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Effect of Planting Date and Potassium Rates On the Productivity, Potassium Use Efficiency and Tuber Roots Quality of Sweet Potato Plants

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Abstract: A filed experiment was carried out during the two successive summer seasons of 2021 and 2022 at the Experimental Farm, El-Gemmeiza, Agric Res. Station, (ARC), Gharbeya Governorate (Middle Delta, Egypt), to study the effect of the effect of planting date (15th April and 15th May) and potassium rates (24, 48, 72 and 96 kg K_2O/fad.) as soil application as well as their interactions on growth, productivity potassium use efficiency and tuber roots quality of sweet potato (Beauregard cv.) under clay soil conditions. Under clay soil conditions and during summer plantations, planting sweet potato on 15th May and fertilizing with 72 kg K_2O/fad. in the form of potassium sulphate increased vine length, number of branches/ plant, leaf area / plant, shoot dry weight, average weight of tuber roots, yield/ plant and total yield /faddan. Faddan = 4200 m^2 = 0.42 hectare.

Key words: *Ipomoea batatas*, Sweet potato, planting date, potassium rates, growth, yield, potassium use efficiency.

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INTRODUCTION

Ipomoea batatas (L.) Lam., family *Convolvulaceae*, sometimes known as the sweet potato, is a significant vegetable crop that thrives in tropical and subtropical climates. After wheat, rice, maize, potato, barley, and cassava, it is the seventh-most significant food crop in the world (**Luan *et al.*, 2007**). It is a crucial source of protein and carbohydrates for both human and animal use. One of the most commercially significant vegetable crops in Egypt is the sweet potato.

The total sweet potato cultivated area in 2020 in Egypt was 35, 839 fad. (7.939 fad. in new land and 28.446 fad. in old land) which produced 502.386 tons (85.704 tons from new land and 416.682 tons from old land) with average 14.018 ton/fad. (11.593 tons / fad. in new land and 14.648 tons/ fad. in old land) according **(FAO, 2020)**.

Planting dates play an important role in the growth of plants and increase the productivity of vegetables and crops because of the availability of appropriate temperatures for growth and yield, which

leads to an increase in the total return or profit due to the increase in productivity, or crops may be planted at close dates to the appropriate dates with the aim of high prices and return (**Sandhu *et al*., 2014**).

There were signifcant diffrencess between planting dates of sweet potato on plant grwoth growth, productivity and tuber root quality of sweet potato had affected by different plant date (**Adisak *et al*., 1988, Allolli *et al.*, 2011; Kushwah *et al*., 2011; Mishra *et al.*, 2019; Nisha *et al*., 2020; EL-Anany 2021; Balogun and Nwokah, 2021; Komiljon and Dilnoza, 2021 and Olori-Great and Okpara 2021).**

Potassium is a crucial nutrient for plants and is essential for their growth and development as well as photosynthesis. It also improves the synthesis of carbohydrates, proteins, and fats, transports sugars, and strengthens cells and tissues to protect them from pests and diseases (**Byju and George, 2005**). Fertilization with potassium (K) is an essential step in the formation of sweet potatoes. K is necessary for the photosynthesis, transport of sugar, movement of water and nutrients, protein synthesis, and creation of starch in sweet potatoes (**Pettigrew, 2008**).

Several investigators reported that plant growth, chemical constituents, yield and tuber roots quality were increased by potassium fertilization (**Sokoto *et al.*, 2007; Abd El-Aal *et al*., 2010; Uwah *et al.*, 2013; Zelelew *et al*., 2016; El- Afifi *et al.*, 2016; Pushpalatha *et al*, 2017; Putra and Edy, 2018; Sulistiani *et al*., 2020; Harvey *et al.*, 2022; Luiz *et al*., 2022; Suwarto *et al*., 2022 and Elwaziri *et al*., 2023**).

Thus, this study was planned to determine the suitable level of potassium as soil application with the best planting date to obtained high yield and best tuber roots quality of sweet potato Beauregard cultivar under the conditions of clay soil.

MATERIALS AND METHODS

This experiment was carried out during the two successive summer seasons of 2021 and 2022 at the Experimental Farm, El-Gemmeiza, Agric Res. Station, (ARC), Gharbeya Governorate (Middle Delta, Egypt), to study the effect of the effect of planting date and potassium rates as soil application as well as their interactions on growth, plant chemical constituents, yield and its tuber roots quality as well as potassium use efficiency sweet potato (Beauregard cv.) under clay soil conditions.

