37 *Egypt. J. Hort.* **Vol. 42,** No. 1, pp. 557 – 576 (2015)

The Influence of Subsurface Drip Irrigation and Molybdenum Application on Morphological and Yield Component of Two Common Bean Cultivars under Greenhouse Conditions

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SAVING IRRIGATION water and thereby increasing crop water-use efficiency are especially important in water-scarce regions. For that, a greenhouse experiments were carried out during the winter season of 2012 and 2013 at the Army Farm, El Amria region, Alexandria, Egypt in order to study the effect of line depth placement of drip lines and different levels of molybdenum on two common bean varieties .Irrigation systems,(surface drip irrigation (SDI) , subsurface drip irrigation at 15cm and 30 cm. were arranged as main plots . Two green beans varieties 'Bronco' and 'Paulista' were arranged within each irrigation system (greenhouse) and were considered as sub-plot. Ammonium molybdate concentrations (0, 0.25, 0.50 and 1 g/ L. water) were arranged within each variety and considered as sub-sub plot. The obtained results could be summarized as follows ; generally the subsurface drip irrigation at 15 cm was the best irrigation treatment for foliage fresh weight, number of nodules per plant , early yield / plant , number of pods /plant and total yield of green pods / plant and per plot. However, application of ammonium molybdate levels 0.25 or 0.5 gm./L. had significant effect on leaf area/ plant , root length and number of nodules /plant . No significant difference between Bronco and Paulista on total yield. The Highest significant total yield of green pods plant^{-1} and yield of green pods plot^{-1} (654.17 g/plant and 15.70kg /plot) were obtained when "Bronco" cultivar plants grown under subsurface drip irrigation system at 15 cm depth (SSDI-15) and sprayed with 0.50g ammonium molybdate.

Common beans (*Phaseolus vulgaris* L.) as legume vegetable crop occupied, recently, in Egypt a progressive site among the others with respect to the national income, due to the export amount of the green pods especially, to the European countries. The demand of this crop increasing in a large scale either in the local or in the international markets So, it becomes more necessary to enhance the productivity of such crop with respect to the yielding performance and quality aspects. That could be maintained through the use of a good cultivars characterized especially; by high yielding ability of the green pods and quality components and adapted for the growing under the greenhouses established in the semi-desert region.

Well-managed subsurface drip irrigation (SDI) systems save water in the irrigation of many agricultural crops because water is directly applied in the root zone without losses due to evaporation or runoff (Suarez-Rey *et al*., 2006). Also, SDI improves the plants' health, farming operations and management (Elmaloglou and Diamanto-poulos, 2009). One of the most commonly discussed aspects of SDI system is installation depth of drip lateral. In designing subsurface drip irrigation systems for row crops, the dimensions of the wetted volume and the distribution of soil moisture within this volume are two of the main factors in determining installation depth and spacing of drippers to obtain an optimum distribution of water in the crop root zone (Kandelous and Suimunek, 2010). Moreover, determination of quantity and direction of water flow is very important for sustainable land management. While deeper lateral depth leads to the reduction of soil evaporation, a deep installation of emitters can increase water losses due to deep percolation and decrease availability of water for crop roots (Dukes and Scholberg, 2005). Lateral depths have been poorly studied as a treatment variable; hence, little can be said about crop yield differences with lateral depth. Lateral depths vary from 0.02 to 0.70 m, depending upon both the soil and crop (Elmaloglou and Diamantopoulos, 2009). The effects of subsurface drip irrigation with different drip line depths on yield, yield components and water use characteristics of common bean and other vegetable crops were previously studied by many researchers El Noamani *et al.* (2010) , El Mogy *et al.* (2012) , Gencoglan *et al.* (2006) , Scholberg and Locasio (1999) , Halin *et al.* (2010) on common bean , Bozkurts and Mansurolu (2011) on lettuce, Rouphael *et al.* (2006) 0n summer squash, Camp *et al.* (2000) and Neelon and Rajput (2007) on potato Enciso *et al.* (2007) on onion and Cetain and Uygan (2008) on tomato.

Molybdenum is of essential importance for (nearly) all biological systems The metal itself is biologically inactive unless it is complexes by a special cofactor. With the exception of bacterial nitrogenase, where Mo is a constituent of the FeMo-cofactor, Mo is bound to a protein, thus forming the ammonium molybdatecofactor (Moco) which is the active compound at the catalytic site of all other Mo-enzymes. The plant needs some macro- and micronutrients for its normal growth. Some of these elements play an important role in the process of Rhizobium symbiosis: for example, molybdenum is a constituent of the nitrogenase enzyme, and every bacteria which fixes nitrogen needs molybdenum during the fixation process. Molybdenum has a positive effect on yield, quality and nodule forming in legume crops especially in soils which are deficient in this element like acidic and calcareous soil. Mendel and Hansch (2002).

The present work could be considered as an approach in this direction aiming to study the effectiveness of the use of a molybdenum as a nutritive microelement has an effective role in the nitrogen fixation, since this element is involved in the biosynthesis of several enzymes necessary for growth of plants as given by Bouzid and Rahmoum (2012). That could be applied in form of sodium or ammonium molybdate as previously demonstrated by Weir (2004). The availability of molybdenum for plant growth is strongly dependent on the soil pH, concentration of adsorbing oxides (e.g. Fe oxides), extent of water drainage, and organic compounds found in the soil colloids. In alkaline soils, molybdenum becomes more soluble and is accessible to plants mainly in its anion form as Mo⁻· The effect of different doses of molybdenum on growth , yield and nodulation of legume crops were also studied by Campo *et al*. (2009), Kandil *et al*. (2013) Bhuiyan *et al*. (2008), Sylvie and Ndakidemi (2010), Tayoga *et al*. (2008), Tahir *et al*. (2011) and Abdul Jabbar & Saudi (2012).

As a result of the continues increase in population number, progressive increment in fresh local consumption, and both processing and exportation demands, efforts should be directed towards increasing yield potential per unit area to face all these necessities. For this reason the present work is a contribution in this way aiming to evaluate four levels of molybdenum application under three irrigation methods (surface drip irrigation, 15 and 30cm subsurface drip irrigation) on two common bean cultivars (Bronco and Paulista). Interactions among studied factors with respect to morphological and yield component of common bean plants are also considered herein.

Material and Methods

Two greenhouse experiments were carried out during the winter seasons of 2012 and 2013, at Army Farm, El Amria region, Alexandria, Egypt. El Amria region located in Alexandria at the northern cost in Egypt, with latitude 31.2^o N and the longitude 29.9^o E and altitude 7m above sea level .Preceding the initiation of each experiment, soil samples at 30cm depth were tested and analyzed for some soil's physical and chemical properties as listed in Table 1.

