The chemical composition and physical properties of Perlhumus are presented in Table 1. 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.

Table 1. Chemical composition and physical properties of perlhumus

Humic acids	approx. 60%
Moisture	15-20% as shipped
CEC	400-600mval/100g
Water holding capacity	about 20 times
pH-value	4-5
Salinity	0.41%
N (organic)	1.0%
P_2O_5	0.2%
K_2O	0.3%
CaO	0.5%
Fe	1.1%
Mg	0.1%
Color	dark brown
Product type	Granulates

Soil and irrigation water analysis**:** Preceding initiation of each experiment, some important physical and chemical properties of the experimental soil (0-30 cm depth), and chemical properties of irrigation water obtained from a local well, were estimated according to the published procedures (Page *et al*., 1982). The soil texture was sandy loam-clay (65.5 % sand, 20.1% silt and 14.4% clay) with pH= 7.4 and organic matter = 0.3%. Available soil N, P and K were 30, 11 and 19 mg kg^{-1}, respectively. The irrigation water had an EC value of 3.1 dSm^{-1} and contained Na = 26.1, Mg = 0.95, Ca = 7.25, HCO_3= 0.59, Cl=38.8 and SO_4= 8.52 meq l^{-1}.

Experimental design**:** The treatments were set in factorial randomized complete block design with three replicates. Each experimental unit contained two rows; 3 m × 2 m. Before sowing immediately, Perlhumus treatments (HA) were incorporated into the soil of rows at 10 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. Seeds of the snap bean were sown on March 9, 2011 and March12, 2012, in four lines on each row. The row spacing was 15 cm between the seeds and 20 cm between the lines.

Irrigation and fertilization**:** The actual evapotranspiration of the snap bean crop (ETc), 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 2), throughout the growing season (March–June), 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 4L 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.

All treatments received N, P and K fertilizers at the rates of

Table 2. 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}	15.00	25.00	50.00
Crop Coefficients (K_C)	0.50	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)	3.10	4.20	4.80
Water requirements of snap bean crop (ET_c) mm day^{-1}	1.55	4.41	4.32
Total water requirements per growth stage (mm)= 349.5	23.25	110.25	216.00

100-150-200 kg ha^{-1} as NPK (20-20-20), urea (46%N), phosphoric acid (58% P_2O_5), potassium sulfate (48% K_2O). NPK fertilizers were injected directly into the irrigation water (fertigation) using a venture injector at two doses weekly starting in the 2nd week after transplanting (WAT) up to the 12th week. 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 25 ± 2.6°C and 73 ± 4% through snap bean growth stages, respectively.

***Data recorded*:** In each experimental unit, the snap bean plants in the first row were allocated to estimating the dry mass accumulation (kg ha^{-1}), after 75 days from sowing. Moreover, concentrations of the N, K and P of root, shoot, and the pods were estimated as described by Cottenie (1980). The uptake of N, P and K (kg ha^{-1}) calculated as the product of the crop biomass (dry weight). The plants of second row were saved to find the green pods yield and its component characters. Water-use efficiency (kg m^{-3}) was calculated by dividing the total green pods yield (kg ha^{-1}) by total water applied (3495 m^3 ha^{-1}).

***Statistical analysis*:** 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 ($P<0.05$).

RESULTS

Effects on dry mass accumulation: Dry mass of snap bean plants was mainly distributed in pods, followed by shoot, and roots (Table 3). Soil application of HA had marked and significant effect on dry mass accumulation of different organs of snap bean plants. Increasing HA rate up to 1.0 t ha^{-1}(HA_2) was associated with significant increments in the dry mass (Kg ha^{-1}) of roots (78.4%), shoot (26.3%), pods (48.0%), and total dry mass (39.4%) over control, as an average of the two season.

Inoculation the seed of snap bean with the biofertilizer Halex-2 significantly gave the higher magnitudes of root, shoot, and pods dry mass as well as total dry mass (Kg ha^{-1}) with an increase of 52.2, 17.9, 10.8 and 16.3%, respectively, over the non-inoculated ones (Table 3).

