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Effect of Potassium Fertilizer and Foliar Zinc Application on Yield and Quality of Sweet Potato

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Abstract: Field experiments were conducted during the two successive spring seasons of 2008 and 2009 in the International Potato Center (ICP), Agriculture Research Center (ARC), Kafr El-Zayat, El-Gharbia Governorate, Egypt to evaluate the effect of different levels of potassium fertilization and foliar application of different rates of zinc on sweet potato (*Ipomoea batatas* L) (cv. Abeese) performance. Four rates of potassium fertilizer (60, 90, 120 and 150 kg K_2O/fed.) in the form of potassium sulfate (48% K_2O) and four levels of foliar zinc fertilizer (0, 10, 20 and 30 ppm) in the form of zinc sulfate were applied. The individual effects showed that the highest sweet potato yield was obtained from plants received 150 kg K_2O/fed., meanwhile the lowest root yield was obtained from control treatment (60 Kg K_2O/fed.). On the other hand, the highest zinc dose recorded the highest production of root yield compared with other low doses. The interaction effect between potassium and zinc fertilizer showed the highest value of vegetative growth, yield and quality of roots when potassium and zinc were applied at the highest levels.

Key words: Sweet potato,Potassium Fertilizer, foliar Zinc, roots quality and yield

INTRODUCTION

Sweet potato (*Ipomoea batatas* L) is a dicotyledonous root crop and a member of the family Convulvulaceæ. As well as, sweet potato is the seventh most important food crop in the worldwide, after wheat, rice, maize, potato, barley and cassava. The primary importance of sweet potato is in poor regions of the world. It is the fourth most important food crop in developing tropical countries and is grown in most of the tropical and subtropical regions of the earth, where the vine, as well as the roots, is consumed by humans and livestock[1].

Sweet potato root vegetable qualified as an excellent source of vitamin A (in the form of beta-carotene), a very good source of vitamin C and manganese, and a good source of copper, dietary fiber, vitamin B6, potassium and iron[2-3].

Fertilizer is one of the most important inputs of increasing the productivity of crops[4]. Potassium is a part of many important regulatory roles in the plant. It is essential in nearly all processes needed to sustain plant growth and reproduction i.e. photosynthesis translocation of photosynthates, protein synthesis, control of ionic balance, regulation of plant stomata, turgor maintenance, stress tolerance and water use, activation of plant enzymes and many other processes[5-11].

Potassium uptake also depends on plant factors, including genetics and developmental stage[12]. All plants require potassium, especially crops high in carbohydrates, such as potatoes. Studies have shown that adequate K nutrition has also been associated with increased yields, fruit size, increased soluble solids and ascorbic acid concentrations, improved fruit color, increased shelf life, and shipping quality of many horticultural crops[13-18]. Potassium enhances crop growth, quality parameters, storage and shipping quality of tomatoes, potatoes, onions, cucumbers, watermelons and many other crops, and also extends their shelf life[6,19-26].

With a shortage of potassium many metabolic processes are affected, such as the rate of photosynthesis, the rate of translocation and enzyme systems[10,23]. At the same time, the rate of dark respiration is increased[6]. Potassium deficiencies can limit the accumulation of crop biomass. This is attributed to that, K increases the photosynthetic rates of crop leaves, CO_2 assimilation and facilitates carbon movement[27].

Zinc is a micronutrient necessary for plant growth. Zinc promotes growth hormone biosynthesis, the formation of starch, and seed production and maturation[28]. Zinc has many important roles in plant growth, and a constant and continuous supply is necessary for optimum growth and maximum yields. Zinc is needed for a plant’s enzyme formation and associated with hormone (indole acetic acid) formation. Zinc enters the plant mainly via root absorption of Zn^{2+} ionic form from the soil solution, zinc uptake appears to be a function of transport across the plasma membrane, which is largely

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metabolism-dependent and genetically controlled[29].