Three irrigation systems were used in the present study; representing surface drip irrigation (SSDI), subsurface drip irrigation at 15 and 30 cm depth (SSDI-15 &30 cm.).

A trickle irrigation system was designed for the experiments. Two GR laterals 16 mm in diameter were laid for each plant row, and inline emitters with discharge rate of 4.2 L / hr were spaced at 50 cm intervals on the lateral line without distance between each other. The system was operated at 3 bars throughout the growing season. For subsurface drip irrigation systems the GR laterals were placed at 15 and 30cm depths under the soil surface the laterals were laid under the soil surface alternative to each other, then the trenches were carefully backfilled with the previously removed soil. For good plant establishment, before planting a total of 5 m^3 of irrigation water was applied equally to all treatment plots in the nine different greenhouses. After the stand establishment, surface drip laterals were removed in all the subsurface irrigation greenhouses.

The irrigation system has a typical control unit consisted of a pump, fertilizer tank, gravel and disc filters, control valves, pressure gauges and a flow meter. The applied water was controlled by the flow meter.

TABLE 1. Physical and chemical properties of greenhouse soil experimental sites, analyzed in 2011/2012 and 2012/2013.

Season		**2011-2012**	**2012-2013**
Depth		**0 – 30**	**0 – 30**
Physical properties		Calcareous	Calcareous
Chemical properties pH E.C ds.m^{-1}		 8.04 5.97	 7.69 6.09
Soluble Cations (mg^{+1})	Na^{+}	17.8575	17.39
	K^{+}	5.015	3.85
	Ca^{++}	28.05	34.40
	Mg^{++}	14.65	14.20
Soluble Anions (mg^{+1})	CO^{-3}	0	0
	HCO^{-3}	7.05	8.20
	CL^{-}	21.75	22.0
	SO^{-4}	30.9	3.70
SAR		4.145	3.53
CaCo3 (%)		8.72	9.77
O.C (%)		.75	.79
Mo (%)		1.20	1.36
P (ppm)		160.00	180.00
K (ppm)		220.00	230.00
$NR._3$ (ppm)		300.00	301.00
NH_4 (ppm)		150.00	154.00
MoO_4^- (mg kg^{-1})		0.81	0.92
Mechanical properties	Sand (%)	92	89
	Silt (%)	4	5
	Clay (%)	6	6
Textures		Sandy	Sandy
Average of Virtual Density (gm /c m^3)		1.45	1.59
Porosity Average (%)		39.5	41.13
Field Capacity (%)		11.92	12.39

Irrigations were started when the readings of the Profile Prop (Model: KCB-300) approached the reading (Dry). The Profile Prop was calibrated to detect soil moisture content percentage, using the gravimetric soil samples by soil auger. Moisture content for each location was measured at 0.15-m increments to a depth of 0.60 m shortly before and 48 hours after irrigation. Soil samples oven-dried at 105^{o}C and the gravimetric soil water contents (%) were measured. This procedure was carried out for all treatments two times during the agricultural season. The average soil moisture was (5.2%) when the Profile Prop shows (Dry) reading. It is important to wet a relatively large part of the potential root system and to have a large enough volume of moist soil to promote root intention and water uptake. Water distribution in the soil profile was presented in a separate experiment conducted in the winter season of 2010 before the beginning of the experiments to measure the dimensions of the wetted volume and the distribution of soil moisture within this volume Radius of wetting of area the soil surface and to detect the best irrigation period.

Two commercial , common and widely grown cultivars in Egypt -green bean cultivars were used in this study namely; Bronco and Paulista. The 'Bronco' and 'Paulista'.

Ammonium molybdate levels (NH_4) $6Mo_7O_{24}$- $4H_2O$) (0, 0.25, 0.50 and 1.00g ammonium molybdate / L. water were applied as foliar application in three times. The first addition was done after two weeks from sowing, the second one was carried out after two weeks from the first one and the third addition was carried out after one month from the first addition.

Experimental Layout

A split - split - plot experiment in randomized complete block design (RCBD) with three replicates was used in the two experiments of 2012 and 2013. Twenty four different treatments were used in these experiments during each season .Irrigation systems ,surface drip irrigation (SSDI), subsurface drip irrigation at 15 and 30cm depth (SSDI – 15 & 30) were arranged as main plots Fig.1. each main type of irrigation method represent by three greenhouses 9m. x 40m. (360m^2) with a total number of nine greenhouses in each growing season.

Two green beans 'Boronco' and 'Paulista' varieties were arranged within each irrigation system and were considered as sub-plot. Each cultivar was sown in three longitudinal rows 0.7 m wide and 40m long. Ammonium molybdate concentrations (0, 0.25, 0.50 and 1 g/ l water) were arranged within each variety and considered as sub-sub plot. Each plot dimension was 8m long x 0.7m width with total net area of 5.95m^2 with total number of 24 plants per each plot.

Seeds of green beans “Bronco and Paulista” cultivars without ' Okadeen ' (bacterial inoculation) were sown in the plastic greenhouse covered with 200 mμ on (October 10th, in both seasons. Plant distances were 10cm apart with plant occupied area 0.02 m^2/plant. Other culture practices such as pest control, cultivation were carried out, whenever; it was necessary and as applied for the commercial green beans production under greenhouse conditions. Harvesting was carried out after 60 days from sowing. A common recommended fertilization program was followed in the experiment. All the treatment plots received the same amounts of fertilizer in each irrigation time. The amount of fertilizers added per each greenhouse (360 m^2) were consisted of, 2 m^3 of cattle manure, 50 kg calcium super phosphate 15.5 %. Ammonium nitrate (33.5 %N), Nitric acid (55 %), NPK compound fertilizer (19-19-19) and Mono potassium phosphate (0 -52 -34) were used as a source for nitrogen, potassium and phosphorus in this experiment. All fertilizers were applied using drip fertigation through split application according to the readings of the Profile Prop (Model: KCB-300) approached the reading (Dry).

Recorded data

Vegetative growth characters

Samples of ten plants from each plot were randomly selected at 15 days intervals from sawing till harvest for determination of foliage fresh weight (gm) , leaf area / plant cm^2 and stem diameter .

Root growth characters

The same ten plants were taken to determine root length /plant cm and nodules number / plant .

Early green pods yield

Pods of all plots were collected of the first and second harvestings in kg. to determine number of early green pods / plant , average pod weight gm. And early green pods / plot.

Total yield of green pods

At harvest stage the mature and marketable pods from each experimental plot were collecting along the harvesting season and total yield was recorded as kg. / plant and/ plot .