The soil application of HA_2 (1.0 t ha^{-1}) and the inoculation of the seeds by the Halex-2 bio fertilizer recorded the highest mean values of dry mass accumulation of the root, shoot, and pods as well as a total dry mass of snap bean plants compared to the other treatments, in both seasons (Table 3). The maximum increase in the accumulation of the dry mass was achieved of roots (219.2 %), followed by total dry mass (70.8%), pods (68.1%) and shoot (59.6%), over control, as an average of the two season.

***Effects on N, P_2O_5 and K_2O uptake*:** The results showed that there were significant differences in N, P_2O_5 and K_2O uptake of snap bean plants based on soil application of HA (Table 4). Increasing rate of HA up to 1.0 t ha^{-1} was associated with corresponding and significant increments in N, P_2O_5 and K_2O uptake kg ha^{-1}.

Inoculation the seeds of the snap bean with the biofertilizer Halex-2 significantly increased N, P_2O_5 and K_2O uptake kg ha^{-1}compared to the non-inoculated treatment. Generally, the soil application of HA_2 (1.0 t ha^{-1}) with the inoculation the seeds by the Halex-2 recorded the highest mean values of N,

Table 3. Effect of organic soil amendments (humic acid) and biofertilizer on the dry mass accumulation of snap bean during seasons of 2011 and 2012

Treatments	Root dry mass (kg ha^{-1})		Shoot dry mass (kg ha^{-1})		Pods dry mass (kg ha^{-1})		Total dry mass (kg ha^{-1})	
	2011	2012	2011	2012	2011	2012	2011	2012
HA_0*	265.6c	307.2c	2236.8c	2361.6c	2165.6d	2304.8c	4668.0c	4973.6c
HA_1	261.6c	322.4c	2101.6d	2209.6d	2311.2c	2341.6c	4674.4c	4873.6c
HA_2	492.0a	529.6a	2893.6a	2912.8a	3310.4a	3305.6a	6696.0a	6748.0a
HA_3	332.0b	371.2b	2525.6b	2581.6b	2950.4b	3061.6b	5808.0b	6014.4b
Non Halex-2	263.6b	307.6b	2219.2b	2329.2b	2560.0b	2598.4b	5042.8b	5235.2b
Halex-2	412.0a	457.6a	2659.6a	2703.6a	2808.8a	2908.4a	5880.4a	6069.6a
HA_0*	169.6d**	204.8e	1918.4e	2025.6d	2008.0f	2209.6e	4096.0e	4440.0f
HA_0+ Halex-2	361.6bc	409.6bc	2555.2c	2697.6b	2323.2de	2400.0d	5240.0cd	5507.2d
HA_1	198.4d	280.0de	1990.4e	2084.8d	2211.2e	2241.6e	4400.0e	4606.4f
HA_1+ Halex-2	324.8bc	364.8bcd	2212.8d	2334.4c	2411.2d	2441.6d	4948.8d	5140.8e
HA_2	411.2b	436.8b	2652.8bc	2664.0b	3140.8b	3003.2c	6204.8b	6104.0bc
HA_2+ Halex-2	572.8a	622.4a	3134.4a	3161.6a	3480.0a	3608.0a	7187.2a	7392.0a
HA_3	275.2cd	308.8cde	2315.2d	2542.4b	2880.0c	2939.2c	5470.4c	5790.4cd
HA_3+ Halex-2	388.8b	433.6b	2736.0b	2620.8b	3020.8bc	3184.0b	6145.6b	6238.4b

* Humic acid (HA) treatments; HA_0 (0), HA_1 (0.3), HA_2 (0.6) and HA_3 (1.2) ton humic acid ha^{-1}. **Values having the same alphabetical letter in common, within a particular group of means in each character, do not significantly differ, using the revised LSD test at $P<0.05$.

