Assiut Journal of Agricultural Sciences 55 (2) 2024 (in press)
ISSN: 1110-0486 / EISSN: 2356-9840
Website: http://ajas.journals.ekb.eg/
E-mail: ajas@aun.edu.eg

(Original Article)

Response of Cassava Tubers Yield and its Components to Different Agricultural Treatments

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DOI: 10.21608/AJAS.2024.277501.1347

Abstract

Two field experiments were conducted at the Experimental Farm of Vegetable Department, Faculty of Agriculture, Assiut University, Egypt, to observe the effect of harvest time and planting method under two different planting dates on cassava yield and its components (c.v. Indonisi). Planting dates were on the 1st and 15th of April in 2021/2022 and 2022/2023 seasons, respectively which were laid in two separate experiments. Each experiment is laid out in a Randomized Complete Block Design (RCBD) using a split-plot arrangement with three replications. Where harvesting times (8, 9 and 10 months from planting) were arranged in the main plots while planting methods (direct and stored stakes for 15 days underground) were localized in the subplots. The acquired results exhibited that all the first and second interactions had significant or highly significant effects on tubers yield /fed in both seasons except the interaction between planting date × planting method in the second season. Hence, the highest average values of tuber yield /fed (8.483 and 7.963 tons in the two respective seasons) were obtained from cassava plants which were planted using direct stakes on April 1 and harvested after 9 months from planting. So, to achieve the highest yield from cassava, it will be recommended to cultivate cassava with direct stakes at the beginning of April and harvest after 9 months under Assiut conditions.

Keywords: *Cassava, Planting method, Harvest time, Planting Time, Tubers yield*

Introduction

Cassava (*Manihot esculenta* Crantz) is a perennial plant belonging to the family *Euphorbiaceae*. It is mostly grown in tropical and subtropical areas (Alves, 2002; Li *et al*., 2016 and Wang *et al*., 2018). Cassava is reasonably drought tolerant and is expected to be highly adaptable to future climate change, making it an important crop for food security (Jarvis *et al*., 2012; Duque and Setter, 2019). Cassava is Africa's fourth largest source of calories (FAO, 2020). Cassava is an important food source for more than 800 million people worldwide (McCallum *et al*., 2017). The cassava plant is a perennial woody shrub that can grow up to three meters tall in tropical regions. The plant is thought to have originated in Latin America, where local Indians discovered it 4,000 years ago (Akinpelu, *et al.* 2011). However, cassava has been less studied compared to other crops although its

Received: 17 March 2024/ Accepted: 1 April 2024/ Published online: 17 April 2024

importance as a food in many developing countries (Varshney *et al.*, 2010 and Leal *et al.*, 2014) and its commercial use for starch in the tropics and subtropics (Nweke, 2005; Karlstrom *et al.*, 2016). The main factor of the cassava plant's economic value is its tuberous roots; differences in production are caused by the interaction between the roots and the physicochemical properties of the soil (Oliveira, *et al.* 2001). In addition to the use of cassava roots, its leaves can be used as a calcium and vitamin foundation, as well as a protein-rich food, responsible for the removal of cyanogenic compounds (cooking and drying) (Lancaster and Brooks 1983). Planting time is the core factor related to the production of tuberous roots, regardless of the cultivar or any other cultural practice that may be approved, and it depends on the region it is produced. The best planting times for cassava are also related to the availability of mature branches and climatic conditions favoring sprouting and root formation (Takahashi and Gonçalo 2005). Accordingly, farmers need to understand how cassava varieties reply to different planting dates and crop ages at harvest to revenue advantage of flexible planting and harvest dates increasing prices, and dry matter. Thus, this study was conducted to identify the best time to both cultivate the stakes and harvest the tubers and the best method to cultivate stakes on root yield and quality in Assiut Governorate, over two seasons.