Physical and chemical properties of the used experimental soil were: Clay loam soil in texture for the average two seasons, while it had 1.32% organic matter, 8.12 pH, 1.04 mmhos/cm EC, 65.79 available N, 11.24 available P and 246 available K as mg/kg soil. Meteorological data at Gharbiya Governorate during the two growing seasons of 2021 and 2022 are presented in **Table (A).**

Table (A). Meteorological data at Gharbiya Governorate during the two growing seasons of 2021 and 2022

Month	Temperature (°C)						RH%	
	Max.		Min.		Mean			
	2021 season	2022 season	2021 season	2022 season	2021 season	2022 season	2021 season	2022 season
April	28.22	29.13	12.24	14.23	20.23	21.68	51.18	49.42
May	34.22	32.35	17.12	16.80	25.67	24.58	44.76	47.18
June	34.17	36.28	19.37	21.19	26.77	28.74	50.79	48.72
July	38.04	37.24	22.42	21.22	30.23	29.23	48.10	49.22
August	38.15	37.22	23.19	23.32	30.67	30.27	49.27	53.49
September	34.36	34.24	21.79	21.34	28.08	27.79	56.34	57.17

These data were obtained from the Central Laboratory for Agricultural Climate (CLAC), Giza, Egypt.

The experiment included eight treatments, which were the interactions between two planting dates (planting on 15th April and 15th May) and four rates of potassium as soil application (24, 48, 72 and 96 kg K_2O/fad. in the form of potassium sulphate (48-52% K_2O). These treatments were arranged in a split plot design with three replicates. The planting dates were arranged in the main plots and potassium rates were randomly distributed in the sub plots.

The experimental unit area was 12.6 m^2. It contains three ridges with 6 m length each and 70 cm distance between each two ridges. One ridge was used to measure the morphological and chemicals traits and the other two lines were used for yield determinations.

Sweet potato stem cuttings, about 20 cm length, were transplanted on the third top of slope ridges at 25 cm apart. All treatments received ammonium sulphate (20.5% N) and calcium superphosphate (15.5%) at a rate of 200 and 150 kg/ fed., respectively. One third of N and K_2O and all P_2O_5 were added during soil preparation. The rest of N and K_2O (two thirds) were added twice after 45 and 90 days after planting. The normal agricultural practices were carried out as commonly followed in the district.

Data Recorded

A random sample of nine plants from every treatment (three plants from each replicate) were randomly taken at 120 days after planting in the two seasons (2021 and 2022) for measuring the following items,

Vine length (cm), number of branches/ plant and shoot dry weight (leaves + stems)/ plant (g). Additionally, leaf area/ plant (m^2) was calculated according to the described formula by **Koller (1972)** as follows:

$$\text{Leaf area } (m^2) = \frac{\text{Leaves dry weight / plant x number of disks x disk area}}{\text{Dry weight of disks}}$$

Nitrogen, phosphorus and potassium contents

Nitrogen, phosphorus and potassium percentages were determined in dried and wet digested shoot according to the methods described by A.O.A.C. (2018), and then uptake of N, P and K by shoots was calculated.

Yield and its components

At harvest time (140 days after planting) in the both seasons, the tuber roots of every plot were harvested and weighed, and the following data were recorded:

$$\text{1-Average number of tuber roots/plant} = \frac{\text{Total number of tuber roots/plot}}{\text{Total number of plants /plot}}$$

$$\text{2-Average weight of tuber roots/plant (gm)} = \frac{\text{Total weight of tuber roots/plot (kg)}}{\text{Total number of plants /plot}}$$

In addition, total yield /fad. were calculated. In the same time, tuber root samples (each of 10 storage tuber roots) were randomly chosen from each treatment, to determine average tuber root weight (g) and average tuber root length (cm).

Potassium use Efficiency (KUE)

It was determined by dividing the yield/ fad., by the potassium quantity/ fad., and expressed as kg fruits /kg K_2O according to Clark **(1982)**.

Tuber roots quality

Assessing tubers quality, implicated determination of tuber tissue contents, of total N, P, K and starch (as percentages in dried tissues) as well as carotenoides (as mg/g in fresh weight) according to the methods of **A.O.A.C. (2018**).

Statistical Analysis: Recorded data were subjected to the statistical analysis of variance according to **Snedecor and Cochran (1980**), and means separation was done according to **Duncan (1958).**

RESULTS AND DISCUSSION

1. Plant growth

Effect of planting date

Data in Table 1 show that there was significant effect between two planting dates (15th April and 15th May) in plant growth of sweet potato at 120 days after planting in both growing seasons and planting date on 15th May gave higher vine length, number of branches/plant, leaf area and shoot dry weight/ plant than planting on 15th April. The increases in shoot dry weight/ plant were about 13.42 and 21.97 g/ plant for planting on 15th May over the planting on 15th April in the 1st and 2nd seasons, respectively.