Table 4. Effect of organic soil amendments (humic acid) and biofertilizer on the N, P_2O_5 and K_2O uptake of snap bean during seasons of 2011 and 2012.

Treatments	N uptake (kg ha^{-1})		P_2O_5 uptake (kg ha^{-1})		K_2O uptake (kg ha^{-1})	
	2011	2011	2011	2012	2011	2012
HA0*	131.66c	139.76d	48.33d	48.19d	75.35c	77.07c
HA1	135.80c	143.85c	60.15c	62.35c	74.83c	81.12c
HA2	203.16a	213.63a	132.15a	129.95a	120.07a	127.23a
HA3	163.22b	173.33b	96.83b	84.61b	99.22b	102.80b
Non Halex-2	135.74b	145.40b	75.02b	74.56b	79.97b	82.22b
Halex-2	181.18a	189.88a	93.71a	87.98a	104.76a	111.89a
HA_0*	104.14g**	113.89h	26.11f	34.62h	54.64g	55.20f
HA_0+ Halex-2	159.17d	165.63d	70.55d	61.76f	96.06c	98.95c
HA_1	122.76f	132.32g	52.97e	55.46g	67.48f	69.39e
HA_1+ Halex-2	148.84e	155.38f	67.33d	69.23e	82.18e	92.84d
HA_2	167.53c	171.68c	131.84a	118.46b	106.42b	110.23b
HA_2+ Halex-2	238.79a	255.58a	132.45a	141.43a	133.71a	144.23a
HA_3	148.52e	163.72e	89.17c	89.70c	91.34d	94.07d
HA_3+ Halex-2	177.92b	182.94b	104.49b	79.51d	107.09b	111.53b

* Humic acid (HA) treatments; HA_0 (0), HA_1 (0.3), HA_2 (0.6) and HA_3 (1.2) ton humic acid ha^{-1}. **Values having the same alphabetical letter in common, within a particular group of means in each character, do not significantly differ, using the revised LSD test at $P<0.05$.

Table 5. Effect of organic soil amendments (humic acid) and biofertilizer on the green pods yield, its components, and water use efficiency (Kg m^{-3}) of snap bean during seasons of 2011 and 2012.

Treatments	Pods yield (ton ha^{-1})		Pods No. per plant		Pod weight (g)		Pod thickness (mm)		Water use efficiency (Kg m^{-3})	
	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
HA_0*	10.01b	9.80c	13.7d	12.6c	5.0a	4.9a	6.9a	7.0a	2.63c	2.57c
HA_1	11.03b	10.77b	15.9b	14.7b	4.5b	4.6b	6.4b	6.4c	2.89b	2.82b
HA_2	16.21a	15.58a	22.1a	21.8a	4.7b	4.6b	6.9a	6.7b	4.25a	4.08a
HA_3	11.16b	10.64b	14.5c	14.4b	4.6b	4.5b	6.5b	6.5c	2.92b	2.79b
Non Halex-2	11.20b	11.00b	14.6b	13.8b	4.9a	4.8a	6.8a	7.0a	2.94b	2.88b
Halex-2	13.00a	12.40a	18.5a	18.0a	4.5b	4.3b	6.5b	6.3b	3.41a	3.25a
HA_0*	9.19d**	9.16c	12.0e	11.3d	5.4a	5.2a	7.2a	7.7a	2.63b	2.62c
HA_0+ Halex-2	10.83cd	10.44bc	15.3c	13.8cd	4.6cd	4.5bc	6.5a	6.3a	3.10b	2.99bc
HA_1	10.19cd	9.90bc	14.9cd	13.0d	4.6cd	4.5bc	6.3a	6.3a	2.92b	2.83bc
HA_1+ Halex-2	11.87c	11.64b	16.8bc	16.4bc	4.4de	4.2c	6.4a	6.4a	3.40b	3.33b
HA_2	15.18b	14.89a	18.9b	18.3b	4.8bc	4.8b	7.1a	7.0a	4.34a	4.26a
HA_2+ Halex-2	17.24a	16.27a	25.3a	25.3a	4.6cd	4.4c	6.6a	6.4a	4.93a	4.66a
HA_3	10.25cd	9.95bc	12.5de	12.4d	4.9b	4.8b	6.5a	6.8a	2.93b	2.85bc
HA_3+ Halex-2	12.07c	11.33bc	16.4bc	16.3bc	4.2e	4.2c	6.4a	6.2a	3.45b	3.24bc