Data of the two experiments statistically, analyzed using CoSTAT software. The comparisons among means of the different treatments were carried out using Duncan's Multiple Range Test as illustrated by Gomez and Gomez (1983).

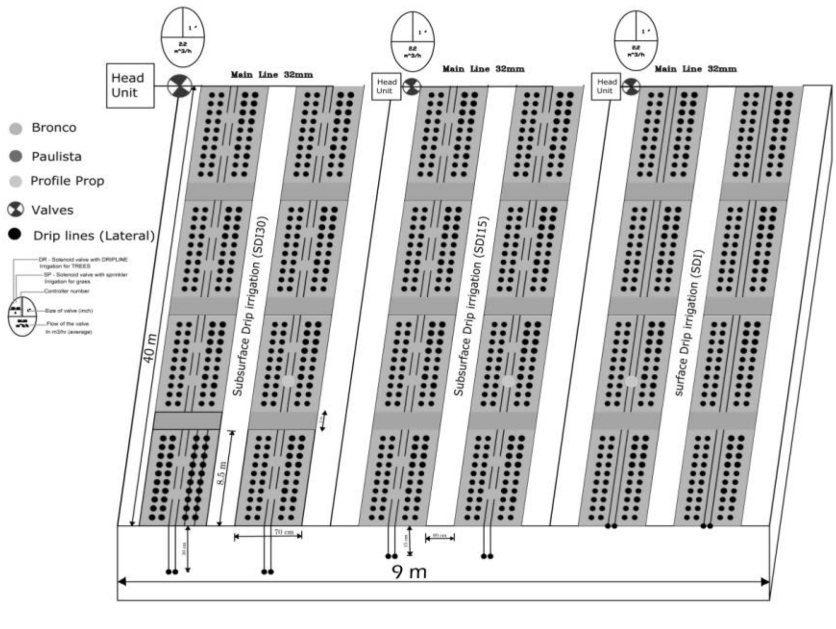

Fig. 1. Common bean plant spacing ling in the experiment of 2012 and 2013.

Results and Discussion

The results regarding the main effect of the three studied factors; i.e., irrigation systems, common bean cultivars and ammonium molybdate levels as well as their first and second order interactions on the various characters of common bean plants, during the winter seasons of 2012 and 2013 were tabulated. The characters could be classified under four main headings, vegetative growth characters, Root growth character , early and total green pods yield and its components. . The experimental results show that half an hour irrigation period is the best for optimum distribution of water in the crop root zone and good quality of common bean pods. It was found from this demonstrative experiment that the best duration time of watering, when 30 minutes was used.

Vegetative growth characters

Results in Table 2 show that application of sub-surface drip irrigation at (SSDI-15) increased foliage weight/ plant compared with (SDI) in both growing seasons. Meanwhile, application of (SSDI-30) gave insignificant leaf area/ plant of common bean plants compared with other treatments. The obtained results are in good agreement by those of *El-Noamani et al.* (2010) who demonstrated that subsurface drip system (SSDI) exhibited the highest value of vegetative growth in both (Bronco and Paulista) cultivars and *Scholberg and Locascio* (1999) on common bean.

Data in Table 2 revealed that "Bronco" cultivar gave heavier significant foliage fresh weight plant^{-1} (g) compared with "Paulista" cultivar in both seasons under greenhouse conditions. Meanwhile, "Paulista" exceed "Bronco" for leaf area character in both growing season however, the increase didn't reach the significance level. It seems that the two common bean cultivars varied to some extent regarding the vegetative growth parameters. That reflects the role of the genetic effect, mainly on the different parameters of the vegetative growth of bean cultivars. These results, are being in agreement with the finding of Hafez *et al.* (1997), *Mohamed* (1997), *Ewais* (2003), Sharma *et al.* (2009) and Singh *et al.* (2009).

Concerning the influence of the main effect of ammonium molybdate levels (0.00, 0.25, 0.50 and 1.00 g / L. water) on the vegetative growth characters, results listed in the illustrate that increasing the levels of ammonium molybdate from 0.25 g/ liter water to 1.0 g/ liter water were associated with marked and significant simulative effects for foliage fresh weight plant^{-1} and leaf area plant^{-1} in both studied seasons as shown in Table 2.. These results agree with the findings of (Mendel and Hansch, 2002) who indicated that ammonium molybdate (Mo) is a micronutrient essential for plant growth, due to its role as several key enzymes of plant metabolic pathways contain Mo cofactor in their catalytic centers. Also, *Kandil et al.* (2013) cleared that the use of three different levels of ammonium molybdate (0.3 and 6ppm) on two common bean cultivars gave the maximum plant height number of leaves / plant and fresh weight through the rate 6ppm MO.

TABLE 2. Vegetative growth characters of two common bean cultivars as affected by the main effects of irrigation systems, cultivars and ammonium molybdat levels for the winter seasons of 2012 and 2013.

Winter season			2012			2013		
Plant Treats / Characters			Foliage fresh weight plant^{-1} (g)	Leaf area plant^{-1} (cm^2)	Stem diameter (cm)	Foliage fresh weight plant^{-1} (g)	Leaf area plant^{-1} (cm^2)	Stem diameter (cm)
Irrig. Systems	Cultivar	Mo Conc. (g/l water)						
SDI			136.7 a	1739.4 a	0.68 a	135.8 a	1695.1 a	0.64 a
SSDI-15cm			150.0 a	1626.2 a	0.68 a	156.7 a	1672.2 a	0.66 a
SSDI-30cm			132.9 a	1660.1 a	0.69 a	118.8 a	1738.3 a	0.64 a
	Bronco		150.0 a	1612.7 a	0.70 a	148.1 a	1636.5 a	0.66 a
	Paulista		129.7 b	1737.8 a	0.66 a	126.1 b	1767.3 a	0.64 a
		0.00	138.9 a	1471.1 b	0.69 a	131.7 a	1479.9 b	0.63 a
		0.25	138.9 a	1537.4 b	0.67 a	140.6 a	1637.3 ab	0.66 a
		0.50	135.6 a	1816.2 a	0.66 a	129.4 a	1805.4 a	0.65 a
		1.00	146.1 a	1876.2 a	0.71 a	146.7 a	1885.1 a	0.64 a

*Value marked with the same alphabetical letter(s), within comparable group of means, do not differ significantly, using the Duncan's Multiple Range Test at 0.05 level.

