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EFFECT OF IRRIGATION RATES AND POTASSIUM FERTILIZATION ON GROWTH AND CHEMICAL COMPOSITION OF MOGHAT *(Glossostemon bruguieri,* Desf*)* GROWN IN SANDY SOIL

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ABSTRACT

This work was carried out during the two successive seasons of 2015/16 and 2016/17 at the Expt. Farm of South Tahrir, Hort. Res. Station. The experiment aimed to evaluate the effect of three irrigation rates (1200, 1500 and 1800 m^3 water/ fadand four potassium fertilization levels (0, 50, 100 and 150 kg K_2SO_4/ fad) and their interactions on moghat growth and productivity as well as evaluate to what extent these treatments affect soil properties.

Gradual increases in plant height, root length, root diameter, as well as, roots fresh and dry weights/ plant were noticed with increasing irrigation rate from 1200 m^3/ fad up to 1800 m^3/ fad. This was associated with an improvement in roots quality. Increasing irrigation rate significantly increased percentages of total protein and potassium in moghat root tissues, but decreased mucilage percentage. The highest mucilage percentages in roots were found in plants irrigated with the lowest irrigation rate (1200 m^3/fad).

Potassium fertilization enhanced plant growth as plant height, root length and root diameter. This was reflected as increases in root fresh and dry weights/ plant. The highest values represented the abovementioned measurements were found in plants received the highest potassium fertilization level (150 kg K_2SO_4/ fad). Moghat plants received 150 kg K_2SO_4/ fad resulted roots contained high percentages of mucilage, protein, potassium and total amino acids.

When, irrigation rates interacted with K fertilization levels, more increases in plant height, root length, root diameter, roots fresh and dry weights/ plant and K percentage in root tissues were found. The highest values of the abovementioned measurements were recorded in plants irrigated with 1800 m^3/ fad and fertilized with 150 kg K_2SO_4/ fad. The *same treatment resulted in increases in number of capsule/ plant, number of seeds/ capsule and seed weight/plant. Interaction treatment of 1200 m^3 irrigation water/ fad combined with 100 Kg K_2SO_4/fad resulted in the highest mucilage % in roots comparing to the all other interaction treatments.*

Conclusively, *the obtained data showed that addition any of the previous treatments led to an improvement in some of the physical and chemical properties of soil, due to increasing organic content. While, bulk density, hydraulic conductivity, EC and pH values were decreased.*

Key Words: Amino acids, irrigation, moghat, (*Glossostemon bruguieri* Desf), mucilage, potassium fertilizer, proline, sandy soil.

INTRODUCTION

Moghat (*Glossostemon bruguieri* Desf), Family *Sterculiaceae*, is a mucilaginous plant, its roots is commonly used in traditional medicine in Egypt as a nutritive tonic and for many purposes such as promoting lactation, increasing body weight, treating gout and spasm. According to Ibrahim *et al*., (1997) moghat roots contain 24% starch, 5.5% protein, 3% sugars, 3% fats, 23% mucilage on basis of dry matter, as well as mineral elements.

Irrigation water quantity affects plant growth and its production. Previous researches on tuberous plants or on plants produced swollen roots like potato or carrots confirmed an importance role of irrigation water quantity in enhancing plants growth and in turn reflected on tubers or roots yield. Dealing with potato plant, El-Ghamriny *et al*., (2005) found that irrigation water quantity of 2000 m^3/ fad enhanced potato plant growth and increased free and total water in leaf tissues as well as N, P and K concentrations and their uptakes, which increased tuber yield and its components. Also, Wang *et al*., (2006 and 2007) when used drip irrigation system examined effect of six irrigation frequencies; *i.e.,* once every 1, 2, 3, 4, 6 or 8 days, they noticed that reducing irrigation frequency from once every 1 day to once every 8 days resulted significant reduction in tuber yield. Moreover, Abou EL-Khair *et al.,* (2011) found that water quantity of 1250 or 1750 m^3/ *fad* increased accumulation of carbohydrates and starch in potato tuber tissues, and so increased tuber yield/ *fad*. Recently, Abdel-Monnem (2015) recorded significant reductions in number of produced tubers/ plant and average weight / tuber as well as total yield of tubers/ *fad* of potato by increasing irrigation intervals from 3 days to 6 days. Also, Baba and Simon (2015) reported that carrot plants produced longer roots with high diameter by applying 5 or 7 days of irrigation intervals. Zeinab Safaei *et al.,* (2014) mentioned that irrigation intervals had significant effects on number of capsule per plant, number of seeds per capsule and per plant, seed weight per plant, seed yield per fad, biological yield and harvest index of black cumin (*Nigella sativa*). Additionally, Makarim *et al*., (2014) recorded decreases in plant height, number of leaves/ plant, leaf width and fresh and dry weights of rhizomes per *Curcuma spp* plant and in total carbohydrate, volatile oil and curcumin in dry rhizomes by prolonging irrigation intervals. While, irrigated plants every week, compared to every two or three weeks, resulted in more total carbohydrate, volatile oil and curcumin in dry rhizomes.

Potassium plays vital role in synthesis, transformation and storage of carbohydrates, thus affects tuber quality and its characteristics as well as plant resistance to stress and diseases (Ebert, 2009). Studies of EL-Gengaihi *et al.,* (1995) on moghat found that potassium had great effects in increasing root length, diameter and weight/ plant as well as seeds yield per plant. Also, they noticed that potassium fertilization decreased mucilage content and increased fat content in roots of old moghat plants. Al-Moshileh *et al*. (2005) noticed increases in potato tubers yield and improvements in its quality characteristics with applying 450 kg K_2SO_4/ h. On carrot plant, Kevin and Brian (2006) indicated that application of 300 kg K_2O/ h increased total roots yield. And in another study, Kadar (2008) reported that increasing of the applied potassium dose up to 300 kg K_2O/ *h* enhanced carrot roots growth in calcareous sandy soil. Attoe *et al.,* (2013) recorded increases in plant height, number of leaves and shoots/ plant and yield of ginger with K fertilization. Additionally, Akhter *et al*., (2013) published that application of K fertilizer increased fresh rhizome yield of ginger. Moreover, Ali *et al.,* (2014) reported that increasing levels of solopotasse fertilizer resulted in increases in plant height, number of seed per umbel and 1000 seed weight of cumin (*Cuminum cyminum* L.). Recently on turnip plant, Shafeek *et al.,* (2015) found that the high level of potassium fertilizer (200 kg K_2SO_4/ fad) increased plant height number of leaves per plant and fresh and dry weights of leaves/ plant compared to medium (150 kg K_2SO_4/ *fad*) or low K (100 kg K_2SO_4/ fad) fertilizer levels.

