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IMPACT OF PLANTING DATES OF CASSAVA INTERCROPPED WITH DIFFERENT SESAME DENSITIES ON BOTH CROPS IN NEW RECLAIMED LAND

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ABSTRACT

A field study was conducted at the Ismailia Agricultural Research Station, Egypt, during the 2023/2024 and 2024/2025 growing seasons to investigate the effect of cassava planting dates and sesame planting densities on the yield and yield components of both crops. The experiment was laid out in a split-plot design with three replications. The main plots were assigned to cassava planting dates (March 1st [D1], March 15th [D2], and April 1st [D3]), while the sub-plots were allocated to sesame planting densities (31.2%, 62.5%, and 93.7% of its pure stand). The results revealed that planting cassava on April 1st (D3) resulted in the highest values for plant height, tuber length and diameter, number and weight of tubers per plant, and tuber yield per feddan. Intercropping one row of sesame (S1) significantly improved all cassava traits compared to intercropping three rows of sesame (S3).The interaction between cassava planting dates and sesame planting densities significantly affected all cassava characteristics. Intercropping one row of sesame with cassava planted on April 1st (D3S1) produced the highest values for all cassava traits, except for plant height. Cassava planting dates had no significant effect on the yield and yield components of sesame. However, sesame planting densities significantly affected sesame yield and its components. Although intercropping three rows of sesame across all cassava planting dates resulted in the lowest values for yield components, treatments D1S3 and D2S3 recorded the highest seed yield (kg/fed).The Land Equivalent Ratio (LER) and percentage increase in net revenue for the D3S3 treatment surpassed all other intercropping combinations in both growing seasons.

INTRODUCTION

Cassava (Manihot esculenta Crantz) is one of the most important sources of dietary energy in several tropical countries **(Alves, 2002)**. It is widely cultivated as an annual crop throughout much of tropical Africa. Cassava is rich in carbohydrates, vitamins B and C, calcium, and essential minerals **(MoC, 2014)**, and is commonly consumed in the form of flour **(Patil et al., 2015).**The crop is relatively easy to cultivate for household consumption due to its low labor requirements, even in soils with low fertility and under unfavorable climatic conditions **(Onubuogu et al., 2014).** Introducing cassava as a new crop in newly reclaimed lands in Egypt is feasible, as it demonstrates strong adaptability to extreme heat, drought, and repeated high-temperature events during the summer season. Cassava performance is influenced by various environmental factors, including temperature, rainfall, soil moisture **(Aina et al., 2007),** and nutrient availability. In response to fluctuations in precipitation and soil moisture during its growth cycle, cassava exhibits adaptive mechanisms such as reduced leaf canopy and stomatal closure **(Santisopasri et al.,**

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2001). According to **Ologunde et al. (2023),** cassava was planted in April, June, and August, and harvested at 9, 11, and 13 months after planting. The study found that cassava varieties responded differently to the planting dates.

Likewise, sesame *(Sesamum indicum L.*) is a major oilseed crop, and its oil has high commercial value due to its palatable quality and medicinal properties. However, the slow growth in national oilseed production—mainly due to the limited area cultivated with oil crops—has not kept pace with the increasing demand in Egypt. Therefore, intercropping oilseed crops is considered one of the most effective strategies to expand the cultivated area of these crops and reduce the gap between production and consumption **(Mourad and El-Mehy, 2021).** Sesame performance is significantly influenced by plant density. According to **El-Shamy, Moshira et al. (2021),** plant density had a highly significant effect on plant height, number of capsules per plant, seed index, and seed yield per plant. However, it had no significant effect on the number of branches per plant during the two growing seasons.

Cassava, a wide-spaced and long-duration crop, is often intercropped with short-duration crops such as cereals **(Nwokoro, 2021),** legumes **(Nyi et al., 2014; Legodi and Ogola, 2019; Kando and Bitane, 2023**), and oilseeds (**Idoko et al., 2018)** to enhance the efficient use of environmental resources, including light, water, land, and nutrients. Therefore, intercropping short-duration crops such as sesame with cassava can be proposed as a strategy to optimize resource use, reduce production inputs, and improve total productivity and profitability in reclaimed soils. Furthermore, intercropping sesame with other crops has been shown to improve land equivalent ratio **(El-Karamity et al., 2020)**, increase farm income **(Afe, 2017; Mandal and Chhetri, 2019)**, and reduce the risk of crop failure **(Ram, 2020).** Cassava and sesame are also considered compatible companion crops, contributing to weed suppression **(Ijoyah et al., 2015).** Therefore, this study was conducted to determine the optimal planting dates for cassava and the appropriate sesame planting densities in an intercropping system that would maximize the productivity of both crops and enhance farm income.

MATERIAL AND METHODS

A field study was conducted at the Ismailia Agricultural Research Station, Agricultural Research Center (ARC), Ismailia Governorate, Egypt, during the 2023 and 2024 growing seasons. The objective was to evaluate the effect of three cassava planting dates and three sesame planting densities, intercropped with cassava, on the yield and yield components of both crops.