The interaction of the irrigation systems, cultivar and ammonium molybdate levels on the vegetative growth characters are illustrated in Table 3. The data showed that “Bronco” common bean cultivar plants sprayed with 1.00g ammonium molybdate under (SSD -15cm) gave the heaviest significant foliage fresh weight plant^{-1} (183.3 and 253.3g) in the winter seasons of 2012 and 2013, respectively. It was also noticed that ,both cultivars Bronco and Paulista responded positively and in significantly for leaf area with gradual increase with molybdenum levels from to 1gm ammoni molybdate . It seems also that, Paulista was sensitive to high levels of molybdenum in foliage fresh weight which the lower rates (0.25g /gave the highest mean value however ,Bronco responded better for foliage weight under higher rates 0.5 and 1gm ammonium molybdate . These results were true in both growing seasons as stated by (Tahir *et al.*, 2011) and (Abdul Jabbar *et al.*, 2012). On the other hand , the lowest value for foliage fresh weight was obtained when Paulista cultivar treated with 0.5g of molybdenum under sub-surface irrigation method at 30cm depth (SSDI-30)in both growing season.

TABLE 3. Vegetative growth characters of two common beans cultivars as affected by the second order effects for the winter seasons of 2011 and 2013.

Winter season			2012			2013		
Plant Treats / Characters			Foliage fresh weight (g) plant^{-1}	Leaf area plant^{-1} (cm^2)	Stem diameter (cm)	Foliage fresh weight (g) plant^{-1}	Leaf area plant^{-1} (cm^2)	Stem diameter (cm)
Irrigation system	Cultivars	Mo Conc. (g/l water)						
SDI	Bronco	0.00	163.3 abc	1566.5 a	0.77 ab	150.0 b	1469.1 a	0.67 a
		0.25	140.0abc	1427.8 a	0.67 abc	143.3 b	1392.4 a	0.67 a
		0.50	166.7 ab	1935.2 a	0.60 bc	156.7 ab	1899.8 a	0.67 a
		1.00	123.3abc	2200.7 a	0.80 a	120.0 b	2186.0 a	0.63 a
	Paulista	0.00	113.3abc	1436.7 a	0.77 ab	86.7 b	1348.2 a	0.57 a
		0.25	156.7abc	1324.6 a	0.63 abc	166.7 ab	1445.5 a	0.67 a
		0.50	100.0 bc	1832.0 a	0.57 c	123.3 b	1572.4 a	0.63 a
		1.00	130.0abc	2192.0 a	0.60 bc	140.0 b	2247.9 a	0.63 a
SSDI-15	Bronco	0.00	146.7abc	1870.3 a	0.67 abc	160.0 ab	2000.1 a	0.63 a
		0.25	146.7abc	1649.1 a	0.67 abc	150.0 b	1711.0 a	0.70 a
		0.50	163.3abc	1421.9 a	0.77 ab	156.7 ab	1395.4 a	0.63 a
		1.00	183.3 a	1168.2 a	0.70 abc	253.3 a	1168.2 a	0.63 a
	Paulista	0.00	140.0abc	1528.1 a	0.63 abc	140.0 b	1454.4 a	0.67 a
		0.25	150.0abc	1896.9 a	0.70 abc	140.0 b	2200.7 a	0.67 a
		0.50	126.7abc	2106.3 a	0.60 bc	123.3 b	2203.7 a	0.63 a
		1.00	143.3abc	1368.8 a	0.73 abc	130.0 b	1244.9 a	0.70 a
SSDI-30	Bronco	0.00	123.3abc	1183.0 a	0.63 abc	110.0 b	1227.2 a	0.63 a
		0.25	120.0abc	1318.7 a	0.70 abc	106.7 b	1318.7 a	0.60 a
		0.50	163.3abc	1483.9 a	0.73 abc	126.7 b	1669.7 a	0.63 a
		0.10	163.0abc	2127.0 a	0.70 abc	143.3 b	2200.7 a	0.67 a
	Paulista	0.00	146.7abc	1242.0 a	0.70 abc	143.3 b	1380.6 a	0.63 a
		0.25	120.0abc	1607.8 a	0.63 abc	136.7 b	1755.3 a	0.63 a
		0.50	93.3 c	2118.1 a	0.67 abc	90.0 b	2091.6 a	0.70 a
		1.00	136.7abc	2200.7 a	0.73 abc	93.3 b	2262.7 a	0.60 a

*Value marked with the same alphabetical letter(s), within comparable group of means, do not differ significantly, using the Duncan's Multiple Range Test at 0.05 level.

Root growth characters

The results of the main effects for each of the three irrigation systems, common bean cultivars (Bronco and Paulista) and four levels of ammonium molybdate in addition to their interactions on the mean values of the root growth characters; (root length (cm) and number of nodules plant^{-1} of common bean cultivars (Bronco and Paulista) during the winter seasons of 2012 and 2013, are illustrated in Tables 4 and 5.

Generally, sub-surface drip irrigation system at 15 or 30cm depths were superior and gave higher root length (cm) and number of nodules plant $^{-1}$ compared with surface drip irrigation system for the winter seasons of 2012 and 2013. these results could be explained by the fact that under subsurface irrigation especially at 15cm depth, an adequate amount of water were added to the plant on the root zone which consequently increase root length.

The results listed in Table 4 revealed that the cultivars " Bronco" and "Paulista" differed significantly, for the root length plant^{-1} and number of nodules plant^{-1}characters "Paulista" cultivar plants were superior and gave higher mean values for root length plant $^{-1}$ (cm) and number of nodules compared with "Bronco" cultivar in both seasons under greenhouse conditions. However, the difference was high enough to reach the significance level just in the second season.

Concerning the influence of ammonium molybdate levels on the root growth characters, the results listed in the Table 4 show that root growth traits of common bean plants received four ammonium molybdate levels were generally, improved compared with untreated plants, especially in the second growing season.. It is also clear from the obtained results that spraying common bean plants with 0.25g ammonium molybdate $(NH_4)6Mo_7O_{24}$. 2 H_2O/liter water was associated with marked significant simulative effects for root length plant^{-1} and number of nodules plant^{-1} characters in season of 2013. These results agree the findings of Mendel and Hansch, *2002* who indicated that ammonium molybdate (Mo) is a micronutrient essential for plant growth because of the multirole of this element in the plant metabolism, since enzymes like nitrate reductase, sulphite oxidase containing molybdenum .These are involved in nitrate assimilation and supplied detoxification in this direction . (Bhuiyan *et al*., 2008), found that, nodulation was the highest with 1.0 kg Mo/ha in mung bean.

TABLE 4. Root length and number of nodules plant^{-1} as affected by the main effects of irrigation systems, cultivars and ammonium molybdate levels for the winter seasons of 2012 and 2013.