Deficiency of zinc has been found to reduce leaf size and shortened internodes and hence, limit plant growth. The availability of micronutrients to plants is closely related to the solubility of the forms in which they appear[30]. Several environmental factors can affect the solubility of micronutrients. Leached, acid, sandy soils, organic soils, soils that have supported intensive cropping, soils with high pH, and eroded soils all tend to be low in available iron and zinc[28]. Different zinc fertilizer materials are commercially available. Zinc sulfates ($ZnSO_4$) and zinc chelates ($Na_2ZnEDTA$ 14%) are probably the most common zinc fertilizer materials used. Commercial zinc fertilizer can either be added to the soil or used as a foliar application. Since zinc is not very mobile in the plant, repeated spraying may be required for new growth. More than one foliar application of zinc during the growing season may be needed.

The aim of this work was to investigate the interactive effect of different potassium rates and foliar zinc application on vegetative growth, yield and quality of sweet potato.

MATERIALS AND METHODS

Two field experiments were conducted during two successive seasons of 2008 and 2009 in clay loam soil at the International Potato Center (ICP), Agriculture Research Center (ARC), Kafr El-Zayat, El-Gharbia Governorate, Egypt to study the effect of potassium fertilizers and foliar zinc application on vegetative growth, roots yield and quality of sweet potato.

The physical and chemical analysis of the soil is shown in Table (1). the experiment contained 16 treatments, which were combination of four potassium, levels i.e.,60,90, 120 and 150 Kg K2O/fed .and four Zinc treatments i.e.,0.10,20 and 30 ppm each treatment replicated three times. Potassium was added in the form of potassium sulphate (48%),at 30 and 60 dayes from transplanting into two equal doses.Zinc was foliary added at 30,60 and 90 days after transplanting in the form of Zinc sulphate(ZnSo4). Vine cuttings were planted on one sides of the ridge (width 75cm) at 25 cm apart. Disease-free, healthy, vigorous slips vine cuttings. Vine cuttings were planted on first week of May in 2008 and 2009. Abeese cultivar was used in this experiment. Standard agricultural practices for sweet potato production other than experimental treatments were carried out according to the recommendations of the Egyptian Ministry of Agriculture. Roots yield was hand-harvested 150 days after transplanting.

Vegetative Growth Characters: i.e., vine length (cm), leaf area/plant (m^2), leaves and branches number/plant, fresh and dry weight of leaves and branches/plant and fresh weight of whole plant (gm). Whereas, three plants were taken randomly from each experimental plot as a representative sample at 140 days after transplanting for measuring the previous vegetative growth characters. Root yield where measured 150 days after transplanting. Roots quality i.e., root length (cm), root diameter (cm) and root weight (gm/root) as well as roots number/plant and roots yield/plant (gm) were also determined. Total yield was calculated as ton fed^{-1} (feddan = $4200m^2$).

Chemical Constituents: The roots were washed in tap water containing a small amount of detergent. After excess water was allowed to drain away, they were placed in paper towels to remove additional moisture and oven dried at 70°C the dry samples of roots were grounded and then 0.2 g of each was digested and then used for N determination. Total nitrogen percentage was determined as percentage using microkjeldahle apparatus. Crude protein percentage was calculated using the factor (N% X 6.25) as described by Pregl[31]. Root content of carotenoids pigments was determined according to AOAC[32]. Total sugars percentage was determined according to Nelson[33]. Total carbohydrates percentage was determined according to Dubais[34]. Potassium percentage in leaves was determined using flam photometer according to Brown and lilleland[35]. However, Zn contents in leaves were determined using flame ionization atomic absorption, spectrometer model 1100 13 of perkin elemer and according to the method of Chapman and Pratt[36].

