J. Plant Production, Mansoura Univ., Vol. 6 (1): 57 -72 , 2015

VEGETATIVE GROWTH, YIELD AND SOME CHEMICAL CONSTITUENTS IN LEAVES AND PODS OF COMMON BEAN AS AFFECTED BY SALICYLIC ACID AND POTASSIUM FOLIAR APPLICATION UNDER DIFFERENT IRRIGATION INTERVALS

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ABSTRACT

Two field experiments were carried out at a Private Farm located in Salaka village, El-Mansoura, Egypt, during two successive seasons of 2011/2012.These experiments aimed to study the effect of irrigation intervals and some foliar application treatments (salicylic acid and potassium) on common bean(Bronco cultivar) vegetative growth parameters (plant height, number of leaves ,fresh and dry weights and leaf area/plant) , yield (early yield and total yield) , Chemical constituents in leaves(chlorophyll a, b and total, N, P , K and proline content) and Chemical constituents in pods(protein, carbohydrates and sugar content).This study included 15 treatments, which were the combinations between three irrigation intervals (10, 13 and 16 days) and five foliar application treatments including control. These treatments were arranged in a split plot in a complete randomized block design with three replicates.

The obtained results showed that the mean values of vegetative growth parameters ,yield and Chemical constituents in leaves and pods of common bean plants were reduced due to increasing irrigation intervals up to 16 days during both seasons of study, while proline content increased by increasing irrigation intervals up to 16 days.

Generally, results showed that foliar application of Salicylic Acid at 15 and 30 ppm and foliar potassium at 1% and 2% improved all measured traits under both well watered and water stress conditions.

The highest significant values of the aforementioned parameters were recorded with spraying plants with Salicylic Acid at 30 ppm and irrigation every 13 days (5 irrigations) followed with salicylic acid at 15 ppm and foliar potassium at 1% and 2% as compared with every 10 or 16 days (4 or 6 irrigations) . However, the highest mean value of leaf`s proline content was obtained from the plants which irrigated every 16 days. Thus, results signify the role of SA and K in regulating drought response of plants and suggest that foliar salicylic acid and potassium could be used as a potential growth regulator, for improving common bean growth under water stress conditions.

Keywords: Common bean, *Phaseolus vulgaris*, Irrigation intervals, Salicylic acid, Potassium and proline.

INTRODUCTION

Common bean (*Phaseolus vulgaris* L.) is one of the most important vegetable crops grown in Egypt that occupies a great figure in local consumption and export, green bean can be grown as a summer and fall crop. According to statistics of the ministry of Agriculture and Land

Recrimination of Egypt (2012), the total cultivated area devoted for green bean were about 62657 feddans, which produced about 270740 tons with average of 4.320 tons per feddan, respectively. About 60 % of common beans produced world-wide are grown in regions subjected to water stress, making drought after diseases the second largest contributor to the yield reduction in bean (Martinez *et al.*2007). Thus, improving productivity of bean under such conditions is essential. Singer *et al.* (1996)showed that plant height, number of leaves and pods number/plant were significantly affected by water stress. Szilagyi (2003) showed that Drought stress reduced seed yield by 80%, pods number per plant by 60%, seeds number per pod by 26%, 100-seed weight by 13%.Teran*et al.* (2002)reported that yield of common bean which grown in regions where water deficits during reproductive development was significantly reduced. Ucar*et al.* (2009) determined optimum water use of the dry bean (*Phaseolus vulgaris* L.) and showed that, high grain yields was obtained by meeting the full water needs of the crop. Grain yields were reduced when irrigation water was not provided during the flowering and yield formation periods. Emam*et al.,* (2012) studied the responses of two common bean cultivars with different growth habits (Sayyad as an indeterminate and D81083 as a determinate cultivar) to drought stress. The results showed that number of pods, pod dry matter (DM) and total plant DM weights of both cultivars, were significantly reduced under drought stress. Furthermore, at 50 and 25% offull capacity, all plant pods of both cultivars were aborted. Sadeghipour and Aghaei (2012) showed that Water stress reduced number of pods per plant, number of seeds per pod, 100-seeds weight and finally seed yield of common bean. Exogenous application of SA (especially 0.5 mM) improved all measured traits under both well watered and water stress conditions. Also, Water stress reduced total chlorophyll content, stomatal conductance, net photosynthetic rate and proline content. Kassab and El-Zeiny (2004) investigated the effect of water stress and potassium foliar application on the productivity of faba bean plants and the results suggested that irrigation every 30 days and application of K with 1.5l/fed. could be recommended for maximum yield of faba bean under similar conditions. Thalooth *et al.*(2006) studied the effect of foliar application of zinc, potassium or magnesium on growth, yield and yield components and some chemical constituents of mungbean plants grown under water stress conditions(missing one irrigation at vegetative, flowering and pod formation growth stages). The results revealed that missing one irrigation at any of the three studied stages significantly reduced all the tested growth parameters, yield and yield components as well asphotosynthetic pigments content as compared with unstressed plants (control). However, stress at a pod formation stage produced the least yield and yield components' values. On the other hand, water stress had a stimulating effect on proline contents). Also data revealed that withholding one irrigation at any growth stage decreased the content of chl. a+b and carotenoids in the leaves of mungbean plants, Data also showed that there was significantly increase in photosynthetic pigments content (chl. a+b and carotenoids) under foliar application of potassium .The present studies also indicate that foliar application of Zn, K or Mg had a positive effect on growth parameters, yield and yield components but K application surpassed the two other nutrients.

