J. Agric. Sci. Mansoura Univ., 32 (12): 10653 - 10664, 2007

POTASSIUM UPTAKE EFFICIENCY OF COTTON CROP AS AFFECTED BY SOIL TYPE AND K FERTILIZER LEVELS

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ABSTRACT

A pot experiment was carried out to study potassium uptake efficiency for cotton crop as affected by soil type (clay loam soil and sandy loam soil), and K fertilizer levels under the conditions of El-Sharkia Governorate during 2004 season.

This work ended to many positive results:

1. Potassium additions tended to increase the dry weight of cotton plants (g pot^{-1}) high significantly during different growth stages.
2. Values of potassium uptake (mg pot^{-1}) were increased in clay loam soil more than sandy loam soil. The highest values were at harvest and at the fertilizer level K_2 compared with control treatment.
3. Increasing potassium fertilizer level led to increasing the yield. Data reveal the relation and the correlation between the potassium, soil type, the yield and the crop yield through the equations.

Keywords: Potassium, Cotton, Soil types, Sharkia Governorate soil.

INTRODUCTION

Cotton (*Gossypium hirsutum* L) production occupies an unique position among all other field crops in Egypt; it is the most important cash crop in the country. One of the most important production inputs for irrigated cotton is fertilization. Potassium is commonly recognized as an essential nutrient for plant growth and development and is important to cotton plants for many physiological processes Silvertooth *et al.*, (1992).

Although, potassium fertilization for cotton and most crops in Egypt has been considered to be less important comparing with N or P, however, many researches within the last few years indicated that most field crops responded to K fertilization in different cultivated areas Abd El-Hadi, (1988).

The fundamental roles of this element in plant metabolism are regulatory or catalytic. Therefore, K in the soil must be monitored to ensure that it will not be a limiting factor in crop production. Contents of available K in most Egyption soils are considered adequate for meeting cotton plant needs. Ghourab *et al.*, (2000) and Abou El- Nour *et al.*, (2000).

In modern cotton production systems, potassium (K) deficiency is one of the major factors limiting lint yield and affecting fiber quality. Although influence of K deficiency on cotton plant physiology and growth and lint yield responses to K fertilizer applications have received intensive studies K. John J. Reada., (2005).

Therefore, the objective of this investigation was to study the effect of different levels of potassium on growth, yield and potassium uptake by cotton crop grown on two soil types (clay loam and sandy loam) under the Sharkia Governorate conditions.

MATERIALS AND METHODS

A pot experiment was conducted in Bilbies, EL-Sharkia Governorate Egypt to study potassium uptake efficiency on the growing cotton crop on two soil types of (clay loam soil and sandy loam soil), and K fertilizer levels under conditions of El-Sharkia Governorate, during 2004 season.

Studied soils:

Two surface soil samples (0-30 cm) were collected from Bilbies District, Sharkia Governorate. The soil samples represented two types (clay loam soil and sandy loam soil).

Containers:

Plastic pots of 55 cm. diameter were used. Two plastic tube of 60 to 70 cm length were put in each pot on two sides by different deeps to improve soil aeration. Each pot was filled with 50 kg air-dried soil.

Statistical design:

In order to carry out this study a pot experiments were conducted on cotton crop. Experiment included 2 soil types (clayey loam and sandy loam soil), and 3 levels of potassium having 6 treatments, arranged as randomized block with 4 replications and giving a total of 24 pots. The statistical analysis of the data was done according to Snedcor and Cochran (1990**).**

Cotton experiment:

- Five cotton seeds (Giza 85.V.) were cultivated in each pot for each type of soil in 3/3/2004.
- P_2O_5 was added at the rate of 22.5 kg. fed^{-1} (7.25 g single superphosphate 15.5% pot$^{-1)}$ before cultivation.
- The nitrogenous fertilizers were added in two doses after 30 and 60 days from sowing at the rate of 62 kg N fed^{-1} as ammonium nitrate 33.5 %.

Potassium treatments:

Potassium sulphate (39.8% K) was added after 21 days from cultivation as follow:

1. No fertilizer K (control).
2. 20 kg. K fed^{-1} (2000 mg. K pot^{-1}). The recommended dose.
3. 30 kg. K fed^{-1} (3000 mg. K pot^{-1}). The recommended + 50%.

- The pots were irrigated at 70% of the field capacity or according to needing of plants.
- Plant and soil samples were taken after 60 days from cultivation (green growth), 110 days from cultivation (opening of the flowers) and 175 days at harvest Plant samples were oven dried (at 70 ^{0}C), crushed for analysis, prepared for K determination.