The preceding crop in both seasons was Egyptian clover (*Trifolium alexandrinum* L., multi-cut variety). The soil at the experimental site is sandy. Its physical and chemical properties (0–30 cm depth) were analyzed by the Water and Soil Research Institute, ARC, and are presented in Table 1.

The average monthly weather data at the experimental site during both growing seasons are presented in Table 2 (https://power.larc.nasa.gov/data-access-viewer/site).

The experiment was conducted using a split-plot design with three replications. The main plots were assigned to cassava planting dates, while the subplots were allocated to sesame planting densities intercropped with cassava.

Experimental treatments were as follow:

Table 1. Selected physical and chemical properties of the experimental soil during the 2022/2023 and 2023/2024 seasons

Season	Physical analysis				Chemical properties			
	Sand%	Silt%	Clay%	Texture	PH	EC dsm^{-1}	OM %	Ca CO_3 %
2023	94.10	2.40	3.50	Sandy	7.85	0.95	0.43	1.95
2024	92.15	3.50	4.35		7.90	1.05	0.52	2.13
Season	**Soluble cations (mmolic l^{-1})**				**Soluble anions (mmolic l^{-1})**			
	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	CO_3^{2-}	HCO_3^{-}	Cl-	SO_4^{2-}
2023	4.30	1.85	2.45	0.95	-	2.20	2.60	4.75
2024	4.35	1.95	2.50	1.63	-	2.30	2.75	5.38

Table 2. Average monthly weather data at the experimental site during the 2023 and 2024 seasons

	T_{Max} (°C)	T_{Min} (°C)	RH (%)	Rain (mm/ day)	WS (m/s)	T_{Max} (°C)	T_{Min} (°C)	RH (%)	Rain (mm/ day)	WS (m/s)
	2022/2023 season					2023/2024 season				
Mar.	20.2	7.81	61.94	0.65	3.12	25.42	11.68	53.44	0.41	2.87
Apr.	29.47	13.65	51.84	0.00	3.22	28.82	13.71	51.22	0.40	3.03
May	31.9	16.55	48.41	0.00	3.3	32.03	17.11	51.8	0.07	3.29
Jun.	36.04	20.81	50.28	0.00	2.94	35.82	20.77	49.02	0.04	3.30
Jul.	37.09	21.96	49.76	0.01	2.76	39.02	22.96	49.15	0.00	300
Aug.	37.1	23.41	53.1	0.09	3.05	37.67	23.32	53.9	0.0	3.07
Sep.	34.76	21.69	57.03	0.11	3.05	36.39	22.66	53.56	0.05	2.79
Oct.	30.03	18.87	62.1	0.34	2.55	31.33	20.24	63.19	0.30	2.51
Nov.	25.3	14.45	64.29	0.19	2.31	26.94	16.00	64.19	0.15	2.59
Dec.	22.53	11.54	69.25	0.84	2.21	22.87	12.29	69.07	0.45	2.47
Jan.	20.43	9.2	67.56	1.72	2.28	20.03	8.67	62.5	1.11	2.28
Feb.	18.59	7.17	69.04	0.51	2.69	20.54	8.61	68.27	0.32	2.51

T_{Max}= maximum temperature, T_{Min}= minimum temperature, RH =Relative humidity, WS = wind speed

I. Cassava planting dates (main plots):
D1: Planting cassava stakes on March 1st.,
D2: Planting cassava stakes on March 15th.
D3: Planting cassava stakes on April 1st.
Meanwhile, sesame was sown on April 1st in both seasons.

II. Sesame plant densities intercropped with cassava (subplots): S1: One row of sesame planted in the middle of the bed, with one plant per hill spaced 10 cm between hills, resulting in 26,250 plants/fed (equivalent to 31.25% of the sesame sole crop density), **S2:** Two rows of sesame planted; 60 cm spacing between cassava and sesame rows, and 40 cm spacing between sesame rows, with one plant per hill spaced 10 cm between hills, resulting in 52,500 plants/fed (equivalent to 62.50% of the sesame sole crop density) and **S3:** Three rows of sesame planted at 40 cm spacing between rows, with one plant per hill spaced 10 cm between hills, resulting in 78,750 plants/fed (equivalent to 93.75% of the sesame sole crop density). The subplot area consisted of 4 beds, each 1.6 m wide and 3 m long, totaling 19.2 m². Sole crops of cassava (4,200 plants/fed) and sesame (84,000 plants/fed) were also grown to assess competitive relationships and yield advantage.

Cassava stakes of cv. Misr 1 were provided by the Crop Intensification Research Department at Ismailia Agricultural Research Station, Agricultural Research Center, Egypt. Stalks of uniform thickness, approximately 2.5–3 cm in diameter, were cut into 30 cm long stakes, sharpened at one end, and planted vertically into the soil to a depth of two-thirds, leaving one-third above the ground. The stakes were irrigated immediately after planting. In the intercropping system, cassava was planted at one plant per hill on one side of the bed, with spacing of 1.6 m between rows and 0.65 m between plants within the row. Meanwhile, sesame cv. Shandaweel-3 was planted in the middle of the bed in one, two, or three rows, with plants spaced 10 cm apart within rows, and one plant per hill.