MATERIALS AND METHODS

Two field experiments were carried out at private farm located in Salaka village, El- Mansoura, Egypt,(GPS, 30^{O} 59 N 31^{O}21 E) during two successive summer seasons of 2011/2012.The experiments aimed to study the effect of irrigation intervals and some foliar application treatments of salicylic acid and potassium on common bean (*Phaseolus vulgaris* L.).

Soil analyses and layout of the Experiment

Soil analyses were done at Soil and water analysis institute, El-Mansoura laboratory, Agriculture Research Center. According to Black (1965) and the results were presented in Table (1).

Dry seeds of bronco cultivar was obtained from Horticulture Research Institute, Agricultural Research Center, Egypt and sown immediately in the moderately moist soil in March 3^{rd} in both seasons.

Other agriculture practices were done as instructed by the Ministry of Agriculture and Soil Reclamation.

The study included 15 treatments, which were the combination between three irrigation intervals and five foliar application treatments including control as follows: Irrigation intervals (10 days, 13 days and 16 days), Foliar applications Control (tap water), Salicylic acid at 15 ppm and 30 ppm and foliar potassium at 1%and 2 % as Potassium Chloride. All foliar treatments were applied three times at 30, 40 and 50 days after sowing.

These treatments were arranged in a split plot in a complete randomized block design with three replicates. The main plots were used for irrigation intervals and the foliar applications were randomly arranged in the sub plots**.**

Vegetative growth characters

One sample of five plants of each sub-plot were randomly obtained at 60 days after sowing for measuring growth characters of common bean plants, i.e., plant height, number of leaves/plant, fresh and dry weights (leaves) and leaf area/plant according to Koller (1972).

Green pods yield

Early yield / (ton / fed.): It was determined in ton from the first harvest.

Total yield / plot (ton /fed.): It was calculated by weighing all harvest green pods.

Chemical constituents in leaves and green pods

- Chlorophyll a, b and total were extracted from fresh leaves and determined according to the method of Mackinny (1941) by using spectrophotometer.
- Proline content: It was determined in leaves according to Bates *et al*. (1973).
- N, P and K in leaves: Nitrogen and phosphorus were calorimetrically determined according the methods described in (A.O.A.C., 1992).

Potassium was measured using the flame photometer according to Chapman and Pratt (1961).

- Protein content, Carbohydrates content and Total sugar content: It was determined in pods according to Piper (1947), Shaffer and Hartman (1921) and Smith *et al*. (1956).

The obtained data were subjected to statistical analysis as the technique of the split plot design to Sendcore and Corchran, (1968). The treatments means were compared using Duncan's Multiple Rang test as published by Duncan (1955).

Table (1): Soil physical and chemical properties in the two growing seasons of 2011 and 2012.

Parameters		**2011**	٢٠١٢
Mechanical Analysis (%)	Coarse sand	٢.٧	2.9
	Fine sand	٣٤.١	٣٤.٢
	Silt	٣٣.٣	٣٣.٦
	Clay	٢٩.٢	٢٩.٣
	Texture	Sandy clay loam	Sandy clay loam
E.C.dS.m(1:5)		٠.٩٤	0.96
PH. (1:2.5)		٨.١٢	٨.١٦
S.P. %		٤٢	٤٣
O.M. %		١.٧٢	١.٧٦
$CaCo_3^-$ %		١.٩٦	١.٩٨
Water soluble ions meq/100g soil	Ca^{++}	٠.٩٧	٠.٩٥
	Mg^{++}	٠.٤٧	٠.٤٩
	Na^+	٣.٤١	٣.٤٠
	K^+	٠.٠٨	٠.٠٨
	Hco_3^-	٠.٦٢	٠.٦٥
	Cl^-	٣.٠١	٣.٠٧
	SO_4^{--}	١.١٩	١.٢٠
Available (mg/kg)	N	٥٧.١	٥٦.٢
	P	٥.١٢	٥.٩
	K	٣١١	٣١٥

RESULTS AND DISCUSSION.

Vegetative growth characters

The results in Table(2) showed the main effect of the three irrigation intervals tested and the foliar applications of salicylic acid and foliar potassium on vegetative growth parameters (plant height, number of leaves, fresh and dry weights and leaf area/plant) of bean plants in the two growing seasons of 2011 and 2012. The results exhibited significant differences between the three irrigation intervals. The plants irrigated every 13 days recorded the highest mean value of vegetative growth parameters in comparison to irrigation every 10 days or 16 days in the two growing seasons.

With respect to the main effect of the different foliar application treatments on vegetative growth parameters, the results in Table (2) showed that application of foliar salicylic acid and potassium significantly increased the mean values of vegetative growth parameters, in relation to the control treatment in both seasons.