Thus, presented work was conducted aiming to study effects of irrigation water rates, potassium fertilization levels and their interactions on moghat (*Glossostemon bruguieri* Desf) plant growth and productivity for optimizing water management and potassium fertilization in order to maximizing growth and yield of plants grown under drip irrigation system in sandy soil. Also, the aim of this work was extended to evaluate to what extent the above treatments effect on physical and chemical properties of soil after harvesting.

MATERIALS AND METHODS

This work was carried out during the two successive seasons of 2015/2016 and 2016/2017 at the Experimental Farm of South Tahrir, Horticulture Research Station to evaluate the effect of irrigation rates, potassium fertilization levels and their interactions on moghat (*Glossostemon bruguieri* Desf) growth, root yield and its chemical constituents under drip irrigation system and sandy soil conditions.

1- Physical and chemical properties of the used experimental soil (Table A) were determined before moghat seed sown. In addition, irrigation water was analyzed and its characteristics are recorded in Table B. Soil and water analysis were done at Soils, Water and Environment Research Institute laboratories (ARC) according to the methods of Donald L Sparks; 1996.

Table A: Some physical and chemical properties of the experimental soil

Soil characteristics	Values
Particle size distribution	
Coarse sand (%)	14.6
Fine sand (%)	74.1
Silt (%)	6.1
Clay	5.2
Soil texture	Sandy soil
Bulk density (Mg m^{-3})	1.65
Hydraulic conductivity (cm h^{-1})	34.3
$CaCO_3$ ($g.kg^{-1}$)	1.86
Organic matter ($g.kg^{-1}$)	0.21
EC (dSm^{-1})	2.24

Table b: Chemical analysis of irrigation water

EC (dSm^{-}	Cations ($meq.L^{-1}$)				Anion ($meq.L^{-1}$)			pH	RSC	Adj.
	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	HCO_3^{-}	CL^{-}	SO_4^{2-}		($meq./L^{-}$)	SAR.
2.04	4.5	3.72	8.4	1.57	2.07	7.5	8.64	7.53	-	8.07

Moghat seeds were purchased from Bedef Village, El-Hawamdya City, Giza Governorate. On 8th March of 2015 and 2016, for first and second experimental seasons, seeds were soaked in tape water for 48 hours and then were directly planted in hills on rows at distances of 30 cm. Planting was done in plots. The experimental plot area was 11.55 m^2, which contained three lines 5.50 m length and 70 cm between each one. The used drippers were with discharge of 2 liters/ hour. One month after planting, the seedlings were thinned to leave one plant/ hill.

This experiment included 12 treatments, which were the combinations between three irrigation quantity rates (1200, 1500 and 1800 m3/ *fad*) and four potassium fertilizer levels (0, 50,100, and 150 kg K_2SO_4/ fad). The twelve treatments were as follow:

Irrigation quantity rats (m^3/ fad)	**Potassium fertilizer levels (K_2SO_4/ fad).**
1200	0
	50
	100
	150
1500	0
	50
	100
	150
1800	0
	50
	100
	150

***The experimental design*:**

The experimental treatments were arranged in a factorial experiment between the above mentioned irrigation quantity rates (3 levels) and potassium fertilizer levels (4 levels) in a split-plot design with three replicates, each plot represented an experimental unit. Irrigation levels were allocated at the main plots, while K fertilizer levels were at the sub-plots.

Potassium fertilization was applied by divided the abovementioned designed doses into two equal portions, the half dose was applied just after thinning, while the second half was applied after one month of the first one. Potassium sulphate 48 % K_2O was used as a potassium source.

During soil preparation before sowing, compost at rate of 5 ton/ fad and calcium superphosphate (15.5% P_20_5) at rate of 300 kg/fad were mixed with the soil of all experimental plots. Also, N fertilization at rate of 300kg/ fad as ammonium nitrate (33.5% N) was applied equally for all experimental plots. It was applied at two equal portions at the same time of K fertilization treatments were done. Chemical characteristics of used compost are shown in Table C

Table C: Chemical characteristics of the used compost

Characteristics	Value
pH (1:10 soil water extract)	7.06
Organic matter ($g.kg^{-1}$)	46.3
Organic Carbon ($g.kg^{-1}$)	27.0
C\N ratio	14.3
Total Nitrogen ($g.kg^{-1}$)	1.56
P ($g.kg^{-1}$) Total	1.88
K ($g.kg^{-1}$) Total	3.05
Density (Mg^{-1})	0.54

Recorded data

At the end of both experimental seasons, the following data were recorded:

a. Plant growth and roots yield:

1. Plant vegetative growth was recorded as plant height (cm).
2. On October 9th 2016 and 4th 2017 for first and second seasons, respectively roots were harvested. Then, root length (cm) and root diameter (cm) as well as roots fresh (kg) and dry (g) weights per plant were recorded.
3. At capsules maturation, numbers of capsules/ plant, number of seeds/ capsule and seeds weight/ plant (g) were recorded.

b. Roots chemical analysis:

In dried roots the following determinations were done:

1. Mucilage percentage was determined according to **Woolfe *et al*., (1977).**
2. Total nitrogen was determined using micro-Kjeldahl method (A.O.A.C. 1984), then crude protein was calculated using conversion factor (6.25).
3. Potassium percentage was determined according to the methods described by A.O.A.C. (1990).
4. Total amino acids content (g/100g) was determined as described by Yemm and Cocking (1955).

5. Proline content (mg/100g) was determined as described by Troll (1955).

c. Soil determinations:

Soil salinity (EC), soil pH, bulk density (B.D) and hydraulic conductivity (K) in soil after harvesting of the two of experimental seasons were determined.

Statistical analysis

The collected data were statistically analyzed using computer package program of MSTAT-C. Mean separation was done using least significant difference (LSD) at 5% level of significance as described by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

I- Effect of irrigation rates, potassium fertilization levels and their interactions on growth characteristics:

Plant length (cm):

Data represented plant length of moghat plant in Table 1 revealed that high irrigation rate (1800 m^3) significantly increased shoot length in both seasons, plants irrigated by 1800 m^3/fad gave the tallest plants (52.25 and 52.95 cm) in the first and second seasons, respectively, while the lowest irrigation rate (1200 m^3/fad) gave the shortest plants (38.38 and 38.64 cm) in the two seasons respectively. These results are in agreement with those found by Alam *et al.,* (2010) on carrot; they reported that different irrigation treatments significantly increased plant height over than control.