* Humic acid (HA) treatments; HA_0 (0), HA_1 (0.3), HA_2 (0.6) and HA_3 (1.2) ton humic acid ha^{-1}. **Values having the same alphabetical letter in common, within a particular group of means in each character, do not significantly differ, using the revised LSD test at $P<0.05$.

P_2O_5 and K_2O uptake kg ha^{-1}of snap bean plants compared to the other treatments (Table 4).

***Green pods yield, its components, and water use efficiency*:** Increasing soil application levels of HA up to 1.0 t ha^{-1} (HA_2), led to increase pods green yield (t ha^{-1}), the number of pods per plant and water use efficiency (kg m^{-3}). However, it reduces the weight and thickness of the pod (Table 5). The increases in pods green yield ha^{-1}, the number of pods plant^{-1} and water use efficiency were 60.4, 66.9 and 60.2%, respectively, over the control treatment, as an average of the two seasons.

Inoculation of snap bean seeds with the biofertilizer Halex-2 achieved significant positive influence on the total green pods yield ha^{-1}, number of pods plant^{-1} and water use efficiency as well as a negative effect on the weight and thickness of the pod, as compared to the non-inoculated ones, in both growing seasons (Table 5).

The comparisons presented in Table 5 illustrated the presence of significant interaction effects between different HA rates and biofertilizer treatments, on the pods yield characters and water use efficiency, in both seasons. The comparisons among the eight interactive treatments, generally, indicated that, the combination treatment of 1.0 t HA ha^{-1}+ Halex-2 was the most beneficial treatment which gave significantly higher mean values for total green pods yield ha^{-1}, number of pods $plant^{-1}$ and water use efficiency , in both seasons. The increments were 82.7, 117.2, and 82.7 % in pods yield ha^{-1}, number of pods $plant^{-1}$ and water use efficiency over the control treatment, orderly, as an average of the two seasons. However, weight and thickness pod^{-1} showed insignificantly decreased with the application of HA in combined with Halex-2.

DISCUSSION

Snap bean is poor N fixers compared to other legumes (Feleafel and EL-Araby, 2001). Therefore, the use of biological N_2 fixation technology, through application the biofertilizer as a promising way to supply the snap bean by some or all of its N requirements, but it not is an effective way under the sandy soil in arid regions, due to lower content of organic carbon in sandy soil. This research proposed to promote the activity of the useful micro-organisms (microbial biomass) in the soil through application the biofertilizer; Halex-2 and the organic soil amendment; humic acid, and its impact on the productivity, NPK uptake and water use efficiency of snap bean. The results indicated that humic acid and biofertilizer; Halex-2 as well as their interactions, appeared to have a clear effect on all the tested characters of snap bean.

Increasing HA rate up to 1.0 t ha^{-1} (HA_2) led to significant increments in the dry mass accumulation of roots, shoot, pods, and total dry mass, uptake of N, P and K, green pods yield, the number of pods and water use efficiency characters. The promoting effects of HA on the dry mass of snap bean plant could be related to uptake HA into the plant tissue resulting in an increase cell membrane permeability, which increases the uptake of nutrients (Sial *et al.*, 2007). In addition to its role in increasing oxygen uptake and photosynthesis (Chen *et al*., 1994), phosphorus uptake and accelerates cell division and root development (Cimrin and Yilmaz, 2005). Root growth enhancement has been may be attributed to improved soil structure, stimulation and proliferation of desirable soil microflora, and hormone-like activities (El-Hefny, 2010). A positive response of morphological characters to application of HA is previously obtained by EI-Bassiony *et al*. (2010) on snap bean and El-Ghamry *et al.* (2009) on faba bean. The superiority in pods green yield ha^{-1}, the number of pods $plant^{-1}$ and water use efficiency resulted from HA application owes directly to the increase in the dry mass accumulation of roots and uptake of N, P and K go forward and accelerates the photosynthetic rate, consequently, increased pods yield. These results are confirmed with those reported by Santos *et al.* (2001) and Hassan *et al.* (2012).