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Concerning the interaction between irrigation intervals and foliar treatments The obtained results illustrated that the highest mean value of vegetative growth parameters was obtained from the plants that received foliar salicylic acid at 30 ppm and irrigated every 13 days, followed by that salicylic acid at 15 ppm and irrigated every 13 days, followed by foliar K (1%) irrigated every 13days, followed by foliar k (2%).

The reduction of bean plant growth parameters as a result of increasing water irrigation intervals up to 16 days may be due to that water deficit is one of the major abiotic stresses which adversely affects plant growth and development. Generally, legumes are highly sensitive to water deficit stress (Labidi*et al.,* 2009). Also water stress affected many physiological processes including photosynthesis, respiration, translocation, ion uptake, nutrient metabolisms, biosynthesis of proteins, carbohydrates and growth promoters (Sadeghipour and Aghaei, 2012).Similar studies by Emam*et al.* (2010) reported that plant height and leaf area were decreased significantly due to water stress.The obtained results of the study are in agreement with singer *et al.* (1996) on snap bean, Manjeru*et al.* (2007), Emam*et al.* (2012) and Ghanbari*et al*. (2013)on common bean.

Green pods yield

Early yield ton/fed:

Concerning the effect of irrigation intervals on early yield/fed, data presented in Table (3) indicate that bean plants which irrigated every 13 days recorded the highest mean value of early green pods per fed. On the other hand, the lowest mean value of early green pods per fed. is recorded by bean plants which irrigated every 16 days.

Also the results showed that all foliar application treatments significantly increased early green pods/fed in both growing season as compared to the control. It is evident from Table (3) that bean plants which sprayed with salicylic acid at 30 ppm show the absolutely highest values for early green yield/ fed during the two growing seasons .Also, foliar application of K at the two used concentrations (i.e, 1% and 2%) recorded higher significant early yield as compared to the control.

Data in Table (3) illustrated the effect of interaction between irrigation intervals and foliar treatments. The results reveal that foliar application of salicylic acid at 30 ppm and irrigation every 13 days being the most effective treatment and recorded the greatest increments of early yield per fed in both seasons, followed by salicylic acid at15 ppm, followed by foliar potassium at 1% and 2%.

Total yield ton/fed:

The results presented in Table (3) indicated that there is a significant differences between the different irrigation intervals since the irrigation every 13 days recorded the highest value of yield as 6.07 and 6.33 ton/fed for the first and second seasons, respectively while irrigation every 16 days reduced the total yield to 4.84 and 5.12 33 ton/fed for the first and second seasons, respectively.

Concerning the effect of foliar application either by salicylic acid or potassium, data in the same table showed that there is a markedly increment in yield over control as a result of using salicylic acid or potassium. Foliar application of salicylic acid at 30 ppm increased the yield by 37.25 and 38.74 % followed by salicylic acid at 15 ppm with 27.45 and 24.34 % for the first and second season, respectively. While potassium at 1 % came in the third rank with 16.33 and 15.41 % and finally potassium at 2 % with 12.2 and 9.9 % increment over control plants for the first and second seasons, respectively

Table (3): Early yield and total yield of bean plants as affected by three irrigation intervals , foliar treatments and their interactions during 2011and 2012 seasons.

Treatments \ Characters		Early yield Ton/fed		Total yield Ton/fed	
		2011	2012	2011	2012
Irrigation intervals					
10 days		1.75a	2.08 b	5.50b	5.95b
13 days		1.74 a	2.19 a	6.07a	6.33a
16 days		0.95 b	1.18 c	4.84c	5.12c
Foliar treatments					
Control		1.16 e	1.31 e	4.59e	4.93e
SA (15ppm)		1.66 b	2.03 b	5.85b	6.13b
SA (30ppm)		1.85 a	2.42 a	6.32a	6.84a
K (1 %)		1.40 c	1.74 c	5.43c	5.69c
K (2 %)		1.33 d	1.58 d	5.15d	5.42d
Interaction					
10 days	Control	1.53 c	1.19h	4.95f	5.39f
	SA (15ppm)	1.99 b	2.41 c	5.85d	6.16d
	SA(30ppm)	2.04 b	2.54 b	6.60b	7.31 a
	K (1 %)	1.64 c	2.00e	5.07f	5.43f
	K (2 %)	1.55 c	1.72g	5.01f	5.42f
13 days	Control	1.16 d	1.93f	4.75g	5.04gh
	SA (15ppm)	2.02 b	2.50b	6.66b	6.92b
	SA(30ppm)	2.33 a	2.97a	7.01a	7.35a
	K (1 %)	1.63 c	2.08d	6.22c	6.49c
	K (2 %)	1.55 c	1.98ef	5.7 d	5.91e
16 days	Control	0.77 f	0.80j	4.05h	4.36i
	SA (15ppm)	0.98 e	1.18h	5.06f	5.31f
	SA (30ppm)	1.19 d	1.76g	5.36e	5.87e
	K (1 %)	0.94 e	1.14h	4.98f	5.15g
	K (2 %)	0.89ef	1.04i	4.73g	4.93h

Values within the same column followed by the same letters are not significantly different using Duncan's Multiple Range Test at 5% level.

