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EFFECT OF INTERCROPPING CASSAVA WITH SOME LEGUME CROPS ON GROWTH, YIELD AND YIELD COMPONENTS UNDER SANDY SOIL CONDITIONS

BY

Sahar A. Sherif,* and Safaa A. Mansour **

* Crop Intensification Res., Dept., Field Crops Res. Inst., Agric. Res. Cen., Giza, Egypt.

** Potato and Vegetative Propagated Vegetable Crops Res., Dept., Horticulture Res. Inst., Agric. Res. Cen., Giza, Egypt.

ABSTRACT

Two field experiments were carried out at South Tahrir Research Station (Ali Moubarak) in 2004/2005 & 2005/2006 seasons to study the effect of intercropping groundnut or soybean with cassava under different intercropping patterns; cassava plants alternated with two or four rows of the base crop, i.e, cassava: base crop (1:2), (1:4) and three dates of planting cassava stakes (mid of March, first and mid of April). A split – split plot design was used. Data concerning the effect of date of planting cassava indicated that maximum yield of cassava tubers was associated with the first of April planting, whereas, minimum yield was obtained at the earliest date (mid of March). Cassava yield was superior when plants were grown in (1:2) to those orientated in (1:4). Cassava yield when plants were grown with soybean exceeded those grown with groundnut. The results of the base crop indicated that groundnut and soybean grown in four rows at the latest date (mid of April) had the highest yield, whereas, the lowest yields of the base crop were associated with the earliest date. The highest Land Equivalent Ratio (LERs) (1.53 and 1.59) were obtained when four rows of groundnut were grown with cassava at mid of April in both seasons. LERs of soybean reached the maximum (1.48 and 1.62) when same treatments were applied. Cassava was the dominated crop when intercropped with groundnut, and in most cases with soybean.

INTRODUCTION

The introduction of cassava in Egypt is very promising in the new reclaimed areas. Cassava can be grown successfully in Egypt on low fertility soil. The crop is a low cost production and is one of the cheapest food. It requires low labour and low fertilizer, easy to cultivate and has the ability to grow on already depleted soil. But the most important is that the crop can substitute wheat at a ratio of 30% cassava flour used in bread and can substitute maize with a ratio of 20-25% of dried cassava chips used in animal feed. Nevertheless, scarcity local research work has been devoted to this crop.

Cassava intercropping has several advantages over sole- cropped cassava. Intercropping may provide yield stability by minimizing the adverse effects of weeds, pests and diseases (Mareno, 1979). It can also be more productive than sole- cropping, particularly when wide – row cassava is intercropped with a short duration crop

(Leihner, 1983). The associated crop can mature before severe competition develops between the two species and cassava growth may be affected by the associated crop. Furthermore, there is also sufficient time to recover after the short – duration crop is harvested and thus cassava produces almost a full yield (Tsay *et al.* 1988). Cassava may depend on the intercrop species and growth conditions, so that intercrop competition is minimized and complementary effects are maximized (Willey, 1979). On the other hand, Kayhan *et al.* (1999) showed that leaf area, number of leaves/plant and branching of legume (the base crop) had a strong positive correlation with fractional diameter of the legume plant over time FD (a parameter to estimate the degree of branching), whereas, light penetration was negatively correlated with branching of individual legume plant over time. Several investigators studied the effect of date of planting on growth, and yield of cassava. Indira and Ramanujam (1981) reported that cassava grew at the earliest date had the tallest plants. Okigho (1971) studied the effect of eleven dates of planting at intervals of three weeks from 23 April to 24 October. He found that delaying planting decreased weight of tops, number of tubers /plants, number of branches per plant and the ratio of top: tubers, but tended to increase yield of tubers. Sahar - Ibrahim *et al.* (2004) found decreases in tuber yield with delaying planting from 15 March to mid of April. Prasad (1989) came to similar trend and Ambe *et al.* (1999) reported that April /May was the most appropriate period for planting cassava. Indira and Ramanujam (1981), reported that cassava grew faster and flowered earlier in July than other months. Keating *et al.* (1982) reported that 89% of growth variation was due to effects of mean air temperature and solar radiation. Sahar - Ibrahim *et al.* (2004) found similar results. Manrique (1990), reported that maximum leaf number, primary branching, tuber yield of marketable size were positively correlated with higher temperatures.

Cassava is very flexible due to its high response to different intercropping pattern. Moreover, there was more inherent flexdibility of cassava – legume intercropping. Despite of this flexibility, cassava has shown different response to the base crop. Cassava is intercropped with many base crops; such onion, green and blackgram, cowpea, okra and sunflower. Onion had the favourest effect on cassava yield, green gram ranked the second, whereas, groundnut showed deleterious effect on cassava yield. (CIAT 1975). Muthukrishuan and Thamburay (1978) reported that cassava growth and yield decreased by 20.9% when intercropped with groundnut. Although Cenpukdee and Fukai (1992), Sahar –Sherif (2000) found lower values of the relative yield of the base crops when associated with cassava due to the interspecific competition, intercropped cassava in most cases resulted in higher values of land equivalent ratio.

MATERIAL AND METHODS

Two field experiments were carried out at South Tahrir Research Station (Ali Moubarak), during 2004/2005 & 2005/2006 seasons to study the effect of intercropping cassava with groundnut or soybean and date of planting cassava on growth, yield and yield components of crops. The treatments used were as follows:

1-Date of planting cassava

a- cassava stakes were planted on the 15th of March
b- cassava stakes were planted on the 1st of April
c- cassava stakes were planted on the 15th of April

2-Cropping patterns

a- cassava was intercropped with groundnut or soybean in alternative pattern (1:2)
b- cassava was intercropped with groundnut or soybean in alternative pattern (1:4)
c- Cassava, groundnut and soybean were grown in pure stand as check.

3-Base crops (understory) were:

a- Groundnut b- Soybean

Experimental design.