This superiority may be attributable to the beneficial effects of high temperatures and long days during these times, which simulate plant metabolism and accelerate vegetative development, resulting in the storage of more metabolites in tubers. Such increments in studied morphological characters during early and late planting dates may be due to the suitable and prevalent metrological factors specially temperature (Table A) which affect positively and increased the vegetative growth phase of plants, photosynthetic assimilation rate and duration of the period of plant growth. According to earlier studies, both temperature (**Kocsis *et al*., 2007**) and tropical (**Pimsaen *et al*., 2010**) locations' temperatures have a significant impact on the growth of Jerusalem artichokes. Similar results were obtained by **Mohamed (2020**) on Jerusalem artichoke.

These results agreement **Mishra *et al*. (2019)** on sweet potato. They showed that there were significant differences between different planting dates on vine length, number of branches/ plant, leaf area and shoot dry weight/ plant.

Table (1). Effect of planting date on plant growth at 120 days after planting of sweet potato during 2021 and 2022 seasons under clay soil conditions

Treatments	Vine length (cm)	Number of branches / plant	Leaf area / plant (m^2)	Shoot dry weight (g/ plant
		2021 season		
15th April	143.02 b	16.695 b	0.888 b	128.43 b
15th May	151.61 a	18.527 a	1.126 a	141.85 a
		2022 season		
15th April	137.46 b	16.083 b	0.737 b	118.28 b
15th May	146.91 a	18.162 a	1.042 a	140.25 a

Values having the same alphabetical letter(s) did not significantly differ at the 0.05 level of significance, according to Duncan's multiple range test.

Effect of K_2O rates

Fertilizing sweet potato plants grown in clay soil with different rates of K_2O (24, 48, 72 and 96 kg /fad.) had significant effect on vine length, number of branches / plant, leaf area/ plant and shoot dry weight at 120 days after planting in both seasons (Table 2).

Vine length, number of branches / plant, leaf area/ plant and shoot dry weight significantly increased with increasing K_2O up to 96 kg /fad. in the both seasons. This means that K_2O at 96 kg /fad. increased vine length, number of branches/plant, leaf area/ plant and shoot dry weight/ plant compared to other rates. The increases in shoot dry weight/ plant were about 12.35 and 7.54 g/ plant for K_2O at 48 kg, 24.73 and 19.77 g for K_2O at 72 kg /fad. and 29.29 and 22.83 g for K_2O at 96 kg /fad. over K_2O at 24 kg /fad. in the 1st and 2nd seasons, respectively.

These findings could be attributed to the role of potassium, an element important for numerous metabolic processes, including those that support and encourage vegetative growth and development in plants. The metabolism of carbohydrates and protein molecules, as well as cell division and elongation, are other physiological and biochemical processes that K plays a significant part in (**Marschner, 1995**). Also, potassium plays a number of significant regulatory roles. It is crucial for many processes that are required to support plant growth and reproduction, including protein synthesis, control of the ionic balance, regulation of plant stomata, maintenance of turgor, stress tolerance, water use, activation of plant enzymes, and many others (**Cakmak, 2005**).

Table (2). Effect of potassium rates on plant growth at 120 days after planting of sweet potato during 2021 and 2022 seasons under clay soil conditions

Treatments K2O (kg /fad.)	Vine length (cm)	Number of branches / plant	Leaf area / plant (m^2)	Shoot dry weight (g/ plant
	2021 season			
24	130.41 b	14.745 d	0.794 d	118.55 d
48	150.61 a	16.870 c	0.902 c	130.90 c
72	152.82 a	18.825 b	1.123 b	143.28 b
96	155.42 a	20.005 a	1.209 a	147.84 a
	2022 season			
24	131.12 c	14.815 c	0.729 d	115.98 d
48	140.30 b	17.035 b	0.826 c	126.52 c
72	146.77 a	17.875 b	0.972 b	135.75 b
96	150.56 a	18.765 a	1.031 a	138.81 a

Fad. = 4200 m^2= 0.42 hectare,
Values having the same alphabetical letter(s) did not significantly differ at the 0.05 level of significance, according to Duncan's multiple range test.

These results are consistent with the results obtained by **Sokoto *et al.* (2007), Abd El-Aal *et al.* (2010), Zelelew *et al.* (2016) and Putra and Edy (2018)** they indicated that increasing potassium fertilization significantly increased all plant growth parameters such as vegetative growth traits and shoots dry weight of sweet potato.

Effect of the interaction

The interaction between planting date and K_2O rates had significant effect on vine length, number of branches / plant, leaf area/ plant and shoot dry weight/ plant at 120 days after planting in both seasons (Table 3).

The interaction between planting date on 15th May and K_2O at 72 kg /fad. increased vine length, number of branches / plant, leaf area/ plant and shoot dry weight/ plant in both seasons.

The observation is in conformity with **Balogun and Nwokah (2021)** on sweet potato.