Material and Methods

Two field experiments were conducted at the Experimental Farm of Vegetable Department, Faculty of Agriculture, Assiut University, Egypt (longitude:31.25 E, latitude:27.25N, deviation: 45m/148ft), to survey the effect of harvest time and planting method under two different dates of planting on cassava yield and its components (c.v. Indonisi). Planting dates (D) were on the 1st and 15th of April in 2021/2022 and 2022/2023, respectively which were laid in two separate experiments. Each experiment is laid out in a Randomized Complete Block Design (RCBD) using a split-plot arrangement with three replications. Where harvesting times, T (8, 9, and 10 months from planting) were arranged in the main plots while planting methods, M (direct and stored stakes for 15 days underground) were localized in the subplots.

Each experiment contained 18 experimental units (3 harvest times × 2 planting methods × 3 replicates) each of them was 30 m^2. Each plot consists of three terraces of 5 m in length and 1m in width, spacing 50 cm between terraces and 1 m between plants.

The experimental soil site was clay with the assets as presented in Table 1 (Page *et al*., 1982).

Table 1. The physical and chemical properties of the experimental farm soil.

Characteristic	Values	Characteristic	Values
pH (1:2.5)	8.01	**Clay %**	53.23
EC1:1 dSm^{-1}	1.35		
ECe dSm^{-1}	2.01	**Silt %**	28.35
Organic matter (OM) %	1.10		
Soluble cations, (meq/kg soil)		**Sand %**	18.42
Ca^{2+}	10.00		
Mg^{2+}	4.00	**Soil texture**	Clay
Na^{+}	4.70		
K^{+}	1.30	**Bulk density, (g/cm^3)**	1.63
Soluble anions, (meq/100 g soil)			
Cl^{-}	5.70	**Field capacity, (F.C) %**	45.70
HCO_3^{-}+CO_3^{2-}	4.30		
SO_4^{2-}	10.00	**Wilting Point (W.P) %**	21.30
Total nitrogen (ppm)	13.00		
Available phosphorus (ppm)	10.20	**W. Saturation %**	67.30
Available potassium (ppm)	312.00		

All the other agricultural practices that were recommended for cassava plants were done in the two growing seasons.

At harvested times after 8,9,10 months in both experiments, the following characteristics were determined:

1-Tubers' number/plant: As a mean of five plants randomly chosen from each experimental unit

2-Tuber diameter (cm): As a mean of ten tubers randomly chosen from each experimental unit, measured of the middle part using the pachymeter

3-Tuber length (cm): As a means of ten tubers randomly chosen from each experimental unit, measure the distance between the base and the apex of the root using a graduated ruler.

4-Tuber weight (g): As a means of ten tubers randomly chosen from each experimental unit.

5-Tubers' weight /plant (kg): As mean weight of tubers of five plants randomly chosen from each experimental unit.

6-Tubers yield (ton/fed): Weight of tubers of all plants in each experimental unit then transfer to ton per feddan.

Statistical analysis

Each experiment was analyzed separately and Bartlett's test for homogeneity of error variances was examined by analyzing covariance between the studied planting dates to reveal the effect of the planting factor and its interactions with the other tested factors. Collected data were analyzed using the SAS Statistical Software Package and means were compared using the LSD at $P \leq 0.05$ according to Gomez and Gomez (1984).

Results and Discussion

1-Tubers' number /plant

Exhibited data in Table 2 clearly show that the tested planting dates had a highly significant influence on the number of tubers per plant in the two growing seasons. Cassava plants that were planted on the first of April gave the highest number of tubers per plant (9.569 and 9.941 in the first and the second seasons, respectively) as compared to the 15th of April in both seasons. This may be due to the suitable environmental conditions prevailing at the first planting date which were more encourage the growth of stakes buds than 15th April.

Furthermore, illustrated data in Table 2 reveal that the testing harvest time had a highly significant effect on the cassava tubers number per plant in both seasons. Thus, the collecting of cassava tubers after 9 months surpassed the other harvest time and produced the maximum average values (9.525 and 9.425 tubers per plant in the two respective seasons). These results may be attributed to the harvest time, 9 months after planting, was later than the other harvest date (8 months). This may be due to the increase in synthesis products as a result of the increase in age from 8 to 9 months, which led to the formation of new tubers and consequently increased the number of tubers per plant as the age exceeded 9 months, especially with the prevention of irrigation, which led to Some tubers were lost, which led to a decrease in number after that (at 10 months). These results agree with Lilian *et al* (2019) and Samidjo (2020).