The twelve treatments were laid out randomly in split - split plot design. Check plots were also involved in the replications and devoted only for biological evaluation. Date of planting occupied the main plots, the subplots were devoted for the intercropping treatments, whereas, the sub –subplots were devoted for the different crops. Each treatment was replicated three times. The plot area was $28m^2$ and included 4 rows. Each row was7.0m in length and 1.0m in width. Both inter and intra row spacing was 100 cm for cassava. Plant spacing for the base crops was 10 cm apart for groundnut and 20 cm apart for soybean

Soil analysis

Soil analysis was carried out according to Wilde *et al.* (1985) and the obtained data are shown in Table (1)

Table (1): Physical and chemical properties of the experimental soil

Mechanical analysis	Chemical an lysis
Sand % 90.27	Organic matter % 0.45
Silt % 3.35	pH 7.83
Clay % 5.53	
Texture class Sandy	EC (ds / m) 1.49
	Soluble cations mmol.e L^{-1}
	Ca^{+2} 5.75
	Mg^{+2} 4.60
	K^{+} 0.20
	Na^{+} 3.60
	Soluble anions mmol.e L^{-1}
	HCO3- 4.60
	Cl- 6.80
	S04-- 2.75
	Soluble nutrients (mg. Kg^{-1})
	N 10.0
	P 12.0
	K 60.0

The name of the textural class was ascertained from the textural triangle given by Alexander (1977).

Cultural practices

Sufficient cassava stakes of Brazilian variety were taken from Ismaillia Agricultural Research Station. Primary and secondary stakes were cut into 25-30

cm in length inserted according to the treatment of planting date in wetty soil at the three dates of planting and intercropping patterns. Irrigation was practiced every day under drip irrigation system during the first two weeks, thereafter, as needed during the season until two weeks before time of harvest.

The stakes were planted vertically by inserting two thirds of the stakes into the soil keeping one third of them above ground, and irrigated immediately after planting. Nitrogen, phosphorus, and potassium were applied within the fertigation system at the rates of 30kg N/fed in the form of ammonium nitrate (33.5%N), 30 kg P2O5/fed in the form of calcium superphosphate and 46 kg K2O/fed in the form of potassium sulphate. Tuber yield was harvested on 6th and 11th February in both seasons, respectively. One week before harvesting, five guarded plants were taken randomly from each plot to determine the following characters.

1- Plant height (cm)
2- Number of branches /plant
3- Average of total number of tubers /plant
4- Average length of marketable and unmarketable tubers (cm)
5- Average diameter of marketable and unmarketable tubers (cm)
6- Weight of fresh tubers /plant (kg)
7- Yield of fresh tubers /fed (ton)

Groundnut (Giza 5) in sole and mixed cropping was sown on 22th and 25th of May in the first and second seasons, respectively at 10 cm apart. The seeds were inoculated with Rhizobium bacteria before sowning and immediately irrigated. Groundnut was harvested after 140 days from seeding. At full growth and one week before harvesting, samples of ten plants were taken from each sub-sub plot and the following data were recorded on growth and yield components of groundnut.

1-Plant height (cm)
2- Number of branches/plant
3- Number of pods /plant
4- Weight of pods /plant (gm)
5-Weight of 100 seeds (gm)
6- Yield / fed (ardab)

Soybean (cv. Clark) in sole and the cropping pattern was sown on 23th and 29th of May in the first and second seasons at 20 cm apart The seeds were inoculated with Rhizobium bacteria before sowning and immediately irrigated. Soybean was harvested after 120 days from seeding. At full growth and prior to harvest, samples of ten plants were taken from each sub – sub plot and the following data were recorded on growth and yield components of soybean.

1-Plant height (cm)
2- Number of branches/plant
3- Number of pods /plant
4- Weight of pods /plant (gm)
5-Weight of 100 seeds (gm)
6- Seed yield / fed (kg)

Competitive relationships

1- Land Equivalent Ratio (LER) was described by Mead and Willey (1980) as follows

$$\mathbf{LER} = \frac{Yab}{Yaa} + \frac{Yba}{Ybb}$$

Where Yab = intercropped yield of a
Yaa = yield of a in pure stand
Yba = intercropped yield of b
Ybb = yield of b in pure stand

2- Aggressivity (A)

This parameter was proposed by Mc Gilichrist (1965). It gives a simple measurement of the increase in the relative yield of species (a) over species (b). it is usually denoted as A and determined according to the following formula:

$$A_{ab} = \frac{\text{Mixture yield of a}}{\text{Expected yield of a}} - \frac{\text{Mixture yield of b}}{\text{Expected yield of b}}$$

$$A_{ab} = \frac{Yab}{Yaa \times Zab} - \frac{Yba}{Ybb \times Zba}$$

An aggressively value of zero indicates that the component species are equally competitive. For any other situation, both species will have the same numerical value but the sign of the dominant species will be positive and the dominated negative. The greater the numerical value the bigger the difference in competitive abilities and the bigger the difference between actual and expected yield.

3- **Competition Ratio (CR)** is based on yield and space assigned to each species in an intercropping system (Mason *et al.*, 1986). From the definition, the term CR is therefore the ratio of the particular LERs of the two intercrops, but corrected for the sown proportion of either crop (Willey and Rao, 1980). The CR of crop B is the reciprocal of the CR of crop A.

$$\mathbf{CR_A = (LER_A / LER_B)\ (S_B / S_A)}$$

Where: S_A = relative space occupied by crop A S_B = Relative space occupied by crop B

The statistical analysis was applied according to Snedecor and Cochran (1980). LSD at 0.05 level was used to compare among treatments.

RESULTS AND DISCUSSION

1- Effect of planting date on growth, yield and yield components of cassava plants

Data in Table (2) indicated clearly that planting date of cassava stakes had significant effect on plant height in both seasons. Cassava grown at the earliest date had the tallest plants in both seasons, whereas, plant height gradually decreased with delaying time of planting the stakes. Indira and Ramanujam (1981) supported these results. Interpretation for the increase in plant height

might be explained by a longer season for growth, coupled with more favourable environmental conditions which stimulate growth of the crop.