The experiments were arranged in split plot design; potassium treatments were in main plot while zinc treatments were randomizly distributed in sub plot. Each plot consisted of 3 ridges,6.25m long and 0.75 width, occupying an area of 14 m2 and replicated three times. Data of the experiment were subjected to statistical analysis of variance and significant differences were determined at the level 0.05 according to Snedicor and Cochran[37].

RESULTS AND DISCUSSION

Effect of potassium: Potassium fertilizer had positive effect on sweet potato plants shown in (Table 2). The highest values of vegetative growth characters (vine length, number of leaves and branches, fresh and dry weight of leaves and branches, total fresh weight and leaves area) were recorded by the treatment that received 150 kg k_2O.

Table 1: Physical and chemical properties of the experimental soil.

	Mechanical analysis (%)								
Depth of soil	Coarse sand	Fine sand	Silt	Clay	texture	pH	EC(dsm^{-1})	Ca_2CO_3--(meq/L.)	Organic matter (%)
0-40 cm	2.60	19.50	28.80	49.00	Clay loam	7.5	2.20	1.90	1.80

	Cations			Anions (meq $^{L-1}$)		
	Total N	Available P	Available K	Co_3	Cl	So_4
Depth of soil		mg/100 g soil		meq/L	meq/L	ppm
0-40 cm	148.80	5.50	0.41	5.50	1.80	80.95

Table 2: Effect of potassium fertilizer on the morphological characters of sweet potato plants during 2008 and 2009 seasons.

Treatments K_2O (Kg/fed)	Vine length (cm)	Leaves number	branches number	Leaves F. W. (g)	Branches F. W. (g)	Leaves D. W.(g)	Branches D. W.(g)	Total F.W (g)	Leaf Area(m^2)
				Morphological characters/plant					
				First season					
60	132.50	227.33	10.58	282.40	432.63	55.11	72.48	715.03	0.64
90	135.42	335.25	13.500	374.30	545.26	66.82	77.78	919.56	0.90
120	142.50	403.75	18.42	459.73	582.79	75.88	101.58	1042.53	1.17
150	151.67	475.08	26.00	527.98	602.44	83.85	112.28	1130.42	1.79
L.S.D 5%	9.31	36.68	0.68	48.03	46.20	6.11	11.76	128.28	0.19
				Second season					
60	125.75	224.75	10.500	289.95	423.78	56.71	65.79	713.73	0.57
90	132.42	330.50	13.00	374.68	512.63	65.27	71.98	887.30	0.87
120	139.83	376.00	17.500	453.84	533.09	66.86	99.68	986.93	1.06
150	145.83	422.50	24.58	518.10	593.52	77.02	109.15	1111.62	1.56
L.S.D 5%	6.54	17.87	0.40	36.31	54.64	8.84	6.54	45.93	0.10

Table 3: Effect of potassium fertilizer on the yield and its components of sweet potato plants during 2008 and 2009 seasons.

Treatments K_2O (Kg/fed)	Root length (cm)	Root diameter (cm)	Number of roots /plant	M. Weight of root /plant (g)	Yield/ Plant (g)	Yield /fedaan (ton)
			First season			
60	13.14	4.53	3.85	216.34	833.32	12.50
90	14.43	4.35	4.30	224.03	963.70	14.46
120	16.42	4.76	4.85	252.17	1223.52	18.35
150	18.21	5.59	5.43	275.35	1494.81	22.42
L.S.D 5%	0.23	0.46	0.03	1.66	18.91	0.31
			Second season			
60	12.86	4.17	2.78	203.13	564.09	8.46
90	14.21	4.33	3.45	205.98	710.75	10.66
120	16.07	4.66	4.53	232.11	1050.61	15.76
150	17.95	5.58	4.98	238.67	1187.59	17.81
L.S.D 5%	0.17	0.12	0.12	0.82	26.72	0.34

Table 4: Effect of potassium fertilizer on the chemical constituents of sweet potato plants during 2008 and 2009 seasons.

