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Evaluating the efficiency of intercropping systems for three maize hybrids with cowpea on yield productivity and net profit

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ABSTRACT

A field experiment was conducted at the Experimental Farm of Sakha Agricultural Research Station, Agricultural Research Center(A.R.C.), Kafr El-Sheikh Governorate, Egypt, (31^0 07¯ N Latitude and 30^0 57¯ E longitude with an elevation of about 6 meters above mean sea level) during 2019 and 2020 seasons to investigate the effect of four intercropping systems [sole maize,(A)100% maize +50% cowpea on other side of the ridge (CowPea crop was sown in hills 20 cm apart 2plants in hill), (B) 100% maize +50% cowpea on other side of the ridge (cowpea was sown in hills 10 cm apart 1 plants in hill), (C) 100% maize +50% cowpea at the two sides of maize beds120 cm (cowpea crop was sown in hills 20 cm apart 2 plants in hill),(D) 100% maize +50% cow pea at the two rows on the top of maize beds (cowpea was sown in hills 20 cm apart 2 plants in hill), sole cowpea] with three maize hybrids(Single cross 168, Single cross176 and T. W.C 352) on growth, yield and yield components of both crops. Each experiment was carried out in a split-plot design with three replications. Results could be summarized as follow: 1-Maize: Maize hybrids had a significant effect on all studied characters. S.C 168 hybrid gave the tallest plants and the highest values in the two seasons and combined. While T. W.C 352 hybrid gave the shortest plants and the lowest values in two seasons. Intercropping systems had a significant effect on all studied characters in both seasons. The intercropping system (A) showed that the tallest plants in the two seasons. While, the intercropping system (D) showed that the shortest plants seasons. The highest values were obtained at the intercropping system (C). 2-cowpea: Maize hybrids had a significant effect on all studied characters in both seasons. Planting cowpea intercropped with Giza168 hybrid, attained the highest values in plant height, number of leaves, stem diameter, seed yield/fed and crud protein. Giza168 hybrid according the highest value in two seasons 2019 and 2020 respectively. Intercropping systems had a significant effect in all studied characters, the highest values were obtained when cowpea was grown under intercropping system (C), while the lowest values were obtained under system (B) in both seasons. Results revealed that intercropping all maize cultivars under study with cowpea attained the highest values of Land Equivalent Ratio and total income for Giza 168 hybrid gave the highest value under system C) 100% maize +50% cowpea at the two sides of maize beds (cowpea crop was sown in hills 20 cm apart 2 plants in hill) in both seasons.

Keywords: Maize, Intercropping, cowpea, varieties, Productivity, Quality, LER.

1. Introduction

Maize is one of the most important cereal crops grown in Egypt for human consumption and animal feeding. Cowpea is a leguminous crop mainly cultivated for its seeds, which contain high protein percentages. The protein is characterized with its essential amino acids. Indeed, Cowpea is considered useful for many uses and seeds are used as animal feed and the plants as hay silage, pasture and green manure crop.

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Cowpea (*Vigna unguiculata.* L.*)* has been introduced to Egyptian agriculture as promising double purpose forage and seed crop for green canopy or using it in animal diets as dry seed, as well as it is a primary source of protein for humans and animals. It is a high nutritive value and is known in Africa for human consumption. Forage cowpea as summer crop will compete with other summer dominant crops, likely, it has a wide range of compatibility with other crop species in intercropping systems. At the same time, cowpea is solid. Therefore, cowpea intercropping may offer a potential method of incorporating such crop in the Egyptian agricultural structure.

Intercropping of field crops is regarded as an essential practice when several economic field crops are competing for the same limited land area. It is a common practice on small scale farming system in developing countries. Intercropping offers to farmers the opportunity to engage nature's principle of diversity at their farms. Spatial arrangements of plants, planting rates and maturity dates must be considered when planning intercrops. Intercropping can be more productive than growing pure stands. Pest management benefits can also be realized from intercropping due to increased diversity. Many researchers work on intercropping procedures one of them has been emphasized that intercropping is the most effective tool which permits higher grain yields and greater land use efficiency per unit of land area. Moreover, an additional proven benefit from intercropping is the improvement in soil fertility through the addition of nitrogen by fixation from the component legume. A great deal of work has been focused on maize-cowpea intercrops (Takim 2012; HamdAlla *et al*., 2014 and Asmat *et al*., 2007).

The objective of this study was to evaluate the efficiency of three maize cultivars under different intercropping systems with cowpea. Also, to investigate the most efficient maize cultivar for intercropping and the best intercropping system for maximizing the net profit per unit area.