The average number of branches/plant was significantly affected in contrast to the effect of planting dates on cassava height in both seasons. Several investigators had contradictory results, however, Manrique (1990) came to plausible and cogent explanation when reported positive correlation between high temperatures and copious branching supporting that delaying time of planting was accompanied by copious branching and with raising temperature- deep in summer of Egypt.

On the other hand, yield traits had distinctive trend as influenced by date of planting. The length of marketable and unmarketable tubers increased gradually with delaying time of planting up to the latest date (mid of April). These results were true in both seasons. The diameter of marketable and unmarketable tubers had different trend to the tuber length. The data revealed that both traits increased with the first delaying time of planting, thereafter, decreases in tuber diameter were observed in both seasons with delaying to the latest date (mid of April). Moreover, differences among the treatments were also significant in both seasons. It is also obvious that the average number of tubers /plant, weight of fresh tubers /plant and the yield of fresh tubers /fed followed the same trend of tuber diameter in both seasons. However, the data revealed that values of number of total tubers /plant, diameter of marketable and unmarketable tubers, average weight of fresh tubers/ plant and yield of fresh tubers /fed were maximized at the medium date (first of April), and decreased to minimum at the earliest date of planting (mid of March). This trend might be correlated with a deleterious environmental conditions prevailed during the early date of planting, very pertinent to the middle date of planting, or the exposure of cassava plants to the optimal conditions which prevail during the latest date of planting. Prasad (1989) supported the positive correlation between the late planting of cassava and reduction in yield and yield traits. Manrique (1990) also emphasized the importance of the surrounding microenvironment (in particular, the weather conditions) on growth and yield of the crop. Yield of cassava tubers planted in the first of April was higher than that of 15 March and 15 April, the corresponding date were 22.26 and 11.11 % in the first season and 24.70 and 13.78% in the second season, respectively.

2- Effect of intercropping cassava with groundnut or soybean on its yield and yield components.

Data in Table (3) showed that intercropping four rows of the understory crops (groundnut or soybean) resulted in higher cassava plants. These results hold true in both seasons. Higher interspecific competition between the main crop (cassava) and the base crops (groundnut or soybean) resulted in higher cassava plants. The effect of intercropping patterns on the number of total branches of cassava plants was dissimilar to that on plant height. More copious branching was associated with cassava alternated with two rows of the base crop in both seasons. This trend might be due to the low below and above ground competition between both cassava plants and the base crop, supporting the results and conclusion

obtained by Cenpukdee and Fukai (1992). The effect of intercropping patterns on cassava yield components was not regular, although differences were significant between both patterns. While the length of marketable and unmarketable tubers increased with increasing the number of rows of the base crops, the trend was reversed in case of the diameter of marketable and unmarketable tubers. There were decreases in the values of these traits in the four rows pattern of the base crops, in both seasons. Number of total tubers /plant and weight of fresh tubers/plant followed the same trend as the effect on tuber diameter. The values of both traits were higher when the base crop grown in two rows than those grown in four rows. Furthermore, the yield of fresh tubers /fed showed also the same trend. Cassava plants intercropped with two rows of the base crop outyielded those intercropped with four rows of the base crop (groundnut or soybean). The excess in yield of cassava tubers estimated to 11.00 and 10.15% in the first and second seasons, respectively. The yield of fresh tubers /fed was correlated with weight of fresh tubers /plant and number of total tubers /plant as well as the diameter of tubers. Leihner (1983) supported these results. He found a reduction in cassava yield when intercropped in two and three rows of tall crops estimated as 78.82 and 84.48%, respectively as compared with a single row of the base crop. Competition for land resources might be the main reason for yield differences in the two cases.

Table (2): Effect of planting date of cassava intercropped with groundnut or soybean on yield and yield components of cassava in both seasons.

Characters / Date of planting	Plant height (cm)	No. of branches /plant	No. of tubers /plant	Length of mark. Tubers (cm)	Length of unmark. tubers (cm)	Diameter of mark. tubers (cm)	Diameter of unmark. tubers (cm)	Weight of fresh tubers/plant (kg)	Yield of fresh tubers ton /fed
2004/2005									
15th March	150.8	3.1	5.7	34.3	19.1	2.3	3.3	4.0	16.3
1st April	132.7	3.3	7.9	36.7	23.6	3.8	4.8	5.1	21.0
15th April	117.3	3.7	7.3	39.8	25.5	3.5	4.5	4.5	18.7
LSD at 5%	**0.82**	**0.05**	**0.29**	**0.19**	**0.45**	**0.11**	**0.06**	**0.21**	**1.21**
2005/2006									
15th March	146.3	2.8	5.1	33.5	18.4	2.3	3.3	3.8	15.0
1st April	124.6	3.1	7.3	36.1	22.6	3.8	4.8	4.8	20.0
15th April	109.2	3.5	6.7	38.9	24.2	3.3	4.6	4.1	17.2
LSD at 5%	**0.71**	**0.07**	**0.38**	**0.41**	**0.22**	**0.31**	**0.29**	**0.16**	**0.38**

Table (3): **Effect of intercropping patterns on cassava intercropped with groundnut or soybean on yield and yield components of cassava in both seasons.**

Characters / Patterns	Plant height (cm)	No. of branches/plant	No. of tubers /plant	Length of mark. Tubers (cm)	Length of unmark. Tubers (cm)	Diameter of mark. Tubers (cm)	Diameter of unmark. Tubers (cm)	Weight of fresh tubers /plant (kg)	Yield of fresh tubers ton /fed
2004/2005									
1: 2	128.8	3.7	7.5	35.9	21.8	3.5	4.5	4.8	19.7
1: 4	138.4	3.0	6.4	37.9	23.6	2.9	3.8	4.3	17.6
Significance at 5%level	*	*	*	*	*	*	*	*	*
2005/2006									
1: 2	121.5	3.4	6.9	35.1	20.7	3.4	4.5	4.5	18.3
1: 4	131.8	2.8	5.8	37.2	22.7	2.8	3.9	4.0	16.5
Significance at 5% level	*	*	*	*	*	*	*	*	*

3- Effect of the base crop (groundnut or soybean) on yield and yield components of cassava.

