Performance of Cassava Plant Under Different Plant Densities and Potassium Levels in Newly Reclaimed Lands

Nagwa M. K. Hassan*, Safaa A. A. Mansour and M. E. Ragab*****
* Vegetable Res. Dept., National Research Center, Dokki, Cairo, Egypt.
** Potato and Vegetative Propagated Vegetables Dept., Hort. Res. Inst., A.R.C., Giza, Egypt.
*** Hort. Dept., Fac. Agric., Ain Shams Univ., Shoubra El-Kheima, Cairo, Egypt.

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Abstract: The present study was performed in a newly reclaimed sandy soil area during the two successive seasons of 2003/2004 and 2004/2005, to investigate the effect of various levels of K fertilizer, i.e., 60, 75, 96 and 120 kg K_2O/fed., under different plant densities 8000, 4000 and 2666 shrubs/fed. (equivalent. 50, 100 and 150 cm apart, respectively) on the productivity and quality of cassava crop, in an attempt to spread the cultivation of cassava under newly reclaimed land conditions associated with optimum productivity. The highest plant density had a considerable influence on stimulating the vegetative growth parameter, i.e., plant height, number of leaves and lateral branches as well as average diameter of stems (main branches) per plant and increasing total yield expressed as fresh weight/plant, average fresh and dry weight and number of tuber roots/plant. Reversely, this density gave the shortest average length of tuber roots. As for chemical components of tuber roots, both percentage and total amount of starch were increased progressively and significantly with the increment in plant density. On the other hand, protein and hydrocyanic acid (HCN) contents of tuber roots were reduced. With regard to plant nutrient compositions, increasing plant densities caused a significant increase in nitrogen and potassium percentages in plant leaves. However, a remarkable and significant reduction in the previous element concentrations was observed in tuber roots resulted with increasing plant density. No significance variations were recorded for phosphorus percentage whether in leaves or in tuber roots. Concerning K fertilizer, in general, the moderate fertilizer level of (96 kg K_2O/fed.) exceeded all other experimented rates. This rate significantly gave the greatest enhancement of all studied vegetative growth traits, the maximum average of total yield, dry weight (%), length as well as diameter of tuber roots. Identically, consistent increases in the percentage and total amount of starch and a favorable minimum content of HCN in tuber roots were corresponded with the moderate potassium application. All percentages of macro nutrients in leaves generally, responded by similar manner. On the contrary, adding K_2O at level of (120 kg /fed.) resulted in the highest significant potassium concentration in tuber roots. Whereas, no significance influence on other macro nutrients was registered. The interaction effects indicated that cultivating cassava at the narrowest plant spacing (50cm apart equivalent 8000 shrubs/fed.) combined with K fertilizer at rate of 96 kg K_2O/fed) recorded the highest values in most cases. Accordingly, it can be recommended and considered as an appropriate and profitable practical for use under similar growing conditions.

Keywords: Cassava, plant densities, Potassium levels, Sandy soil.

INTRODUCTION

Cassava (*Manihot esculenta.* Crantz.) is considered one of the most important tropical root crops, known as "Africa's food security crop" (Tewe and Egbunike, 1988). It ranks the fourth food crop in the developing countries which is a major source of low cost carbohydrates, cheapest caloric source and contains nearly the maximum concentration of starch compared to other crops (Hair, 1995). Cassava crop is consumed as human food throughout varying degrees of processing. Sometimes, leaves are consumed as a vegetable which contain high levels of protein (Cock, 1985). Moreover, it is cultivated and processed for animal feed, either, an efficient crop and important commercially as a row material for a large and complex industrial systems and purposes (FAO,1991).The comparatively low cost of cassava production is evident in its being one of the cheapest foods in most growing area. This is attributed to several factors such as low labor requirement, easy cultivation, high productivity value for at least three outstanding ecological adaptation, e.g., drought tolerance, ability to grew in sub-optimal soils, and aggressiveness towards weeds and insect pests, as well as low investment (Saqui, 1984).Hence, the production of cassava in the newly reclaimed land in Egypt seems very promising. Thus, cassava crop has a tremendous future.

Plant spacing is one of the most important factors among the several growth factors affecting the production. Appropriate cassava plant population is considered the most important cultural practices for improved the productivity of cassava (Jalloh, 1998). In this respect, Eke-Okoro and George (2001) reported that fresh root yield increased significantly with an optimum plant population. Similarly, Workatyehu (2002) pointed out that yield was positively correlated with plant density which optimum planting had a considerable effect. As known, optimum plant density varies and depends on other factors such as, soil, climate, cultivar, soil fertility ...etc. In this regard, the adequate fertilizer application is considered as one of the most limited factors affecting in association with plant density the cassava yield (Asafu, 1999).

As a root crop, sandy soil is one of the most suitable lands for production. However, low levels of nutrients such as potassium is considered one of a major production constrains of this type of soil. Corps (1981) stated that starch crops like potatoes, cassava and sweet potato have particularly high K needs. In a study conducted by Lessa *et al.* (1996) they observed that K was the most limiting nutrient for cassava growth at the research site. Cadavid *et al.* (1998) reported that, in order to sustain cassava productivity in poor sandy soils, applications of K fertilizer was highly desirable. Considerably, the application of potassium fertilizer significantly increased the yield of cassava (Ezumah *et al.*, 1994; El-Sarkawy and Cadavid, 2000; Wayan *et al.*, 2002; CarsKy and TouKourou, 2005; John and Venugopal, 2005). It has been reported that K application had a positive influence on the quality parameters of roots (Mohan Kumar *et al.*, 1998; Attalla *et al.*, 2001; SRI., 2003; Sherif *et al.*, 2003). Root HCN content was significantly reduced by adequate application of K (Nayer *et al.*, 1993; Cadavid *et al.*, 1998 and John *et al.*, 2003). As a new non-traditional crop, research work on cassava is still rather limited in Egypt. Therefore, the present study aimed to investigate the effect of various rates of K fertilization under different plant densities on the productivity and quality of cassava under our newly reclaimed land conditions.