Table 2. Means of tubers number/plant as affected by planting date (D), harvesting time (T) and planting methods (M) as well as their interactions in 2021/2022 and 2022/2023, seasons

Seasons		2021/2022			2022/2023		
Harvesting time (T)	Planting methods (M)	Planting date (D)		Mean	Planting date (D)		Mean
		D_1 1st April	D_2 15th April		D_1 1st April	D_2 15th April	
T_1 8 Months	**Direct** stakes	9.100	8.167	8.634	9.233	6.933	8.083
	Storage stakes	9.000	7.833	8.417	8.500	6.500	7.500
Mean		**9.050**	**8.000**	**8.525**	**8.867**	**6.717**	**7.792**
T_2 9 Months	**Direct** stakes	10.267	8.967	9.617	11.643	7.923	9.783
	Storage stakes	10.067	8.800	9.434	10.533	7.600	9.067
Mean		**10.167**	**8.883**	**9.525**	**11.088**	**7.762**	**9.425**
T_3 10 Months	**Direct** stakes	9.633	8.467	9.050	10.000	7.400	8.700
	Storage stakes	9.267	8.400	8.834	9.667	7.200	8.434
Mean		**9.450**	**8.433**	**8.942**	**9.833**	**7.300**	**8.567**
T × M	**Direct** stakes	9.667	8.533	9.100	10.292	7.419	8.856
	Storage stakes	9.444	8.344	8.894	9.567	7.100	8.334
General Mean		**9.569**	**8.440**	**9.005**	**9.941**	**7.254**	**8.598**
F test and LSD 0.05		**F test**		**LSD 0.05**	**F test**		**LSD 0.05**
(D) Planting date		**		-	**		-
(M) Planting methods		**		-	**		-
(T) Harvesting time		**		0.278	**		0.280
D × M		n.s		-	**		0.391
D × T		**		0.393	**		0.396
M × T		n.s		-	**		0.396
D × T × M		**		0.556	*		0.561

Where ns., * and ** were non-significant and significant at 5 and 1% levels of probability, respectively.

Also, the data presented in the same previous table show that the plants which were cultivated with direct and storage stakes for 15 days varied highly significantly in both seasons. The cultivation with direct stakes provided the highest number of tubers per plant (9.100 and 8.856 in the first and second seasons respectively). This may be caused by the direct stakes being ready to grow rather than storage stakes which help the farmers to save the costs of storage of the stakes and consequently enhance the net return. Concerning the interactions involved in this respect, data presented in Table 2 focus that all first and second interactions had a significant or highly significant effect on tubers number per plant in both seasons except the interaction between planting date D × planting method M and planting method M × harvesting time T in the first season. Thus, the highest average values of tubers number per plant (10.267 and 11.643 in the two respective seasons) were obtained from cassava plants which were cultivated using direct stakes on 1st of April and harvested after 9 months from planting.

2-Average tuber diameter (cm)

The illustrated data in Table 3 show that the tested planting dates had a significant effect on the tuber diameter of cassava in the two growing seasons. Cassava plants that were planted on April 1st gave the highest tuber diameter (3.909 and 3.887 cm in the first and second seasons, respectively). This may be due to the appropriate environmental conditions prevailing at the first planting date, which were more encouraging the cell deviation and the fullness of the tubers which reflected on the tuber's diameter compared to April 15.

Here too, the data shown in Table 3 reveal that the tested harvest time had a highly significant effect on the diameter of cassava tubers in both seasons. Thus, cassava tuber diameters after 9 months exceeded the other harvest time and produced maximum mean values (3.871 and 3.883 cm in the two seasons, respectively). These results may be because the harvest date, 9 months after planting, was later than the other harvest date (8 months). This may be due to the increase in synthetic products as a result of increasing the age from 8 to 9 months, which led to the tubers storing nutrients and thus increasing the diameter of the tubers in the plant, as the age exceeded 9 months, especially with the prevention of irrigation, which led to some tubers losing their moisture, which led to a decrease in their number after that (at 10 months). Similar findings were detected by Lilian *et al* (2019) and Samidjo (2020).