Table (3). Effect of the interaction between planting dates and potassium rates on plant growth at 120 days after planting of sweet potato during 2021 and 2022 seasons under clay soil conditions

Treatments		Vine length (cm)		Number of branches / plant		Leaf area / plant (m^2)		Shoot dry weight (g/ plant	
Planting dates	K_2O (kg /fad.)	2021 season	2022 season	2021 season	2022 season	2021 season	2022 season	2021 season	2022 season
15th April	24	121.61 d	124.97 e	13.81 e	14.32 d	0.670 h	0.637 g	112.68 e	104.40 f
	48	146.02bc	135.76 d	15.57d	15.47 cd	0.756 g	0.821 e	124.16 d	118.39 e
	72	149.90ab	142.02bcd	17.68 c	16.60 c	0.950 e	0.648 g	135.12 c	118.02 e
	96	154.55 a	147.10abc	19.72 ab	17.94 b	1.177 c	0.702 f	141.76 b	132.30 c
15th May	24	139.21 c	137.27 cd	15.68 d	15.31 cd	0.918 f	0.961 d	124.42 d	127.55 d
	48	155.20 a	144.83bcd	18.17 bc	18.60 ab	1.048 d	1.004 c	137.64 bc	134.64 c
	72	155.74 a	151.52 ab	19.97 a	19.15 ab	1.296 a	1.242 a	151.43 a	153.48 a
	96	156.28 a	154.01 a	20.29 a	19.59 a	1.242 b	1.102 b	153.92 a	145.31 b

Fad. = 4200 m^2= 0.42 hectare,
Values having the same alphabetical letter(s) did not significantly differ at the 0.05 level of significance, according to Duncan's multiple range test.

Nitrogen, P and K contents and uptake

Effect of planting date

Planting date on 15th may increase N, P and K contents in shoots and N, P and K uptake by shoots except P content in the 1st season and P uptake in the 2nd season (Table 4). This may due to that planting date on 15th May gave the higher shoots dry weight/ plant than planting on 15th April.

The results are agreement with These results agreement **Kushwah *et al*. (2011), Nisha *et al*. (2020) and Balogun and Nwokah (2021) on sweet potato.**

Table (4). Effect of planting dates on N, P and K contents in shoots and its uptake by shoots at 120 days after planting of sweet potato during 2021 and 2022 seasons under clay soil conditions

Treatments	Contents (%)			Uptake (mg / plant)		
	N	P	K	N	P	K
			2021 season			
15th April	3.04 b	0.406 a	2.06 b	3948 b	528.6 b	2672 b
15th May	3.44 a	0.414 a	2.10 a	4917 a	593.9 a	3014 a
			2022 season			
15th April	3.20 b	0.344 b	2.17 b	3814 b	409.2 a	2603 b
15th May	3.63 a	0.356 a	2.24 a	5130 a	501.6 a	3185 a

Values having the same alphabetical letter(s) did not significantly differ at the 0.05 level of significance, according to Duncan's multiple range test.

Effect of K_2O rates

Data in Table 5 indicate that fertilizing sweet potato plant with 96 kg K_2O/fad. significantly increased N, P and K contents in shoots and N, P and K uptake by shoots in both growing seasons. The stmulative effect of 96 kg K_2O/fad. on uptake of N, P and K by shoots may be due to that K_2O at 96 kg /fad. increased shoot dry weight/ plant as shown in (Table 2).

The response of plant vegetative development to the planting date was related to the influence of the planting date on K contents and its uptake. The prevailing temperature at the various planting dates (Table,1), which affects nutrient absorption and movement of it to different morphological regions, may be the cause of the variations in the concentration of K in shoot among the studied planting dates.

Table (5). Effect of potassium rates on N, P and K contents in shoots and its uptake by shoots at 120 days after planting of sweet potato during 2021 and 2022 seasons under clay soil conditions

Testaments (Kg/ K_2O fad.)	Contents (%)			Uptake (mg / plant)		
	N	P	K	N	P	K
	2021 season					
24	2.82 d	0.336 d	1.78 d	3362 d	398.5 d	2118 d
48	3.04 c	0.389 c	1.95 c	4001 c	509.9 c	2554 c
72	3.40 b	0.437 b	2.21 b	4890 b	627.1 b	3176 b
96	3.70 a	0.480 a	2.38 a	5476 a	709.4 a	3525 a
	2022 season					
24	2.91 d	0.315 d	1.65 d	3401 d	367.8 d	1928 d
48	3.28 c	0.345 c	1.99 c	4152 c	434.9 c	2511 c
72	3.62 b	0.361 b	2.44 b	4962 b	491.0 b	3330 b
96	3.86 a	0.380 a	2.74 a	5372 a	528.0 a	3806 a

Fad. = 4200 m^2= 0.42 hectare, Values having the same alphabetical letter(s) did not significantly differ at the 0.05 level of significance, according to Duncan's multiple range test.

Similar results were reported by **El- Afifi *et al.* (2017), Harvey *et al*. (2022), and Suwarto *et al*. (2022)** on sweet potato. They found that fertilizing plants with potassium recorded the highest N, P and K contents and their uptake by plant as compared to unfertilized plants.