Winter season / plant characters / Treats: Irrig. System, Cultivar, Mo Conc. (g) g/l H_2O	2012 Root length (cm)	2012 no. of nodules plant^{-1}	2013 Root length (cm)	2013 no. of nodules plant^{-1}
SDI	14.7 b	16.9 b	13.8 b	17.8 b
SSDI-15	21.5 a	31.9 a	21.5 a	32.4 a
SSDI-30	23.0 a	19.2 b	22.0 a	16.3 b
Bronco	19.2 a	18.2 a	18.2 b	16.5 b
Paulista	20.3 a	20.1 a	27.1 a	27.8 a
0.00	19.9 a	19.8 a	17.4 bc	18.4 bc
0.25	19.5 a	19.6 ab	34.6 a	34.4 a
0.50	20.0 a	18.1 b	15.3 c	13.8 c
1.00	19.6 a	18.9 ab	23.3 b	22.1 b

*Value marked with the same alphabetical letter(s), within comparable group of means, do not differ significantly, using the Duncan's Multiple Range Test at 0.05 level.

The favorable significant interactions were obtained for the number of nodules plant^{-1} character when the "Paulista" common bean cultivar plants was sprayed with 0.25g ammonium molybdate under sub-surface drip irrigation system at depth 15cm compared with other combination treatments, during the winter seasons of 2012 and 2013, respectively Table 5. Meanwhile, "Paulista" common bean cultivar plants sprayed with 0.00g or 0.50g ammonium molybdate during the first season and under sub-surface drip irrigation system at depth 15cm gave significant taller root length in the winter seasons of 2012.

TABLE 5. Root growth characters of two common beans cultivars as affected by the second order effects for the winter seasons of 2012 and 2013.

Winter season			2012		2013	
Treat's / Plant characters			Root Length plant^{-1} (cm)	no. of nodules Plant^{-1}	Root length plant^{-1} (cm)	no. of nodules Plant^{-1}
Irrig. system	Cultivars	Mo Conc. (g/l water)				
SDI	Bronco	0.00	15.33 efg	5.3 f	12.33 e	8.7 cd
		0.25	13.33 g	27.3 bcdef	14.67 de	26.7 bcd
		0.50	14.67 fg	6.7 ef	13.00 e	3.3 d
		1.00	12.00 g	18.3 cdef	11.33 e	16.7 cd
	Paulista	0.00	16.00 efg	12.3 cdef	15.00 cde	10.0 cd
		0.25	16.67 cdefg	33.3 bcde	14.67 de	41.7 b
		0.50	12.67 g	16.0 cdef	13.67 e	19.0 cd
		1.00	16.33 defg	15.7 cdef	15.33 bcde	16.7 cd
SSDI-15	Bronco	0.00	20.00 bcdef	10.0 def	21.67 a	11.7 cd
		0.25	20.67 bcde	26.7 bcdef	20 .00 abcd	23.3 bcd
		0.50	20.67 bcde	20.0 bcdef	19.33 abcd	16.7 cd
		1.00	19.00 cdef	43.3 b	19.33 abcd	41.7 b
	Paulista	0.00	20.67 bcde	38.0 bc	24.00 a	42.3 b
		0.25	22.00 bc	85.3 a	24.00 a	78.3 a
		0.50	27.67 a	15.0 cdef	21.67 a	18.3 cd
		1.00	21.67 bcd	16.7 cdef	23.33 a	26.7 bcd
SSDI-30	Bronco	0.00	24.00 ab	3.3 f	21.67 a	4.3 d
		0.25	22.67 ab	24.7 bcdef	20.67 ab	22.3 cd
		0.50	24.33 ab	15.0 cdef	20.67 ab	11.7 cd
		1.00	24.00 ab	18 .0 cdef	23.33 a	10.7 cd
	Paulista	0.00	23.33 ab	35.3 bcd	24.33 a	33.3 bc
		0.25	21.67 bcd	10.0 def	23.33 a	14.0 cd
		0.50	20.00 bcdef	19.3 cdef	20.33 abc	13.7 cd
		1.00	24.33 ab	27.7 bcdef	22.00 a	20.0 cd

*Value marked with the same alphabetical letter(s), within comparable group of means, do not differ significantly, using the Duncan's Multiple Range Test at 0.05 level.

Green yield and its components

Early yield

Results presented in Table 6 show presence of significant differences among the different mean values of three irrigation systems used namely; surface drip irrigation SDI, sub-surface drip irrigation at 15 cm depth (SSDI-15) and sub-surface drip irrigation at 30 cm depth (SSDI-30) reflecting the effect of watering regimes on the number of early green pods plant^{-1}, average pod weight (g) and early yield per plant, during the winter seasons of 2012 and 2013.Application of subsurface drip irrigation systems at 15cm (SSDI-15) or 30cm depths, (SSDI-30) increased the early yield plant $^{-1}$ by 53.2 and 29.8 and 49.3 and 22.9 % compared with (SDI) in the first and second growing seasons, respectively. The superiority of the watering regimes subsurface dripping particularly at 15cm depth regarding the early yield components of common bean green pods could be explained on basis of the higher efficiency of such regime for yielding beans under the conditions of soil characterized by low field capacity as given in Table 1. Such watering regime supplies enough water at the root zone of bean plants as well as reducing the evaporating. Previously Bozkurt and Mansurolu (2011) and Enciso *et al*. (2007) pointed out to the importance of the buried emitters to increase the potential to reduce evaporation.

In general, results listed in Table 6 reveal that the cultivar "Paulista" gave higher number of early green pods plant^{-1} and heavier early yield plant^{-1}(g) in both seasons comparing to Bronco, but the differences did not reach the significant level (0.05) under greenhouse conditions in both seasons.

TABLE 6. Average number of early green pods plant^{-1}, average pod weight (g) and early yield plant^{-1}(g) of two common beans cultivars as affected by the main effects of irrigation systems, cultivars and ammonium molybdate levels for the winter seasons of 2012 and 2013.