As regards the effect of interaction between irrigation intervals and foliar application of salicylic acid and potassium on total yield of bean plants, data in Table 4 indicate that in both seasons of study, irrigation every 13 days and spraying plants with salicylic acid at 30 ppm was the best treatment in both seasons followed by irrigation every 13 days and spraying plants with salicylic acid at 15 ppm, followed by foliar potassium at 1 % under irrigation every 13days, followed by foliar potassium at 2% under 13 days interval of irrigation , while the lowest values were recorded by extended the irrigation interval up to 16 days without any alleviation treatments.

The reduction effect of prolonging water irrigation intervals (16 days) on yield of common bean and its attributes may be due to many reasons reported by many researchers. The researchers stated that high moisture stress during the reproductive stage exposed the plant to floral abortion and resulted in low seed yield. (Barrios *et al.,* 2005; Singh 1995 and Sponchiado*et al.,*1989)they reported that water stress imposed during flowering and pod setting causes flower and pod abortion. The reproductive stage is the most sensitive stage to drought stress (Nielsen and Nelson, 1998). This phase includes flower formation (Pedroza and Muñoz, 1993), full flowering (Pimentel *et al.,* 1999), pod formation (Castañeda*et al.,* 2006), or grain filling (Nielsen and Nelson, 1998).

Spraying Salicylic acid at 30 and 15 ppm showed significant increase in yield and yield. Components in both non stress and water stress conditions. Drought-related reduction in yield and yield components of plants could be ascribed to stomatal closure in response to low soil water content, which decreased the intake of CO_2 and, as a result, photosynthesis decreased (Chaves, 1991.;Cornic, 2000, Flexas, *et al* 2004). In summary, prevailing drought reduces plant growth parameters (Table 2), leading to hampered flower production. Many studies similar to our experiment reported that water stress reduces yield and its components of common bean.

Exogenous SA application significantly improved yield and yield components of common bean in well watered and water stressed plants. Similarly Gomez, *et al.* (1993) found that exogenous application of SA can improve yield and yield attributes under drought stress.

Foliar application of K at 1% or 2% recorded higher values for all yield parameters under all irrigation treatments as compared to the untreated plants (control plants which sprayed with tap water only). The stimulator effect of potassium on the yield may be due to that potassium plays an important role in water status of plant, promoting the translocation of newly synthesized photosynthetic and mobilization of metabolites as well as promoting the synthesis of sugars and polysaccharides (Mengel and Kirkby, 1982).

Similar results were reported by Pannu and Singh (1988) on mungbean, Singer *et al.* (1996) on snap bean, Peterson (1989) ,Elivera*et al.* (2003), Manjeru*et al.* (2007), Emam*et al.* (2012), Sedeghipour and Aghaei (2012) on common bean and Thalooth*et al.* (2006) on mungbean.

Chemical constituents in leaves

leaf`s chlorophyll content

It is clear from the data in Table 4 that the mean values of chlorophyll a, b and total in the leaves of bean plants were significantly affected as a result of irrigation intervals, the highest values were recorded with irrigation every 13 days followed by irrigation every 10 days. The lowest values were obtained with irrigation every 16 days in both growing seasons 2011 and 2012.

In the same table, the effect of foliar treatments showed significant differences in both seasons. Foliar treatment with salicylic acid (30 ppm) recorded the highest mean values followed by foliar treatment with salicylic acid (15 ppm). Also, foliar potassium at (1%) and foliar potassium at (2%) gave higher significant values compared with (control).

In respect to the interaction effect between irrigation intervals and foliar treatments, data in Table (4) showed that the combination treatment of foliar salicylic acid 30 ppm and irrigation every 13 days significantly gave the highest mean values for chl. a, chl. b and total chl. in both seasons.

Leaf`s proline content

Data presented in Table (4) showed the effect of the three irrigation intervals tested on leaf`s proline content in both growing seasons. The results showed that the leaves of plants irrigated every 16 days had higher proline content, in the two seasons 2011 and 2012.

Regarding the leaf`s content of proline, in the two growing seasons of 2011 and 2012 due to the application of different foliar treatments are shown in Table (4),

Table (4):Leaf`s chlorophyll content and proline of common bean plants as affected by three irrigation intervals , foliar treatments and their interactions during 2011 and 2012 seasons.