Data in Table (4) showed the effect of the base crop on growth, yield and yield components of cassava plants. It was in favour with soybean which showed more pertinency as a companion crop. The values of growth traits, yield components and yield of fresh tubers /fed were higher when soybean was intercropped with cassava rather than with groundnut. The only exception was in case of length of marketable and unmarketable tubers where the trend was only reversed in the second season. The increases in cassava yield /fed when grown with soybean over that intercropped with groundnut were estimated as 8.08 and 7.63% in the first and second seasons, respectively. These results are in agreement with those obtained by Muthukrishuan and Thamburay (1978), they reported that groundnut affected the growth of cassava plants and yield by 20.9%, such low yield is due to a severe competition of groundnut with cassava for the nutrients. The low yield of groundnut as an intercrop in comparison with other base crops also exhibits its unsuitability for growing with cassava.

Many vegetation and yield variables are potentially influenced by the competition of the plant with a second crop in an intercrop system, whether the competition with other plants of different species or same species. The structure of plant vegetation and its geometric elements combined with total amount of leaf area determine the distribution of light within the canopy. In adequate irradiance, legume plants can array their foliage in space to optimize light interception and gas exchange and the geometric structure of the canopy can have a great impact on the ability of plants to intercept light, a cogen reason for higher branching with less shading of the understory crop in case of soybean crop, (Kayhan *et al.*, 1999).

They also reported that leaf area per plant, number of leaves /plant and legume branching showed strong positive correlation with fractional diameter

(FD) (a parameter to estimate the degree of branching) of legume plant over time, whereas, light penetration (%per plant) was negatively correlated with FD. The conclusions could offer plausible reasons for the specific reaction of cassava with different legumes in the association.

4- Interaction effect of planting date, intercropping patterns and different base crops intercropped with cassava on growth, yield and yield components of cassava.

Although yield and yield components of cassava plants were insignificantly affected by the combined interactions of the three main variables in most traits in both seasons i.,e, cassava planting dates, intercropping patterns and the base crops intercropped with cassava, however regular trends could be detected in Table (5). The interaction data revealed that the date of cassava planting had a more pronounced effect. The medium date as interacted by cropping patterns and the crop base intercropped with cassava tended to have the highest values of yield of fresh tubers /fed under the same respective pattern and the base, crop either. These results seemed valid in both seasons. Furthermore, the highest values within this category were obtained when the medium date was associated with double rows of the base crop groundnut or soybean either. The yield of cassava grown at the latest date with double rows of soybean or groundnut ranked the second. The average number of total tubers, diameter of marketable tubers and the weight of fresh tubers which might be the main contributors to yielding the fresh tubers followed the same ranks and pattern of change.

Table (4): Effect of the base crops (groundnut or soybean) on yield and yield components of cassava in both seasons.

2004/2005									
Characters / Base crops	Plant height (cm)	No. of branches/plant	No. of tubers /plant	Length of mark. Tubers (cm)	Length of unmark. Tubers (cm)	Diameter of mark. Tubers (cm)	Diameter of unmark. Tubers (cm)	Weight of fresh tubers /plant (kg)	Yield of fresh tubers ton /fed
Groundnut	113.1	3.4	6.2	36.5	22.7	2.9	3.9	4.4	17.9
Soybean	154.1	3.4	7.8	37.1	22.7	3.4	4.4	4.7	19.4
Significance at 5% level	*	N. S	*	N. S	N. S	*	*	N. S	*
2005/2006									
Groundnut	109.4	3.1	5.6	36.4	22.0	2.6	4.0	4.1	16.7
Soybean	144.0	3.1	7.1	35.9	21.5	3.6	4.4	4.3	18.1
significance at 5% level	*	*	*	*	*	*	*	*	*

5- Effect of planting date of cassava intercropped with groundnut on yield and yield components of groundnut.

Data in Table (6) showed decreases in plant height of groundnut with late planting of cassava. The statistical analysis revealed significant differences in both seasons. On the other hand, yield and yield component traits of groundnut behaved reversed trends and differences were also significant. Superiority of yield components and yield /fed with delaying cassava planting might be attributed

much to environmental conditions. The increases in groundnut yield /fed at 15 April over that grown at 15 March were estimated by 30.74 and 29.82% in the first and second seasons, respectively.

Table (5): Interaction effect of planting date, intercropping patterns and the base crops intercropped with cassava on growth, yield and yield components of cassava in both seasons.