Treatments	Roots				Leaves	
K_2O (Kg/fed.)	Carotene mg/100g F.W.	Total sugar (%)	Total carbohy-drates (%)	Crude protein (%)	K(%)	Zn(ppm)
			First season			
60	4.07	10.42	84.67	6.98	3.26	1.63
90	4.13	12.23	85.80	7.28	3.39	1.88
120	4.58	14.94	87.46	7.69	3.47	2.20
150	5.84	16.41	89.06	8.03	3.64	2.59
L.S.D 5%	0.07	0.25	0.71	N.S	0.03	0.07
			Second season			
60	3.58	10.33	84.20	6.94	3.22	1.56
90	3.77	11.70	85.40	7.24	3.34	1.83
120	3.81	14.62	87.18	7.65	3.42	2.13
150	5.90	16.32	88.77	8.00	3.50	2.47
L.S.D. 5%	0.02	0.21	0.25	N.S	0.01	0.05

Table 5: Effect of zinc foliar on the morphological characters of sweet potato plants during 2008 and 2009 seasons.

Treatments K_2O (Kg/fed.)	Vine length (cm)	Leaves number	branches number	Leaves F.W. (g)	Branches F.W. (g)	Leaves D.W. (g)	Branches D.W. (g)	Total F.W. (g)	Leaf area(m^2)
				Morphological characters/plant					
				First season					
0	130.00	277.75	14.92	362.38	488.60	59.68	79.04	850.98	0.93
10	135.42	372.67	15.83	400.25	508.16	69.55	84.63	908.41	1.03
20	145.83	388.25	18.00	422.28	522.24	73.12	86.71	944.52	1.15
30	150.83	402.75	19.75	459.51	644.13	79.31	113.73	1103.63	1.39
L.S.D 5%	6.72	42.58	0.42	48.97	59.35	9.89	10.67	94.11	0.12
				Second season					
0	126.67	271.25	14.25	361.90	477.50	56.91	75.64	839.40	0.85
10	132.92	350.25	15.75	409.13	500.76	66.68	80.78	909.89	0.98
20	139.92	358.00	17.00	416.81	520.12	67.37	84.05	936.93	0.99
30	144.33	374.25	18.58	448.73	564.64	74.89	106.13	1013.37	1.22
L.S.D 5%	5.06	50.20	0.51	41.59	38.68	7.61	8.62	85.54	0.10

Table 6: Effect of zinc foliar on the yield and its components of sweet potato plants during 2008 and 2009 seasons.

Treatments K_2O (Kg/fed)	Root length (cm)	Root diameter (cm)	Number of roots /plant	M. Weight of root /plant (g)	Yield/ Plant (g)	Yield /fedaan (ton)
			First season			
0	15.09	4.63	4.43	236.09	1056.99	15.86
10	15.27	4.79	4.55	240.56	1108.57	16.63
20	15.75	4.82	4.66	243.24	1150.77	17.26
30	16.09	4.98	4.78	248.00	1199.02	17.99
L.S.D. 5%	0.19	0.09	0.03	1.81	17.39	0.22
Second season						
0	14.87	4.50	3.65	218.07	810.14	12.15
10	15.20	4.60	3.88	219.28	863.24	12.95
20	15.28	4.77	4.03	220.58	900.34	13.51
30	15.74	4.86	4.18	221.94	939.32	14.09
L.S.D. 5%	0.14	0.10	0.11	0.71	21.96	0.30

Table 7: Effect of zinc foliar on the chemical constituents of sweet potato plants during 2008/ and 2009 seasons.