In the sole cropping system, cassava was planted at one plant per hill on one side of the bed, with spacing of 1 m between rows and 1 m between plants within the row. Meanwhile, sesame was planted in ridges with 50 cm spacing between rows and 10 cm between hills, with one plant per hill.

Phosphorus fertilizer was applied during soil preparation in the form of mono-calcium superphosphate (15.5% P_2O_5) at a rate of 400 kg/fed. Nitrogen fertilizer was applied as ammonium nitrate (33.5% N) at a rate of 150 kg N/fed, divided into five equal doses and applied once every two weeks. Potassium was supplied as potassium sulfate (50% K) at a rate of 200 kg/fed, divided into two equal doses: the first during soil preparation and the second after sesame harvesting.

Cassava tubers were harvested on January 3rd, 14th, and 28th in the first season, and on January 2nd, 17th, and February 1st in the second season. Sesame was harvested on July 12th and July 9th in the first and second seasons, respectively. All cultural practices were carried out according to the recommended guidelines for both crops.

Table 3. Harvest dates of cassava and sesame during the 2023 and 2024 seasons

	First season	**Second season**
Cassava harvest dates	February 3th	February 2th
	February 14th	February 17th
	February 28th	February 29 th
Sesame harvest dates	July 12th	July 9th

COLLECTED DATA

Growth and yield characters of both crops

1-Cassava:

At harvest time, ten plants were randomly selected to determine plant height (cm), number of tubers per plant, tuber length (cm), tuber diameter (cm), and tuber weight per plant (kg). Cassava yield was estimated from the entire plot (kg) and then converted to tons per feddan (ton/fed).

2- Sesame

Ten plants were randomly selected to determine plant height (cm), number of capsules per plant, 1000-seed weight (g), seed weight per plant (g), and oil percentage. Sesame yield was estimated from the plot and then converted to kg per feddan (kg/fed). The oil content was analyzed at the Central Laboratory of the Faculty of Agriculture, Zagazig University.

Competitive relationships and yield advantages

Land Equivalent Ratio (LER) is an index used to estimate the performance of intercropping systems (**Mead and Willey, 1980**), calculated as follows:

$$LER = Yab/Yaa + Yba/Ybb$$

Where, Yaa and Ybb are the solid crop yield of cassava and sesame respectively, while Yab and Yba are the intercrop yields of the same crops, respectively.

Aggressivity (A): It refers to the relative yield advantage of one intercropped species (crop a) over another (crop b), used to determine which of the two crops is more dominant in yield, according to McGilchrist (1965).

$$Aab = Yab/(Yaa\ x\ Zab) - Yba/(Ybb\ x\ Zba)$$

$$Aba = Yba/(Ybb\ x\ Zba) - Yab/(Yaa\ x\ Zab)$$

Where: Zab and Zba are the crop area ratio to cassava and sesame when intercropping respectively.

In all cases, the aggressivity values of the two crops are equal in magnitude but opposite in sign; the dominant crop has a positive value, while the dominated crop has a negative value. The larger the absolute value of aggressivity (A), the greater the difference in competitive abilities between the crops, reflecting a higher deviation between actual and expected yields.

Economic evaluation

Total return

Total return of intercropping = Yield of cassava x price + yield of sesame x price.

The market prices were used to represent the average prices of sesame while, international price were used to represent the average prices of cassava.

The average prices of cassava were 3,500 and 4,000 L.E. per ton, while the average prices of sesame were 29 and 100 L.E. per kg in the first and second seasons, respectively.

Net return = total return- costs

Statistical analysis

The MSTAT-C statistical package was used to analyze the variables by ANOVA (Freed, 1991). The Least Significant Difference (LSD) test was employed to compare treatment means at the 0.05 significance level, as described by Snedecor and Cochran (1980).

RESULTS AND DISCUSSION

First: cassava

1-Effect of cassava planting dates on cassava yield and its components :

Significant differences were observed among cassava planting dates for plant height, number of tubers per plant, tuber length, tuber diameter, tuber weight per plant, and tuber yield (ton/fed) in both seasons, as shown in Tables 4 and 5.

Planting cassava stakes on April 1st (D3) resulted in the highest values of plant height, number of tubers per plant, tuber length, tuber diameter, tuber weight per plant, and tuber yield per feddan in both seasons. On the other hand, planting cassava on March 1st (D1) produced the lowest values for all studied traits. Compared to the March 1st planting date (D1), the April 1st planting date (D3) increased cassava traits by 11.4% and 8.4% for plant height, 11.2% and 9.3% for tuber number per plant, 15.6% and 17.3% for tuber length, 23.3% and 19.1% for tuber diameter, 20.6% and 16.3% for tuber weight per plant, and 20.5% and 16.3% for tuber yield (ton/fed) in the first and second seasons, respectively.