Concerning the effect of potassium fertilization, data in Table 1 showed that potassium fertilization significantly increased plant length, and the highest values of shoot length (52.62 and 53.00 cm) were obtained in plants supplied with 100kg/fad compared to the control in both years. Whereas, the least effective treatment (excluding the control) was supplying the plants with 50 kg Potassium sulphate /fad, which recorded the lower values (47.08 and 47.39 cm) in the two seasons, respectively comparing to other fertilization treatments. These results are in close agreement with the findings of Attoe *et al.,* (2013) on ginger and Shafeek *et al.,* (2015) on turnip.

Concerning the effect of potassium fertilization, data in Table 1 showed that potassium fertilization significantly increased plant length, and

Table 1: Effect of irrigation rates, potassium fertilization levels and their interactions on plant length (cm) of moghat plant at 2015/ 2016 and 2016/ 2017 seasons.

Potassium fertilizer levels (K_2SO_4/ fad). P	Irrigation quantity rats (m^3/ fad) (I)							
	1200	1500	1800	Mean	1200	1500	1800	Mean
	2015/ 2016				2016/ 2017			
0	35.51	39.59	42.52	**39.21**	35.33	39.61	43.31	**39.42**
50	37.60	48.41	55.22	**47.08**	37.83	49.77	54.56	**47.39**
100	42.04	56.81	59.01	**52.62**	42.76	55.27	60.98	**53.00**
150	39.76	50.6	61.12	**50.49**	40.64	50.12	62.78	**51.18**
Mean	38.38	48.27	52.25	**–**	38.64	48.22	52.95	**–**
LSD at 0.05 for:								
I	**4.88**				**3.60**			
P	**3.96**				**4.08**			
I X P	**8.51**				**7.79**			

the highest values of shoot length (52.62 and 53.00 cm) were obtained in plants supplied with 100kg/fad compared to the control in both years. Whereas, the least effective treatment (excluding the control) was supplying the plants with 50 kg Potassium sulphate /fad, which recorded the lower values (47.08 and 47.39 cm) in the two seasons, respectively comparing to other fertilization treatments. These results are in close agreement with the findings of Attoe *et al.,* (2013) on ginger and Shafeek *et al.,* (2015) on turnip.

Results presented in Table 1 shows also that interaction between irrigation rates and potassium fertilization levels resulted significant effects on shoot length in both seasons. Combination treatment of irrigation quantity of 1800 m^3/fad + K fertilization at 150 kg potassium sulphate/ fad resulted the tallest plants during the two experimental seasons, 61.12 cm and 62.98 cm for 1st and 2nd seasons, respectively.

Number of capsules/ plant and number of seeds/ capsule:

Data in Table 2 indicate that irrigation quantities of 1200, 1500 and 1800 m^3/fad significantly affected on number of capsules/ plant and number of seeds/capsule in both seasons. The superiority mean values (10.34 and 11.13 capsule/plant and 19.60 and 20.93 seeds/capsule) were recorded with irrigated plants with 1800 m^3/fad, in the first and second seasons, respectively while the lowest irrigation rate (1200 m^3/ fad) resulted the lowest values (8.34 and 8.22 capsule/plant and 15.17 and 17.39 seeds/capsule). Rahimi *et al.,* (2011) and Arun *et al.,* (2012) reported that

Table 2: Effect of irrigation rates, potassium fertilization levels and their interactions on number of capsules per plant and number of seeds per capsule of moghat plant at 2015/ 2016 and 2016/ 2017 seasons

Potassium fertilizer levels (K_2SO_4/ fad). P	Irrigation quantity rats (m^3/ fad) (I)							
	1200	1500	1800	Means	1200	1500	1800	Mean
	Number of capsules/plant							
	2015/ 2016				2016/ 2017			
0	5.20	5.14	5.51	**5.28**	5.26	5.51	6.75	**5.84**
50	8.45	9.72	11.51	**9.89**	8.75	9.86	11.25	**9.95**
100	9.40	10.44	11.60	**10.48**	8.95	10.78	12.51	**10.75**
150	10.31	11.82	12.75	**11.63**	9.92	11.28	13.99	**11.73**
Mean	**8.34**	**9.28**	**10.34**	—	**8.22**	**9.36**	**11.13**	—
LSD: at 0.05								
I	0.20				0.87			
P	0.79				0.97			
I X P	2.40				2.93			
Number of seeds/capsule								
0	8.11	9.11	9.81	9.01	7.75	8.77	9.00	8.51
50	13.01	16.21	18.61	15.94	18.01	19.27	21.45	19.58
100	18.11	19.31	23.46	20.29	19.05	22.52	25.26	22.28
150	21.43	22.51	26.51	23.48	23.76	25.26	28.01	25.68
Mean	15.17	16.79	19.60	—	17.14	18.96	20.93	—
LSD: at 0.05								
I	0.74				1.60			
P	0.80				1.99			
I X P	2.43				4.36			

water stress decreased seed yield of *Plantago psyllium* and *Plantago ovate* Forks plants. It seems that under optimum conditions of irrigation, it is possible for the plant to create a close relationship between the number of capsules per plant and abundant water. Optimum irrigation conditions enhance greater vegetative growth, produce more branches and thus increase number of capsules and seed yield of *Nigella sativa* (Bannayan *et al.*, 2008).

It is evident from data in Table 2 that both number of capsules/ plant and number of seeds/capsule were gradually increased as K application level increased up to the highest K level. The highest values reached 11.63 and 11.73 capsules/ plant and 23.48 and 25.68 seeds/ capsule in 1st and 2nd seasons, respectively under effect of the higher K level compared to 5.28 and 5.84 capsules/ plant and 9.01 and 8.51 seeds/ plant for the control. These results are in agreement with the findings of Ali *et al.,* (2014) on cumin (*Cuminum cyminum* L.).

With regard to the interaction, it was clear that irrigation rate at 1800 m^3/fad combined with 150 kg potassium sulphate/ fad gave the highest numbers of capsule/ plant and seeds/ capsule (12.75 and 13.99 capsule/plant) and (26.51 and 28.01seeds/ capsule) in the first and second seasons, respectively. While the irrigation quantity of 1200 m^3/fad combined with 50 kg K potassium sulphate/ fad gave the lowest values (8.45 and 8.75 capsules/plant and 13.01 and 18.01 seeds/capsule) in the two seasons, respectively.