Effect of the interaction

The interaction between planting date on 15th May and K_2O at 96 kg /fad. gave the highest values of N, P and K contents in shoots and N, P and K uptake by shoots with no significant differences with the interaction between planting date on 15th April and K_2O at 96 kg /fad. with respect to P and K contents in shoots in both seasons (Table 6).

3. Yield and its components

Effect of planting date

Data in Tables and 7 and 8 illustrate that planting sweet potato on 15th May increased average number of tuber roots/ plant, average weight of tuber roots, tuber root length, yield / plant and total yield/fad. compared to planting on 15th April in both seasons.

The increases in total yield /fad. were about 3.986 and 2.704 ton for planting on 15th May over planting on 15th April in the 1st and 2nd seasons, respectively. These results may be due to that planting on 15th May increased plant growth (Table 1), N, P and K uptake by shoots (Table 4) as well as number and weight of tuber roots (Table 7).

Table (6). Effect of the interaction between planting date potassium rates on N, P and K contents in shoots and its uptake by shoots at 120 days after planting of sweet potato during 2021 and 2022 seasons under clay soil conditions

Treatments		Contents (%)			Uptake (mg / plant)		
Planting date	K_2O (kg /fad.)	N	P	K	N	P	K
		2021 season					
15th April	24	2.59 f	0.332 d	1.74 e	2918 g	374.1 g	1960 e
	48	2.81 e	0.378 c	1.93 cd	3488 f	469.3 e	2396 cd
	72	3.17 cd	0.434 b	2.18 b	4283 d	586.4 c	2945 b
	96	3.60 b	0.483 a	2.39 a	5103 c	684.7 b	3388 a
15th May	24	3.06 d	0.340 d	1.83 de	3807 e	423.0 f	2276 de
	48	3.28 c	0.400 c	1.97 c	4514 d	550.6 d	2712 bc
	72	3.63 b	0.441 b	2.25 ab	5496 b	667.8 b	3407 a
	96	3.80 a	0.477 a	2.38 a	5849 a	734.2 a	3663 a
		2022 season					
15th April	24	2.68 f	0.299 d	1.58 f	2797 e	312.2 e	1649 e
	48	3.00 e	0.336 c	1.91 de	3511 d	393.3 d	2235 d
	72	3.39 cd	0.360 b	2.38 c	4000 c	424.9 c	2808 c
	96	3.74 ab	0.383 a	2.81 a	4948 b	506.7 b	3717 b
15th May	24	3.14 de	0.332 c	1.73 ef	4005 c	423.5 cd	2206 d
	48	3.56 bc	0.354 b	2.07 d	4793 b	476.6 b	2787 c
	72	3.86 a	0.363 b	2.51 bc	5924 a	557.1 a	3852 ab
	96	3.99 a	0.378 a	2.68 ab	5797 a	549.3 a	3894 a

Fad. = 4200 m^2= 0.42 hectare,
Values having the same alphabetical letter(s) did not significantly differ at the 0.05 level of significance, according to Duncan's multiple range test.

Table (7). Effect of planting date and potassium rates on tuber root characteristics of sweet potato at 150 days after planting during 2021 and 2022 seasons under clay soil conditions

Treatments	Average tuber root number / plant		Average tuber root weight (g)		Average tuber root length / plant	
	2021 season	2022 season	2021 season	2022 season	2021 season	2022 season
	Effect of planting date					
15th April	3.73 b	3.97 b	105.19 b	103.88 b	13.58 b	12.98 a
15th May	4.63 a	4.38 a	120.50 a	128.59 a	14.94 a	13.70 a
	Effect of potassium rates (kg /fad.)					
24	3.37 d	3.57 d	90.48 d	87.41 d	12.33 d	12.03 d
48	3.94 c	4.03 c	104.48 c	107.55 c	13.81 c	12.96 c
72	4.62 b	4.46 b	125.40 b	131.58 b	15.26 b	13.69 b
96	4.79 a	4.63 a	131.03 a	138.39 a	15.645 a	14.70 a

Fad. = 4200 m^2= 0.42 hectare,
Values having the same alphabetical letter(s) did not significantly differ at the 0.05 level of significance, according to Duncan's multiple range test.