2004/2005											
Characters			Plant height (cm)	No. of branches /plant	No. of tubers /plant	Length of mark. Tubers (cm)	Length of unmark. Tubers (cm)	Diameter of mark. Tuber (cm)	Diameter of unmark tubers (cm)	Weight of fresh tubers /plant (kg)	Yield of fresh tubers ton /fed
Date of planting	Patterns	Base crops									
15th March	1:2	G	130.7	3.3	5.1	30.8	19.5	2.4	3.3	4.0	15.8
		S	166.6	3.4	7.3	35.6	16.8	2.8	3.8	4.5	18.8
	1:4	G	135.5	2.8	4.6	33.9	21.9	1.8	2.6	3.5	13.5
		S	170.4	2.9	5.8	36.8	18.1	2.2	3.4	4.1	17.2
1st April	1:2	G	107.8	3.7	7.6	35.6	20.3	3.9	4.8	5.6	22.1
		S	145.8	3.6	9.4	36.0	24.5	4.3	5.4	5.3	22.2
	1:4	G	115.5	3.1	6.3	37.8	23.1	3.1	4.1	4.8	19.8
		S	161.8	2.9	8.1	37.2	26.4	3.7	4.7	4.8	19.9
15th April	1:2	G	88.6	4.0	7.1	40.0	24.8	3.2	4.5	4.6	19.3
		S	133.5	4.1	8.5	37.3	24.8	4.2	5.2	4.8	20.3
	1:4	G	100.7	3.3	6.1	42.0	26.5	3.0	4.0	4.1	16.8
		S	146.3	3.2	7.6	39.7	25.7	3.4	4.2	4.4	18.2
LSD at 5% level			1.51	N. S	0.33	N. S	N. S	N. S	N. S	N. S	N. S
2005/2006											
15th March	1:2	G	129.3	2.8	4.6	30.3	19.0	2.2	3.6	3.7	14.6
		S	157.4	3.1	6.6	34.5	15.8	2.7	3.4	4.2	17.7
	1:4	G	133.3	2.6	3.7	33.1	21.2	1.4	2.6	3.5	12.4
		S	165.3	2.6	5.5	36.0	17.4	2.8	3.4	3.7	15.4
1st April	1:2	G	103.2	3.3	7.1	34.6	19.3	3.6	4.9	5.2	20.8
		S	135.2	3.5	8.7	35.8	23.4	4.6	5.3	5.0	20.8
	1:4	G	110.0	2.8	5.7	37.2	22.3	2.9	4.1	4.4	19.0
		S	149.8	2.8	7.6	36.8	25.2	3.9	4.7	4.6	19.3
15th April	1:2	G	83.4	3.8	7.0	39.5	24.0	3.1	4.7	4.2	17.5
		S	120.5	3.9	7.6	35.8	22.7	4.2	5.1	4.4	18.6
	1:4	G	97.1	3.1	5.7	43.5	25.9	2.5	4.0	3.8	16.0
		S	135.6	3.0	6.5	36.8	24.3	3.3	4.7	4.0	16.8
LSD at 5% level			0.62	N. S	N.S	0.44	0.40	N. S	N. S	N. S	N. S

G: groundnut S: soybean

6- Effect of intercropping patterns on growth, yield and yield components of groundnut

Data in Table (7) revealed that groundnut height was reduced when groundnut was grown in four rows between cassava plants (1:4) rather than when two rows of groundnut were grown between cassava plants (1:2). The yield components decreased with increasing groundnut populations, groundnut yield

/fed increased with increasing groundnut rows between cassava plants. The increases in yield were 43.74 and 45.38% in first and second seasons, respectively. Such difference seemed to be attributed to more intraspecefic competition between groundnut plants .

7- Effect of the interaction of planting date of cassava and the intercropping patterns on growth, yield and yield components of groundnut.

Plant height of groundnut was statistically influenced by the interaction effect of date of planting cassava and the intercropping patterns in Table (8). The data showed regular trends over dominated both main variables. There was consistent decrease in plant height of groundnut with delaying time of planting cassava stakes up to the latest date. These observations hold true in both seasons. On the other hand, at any date of planting cassava, groundnut height when grown in four rows was less than plants grown in two rows, probably due to more below ground competition for water, macro and micro nutrients. The effect on number of branches/plant was reversed, branching of groundnut increased with delaying time of cassava planting under the same respective intercropping pattern. Moreover, consistent increases in branching was observed with increasing groundnut rows regardless of the time of planting cassava stakes. Furthermore, the statistical analysis revealed significant differences among the interacted treatments. It seemed that delaying planting date of cassava probably exerted more favourable effect on the base crop, which render groundnut stimulate more branching. On the other hand, the trends of the number and weight of pods /plant and weight of 100 seeds were reversed as compared with interaction effect on number of branches /plant. The interaction effects on these traits were also significant in both seasons, except, for the values of weight of 100 seeds in the second season only. Concerning cassava planting date, these trais s increased by delaying the date of planting cassava up to the latest date. Data on yield of groundnut as influenced by the interaction indicated the same trend with delaying time of planting cassava but, the yield of four rows of groundnut was superior to planting two rows of the base crop. The data also revealed that groundnut grown in four rows at the latest date of cassava resulted in highest yield of groundnut, whereas, groundnut grown in two rows between cassava rows at the earliest date yielded the least. These results were also true in both seasons. Furthermore, the differences were significant in the second season. It seemed that delaying cassava planting, the overstory crop, allowed the favourable conditions for the base crop to grow and develop.

8- Effect of planting date of cassava intercropped with soybean on yield and yield components of soybean.

Data in Table (9) revealed that there were increases in all traits with delaying time of planting cassava up to the latest date (15th April). Moreover, the statistical analysis revealed significant differences, except for the cases of number and weight of pods/plant and weight of seeds/ plant in the second season. The increases in soybean yield /fed at the latest date over that grown at earliest date were estimated to 17.31 and 18.30% in the first and second seasons, respectively.

9- Effect of intercropping patterns on yield and yield components of soybean

Data in Table (10) revealed that heights of soybean plants significantly diminished when four rows of soybean plants were planted between cassava rows as compared with two rows of soybean grown between cassava rows. On the other hand, yield components followed reversed trends. The data also revealed that growing four rows of soybean resulted in higher yield of soybean seeds/fed as compared with the two rows system. The increases in yield were estimated by 45.27 and 46.69% in first and second seasons, respectively. Interpretation for this superiority is attributed much to increases in soybean plant density in (1: 4) pattern.

Table (6): Effect of planting date of cassava intercropped with groundnut on yield and yield components of groundnut in both seasons.

2004/2005						
Characters / **Date of planting**	**Plant height (cm)**	**No. of branches /plant**	**No. of pods /plant**	**Weight of pods/ plant (gm.)**	**Weight of 100 seeds (gm)**	**Yield ardab /fed**
15th March	56.7	5.7	29.3	29.3	47.3	4.8
1st April	52.0	6.7	32.9	38.0	60.4	6.4
15th April	50.4	7.9	44.4	47.9	69.4	7.0
LSD at 5%	**1.14**	**0.26**	**0.38**	**0.31**	**0.54**	**2.38**
2005/2006						
15th March	54.7	5.3	27.9	27.8	46.1	4.5
1st April	50.9	6.4	31.8	36.8	60.5	6.0
15th April	49.3	7.6	42.0	45.9	67.9	6.4
LSD at 5%	**0.22**	**0.14**	**0.36**	**0.67**	**3.30**	**2.17**

Table (7): Effect of intercropping patterns on groundnut intercropped with cassava on yield and yield components of groundnut in both seasons.