Treatments	Roots				Leaves	
K_2O (Kg/fed)	Carotene mg/100g F.W.	Total sugar (%)	Total carbohy-drates (%)	Crude protein (%)	K(%)	Zn(ppm)
			First season			
0	4.57	12.66	86.03	7.34	3.41	1.97
10	4.59	13.45	86.43	7.45	3.41	2.03
20	4.71	13.82	87.03	7.56	3.42	2.13
30	4.75	14.07	88.00	7.62	3.54	2.17
L.S.D 5%	0.07	0.30	0.15	N.S	0.04	0.05
			Second season			
0	4.16	12.42	85.93	7.32	3.33	1.90
10	4.21	13.01	86.33	7.40	3.36	1.97
20	4.26	13.57	86.56	7.52	3.39	2.03
30	4.41	13.98	86.74	7.60	3.40	2.10
L.S.D 5%	0.03	0.21	0.18	N.S	0.01	0.02

Table 8: Effect of interaction between potassium fertilizers and zinc foliar application on the morphological characters of sweet potato plants during 2008 and 2009 seasons.

Treatments K_2O (Kg/fed.)	Zn ppm	Vine length (cm)	Leaves number	branches number	Leaves F.W. (g)	Branches F.W. (g)	Leaves D.W. (g)	Branches D.W. (g)	Total F.W. (g)	Leaf area(m^2)
				Morphological characters/plant						
				First season						
60	0	120.00	148.33	9.00	242.60	394.60	43.26	55.07	637.20	0.49
	10	136.67	311.00	9.33	294.80	458.83	54.13	78.13	753.63	0.65
	20	146.67	194.00	12.00	205.90	381.10	54.33	67.83	587.00	0.69
	30	126.67	256.00	12.00	386.30	496.00	68.70	88.87	882.30	0.74
90	0	115.00	319.33	12.00	294.50	488.10	93.90	72.10	782.60	0.79
	10	143.33	265.67	12.00	290.30	513.23	45.43	88.50	803.53	0.87
	20	143.33	276.00	15.00	593.80	708.30	48.73	53.93	1302.10	0.93
	30	140.00	480.00	15.00	318.60	471.40	79.20	96.60	790.00	1.00
120	0	146.67	296.00	16.67	312.90	587.50	55.43	106.00	900.40	1.06
	10	123.33	230.00	18.00	684.90	412.77	116.97	69.26	1097.67	1.13
	20	146.67	596.00	18.00	362.00	507.10	62.80	82.10	869.10	1.21
	30	153.33	493.00	21.00	479.13	823.80	68.33	148.97	1302.93	1.29

Table 8: Continue

150	0	138.33	347.33	22.00	599.50	484.20	46.13	83.00	1083.70	1.37
	10	138.33	684.00	24.00	331.00	647.80	61.67	102.63	978.80	1.46
	20	146.37	487.00	27.00	527.40	492.47	126.60	142.97	1019.87	1.78
	30	183.33	382.00	31.00	654.00	785.30	101.00	120.50	1439.30	2.55
L.S.D 5%		13.44	85.16	0.83	97.94	118.69	19.78	21.35	188.22	0.24
Second season										
60	0	108.33	136.00	9.00	239.60	347.20	43.53	59.33	586.80	0.28
	10	126.67	312.00	9.00	328.00	470.73	56.23	54.07	798.73	0.59
	20	141.00	195.00	12.00	205.80	381.20	54.30	53.43	587.00	0.67
	30	127.00	256.00	12.00	386.40	496.00	72.77	96.33	882.40	0.72
90	0	115.00	301.00	12.00	295.60	488.20	40.80	56.37	783.80	0.78
	10	143.33	264.00	12.00	290.70	401.73	53.13	74.97	692.43	0.83
	20	129.67	277.00	13.00	593.80	735.60	87.93	67.87	1329.40	0.90
	30	141.67	480.00	15.00	318.60	424.97	79.20	88.70	743.57	0.97
120	0	147.00	297.00	15.00	312.9	590.30	87.83	80.56	903.20	1.03
	10	123.33	231.00	18.00	688.10	482.77	45.26	98.23	1170.87	1.11
	20	147.00	597.00	18.00	368.56	507.10	56.13	129.53	875.67	0.83
	30	142.00	379.00	19.00	445.80	552.20	78.20	90.37	998.00	1.25
150	0	136.33	351.00	21.00	599.50	484.30	55.47	106.30	1083.80	1.33
	10	138.33	594.00	24.00	329.73	647.80	112.10	95.83	977.53	1.40
	20	142.00	363.00	25.00	499.07	456.56	71.10	85.37	955.63	1.56
	30	166.67	382.00	28.33	644.10	785.40	69.40	149.10	1429.50	1.95
L.S.D. 5%		10.11	100.41	1.03	83.18	77.36	15.22	17.23	171.1	0.20