Seeds weight/ plant (g.):

Data presented in Table 3 indicated that irrigation rates of 1200, 1500 and 1800 m^3/fad had a significant effect on seeds weight/ plant (g) in both seasons. Increasing the irrigation rate increased seed weight/ plant. The greatest mean values due to irrigation treatments (21.41 and 23.98 g/plant) were recorded with plants received the highest water amount 1800m^3/fad in the first and second seasons, respectively. While the lowest irrigation rate (1200 m^3/fad) gave the least values (15.48 and 15.57 g/ plant) in the two seasons, respectively. The superiority of the plants that received the highest rate of irrigation treatments in producing the heaviest seeds weight /plant was in agreement with Zeinab Safaei *et al.,* (2014) on black cumin (*Nigella sativa*).

Potassium rates significantly increased seeds weight/ plant as compared to unfertilized control plants. The highest seed weight/ plant (26.60 and 26.72 g/plant) was observed in plants received 150 kg potassium sulphate/ fad. This was confirmed during the two seasons (Table 3). These results are in harmony with the earlier reported of EL-Gengaihi *et al.,* (1995).

Interaction treatments between irrigation rates and K levels had significant effect on seeds weight/ plant (Table 3). Plants received 1800 m^3/fad irrigation water quantity combined with potassium at 150 kg potassium sulphate/ *fad* gave the heaviest seed weight/plant (31.72 and 32.95 g/ plant) in the first and second seasons, respectively comparing to other combination treatments. Moreover, the lowest values (6.01 and 6.31 g/ plant) were obtained from plants irrigated 1200 m^3/fad and received 0 kg potassium sulphate/ fad (Control). This was true during the two seasons.

Table 3: Effect of irrigation rates, potassium fertilization levels and their interactions on seeds weight/ plant (g) of moghat plant at 2015/ 2016 and 2016/ 2017 seasons

Potassium fertilizer levels (K_2SO_4/ fad). P	Irrigation quantity rats (m^3/ fad) (I)							
	1200	1500	1800	Mean	1200	1500	1800	Mean
	2015/ 2016				2016/ 2017			
0	6.01	7.03	7.16	**6.73**	6.31	9.52	9.74	**8.52**
50	14.42	19.04	23.34	**18.93**	15.58	21.01	25.23	**20.61**
100	17.90	19.19	23.42	**20.17**	18.27	21.91	28.00	**22.73**
150	23.57	24.50	31.72	**26.60**	22.12	25.09	32.95	**26.72**
Mean	**15.48**	**17.44**	**21.41**	—	**15.57**	**19.38**	**23.98**	—
LSD: at 0.05								
I	1.53				3.26			
P	3.99				4.99			
I X P	9.92				11.79			

II- Effect of irrigation rates, potassium fertilization levels and their interactions on root characteristics:

Root length and diameter (cm):

Data in Table 4 indicate that, in general, the highest irrigation rate (1800 m^3/fad) resulted in the highest values of the root length and root diameter (39.63 and 40.03 cm) and (4.27and 4.24cm) in the first and second seasons, respectively, followed by those irrigated with 1500 m^3/fad . Whereas, the lowest values (31.54 and 33.67cm) and (2.29 and 2.66 cm) were obtained from plants irrigated with rate of 1200 m^3/fad. However, increasing root length and root diameter under the effect of proper irrigation quantity of 1800 m^3/fad might be due to absorption of ample moisture throughout the growing period that facilitated lower soil strength, greater nutrient uptake and proper physical environment for better root growth and ultimately increased the root yield. Also, increases of root length and root diameter as a result of optimum irrigation rates have been reported by AbouEL-Khair *et al.,* (2011) on potato plant and Baba and Simon (2015) on carrot.

Data in Table 4 also, showed that all potassium fertilization treatments caused significant increases in root length and root diameter (cm). In both seasons, the highest values (38.54 and 41.40 cm) and (3.87and 3.94 cm) in the first and second season, respectively were obtained from plants fertilized with 150kg/ fad compared with control, Furthermore, 50kg potassium sulphate/ fad had the least effect in this regard. These findings are in agreement with the results of EI-Gengaihi *et al.,* (1995) on moghat plant.

Table 4: Effect of irrigation rates, potassium fertilization levels and their interactions on root length and root diameter of moghat plant at 2015/ 2016 and 2016/ 2017 seasons

Potassium fertilizer levels (K_2SO_4/ fad). P	Irrigation quantity rats (m^3/ fad) (I)							
	1200	1500	1800	Mean	1200	1500	1800	Mean
	2015/ 2016				2016/ 2017			
	Root length (cm)							
0	28.07	29.25	31.28	**30.12**	27.00	27.51	29.68	**28.06**
50	32.04	35.12	39.25	**35.47**	35.12	35.60	38.25	**36.32**
100	32.52	35.22	43.21	**36.98**	35.22	36.76	44.21	**38.73**
150	33.53	37.33	44.77	**38.54**	37.33	38.90	47.97	**41.40**
Mean	**31.54**	**34.67**	**39.63**	**–**	**33.67**	**34.69**	**40.03**	**–**
LSD: at 0.05								
I	1.25				1.83			
P	1.68				2.85			
I X P	3.75				4.56			
	Root diameter (cm)							
0	1.80	2.30	3.11	**2.40**	2.24	2.70	3.10	**2.68**
50	2.00	2.71	3.81	**2.84**	2.40	3.00	4.47	**3.29**
100	2.51	3.00	4.82	**3.44**	2.75	3.30	4.47	**3.51**
150	2.85	3.41	5.34	**3.87**	3.25	3.65	4.92	**3.94**
Mean	**2.29**	**2.86**	**4.27**	**–**	**2.66**	**3.16**	**4.24**	**–**
LSD: at 0.05								
I		0.13			0.32			
P		0.45			0.42			
I X P		1.32			1.26			

Regarding the combination between irrigation rates and potassium fertilizer levels, significant effects were obtained in root length and root diameter of plants received different combinations of irrigation rates and K fertilization levels. In both seasons, the highest values (44.77 and 47.97 cm) and (5.34 and 4.92 cm) in root length and root diameter during the first and second seasons, respectively, were obtained from plants irrigated 1800 m^3/fad and fertilized with 150kg potassium sulphate/ fad. Whereas, the lowest value were obtained from those irrigated with the least irrigation rate (1200 m^3/fad) and did not received potassium fertilization (Table 4).