Inoculation of snap bean seeds by biofertilizer Halex-2 indicated that significantly increased all studied parameters of snap bean plants. The promoting effects of biofertilizer on the dry mass characters could be related to the role of the non-symbiotic N_2 fixing bacteria on improving the availability of nutrients and to the modification the growth, morphology and physiology of roots, through hormonal exudates of biofertilizers bacteria (Jagnow *et al.*, 1991). The detected positive effects of biofertilizer on snap bean yield might be related to the fact that biofertilizer inoculation stimulates root growth (Carletti *et al.*, 1996) and enhances uptake of minerals. It may be, also, due to the involvement in phytohormones production such as IAA and cytokinins (Noel *et al.*, 1990) which all might together cause promotion of vegetative growth characters, which reflected positively on the pods yield and water use efficiency. These results matched well with those reported on potato by many investigators (El-Gamal, 1996; Ashour *et al*., 1997; Feleafel, 2005).

The combination treatment of 1.0 t HA ha^{-1} + Halex-2 was the most beneficial treatment which gave significantly higher mean value for dry mass accumulation, N, P_2O_5 and K_2O uptake, total green pods yield ha^{-1}, number of pods $plant^{-1}$ and water use efficiency. The positive effects of this interaction may be attributed to the ability of HA and biofertilizer on improving nutrient availability in the root zone and accordingly, reflected this effect on increasing the dry mass accumulation of the root, shoot, and pods as well as a total dry mass of snap bean plants. Moreover, this effect may be attributed to HA is a source of plant nutrients essential for the plant growth (Yildirim *et al*., 2007), enhanced nutrient availability through the chelation of nutrients by the functional groups of HA (Varanini and Pinton, 1995) and promotes the conversion of insoluble nutrients into forms available to plants. Furthermore, HA increases the phosphorus uptake and accelerates cell division and root development (Cimrin and Yilmaz, 2005).

***Conclusions*:** Generally, it could be concluded that soil application of the humic acid at the rate 1.0 t ha^{-1} combined with inoculation of the seeds of snap bean with biofertilizer Halex-2 lead to increased productivity and water use efficiency of snap bean, as approach encompassing a low-input, safe and environment friendly.

***Acknowledgement*:** This work was funded by the Deanship of Scientific Research (DSR), King Abdulaziz University, Jeddah, under grant No. (155-001-D1433). The authors, therefore, acknowledge with thanks (DSR) technical and financial support.

REFERENCES

Abdel-Hakim, W.M., Y M M. Moustafa and R H M. Gheeth. 2012. Foliar application of some chemical treatments and planting date affecting snap bean (*Phaseolus vulgaris* L.) plants grown in Egypt. J. Hort. Sci. & Ornamen. Plants. 4: 307-317.

Allen, R.G., L.S. Pereira, D. Raes and M. Smith. 1998. Crop evapotranspiration- Guidelines for computing crop water requirements, pp.104-114. In: FAO Irrigation and drainage paper No. 56. FAO Rome, Italy.

Ashour, S.A., A.E. Abdel-Fattah and A.A. Tawfik. 1997. Effect of nitrobien (biofertilizer) and different levels of nitrogen on growth and yield of potato (*Solanum tuberosum* L.). J. Agric. Sci. Mansoura Univ. 22: 3979-3986.

Bricker, B. 1991. MSTATC: A micro computer program from the design management and analysis of agronomic research experiments. Michigan State University, USA.