The observed increases in cassava growth and yield from planting on April 1st may be attributed to cassava's preference for a warm, frost-free climate, with optimal growth temperatures ranging from 25 to 29 °C, as shown in Table 2. These findings are consistent with **Ibrahim *et al.* (2004),** who reported that cassava planted on April 15th had higher yield and yield components than those planted on May 1st, due to more favorable average temperatures, day-night temperature differences, and humidity levels impacting tuber yield. Differences in cassava traits among planting dates can also be explained by weather factors such as temperature and solar radiation during the growing period (**Phoncharoen et al., 2019).** The first of April was identified as the best planting date, as the climatic conditions during this period favor sprouting and root development (**Nassef et al., 2024**).

2- Effect of sesame plant density on cassava yield and its components:

The results presented in Tables 4 and 5 indicate that sesame plant density significantly affected all studied traits of cassava in both growing seasons. Intercropping with one row of sesame (S1) increased tuber number per plant, tuber length, tuber diameter, tuber weight per plant, and tuber yield (ton/fed) compared to intercropping with three rows of sesame (S3). On the other hand, intercropping with three rows of sesame resulted in the tallest cassava plants in both seasons. This increase in plant height may be attributed to intensified inter- and intra-specific competition for light and other essential growth resources. However, intercropping with three rows of sesame reduced cassava agronomic traits the most, followed by two rows (S2), compared to one row (S1) in both seasons. Intercropping with two or three rows of sesame significantly reduced tuber number per plant, tuber length, tuber diameter, tuber weight per plant, and tuber yield per feddan by (5.5% and 10.4%), (6.4% and 11.0%), (7.6% and 12.8%), (7.0% and 13.6%), and (7.0% and 13.6%), respectively, compared to intercropping with one row of sesame, averaged over the first and second seasons.

The reduction in cassava yield resulting from intercropping sesame may be attributed to the decrease in cassava yield component traits. These findings agree with those of **Muoneke and Mbah (2007),** who reported a decrease in the number and weight of marketable tubers per hectare as okra plant density increased from 14,000 to 56,000 plants/ha. Similarly, **Taah *et al.* (2017)** observed a decline in cassava storage tuber yield by 34.6% to 57.9% with increasing the number of cowpea rows intercropped with cassava from one to three rows. Conversely, Sherif and Salem (**2011**) found that higher fodder cowpea densities resulted in increased values for almost all cassava traits across two seasons.

3-Effect of the interaction between cassava planting dates and sesame plant density on cassava yield

The results presented in Tables 4 and 5 indicate that cassava traits were significantly affected by the interaction between cassava planting dates and sesame plant density, except for plant height in the second season. Intercropping three rows of sesame on April 1st resulted in the tallest cassava plants, whereas intercropping one row of sesame on March 1st produced the shortest plants during the first season. Intercropping one row of sesame with cassava planted on April 1st yielded the highest values for yield and its components, while intercropping three rows on March 1 st produced the lowest values. Specifically, intercropping one row of sesame with cassava planted on April 1st increased tuber number per plant, tuber length, tuber diameter, tuber weight per plant, and tuber yield per feddan by (18.3% and 19.4%), (30.3% and 34.0%), (44.6% and 32.9%), (34.3% and 34.0%), and (40.7% and 34.0%), respectively, compared to intercropping three rows on March 1st in the 2023 and 2024 seasons.

With respect to solid planting of cassava, the results in Table 3 show that plant height was shortest in solid planting compared to cassava intercropping, a trend observed in both seasons. The increase in plant height under intercropping with reduced plant spacing may be attributed to higher competition for light, which stimulates elongation of the internodes. Similar findings were reported by **Sherif and Salem (2011).** Regarding tuber characteristics, solid planting exhibited intermediate values for tuber number, length, and diameter compared to the different intercropping treatments (Tables 3 and 4). However, as shown in Table 5, tuber weight per plant and tuber yield per feddan were lower in intercropping systems compared to solid cassava planting. This reduction may be explained by lower cassava plant density per unit area, competition for nutrients, and shading effects in the intercropping system. These findings are consistent with **Shams (2011),** who reported that pure stand cassava had higher values for all studied traits compared to intercropped cassava. Similarly, **Idoko (2018)** found that sole cropping resulted in the highest plant height, number of leaves, number of branches, root diameter, and cassava root yield.

Second: sesame

Effect of cassava planting dates on sesame yield and its components:

The results in Tables 6 and 7 indicate that there were no significant differences among cassava planting dates in terms of sesame yield and its components. This may be attributed to the faster growth rate of sesame compared to cassava, as cassava is a long-duration crop that develops slowly during its early growth stages (**Nyi *et al*., 2014; Legodi and Ogola, 2019; Nwokoro, 2021; Kando and Bitane, 2023**). Sesame plants can complete their growth cycle before cassava forms a closed canopy, allowing for more efficient light utilization. These findings are consistent with those reported by **Nyi *et al.* (2014).**

Effect of sesame plant density on sesame yield and its components:

Plant density of sesame significantly affected sesame yield and its components, as shown in Tables 6 and 7. Intercropping one row of sesame (31.25% of its pure stand) resulted in the highest values of sesame yield components compared to intercropping three rows (93.75%). This may be attributed to the reduced interspecific competition among sesame plants at lower densities. These findings are consistent with those reported by **Rahnama and Bakhshandeh (2006) and El-Shamy, Moshira *et al.* (2021).** Additionally, the proximity of sesame roots to cassava plants in denser plantings likely increases competition between the two crops. Although sesame intercropped in three rows produced the lowest values for most yield components across all sowing dates, seed yield per feddan was highest due to the increased plant density.