Fresh and dry weights of roots/ plant:

Presented data in Table 5 show that high irrigation rate (1800 m^3/fad) resulted the heaviest fresh and dry weights of roots/ moghat plant, (0.92 and 0.95 kg/plant) and (106.10 and 110.70 g/plant) fresh and dry weights of roots/ plant in the first and second seasons, respectively. The lowest values (0.72 and 0.73 kg/ plant) and (96.78 and 97.80 g/plant) fresh and dry weights of root/ plant in the two seasons, respectively, were obtained from plants irrigated with the low irrigation level of 1200 m^3/*fad*/season. These results are in agreement with the previously obtained by Ombodi *et al.* (2015), they stated that high irrigation levels resulted increases in root yield/ carrot plant. Also, similar results were recorded by Wang *et al*., (2006) and Abdel-Monnem (2015) on potato plant.

Table 5: Effect of irrigation rates, potassium fertilization levels and their interactions on fresh and dry weights of roots moghat plant (kg) at 2015/ 2016 and 2016/ 2017 seasons

Potassium fertilizer levels (K_2SO_4/ fad). P	Irrigation quantity rats (m^3/ fad) (I)							
	1200	**1500**	**1800**	**Mean**	**1200**	**1500**	**1800**	**Mean**
	2015/ 2016				**2016/ 2017**			
Fresh weight of roots /plant (g)								
0	0.56	0.69	0.77	**0.67**	0.54	0.69	0.77	**0.67**
50	0.70	0.81	0.90	**0.80**	0.72	0.82	0.90	**0.81**
100	0.79	0.99	0.90	**0.89**	0.80	1.05	0.97	**0.94**
150	0.84	1.06	1.11	**1.01**	0.86	1.07	1.16	**1.03**
Mean	**0.72**	**0.89**	**0.92**	—	**0.73**	**0.91**	**0.95**	—
LSD: at 0.05								
I	0.03				0.03			
P	0.05				0.06			
I X P	0.15				0.18			
Dry weight of roots /plant (g)								
0	54.05	54.75	56.06	**54.95**	55.11	55.23	57.91	**56.08**
50	99.79	108.08	113.51	**107.13**	100.21	109.54	22.54	**110.76**
100	111.00	108.72	118.49	**112.74**	112.54	119.57	22.47	**118.19**
150	122.29	125.81	136.34	**128.15**	123.54	128.65	39.87	**130.69**
Mean	**96.78**	**99.34**	**106.10**	—	**97.85**	**103.25**	**10.70**	—
LSD: at 0.05								
I	1.92				1.61			
P	2.08				3.02			
I X P	5.77				6.45			

It is clear from the results recorded in Table 5 that, in general, the highest potassium fertilization level (150kg potassium sulphate/ fad) resulted in the highest values of roots fresh and dry weights/ plant (1.01and 1.03 kg/ plant) and (128.15 and130.69 g/ plant) in the first and second seasons, respectively. While, the lowest level of 50 kg/fad gave the least values roots fresh and dry weights/ plant compared to the other K fertilization levels in the two seasons. It could be concluded that potassium application promote root growth and increased fresh and dry weights of moghat plant. Likewise, Akhter *et al.,* (2013) reported that the highest rhizome yield of ginger plant was obtained with120 kg K ha^{-1} application. With adequate K supply, yields are enhanced in roots and tubers (Nwaogu and Ukpabi, 2010). Other beneficial effects of K as a plant nutrient also include improve plant-water relations, raise photosynthetic activity, enhance translocation of photosynthetic products to roots and increased resistance to both biotic and abiotic crop stresses (Marschner, 1995).

As for interaction treatments between irrigation levels and K fertilization, the interaction treatment of 1800 m^3 irrigation water/ fad/ season + 150 kg K_2O/ fad resulted in the highest roots fresh and dry weights/ plant (1.11 and 1.16 kg fresh roots/plant and 136.34 and 139.87 g dry roots/ plant in first and second seasons, respectively). While, the lowest fresh and dry weight of roots / plant were observed in plants irrigated with 1200 m^3/fad and did not received potassium fertilizer (Table 5).

III- Effect of irrigation, potassium fertilization and their interaction treatments on roots chemical composition:

1. Mucilage percentage

Results in Table 6 reveal that increasing irrigation quantity caused significant decrease in mucilage% in moghat roots. In both seasons, the highest mucilage percentages in roots (17.10 and 18.10 % in the first and second seasons, respectively) were found in plants irrigated with the lowest irrigation rate (1200 m^3/fad). Whereas, increasing irrigation rate up to 1800 m^3/ *fad* significantly decreased mucilage % to the least values (14.18 and 15.26 % in the two seasons, respectively) comparing to the lower irrigation levels. There is an inverse relationship between mucilage and irrigation: declined irrigation leads to higher percentage of mucilage and vice versa. Rahimi *et al.* (2013) previously reported similar results, since they found that drought stress increased mucilage percentage of *Plantago ovata* and *Plantago psyllium* plants. In addition, Shafeek *et al.* (2015) stated that the highest percentage of mucilage resulted from the lowest irrigation level and the lowest percentage of mucilage resulted from the highest irrigation level, displaying an inverse relationship between irrigation and mucilage production in *Plantago ovata* plant.

It is also observed that K_2O application markedly increased mucilage content of moghat roots in both seasons. It can be noticed that mucilage content was increased with increasing K rates and the highest percentages were recorded in roots of plants received 100 kg K_2O/ fad (17.11and 18.03

Table 6: Effect of irrigation rates, potassium fertilization levels and their interactions on mucilage percentage in dried roots of moghat plant at 2015/ 2016 and 2016/ 2017 seasons

Potassium fertilizer levels (K_2SO_4/ fad). P	Irrigation quantity rats (m^3/ fad) (I)							
	1200	1500	1800	**Mean**	1200	1500	1800	**Mean**
	2015/ 2016				**2016/ 2017**			
0	14.90	14.10	13.25	**14.08**	15.85	14.95	13.80	**14.87**
50	17.65	14.55	13.75	**15.32**	18.79	15.75	14.89	**16.48**
100	19.36	16.74	15.23	**17.11**	19.90	17.75	16.44	**18.03**
150	16.50	15.90	14.50	**15.63**	17.85	16.24	15.90	**16.66**
Mean	**17.10**	**15.32**	**14.18**	**—**	**18.10**	**16.17**	**15.26**	**—**
LSD: at 0.05								
I	0.69				3.26			
P	0.95				4.99			
I X P	1.65				11.79			

%) compared to other tested K levels during the two seasons, respectively). Whereas, 50 kg K_2O/ *fad* was the least effective fertilization treatment, giving 15.32 and 16.48 % in the two seasons, respectively (Table 6).