Characters / treatments		Chl. a Mg g-1fw		Chl. b mg g-1fw		Chl. a + b mg g-1fw		Proline µ mol g-1fw	
		2011	2012	2011	2012	2011	2012	2011	2012
Irrigation intervals									
10 days		0.550 b	0.599 b	0.384 b	0.431 b	0.934 b	1.030 b	7.132 c	6.300 c
13 days		0.577 a	0.624 a	0.402 a	0.461 a	0.977 a	1.085 a	7.452 b	6.783 b
16 days		0.524 c	0.571 c	0.365 c	0.406 c	0.892 c	0.977 c	7.668 a	7.234 a
Foliar treatments									
Control		0.531 e	0.561 e	0.370 e	0.402 e	0.901 e	0.964 e	7.036 e	6.440 e
SA 15 ppm		0.560 b	0.616 b	0.391 b	0.447 b	0.951 b	1.063 b	7.598 b	6.938 b
SA 30 ppm		0.568 a	0.634 a	0.396 a	0.462 a	0.964 a	1.097 a	7.778 a	7.048 a
K 1%		0.552 c	0.599 c	0.384 c	0.434 c	0.934 c	1.034 c	7.451 c	6.788 c
K 2%		0.541 d	0.580 d	0.376 d	0.418 d	0.921 d	0.998 d	7.221 d	6.647 d
Interaction									
10 days	Control	0.530 fg	0.572 h	0.369hi	0.402 gh	0.899hi	0.957 i	6.563 k	5.940 k
	SA 15 ppm	0.561bc	0.614 d	0.392cd	0.445 cd	0.953 e	1.059de	7.380 g	6.476 h
	SA 30 ppm	0.570 b	0.625 c	0.396 c	0.459 bc	0.968cd	1.084 c	7.693 cd	6.590 g
	K 1%	0.550 d	0.600 e	0.384 ef	0.432 de	0.935 f	1.032 f	7.190 i	6.300 i
	K 2%	0.538 ef	0.584 g	0.378 fg	0.418efg	0.916 g	1.002 h	6.833 j	6.196 j
13 days	Control	0.560 c	0.592 f	0.387de	0.434 de	0.947 e	1.027 f	7.123 i	6.460 h
	SA 15 ppm	0.583 a	0.640 b	0.409ab	0.474 ab	0.992 b	1.114 b	7.616 d	6.976 e
	SA 30 ppm	0.591 a	0.654 a	0.415 a	0.485 a	1.006 a	1.139 a	7.746 bc	7.083 d
	K 1%	0.581 a	0.627 c	0.405 b	0.463 bc	0.977 c	1.090 c	7.483 ef	6.783 f
	K 2%	0.571 b	0.608 d	0.393cd	0.448 cd	0.964 d	1.056 e	7.290 h	6.613 g
16 days	Control	0.503 i	0.520 j	0.354 k	0.369 i	0.857 k	0.890 k	7.423 fg	6.920 e
	SA 15 ppm	0.535 ef	0.596 ef	0.374gh	0.423 ef	0.910gh	1.017 g	7.800 b	7.363 b
	SA 30 ppm	0.542de	0.623 c	0.375gh	0.444 cd	0.918 g	1.068 d	7.896 a	7.473 a
	K 1%	0.524gh	0.571 h	0.363 ij	0.409 fg	0.891 ij	0.980 i	7.680 cd	7.283 c
	K 2%	0.515 h	0.546 i	0.358 jk	0.389 h	0.884 j	0.935 j	7.540 e	7.133 d

Values within the same column followed by the same letters are not significantly different using Duncan's Multiple Range Test at 5% level.

The data clearly pointed out that using foliar treatment increased significantly leavesproline content in both seasons comparing with control. The obtained values cleared that treatment with foliar salicylic acid at30 ppm gave the highest significant proline content compared with the other treatments in both seasons.

Data in Table (4) showed the effect of various treatment combinations of irrigation intervals and foliar treatments ofproline content in both seasons.

The combination treatment of foliar salicylic acid at 30 ppm and irrigation every 16 days, recorded the highest mean values of proline content in the both seasons.

Mineral contents of leaves

The results concerning the general effects of the two studied factors as well as their interactions on leaf mineral contents are listed in Table (5), in the two growing seasons. The results of Table (5) indicated that plants irrigated every 13 days had higher leaf N, P and K percentages, in both growing seasons.

Regarding the influences of the applied different foliar treatments on leaf mineral contents, the data presented in Table (5) showed clearly that the application of all foliar treatments, generally, caused higher corresponding significant increase on leaf`s N, P and K percentages, relative to the control, in both seasons.

The interaction between irrigation intervals and foliar treatments had a significant effect on leaf`s N, P and K percentages, in both growing seasons. The highest mean values for leaf`s N, P and K contents were obtained when plants were irrigated every 13 days and plants received foliar salicylic acid at 30 ppm in both growing seasons.

Table (5):Leaf`s contents N, P and K percentage of common bean leaves as affected by three irrigation intervals ,foliar treatments and their interactions during 2011 and 2012 seasons.