MATERIALS AND METHODS

The present study was performed in a newly reclaimed sandy soil at South El-Tahrir Research Station, Horticulture Research Institute, during the two successive growing seasons 2003/2004 and 2004/2005. The mechanical and chemical analyses of the experimental soil are illustrated in Table (1).

Cassava stem cuttings of Indonesian cultivar obtained from El-Kanater Research station were planted on April 26th in the two seasons. The cuttings were of similar thickness (2.5–3.0 cm in diameter), 25-30 cm in length and planted at an angle 45° with inserting two thirds into the soil keeping one third of them over ground, then irrigated after planting directly. A drip irrigation system with nozzles of 50 cm apart was adapted for irrigation. As for fertilization, all experimental plots received an identical amounts of phosphorus fertilizer in the form of calcium super-phosphate at 50 kg P_2O_5/fed. (15% P_2O_5) which, was added during land preparation. Nitrogen in the form of ammonium sulphate (20.5% N) at the rate of 50 kg N/fed was divided into 4 equal doses. Potassium in the form of potassium sulphate (48% K_2O) was added at the four tested levels of K_2O and divided into 6 equal doses. Both N and K fertilizers were applied within the fertigation system. The fertilization program was started at the third week after planting, then, at a period of one month.

The treatments included three plant spaces (50, 100 and 150 cm equivalent to 8000, 4000 and 2666 shrubs / fed., respectively) and four levels of potassium fertilization (60, 75, 96 and 120 kg of K_2O/fed.). A split plot design with three replicates was used during the two growing seasons. Plant spaces resembled the main plots, whereas, the four potassium rates were randomly distributed in the sub ones. The experimental plot area was 15 m^2 consisted of one row of 1m width and 15 m length. All agricultural practices needed for growing the cassava plant were performed.

The following data were recorded:

- **Vegetative growth parameters:** A representative random sample of six plants was taken from each sub plot at 180 days after planting in order to determine the vegetative growth parameters, i.e., plant height (cm), number of leaves, main and lateral branches per plant as well as the main branches diameter.

- **Total yield and its quality characters:** At harvesting time, yield traits, i.e., total yield of tuber roots, average fresh weight, number, length, diameter, and dry weight of tuber roots per plant were measured.

- **Chemical components:** The fifth top full expanded leaf blade was collected from six plants within each treatment at 180 days after planting as samples for determining nitrogen, phosphorus and potassium concentrations in leaves. In addition, ten uniform tuber roots were randomly chosen from each sub plot at harvesting period. Samples of peeled sliced tuber roots were used after oven-dried at 65-70°C in an air-forced ventilated oven until constant weight for determination of the chemical constituent of tuber roots, i.e., N % (Black, 1965), P % (Trough and Meyer, 1939), K % (Brown & Lilleland, 1958), starch % (Shaffer and Hartman, 1921), total yield of starch g/plant, protein (Pregl, 1945) and Hydrocyanic acid (HCN) concentration (A.O.A.C., 1980). All above chemical determination were calculated on dry weight basis.

All obtained data were statistically analyzed according to Snedecor and Cochran (1980), using MSTAT-Computer V4 (1986). The differences among means for all traits were tested for significance according to Waller and Duncan (1969).

RESULTS AND DISCUSSION

1. Vegetative growth parameters:

1. A. Effect of plant spaces: Data presented in Table (2) showed that the decrement in planting distance, in order to increase the plant density, stimulated the vegetative growth parameter expressed as plant height, number of leaves and lateral branches as well as average diameter of main branches. On the contrary, number of main branches was insignificantly affected. The results hold true in both experimented seasons. Many previous investigators obtained results which supported the present results. In this regard, Khalil (1995) and Attalla *et al.* (2001) pointed out that plant height of cassava grown at narrow spacing exceeded that of grown at the wide one. As for sweet potato, Patil *et al.* (1990), Somda and Kays (1990) and Workatyehu (2002) came to a similar trend of the present results The superiority of studied closest spacing may be attributed to beneficial influence of the competitive effect. Hence, the highest cassava population density (as a result of narrowest distance), in turn, leads to more competition efficiency among plants in terms of attain their sufficient requirements of available growth elements. Thus, it encouraged the plants for occurrence more efficiency in order to enhance exploitation and utilization of such growth elements. Therefore, cassava plants which cultivated at narrow spacing, mainly, will be most effective for gaining their needs, subsequently optimized both their utilizing and assimilating processes which, in turn, eventually reflects as an appropriate and vigorously vegetative growth. This view point of explanation is consistent with the opinion of Ibrahim *et al.* (2004) on cassava. They suggested that increases in plant height with decreasing plant spacing might be due to competition between plants to have their needs from light, which in turn resulted in elongated internodes.

1. B. Effect of K fertilization rates: The application of potassium fertilizer caused an enhancement effect on all studied vegetative growth traits (table 2). In a general order, the highest significant measured values resulted from plants subjected to K fertilizer at the rate of 96 kg K_2O/fed., in other words. the moderate level of potassium applications. The same tendency was observed throughout the two growing seasons. Similar findings were declared by Maotong and Jianchang (2002) on sweet potato. Recently, in Egypt, similar K promoting effects on cassava vegetative growth were described by Attalla *et al.* (2001) and Sherif *et al.* (2003). The previous response trend of the vegetative growth to the moderate level of K fertilization may be due to applying potassium fertilizer at the optimum rate, which improves the utilization efficiency of, mainly, nitrogen fertilization, subsequently other fertilizer applications (Ardjasa *et al.*, 2002).