This suggests that yield per area is governed more by plant density than by the yield per individual plant. These results agree with **Sherif and Salem (2011**), who found that increasing cowpea plant density in intercropping with cassava gradually increased the cowpea forage yield. Similarly, intercropping maize with cassava at high density (40,000 plants ha^{-1}) increased grain yield by 11% over two years compared to a lower maize density (20,000 plants ha^{-1}) (**Nwokoro, 2021).**

Effect of the interaction between cassava planting dates and sesame plant density on sesame yield

The interaction between cassava planting dates and sesame plant densities significantly affected all sesame traits except for 1000-seed weight, seed yield per feddan, and oil percentage, as shown in Tables 6 and 7 for both seasons. Intercropping one row of sesame (31.25% of the solid planting density) on March 15 th produced the tallest plants in both seasons. Similarly, intercropping one row of sesame on March 15 th and April 1st resulted in the highest values of 1000-seed weight and seed yield per plant. On the other hand, intercropping one row of sesame on March 1^{st} and April 1^{st} gave the highest number of capsules per plant in the first and second seasons, respectively. Although intercropping three rows of sesame at all cassava planting dates resulted in the lowest values for most yield components, intercropping three rows on March 1^{st} and 15^{th} produced the highest seed yield (kg/fed).

Regarding sole planting of sesame, the shortest plants were observed in sole sesame crops compared to intercropped sesame, which may be attributed to the absence of shading effects caused by cassava plants. Similarly, the number of capsules per plant, 1000-seed weight, and seed weight per plant were lower in sole sesame than in intercropping systems. This reduction in yield components in sole sesame may be primarily due to increased intra-specific competition among sesame plants for growth resources such as light, water, nutrients, and air. Moreover, sesame plants complete their growth cycle before the cassava canopy closes, allowing for more efficient light utilization in intercropping. However, sole cropping recorded the highest seed yield per feddan and oil percentage, mainly due to the higher plant density in sole sesame compared to intercropping systems. These findings are consistent with **Adekunle *et al.* (2014**), who reported significantly ($P < 0.01$) higher seed yields in sole sesame than in sesame intercropped with cassava in the late season. Similarly, **Idoko *et al.* (2018)** found that sole cropping produced significantly higher sesame grain yields than intercropping.

The third: competitive relationships and advantages:

1-Land equivalent ratio (LER):

The results in Table 8 clearly show that the average values of the Land Equivalent Ratios (LER) for all treatments were greater than 1.0, indicating that intercropping provided advantages in land use efficiency. The results also revealed that the mean relative yield of cassava (Lc) was consistently higher than that of sesame (Ls), indicating that cassava is the more competitive crop in the system. These findings agree with those reported by **Muoneke and Mbah (2007) and Idoko *et al.* (2018).** However, increasing sesame plant density from 31.2% to 93.7% reduced the relative yield of cassava (Lc), due to the increased relative yield of sesame (Ls) in both seasons. Furthermore, delaying the cassava sowing date to April 1^{st} increased the relative yields of both cassava and sesame. The highest LER values were obtained from intercropping sesame in three rows (93% of sesame solid planting) with cassava planted on April 1^{st}, recording 1.79 and 1.69 in 2023 and 2024, respectively. This indicates that complementarity between the crops outweighed competition, resulting in 79% and 69% greater biological land-use efficiency. Conversely, the lowest LER values (1.25 and 1.17) were recorded when intercropping one row of sesame planted on March 1st. These results suggest that although intercropping may reduce cassava yield, the total yield of the intercrop system increases. These findings are in harmony with **Legodi and Ogola (2019),** who reported that relative sowing date significantly affects the relative yield of cassava and LER. Similarly, **Adekunle *et al.* (2014)** found that intercropping cassava varieties with sesame and sunflower in the late season resulted in high biological efficiency (LER > 1.00).

Aggressivity (A):

It is clear from the results in Table 8 that the aggressivity values of cassava were positive (+), whereas those of sesame were negative (−). This indicates that cassava was the dominant crop while sesame was the subordinate in all treatments across both seasons. These findings align with Mansaray et al. (2022), who reported that cassava has a higher competitive ability compared to legume crops. Furthermore, the aggressivity values of both crops varied depending on the cassava sowing date and sesame plant density. Aggressivity values gradually increased with higher sesame plant density and when cassava planting was delayed to April 1st. Conversely, the lowest aggressivity values were recorded with early cassava planting on March 1 st combined with low sesame density. Notably, the best cassava planting date (D3) exhibited the highest degree of competition between cassava and sesame for solar radiation, carbon dioxide, nutrients, and water. This suggests that cassava and sesame are partially complementary in resource acquisition. These results are consistent with those reported by Idoko et al. (2018).