Characters / treatments		N %		P %		K %	
		2011	2012	2011	2012	2011	2012
Irrigation intervals							
10 days		3.412 b	3.608 b	0.396 b	0.403 b	2.144 b	2.339 b
13 days		3.584 a	3.866 a	0.428 a	0.429 a	2.240 a	2.524 a
16 days		3.167 c	3.308 c	0.366 c	0.378 c	1.987 c	2.134 c
Foliar treatments							
Control		3.166 e	3.488 e	0.384 e	0.372 e	1.986 d	2.265 d
SA 15ppm		3.482 b	3.645 b	0.402 b	0.413 b	2.177 b	2.365 b
SA 30ppm		3.535 a	3.703 a	0.409 a	0.421 a	2.232 a	2.414 a
K 1%		3.422 c	3.604 c	0.397 c	0.408 c	2.125 c	2.330 c
K 2%		3.334 d	3.528 d	0.392 d	0.402 d	2.096 c	2.286 c
Interaction							
10 days	Control	3.233 ef	3.476 g	0.383 h	0.374ghi	1.986ghi	2.273 f
	SA 15ppm	3.513 c	3.653 e	0.403 f	0.410 e	2.203 cd	2.363 d
	SA 30ppm	3.530 c	3.726 d	0.410 e	0.417 d	2.286 ab	2.446 c
	K 1%	3.420 d	3.640 e	0.395 g	0.408 e	2.150 de	2.330 de
	K 2%	3.366 d	3.543 f	0.391 g	0.405 e	2.093 ef	2.283 ef
13 days	Control	3.166gh	3.763 d	0.420 d	0.372 hi	2.060f g	2.446 c
	SA 15ppm	3.760ab	3.930 a	0.431 b	0.452 a	2.296 ab	2.570 ab
	SA 30ppm	3.793 a	3.963 a	0.435 a	0.457 a	2.356 a	2.603 a
	K 1%	3.703 b	3.866 b	0.428 bc	0.438 b	2.243 bc	2.536 b
	K 2%	3.500 c	3.810 c	0.425 c	0.425 c	2.243 bc	2.463 c
16 days	Control	3.100 h	3.226 k	0.351 l	0.370 i	1.913 i	2.076 i
	SA 15ppm	3.173 fg	3.353 i	0.372 i	0.379 g	2.033fgh	2.163 gh
	SA 30ppm	3.283 e	3.420 h	0.382 h	0.389 f	2.053fgh	2.193 g
	K 1%	3.143gh	3.306 j	0.367 j	0.377gh	1.983 hi	2.123 hi
	K 2%	3.136gh	3.233 k	0.359 k	0.376ghi	1.953 i	2.113 hi

Values within the same column followed by the same letters are not significantly different using Duncan's Multiple Range Test at 5% level.

Photosynthetic efficiency depends to large extent on quantity and quality of photosynthetic pigments such as chlorophyll a and chlorophyll b which play an important role in photochemical reactions of photosynthesis (Taiz and Zeiger, 2002). Water stress can inhibit photosynthesis of plants by affecting chlorophyll components, causing changes in chlorophyll content, and damaging the photosynthetic apparatus in plants (IturbeOrmaetxe*et al.* 1998). The current study showed significant differences among water irrigation interval treatments for chlorophyll a, chlorophyll b and total chlorophyll contents especially after being subjected to water stress. There was a general decrease in the leaf chlorophyll content in plants subjected to water stress.

The decrease in chlorophyll in the study was more in high water stress condition than in the low water stress and normally irrigated condition (Table 4). The highest decrease in total chlorophyll content was obtained from irrigation every16 days. Many workers found that chlorophyll content decreased with water stress indicating that photosynthetic pigments are sensitive to water stress conditions. A reduction in chlorophyll content was also reported in drought stressed common bean (Santos *et al*. 2009).

The obtained results (Table 4) showed that application of salicylic acid at 15 and 30 ppm have revealed appositive effect on photosynthesis pigments (chlorophyll a, b and total chlorophyll) of common bean in both non stress and water stress conditions.

Similar results were reported by Sedeghipour and Aghaei (2012) andMafakheri1 *et al.* (2010)

Under vegetative stage, drought stress increased proline content about tenfold, this increasing roles as an osmotic compatible and adjust osmotic potential which resulted in drought stress avoidance in chickpea. Proline accumulation is believed to play adaptive roles in plant stress tolerance (Verbruggen and Hermans 2008). Accumulation of proline has been advocated as a parameter of selection for stress tolerance (Yancy*et al.* 1982. Jaleel*et al.* 2007).

Chemical constituents of green pods

Protein, Carbohydrates and Total sugar contents

Data given in Table (6) showed the effect of the tested irrigation intervals on protein, carbohydrates and total sugar content of green pods, in two growing seasons of 2011 and 2012. The results of the comparison among the protein content mean values, of three tested irrigation intervals illustrated significant differences of this character, in both growing seasons, since the highest values were recorded with irrigated plants every 13 days.

Also data in Table (6) indicated that using foliar salicylic acid 30 ppm was superior to other foliar treatments in protein, carbohydrates and total sugar content, in both seasons 2011 and 2012. There were significant differences between the foliar treatments in both seasons.

The interaction effect between irrigation intervals and foliar treatments reflected significant differences on protein, carbohydrates and total sugar content in both seasons. The combination treatment of foliar salicylic acid 30 ppm and irrigation every 13 days, recorded the highest mean values of protein content in the both seasons.

The results in this study showed that foliar applications of Salicylic acid and Potassium had appositive effect on quality characters of common bean (i.e. protein content, carbohydrate content and sugar content). This positive effect may be due to the application of Salicylic acid and Potassium improve chlorophyll content, stomatal conductance and finally net photosynthetic rate of common bean in both non stress and stress conditions as mentioned by Sedeghipour and Aghaei(2012).

Also, Sufficient K induces solute accumulation, thus lowering osmotic potential and helping to maintain plant cell turgor under osmotic stress**.**

The result is agreement with Azza*et al.* (2007) who showed that irrigation intervals treatments have a depressing effect on sugar content. And spraying potassium at 50 ppm increased sugar content as compared with the untreated one

Table (6): Protein, carbohydrates and sugar of common bean plants as affected by three irrigation intervals , foliar treatments and their interactions during 2011 and 2012 seasons.