Data of the same Table 6 clear that plants received interaction treatment of 1200 m^3 irrigation water/ fad combined with 100 Kg potassium sulphate/ fa*d* resulted the highest mucilage percentages in their roots (19.36 and 19.90 % in the first and second seasons, respectively) as compare to the all other interaction treatments. At the same time, high irrigation quantity of 1800 m^3/ fad without K fertilization were resulted the least mucilage percentages during the two seasons.

2. Protein percentage

The mean effects of irrigation rates and potassium fertilization on protein content (%) in moghat roots are presented in Table 7.

Linear increases in protein % in moghat roots were noticed with increasing irrigation water quantity up to the highest irrigation rate. This was confirmed during the two seasons (Table 7). Irrigation amount of 1800 m^3/fad gave the highest values (6.44 and 6.01 %) in the first and second season, respectively, whereas 1200 m^3/fad gave the lowest protein percentages (4.76 and 4.66 % in the two seasons, respectively).

It is clear that K fertilization resulted significant increases in protein % in roots (Table 7). Application of potassium at the rate of 100 kg potassium sulphate/fad gave the greatest significant effect on protein

Table 7: Effect of irrigation rates, potassium fertilization levels and their interactions on protein percentage in dried roots of moghat plant at 2015/ 2016 and 2016/ 2017 seasons

Potassium fertilizer levels (K_2SO_4/ fad). P	Irrigation quantity rats (m^3/ fad) (I)							
	1200	1500	1800	Mean	1200	1500	1800	Mean
	2015/ 2016				2016/ 2017			
0	4.25	4.47	6.22	**4.98**	4.21	4.31	6.00	**4.84**
50	5.00	5.77	6.53	**5.77**	4.99	5.00	6.00	**5.33**
100	5.52	5.95	6.98	**6.15**	5.4	5.70	6.75	**5.95**
150	4.76	5.14	6.44	**5.44**	4.66	4.76	6.01	**5.14**
Mean	**4.25**	**4.35**	**6.01**	**—**	**4.02**	**4.02**	**5.30**	**—**
LSD: at 0.05								
I	1.05				1.17			
P	0.64				0.96			
I X P	1.11				1.67			

content (6.15 and 5.95 %) in the 1st and 2nd seasons, respectively. Similar increases in the protein content as a result of potassium fertilizer treatments have been reported by El-Sirafy *et al*., (2008). Also, Al-Shevsku, 2009, reported that tuber protein content increased with increasing K application.
The interaction between irrigation rates and potassium fertilization had a significant effect on protein content in both seasons. The effect of different irrigation treatments had been enhanced by potassium application in both seasons, the highest protein percentages (6.98 and 6.75 %) were found in roots of plants irrigated with 1800 m^3/fad combined with K fertilization with 100 kg potassium sulphate/ fad) in the two seasons, respectively.

3. *Potassium percentage*

Available data in Table 8 revealed that, potassium contents were affected significantly by irrigation treatments, the treatment of 1800 m^3

water/ fad resulted in the highest values (0.50 and 0.51%) in the two seasons, respectively. While, the lowest values (0.33 and 0.33 %) were obtained when 1200 m^3 water/ fad was applied in both seasons, respectively. Similar results were previously reported by Abou EL-Khair *et al*., (2011) they found that irrigation potato plants with 2000 m^3 water/ fad, in sandy soil, increased K concentration in plant tissues. However, increasing applied water quantity may increase soil moisture content which in turn may increase minerals availability.

With respect to the effect of potassium fertilization, the data (Table 8) showed that application of 150 and 100 kg potassium sulphate/ fad were the most effective treatments in increasing potassium content in roots compared

Table 8: Effect of irrigation rates, potassium fertilization levels and their interactions on potassium percentage in roots of moghat plant at 2015/ 2016 and 2016/ 2017 seasons

Potassium fertilizer levels (K_2SO_4/ fad) P.	Irrigation quantity rats (m^3/ fad) (I)							
	1200	1500	1800	Mean	1200	1500	1800	Mean
	2015/ 2016				2016/ 2017			
0	0.30	0.30	0.35	**0.32**	0.31	0.32	0.36	**0.33**
50	0.30	0.39	0.48	**0.39**	0.32	0.40	0.49	**0.40**
100	0.37	0.42	0.55	**0.45**	0.36	0.43	0.56	**0.46**
150	0.34	0.45	0.62	**0.47**	0.34	0.46	0.64	**0.48**
Mean	0.33	0.39	0.50	–	0.33	0.40	0.51	–
LSD: at 0.05								
I	0.02				0.03			
P	0.04				0.05			
I X P	0.09				0.09			

with all treatments in the two seasons. These results are in agreement with Radwan and El- Shall (2011); they reported that the highest K content and total uptakes were obtained with 100 kg potassium sulphate/ fad.

It was also observed that, the interaction between irrigation rate of 1800 m^3/fad and 150 kg potassium sulphate/ fad gave the highest K percentages (0.62 and 0.64 %) in the first and second seasons, respectively. Whereas, irrigation rate of 1200 m^3/fad without potassium fertilization resulted the lowest K percentage in both seasons.

4. *Total amino acids (g/ 100g) and proline (mg/ 100g) contents*

Data presented in Table 9 showed that, the highest contents of total amino acids and proline in moghat root tissues were recorded in plants irrigated with 1200 m^3/ *fad*/ season (0.143, 0.146 g/ 100g for amino acids and 2.27, and 2.22 mg/ 100 g for proline in the first and second seasons, respectively). Whereas, the lowest values (0.112 and 0.113 g/ 100 g) and (1.39 and 1.42 mg/ 100 g) in the two seasons, respectively) were obtained in plants irrigated with the highest rate (1800 m^3/ fad/ season).