1. C. Effect of interaction: As a general notice, the results in Table (2) clearly revealed that cassava plants cultivated at the narrowest spacing (highest density) and received 96 kg K_2O/fed. gave the highest estimated values for most studied traits. With the exception of. the treatment consisted of 50cm apart combined with 75 and/or 96 kg K_2O/fed. recorded the highest cassava plants without significant differences. Additionally, the maximum number of lateral branches was registered from the combination of 100cm spacing and 96 kg K_2O/fed., only in second experimental season.

2. Total yield and its quality characters:

2.A. Effect of plant spaces: As shown in Table (3) narrowing the spacing between plants significantly increased total yield expressed as fresh weight per plant and average fresh and dry weight of tuber root in both studied seasons. Since the vegetative growth is considered as a reliable index of the resultant yield of crop, thereby, increasing the total yield as influenced by decreasing the plant spacing will be an anticipative was result due to its previous stimulating effect on the vigor of cassava plants then on the plant production efficiency. The present results confirm the findings of Akinyemi and Tijani (2000), Spittel *et al.* (2000), Eke.Okoro and George (2001), Ibrahim *et al.* (2004), Tabngoen *et al.* (2004) and Noite *et al.* (2005). All previous researchers concluded that there was a tendency for yield of cassava tuber roots to increase with the increment in plant density.

Both number and the average diameter of tuber roots per plant were not significantly affected in both growing seasons. A reversal effect was declared in case of the average length of tuber roots, increasing the plant distance increased the tuber root length. This may be attributed to the more available area which allows roots to extend more enough than in narrow spacing. Therefore, the longest roots will be expected achieved from the widest space. Similar trend of such suggestion was concluded by Khalil (1995), Asafu (1999) and Tabngoen *et al.* (2004).

2. B. Effect of K fertilization rates: The moderate potassium rate (96 kg K_2O/fed.) obviously exceeded all other studied rates for producing the maximum yield of cassava tuber roots/plant. The beneficial effect of moderate K level on increasing the total yield was already reported on cassava by many workers such as Olasantan (2003), Carsky and Toukourou, (2005), John and Venugopal (2005), Olaleye *et al.* (2006) and Sherif *et al.* (2003) in Egypt.

As for yield quality criteria. in spite of insignificant influence in case of the average length and number of tuber roots per plant, the average tuber root diameter followed the same previous observed pattern. These results were congruent in both seasons. The former result is concordant with Agbaje and Akinlosotu (2004), however, opponent with Attallah *et al.* (2001) and Sherif *et al.* (2003). On the other hand, the later results are in accordance with Attallah *et al.* (2001), Wayan *et al.* (2002) and Sherif *et al.* (2003) on cassava, and, JianWei *et al.* (2001) and Mansour *et al.* (2002) on sweet potato.

The distinct superiority of fertilizing with the moderate K level may be related to that one of the roles of potassium in plant growth is to aid in the translocation of carbohydrates produced in the leaves by photosynthesis to the various plant organs (Norman *et al.*, 1984). Therefore, since K is essential for carbohydrate synthesis and translocation, the application of this element at adequate rate not only increases the yield but also tends to stimulate its quality characters.

2. C. Effect of interaction: From data illustrated in Table (3), it could be observed that, the highest recorded values for most of these characters were registered with plants grown at 50 cm apart and supplemented with 96 kg K_2O/fed.comparing to those planted at 150 cm apart and supplemented with 60 kg K_2O/fed.throughout the two growing seasons.

3. Chemical components:

3. A. Effect of plant spaces: As shown in Table (4), planting density played an important role regarding the performance of starch accumulation in cassava tuber roots. The contents of both starch % and its total yield (g/plant) reached their highest values in corresponding with the maximum increase of plant density. This stimulated influence was probably due to the stimulative effect of decrement of planting distance on vegetative growth, which is, in fact, the main factory of carbohydrate synthesis (Mansour, 1992).In an opposite response, the lowest significant concentration of both protein and HCN contents were associated with the highest plant density. As for protein, cassava tuber roots are inferior in protein content. In this aspect, protein is considered one of the important factors affecting, to some extent, the success of starch extraction from tuber roots (Peter, 2002). The hydrocyanic acid (cyanogenic glucoside) content of cassava tuber roots is responsible for bitterness (NRI, 1987).Therefore, increasing the concentration of former component or reducing the content of later constituents or both will lead, in turn, to an improvement of cassava tuber root quality (NRI, 1987).

These results are in agreement with those obtained by Montaldo *et al.* (1994) and Peter (2002), who demonstrated stimulative effect on the quality parameters and components of tuber roots when plants were grown at narrow spacing (highest plant population).

3. B. Effect of K fertilization rates: Chemical components of tuber roots were influenced positively by potassium fertilization Table (4). Adding the moderate level of 96 kg K_2O/fed surpassed the other K fertilizer levels and resulted in the highest percentage and total yield of starch. The increase of starch accumulation associated with the moderate rate of K fertilizer may be due to the optimum potassium level, that proved to be the most important nutrient for the formation and construction of starch in tuber roots (Ezumah *et al.*, 1994). Moreover, tuber roots collected from plants subjected to K_2O at levels of 96 or 75 kg/fed. produced the highest content of protein. These results are matched with those obtained by Mohan Kumar *et al.* (1998) and Olasantan (2003). Additionally, JianWei *et al.* (2001) and George *et al.* (2002) came to similar conclusions on sweet potato. Remarkably, supplying the moderate rate of K had a favorable reversal effect on the HCN content in tuber roots. This application caused the highest decrement in HCN content of cassava tuber roots comparing to the other K levels. According to John *et al.* (2003), potassium deficiency lead to the increase of hydrocyanic acid content of tuber roots then had undesirable influence on the value of tuber roots for consumption. Thus, adding K fertilization on appropriate rate will in turn lead to diminish the deleterious content of HCN in tuber roots (John *et al.*, 1998 and El-Sharkawy and Cadavid, 2000). The previous results hold true in the two growing seasons.