Also, the data presented in the same previous table shows that the tuber diameter trait varied significantly between cassava plants grown by direct stakes and stored for 15 days in both seasons. Direct stakes cultivation gave the highest diameter of tuber (3.783 and 3.723 cm in the first and second seasons, respectively) as compared with indirect planting (stored for 15 days before planting). This may be because direct stakes were ready for growth instead of storage stakes, which helps farmers save on the costs of storing stakes and thus enhances the net yield.

Regarding the interactions involved in this respect, the illustrated data in Table 3 indicated that all of the first and second interactions had a significant or

highly significant effect on the diameter of the cassava tubers in both seasons, except the interaction between planting date D × planting method M and Planting method M × harvest time T in the second season. Thus, the highest average values of tuber diameter per plant (4.087 and 4.213 in the two seasons, respectively) were obtained from cassava plants that were planted using direct stakes s on April 1st and harvested after 9 months after planting.

Table 3. Means of tuber diameter (cm) as affected by planting date (D), harvesting time (T) and planting methods (M) as well as their interactions in 2021/2022 and 2022/2023, seasons

Seasons		2021/2022			2022/2023		
Harvesting time (T)	Planting methods (M)	Planting date (D) D_1 1st April	Planting date (D) D_2 15th April	Mean	Planting date (D) D_1 1st April	Planting date (D) D_2 15th April	Mean
T_1 8 Months	**Direct** stakes	3.810	3.530	3.670	3.712	3.340	3.526
	Storage stakes	3.763	3.423	3.593	3.683	3.193	3.438
Mean		**3.787**	**3.477**	**3.632**	**3.697**	**3.266**	**3.482**
T_2 9 Months	**Direct** stakes	4.087	3.727	3.907	4.213	3.662	3.937
	Storage stakes	4.000	3.670	3.835	4.051	3.606	3.828
Mean		**4.043**	**3.698**	**3.871**	**4.132**	**3.634**	**3.883**
T_3 10 Months	**Direct** stakes	3.920	3.627	3.773	3.884	3.529	3.707
	Storage stakes	3.873	3.617	3.745	3.777	3.458	3.618
Mean		**3.897**	**3.622**	**3.759**	**3.831**	**3.493**	**3.662**
T × M	**Direct** stakes	3.939	3.628	3.783	3.936	3.510	3.723
	Storage stakes	3.879	3.570	3.724	3.837	3.419	3.628
General Mean		**3.909**	**3.599**	**3.754**	**3.887**	**3.464**	**3.676**
F test and LSD 0.05		**F test**		**LSD 0.05**	**F test**		**LSD 0.05**
(D) Planting date		**		-	**		-
(M) Planting methods		**		-	**		-
(T) Harvesting time		**		0.019	**		0.041
D × M		*		0.031	n.s		-
D × T		**		0.027	**		0.059
M × T		**		0.027	n.s		-
D × T × M		**		0.071	**		0.083

Where n.s., * and ** were non-significant and significant at 5 and 1% level of probability, respectively.

3-Average tubers length (cm)

Data in Table 4 cleared that, the tested planting dates had a highly significant ($P \leq 0.01$) effect on the tuber length in both seasons. Cassava plants that were planted on the first of April gave the highest length of tuber (39.45 and 40.47 cm in the first and the second seasons respectively) as compared to the 15th of April in both seasons. This may be due to the suitable environmental conditions prevailing at the first planting date which were more encourage the cell elongation of cassava tubers as compared with the late one.

Furthermore, illustrated data in Table 4 reveal that, the testing harvest time had a highly significant effect on the cassava tuber length in both seasons thus, cassava tuber length in plants that were harvested after 9 months from planting exceeded the other tested harvesting time and produced maximum mean values (38.82 and 39.95cm in the two respective seasons). These results may be because the harvest date, 9 months after planting, was later than the other harvest date (8

months) and gave a chance for cassava plants to store and transfer the photosynthesis products to tuber and enhancement cell elongation and division which led to an increase in tuber length than other tested harvesting time. These results are in harmony with those obtained by Lilian *et al* (2019) and Samidjo (2020).