Table (8). Effect of planting dates and potassium rates on yield and its components of sweet potato at 150 days after planting during 2021 and 2022 seasons under clay soil conditions

Treatments	Yield / plant (g)		Total yield (ton/fad.)		KUE (kg tuber roots/1 kg K_2O)	
	2021 season	2022 season	2021 season	2022 season	2021 season	2022 season
	Effect of planting date					
15th April	400.0 b	423.2 b	9.413 b	9.960 b	176.59 b	190.15 b
15th May	568.5 a	535.6 a	13.399 a	12.664 a	249.12 a	239.88 a
	Effect of potassium rates (kg K_2O /fad.)					
24	306.1 d	324.1 d	7.234 d	7.645 d	301.40 a	318.55 a
48	414.5 c	423.0 c	9.820 c	9.971 c	204.58 b	207.73 b
72	585.5 b	561.9 b	13.779 b	13.237 b	191.37 b	183.85 b
96	630.8 a	608.7 a	14.792 a	14.394 a	154.08 c	149.94 c

Fad. = 4200 m^2= 0.42 hectare,
Values having the same alphabetical letter(s) did not significantly differ at the 0.05 level of significance, according to Duncan's multiple range test. and KUE= potassium use efficiency

Increases of the tuber roots yield during the second date may be attributed to the availability of a suitable climate of temperature and humidity during the period of plant growth, which led to the formation of a strong vegetative group that contributed to the activation of the photosynthesis process and the formation of an excess of carbohydrates over the plant's need (Table A).

Obtained results agree with those reported by **Allolli *et al*. (2011), Kushwah *et al*. (2011), EL-Anany (2021) and Olori-Great, and Okpara (2021).** They showed that there were significant differences between planting dates on yield and its components

Effect of K_2O rates

Average number of tuber roots / plant, average weight of tuber roots, tuber root length, yield / plant and total yield/fad. of sweet potato grown in clay soil significantly increased with increasing K_2O up to 96 kg /fad. in both seasons (Tables 7 and 8).

Average weight of tuber roots (as average of the two seasons) were about 88.95 g for 24 kg K_2O/fad., 105.015 g for 48 kg K_2O/fad., 128.49g for 72 kg K_2O/fad. and 134.71 g for 96 kg K_2O/fad. This means that there was positive correlation between K_2O quantity and average weight of tuber roots.

The increases in total yield /fad. were about 2.536 and 2.326 ton for K2O at 24 kg /fad., 6.545 and 5.592 ton for K2O at 72 kg /fad. and 7.558 and 6.745 ton for K2O at 96 kg /fad., over K2O at 24 kg /fad. in the 1st and 2nd seasons, respectively.

The simulative effect of 96 kg K_2O/fad. on total yield may be due to that K_2O at 96 kg /fad. increased vine length, number of branches / plant, leaf area/ plant and shoot dry weight/ plant (Table 1), N, P and K uptake by shoots (Table 5) as well as average number and weight of tuber roots (Table 7).

The role of potassium in increasing the yield and its components might be attributed to its function in plants which includes energy metabolism and enzyme activation that increase exchange rate and nitrogen activity as well as enhance carbohydrates movement from shoots to storage organs. Application of potassium enhanced the stomata resistance coupled with reduced transpiration rate and increased relative water content, thus, may improve water storage capacity of the cells and providing favorable conditions for better yields (**Umar and Bansal 1995**).

These results are in harmony with those reported by **Abd El-Aal *et al*. (2010), Zelelew *et al*. (2016), El- Afifi *et al*. (2017), Putra and Edy (2018) and Elwaziri *et al*. (2023**). They found that yield and its

components of sweet potato such as average number of tuber roots, weight of tuber rots, yield/ plant and total yield significantly increased with increasing potassium rates.

Effect of the interaction

The interaction between planting date on 15th May and K_2O at 96 kg/ fad. increased average number of tuber roots / plan, average weight of tuber roots, tuber root length, yield / plant and total yield/fad. of sweet potato with no significant differences with the interaction between planting date on 15th May and K_2O at 72 kg /fad. with respect to average weight of tuber root, yield / plant and total yield /fad. in both seasons (Tables 9 and 10).

This means that the interaction between planting date on 15th May and K_2O at 72 kg /fad. increased yield/plant and total yield /fad. in both seasons. The interaction between planting date on 15th May and K_2O at 96 kg /fad. increased average number of tuber roots/plant and average length of tuber root in both seasons.

For all the interaction treatments, total yield/ fad. of sweet potato cv Beauregard ranged from 6.58 to 12.77 tons and average tuber root weight ranged from 84.97 to 121.77 g (as average of the two seasons) for planting date on 15th April, whereas total yield / fad. ranged from 8.29 to 16.41 tons and average tuber root weight ranged from 92.92 to 147.64 g (as average of the two seasons) for planting date on 15th May.

The results agree with those of **Balogun and Nwokah (2021)** on sweet potato.