Also, data of the same Table 9 showed that potassium fertilization caused significant increases in total amino acids and proline contents in both seasons. The highest values (0.134 and 0.137g./100g) for amino acids and (2.14 and 2.25 mg/100g) for prolines in the first and second seasons, respectively were found in plants fertilized with 150 kg potassium sulphate/ fad. Whereas, 50 kg potassium sulphate/ fad was least effective, since gained 0.124 and 0.125g amino acids /100g and 1.70 and 1.73 mg proline /100g during first and second seasons, respectively.

Table 9: Effect of irrigation rates, potassium fertilization and their interactions on total amino acids and proline contents in roots of moghat plant at 2015/ 2016 and 2016/ 2017 seasons

Potassium fertilizer levels (K_2SO_4/ fad). P	Irrigation quantity rats (m3/ fad) (I)							
	1200	1500	1800	Means	1200	1500	1800	Mean
	2015/ 2016				2016/ 2017			
	Total amino acids							
0	0.139	0.119	0.110	**0.122**	0.140	0.120	0.109	**0.123**
50	0.139	0.124	0.110	**0.124**	0.141	0.125	0.110	**0.125**
100	0.144	0.129	0.112	**0.128**	0.147	0.130	0.115	**0.131**
150	0.150	0.135	0.117	**0.134**	0.156	0.137	0.118	**0.137**
Mean	**0.143**	**0.127**	**0.112**	—	**0.146**	**0.128**	**0.113**	—
LSD: at 0.05								
I	0.005				0.006			
P	0.002				0.003			
I X P	0.009				0.010			
Proline (mg/100g dried roots)								
0	2.04	1.71	1.09	**1.61**	1.99	1.70	1.10	**1.60**
50	2.06	1.72	1.31	**1.70**	2.05	1.85	1.29	**1.73**
100	2.27	1.93	1.46	**1.89**	2.15	2.00	1.50	**1.83**
150	2.72	2.01	1.70	**2.14**	2.69	2.27	1.79	**2.25**
Mean	**2.27**	**1.84**	**1.39**	—	**2.22**	**1.95**	**1.42**	—
LSD: at 0.05								
I	0.09				0.12			
P	0.13				0.07			
I X P	0.23				0.21			

The interaction treatments between irrigation rates and potassium fertilization levels exhibited significant effects on the total amino acids and proline contents in moghat root tissues (Table 9). Irrigated plants with 1200m^3/fad/season and received 150 kg potassium sulphate/ fad resulted higher values in both seasons (0.150 and 0.156 g /100g) and (2.72 and 2.69 mg/ 100g) for amino acid and proline contents in the first and second seasons, respectively) than any other combination treatments. An increase in proline concentration in response to drought stress has been observed in many plant species and has led to the hypothesis that it is not just a symptom of stress but part of the stress response, decreasing cell osmotic potential and thereby increasing turgor while decreasing plant water potential (Lawlor, 2013). However, the present findings are confirmed with Bahreininejada, *et al*., (2013). They found that water stress increased proline content in *Thymus daenensis* plant.

Table 10: Effect of irrigation rates, potassium fertilization levels and their interactions on salinity (EC dSm^{-1}) and pH in soil after harvesting two seasons (2015/ 2016 and 2016/ 2017)

Potassium fertilizer levels (K_2SO_4/ *fad*). P	Irrigation quantity rats (m^3/ fad) (I)							
	1200	1500	1800	Means	1200	1500	1800	Mean
	2015/ 2016				2016/ 2017			
	(EC dSm^{-1})							
0	2.24	2.01	1.89	**2.05**	2.34	2.10	1.95	**2.13**
50	2.36	2.12	1.91	**2.13**	2.47	2.22	2.00	**2.23**
100	2.67	2.33	1.99	**2.33**	2.72	2.39	2.07	**2.39**
150	2.89	2.41	2.10	**2.47**	2.93	2.49	2.13	**2.52**
Mean	**2.54**	**2.22**	**1.97**	—	**2.62**	**2.30**	**2.04**	—
LSD: at 0.05								
I	0.65				0.71			
P	0.47				0.50			
I X P	1.14				1.21			
pH								
0	7.9	7.85	7.80	**7.85**	7.92	7.86	7.83	**7.87**
50	7.75	7.63	7.55	**7.64**	7.78	7.67	7.62	**7.69**
100	7.70	7.60	7.50	**7.60**	7.74	7.62	7.60	**7.65**
150	7.65	7.55	7.45	**7.55**	7.70	7.60	7.54	**7.61**
Mean	**7.75**	**7.66**	**7.58**	—	**7.79**	**7.69**	**7.65**	—
LSD: at 0.05								
I	0.07				0.06			
P	0.06				0.07			
I X P	0.12				0.14			

IV-Effect of irrigation rates, potassium fertilizer levels and their interaction treatments on soil salinity and pH:

The movement of soluble salts in the soil depends mainly on soil texture, structure, total porosity and permeability. Data in Table 10 demonstrated that the values of EC and pH of the studied soil were influenced by application of compost, irrigation rates and potassium fertilization treatments. Gradual decreases in soil EC and pH values were noticed as irrigation water rate increased.

The highest irrigation rate of 1800 m^3/*fad* resulted in the lowest significant values for EC (1.97 and 2.04) and for pH (7.58 and 7.65) after first and second seasons, respectively. This may be attributed to the improvement of soil physical properties and enhance the leaching process of salts, as well as to the high adsorption of ions by the growing plant. (Khafagy *et al.*, 2015).

V- Effect of irrigation rates, potassium fertilizer levels and their interaction treatments on soil bulk density and hydraulic conductivity (K):

Mean values of soil bulk density (Mg^{-3}) and hydraulic conductivity after moghat harvesting are presented in Table 11. Data revealed that applied of compost, irrigation rates and potassium fertilization to the light soil led to reduce the values of soil bulk density, and consequently, caused an increase in total porosity compared the treatment of 1200 m^3/fad. The treatment of 1800 m^3/ fad from available water gave the lowest significant values (1.53 Mg^{-3}) The efficiency of the studied compost on reducing the values of bulk density could be arranged in the following descending order: 1200 >1500 >1800 m^3/ fad. These results may be attributed to the addition of compost low specific gravity of organic material and their decomposition material which enhanced the formation of large soil aggregates and, subsequently, decrease soil bulk density. These results are in agreement with those of Mansour (2007), while hydraulic conductivity (K) values gave the same trend observed in soil bulk density. This could be attributed to the effect of applied compost increasing the micro pores and decreasing the macro pores. Similar results were obtained by Mariano *et al*., (2009).