Table 4. Means of tuber length (cm) as affected by planting date (D), harvesting time (T) and planting methods (M) as well as their interactions in 2021/2022 and 2022/2023, seasons

Seasons		2021/2022			2022/2023		
Harvesting time (T)	Planting methods (M)	Planting date (D)		Mean	Planting date (D)		Mean
		D_1 1st April	D_2 15th April		D_1 1st April	D_2 15th April	
T_1 8 Months	**Direct** stakes	38.41	34.00	36.21	39.05	35.10	37.08
	Storage stakes	37.27	33.18	35.23	38.27	34.04	36.16
Mean		**37.84**	**33.59**	**35.72**	**38.66**	**34.57**	**36.62**
T_2 9 Months	**Direct** stakes	42.03	36.62	39.33	43.69	37.47	40.58
	Storage stakes	40.48	36.13	38.31	41.77	36.87	39.32
Mean		**41.26**	**36.38**	**38.82**	**42.73**	**37.17**	**39.95**
T_3 10 Months	**Direct** stakes	39.58	35.79	37.69	40.18	36.13	38.16
	Storage stakes	38.76	34.98	36.87	39.45	35.72	37.59
Mean		**39.17**	**35.39**	**37.28**	**39.82**	**35.93**	**37.88**
T × M	**Direct** stakes	40.01	35.47	37.74	40.98	36.23	38.61
	Storage stakes	38.84	34.77	36.81	39.83	35.54	37.69
General Mean		**39.45**	**35.09**	**37.27**	**40.47**	**35.88**	**38.18**
F test and LSD 0.05		**F test**		**LSD 0.05**	**F test**		**LSD 0.05**
(D) Planting date		**		-	**		-
(M) Planting methods		**		-	**		-
(T) Harvesting time		**		1.082	**		1.272
D × M		*		0.962	n.s		-
D × T		**		1.530	**		1.799
M × T		n.s		-	n.s		-
D × T × M		n.s		-	*		2.123

Also, the presented data in the same previous table show that the plants that were cultivated with direct and storage stakes for 15 days varied highly significantly in tuber length trait in both seasons. The cultivation with direct stakes gave the highest length of tubers (37.74 and 38.61 cm in the first and second seasons respectively). This may be due to the direct stakes being ready to grow rather than storage stakes which led to an increase in the elongation and division of cassava cells and consequently encouraged tuber length.

Regarding the interactions involved in this respect, the presented data in Table 4 focuses that all the first and second interactions had a significant or highly significant effect on the length of tubers in both seasons except the interaction between planting date D × planting method M in the second season, planting method M × harvest time T in both seasons and the second order interaction in the first season. Whatever, the highest average values for the tuber length trait (42.03 and 43.69 cm in the two seasons, respectively) were obtained from cassava plants that were planted using direct stakes on April 1st and harvested 9 months after planting.

4-Average tuber weight (g)

Illustrated data in Table 5 reveal that the average tuber weight was affected significantly by the tested planting dates in both seasons. Cassava plants which were planted on the first of April gave the highest weight per tuber (404.7 and 383.1g in the two respective seasons) compared to April 15 in both seasons. This is to be expected since the same trend was observed regarding tuber diameter and tuber length traits (Tables 3 and 4).

Furthermore, the data shown in Table 5 reveal that the harvest time test had a highly significant effect on average tuber weight in both seasons. Thus, the average tuber weight that was harvested after 9 months from planting exceeded the other studied harvesting time and produced the maximum average values in this respect (400.3 and 375.9 g in the two respective seasons). This is to be logical since the same obtained were detected from the same harvesting time about tuber diameter and length (Tables 3 and 4). These findings are in harmony with those obtained by Lilian *et al* (2019) and Samidjo (2020).

Table 5. Means of tuber weight (g) as affected by planting date (D), harvesting time (T) and planting methods (M) as well as their interactions in 2021/2022 and 2022/2023, seasons.