Carletti, S., C.E. Rodriguez and B. Liorente. 1996. Effect of biofertilizer application on jojoba cultivation. Proc. 3rd Intl. Conf. New Industrial Crops and Products, 25-30 Sept 1994, Catamarca, Argentina; pp. 53-55.

Chen, Y., H. Magenand and J. Riov. 1994. Humic substances originating from rapidly decomposing organic matter: properties and effects on plant growth, pp.427-443. In: N. Senesi and T. M. Miano (eds.), Humic Substances in the Global Environment and Implication on Human Health. Elsevier, Amsterdam, The Netherlands.

Cimrin, K.M. and I. Yilmaz. 2005. Humic acid applications to lettuce do not improve yield but do improve phosphorus availability. Acta. Agr. Scand. B-S P. 55: 58-63.

Cottenie, A. 1980. Soil and plant testing as a basis of fertilizer recommendations, pp.55-60. In: FAO Soil Bulletin. Soil Resources, Management and Conservation Service No. 38/2. FAO Rome, Italy.

Dauda, S.N., F.A. Ajayi and E. Ndor. 2008. Growth and yield of watermelon (*Citrullus lanatus*) as affected by poultry manure application. J. Agric. Soc. Sci. 4: 121–124.

El-Bassiony, A.M., Z.F. Fawzy, M.M. Abd El-Baky and A.R. Mahmoud. 2010. Response of snap bean plants to mineral fertilizers and humic acid application. Res. J. Agric. & Biol. Sci. 6:169-175.

El-Gamal, A.M. 1996. Response of potato in newly reclaimed areas to mineral nitrogen fertilizer levels and nitrogen fixing biofertilizer “Halex-2”. Assiut. J. Agric. Sci. 27: 89-99.

El-Ghamry, A.M., K.M. Abd El-Hai and K.M. Ghoneem. 2009. Amino and humic acids promote growth, yield, and disease resistance of faba bean cultivated in clayey soil. Austr. J. Basic & Appl. Sci. 3:731-739.

El-Gizy, S.M. 1994. Comparative study for influence of manure sources on growth, yield and pod quality of pea. Minufiya J. Agric. Res. 19: 3243-3257.

El-Hefny, E.M. 2010. Effect of saline irrigation water and humic acid application on growth and productivity of two cultivars of cowpea (*Vigna unguiculata* L. Walp). Austral. J. Basic & Appli. Sci. 4: 6154-6168.

Feleafel, M.N. and S.M. EL-Araby. 2001. Response of snap bean cultivars (*Phaseolus vulgaris* L.) to varying rates of nitrogen and phosphorus fertilization. J. Agric. Sci. Mansoura Univ. 26: 1391–1404.

Feleafel, M.N. 2005. Effect of NPK and biofertilizer types on vegetative growth, tuber yield and quality of potato. J. Agric. & Env. Sci. Alex. Univ. 4: 96-113.

Frankenberger, Jr. W.T. and M. Arshad. 1995. Phytohormones in soil: Microbial production and function. Marcel Dekker Inc., New York, USA.

Friedel, J.K. and E. Scheller. 2002. Composition of hydrolysable amino acids in soil organic matter and soil microbial biomass. Soil Biol. Biochem. 34: 315-325.

Hassan, M.M., A.G. Osman, Y.S. Osman, A.M. Sherif, A.M. Rugheim, I. Sa Mohamed, M.E. Abdel Gani and A.E. Babiker. 2012. Effects of bacterial strains and chicken manure on *Orobanche crenata* infesting faba bean. Inter. J. Appli. Sci. Tech. 2: 122-129.

Irissarri, P. and B. Reinhold-Hurek. 2001. *Azoarcus* sp. strain BH72 as a model for nitrogen-fixing grass endophytes. J. Biotech. 106: 169-178.

Jagnow, G., G. Hoflich and K.H. Hoffmann. 1991. Inoculation of non-symbiotic rhizosphere bacteria: Possibilities of increasing and stabilizing yields. Angew Botanik. 65: 97-126.