Table 9: Effect of interaction between potassium and zinc application on the yield and components of sweet potato plants during 2008 and 2009 seasons.

Treatments K_2O (Kg/fed)	Zn ppm	Root length (cm)	Root diameter (cm)	Number of roots /plant	M. Weight of root /plant (g)	Yield/ Plant (g)	Yield /fedaan (ton)
First season							
60	0	12.81	4.45	3.70	210.00	777.01	11.66
	10	13.09	4.50	3.80	216.01	820.85	12.31
	20	13.26	4.56	3.90	219.15	854.70	12.82
	30	13.38	4.58	4.00	220.17	880.70	13.21
90	0	14.01	4.29	4.10	221.53	908.29	13.62
	10	14.18	4.31	4.20	222.49	934.47	14.02
	20	14.28	4.34	4.40	224.39	987.33	14.81
	30	15.23	4.44	4.50	227.71	1024.71	15.37
120	0	15.74	4.55	4.70	248.17	1166.42	17.50
	10	15.83	4.70	4.80	248.65	1193.54	17.90
	20	16.83	4.83	4.90	251.27	1231.24	18.47
	30	17.28	4.96	5.00	260.57	1302.87	19.54
150	0	17.77	5.21	5.20	264.66	1376.25	20.64
	10	17.96	5.66	5.40	275.07	1485.40	22.28
	20	18.62	5.55	5.50	278.14	1529.79	22.95
	30	18.46	5.94	5.60	283.53	1587.79	23.82
L.S.D 5%		0.37	0.18	0.05	3.62	34.79	0.45
Second season							
60	0	12.413	4.097	2.200	201.873	444.123	6.662
	10	12.94	4.14	2.70	201.94	545.25	8.18
	20	13.11	4.19	3.00	204.01	612.04	9.18
	30	12.95	4.24	3.20	204.67	654.96	9.82
90	0	13.87	4.27	3.30	204.88	676.12	10.14
	10	14.09	4.30	3.40	205.08	697.29	10.46
	20	14.24	4.32	3.50	205.96	720.87	10.81
	30	14.62	4.41	3.60	207.97	748.71	11.23
120	0	15.54	4.51	4.30	228.30	981.71	14.73
	10	15.82	4.45	4.50	232.68	1047.03	15.71
	20	15.77	4.77	4.60	233.34	1073.38	16.10
	30	17.15	4.91	4.70	234.11	1100.34	16.51
150	0	17.64	5.11	4.80	237.21	1138.63	17.08
	10	17.94	5.51	4.90	237.42	1163.38	17.45
	20	17.98	5.80	5.00	239.01	1195.07	17.93
	30	18.22	5.88	5.20	241.01	1253.27	18.80
L.S.D 5%		0.29	0.21	0.23	1.41	43.92	0.60

Table 10: Effect of interaction between potassium fertilizer and foliar zinc application on the chemical constituents of sweet potato plants during 2008 and 2009 seasons.