Soil analyses:

General soil analyses:

Table 1 shows some physical and chemical proper ties of the experimental soils. These methods were used according to the global standard methods of soil studies.

- Mechanical analysis for soil was carried out using the pipette method as described by Dewis and Freitas (1970).
- Saturation percentage of the soil was determined using the method described by Richards (1954).
- The Soil organic matter content was determined by Walkely and Black method described by Hesse (1971).
- Total carbonate was estimated gas metrically using Collin's calcimeter and calculate as $CaCO_3$ Dewis and Freitas (1970).
- Electrical conductivity (EC) was measured in saturation extract using an electrical conductivity meter Richards (1954).
- Soil reaction pH was measured in soil paste using combined electrode pH meter according to Black *et al.* (1982).
- Total nitrogen in the soil was determined using the conventional method of kjeldahl Jackson (1967).
- Water soluble cations and anions were determined in saturation extract according to the methods described by Jackson (1958).
- Exchangeable cations were determined by methods described by Hesse (1971).
- Cation exchange capacity was determined by sodium acetate method as described by Hesse (1971).
- Cation exchange capacity was determined by sodium acetate method as described by Hesse (1971).

Analyses of soil potassium:

Total potassium in soil was determined by digesting 0.1 g of fine soil 0.2 mm with concentrated HF and $HClO_4$ acid Jackson (1958). Also total potassium in soil fractions of 0-30 cm samples (total sand (coarse fine, silt and clay) was determined by the some method.

The following analysis was done in 0-30 cm samples:

- Water soluble potassium was determined in saturation extract according to Richards (1954).
- Exchangeable potassium was determined by extracting 5 g soil with one N NH_4OAC (pH 7), and subtracting water soluble K according to Hesse (1971).

Plant uptake calculation:

The uptake of nutrients by plant organs was calculated by multiplying element concentration by dry weight of plant.

Potassium in plant tissue:

* 0.2 g dry ground plant material was digested by a mixture of H_2SO_4 and $HCLO_4$ acids as described by Peterburgski (1968).

* Potassium in all soil extractions and plant acid digestion was determined using a flame photometer.

Table1: Some physical and chemical properties of the experiment soil before cultivation.

Soil characteristics		Clay loam soil	Sandy loam soil
Mechanical analysis	Coarse Sand%	33.82	58.94
	Fine Sand%	9.45	11.46
	Silt%	24.26	12.38
	Clay%	32.47	17.22
	Texture Class	Clay loam	Sandy loam
Some physical and chemical properties of the studied soils	pH* (in suspension)	8.73	8.76
	EC** dS m^{-1} (soil Paste extract)	0.35	0.38
	$CaCO_3$	1.98	3.32
	OM%	1.06	0.87
	SP (saturation %)	70.06	56.13
	CEC	52.86	46.43
	ESP%	5.45	7.75
	C %	0.21	0.063
Soluble Cations (meq L^{-1} solution)	Ca^{++}	0.55	0.60
	Mg^{++}	0.20	0.05
	Na^{+}	1.17	2.73
K forms (meq 100g $soil^{-1}$	Total K^{+}	11.03	8.95
	Soluble K^{+}	0.016	0.009
	Exch K^{+}	1.60	0.98
Soluble Anions (meq L^{-1} solution)	CO_3^{-}	0.00	0.00
	HCO_3^{--}	0.22	0.36
	Cl^{-}	0.35	0.05
	SO_4^{--}	0.74	0.59
Available nutrients (ppm)	Nitrogen (N)	9.02	4.16
	Phosphorus (P)	3.20	156
	Potassium (K)	26.6	13.05

*** pH was determined in saturated soil paste.**
**** EC and soluble ions were determined in soil paste extract.**

RESULTS AND DISCUSSION

1. Dry weight of cotton plants:

1. 1. Effect of soil type:

Data in Table 2 and Fig. 1 reveal that the dry weight means of cotton plants were higher in the clay loam soil than the sandy loam soil at all growth stages. The differences reached to the level of significance. This may be due to the better growth of cotton in the clay loam soil than the sandy loam soil. This finding fully confirms the results of Rosolem *et al.*, (2003).

1. 2. Effect of potassium levels:

Data in Table 2 and Fig. 1 reveal that the means of dry weight of cotton plants were increased high significantly due to increasing the level of K_2 at 110 and 175 days after sowing in both soil types as compared to the control. This finding fully confirms the results of El-Tabbakh (2002).