Knicker, H., R. Frund and H.D. Ludemann. 1993. The chemical nature of nitrogen in native soil organic matter. Naturwissenschaften 80: 219-221.

Mahdi, S.S., G.I. Hassan, S.A. Samoon, H.A. Rather, S.A. Dar and B. Zehra. 2010. Bio-fertilizers in organic agriculture. J. Phytology 2: 42-54.

Nardi, S., D. Pizzeghello, A. Muscolo and A. Vianello. 2002. Physiological effects of humic substances on higher plants. Soil Biol. Biochem. 34: 1527-1536.

Noel ,T.C., C. Cheng, C.K .Yost, R.P. Pharis and M.E. Hyne. 1996. *Rhizobium leguminosarum* as a plant growth Promoting rhizobacterium: direct growth promotion of canola and lettuce. Can. J. Microbiol. 42: 279-383.

Page, A.L., R.H. Miller and D.R. Reeney. 1982. Methods of Soil Analysis, part 2. ASA, SSSA, Madison, Wisconsin, USA.

Patil, R.B., A.S. Kadam and S.S. Wadje. 2011. Role of potassium humate on growth and yield of soybean and black gram. Inter. J. Pharma and Bio. Sci. 2: 242-246.

Qassim, A . and B. Ashcroft. 2002. Estimating vegetable crop water use with moisture-accounting method # AG1192, DPI Victoria. Available online with updates at http://www.dpi.vic.gov.au/agriculture/horticulture/vegetables/vegetable-growing-and-management/estimating-vegetable-crop-water-use

Raimam, M.P., U. Albino, M.F. Cruz, G.M. Lovato, F. Spago and T.P. Ferracin. 2007. Interaction among free-living N-fixing bacteria isolated from *Drosera villosa* var. villosa and AM fungi (*Glomus clarum*) in rice (*Oryza sativa*). Appli. Soil Eco. 35: 25-34.

Razmi, Z., A.A. Ghaemi. 2011. Crop and soil-water stress coefficients of tomato in the glass-greenhouse conditions. J. Sci. & Tech. Greenhouse Culture 2:87-92.

Remesh, P. 2008. Organic farming research in M.P. Organic farming in rain fed agriculture, pp.13-17. Central institute for dry land agriculture, Hyderabad, India.

Santos, G.M., A.P. Oliveira, J.L. Silva, E.U. Alves and C.C. Costa. 2001. Characteristics and yield of snap-bean pod in function of sources and levels of organic matter. Hortic. Bras. 19: 30–35.

Sial, R.A, E.H. Chuadhary, S. Hussain and M. Naveed. 2007. Effect of organic manures and chemical fertilizers on grain yield of maize in rain fed area. Soil Environ. 26: 130-133.

Solange, L.M. and M.O. Rezende. 2008. Capillary Electrophoresis (CE): A powerful tool to characterize humic acid (HA). J. Brazil. Chem. Soc. 19: 24-28.

Suresh, K.D., G. Sneh, K.K. Krishn and C.M. Mool. 2004. Microbial biomass carbon and microbial activities of soils receiving chemical fertilizers and organic fertilizers. Archives Agron. Soil Sci. 50: 641–647.

Tan, K.H. 1998. Colloidal chemistry of organic soil constituents, pp.177-258. In: H. Tan (ed.), Principles of Soil Chemistry. Marcel Dekker, New York, USA.

Varanini, Z. and R. Pinton. 1995. Humic substances and plant nutrition. Prog. Bot. 56: 97–117.

Wani, SP., K.K. Lee. 1995. Microorganisms as biological inputs for sustainable agriculture in organic agriculture, pp.39-76. In: P.K. Thampan (ed.), Peekay Tree Crops Development Foundation, Cochin, India.

Yildirim, E. 2007. Foliar and soil fertilization of humic acid affect productivity and quality of tomato. Soil Plant Sci. 57: 182-186.