Table (9). Effect of the interaction between planting date and potassium rates on tuber root characteristics of sweet potato at 150 days after planting during 2021 and 2022 seasons under clay soil conditions

Treatments		Average tuber root number / plant		Average tuber root weight (g)		Average tuber root length / plant	
Planting date	K2O (kg /fad.)	2021 season	2022 season	2021 season	2022 season	2021 season	2022 season
15th April	24	3.08 h	3.42 e	86.10 f	83.85 d	12.33 e	11.82 e
	48	3.23 g	3.68 d	100.35 de	96.60 c	13.18 d	12.67 cd
	72	4.23 e	4.32 c	111.30 c	114.51 b	14.45 c	13.18 cd
	96	4.39 d	4.46 bc	123.00 b	120.55 b	14.37 c	14.28 ab
15th May	24	3.66 f	3.73 d	94.85 ef	90.98 cd	12.33 e	12.24 de
	48	4.65 c	4.39 c	108.60 cd	118.50 b	14.45 c	13.26 c
	72	5.02 b	4.61 ab	139.50 a	148.65 a	16.07 b	14.20 b
	96	5.19a	4.81 a	139.05 a	156.23 a	16.92 a	15.13 a

Fad. = 4200 m^2= 0.42 hectare,
Values having the same alphabetical letter(s) did not significantly differ at the 0.05 level of significance, according to Duncan's multiple range test.

Potassium use efficiency (KUE)

Effect of planting date

Planting date on 15th May gave higher KUE as average of the two seasons (249.5 kg tuber roots/1 kg K_2O) compared to plant date on 15th April (183.37 kg /1 kg K_2O) as shown in Table 8.

Effect of K_2O rates

Potassium use efficiency by sweet potato plants decreased with increasing K_2O rates up to 96 kg /fad. (Table 8). This means that 24 kg K_2O/fad. gave the highest KUE as average of the two seasons (309.97 kg tuber roots/1 kg K_2O) compared to the other treatments as shown in (Table 8)

Effect of the interaction

The interaction between planting date on 15th May and K_2O at 24 kg /fad. recorded the highest KUE as average of the two seasons (345.675 kg tuber roots/1 kg K_2O) compared to the other treatments (Table 10).

Table (10). Effect of the interaction between planting date and potassium rates on yield and its components of sweet potato at 150 days after planting during 2021 and 2022 seasons under clay soil conditions

Treatments		Yield / plant (g)		Total yield (ton/fad.)		KUE (kg tuber roots/1 kg K_2O)	
Planting date	K_2O (kg /fad.)	2021 season	2022 season	2021 season	2022 season	2021 season	2022 season
15th April	24	265.1 e	294.4 e	6.265 e	6.900 e	261.04 b	287.50 b
	48	324.1 d	369.2 d	7.679 d	8.700 d	159.98 cd	181.25 de
	72	470.8 c	480.8 c	11.050 c	11.340 c	153.47 cd	157.50 ef
	96	539.9 b	548.5 b	12.659 b	12.899 b	131.86 d	134.36 f
15th May	24	347.1 d	353.7 de	8.202 d	8.390 d	341.75 a	349.60 a
	48	504.9 bc	476.7 c	11.960 bc	11.242 c	249.17 b	234.21 c
	72	700.2 a	643.1 a	16.507 a	15.134 a	229.26 b	210.19 cd
	96	721.6 a	668.8 a	16.925 a	15.889 a	176.30 c	165.51 ef

Fad. = 4200 m^2= 0.42 hectare,
Values having the same alphabetical letter(s) did not significantly differ at the 0.05 level of significance, according to Duncan's multiple range test. and KUE= potassium use efficiency

Tuber root quality

Effect of planting date

There were no significant differences between planting dates 15th April and 15th May in K content in the 1st season and N and P in the 2nd season, whereas there were significant differences between them in starch and root flesh carotene (Table 11). Planting date on 15th April increased starch (52.98 %) and root flesh carotene (12.045 mg /gm FW) as average of the two seasons.

Table (11). Effect of planting date on tuber roots quality at harvesting of sweet potato during 2021 and 2022 seasons under clay soil conditions

Treatments	Mineral contents (%)			Starch (%)	Root flesh carotene (mg/g) F. W
	N	P	K		
	2021 season				
15th April	0.74 b	0.435 b	1.30 a	53.22 a	11.57 a
15th May	0.80 a	0.462 a	1.37 a	48.70 b	9.53 b
	2022 season				
15th April	0.80 a	0.402 a	1.30 b	52.75 a	12.52 a
15th May	0.84 a	0.419 a	1.45 a	48.18 b	9.54 b

Values having the same alphabetical letter(s) did not significantly differ at the 0.05 level of significance, according to Duncan's multiple range test.

This superiority may be attributable to the beneficial effects of high temperatures and long days during these times, which simulate plant metabolism and accelerate vegetative development, resulting in the storage of more metabolites in tubers.

Similar findings were obtained by These results agreement (**Balogun and Nwokah (2021) and Komiljon and Dilnoza (2021**).

Effect of K_2O rates

The contents of N, P and K, starch and root flesh carotene in tuber roots significantly increased with increasing K_2O up to 96 kg /fad. (Table 12). This means that there was positive correlation between K_2O and starch content and K_2O and flesh carotene in tuber roots of sweet potato.