1. 3. Effect of growth stages:

Data in Table 2 and Fig. 1reveal that dry weight values were increased at in both soil types and increased at 175 day more than 60 days, and were due to the better growth for cotton in clay loam soil, potassium application and K uptake increasing. This result could be supported by those obtained by El-Tabbakh (2002).

1. 4. Effect of the interaction:

Data in Table 2 and Fig. 1 reveal that reveal the highly significant effects were observed on the dry matter due to interaction between soil types and K led of cotton plants at both growing stages on both soil types. This finding fully confirms the results of Rosolem *et al.*, (2003).

Table 2: Means of dry weights of cotton plants (g pot^{-1}) at different growth stages, cotton and seeds yield (g pot^{-1}) as affected by soil type and K fertilizer levels.

A- Soil type	B- K levels	Days after sowing			Yield	
		60	110	175	Cotton	Seeds
Clay loam soil	Control	8.68	13.21	46.16	4.83	4.73
	K_1	11.42	17.15	59.33	5.25	4.83
	K_2	12.31	24.07	59.75	5.53	5.04
Mean		**10.80**	**18.14**	**55.08**	**5.20**	**4.87**
Sandy loam soil	Control	7.91	12.03	31.15	3.62	3.53
	K_1	8.91	15.95	46.03	4.02	3.85
	K_2	11.95	19.32	50.02	4.43	4.24
Mean		**9.59**	**15.77**	**42.40**	**4.02**	**3.87**
F. Test A		*	*	**	*	*
LSD B		**1.06**	**1.24****	**7.05****	**NS**	**NS**
LSD A x B		**NS**	**1.74***	**NS**	**NS**	**1.32***

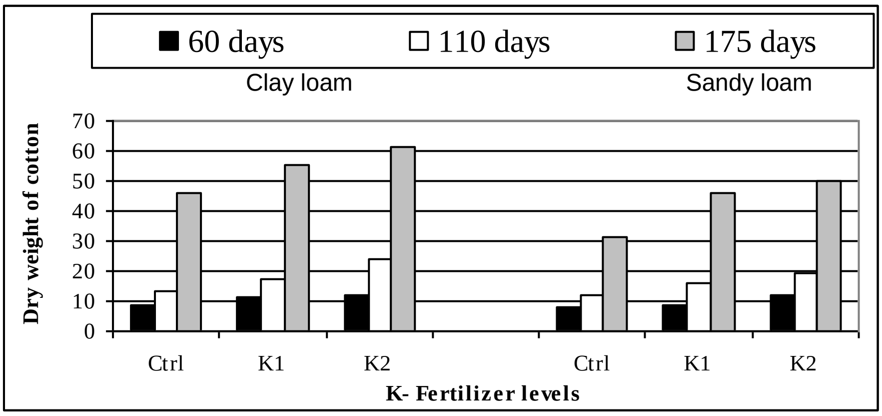

Fig 1: Means of dry weights (g pot^{-1}) of cotton plants as affected by soil type and K fertilizer levels at different growth stages.

2. K (%) in tops of cotton plants:

2. 1. Effect of soil type:

Data in Table 3 and Fig. 2 show that the means of K % were increased significantly in plants grown on clay loam soil compared with those grown on the sandy loam soil at different growth stages. This is may be due to the more available potassium existence in the clay loam soil. This result could be enhanced by that obtained by El-Tabbakh (2002).

2. 2. Effect of potassium levels:

Data Table 3 and Fig. 2 reveal that values were increased at K_2 level in both soil types, also increased in clay loam soil more than sandy loam soil due to potassium application and available potassium existence. This result could be enhanced by that obtained by of Rosolem *et al.*, (2003).

2. 3. Effect of growth stages:

Data in Table 3 and Fig. 2 reveal that values of K % means in the dry matter of cotton plants were decreased with the advance of the season in both soil types. This result could be attributed to the dilution effect, where the production of dry matter tended to increase with the advance of the season. This result could be supported by that obtained by Rosolem *et al.*, (2003).

2. 4. Effect of the interaction:

Data in Table 3 and Fig. 2 reveal the highly significant effects were observed on the dry matter due to interaction between soil types and K led of cotton plants at both growing stages on both soil types. These findings fully confirm the results of Rosolem *et al.*, (2003).

Table 3: Means of K (%) in cotton plants and cotton yield as affected by soil type and K fertilizer levels at different growth stages.