Winter season			2012			2013		
Plant characters / Treats			nr. of early green pods plant^{-1}	Average pod weight (g)	Early yield plant^{-1} (g)	nr. of early green pods plant^{-1}	Average pod weight (g)	Early yield plant^{-1} (g)
Irrig. System	Cultivar	Mo Conc. (g) g/l H_2O						
SDI			75.64 c	4.63 a	349.00 c	79.99 c	4.70 a	373.25 b
SSDI-15			125.75 a	4.30 b	534.55 a	130.10a	4.35 b	557.12 a
SSDI-30			101.50 b	4.48ab	452.87b	105.85b	4.42 ab	458.85ab
	Bronco		97.53 a	4.48 a	434.09 a	99.21 a	4.53 a	442.29 a
	Paulista		104.40 a	4.46 a	456.83 a	111.42a	4.44 a	483.85 a
		0.00	103.66ab	4.62 a	477.32 a	99.40ab	4.71 a	454.63 a
		0.25	92.93 b	4.39 a	404.40b	95.98 b	4.51 ab	430.09 a
		0.50	106.30 a	4.37 a	459.84 a	115.40a	4.41 ab	500.58 a
		1.00	100.97ab	4.48 a	440.28ab	110.47ab	4.33 b	466.99 a

*Value marked with the same alphabetical letter(s), within comparable group of means, do not differ significantly, using the Duncan's Multiple Range Test at 0.05 level.

Results of spraying common bean plants with different ammonium molybdate levels indicate that foliar spray by (NH_4 $6Mo_7O_{24}.4H_2O$ did not increase the average number of early green pods per plant as well as early yield per plant (g) since the difference between levels of the molybdenum compound were found in significant, for the two common bean cultivars in both season. Also, data indicated that there was unclear trend from application of ammonium molybdate with different levels regarding to effect on the early yield characters (Table 18).

The second order interactions among irrigation systems, cultivar and ammonium molybdate levels on the number of early green pods plant^{-1}, average pod weight (g) and early yield plant^{-1}(g) characters of the common bean plants grown under greenhouse conditions in the winter season of 2012 and 2013 are illustrated in Table 7. Results indicated that there were significant differences among common bean plants for "Paulista and Bronco" cultivars grown under three irrigation systems namely; SDI - SSDI-15 and SSDI-30 and sprayed with ammonium molybdate levels ranged from 0.00 to 1.00g $NH_4)_2MoO_4$ / l water in both seasons. The highest early yield / plant were obtained when treated Paulista cultivar with 0.5 g. of ammonium molybidate / L. under sub surface drip irrigation at 15 cm. depth .The obtained results are agreed with the finding of Neelon and Rajput (2007) and Encis *et al*. (2007) .

Total yield of green pods

Influence of the three irrigation systems; surface drip irrigation (SDI), sub-surface drip irrigation at 15cm depth (SSDI-15) and sub-surface drip irrigation at 30cm depth (SSDI-30) on the total green pods characteristics during the winter seasons of 2012 and 2013, are presented in Table 8. Generally, sub-surface drip irrigation system at 15 or 30cm depths increased significantly, the number of green pods plant^{-1}, yield of green pods plant^{-1} and yield of green pods plot^{-1} of common beans plants compared with plants grown under surface drip irrigation system (SDI) in the winter seasons of 2012 and 2013. For subsurface drip irrigation at 15cm depth (SSDI-15) increased significantly, the number of green pods plant^{-1} by 56.3 and 65.1 % and yield of green pods plant^{-1} by 49.3 and 47.5 % and yield of yield of green pods plot^{-1} by 40.9 and 44.0 % on common beans plants compared with those grown under drip irrigation system (SDI) in the two seasons of 2012 and 2013, respectively . The variable effect of the irrigation regimes with respect to yielding ability of green bean , previously discussed by Gencoglan (2006) who found that subsurface drip watering system increased the green bean yield comparing with surface drip irrigation. Moreover, Sezen *et al*. (2005) pointed out to the importance of the irrigation interval for the yielding performance of common bean plants under the field conditions. In this direction, Enciso *et al*. (2007) indicated to the importance of water amount under semiarid climate, since the irrigation, significantly affected yield, which increased with irrigation up to a point where irrigation became excessive.

TABLE 7. Average number of early green pods plant^{-1}, average pod weight (g) and early yield plant^{-1}(g) of two common beans cultivars as affected by the second order effects for the winter seasons of 2012 and 2013.

Winter season			2012			2013		
Treat's / Plants characters			nr. of early green pods plant^{-1}	Average pod Weight (g)	Early yield plant^{-1} (g)	nr. of early green pods plant^{-1}	Average pod weight (g)	Early yield plant^{-1} (g)
Irrig. System	Cultivar	MoConc. (g/l H_2O)						
SDI	Bronco	0.00	74.70 ghi	4.80 a	361.11 efgh	63.80 fg	5.20 a	320.14 de
		0.25	85.40e-h	4.33 ab	370.14d-h	91.43cdefg	4.50 abc	411.11 cd
		0.50	68.40 hi	4.47 ab	308.34 gh	84.40 defg	4.63 abc	397.22 cde
		1.00	78.07 fghi	4.93 a	379.17 efg	70.63 efg	4.70 abc	339.44 de
	Paulista	0.00	107.80b-f	4.60 a	495.83 bcde	99.33 c-f	4.77 abc	473.61abcd
		0.25	51.27 i	4.67 a	240.28 h	48.93 g	4.40abc	211.11 e
		0.50	65.00 hi	4.60 a	299.30 gh	95.13cdefg	4.83abc	452.08bcd
		1.00	74.50 ghi	4.63 a	337.50 fgh	86.27c-g	4.53abc	381.25cde
SSDI-15	Bronco	0.00	107.87b-f	4.43 ab	479.17bc-f	126.40abcd	4.30abc	540.97abc
		0.25	119.77 bcd	4.27 ab	510.42 abcd	123.03abcd	4.50abc	548.61abc
		0.50	132.57 b	4.40 ab	583.33 abc	116.13bcde	4.57 abc	518.06abcd
		1.00	98.93 c-g	4.47 ab	440.97 defg	110.20cdef	4.27 abc	468.05abcd
	Paulista	0.00	124.93 bc	4.73 a	590.28 abc	133.97 abc	4.50 abc	583.33 abc
		0.25	103.40c-g	4.30 ab	437.50 defg	105.60cdef	4.73 abc	497.22abcd
		0.50	158.40 a	4.07 ab	638.89 a	162.17 ab	4.03 bc	659.72 a
		1.00	160.10 a	3.73 b	595.83 ab	163.27 a	3.90 c	640.97 ab
SSDI-30	Bronco	0.00	105.53b-f	4.47 ab	463.89bf	86.73cdefg	4.60 abc	393.06 cde
		0.25	104.47b-f	4.07 ab	427.78 defg	97.93 cdef	4.50 abc	437.50 cd
		0.50	101.97c-g	4.27 ab	433.33 defg	107.07cdef	4.10 bc	433.33 cd
		1.00	92.70 d-h	4.83 a	451.39 cdef	112.7 0 cde	4.53 abc	500.00abcd
	Paulista	0.00	101.13c-g	4.70 a	473.61b-f	86.17c-g	4.87 ab	416.67 cd
		0.25	93.27 d-h	4.73 a	440.28 defg	108.97cdef	4.43 abc	475.3 abcd
		0.50	111.47 bcde	4.43 ab	495.83bcde	127.50a-d	4.30 abc	543.05 abc
		1.00	101.50c-g	4.30 ab	436.81d-g	119.73abcd	4.03 bc	472.22abcd

*Value marked with the same alphabetical letter(s), within comparable group of means, do not differ significantly, using the Duncan's Multiple Range Test at 0.05 level.