3. C. Effect of interaction: The highest significant percentage and total yield of starch were gained from treatment 50 cm distance combined with 96 kg K_2O/fed.which also produced tuber roots with the lowest HCN content. These results were true in both experimented seasons.

4. Plant nutrient compositions:

4.1. Macro nutrient percentages in leaves and tuber roots:

4.1. A. Effect of plant spaces: Data illustrated in Table (5) showed that decrement the plant spacing caused a significant increment in nitrogen and potassium concentrations of cassava leaves and reduction of both elements in tuber roots. As for phosphorus percentage, it was not affected by the tested spacing. This trend of results held true in the growing seasons. The tendency of results for the response of nutrients in leaves, irrespective the phosphorus response may be attributed to the direct relationship between the competitive effect and the plant efficiency in competing for attain available nutrients. According to this interpretation, cassava plants spaced in closest distance (highest plant population) seemed to be most effective in absorption more nutrient elements from the soil solution, so far, their concentrations raised in plant tissues such as leaves. However, the reversal trend for those in tuber roots may be due to the stimulative effect of this factor on the plant growth. As a result, it caused an enhancement in its absorption and utilization of nutrient elements. Subsequently, these plants efficiently utilized and assimilated most of its absorbed nutrients in order for producing highest production and better quality in comparison with other treated plants. Therefore, it may be, in turn, lead to reduce the remainder and deposited storable amounts of such nutrients in tuber roots.

4.1. B. Effect of K fertilization rates: Applying K fertilizer at the rate 96 kg K_2O/ fed. gave the highest leaf N and K as well as tuber root N, whereas, the addition of the highest K level resulted in the highest K value in tuber roots, in both growing seasons (table 5). But P content was not affected. Similar results are reported by Nguyen *et al.* (2002).According to Mansour *et al.* (2002), macro elements contents in plant leaves of studied sweet potato cultivar increased by increasing potassium fertilizer rates up to moderate tested levels.

4.1. C. Effect of interaction: Using 50cm spacing in addition with 96 kg K_2O/fed., revealed the highest concentrations of N and in K in leaves. Whereas, in tuber roots, the highest value of K was obtained from 150 cm spacing combined with 120 kg K_2O/fed.

Table (1): Chemical and mechanical analysis of the soil at the experimental site.

Soil depth (cm)	EC dsm^{-1}	pH	Soluble cations (meq/L)				Soluble anions (meq/L)			Mechanical analysis			
			Ca^{+2}	Mg^{+2}	Na^{+}	K^{+}	HCO^{-3}	CL^{-}	SO_4^{-2}	Sand%	Sit%	Clay%	Texture class
0-30	1.38	9.16	1.25	0.60	1.60	0.20	1.18	1.80	0.75	90.9	3.60	5.50	Sandy
30-60	1.32	9.25	1.10	0.55	1.44	0.15	1.02	1.60	0.63	91.5	2.80	5.70	Sandy

Table (2): Effect of plant spacing and potassium fertilization levels on vegetative growth parameters of cassava plants in the two successive seasons 2003/2004 and 2004/2005.

Plant spacing	k_2o Levels kg/fed	Plant height (cm)		No. of leaves		No. of main branches		No. of lateral branches		Average diameter of main branches (cm)	
		1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
50 (cm)	60	152.5^{cde}	143.8^{bc}	250.0^{e}	264.0^{c}	1.83^{cd}	2.33^{a}	4.17^{ef}	10.00^{bcd}	2.25^{c}	1.77^{abc}
	75	180.7^{a}	149.5^{a}	333.0^{bc}	346.0^{ab}	2.33^{abc}	2.17^{a}	4.50^{def}	10.67^{bcd}	2.69^{ab}	1.90^{abc}
	96	179.3^{a}	148.2^{a}	445.0^{a}	400.0^{a}	2.67^{a}	2.67^{a}	9.67^{a}	12.67^{b}	2.87^{a}	2.20^{a}
	120	173.7^{b}	147.2^{ab}	263.0^{de}	308.0^{bc}	2.50^{ab}	2.17^{a}	7.00^{bcd}	11.67^{bcd}	2.51^{bc}	1.90^{abc}
	Mean	**171.5A**	**147.2A**	**322.8A**	**329.5A**	**2.33A**	**2.33A**	**6.33A**	**11.25A**	**2.58A**	**1.94A**
100(cm)	60	149.7^{de}	138.5^{d}	285.0^{cde}	290.0^{bc}	1.83^{cd}	2.00^{a}	6.67^{bcde}	5.33^{e}	2.36^{c}	1.97^{abc}
	75	154.0^{cd}	141.0^{cd}	286.0^{cde}	290.0^{bc}	2.17^{abcd}	2.50^{a}	6.50^{bcde}	12.00^{bc}	2.47^{bc}	1.73^{abc}
	96	156.8^{c}	142.5^{cd}	341.0^{b}	334.0^{abc}	2.50^{ab}	2.33^{a}	8.17^{ab}	16.00^{a}	2.48^{bc}	2.03^{abc}
	120	152.0^{cde}	141.0^{cd}	298.0^{bcde}	298.0^{bc}	1.67^{d}	1.67^{b}	3.83^{f}	9.33^{cd}	2.46^{bc}	2.03^{abc}
	Mean	**153.8B**	**140.8B**	**302.5A**	**303.0B**	**2.04A**	**2.13A**	**6.29A**	**10.67AB**	**2.44B**	**1.94A**
150(cm)	60	148.8^{c}	138.3^{d}	279.0^{cde}	268.0^{c}	2.00^{bcd}	2.00^{a}	3.50^{f}	6.00^{e}	2.37^{c}	1.50^{bc}
	75	155.2^{c}	139.3^{d}	286.0^{cde}	280.0^{bc}	2.17^{abcd}	2.00^{a}	6.67^{bcde}	9.00^{d}	2.27^{c}	2.23^{a}
	96	156.5^{c}	141.2^{cd}	317.0^{bcd}	350.0^{ab}	2.17^{abcd}	2.00^{a}	7.83^{abc}	10.00^{bcd}	2.39^{c}	2.07^{ab}
	120	154.5^{cd}	140.7^{cd}	318.0^{bcd}	300.0^{bc}	1.67^{d}	2.33^{a}	5.33^{cdef}	9.00^{d}	2.28^{c}	1.47^{c}
	Mean	**153.1B**	**139.9B**	**300.0A**	**299.5B**	**2.00A**	**2.08A**	**5.83B**	**8.50B**	**2.33C**	**1.82A**
Mean	60	**150.3C**	**140.2B**	**271.3C**	**274.0B**	**1.89C**	**2.06A**	**4.78B**	**7.11C**	**2.33B**	**1.74B**
	75	**163.3A**	**143.3A**	**301.7B**	**305.3B**	**2.22AB**	**2.22A**	**5.89B**	**10.56B**	**2.48AB**	**1.96AB**
	96	**164.2A**	**144.0A**	**367.7A**	**361.3A**	**2.44A**	**2.33A**	**8.56A**	**12.89A**	**2.58A**	**2.10A**
	120	**160.1B**	**143.0A**	**293.0BC**	**302.0B**	**1.94BC**	**2.11A**	**5.39B**	**10.00B**	**2.42B**	**1.80AB**