Treatments		Roots				Leaves	
K_2O (Kg/fed)	Zn ppm	Carotenoids mg/100g F.W.	Total sugars (%)	Total carbohydrates (%)	Crude protein (%)	K(%)	Zn(ppm)
First season							
60	0	4.04	10.17	84.10	6.81	3.26	1.53
	10	4.06	10.26	84.48	6.96	3.27	1.60
	20	4.08	10.59	84.91	7.06	3.29	1.65
	30	4.10	10.64	85.20	7.09	3.28	1.73
90	0	4.10	11.47	84.91	7.14	3.39	1.80
	10	4.11	11.65	85.21	7.22	3.39	1.85
	20	4.13	12.80	86.11	7.34	3.40	1.90
	30	4.16	13.00	86.96	7.43	3.40	1.95
120	0	4.51	13.07	86.91	7.52	3.44	2.10
	10	4.53	15.59	87.40	7.60	3.47	2.18
	20	4.61	15.30	87.61	7.79	3.48	2.18
	30	4.66	15.78	87.91	7.86	3.48	2.33
150	0	5.61	15.93	88.21	7.96	3.54	2.43
	10	5.66	16.29	88.61	8.01	3.52	2.50
	20	6.01	16.59	89.48	8.04	3.52	2.78
	30	6.05	16.83	89.91	8.11	3.99	2.65
L.S.D 5%		0.14	0.61	0.31	N.S	0.07	0.10
second season							
60	0	3.41	10.16	83.51	6.76	3.15	1.47
	10	3.46	10.19	84.21	6.91	3.19	1.55
	20	3.51	10.43	84.46	7.01	3.27	1.57
	30	3.91	10.53	84.61	7.08	3.25	1.67
90	0	3.71	10.66	85.26	7.13	3.28	1.75
	10	3.72	11.17	85.52	7.15	3.34	1.80
	20	3.78	12.11	85.89	7.27	3.36	1.85
	30	3.81	12.85	84.92	7.42	3.38	1.90
120	0	3.71	13.04	86.81	7.48	3.41	2.00
	10	3.77	14.41	87.11	7.54	3.40	2.07
	20	3.82	15.27	87.00	7.76	3.44	2.18
	30	3.91	15.75	87.80	7.81	3.44	2.27
150	0	5.81	15.81	88.11	7.91	3.49	2.37
	10	5.86	16.26	88.46	7.99	3.49	2.45
	20	5.91	16.44	88.89	8.02	3.50	2.50
	30	6.01	16.78	89.61	8.06	3.51	2.55
L.S.D 5%		0.06	0.41	0.35	N.S	0.02	0.03

It is clear from Tables (3 and 4) that potassium played an important role in yield and quality of sweet potato. Increasing rate of potassium fertilizers from 60 to 150 kg K_2O resulted in a significant effect on the yield. On the other hand, quality of sweet potato roots expressed as root length, root diameter, mean weight of roots, carotenoids, total sugars, total carbohydrates and crude protein were increased with increasing K rates. In addition total yield per plant and yield/fed. showed a positive response to potassium. Also, previous results were statistically significant with exception to crude protein in both seasons.

Increasing rate of potassium caused significant increment in K and Zn contents in sweet potato leaves in both seasons. Plants that received 150 kg K_2O had the highest K andZn contents in comparison with other treatments (Table 4).

Effect of zinc: Zinc foliar application fertilizer had a positive effect on vegetative growth of sweet potato plants i.e. vine length,number of leaves and branches and leaf area per plant (Table 5). The results indicated that the highest values were recorded by the treatment that received 30 ppm of zinc.

Results illustrated in Tables (6 and 7) presented that zinc had a positive effect on total yield, quality and chemical constituents of sweet potato plants. Increasing rate of zinc foliar application up to 30 ppm resulted in a significant effect on the yield. Quality of sweet potato tuber expressed as root length, root diameter, mean weight of roots, carotenoids, total sugars, total carbohydrates and crude protein were increased with increasing zinc application rate. These increments were statistically significant excluding crude protein in both seasons. Increasing rate of zinc caused significant increment in K and Zn contents in sweet potato leaves in both seasons. Plants that received 30 ppm had the highest Zn content in comparison with other treatments (Table 7).