Fourth: Economic evaluation

Total revenue, net revenue and increase % of net revenue:

Results in Table 9 show the total and net revenue of both crops, along with the percentage increase in net revenue compared to sole cassava, based on the average market and international prices over the two seasons. It is evident that delaying the planting date of cassava to mid-March and April 1 st outperformed the sole cassava cropping system. Planting cassava on April 1 st resulted in the highest total and net revenue, as well as the greatest percentage increase in net revenue compared to sole cassava, regardless of the sesame plant density intercropped with cassava. On the other hand, planting cassava on March 1 st resulted in the lowest total and net revenue values. Intercropping three rows of sesame with cassava produced the highest total revenue and percentage increase in net revenue. Specifically, intercropping three rows of sesame with cassava planted on April 1 st maximized total revenue and increased net revenue by 87.34% over sole cassava on average across the two seasons. The lowest total and net revenue were recorded when one row of sesame was intercropped with cassava planted on March 1 st; however, this treatment still increased net revenue by 19.24% compared to sole cassava. The increase in grower profits from intercropping cassava with sesame represents one of the greatest benefits of this system. These findings are in agreement with the results of **Nyi *et al.* (2014), Mansaray et al. (2022), and Kando and Bitane (2023).**

CONCLUSION

To optimize land use efficiency and maximize total income, it is recommended to plant cassava on April 1 st and intercrop it with sesame by planting three rows of sesame in the middle of the cassava bed. This planting strategy balances crop competition and complementarity, resulting in improved yield components and economic returns for both crops. Implementing this system in the Ismailia district can enhance resource utilization, reduce risk by diversifying production, and increase farmers' profitability. Additionally, this intercropping pattern can contribute to sustainable farming by optimizing water and nutrient use. Therefore, adopting this combination of planting date and sesame density is a promising approach for farmers aiming to achieve higher productivity and better economic outcomes in the region.

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APPENDIX

Table 4. Effect of cassava planting date, sesame plant density, and their interaction on cassava plant height, tuber number per plant, and tuber length during the 2023/2024 and 2024/2025 seasons

Trait		Plant height (cm)		Tuber No. / plant		Tuber length (cm)	
Treatment		2023/24	2024/25	2023/24	2024/25	2023/24	2024/25
planting date of cassava							
D1		154.00	161.77	13.82	13.64	21.07	19.80
D2		162.11	167.11	14.82	13.98	23.00	20.90
D3		171.66	175.33	15.37	14.91	24.36	23.23
LSD at 5%		4.07	2.96	0.70	0.24	0.31	0.32
Density of sesame							
S1		161.66	165.55	15.53	14.93	23.98	22.85
S2		161.55	168.44	14.64	14.15	22.68	21.15
S3		164.55	170.22	13.84	13.45	21.76	19.92
LSD at 5%		1.50	2.15	1.108	0.36	0.39	0.38
Interaction							
	S1	154.66	159.33	14.36	14.10	22.5	20.86
D1	S2	152.66	162.33	13.96	13.60	21.06	19.73
	S3	154.66	163.66	13.13	13.23	19.66	18.80
	S1	162.66	164.66	16.33	14.90	23.83	22.50
D2	S2	160.00	167.00	14.43	14.06	22.96	20.53
	S3	163.66	169.66	13.70	13.00	22.2	19.66
	S1	167.66	172.66	15.90	15.80	25.63	25.20
D3	S2	172.00	176.00	15.53	14.80	24.03	23.20
	S3	175.33	177.33	14.70	14.13	23.43	21.30
LSD at 5%		2.60	N.S	0.9	0.31	0.35	0.67
Pure stand		147.00	145.00	13.70	13.50	22.40	21.70

Table 5. Plant height, tuber number / plant and tuber length of cassava as affected by planting date of cassava and density of sesame and their interactions across 2023/2024 and 2024/2025 seasons.

Trait / Treatment		Tuber diameter (cm)		Tuber weight/plant (kg)		Tuber weight (ton/fed)	
		2023/24	2024/25	2023/24	2024/25	2023/24	2024/25
planting date of cassava							
D1		2.87	2.87	3.883	3.884	11.42	11.41
D2		3.35	3.15	4.472	4.290	13.14	12.60
D3		3.54	3.42	4.686	4.517	13.77	13.28
LSD at 5%		0.10	0.15	0.089	0.292	0.26	0.85
Density of sesame							
S1		3.54	3.33	4.671	4.541	13.72	13.34
S2		3.18	3.16	4.306	4.256	12.66	12.51
S3		3.04	2.95	4.064	3.894	11.95	11.44
LSD at 5%		0.13	0.16	0.147	0.143	0.43	0.42
Interaction							
	S1	3.23	3.03	4.380	4.136	12.87	12.15
D1	S2	2.80	2.86	3.793	3.890	11.15	11.43
	S3	2.60	2.73	3.476	3.626	10.24	10.65
	S1	3.63	3.33	4.730	4.626	13.9	13.59
D2	S2	3.30	3.16	4.493	4.313	13.20	12.67
	S3	3.13	2.96	4.193	3.930	12.32	11.55
	S1	3.76	3.63	4.903	4.860	14.41	14.28
D3	S2	3.46	3.46	4.633	4.566	13.62	13.43
	S3	3.40	3.16	4.523	4.126	13.29	12.12
LSD at 5%		0.12	0.15	0.12	0.16	0.33	0.60
Pure stand		3.40	3.50	4.52	4.62	14.28	14.76

Table 6. Plant height, capsules number/ plant and 1000- seed weight of sesame as affected by planting date of cassava and density of sesame and their interactions across 2023/2024 and 2024/2025 seasons.