Seasons		2021/2022			2022/2023		
Harvesting time (T)	Planting methods (M)	Planting date (D)		Mean	Planting date (D)		Mean
		D_1 1st April	D_2 15th April		D_1 1st April	D_2 15th April	
T_1 8 Months	**Direct** stakes	377.5	322.4	350.0	367.0	297.5	332.3
	Storage stakes	360.0	315.2	337.6	356.8	255.9	306.4
Mean		**368.7**	**318.8**	**343.8**	**361.9**	**276.7**	**319.3**
T_2 9 Months	**Direct** stakes	455.9	354.4	405.2	415.4	350.3	382.9
	Storage stakes	442.1	348.5	395.3	394.6	343.0	368.8
Mean		**449.0**	**351.5**	**400.3**	**405.0**	**346.7**	**375.9**
T_3 10 Months	**Direct** stakes	396.9	337.5	367.2	386.8	330.0	358.4
	Storage stakes	387.4	332.0	359.7	377.7	315.8	346.8
Mean		**392.2**	**334.8**	**363.5**	**382.2**	**322.9**	**352.6**
T × M	**Direct** stakes	410.1	338.1	374.1	389.7	325.9	357.8
	Storage stakes	396.5	331.9	364.2	376.3	304.9	340.6
General Mean		**404.7**	**335.0**	**369.9**	**383.1**	**314.5**	**348.8**
F test and LSD 0.05		**F test**		**LSD 0.05**	**F test**		**LSD 0.05**
(D) Planting date		**		-	**		-
(M) Planting methods		**		-	**		-
(T) Harvesting time		**		10.38	**		12.67
D × M		n.s		-	**		14.25
D × T		**		14.69	**		17.92
M × T		**		14.69	**		17.92
D × T × M		n.s		-	**		25.34

Where n.s., * and ** were non-significant and significant at 5 and 1% level of probability, respectively.

Here too, the presented data in the same previous table also showed that the plants grown by direct stakes and stored for 15 days differed significantly in both seasons. Direct stakes cultivation gave the highest weight of single tuber (374.1 and 357.8 g in the first and second seasons, respectively). This is to be expected

since the same trend was obtained about tuber diameter and length (Tables 3 and 4) which are considered the main contributors in weight.

Concerning the interactions involved in this respect, the illustrated data in Table 5 indicated that all interactions had a significant or highly significant effect on the average tuber weight in both seasons, except the interaction between planting date D × planting method M, and the second order interaction in the first season (D × M × T). Thus, the highest average values for average tuber weight (455.9 and 415.4 g in the two seasons, respectively) were obtained from cassava plants that were planted using direct stakes on April 1st and harvested after 9 months.

5-Tubers' weight/plant (kg)

It's clear from the illustrated data in Table 6 that the studied planting dates had a significant effect on the weight of tubers per plant in the two growing seasons. Cassava plants which were planted on April 1st gave the highest weight of tubers per plant (3.558 and 2.704 kg in the two respective seasons) as compared to the April 15 planting date. This is to be logical since the same planting time produced the maximum average values of the number of tubers /plant and average tuber weight (Tables 2 and 5) as mentioned before which the main consist of tubers weight /plant.

Table 6. Means of tubers weight /plant (kg) as affected by planting date (D), harvesting time (T) and planting methods (M) as well as their interactions in 2021/2022 and 2022/2023, seasons