Tuber formation of sweet potato was positively affected by synthesis and accumulation of starch, since K plays a key role in this regard as it influences cell division, tuberous initiation and thickening, photosynthesis, formation of carbohydrates, translocations of sugars, mineral nutrients and photosynthetic matter and it also influences enzyme activity (**Byju and George, 2005**). Also, Potassium activates several enzymes especially in the metabolism of carbohydrates. The main effect of K_2O on carbohydrate, nitrogen and phosphorus percentages confirm that these percentages were raised as K_2O rate increased. Potassium percentage in plant leaves followed similar the above mention trend, but a significant linear relationship between increase in K_2O rate and increase in potassium percentage was detected **(Liu *et al.*, 2010)**.

These results agree with those reported by **Zelelew *et al*. (2016), El- Afifi *et al*., (2017), Pushpalatha *et al*. (2017), Luiz *et al*., 2022 and Elwaziri *et al*. (2023).** They indicated that tuber roots quality such as starch contents and flesh carotene significantly increased with increasing potassium application.

Table (12). Effect of potassium rates on tuber roots quality at harvesting of sweet potato during 2021 and 2022 seasons under clay soil conditions

Treatments (Kg /fad.)	Mineral contents (%)			Starch (%)	Root flesh carotene (mg/gm) F. W
	N	P	K		
	2021 season				
24	0.62 d	0.361 d	1.10 d	45.15 d	9.13 d
48	0.70 c	0.433 c	1.20 c	49.35 c	9.82 c
72	0.85 b	0.489 b	1.47 b	52.62 b	11.12 b
96	0.92 a	0.513 a	1.59 a	56.72 a	12.15 a
	2022 season				
24	0.66 c	0.316 d	1.13 c	43.74 d	10.07 c
48	0.74 b	0.403 c	1.27 b	48.98 c	10.53 bc
72	0.97 a	0.441 b	1.53 a	53.03 b	11.17 b
96	0.90 a	0.484 a	1.56 a	56.12 a	12.35 a

Fad. = 4200 m^2= 0.42 hectare,
Values having the same alphabetical letter(s) did not significantly differ at the 0.05 level of significance, according to Duncan's multiple range test.

Effect of the interaction

The interaction between planting date on 15th May and K_2O at 96 kg /fad. gave the highest N, P and K contents in tuber roots, whereas the interaction between planting date on 15th April and K_2O at 96 kg/fad. gave the highest of starch content and root flesh carotene in tuber roots of sweet potato in both seasons (Table 13).

Table (13). Effect of the interaction between planting date and potassium rates on tuber roots quality at harvesting of sweet potato during 2021 and 2022 seasons under clay soil conditions

Treatments		Mineral contents (%)			Starch (%)	Root flesh carotene (mg/gm) F. W
Planting date	K_2O (kg /fad.)	N	P	K		
				2021 season		
15th April	24	0.58 f	0.334 e	1.07 e	46.12 ef	9.75 cd
	48	0.67 e	0.412 d	1.16 de	50.49 cd	10.42 c
	72	0.83 c	0.482 b	1.43 c	55.06 b	12.35 b
	96	0.90 ab	0.514 a	1.56 ab	61.22 a	13.79 a
15th May	24	0.66 e	0.388 d	1.13 e	44.19 f	8.51 e
	48	0.73 d	0.454 c	1.25 d	48.22 de	9.23 de
	72	0.88 bc	0.496 ab	1.51 bc	50.18 cd	9.89 cd
	96	0.94 a	0.512 a	1.62 a	52.23 bc	10.52 c
				2022 season		
15th April	24	0.62 e	0.296 g	1.07 f	45.22 d	11.37 c
	48	0.70 de	0.400 e	1.20 de	51.18 c	12.12 bc
	72	1.02 a	0.432 cd	1.45 c	54.28 b	12.89 ab
	96	0.86 bc	0.482 ab	1.48 bc	60.35 a	13.72 a
15th May	24	0.70 de	0.336 f	1.20 ef	42.27 e	8.77 d
	48	0.78 cd	0.406 de	1.35 cd	46.79 d	8.95 d
	72	0.93 ab	0.450 bc	1.61 ab	51.79 c	9.46 d
	96	0.95 ab	0.486 a	1.64 a	51.89 c	10.98 c

Fad. = 4200 m^2= 0.42 hectare,
Values having the same alphabetical letter(s) did not significantly differ at the 0.05 level of significance, according to Duncan's multiple range test.

Conclusion

Under clay soil conditions and during summer plantations, planting sweet potato cv Beauregard on 15th May and fertilizing with 72 kg K_2O/fad. in the form of potassium sulphate increased vine length, number of branches / plant, leaf area / plant, shoot dry weight, average weight of tuber roots, yield / plant and total yield /faddan.

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