A- Soil type	K levels	Days after sowing			Yield	
		60	**110**	**175**	**Cotton**	**Seeds**
Clay loam soil	**Control**	2.61	1.75	1.69	1.15	3.68
	K_1	3.13	2.22	2.15	1.50	4.03
	K_2	3.52	2.23	2.28	1.96	4.26
Mean		**3.09**	**2.07**	**2.04**	**1.54**	**3.99**
Sandy loam soil	**Control**	2.49	1.61	1.63	1.04	3.22
	K_1	2.89	2.10	2.06	1.28	3.57
	K_2	3.20	2.22	2.30	1.58	3.86
Mean		**2.86**	**1.98**	**2.00**	**1.30**	**3.55**
F. Test A		*	*	*	*	*
LSD B		**0.11***	**0.18***	**0.20***	**1.2***	**1.6***
LSD A x B		**0.16***	**0.19***	**NS**	**NS**	**0.18**

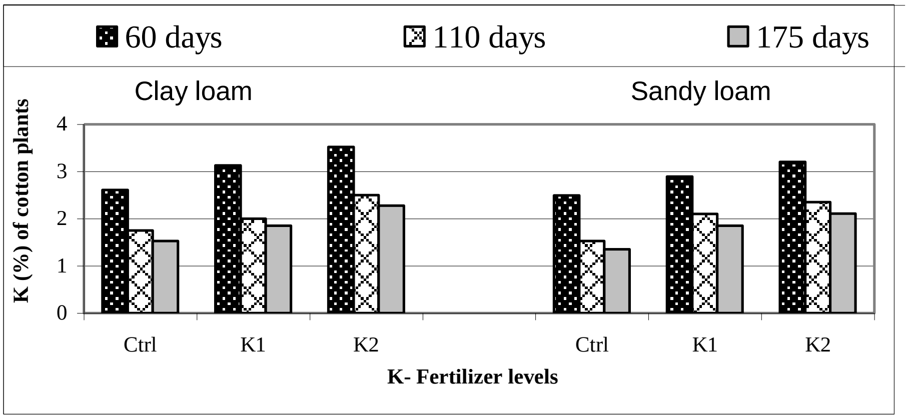

Fig 2: Means of K (%) in cotton plants as affected by soil type and K fertilizer levels at different growth stages.

3. K uptake of cotton plants:

3.1. Effect of soil type:

The value uptake (mg pot^{-1}) in cotton as it was affected by soil type and K fertilizer levels at different growth stages are recorded in Table 4 and illustrated in Fig. 3. The data reveal that Potassium uptake was increased high significantly in both soil types and in clay loam soil more than sandy loam soil. This result is due to K application and of potassium availability by clay loam soil than sandy loam soil. This result could be enhanced by that obtained by Rahmatullah, and Konrad Mengelb (2000).

3.2. Effect of potassium levels:

Data in Table 4 and Fig. 3 reveal that K uptake increased high significantly at level K2 compared with control treatment in both soil types due to the incremental addition of K fertilizer during both growth stages. The increase reached to the level of significance. This result could be supported by those obtained by Rahmatullah, and Konrad Mengelb (2000).

3.3. Effect of growth stages:

The value uptake (mg pot^{-1}) in cotton as it was affected by soil type and K fertilizer levels at different growth stages are recorded in Table 4 and illustrated in Fig. 3. show that values K uptake were increased high significantly from 60 day to 175 days in both soil types due to K application during different growth stages and root existence beefy for cotton by clay loam soil more than sandy loam soil. This results findings similar as Adeli and Varco (2002).

3.4. Effect of the interaction:

Data in Table 4 and Fig. 3 reveal highly significant effects were observed on the K uptake of cotton plants due to interaction between soil types and K led of cotton plants at both growing stages on both soil types. This result could be supported by those obtained by Adeli and Varco (2002).

Table 4: Means of K uptake (mg pot^{-1}) of cotton plants as affected by soil type and K levels at different growth stages.