Trait		Plant height (cm)		Capsules no./ plant		1000- seed weight	
Treatment		2023/24	2024/25	2023/24	2024/25	2023/24	2024/25
planting date of cassava							
D1		167.60	164.77	173.28	175.23	3.44	3.40
D2		168.20	164.91	171.00	174.00	3.45	3.40
D3		165.00	165.04	170.94	174.57	3.45	3.39
LSD at 5%		N.S	NS	N.S	N.S	N.S	N.S
Density of sesame							
S1		179.74	175.5	191.18	187.41	3.52	3.46
S2		167.09	164.36	172.72	179.16	3.46	3.39
S3		154.09	154.88	151.01	156.95	3.37	3.34
LSD at 5%		4.21	3.14	4.73	3.76	0.02	0.02
Interaction							
	S1	179.30	174.96	193.30	186.60	3.52	3.44
D1	S2	168.20	164.33	174.06	180.23	3.44	3.40
	S3	155.20	155.03	152.50	158.86	3.38	3.35
	S1	182.00	175.83	189.00	187.00	3.51	3.47
D2	S2	168.50	163.96	172.00	179.00	3.47	3.39
	S3	154.20	154.93	151.00	155.00	3.37	3.34
	S1	177.80	175.70	191.20	188.23	3.54	3.45
D3	S2	164.50	164.76	172.40	178.40	3.46	3.38
	S3	152.80	154.66	149.23	157.10	3.35	3.33
LSD at 5%		3.10	2.20	3.50	3.10	N.S	N.S
Pure stand		140.70	145.30	136.60	142.60	3.26	3.23

Table 7. Seed weight/plant, seed yield /fed and oil percentage of sesame as affected by planting date of cassava and density of sesame and their interactions across 2023/2024 and 2024/2025 seasons.

Trait / Treatment		Seed weight/plant (g)		Seed yield (kg/fed)		Seed oil content (%)	
		2023/24	2024/25	2023/24	2024/25	2023/24	2024/25
planting date of cassava							
D1		9.82	9.58	389.9	400.1	49.61	49.47
D2		9.78	9.65	388.1	402.0	49.83	49.36
D3		9.88	9.57	392.5	396.4	49.73	49.36
LSD at 5%		N.S	N.S	N.S	N.S	N.S	N.S
Density of sesame							
S1		10.56	10.28	221.5	228.8	48.15	48.46
S2		9.78	9.52	410.6	402.5	50.04	49.08
S3		9.14	9.01	538.4	567.2	50.97	50.65
LSD at 5%		0.28	0.16	9.94	9.20	0.51	0.41
Interaction							
	S1	10.46	10.23	219.8	227.6	47.93	48.53
D1	S2	9.76	9.43	409.6	400.0	49.9	49.13
	S3	9.23	9.10	540.4	572.8	51.00	50.76
	S1	10.66	10.30	224.8	228.8	48.23	48.40
D2	S2	9.66	9.63	405.6	408.4	50.16	49.06
	S3	9.03	9.03	534.0	568.8	51.10	50.63
	S1	10.56	10.33	220.0	230.0	48.30	48.46
D3	S2	9.93	9.50	416.8	399.2	50.06	49.06
	S3	9.16	8.90	540.8	560.0	50.83	50.56
LSD at 5%		0.22	0.18	N.S	N.S	N.S	N.S
Pure stand		9.3	9.1	621.6	638.4	51.7	51.5

Table 8. Land equivalent ratio (LER) and Aggressivity (Ag) as affected by sowing date of cassava and density of sesame and their interactions across 2023/2024 and 2024/2025 seasons.

		2023/2024 season					2024/2025 season				
		Land equivalent ratio			Aggressivity		Land equivalent ratio			Aggressivity	
		L c	L s	LER	Ag. c	Ag. s	L c	L s	LER	Ag. c	Ag. S
D1	S1	0.90	0.35	1.25	1.10	-1.10	0.82	0.35	1.17	0.94	-0.94
	S2	0.78	0.66	1.44	1.38	-1.38	0.77	0.62	1.40	1.41	-1.41
	S3	0.71	0.87	1.59	1.70	-1.70	0.72	0.89	1.61	1.69	-1.69
D2	S1	0.97	0.36	1.33	1.22	-1.22	0.92	0.35	1.27	1.13	-1.13
	S2	0.92	0.65	1.57	1.83	-1.83	0.85	0.63	1.49	1.65	-1.65
	S3	0.86	0.85	1.72	2.31	-2.31	0.78	0.89	1.67	1.94	-1.94
D3	S1	1.00	0.35	1.36	1.27	-1.27	0.96	0.35	1.32	1.22	-1.22
	S2	0.95	0.66	1.62	1.89	-1.89	0.90	0.62	1.53	1.83	-1.83
	S3	0.93	0.86	1.79	2.56	-2.56	0.82	0.87	1.69	2.12	-2.12

Table 9. Total, net revenue (L.E/fed) and increase % of net revenue as affected by sowing date of cassava and density of sesame and their interactions across 2023/2024 and 2024/2025 seasons.