Effect of Interaction: The effect of interaction between potassium and zinc were presented in (Table 8). The interaction showed that increasing rate of both potassium fertilizers (from 60 to 150 kg K2O/fed.) and zinc application (from 0 to 30 ppm ZnSO4) resulted in a positive effect on vegetative growth characters of sweet potato plants. Generally, the highest value of interaction effect were recorded with treatments that received 150 kg K2O/fed. with 30 ppm ZnSO4 in both seasons. Whereas, the lowest values were obtained with low potassium level (60 kg K2O/fed.) with control of zinc (0 ppm ZnSO4).

Results reported that in Tables (9 and 10) showed that the highest total yield was recorded with when K was applied at the rate of 150 Kg/fed. with Zn at rate of 30 ppm in both seasons. The highest values of tuber quality i.e. root length, root diameter, mean weight of root, carotenoids, total sugars, total carbohydrates and crude protein were recorded when potassium applied at the rate of 150 kg K2O/fed. with ZnSO4 at rate of 30 ppm in both seasons. These increments were statistically significant with exception to crude protein in both seasons. Increasing potassium and zinc application rate resulted in similar positive effect on potassium and zinc content in the leaves (Table 10).

Discussion: In this study increasing the rate of potassium fertilizer enhanced vegetative growth expressed as vine length, leaves and branches number/plant, leaves area, fresh of whole plant, and its fresh and dry weight of leaves and branches. This can be explaind on the basis that increasing K enhances N uptake. The increment in vegetative growth and significant yield response to K fertilization was reported previously by Marschner[10].

The observed increment in average roots weight per plant in response to increasing potassium application rate resulted in high total yield. This effect may be due to the fact that potassium plays an important role in promoting synthesis of photosynthates and their transport to roots[38]. Increasing roots yield of plants due to increasing potassium application rate can be attributed as reported by Marschner[10] to the crucial role of potassium in the energy status of the plant, translocation and storage of assimilates and maintenance of tissue water relations.

The observed increment in the percentage of K in the leaves due to increasing of K application rate can be explained on the basis of increasing the availability of nutrients in the soil[10,39]. In addition, the increment of the concentration of K in leaves in responses to the high rate of potassium may be due to the high mobility of K nutrient in the plant as supported by the findings of Clarkson and Hanson[41].

The observed improvement in the fruit quality parameters (total sugar content, TSS, ascorbic acid, fruit weight and flesh thickness) as affected by potassium nutrition can be explained on the basis of the positive effect of translocation of assimilates[10,23].

Moreover, Wallingford[41] mentioned that potassium is involved in the activation of more than 60 enzymes, which are necessary for essential plant processes such as energy utilization, starch synthesis, N metabolism and respiration this can explain the previous findings in this study. The enhancement of root quality due to potassium application has been reported also by previously[6,19-23].

In this study, the responses of vegetative growth, yield and roots quality of sweet potato were statistically significant. The observed improvement in vegetative growth and the root quality parameters (root length, diameter and weight roots, carotenoids, total sugars, total carbohydrates and Crude protein) as affected by zinc nutrition can be explained on the basis of that zinc promotes growth hormone biosynthesis, the formation of starch, and maturation[28].

Moreover, Acquaah[30] mentioned that zinc has many important roles in plant growth, a constant and continuous supply is necessary for optimum growth and maximum yields. It's needed for a plant's enzyme formation and associated with hormone (indole acetic acid) formation and deficiency of zinc has been found to reduce leaf size and shortened internodes and hence, limit plant growth.

Concerning the interaction between K fertilizer and Zn foliar application, sweet potato responded positively to K and Zn increasing rate. This positive effect may be attributed to the increasing K availability in soil. In addition, K is a key factor in regulating plant water status[10], which reflects on plant growth and hence yield. In addition Zn plays an important role in enzyme formation and associated with hormone (indole acetic acid) formation[28].

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