A- Soil type	K levels	Days after sowing		
		60	110	175
Clay loam soil	Control	226.59	231.18	780.11
	K_1	358.00	380.73	1275.60
	K_2	433.31	550.81	1362.30
Mean		**339.30**	**387.57**	**1139.34**
Sandy loam soil	Control	197.00	193.68	507.75
	K_1	257.50	334.95	948.22
	K_2	382.40	428.91	1150.46
Mean		**278.97**	**319.18**	**868.81**
F. Test A		**	**	**
LSD B		**36.52****	**30.70****	**22.72****
LSD A x B		**51.88****	**42.06****	**32.24****

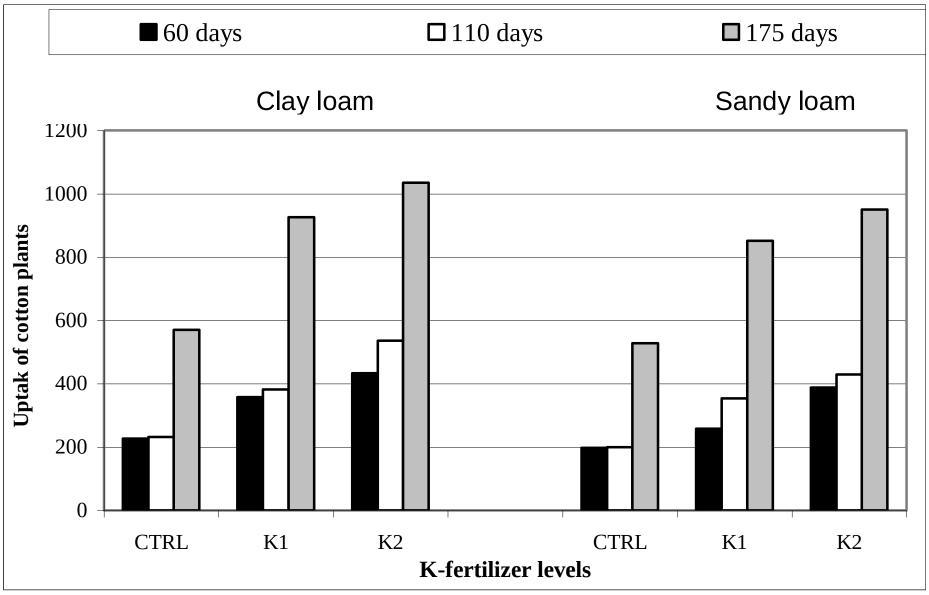

Fig 3: Means of K uptake (mg pot^{-1}) of cotton plants as affected by soil type and K levels at different growth stages.

4. K uptake of cotton yield:

4.1. Effect of soil type:

Data in Table 5 show that the values of K uptake (mg pot^{-1}) in cotton were affected by soil type and K fertilizer levels at different growth stages. Potassium uptakes was increased high significantly in both soil types and in clay loam soil more than sandy loam soil. and also in cotton yield and seeds and total uptake increased at clay loam soil more than sandy loam soil due to the increase in potassium application and root existence beefy for cotton by clay loam soil more than sandy loam soil. This results findings similar as Adeli and Varco (2002). 4.2. Effect of potassium levels:

Data in Table 5 show that values of K uptake (mg pot^{-1}) in cotton were affected by soil type and K fertilizer levels at different growth stages. Values were increased at K_2 fertilizer level, compared with control treatment in both soil types due to potassium application and root existence beefy for cotton by clay loam soil more than sandy loam soil. This result could be supported by those obtained by Camberato and Jones (2005).

4.3. Effect of the interaction:

Data in Table 5 reveal that high significantly interaction between both soil types and potassium fertilizer level, and was the highest means of interaction at 175 days after sowing and total uptake, while was interaction lowest was at cotton yield. This is due to the potassium application and the potassium concentration increase in the plants and seeds. This finding fully confirms the results of Rosolem *et al.*, (2003).

Table 5: Means of K uptake (mg pot) of plant after harvest, cotton yield and seeds yield as affected by soil type and K levels at different growth stages.

A- Soil type	K levels	Plant at 175 days	Yield		
			Cotton	Seeds	Total
Clay loam soil	Control	780.11	55.55	174.07	1009.73
	K_1	1275.60	78.75	194.65	1549.00
	K_2	1362.30	108.39	214.71	1685.40
Mean		**1139.34**	**80.90**	**194.48**	**1414.71**
Sandy loam soil	Control	507.75	37.65	113.67	659.07
	K_1	948.22	51.46	137.45	1137.13
	K_2	1150.46	70.00	163.65	1384.11
Mean		**868.81**	**53.04**	**138.26**	**1060.10**
F. Test A		**	**	**	**
LSD B		**36.52****	**1.18***	**30.70****	**22.72****
LSD A x B		**51.88****	**1.92***	**42.06****	**32.24****

Correlation between factors affecting plants:
Cotton under clay loam soil conditions:

Table 6: Correlations (Pearson) between some factors affecting dry tuber of cotton plant in clay loam soil.