		2023/2024 season			2024/2025 season			
		Total revenue	Total cost	net revenue	Total revenue	Total cost	net revenue	Average increase in the two seasons%
D1	S1	51450	19015	32435	77355	32900	44455	19.24
	S2	50960	19015	31945	91395	32900	58495	40.25
	S3	51695	19015	32680	105165	32900	72265	62.74
D2	S1	55206	19015	36191	83955	32900	51055	35.29
	S2	58030	19015	39015	97815	32900	64915	61.17
	S3	58695	19015	39680	108855	32900	75955	79.32
D3	S1	56840	19015	37825	87180	32900	54280	42.83
	S2	59815	19015	40800	100275	32900	67375	67.75
	S3	62265	19015	43250	110460	32900	77560	87.34
Pure Cassava		49980	19015	30965	66420	32900	33520	-

الملخص العربي

تأثير مواعيد زراعة الكسافا المحملة بكثافات مختلفة من السمسم على المحصولين بالأراضي المستصلحة حديثاً

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تم اجراء تجربة حقلية بمحطة البحوث الزراعية، محافظه الإسماعيلية، مصر خلال موسم ٢٠٢٤/٢٠٢٣ و٢٠٢٥/٢٠٢٤ لدراسة تأثير مواعيد زراعه الكسافا والكثافة النباتية لمحصول السمسم علي المحصول ومكوناته لكلا المحصولين. صممت التجربة فى قطع منشقه مره واحده فى ثلاث مكررات. القطع الرئيسية وزعت بها مواعيد زراعة نبات الكسافا (١مارس، ١٥ مارس, ١ ابريل)، بينما القطع المنشقة استقبلت الكثافة النباتية لمحصول السمسم (٣١,٢، ٦٢,٥، ٩٣,٧٪ من كثافة المحصول المنفرد) تم توزيعها فى صف وصفين و ٣ صفوف على ظهر مصطبة الكسافا على التوالي. أظهرت النتائج أن زراعة الكسافا أول أبريل (D3) كان له أعلى قيم لارتفاع النبات وطول الدرنة وقطرها وعدد الدرنات/نبات ووزن درنات/نبات ومحصول الدرنات/فدان. بينما أعطت الزراعة المبكرة للكسافا (D1) أقل القيم لجميع الصفات المدروسة. أدى تحميل صف واحد من السمسم إلى زيادة معنوية في عدد الدرنات/نبات وطول الدرنة وقطر الدرنة ووزن الدرنة/نبات ومحصول الدرنات (طن/فدان) مقارنة بتحميل ٣ صفوف من السمسم (S3). أثر التفاعل بين مواعيد زراعة الكسافا وكثافات نباتات السمسم بشكل كبير على جميع صفات الكسافا. حقق تحميل صف واحد من السمسم مع زراعة الكسافا في الأول من أبريل (D3 S1) أعلى القيم في جميع صفات الكسافا، باستثناء ارتفاع النبات، بينما حقق تحميل ٣ صفوف من السمسم مع زراعة الكسافا في الأول من مارس (D1 S3) أقل القيم. لم تؤثر مواعيد زراعة الكسافا معنوياً على محصول السمسم ومكوناته. ومع ذلك، أثرت كثافة نباتات السمسم معنوياً على محصول السمسم ومكوناته. بالرغم من أن مكونات محصول السمسم المحمل في ٣ صفوف كان له أقل القيم، إلا أن محصول البذور/فدان من السمسم أعطى أعلى محصول. على الرغم من ان تحميل ٣ صفوف من السمسم فى كل مواعيد زراعه الكسافا اعطى اقل القيم فى مكونات المحصول للسمسم ولكن تحميل ٣ سطور في الميعاد الاول والثانى اعطى أعلى محصول من السمسم للفدان. كذلك تحميل ٣ سطور من السمسم مع الكسافا المزروعة في ١ ابريل اعطى أعلى معدل لكفاءة استغلال الأرض ونسبة الزيادة فى صافى الدخل بالمقارنة بباقي المعاملات. على الرغم من ان الزراعة المنفردة للكسافا حققت أعلى محصول من الدرنات ١٤,٥ طن/للفدان، لكن تحميل ٣ سطور من السمسم مع الكسافا المنزرعة في ١ ابريل أعطى محصول إضافى من بذور السمسم ٥٥٠,٤ كجم /فدان وزيادة فى كفاءه استغلال الأرض بنسبة ٧٤٪ وأعلى نسبة زيادة فى صافى الدخل.

الكلمات الاسترشادية: كسافا، سمسم، مواعيد الزراعة، الكثافة النباتية، معدل كفاءة استغلال الأرض.

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