Characters / treatments		Protein %		Carbohydrates %		Sugar %	
		2011	**2012**	**2011**	**2012**	**2011**	**2012**
Irrigation intervals							
10 days		13.177 b	13.810b	18.149 b	18.468 b	4.828 b	5.408 b
13 days		13.849a	14.855a	19.256a	19.530a	5.040 a	5.686 a
16 days		12.318 c	12.707c	16.678 c	17.772 c	4.714 c	5.162 c
Foliar treatments							
Control		12.261 e	13.404e	17.706 e	17.502 e	4.705 d	5.326 e
SA 15 ppm		13.586 b	13.978b	18.326 b	18.994 b	4.915 b	5.462 b
SA 30 ppm		13.772a	14.206a	18.530a	19.213a	4.981 a	5.520 a
K 1%		13.085 c	13.778c	18.120 c	18.763 c	4.880 b	5.420 c
K 2%		12.868d	13.586d	17.955d	18.477d	4.822 c	5.367 d
Interaction							
10 days	Control	12.166 l	13.433 i	17.690 j	17.420 l	4.693gh	5.280 i
	SA 15 ppm	13.633 d	13.990 f	18.396 g	18.886 f	4.896 d	5.473 f
	SA 30 ppm	13.740 c	14.183 e	18.616 f	19.113 e	4.933cd	5.553 e
	K 1%	13.250 f	13.843 g	18.113 h	18.653 g	4.816 e	5.403 g
	K 2%	13.096 g	13.603 h	17.930 i	18.266 h	4.800 e	5.333 h
13 days	Control	12.633 i	14.376d	18.920 e	17.923 j	4.776ef	5.606 d
	SA 15 ppm	14.633 b	15.193 a	19.373 b	20.073 b	5.123 b	5.726 b
	SA 30 ppm	14.803 a	15.270 a	19.503 a	20.346 a	5.220 a	5.783 a
	K 1%	13.740 c	14.860 b	19.296 c	19.786 c	5.096 b	5.680 c
	K 2%	13.436 e	14.576 c	19.186 d	19.523 d	4.983 c	5.636 d
16 days	Control	11.983 n	12.403m	16.510 o	17.163m	4.646 h	5.093 l
	SA 15 ppm	12.493 j	12.753 k	17.210 l	18.023 i	4.726fg	5.186hk
	SA 30 ppm	12.773 h	13.166 j	17.470 k	18.180 h	4.790ef	5.223 j
	K 1%	12.266 k	12.633kl	16.950m	17.850 j	4.726fg	5.176 k
	K 2%	12.073m	12.580 l	16.750 n	17.643 k	4.683gh	5.133 l

Values within the same column followed by the same letters are not significantly different using Duncan's Multiple Range Test at 5% level.

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النمو الخضرى والمحصول وبعض الصفات الكيميائية للاوراق والقرونللفاصوليا الخضراءتحت تأثير الرش بحامض السالسليك والبوتاسيوم تحت فترات رى مختلفة

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أجريت تجربتان حقليتان فى مزرعة خاصة بقرية سلكا مركز المنصورة محافظة الدقهليه خلال موسمين زراعيين ناجحين خلال عامى ٢٠١١ و ٢٠١٢ لدراسة تأثير فترات الرى وبعض معاملات الرش بحامض السالسليك والبوتاسيوم على النمو الخضرى (طول النبات و عدد الاوراق على النبات والوزن الطازج والجاف للنبات والمساحة الورقية للنبات) والمحصول (المحصول المبكر للفدان ، المحصول الكلى للفدان) والصفات الكيميائية للاوراق (كلوروفيل أ،ب ، الكلى،البرولين وتركيز النيتروجين والفوسفور والبوتاسيوم) وكذلك الصفات الكيميائية للقرون (نسبة البروتين والكربوهيدرات والسكريات الكلية) للفاصوليا الخضراء صنف البرونكو. تحتوى هذه الدراسة على ١٥ معاملة ناتجة من تفاعل ثلاث فترات رى (الرى كل ١٠ ايام ، الرى كل ١٣ يوم والرى كل ١٦ يوم) وخمس معاملات رش (كنترول ، الرش بحامض السالسليك ١٥ جزء فى المليون ، الرش بحامض السالسليك ٣٠ جزء فى المليون ، الرش بالبوتاسيوم بتركيز ١%و٢% . تم تنفيذ التجربة باستخدام تصميم القطع المنشقة فى قطاعات كاملة العشوائية فى ٣ مكررات.

أظهرت النتائج أن نباتات الفاصوليا المعرضة للاجهاد المائى ادت الى انخفاض متوسط قيم صفات النمو الخضرى ،المحصول والمحتوى الكيميائى للاوراق والقرونلنباتات الفاصوليا انخفضت بزيادة فترات الرى حتى ١٦ يوم خلال موسمى الدراسة. بصفة عامة بينت النتائج أن الرش بحمض السالسليك بتركيز ١٥ أو ٣٠ جزء فى المليون وكذلك الرش بالبوتاسيوم بتركيز ١% أو ٢% أدى الى تحسين كل الصفات التى قيست تحت ظروف الرى الجيد أو عند الاجهاد المائى.