	Dry weight g pot^{-1}	K uptake mg pot^{-1}	A. K. meq 100 g soil^{-1}	Total K meq 100 g soil^{-1}	Exh K. meq 100 g soil^{-1}
K uptake	0.921				
A. K. meq 100 g soil^{-1}	0.312	0.361		0.999	
Exh. K meq 100 g soil^{-1}	0.812	0.919	0.157	0.913	
Total K meq 100 g soil^{-1}	0.976	0.842	-0.070		
Non. K meq 100 g soil^{-1}	0.717	0.736	-0.997	0.978	0.847

With clay loam soil soil, multiple linear regressions from the following equation showed that the Non exchangeable K is highly correlated with other variables. So, expected equation to predict the dry weight was as follow:

The regression equation is:

Dry weight = 29.6 + 2.07 K up t. + 0.88 A. K. - 1.42 total K. + 20.7 Ex. K

(R-Sq = 99.6% R-Sq (adj) = 98.2%)

Stepwise Regression:

Moreover, stepwise linear regression revealed that the most closely variable related to **Y** (dry weight) are exchangeable K. (**R-Sq= 95.28**) and non-exchangeable K. (**R-Sq = 99.58**). So, the predicted equation for dry weight is:

Polynomial Regression:

Y = -60.0655 + 91.6256X - 17.5518X**2 **(R-Sq = 98.7 %)**

Cotton under sandy loam soil conditions:

Table 7: Correlations (Pearson) between some factors affecting dry tuber of cotton plant in sandy loam soil.

	Dry weight g/ pot^{-1}	K uptake mg pot^{-1}	A. K. Meq 100 g pot^{-1}	Total K meq 100 g pot^{-1}	Exh K. Meq 100 g pot^{-1}
K uptake	0.989				
A. K. meq 100 g soil^{-1}	0.878	0.935			
Exh. K meq 100 g soil^{-1}	0. 772	0.843	0.869	0.851	
Total K meq 100 g soil^{-1}	0. 791	0.867	0.984		
Non. K meq 100 g soil^{-1}	0.734	0.820	0.962	0.995	0.831

While multiple linear regressions from the following equation showed that the Non exchangeable K is highly correlated with other variables. So, expected equation to predict the dry weight was as follow:

The regression equation is:

Dry weight = 31.9 + 48.9 K upt. + 1.11 A. K. - 1.55 T. K. - 3.35 Ex. K

(R-Sq = 100% R-Sq (adj) = 100%)

Stepwise Regression:

Moreover, stepwise linear regression revealed that the most closely variable related to Y (dry weight) are K uptake **(R-Sq= 97.81),** exchangeable K. (**R-Sq=99.62)** and non-exchangeable K. (**R-Sq = 100).** So, the predicted equation for dry tuber weight is:

Polynomial Regression:

Y = -9.82642 + 100.975X - 41.4284X**2 **(R-Sq = 99.7 %)**

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كفاءة امتصاص البوتاسيوم لمحصول القطن المتأثر بنوع التربة ومستويات السماد البوتاسي

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أجريت تجربة أصص بلاستيكية لدراسة كفاءة امتصاص البوتاسيوم لمحصول القطن في نوعين من التربة وثلاث مستويات من التسميد البوتاسي بمحافظة الشرقية، في عام 2004 م.

ويمكن تلخيص النتائج المتحصل عليها فيما يلي:

1- زادت قيم الوزن الجاف في نباتات القطن في التربة الطميية الطينية عن التربة الطميية الرملية، وكانت القيم الأعلى عند الحصاد، وعند مستوي التسميد K_2، مقارنة بمعاملة الكنترول أثناء مراحل النمو المختلفة.

2- زادت قيم البوتاسيوم الممتص في العينات النباتية ومحصول القطن والبذور في التربة الطميية الطينية عن التربة الطميية الرملية وكانت القيم الأعلى عند الحصاد، وعند مستوي التسميد K_2، مقارنة بمعاملة الكنترول أثناء مراحل النمو المختلفة.

3- زادت إضافة السماد البوتاسيوم إلي زيادة محصول القطن بسبب تنشيط الخلايا وزيادة امتصاص العناصر المغذية للنبات.

3- زادت إضافة التسميد البوتاسي إلي زيادةكفاءة الاستخدام والمحصول، وأوضحت النتائج العلاقة والارتباط بين البوتاسيوم، ونوع التربة، والمحصول، ومحصول المحصول.