Seasons		2021/2022			2022/2023		
Harvesting time (T)	Planting methods (M)	Planting date (D) D_1 1st April	Planting date (D) D_2 15th April	Mean	Planting date (D) D_1 1st April	Planting date (D) D_2 15th April	Mean
T_1 8 Months	**Direct** stakes	3.391	2.635	3.013	2.544	2.158	2.351
	Storage stakes	3.342	2.480	2.911	2.387	2.053	2.220
Mean		**3.367**	**2.558**	**2.963**	**2.465**	**2.106**	**2.286**
T_2 9 Months	**Direct** stakes	3.887	3.302	3.595	3.127	2.327	2.727
	Storage stakes	3.719	3.221	3.470	2.798	2.306	2.552
Mean		**3.803**	**3.262**	**3.533**	**2.963**	**2.317**	**2.640**
T_3 10 Months	**Direct** stakes	3.507	3.192	3.350	2.721	2.255	2.488
	Storage stakes	3.449	3.140	3.295	2.629	2.211	2.420
Mean		**3.478**	**3.166**	**3.322**	**2.675**	**2.233**	**2.454**
T × M	**Direct** stakes	3.595	3.043	3.319	2.797	2.247	2.522
	Storage stakes	3.503	2.947	3.225	2.605	2.190	2.398
General Mean		**3.558**	**2.974**	**3.266**	**2.704**	**2.217**	**2.461**
F test and LSD 0.05		**F test**		**LSD 0.05**	**F test**		**LSD 0.05**
(D) Planting date		**		-	**		-
(M)Planting methods		**		-	**		-
(T) Harvesting time		**		0.061	**		0.113
D × M		n.s		-	**		0.283
D × T		**		0.086	**		0.159
M × T		*		0.086	**		0.159
D × T × M		**		0.121	**		0.227

Where n.s., * and ** were non-significant and significant at 5 and 1% level of probability, respectively.

Furthermore, illustrated data in Table 6 reveal that the testing harvest time had a highly significant effect on the cassava tubers weight per plant in both seasons. Thus, the collecting cassava tuber's weight after 9 months surpassed the other harvest time and produced the maximum average values (3.533 and 2.640 kg in both respective seasons). These results are predictable since the same planting time produced the maximum average values of the number of tubers /plant and average tuber weight (Tables 2 and 5) as mentioned before which the main consist of tubers weight /plant. These results are in good line with those obtained by Lilian *et al* (2019) and Enesi *et al*. (2022).

The data existing in the same previous table also show that the cassava plants grown by direct stakes and stored for 15 days differed significantly in both seasons. Direct stakes cultivation gave the highest weight of tubers per plant (3.319 and 2.522 kg in the first and second seasons, respectively). These results are likely since the same planting type (direct) produced the maximum average values of the number of tubers /plant-and single tuber weight traits (Tables 2 and 5) as mentioned before which the main consist of tubers weight /plant.

Concerning the interactions involved in this respect, data presented in Table 6 focus that all first and second interactions had a significant or highly significant effect on tubers number per plant in both seasons except the interaction between planting date D × planting method M (D × M) in the first season. Hence, the highest average values of tubers weight/plant (3.887 and 3.127 kg in the two respective seasons) were achieved from cassava plants which were cultivated using direct stakes on the 1st of April and harvested after 9 months from planting.

6-Tubers yield (ton/ feddan)

Illustrated data in Table 7 show that the tested planting dates had a significant impact on the tuber yield in tons in the two growing seasons. Cassava plants which were planted on April 1st gave the highest tubers yield (7.796 and 7.117 tons / fed. in the first and second seasons, respectively) compared to April 15 in both seasons. This is logical since the same planting date produced the maximum mean values of tubers weight /plant which is considered the chief consist of tuber yield /fed.

Moreover, the data shown in Table 7 show that the testing harvest time had a highly significant impact on tuber yield /fed in both seasons. Thus, the tuber yield of cassava after 9 months surpassed the other studied harvest time and produced the maximum average values in this respect (7.683 and 7.026 tons /fed in the two respective seasons. This is to be expected since the same harvest time produced the maximum mean values of tubers weight /plant which painstakingly the main consists of tuber yield /fed. A similar trend was obtained by Ngeve (2003) and Lilian *et al* (2019).

Also, the presented data in the same previous table show that the plants grown by direct stakes and stored for 15 days differed significantly in this respect in both seasons. Direct stakes cultivation gave the highest amount of total tuber yield /fed (7.216 and 6.718 tons in the first and second seasons, respectively). This is to be logical since the same planting method produced the maximum mean

values of tubers weight /plant which is considered the main consist of tuber yield /fed.