Means followed by the same letter are not statistically different at the 5% level (Duncan's multiple range test).

Table (3): Effect of plant spacing and potassium fertilization levels on total yield and quality characters of cassava tuber roots in the two successive seasons2003/2004 and 2004/2005.

Plant spacing	k_2O Levels kg/fed	Total yield kg/plant		Average weight of tuber root (g)		Average dry weight of tuber roots		Average number of tuber roots/ plant		Average length of tuber root (cm)		Average diameter of tuber root (cm)	
		1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
50 (cm)	60	4.04 ^{bc}	3.12 ^{bcd}	334.23 ^{a}	416.13 ^{abc}	38.27 ^{d}	39.02 ^{d}	12.10 ^{a}	7.50 ^{ab}	27.75 ^{b}	38.27 ^{d}	8.17 ^{abc}	9.11 ^{d}
	75	4.31 ^{abc}	3.38 ^{bc}	347.63 ^{a}	417.13 ^{abc}	41.17 ^{ab}	41.02 ^{a}	12.40 ^{a}	8.10 ^{ab}	29.54 ^{ab}	40.47 ^{bcd}	8.35 ^{ab}	9.99 ^{ab}
	96	4.70 ^{a}	3.87 ^{a}	371.33 ^{a}	450.50 ^{ab}	41.22 ^{a}	41.01 ^{a}	12.67 ^{a}	8.60 ^{a}	33.07 ^{ab}	41.20 ^{bcd}	8.71 ^{a}	10.24 ^{a}
	120	4.35 ^{abc}	3.13 ^{bcd}	360.70 ^{a}	371.60 ^{abc}	39.31 ^{c}	39.16 ^{c}	12.07 ^{a}	8.43 ^{a}	29.54 ^{ab}	39.30 ^{d}	7.91 ^{bc}	9.22 ^{cd}
	Mean	**4.35A**	**3.38A**	**353.48A**	**413.84A**	**39.99A**	**40.05A**	**12.31A**	**8.16A**	**29.84B**	**39.81B**	**8.28A**	**9.64A**
100 (cm)	60	4.10 ^{abc}	2.54 ^{e}	366.00 ^{a}	322.70 ^{c}	38.23 ^{d}	38.32 ^{e}	11.47 ^{a}	7.87 ^{ab}	33.08 ^{ab}	39.60 ^{cd}	7.70 ^{bc}	9.14 ^{cd}
	75	4.32 ^{abc}	3.12 ^{bcd}	350.20 ^{a}	419.90 ^{abc}	41.05 ^{b}	41.00 ^{a}	12.33 ^{a}	7.43 ^{ab}	29.25 ^{b}	43.07 ^{bcd}	7.96 ^{bc}	9.59 ^{bcd}
	96	4.57 ^{ab}	3.61 ^{ab}	368.90 ^{a}	475.00 ^{a}	41.10 ^{ab}	41.04 ^{a}	12.40 ^{a}	7.60 ^{ab}	31.06 ^{ab}	40.00 ^{bcd}	8.16 ^{abc}	9.56 ^{bcd}
	120	4.21 ^{abc}	2.97 ^{bcde}	350.10 ^{a}	374.37 ^{abc}	38.33 ^{d}	39.12 ^{c}	11.70 ^{a}	7.93 ^{ab}	31.84 ^{ab}	45.73 ^{ab}	7.80 ^{bc}	9.53 ^{bcd}
	Mean	**4.30A**	**3.06AB**	**358.80A**	**401.80A**	**39.68B**	**39.87B**	**11.98A**	**7.71AB**	**31.31AB**	**42.10B**	**7.90A**	**9.47A**
150 (cm)	60	3.30 ^{d}	2.78 ^{de}	271.43 ^{b}	414.87 ^{abc}	38.09 ^{e}	38.28 ^{e}	12.43 ^{a}	6.70 ^{ab}	31.39 ^{ab}	45.33 ^{abc}	7.59 ^{c}	9.05 ^{d}
	75	3.93 ^{c}	2.56 ^{e}	327.80 ^{ab}	354.90 ^{bc}	41.01 ^{b}	39.30 ^{b}	12.00 ^{a}	7.20 ^{ab}	35.96 ^{a}	45.27 ^{abc}	7.83 ^{bc}	9.32 ^{cd}
	96	4.24 ^{abc}	2.91 ^{cde}	348.13 ^{a}	413.97 ^{abc}	41.03 ^{b}	39.32 ^{b}	12.17 ^{a}	7.03 ^{ab}	32.09 ^{ab}	49.67 ^{a}	7.89 ^{bc}	9.63 ^{bcd}
	120	3.37 ^{d}	2.58 ^{de}	269.47 ^{b}	423.47 ^{ab}	38.02 ^{c}	38.00 ^{f}	12.23 ^{a}	6.10 ^{b}	32.55 ^{ab}	42.07 ^{bcd}	8.07 ^{abc}	9.75 ^{abc}
	Mean	**3.71B**	**2.71B**	**304.21B**	**397.99A**	**39.54C**	**38.72C**	**12.21A**	**6.76B**	**32.99A**	**45.58A**	**7.84A**	**9.44A**
Mean	60	**3.81B**	**2.83B**	**323.89B**	**384.57A**	**38.20C**	**38.54C**	**12.00A**	**7.36A**	**30.74A**	**41.07A**	**7.82B**	**9.11B**
	75	**4.16B**	**3.01B**	**341.88AB**	**397.31A**	**41.08A**	**40.44A**	**12.24A**	**7.58A**	**31.58A**	**42.93A**	**8.05AB**	**9.63A**
	96	**4.50A**	**3.46A**	**362.79A**	**446.49A**	**41.12A**	**40.46A**	**12.41A**	**7.74A**	**32.07A**	**43.62A**	**8.25A**	**9.81A**
	120	**3.98B**	**2.92B**	**326.76B**	**389.81A**	**38.55B**	**38.76B**	**12.00A**	**7.49A**	**31.13A**	**42.37A**	**7.93AB**	**9.51A**