Table 8 showed that Plants of “Paulista” cultivar gave higher number of green pods plant^{-1} compared with those of "Bronco" cultivar in both seasons under greenhouse conditions. While, plants of Bronco cultivar yielded increasingly weight of green pods plant^{-1} as well as weight of green pods per plot compared with those of "paulista" cultivar in both seasons, but the differences did not reach the significant level (0.05) .It is noticed that "Paulista" produced higher number of pods /plant while, Bronco gave a higher yield because average pod weight of Bronco is more heavier.

Influences of ammonium molybdate on the number of green pods plant^{-1}, yield of green pods plant^{-1} and yield of green pods plot^{-1}characters of common bean cultivars in both seasons of 2012 and 2013 are illustrated in Table 8.

The obtained data did not show clear response of the two cultivars, either 'Bronco' or 'Poleasta' to the application of ammonium molybdate in the two experimental seasons, 2012 and 2013. The difference between the mean values of the successive concentration of the used molybdate compound appeared to be insignificant , particularly those of the number of green pods per plant in the first growing season as well as yield of green pods per plant in the second one.

TABLE 8. Number of green pods plant^{-1}, yield of green pods plant^{-1} and yield of green pods plot^{-1} as affected by irrigation systems, cultivars and ammonium molybdate levels for the winter seasons of 2012 and 2013.

Winter season			2012			2013		
Treat's / Plant characters			Number of green pods plant^{-1}	Yield of green pods plant^{-1} (g)	yield of green pods plot^{-1} (kg)	Number of green pods plant^{-1}	Yield of green pods plant^{-1} (g)	yield of green pods plot^{-1} (kg)
Irrig. System	Cultivar	Mo Conc. (g) g/l H_2O						
SDI			125.58 b	390.45 c	9.37 c	104.7 c	415.38 b	9.97 b
SSDI-15			196.31 a	582.96 a	13.99 a	172.9 a	612.74 a	14.71 a
SSDI-30			155.78ab	507.78 b	12.19 b	138.2 b	512.62ab	12.30ab
Bronco			156.01 a	506.71 a	12.16 a	130.4 a	518.69 a	12.45 a
Paulista			162.44 a	480.75 a	11.54 a	146.9 a	508.47 a	12.20 a
0.00			158.39 a	526.27 a	12.63 a	148.3 a	516.39 a	12.39 a
0.25			147.61 a	445.62b	10.70 b	126.5 b	474.72 a	11.39 a
0.50			170.24 a	509.20 a	12.22 a	142.8ab	544.00 a	13.06 a
1.00			160.66 a	493.82ab	11.85ab	136.9ab	519.21 a	12.46 a

*Value marked with the same alphabetical letter(s), within comparable group of means, do not differ significantly, using the Duncan's Multiple Range Test at 0.05 level.

The favorable significant interactions were obtained for number of green pods plant^{-1} character (218.43 and 212.5) when the “Paulista" cultivar plants was sprayed with 1.00 or 0.50g ammonium molybdate under sub-surface drip irrigation system at depth 15 cm in the first season of 2012 and second season 2013, respectively Table 9. Higher significant yield of green pods plant^{-1} and yield of green pods plot^{-1} (654.17g and 15.70kg) were obtained when either cultivar plants grown under subsurface drip irrigation system at 15cm depth (SSDI-15) and sprayed with 0.50g ammonium molybdate compared with those plant of the same cultivar plants under drip irrigation system and sprayed with same levels of ammonium molybdate grown specially in the first season 2012 . However, the effect of ammonium molybdate application was insignificant in the second season. The results are agreed with the findings of Tayoga *et al*. (2008) and Kandil *et al*. (2013).

TABLE 9. Number of green pods plant^{-1}, yield of green pods plant^{-1} and yield of green pods plot^{-1} of two common beans cultivars as affected by the second order effects for the winter seasons of 2012 and 2013.

Winter season			2012			2013		
Treat's / Plant characters			Number of green pods plant^{-1}	Yield of green pods plant^{-1} (g)	Yield of green pods plot^{-1}(kg)	Number of green pods plant^{-1}	Yield of green pods plant^{-1} (g)	Yield of green pods plot^{-1} (kg)
Irrig. System	Cultivar	Mo Conc.						
SDI	Bronco	0.00	107.0 ef	419.44 efg	10.07 efg	100.3 ghi	382.92 fg	9.19 fg
		0.25	140.2bcde	402.09 efgh	9.65 efgh	112.7 efghi	464.86 a-ef	11.16 a-f
		0.50	140.93 bcde	383.33 fgh	9.20 efgh	93.5 hi	455.56 b-f	10.93bcdef
		1.00	108.53 def	443.06 defg	10.63 defg	104.7 fghi	391.81 efg	9.40 efg
	Paulista	0.00	160.50abcde	515.28 a-e	12.37 abcde	153.6 cdef	513.20 a-f	12.32a-f
		0.25	66.00 f	266.67 h	6.40 h	72.0 i	224.86 g	5.40 g
		0.50	152.37 abcde	328.47gh	7.88 gh	105.7 fghi	471.81 bcdef	11.32 a-ef
		1.00	129.13 cde	365.28 fgh	8.77 fgh	95.0 hi	418.05 defg	10.03 defg
SSDI -15	Bronco	0.00	212.37 a	594.44 abc	14.27 abc	155.9 de	686.81 a	16.48 a
		0.25	190.57 abc	589.59 abc	14.15 abc	161.1bcde	620.83 abcd	14.90 abcd
		0.50	180.90 babc	654.17 a	15.70 a	176.8 abcd	668.33 ab	13.94 aef
		1.00	169.53 a-e	482.64 bcdef	11.58 bf	132.4 defgh	652.36 abc	13.23a-f
	Paulista	0.00	206.93 ab	613.89 ab	14.73ab	205.6 ab	615.00 abcde	14.76 abcde
		0.25	174.13 abcde	469.44 bcdef	11.27 bcdef	141.2 defgh	526.39 a-ef	12.63 a-f
		0.50	217.60 a	652.15 a	15.67 a	212.5 a	580.83 a-f	16.04 ab
		1.00	218.43 a	607.36 ab	14.58 ab	198.0 abc	551.39 a-f	15.66 abc
SSDI -30	Bronco	0.00	138.43 cde	525.00 abcde	12.60 abcde	139.5 defgh	460.14 bcdef	11.04 bcdef
		0.25	153.13 abcde	488.20 bcdef	11.72 bcdef	123.2 efgh	513.89 abcdef	12.33 abcdef
		0.50	154.33 abcde	520.83 abcde	12.50 abcde	123.0 efgh	522.00 abcdef	12.60 abcdef
		1.00	176.23 abc	577.78 abcd	13.87 abcd	141.6 defgh	590.28 abcdef	14.17 abcdef
	Paulista	0.00	125.17 cdef	489.58 b-f	11.75 bcdef	134.6 defgh	440.28 cdef	10.57 cdef
		0.25	161.60 abcde	457.78 cdefg	10.99 c-g	149.0 defg	497.50 a-f	11.94 a-f
		0.50	175.30 abcd	516.25 abcde	12.39 abcde	155.8 cde	562.50 abcdef	13.50 abcdef
		1.00	162.07 abcde	486.80 bcdef	11.68 bcdef	139.2 defgh	511.39 abcdef	12.27abcdef