2. Materials and Methods

A field experiment was conducted at the Experimental Farm of Sakha Agricultural Research Station .Agricultural Research Center (A.R.C.), Kafr El-Sheikh Governorate, Egypt, (31^0 07^- N Latitude and 30^0 57^- E longitude with an elevation of about 6 meters above mean sea level) during 2019 and 2020 seasons to study the effect of four intercropping systems (100% maize +50% cowpea at the other side of the ridge (cowpea was sown in hills 20 cm apart 2 plants in hill), 100% maize +50% cowpea at the other side of the ridge (cowpea was sown in hills 10 cm apart 1 plants in hill), 100% maize +50% cowpea at the two sides of maize beds (cowpea was sown in hills 20 cm apart 2 plants in hill), 100% maize +50% cowpea at the two rows on the top of maize beds (cowpea was sown in hills 20 cm apart 2 plants in hill), sole cowpea] with three maize hybrids (Single cross 168, Single cross176 and T. W.C. 352) on growth, yield and yield components of both crops. The soil type was clay with pH value of 8.18 and 1.4% organic matter. Each experiment included sixteen treatments which were the combination of three maize hybrids and four intercropping systems as well as three treatments of pure stand of maize cultivars and one treatment of pure stand of cowpea. Each experiment was carried out in a split-plot design with three replications as follow:

The main plots were occupied with the three maize cultivars:

1- S. c 168 2- S. c 176 3- T. W.C 352

The sub-plots were occupied at random with six growing systems as follow:

1- Sole maize was sown on ridge 60 cm width in hills 30 cm apart one plant in hill (optimum density)
2- Sole cowpea was sown on ridge 60 cm width in hills 10 cm apart one plant in hill in both sides (optimum density).
3- 100% maize +50% cowpea on the other side of the ridge maize was sown in ridge 60 cm width in hills 30 cm apart one plant in hill (optimum density) cowpea was sown in hills 20 cm apart 2 plants in hill), (A).
4- 100% maize +50% cowpea on the other side of the ridge, maize was sown in ridge 60 cm width in hills 30 cm apart one plant in hill (optimum density), cowpea crop was sow in hills 10 cm apart 1 plants in hill), (B).
5- 100% maize +50% cowpea at the two sides of maize beds (120cm), maize was grown on the top of beds in hills 30 cm apart one plant in hill (optimum density), cowpea was sown in hills 20 cm apart 2 plants in hill, (C).

6- 100% maize +50% cowpea at the two rows on the top of maize beds, maize was grown on both sides of beds in hills 30 cm apart one plant in hill (optimum density), cowpea crop was sown in hills 20 cm apart 2 plants in hill. (D).

2.1. Agricultural practices:

The experimental field well prepared two ploughings, Calcium super phosphate (15 % P_2O_5) was applied during soil preparation at the rate of 150 kg/fad, leveling, compaction, division and then divided to the experimental unit which its area was 25.2m^2 consisting of twelve ridges, each of 3.5 m in length and 60 cm in width (1/167 fad)in each of the treatments (1,2,3,4) but treatments (5 and 6) consisting of six beds for each of 3.5 m in length and 120 cm in width (1/167 fad). The preceding winter crop was wheat (*Triticum aestivum,* L.*)* in both seasons. Potassium sulphate (48 % K_2O) at the rate of 24kg /fad was applied before the third irrigation.

Nitrogen in form of ammonium nitrate (33.5%) at the rate of 120 kg N/fed. was added in two equal doses, the first was applied before the second irrigation and the second dose before the third irrigation.

Cowpea seeds were hand sown using the dry sowing method on May 18th and 25th while maize seeds were sown on June 8th and 12th in the first and second seasons, respectively. Plants were kept free from weeds, which were manually controlled by hand hoeing two times. Other cultural practices were performed as recommended. The recorded data could be divided into the following parts:

I. Maize:

At harvest a sample of 10 plants were chosen at random, from each plot to study:
Plant height (cm). Ear length (cm), Ear diameter (cm), Number of rows/ear, Number of grains /row 100-grain weight (g), Grain yield (Ardab/fad.) and Crud Protein (%).

The plants in two ridges of each experimental unit were harvested, collected together, labeled, thrashed and the grain was separated. The grain yield was recorded in kg/square meter and then converted to record.

II. Cowpea:

At harvest, a sample of 10 plants were chosen at random from each plot to study:
Plant height (cm), Number of leaves/plant, Stem diameter, Seed yield (kg /fad), Crud protein (%)

The plants in two ridges of each experimental unit were harvested, collected together, labeled, thrashed and the seeds were separated. The seed yield was recorded in kg/square meter and then converted to record.

III-Competitive relationships and yield advantages:

This was determined according to Mead and Willey (1980).

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

Where:
Yab = Mixture yield of a (when combined with b).
Yaa = Pure stand yield of crop (a)maize
Yba = Mixture yield of b (when combined with a).
Ybb = Pure stand yield of crop (b) cowpea.

IV- Economic evaluation

Farmer's benefit was calculated by determining the total costs and net return of intercropping culture as compared to recommended solid culture of maize.

Total return of intercropping cultures = Price of maize yield + price of cow-pea yield (L.E.).

Net return/fad = Total return – (fixed costs of maize + variable costs of cowpea according to intercropping pattern).

The market price for maize was 750 and 680 LE Ardab and cowpea seeds was 3000 and 3000 LE ton in 2019 and 2020 respectively.