Means followed by the same letter are not statistically different at the 5% level (Duncan's multiple range test).

Table (4): Effect of plant spacing and potassium fertilization levels on chemical components of cassava tuber roots in the two successive seasons2003/2004 and 2004/2005.

Plant spacing	k_2O Levels kg/fed	Starch%		Total yield of starch (g/plant)		Total protein (%)		HCN (ppm)	
		1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
50 (cm)	60	91.90 ^{c}	85.00 ^{c}	1440 ^{g}	1050 ^{e}	2.627 ^{h}	1.983 ^{f}	23.53 ^{a}	28.14 ^{a}
	75	93.87 ^{b}	86.99 ^{b}	1679 ^{b}	1207 ^{b}	2.913 ^{f}	2.493 ^{c}	20.05 ^{f}	24.66 ^{e}
	96	95.01 ^{a}	87.96 ^{a}	1860 ^{a}	1396 ^{a}	2.877 ^{f}	2.420 ^{d}	18.21 ^{i}	22.81 ^{h}
	120	93.73 ^{b}	86.95 ^{b}	1628 ^{d}	1074 ^{d}	2.710 ^{g}	2.060 ^{e}	20.25 ^{e}	24.86 ^{e}
	Mean	**93.63A**	**86.73A**	**1652.A**	**1182.A**	**2.782C**	**2.239C**	**20.51B**	**25.12B**
100 (cm)	60	86.41 ^{e}	79.96 ^{g}	1371 ^{i}	791.2 ^{j}	3.063 ^{e}	2.457 ^{cd}	23.13 ^{b}	27.74 ^{b}
	75	86.86 ^{e}	81.40 ^{d}	1544 ^{e}	1041 ^{f}	3.457 ^{b}	2.570 ^{b}	23.7 ^{b}	27.68 ^{b}
	96	87.81 ^{d}	80.95 ^{e}	1656 ^{c}	1201 ^{c}	3.487 ^{b}	2.570 ^{b}	19.03 ^{h}	23.64 ^{g}
	120	87.52 ^{d}	80.45 ^{f}	1436 ^{h}	940.2 ^{g}	3.243 ^{d}	2.557 ^{b}	20.28 ^{e}	24.89 ^{e}
	Mean	**87.15B**	**80.69B**	**1502.B**	**993.4B**	**3.313B**	**2.538B**	**21.38A**	**25.99A**
150 (cm)	60	79.38 ^{g}	72.07 ^{j}	1002 ^{l}	716.1 ^{l}	3.300 ^{c}	2.550 ^{b}	23.05 ^{b}	27.66 ^{b}
	75	79.93 ^{g}	72.81 ^{i}	1288 ^{j}	807.2 ^{i}	3.657 ^{a}	2.657 ^{a}	22.21 ^{c}	26.82 ^{c}
	96	84.30 ^{f}	77.31 ^{h}	1469 ^{f}	899.1 ^{h}	3.670 ^{a}	2.690 ^{a}	19.31 ^{g}	23.91 ^{f}
	120	84.18 ^{f}	77.27 ^{h}	1079 ^{k}	757.2 ^{k}	3.620 ^{a}	2.643 ^{a}	21.02 ^{d}	25.43 ^{d}
	Mean	**81.95C**	**74.86C**	**1210.C**	**794.9C**	**3.562A**	**2.635A**	**21.40A**	**25.95A**
Mean	60	**85.89D**	**79.01D**	**1271.D**	**852.5D**	**2.997C**	**2.330C**	**23.24A**	**27.84A**
	75	**86.89C**	**80.40C**	**1504.B**	**1018.B**	**3.342A**	**2.573A**	**21.78B**	**26.38B**
	96	**89.04A**	**82.07A**	**1662.A**	**1163.A**	**3.344A**	**2.560A**	**18.85D**	**23.45D**
	120	**88.48B**	**81.56B**	**1381.C**	**923.8C**	**3.191B**	**2.420B**	**80.52C**	**25.06C**

Means followed by the same letter are not statistically different at the 5% level (Duncan's multiple range test).