2004/2005						
Characters / **Patterns**	Plant height (cm)	No. of branches /plant	No. of pods /plant	Weight of pods/ plant (gm.)	Weight of 100 seeds (gm)	Yield ardab /fed
1:2	55.3	6.1	37.8	41.7	62.9	4.4
1:4	50.8	7.3	33.3	35.1	55.1	7.8
Significance at 5% level	*	*	*	*	*	*
2005/2006						
1:2	53.8	5.8	36.1	39.9	61.5	4.0
1:4	49.4	7.1	31.7	33.7	54.8	7.3
Significance at 5% level	*	*	*	*	*	*

Table (8): Effect of the interaction of planting date and intercropping patterns of cassava intercropped with groundnut on yield and yield components of groundnut in both seasons.

2004/2005							
Characters		Plant height (cm)	No. of branches /plant	No. of pods /plant	Weight of pods/ plant (gm.)	Weight of 100 seeds (gm)	Yield ardab/ fed
Date of planting	Patterns						
15th March	1: 2	58.9	5.1	30.6	31.0	50.2	3.3
	1: 4	54.6	6.3	28.1	27.6	44.3	6.3
1st April	1: 2	53.9	6.2	35.1	40.1	64.5	4.6
	1: 4	50.1	7.1	30.6	35.9	56.2	8.2
15th April	1: 2	53.2	7.1	47.7	54.0	73.9	5.2
	1: 4	47.7	8.6	41.1	41.8	64.9	8.8
LSD at 5% level		0.44	0.11	0.19	0.85	0.79	N. S
2005/2006							
15th March	1: 2	56.2	4.6	28.7	29.5	49.2	3.1
	1: 4	53.2	6.1	27.1	26.0	43.0	5.8
1st April	1: 2	53.1	5.9	34.0	38.7	63.0	4.3
	1: 4	48.7	6.8	29.6	34.8	58.0	7.7
15th April	1: 2	52.2	6.9	45.7	51.5	72.3	4.5
	1: 4	46.4	8.3	38.3	40.3	63.4	8.2
LSD at 5% level		0.42	0.23	0.33	0.67	N. S	0.36

Table (9): Effect of planting date of cassava intercropped with soybean on yield and yield components of soybean in both seasons.

2004/2005						
Characters Date of planting	Plant height (cm)	No. of branches /plant	No. of pods /plant	Weight of pods /plant (gm)	Weight of 100- seed (gm)	Yield kg/fed
15th March	48.6	2.2	28.9	49.4	20.9	471.5
1st April	55.2	2.7	30.3	56.9	21.7	558.3
15th April	65.1	3.4	32.7	73.7	25.1	570.2
LSD at 5%	0.18	0.09	0.63	6.36	1.29	34.07
2005/2006						
15th March	47.4	2.1	27.3	44.1	19.2	456.6
1st April	53.9	2.6	29.5	49.3	21.0	541.4
15th April	63.8	3.2	33.3	66.2	24.1	558.9
LSD at 5%	0.41	0.06	N. S	N. S	N. S	21.24

10- The interaction effect of planting date and the intercropping patterns of cassava intercropped with soybean on yield and yield components of soybean

The interaction effect of planting date of cassava and the intercropping patterns on growth, yield and yield components of soybean showed regular trend in Table (11). Two distinctive effects overdominate the trend of all traits. There

were ever increases in the values of all traits i., e, yield and yield components when four rows of soybean were grown between cassava rows and there were also increases in the values of these traits with delaying cassava planting under same respective intercrop patterns. The only deviation was in case of weight of pods /plant. The interaction data also revealed that the highest yield was obtained when soybean was grown in four rows between cassava plants grown at the latest date, whereas, lowest yield of soybean was observed when cassava was grown at the earliest date and soybean was grown in two rows in both seasons.

Table (10): Effect of intercropping patterns on soybean intercropped with cassava on yield and yield components of soybean in both seasons.

2004/2005						
Characters Patterns	Plant height (cm)	No. of branches /plant	No. of pods /plant	Weight of pods /plant (gm)	Weight of 100 seeds (gm)	Yield kg/fed
1:2	58.8	2.6	29.2	55.9	21.8	377.3
1:4	53.8	3.0	32.1	55.0	23.3	689.3
Significance at 5% level	*	*	*	*	*	*
2005/2006						
1:2	57.8	2.5	28.5	20.2	20.2	360.9
1:4	52.2	2.8	31.5	22.7	22.7	677.0
Significance at 5% level	*	*	**N. S**	**N. S**	**N. S**	*

Table (11): Interaction effect of planting date and intercropping patterns of cassava intercropped with soybean on yield and yield components of soybean in both seasons.

2004/2005							
Treatments		Plant height (cm)	No. of branches /plant	No. of pods /plant	Weight of pods /plant (gm)	Weight of 100-seed (gm)	Yield kg/fed
Date of planting	Patterns						
15th March	1: 2	50.7	2.0	27.5	53.7	19.9	342.9
	1: 4	46.5	2.4	30.3	45.0	21.9	600.0
1st April	1: 2	58.4	2.5	28.3	58.5	21.5	388.6
	1: 4	51.9	2.9	32.3	55.3	21.9	728.0
15th April	1: 2	67.3	3.2	31.7	82.5	24.0	400.3
	1: 4	62.9	3.6	33.8	64.8	26.2	740.0
LSD at 5%		**0.32**	**N. S**	**0.06**	**N. S**	**0.13**	**45.17**
2005/2006							
15th March	1: 2	49.7	1.9	26.5	41.9	17.2	317.1
	1: 4	45.0	2.4	28.0	46.2	21.2	596.1
1st April	1: 2	57.6	2.5	28.0	53.3	20.8	376.9
	1: 4	50.3	2.7	31.0	45.3	21.3	706.0
15th April	1: 2	66.1	3.0	31.0	70.7	22.6	388.2
	1: 4	61.4	3.4	35.5	61.6	25.7	728.9
LSD at 5%		**0.52**	**0.06**	**0.02**	**1.46**	**0.06**	**12.85**