Table 11: Effect of irrigation rates and potassium fertilizers on bulk density (B.D Mg^{-3}) and hydraulic conductivity (K) in soil after harvesting two seasons (2015/ 2016 and 2016/ 2017)

Potassium fertilizer levels (K_2SO_4/ fad). P	Irrigation quantity rats (m3/ fad) (I)							
	1200	1500	1800	Mean	1200	1500	1800	Mean
	2015/ 2016				2016/ 2017			
	Bulk density (B.D Mg^{-3})							
0	1.65	1.62	1.58	**1.62**	1.70	1.64	1.61	**1.65**
50	1.63	1.60	1.56	**1.60**	1.65	1.63	1.59	**1.62**
100	1.61	1.54	1.51	**1.53**	1.63	1.59	1.57	**1.60**
150	1.59	1.52	1.48	**1.53**	1.62	1.52	1.52	**1.55**
Mean	**1.62**	**1.57**	**1.53**	—	**1.65**	**1.60**	**1.57**	—
LSD: at 0.05								
I	0.39				0.41			
P	0.01				0.02			
I X P	0.45				0.48			
	K (cmh^{-1})							
0	34.3	33.2	32.8	**33.4**	34.96	33.87	33.47	**34.10**
50	34.5	33.0	32.5	**33.3**	35.16	33.68	32.83	**33.89**
100	34.8	32.8	32.2	**33.3**	35.47	33.47	32.87	**33.94**
150	35.1	32.5	31.9	**33.2**	36.10	32.83	32.23	**33.72**
Mean	**34.7**	**32.9**	**32.4**	—	**35.42**	**33.46**	**32.85**	—
LSD: at 0.05								
I	2.27				3.02			
P	0.39				1.00			
I X P	2.71				4.26			

CONCLUSION

Irrigation rates and potassium fertilizer on moghat can be summarized as follows:

1- Increased produce yield of moghat.

2- Increasing irrigation rate up to 1800 m^3/ *fad* increased roots fresh and dry weights/ plant, length, and diameter of roots, shoot length, number of capsules/ plant, seed weight/ capsule and protein content of the moghat roots. While, the lowest irrigation rate (1200 m^3/ *fad*) increased mucilage, amino acids and proline content in roots tissues.

3- Improved soil properties occurred due to increased organic content. On the contrary, bulk density, hydraulic conductivity, EC and pH values were decreased.

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تأثير معدلات الرى والتسميد البوتاسي علي النمو والتركيب الكيماوي لنبات المغات في الاراضى الرمليه

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اجريت هذه الدراسة خلال الموسمين المتتاليين ٢٠١٦/٢٠١٥ ، ٢٠١٧/٢٠١٦ فى المزرعة التجريبية فى محطة بحوث البساتين بجنوب التحرير ، هدفت التجربة

إلـى تقيـيم أثـر ثـلاث معـدلات للـرى (١٢٠٠ ، ١٥٠٠ ، ١٨٠٠ م٣/ فـدان/ للموسـم) وأربـع مسـتويات مـن التسـميد البوتاسـى (صـفر ، ٥٠ ، ١٠٠ ، ١٥٠ كجـم كبريتـات البوتاسيوم/ فدان) وتفاعلاتهم على نمو وإنتاجية نبـات المغـات بالإضـافة إلـى تقييم أثـر المعاملات على خصائص التربة.

لوحظت زيادات تدريجية فى إرتفاع النبات وفى طول وقطر الجذر وفـى الـوزن الغض والجاف للجذور/ نبات بزيادة معدل الرى من ١٢٠٠ م٣ / فدان إلـى ١٨٠٠ م٣ / فدان ، وإرتبط ذلك بتحسن جودة الجذور الناتجة، أدت زيادة معدل الرى إلى زيـادات معنويـة فـى النسـب المئويـة لكـل مـن البـروتين الكلـى والبوتاسـيوم فـى أنسـجة جـذور المغــات، ولكــن إنخفضــت النســبة المؤيــة للميوســيلاج، وُجــدت أعلــى نســبة مئويــة للميوسيلاج فى جذور النباتات المروية بالمعدل المنخفض ١٢٠٠ م٣ / فدان.

أدى التسميد البوتاسى إلى دفع نمو النباتات مقدراُ كارتفاع النبات وكطول وقطر الجذر، وإنعكس ذلك كزيـادة فـى الـوزن الغض والجـاف للجذور/ نبـات، وُجدت أعلـى القيم للقياسـات سـابقة الـذكر فـى النباتـات التـى سُمدت بالمسـتوى المرتفـع مـن السـماد البوتاسـى (١٥٠ كجم كبريتـات البوتاسـيوم/ فدان) ، أنتجـت النباتـات المعاملـة بـــ ١٥٠ كجم كبريتات البوتاسيوم / فدان جذور محتوية على نسب مؤية مرتفعة من الميوسيلاج والبروتين والبوتاسيوم والأحماض الأمينية الكلية.

أدى تفاعل معدلات الرى مع مستويات التسميد البوتاسـى إلـى زيـادات إضـافية فى كل من إرتفاع النبات وفى طول وقطر الجذر وفـى الوزن الغض والجـاف للجـذور/ نبات وفى النسبة المؤية للبوتاسيوم فى أنسجة الجذر ، سُجلت أعلى قيم القياسات سـابقة الذكر فى النباتات التى رويت بمعدل ١٨٠٠ م٣/فدان وسُمدت بمعدل ١٥٠ كجم بو٢أ/ فدان ، كما أدت نفس المعاملة إلى زيادة عدد الكبسولات (الثمار) الناتجة / نبـات وعـدد البـذور بكـل كبسولة ووزن البـذو/ نبـات ، أنتجـت معاملـة التفاعـل بـين ١٢٠٠ م٣ مـاء رى/ فدان ، ١٠٠ كجم كبريتات البوتاسيوم/ فدان أعلى نسبة مؤية للميوسيلاج بـالجـذر مقارنة بباقى معاملات التفاعل الأُخرى.

التوصية: اشارت النتائج المتحصل عليها أيضاً الي ان : المعـاملات المختلفـة ادت الـى تحسن فى بعض الخواص الطبيعيه و الكميائيه للتربة فقد زاد محتوى التربـه مـن المـاده العضويه وعلى النقيض انخفضت قيم كل مـن التوصـيل الهيدروليكى المشبع والكثافـة الظاهرية، اندماج التربه؛ وحموضة وملوحة التربة.