Table(5): Effect of plant spacing and potassium fertilization levels on macro nutrients concentrations of cassava leaves and tuber roots in the two successive seasons2003/2004 and 2004/2005.

Plant spacing	k_2O Levels kg/fed	Leaves						Tuber roots					
		N%		P%		K%		N%		P%		K%	
		1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
50 (cm)	60	4.91 ^{de}	4.68 ^{d}	0.340 ^{bcd}	0.335 ^{bcd}	2.43 ^{f}	2.30 ^{ef}	0.420 ^{f}	0.317 ^{b}	0.030 ^{a}	0.022 ^{a}	0.410 ^{f}	0.350 ^{f}
	75	5.28 ^{a}	4.90 ^{b}	0.399 ^{ab}	0.389 ^{ab}	2.73 ^{c}	2.69 ^{b}	0.466 ^{def}	0.399 ^{a}	0.037 ^{a}	0.031 ^{a}	0.550 ^{cd}	0.410 ^{de}
	96	5.27 ^{a}	4.98 ^{a}	0.415 ^{a}	0.398 ^{a}	2.99 ^{a}	2.88 ^{a}	0.460 ^{ef}	0.387 ^{a}	0.037 ^{a}	0.032 ^{a}	0.500 ^{de}	0.390 ^{ef}
	120	5.07 ^{b}	4.80 ^{c}	0.379 ^{abc}	0.370 ^{abc}	2.75 ^{c}	2.60 ^{c}	0.433 ^{ef}	0.330 ^{b}	0.035 ^{a}	0.033 ^{a}	0.590 ^{bc}	0.490 ^{b}
	Mean	**5.133A**	**4.84A**	**0.383A**	**0.373A**	**2.72A**	**2.62A**	**0.445C**	**0.358B**	**0.035A**	**0.0230A**	**0.513C**	**0.410A**
100 (cm)	60	4.85 ^{e}	4.58 ^{e}	0.330 ^{cd}	0.329 ^{bcd}	2.21 ^{h}	2.09 ^{g}	0.490 ^{cde}	0.393 ^{a}	0.031 ^{a}	0.020 ^{a}	0.490 ^{e}	0.400 ^{ef}
	75	5.07 ^{b}	4.76 ^{c}	0.391 ^{abc}	0.375 ^{abc}	2.59 ^{de}	2.44 ^{d}	0.553 ^{ab}	0.411 ^{a}	0.033 ^{a}	0.029 ^{a}	0.600 ^{bc}	0.480 ^{bc}
	96	5.11 ^{b}	4.88 ^{b}	0.394 ^{ab}	0.388 ^{ab}	2.81 ^{b}	2.70 ^{b}	0.558 ^{ab}	0.411 ^{a}	0.039 ^{a}	0.029 ^{a}	0.510 ^{de}	0.430 ^{cde}
	120	4.93 ^{cde}	4.68 ^{d}	0.359 ^{abcd}	0.346 ^{abcd}	2.54 ^{e}	2.31 ^{c}	0.519 ^{bcd}	0.409 ^{a}	0.033 ^{a}	0.028 ^{a}	0.640 ^{ab}	0.510 ^{ab}
	Mean	**4.99B**	**4.73B**	**0.369A**	**0.360A**	**2.54B**	**2.39B**	**0.530B**	**0.406A**	**0.034A**	**0.027A**	**0.560B**	**0.455A**
150 (cm)	60	4.58 ^{g}	4.36 ^{g}	0.317 ^{d}	0.301 ^{d}	2.15 ^{i}	1.87 ^{i}	0.528 ^{abc}	0.408 ^{a}	0.021 ^{a}	0.019 ^{a}	0.510 ^{de}	0.400 ^{ef}
	75	5.02 ^{bc}	4.69 ^{d}	0.387 ^{abc}	0.360 ^{abcd}	2.33 ^{g}	2.25 ^{f}	0.585 ^{a}	0.425 ^{a}	0.028 ^{a}	0.025 ^{a}	0.630 ^{b}	0.470 ^{bc}
	96	4.96 ^{cd}	4.75 ^{c}	0.391 ^{abc}	0.373 ^{abc}	2.60 ^{d}	2.41 ^{d}	0.587 ^{a}	0.430 ^{a}	0.029 ^{a}	0.023 ^{a}	0.630 ^{b}	0.460 ^{bcd}
	120	4.73 ^{f}	4.42 ^{f}	0.319 ^{d}	0.317 ^{cd}	2.11 ^{i}	2.03 ^{h}	0.579 ^{a}	0.230 ^{a}	0.026 ^{a}	0.020 ^{a}	0.690 ^{a}	0.550 ^{a}
	Mean	**4.82C**	**4.56C**	**0.354A**	**0.338A**	**2.30C**	**2.14C**	**0.570A**	**0.422A**	**0.026A**	**0.022A**	**0.615A**	**0.470A**
Mean	60	**4.78C\ **	**4.54D\ **	**0.329B\ **	**0.322C\ **	**2.26D\ **	**2.09D\ **	**0.479B\ **	**0.373B\ **	**0.027A\ **	**0.020A\ **	**0.470D\ **	**0.383C\ **
	75	**5.12A\ **	**4.78B\ **	**0.392A\ **	**0.375AB\ **	**2.55B\ **	**2.46B\ **	**0.535A\ **	**0.412A\ **	**0.033A\ **	**0.028A\ **	**0.593B\ **	**0.453B\ **
	96	**5.12A\ **	**4.87A\ **	**0.400A\ **	**0.386A\ **	**2.80A\ **	**2.66A\ **	**0.535A\ **	**0.409A\ **	**0.035A\ **	**0.028A\ **	**0.547C\ **	**0.427B\ **
	120	**4.91B\ **	**4.63C\ **	**0.352B\ **	**0.344BC\ **	**2.47C\ **	**2.31C\ **	**0.510AB\ **	**0.387AB\ **	**0.031A\ **	**0.027A\ **	**0.640A\ **	**0.517A\ **

Means followed by the same letter are not statistically different at the 5% level (Duncan s multiple range test).