11- Effect of planting date and intercropping patterns on the competitive relationships of cassava intercropped with groundnut or soybean.

a- With groundnut

Intercropping cassava with groundnut revealed heavy pressure on the yield of the base crop. Data presented in Table (12) indicated clearly that date of planting and number of rows within the intercrop pattern had regular trend on the relative yield of both cassava and groundnut (RYg, RYc) . While the highest RY values of cassava were observed when cassava was grown on the first of April (medium date) RY values of cassava grown at latest date (the mid of April) ranked the second. RYc values of cassava were the least when cassava was grown at the mid of March. On the other hand, the trend was more regular in case of groundnut. There were gradual increases in RYg values of groundnut with delaying time of planting cassava. These trends were observed whatever the number of groundnut rows in the intercrop pattern were increases in RYg of the base crop with delaying time of cassava planting could be attributed much to lower competitive pressure of cassava grown in proximate timing of the base crop in the intercrop pattern. Meanwhile, when there were decreases in cassava RYc with four rows of the base crop, there were increases in RYg. These opposing trends evidenced the mutual competitive pressure between both components Sahar- Sherif (2000) came to similar results and conclusion. The data also indicate that all values of the relative yield of groundnut were evidently lower than those of cassava which could be also interpreted by higher interspecific competition from the overstory crop. Several investigators came to similar conclusion such Cenpukdee and Fukai (1992). Data on land equivalent ratio revealed also regular trends in both seasons. Highest LER values were associated with growing cassava at the first of April (medium date) under same respective pattern of intercropping (1:4). LER values at the latest date of growing cassava under same respective pattern of intercropping ranked the second, whereas, the least LER values were associated with the earliest date of planting cassava plants. These trends were in parallel with that of RYc of cassava plants indicating the overdominancy of the over story crop rather than the base crop. These results are in agreement with those obtained by Cenpukdee and Fukai (1992) The data also revealed that LER values when the intercrop included four rows of groundnut were higher than those when the intercrop included double rows of groundnut under the three dates of cassava planting. Highest LER (.53, 1.59) were obtained when four rows of groundnut were grown with cassava planted at mid of April indicating 53 and 59% increase in production per unit area over growing cassava and groundnut either as a sole crop, whereas least values of LER (0.96, 0.98) were obtained when cassava was grown with two rows of groundnut at the earliest date (mid of March) in both seasons, respectively. However, all values of LERs exceeded the unit indicating yield advantage, except in case of growing two rows of groundnut with cassava planted on the earliest date in both seasons. The higher the population density (interms of number of rows) of the associated crops get to their respective monoculture levels, the greater the total yields of both components due to an optimal utilization of resources complex was obtained. (CIAT 1975). Cassava is also very flexible regarding its yield response to spatial arrangement of both components, thus different planting patterns may be used in intercropping without sacrificing major portion of root yield of cassava plants. The inherent flexibility of cassava – legume intercropping system appears not to impose major limitations.

Aggressivity data revealed that interacted treatments exerted heavy competitive pressure, where the values were beyond the unit, except in case of planting cassava at the earliest date at mid of March, whether, with two or four rows of groundnut. However, a trend to increase aggressivity was associated with delaying time of planting cassava probably due to narrowing planting time between both the main and the secondary crop. These results were similar in both seasons. The data also revealed that cassava was always the dominated crop, whereas, groundnut was the dominant. These results were similar to those obtained by Sahar – Sherif (2000).

Table (12): Effect of planting date and intercropping systems on competitive relationships of cassava intercropped with groundnut in both seasons.

2004/2005										
characters		Yield		Relative yield		LE R	Aggressivity		Competition ratio (CR)	
Date of planting	Patterns	Cassava ton /fed	Groundnut ardab /fed	RYC	RyG		Cassava	Ground -nut	Cassava	Ground-nut
15th March	1: 2	15.77	3.33	0.69	0.27	0.96	-0.76	+0.76	0.51	1.95
	1: 4	13.49	6.30	0.59	0.50	1.09	-0.93	+0.93	0.47	2.13
1st April	1: 2	22.10	4.58	0.97	0.37	1.34	-1.02	+1.02	0.52	1.90
	1: 4	19.77	8.21	0.87	0.66	1.53	-1.22	+1.22	0.53	1.90
15th April	1: 2	19.25	5.17	0.85	0.41	1.26	-1.45	+1.45	0.41	2.40
	1: 4	16.80	8.75	0.74	0.70	1.44	-1.41	+1.41	0.42	2.38
Pure stand		**22.75**	**12.50**							
2005/2006										
15th arch	1: 2	14.62	3.13	0.70	0.28	0.98	-0.83	+0.83	0.50	2.00
	1: 4	12.37	5.81	0.59	0.52	1.11	-0.98	+0.98	0.45	2.20
1st April	1: 2	20.80	4.25	0.99	0.38	1.37	-1.07	+1.07	0.52	1.89
	1: 4	18.97	7.72	0.90	0.69	1.59	-1.14	+1.14	0.52	1.93
15th April	1: 2	17.50	4.50	0.83	0.40	1.23	-1.45	+1.45	0.42	2.40
	1: 4	16.02	8.23	0.76	0.73	1.49	-1.65	+1.65	0.42	2.40
Pure stand		**21.05**	**11.25**							

The exact degree of the competition in the intercrop as measured by the competitive ratio indicate clearly that groundnut was more competitive than cassava. Moreover, CR values of groundnut increased to maximum with delaying time of planting cassava to the latest date (mid of April). While groundnut was more competitive than cassava by 305% and 400% at the earliest date with two rows of groundnut, groundnut was more competitive than cassava by 571% and 572% at the same treatment with four rows in the first and second seasons, respectively. It seemed that delaying time of cassava planting stimulated more competition between both crops in the association.

b- With soybean.