Table 7. Means of tubers yield (ton/fed) as affected by planting date (D), harvesting time (T) and planting methods (M) as well as their interactions in 2021/2022 and 2022/2023, seasons

Seasons		2021/2022			2022/2023		
Harvesting time (T)	Planting methods (M)	Planting date (D) D_1 1st April	D_2 15th April	Mean	Planting date (D) D_1 1st April	D_2 15th April	Mean
T_1 8 Months	**Direct** stakes	7.317	5.887	6.602	6.760	5.983	6.372
	Storage stakes	7.233	4.700	5.967	6.573	5.503	6.038
Mean		**7.275**	**5.293**	**6.284**	**6.667**	**5.743**	**6.205**
T_2 9 Months	**Direct** stakes	8.483	7.117	7.800	7.963	6.410	7.187
	Storage stakes	8.167	6.963	7.565	7.360	6.370	6.865
Mean		**8.325**	**7.040**	**7.683**	**7.662**	**6.390**	**7.026**
T_3 10 Months	**Direct** stakes	7.907	6.587	7.247	7.050	6.140	6.595
	Storage stakes	7.663	6.210	6.937	6.903	6.057	6.480
Mean		**7.785**	**6.398**	**7.092**	**6.977**	**6.098**	**6.538**
T × M	**Direct** stakes	7.902	6.530	7.216	7.258	6.178	6.718
	Storage stakes	7.688	5.958	6.823	6.946	5.977	6.462
General Mean		**7.796**	**6.225**	**7.011**	**7.117**	**6.075**	**6.596**

F test and LSD 0.05	F test	LSD 0.05	F test	LSD 0.05
(D) Planting date	**	-	**	-
(M) Planting methods	**	-	**	-
(T)Harvesting time	**	0.138	**	0.152
D × M	**	0.143	n.s	-
D × T	**	0.195	**	0.214
M × T	**	0.195	*	0.214
D × T × M	**	0.275	**	0.303

Where n.s., * and ** were non-significant and significant at 5 and 1% level of probability, respectively.

Conclusion

Concerning the interactions involved in this trait, the illustrated data in Table 7 indicated that all of the first and second interactions had a significant or highly significant effect on the tuber yield /fed in both seasons, except the interaction between planting date × planting method (D × M) in the second season. Thus, the highest average values of tuber yield /fed (8.483 and 7.963 tons in the two seasons, respectively) were obtained from cassava plants that were planted using direct stakes on April 1st and harvested after 9 months from planting.

Conclusion

From this study it is clear that, Cassava crops can be cultivated under Assiut conditions easily and get a high yield by planting it with direct stakes on the first of April and harvesting the tubers after 9 months.

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استجابة محصول درنات الكسافا ومكوناته لمعاملات زراعية مختلفة

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الملخص

أجريت هذه الدراسة في مزرعة قسم الخضر البحثية بكلية الزراعة- جامعة أسيوط - مصر. وكانت مواعيد الزراعة فى1 و15 إبريل خلال الموسم الصيفي في الاعوام 2021 /2022 و2023/2022 على التوالي حيث يمثل كل موعد زراعة تجربة منفصلة. ونفذت التجربة البحثية بتصميم القطاعات كاملة العشوائية (RCBD) باستخدام ترتيب القطع المنشقة مرة واحدة في ثلاث مكررات. حيث وضع موعد الحصاد (8، 9، 10 أشهر من الزراعة) في القطع الرئيسية وطريقة الزراعة (الزراعة بالعقل مباشرة او العقل المخزنة لمدة 15 يوم تحت الارض) في القطع الشقية. أظهرت النتائج المتحصل عليها أن جميع التفاعلات من الدرجة الأولى والثانية كان لها تأثير معنوي أو عالي المعنوية على إنتاجية الفدان من الدرنات في كلا موسمي الدراسة، باستثناء التداخل بين موعد الزراعة وطريقة الزراعة في الموسم الثاني فقط. وهكذا، وقد تم الحصول على أعلى قيم لمتوسط إنتاج الدرنات للفدان (8.483 و7.963 طن في الموسمين الأول والثاني على التوالي) من نباتات الكسافا التي تمت زراعتها باستخدام العقل المباشرة في 1 أبريل وحصادها بعد 9 أشهر من الزراعة تحت ظروف أسيوط.