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أداء نبات الكاسافا تحت معدلات مختلفة من الكثافة النباتية والتسميد البوتاسى فى الأراضي حديثة الإستصلاح

نجوى حسن محمد كمال*- صفاء على أحمد منصور- محمد إمام رجب*****

* قسم بحوث الخضر- المركز القومي للبحوث- الدقي- القاهرة- مصر

**قسم البطاطس و محاصيل الخضر خضرية التكاثر- معهد بحوث البساتين- مركز البحوث الزراعية- الجيزة- مصر

*** قسم البساتين- كلية الزراعة- جامعة عين شمس- شبرا الخيمة- القاهرة- مصر

يعتبر نبات الكاسافا أحد محاصيل الخضر الجذرية غير التقليدية التى تمتاز بالعديد من المزايا الزراعية و الاستخدامات الهامة فى غذاء الإنسان، الحيوان و مختلف الأغراض الصناعية، لكنها لا تزال نادرة الشيوع و الزراعة فى جمهورية مصر العربية. هدفت الدراسة الحالية إلى بحث تأثير معدلات التسميد البوتاسى المختلفة (١٢٠،٩٦،٧٥،٦٠ كجم بو٢ أ/فدان) تحت العديد من الكثافات الزراعية :-

١) الزراعة على مسافة ٥٠ سم بين النباتات بما يعادل ٨٠٠٠ شجيرة/فدان. ٢) الزراعة على مسافة ١٠٠سم بين النباتات بما يعادل ٤٠٠٠ شجيرة/فدان. ٣) الزراعة على مسافة ١٥٠سم بين النباتات بما يعادل ٢٦٦٦ شجيرة/فدان. على إنتاجية و جودة محصول الكاسافا المنزرع تحت نظام الرى بالتنقيط فى الأراضي الرملية حديثة الاستصلاح خلال الموسمين الزراعيين ٢٠٠٣/٢٠٠٤و ٢٠٠٤/٢٠٠٥.

أوضحت النتائج ما يلى:-

- أن الكثافة النباتية العالية (٨٠٠٠ شجيرة/فدان) أدت معنوياً إلى تحسين مواصفات النمو الخضري المتمثلة فى ارتفاع النبات، عدد الأوراق و الأفرع الجانبية بالإضافة إلى متوسط قطر الأفرع الرئيسية. ازداد كلا من (المحصول الكلى بالوزن الطازج، عدد الجذور، وزن الجذر الدرني الطازج والجاف للجذور) لكل نبات معنوياً مع كل زيادة فى الكثافة النباتية تحت الدراسة. بينما أمكن الحصول على أعلى متوسط معنوي لطول الجذور بخفض الكثافة النباتية. أدت زيادة الكثافة النباتية إلى زيادة معنوية لكلاً من نسبة النشا و المحتوى الكلى منه فى الجذور الدرنية، بينما أدت إلى نقص محتوى البروتين و نسبة حمض الهيدروسيانيك معنوياً. أدت زيادة الكثافة النباتية إلى إرتفاع نسب النيتروجين و البوتاسيوم بالأوراق بشكل معنوي، فى حين انه أحدث نقصاً معنوياً واضحاً فى نسب هذه العناصر فى الجذور. لم يكن هناك تأثيراً معنوياً على نسبة عنصر الفوسفور سواء فى الأوراق أو الجذور.

- تفوق إضافة معدل التسميد المتوسط (٩٦كجم بو٢ أ/فدان) فى إحداث أفضل تحسين فى جميع مواصفات النمو الخضري المدروسة، وكذلك أعلى زيادة معنوية بالنسبة للمحصول الكلى و صفات الجذور. أدت إضافة المعدل السابق إلى زيادة معنوية لكلاً من نسبة النشا و المحتوى الكلى منه فى الجذور الدرنية، بينما أدت إلى اقل محتوى من حمض الهيدروسيانيك بها. استجابت نسب جميع العناصر الكبرى فى الأوراق بنفس الكيفية سابقة الذكر، وأوضحت النتائج اتجاه آخر بالنسبة لتركيز العناصر الكبرى فى الجذور الدرنية، حيث لم يكن هناك إختلافاً معنوياً بين معدلات التسميد البوتاسى المستخدمة فى نسب النيتروجين والفوسفور، بينما أدى إضافة المعدل العالي من السماد البوتاسى (١٢٠ كجم بو٢ أ/فدان) إلى أعلى إرتفاع فى نسبة عنصر البوتاسيوم.

- سجلت الزراعة بأعلى كثافة نباتية (٥٠سم) مع التسميد بـ٩٦ كجم بو٢ أ/فدان أعلى القيم بالنسبة لمعظم القياسات المختبرة.

فى ضوء النتائج السابقة يمكن زراعة الكاسافا بكثافة نباتية ٨٠٠٠ شجيرة/فدان بالإضافة إلى التسميد البوتاسى بمعدل ٩٦ كجم بو٢ أ/فدان فى المناطق المماثلة لظروف النمو تحت الدراسة الحالية.