سجلت اعلى القيم للصفات السابقة عند رش النباتات بحامض السالسليك بتركيز ٣٠ جزء فى المليون يليه الرش بحامض السالسليك بتركيز ١٥ جزء فى المليون يتبعه الرش بالبوتاسيوم بتركيز ١% و ٢% عند الرى كل ١٣ يوم (٥ ريات) مقارنة بالرى كل ١٠ او ١٦ يوم (٤ و ٦ ريات). عدا محتوى الاوراق من البرولين حيث سجلت أعلى القيم عند الرش بحامض السالسليك اسيد والرى كل ١٦ يوم .

وهذه النتائج توضح دور كلا من حامض السالسليك والبوتاسيوم والذى يمكن استخدامه كمنظم نمو لتحسين نمو وانتاج نباتات الفاصوليا تحت ظروف الاجهاد المائى.

Table (2): vegetative growth characters of bean plants as affected by irrigation intervals, foliar treatments and their interactions during 2011 and 2012 seasons.

Treatments \ Characters		Plant height (cm)		No. of leaves/plant		fresh weight g/plant		Foliage dry weight g/ plant		Leaf area/plant $(cm)^2$	
		2011	2012	2011	2011	2011	2012	2011	2012	2011	2012
Irrigation intervals											
10 days		41.77 b	45.13 b	10.66 b	12.06 b	70.40 b	64.40 b	7.94 b	10.86 b	1043.92 a	967.26 b
13 days		42.37 a	47.40 a	11.20 a	12.86 a	71.49 a	73.26 a	8.66 a	12.06 a	1030.84 b	1064.95 a
16 days		36.28 c	41.90 c	10.00 c	11.13 c	62.36 c	58.67 c	6.43 c	9.27 c	797.11 c	825.1 c
Foliar treatments											
Control		36.80 e	40.83 d	9.77 e	10.66 d	61.54 e	57.46 d	6.92 e	9.72 e	878.12 e	858.71 c
SA 15 ppm		41.45 b	46.40 ab	11.00 b	12.55 b	70.29 b	68.26 b	7.98 b	11.06 b	980.80 b	970.24 ab
SA 30 ppm		43.12 a	46.90 a	11.33 a	13.44 a	72.74 a	70.98 a	8.22 a	11.73 a	989.83 a	999.54 a
K 1%		40.04 c	45.76 b	10.66 c	11.88 c	68.82 c	65.97 c	7.74 c	10.73 c	975.52 c	971.80 ab
K 2%		39.29 d	44.15 c	10.33 d	11.55 c	67.03 d	64.54 c	7.52 d	10.41 d	962.19 d	961.97 b
Interaction											
10 days	Control	39.34 d	42.40 f	10.33 c	11.33def	67.50 e	58.60 h	7.11 f	10.13 i	1004.02 g	928.20 cd
	SA 15 ppm	42.56 b	46.00cd	11.00 b	12.33bcd	71.09 c	66.26 e	8.23 d	11.11 f	1061.83 e	982.50 b
	SA 30 ppm	44.29 a	46.20cd	11.00 b	13.33 ab	73.39 b	69.76 d	8.50 c	11.43 e	1063.51 d	985.25 b
	K 1%	41.40bc	45.63cd	11.00 b	11.66cdf	70.29 cd	64.53 ef	8.17 d	11.05 f	1061.97 e	978.43 bc
	K 2%	41.24 c	45.43 d	10.00 d	11.66cdf	69.72 d	62.86 f	7.71 e	10.62 g	1028.27 f	961.95 bc
13 days	Control	38.58de	41.96 f	10.00 d	11.00 ef	62.28 g	58.26 h	7.62 e	10.34 h	868.90 h	894.23 d
	SA 15 ppm	44.40 a	49.60 a	12.00 a	13.33 ab	73.67 b	78.46 b	9.19 a	12.65 b	1068.57 b	1112.05 a
	SA 30 ppm	45.34 a	49.90 a	12.00 a	14.33 a	77.42 a	81.33 a	9.26 a	13.82 a	1081.87 a	1122.77 a
	K 1%	42.29bc	48.40ab	11.00 b	13.33 ab	73.11 b	74.86 c	8.67 b	11.92 c	1068.05bc	1104.12 a
	K 2%	41.26 c	47.13bc	11.00 b	12.33bcd	70.98 c	73.40 c	8.55 c	11.56 d	1066.81 c	1091.59 a
16 days	Control	32.48 h	38.13 h	9.00 e	9.66 g	54.8 i	55.53 i	6.05 j	8.70 n	761.44 m	753.72 f
	SA 15 ppm	37.40 ef	43.60 ef	10.00 d	12.00cde	66.11 f	60.06 gh	6.50 h	9.42 k	811.99 j	816.18 e
	SA 30 ppm	39.73 d	44.60de	11.00 b	12.66 bc	67.41 e	61.86 fg	6.91 g	9.96 j	824.10 i	890.60 d
	K 1%	36.58 f	43.26 ef	10.00 d	10.66 fg	63.05 g	58.53 h	6.37 i	9.23 l	796.55 k	832.86 e
	K 2%	35.21 g	39.90 g	10.00 d	10.66 fg	60.39 h	57.36 hi	6.31 i	9.05 m	791.50 l	832.36 e

Values within the same column followed by the same letters are not significantly different using Duncan's Multiple Range Test at 5% level.