*Value marked with the same alphabetical letter (s), within comparable group of means, do not differ significantly, using the Duncan's Multiple Range Test at 0.05 level

Conclusion

From the foregoing illustration of the responses of the two common bean cultivars to subsurface irrigation the data assured the importance of line depth at 15 cm. for common bean plants since the dimensions of the wetted volume and the distribution of soil moisture within this volume are two of the main factors in determining installation depth and spacing of drippers to obtain an optimum distribution of water in the crop root zone. While deeper lateral depth leads to the reduction of soil evaporation, a deep installation of emitters can increase water losses due to deep percolation and decrease availability of water for crop roots. In addition, the response of common bean plants to molybdenum application could be interpreted on the basis of the proof the role of nodulation for nitrogen fixation which in return is considered as a main supplier of nitrogen to be uptake by bean plants. Data obtained in the present study, also demonstrate the effectiveness of the three investigated factors ,watering regimens, foliar application of ammonium molybdate and two common bean cultivars adapted to the growing under green house, in combining treatments for enhancement the productivity of common beans representing in yielding performance as well as quality aspects of the green pods although the low water capacity of such saline, sandy and alkaline .

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(*Received* 9/10/2014;
accepted 11/ 2 /2015)

تقييم أستجابة صنفين من الفاصوليا الخضراء لإضافة الموليبدنم و نظام الرى تحت ظروف الصوب الزراعية

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نفذت هذه الدراسة بهدف توضيح تأثير كل من نظم الرى وإضافة الموليبدنم والاصناف بالاضافة الى تأثير التداخل بين هذه العوامل الثلاثة على صفات النمو الخضرى ومحصول القرون ومكوناته لنباتات الفاصوليا صنفي البرونكو والبوليستا.

أجريت تجربتان حقليتان خلال الموسمين الشتويين لعامى ٢٠١٢ – ٢٠١٣ . بمزرعة المنطقة الشمالية العسكرية بمنطقة العامرية -الاسكندرية - جمهورية مصر العربية .

اجريت التجربة باستخدام تصميم القطاعات العشوائية الكاملة فى نظام القطع المنشقة مرتين باستخدام ثلاث مكررات حيث اشتملت على جميع التوافيق الممكنة بين نظم الرى (الرى بالتنقيط السطحى – الرى بالتنقيط تحت سطحى بعمق ١٥ سم - الرى بالتنقيط تحت سطحى بعمق ٣٠ سم) والتى تم توزيعها عشوائيا كقطع رئيسية بالاضافة الى صنفي الفاصوليا الخضراء (برونكو – بوليستا) والتي وزعت عشوائيا داخل كل قطعة رئيسية كقطع تحت الرئيسية ، بالإضافة لتركيزات موليبدات الأمنيوم (٠,٠ و ٢٥. ٠ و٥٠. ٠ و١,٠ جم / لتر) التي وزعت كقطع منشقة مرتين (تحت تحت الرئيسية وذلك خلال موسمى الزراعة .

سجلت خلال هذه الدراسة على بيانات تتعلق بصفات النمو الخضرى والجذري والمحصول الكلي ومكوناته والمكونات الكيماوية والمعدنية فى كل من الأوراق وقرون نباتات الفاصوليا للصنفين المستخدمين.

لقد امكن استخلاص بعض النتائج الهامة لهذه الدراسة والتى يمكن ايجازها فى النقاط التاية :

- تفوق نظام الرى تحت السطحى على عمق ١٥ سم معنويا على نظم الري الأخرى المستخدمة في هذه الدراسة خلال موسمي النمو وأعطى أعلى قيما معنوية لصفات المحصول الكلى ومكوناته .
- اكدت النتائج ان زراعة صنف الفاصوليا الخضراء برونكو تحت نظام رى تحت السطحى على عمق ١٥ سم اعطى اعلى قيم المحصول الكلى (مثل صفة عدد القرون الخضراء للنباتات المعاملة)، بينما اظهر الصنف بوليستا تفوقا نسبيا تحت نظام الرى السطحى .
- ادى استخدام نظام الرى تحت السطحى مع الرش بتركيز ٢٥. ٠ جم / لتر من موليبدات الامونيوم الى اعطاء اعلى قيم معنوية للمحصول الكلى للنباتات المعاملة مقارنة بباقى المعاملات .
- ادى الرش بتركيز ٥٠. جم / لتر من موليبدات الامونيوم على صنف البوليستا الى زيادة معنوية فى عدد القرون كذلك ادى الرش بتركيزات ٢٥. و ٥٠. و ١ جم / لتر موليبدات امونيوم الى زيادة انتاجية محصول النبات الواحد والمحصول لصنف البرونكو .
- اظهرت النتائج ان نظام الرى تحت السطحى على عمق ١٥ سم والرش بتركيز ٥٠. جم / لتر من موليبدات الامونيوم اعطى افضل متوسطات لصفات المحصول الكلى لصنف البرونكو .

من خلال النتائج السابقة يمكن التوصية بالاتى:

فى الظروف المناخية والبيئية المشابهة لظروف المنطقة التى اجريت فيها التجربة يفضل استخدام نظام الرى تحت السطحى على عمق ١٥ سم والرش بالموليبدنم بتركيزات (٢٥. او ٥٠.) جرام / لتر لكلا الصنفين (برونكو وبوليستا)