Effect of planting date and intercropping patterns on the competitive relationships of cassava intercropped with soybean were similar in most cases than when groundnut was intercropped with cassava Table (13). Intercropping had more

depressive effect on soybean rather than cassava. The trends of both components were influenced as in case of groundnut. Minimum and maximum LERs were when two rows of soybean were grown with cassava at the earliest date and four rows of soybean were grown with cassava at the middle date respectively. These trends were similar to those obtained with groundnut, but with higher values than groundnut indicating more land use efficiency when cassava was intercropped with soybean.

Aggressivity data also indicate that none of the intercrop treatments had any heavy aggressive pressure on the intercrop components either, since all values obtained were beyond the unit. Increases in aggressivity values were also apparent with delaying the time of planting cassava. Nevertheless, unlike the trend of cassava-groundnut association, cassava was the dominant crop whereas, the soybean was the dominated in most cases. These results were similar to those obtained by Cenpukdee and Fukai (1992).

Similarly cassava was more competitive than soybean under all the treatments, except, in case of planting cassava at the latest date when two rows of soybean was grown in both seasons or four rows was grown in the second season only.

Table (13): Effect of planting date and intercropping systems on competitive relationships of cassava intercropped with soybean in both seasons

2004/2005										
Characters		Yield		Relative yield		LER	Aggressivity		Competition ratio (CR)	
Date of planting	Patterns	Cassava ton /fed	Soybean kg /fed	RY_C	Ry_S		Cassava	Soybean	cassava	soybean
15th March	1: 2	18.80	342.90	0.83	0.28	1.11	+0.17	-0.17	1.18	0.85
	1: 4	17.17	600.02	0.76	0.50	1.26	+0.28	-0.28	1.22	0.83
1st April	1: 2	22.15	388.59	0.97	0.32	1.29	+0.24	-0.24	1.21	0.83
	1: 4	19.92	727.95	0.88	0.60	1.48	+0.23	-0.23	1.18	0.85
15th April	1: 2	20.33	600.26	0.89	0.50	1.39	-0.48	+0.48	0.71	1.40
	1: 4	18.20	740.04	0.80	0.61	1.41	+0.06	-0.06	1.05	0.95
Pure stand		22.75	1210.67							
2005/2006										
15th March	1: 2	17.72	317.06	0.84	0.31	1.15	+0.09	-0.09	1.08	0.93
	1: 4	15.40	596.07	0.73	0.59	1.32	-0.01	+0.01	0.99	1.01
1st April	1: 2	20.80	376.87	0.99	0.37	1.36	+0.08	-0.08	1.07	0.93
	1: 4	19.28	705.98	0.92	0.70	1.62	+0.08	-0.08	1.05	0.95
15th April	1: 2	18.55	388.81	0.88	0.38	1.26	-0.11	+0.11	0.93	1.08
	1: 4	16.77	728.91	0.80	0.72	1.52	+0.19	-0.19	0.89	1.13
Pure stand		21.05	1015.35							

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تحميل بعض المحاصيل البقولية مع الكسافا فى الأراضى الرملية

سحر على شريف*، صفاء على منصور**

* قسم بحوث التكثيف المحصولى – معهد بحوث المحاصيل الحقلية – مركز البحوث الزراعية – الجيزة – مصر

** قسم بحوث البطاطس ومحاصيل الخضر خضرية التكاثر – معهد بحوث البساتين – مركز البحوث الزراعية – الجيزة – مصر

أجريت تجربتان حقليتان بمحطة بحوث جنوب التحرير (على مبارك) خلال موسمى ٢٠٠٤/٢٠٠٥ و٢٠٠٥/٢٠٠٦ لدراسة تأثير تحميل أى من الفول السودانى أو فول الصويا مع الكسافا تحت نظامين للتحميل وهما: خط كسافا: خطين من المحصول البقولى (١: ٢) ، خط كسافا الى أربعة خطوط من المحصول البقولى (١: ٤) وثلاثة مواعيد لزراعة الكسافا وهى (١٥ مارس ، أول ابريل ، ١٥ ابريل) على كمية للمحصول ومكوناته. وقد صممت التجربة بنظام القطع المنشقة مرتين. وتتلخص أهم النتائج المتحصل عليها فيما يلى:- أعطى الميعاد الثانى لزراعة الكسافا (أول ابريل) أعلى محصول بينما كان أقل محصول مرتبطا بالميعاد الأول للزراعة (١٥ مارس) وكان أفضل نظام لتحميل الكسافا مع المحاصيل البقولية هو (١:٢) مقارنة بنظام (١:٤) كما ازداد محصول درنات الكسافا عند تحميل فول الصويا مقارنة بتحميل الفول السودانى. كما أوضحت النتائج ازدياد كل من محصولى التحميل عند الزراعة بنظام (١: ٤) وزراعة الكسافا فى الميعاد الثالث (١٥ ابريل) بينما كان أقل محصول باتباع نظام (١: ٢) وزراعة الكسافا فى الميعاد الأول (١٥ مارس). كان أعلى معدل لاستغلال الأرض (١,٥٣ ، ١,٥٩) عند زراعة الفول السودانى محملا مع الكسافا

تحت نظام (١:٤) وزراعة الكسافا فى الميعاد الثانى خلال موسمى الزراعة على الترتيب. بينما كان أفضل معدل لاستغلال الأرض عند تحميل فول الصويا مع الكسافا (١,٤٨ ، ١,٦٢) خلال الموسمين على الترتيب باتباع نفس المعاملات كما فى الفول السودانى. كانت الكسافا هى المحصول السائد فى أغلب الحالات عند تحميل فول الصويا معها بينما كانت هى المحصول المسود عند تحميل الفول السودانى.