2.2. Statistical analysis:

The collected data of maize and cowpea were subjected to analysis of variance and combined analysis (where the variance of two seasons were homogenous) and the differences among means were determined by Duncan multiple tests, according to Gomez and Gomz (1984).

3. Results and Discussion

3.1. Maize:

3.1.1. Effect of maize cultivars:

Data in Table (1) showed that maize cultivars (Sc.168, Sc.176 and T.w.c 352) had a significant effect on all studied characters in both seasons and combined data. Sc.168 hybrid gave the tallest plants in the two seasons.

Table 1: Growth, grain yield and components of maize as affected by maize hybrids during 2019 and 2020 seasons and the combined data of the two seasons.

Hybrids	Plant Height (cm)	Ear Length (cm)	Ear diameter (cm)	No. of rows/ear
First season				
A_1	211.72 a	19.22 a	4.90a	15.54a
A_2	209.45 b	19.03 b	4.74b	15.31b
A_3	208.11c	18.54 c	4.66c	15.27b
Solid	212.056a	20.093a	4.99b	15.50a
Second season				
A_1	211.79a	19.28b	4.99a	15.54a
A_2	209.83b	19.01 b	4.83b	15.44ab
A_3	208.31c	18.59 c	4.82b	15.37b
Solid	212.16a	20.15a	5.07b	15.53 ab
Combined data of the two seasons				
A_1	211.76a	19.25a	4.95a	15.56 a
A_2	209.64b	19.02b	4.79b	15.37b
A_3	208.21c	18.56c	4.74b	15.32b
Solid	212.11a	20.12b	5.03b	15.58ab

Means followed by the same letter in the some column are not significantly different at the 5 % probability level.
A_1 = S. c 168 **A_2** = S. c 176 **A_3** = T.w. c. 352

Table 1: cont.

Hybrids	No. of grains /row	100 grain weight (g)	Grain yield (ardb)	Crud Protein %
First season				
A_1	38.48 a	37.11 a	26.91a	8.45 a
A_2	38.32 b	36.27b	26.26 b	8.36a
A_3	37.95 c	35.77 c	25.70c	8.17 b
Solid	40.15a	38.18a	28.36a	8.35b
Second season				
A_1	38.60a	37.23a	27.04b	8.47a
A_2	38.44b	36.37b	26.82c	8.41a
A_3	38.08c	35.89c	26.38a	8.23b
Solid	40.15a	38.17a	28.42a	8.38 bc
Combined data of the two seasons				
A_1	38.54 a	37.17 a	26.97a	8.46 a
A_2	38.38 b	36.32 b	26.32 b	8.39 b
A_3	38.01 c	35.83 c	25.76 c	8.20 c
Solid	40.15 a	38.18a	28.39 a	8.36 bc

Means followed by the some letter in the some column are not significantly different at the 5 % probability level.
A_1 = S. c 168 **A_2** = S. c 176 **A_3** = T.w. c. 352

While T.w.c 352 hybrid gave the shortest plants in the same seasons. Concerning the highest values were obtained at S.c 168 hybrid, while the lowest values were recorded for T.w.c 352 at the two seasons, respectively. Differences in growth, grain yield and its components among maize cultivars under this study due to the differences in their genetic makeup, which affected their response to stress conditions and environmental factors that affected biological activities and consequently, the total biomass. Similar results were obtained by Hassan (2000), Nofal and Mobarak (2003) and Nofal and attalla (2006).

3.1.2. Effect of intercropping:

Data in Table (2) indicated that intercropping systems had a significant effect on all studied characters in both seasons and combined data. The intercropping system (B) 100% maize +50% cowpea at the other side of the ridge (cowpea was sown in hills 10 cm apart 1 plants in hill), showed that the shortest plants in the two seasons. While, the intercropping system (D) 100% maize +50% cowpea at the two rows on the top of maize beds (cowpea was sown in hills 20 cm apart 2 plants in hill) also showed that the shortest plants in the two summer seasons. Concerning the yield components the highest values were found at the intercropping system(C) 100% maize +50% cowpea at the two sides of maize beds (cowpea was sown in hills 20 cm apart 2 plants in hill). This result may be due to more light use efficiency of solar radiation utilized by maize plants, which in turn enhances the conversion of light energy to chemical energy and consequently encourages dry matter accumulation.

Table 2: Growth, grain yield and components of maize as affected by intercropping systems during 2019 and 2020 seasons and combined.

Intercropping	Plant Height (cm)	Ear Length (cm)	Ear diameter (cm)	No .of rows/ear
		First season		
A	209.76 c	19.34 b	4.87 c	15.37 b
B	206.78 e	16.84 d	4.28 a	15.16 c
C	211.63 b	20.31a	5.11 a	15.60 a
D	208.58 d	18.04 c	4.57 d	15.23 c
Solid	212.06 a	20.09 a	5.01 b	15.50 a
		Second season		
A	210.01 b	19.27 b	4.97 b	15.50 bc
B	207.02 d	16.88 d	4.97 d	15.27 d
C	211.96 a	20.37 a	5.23 a	15.66 a
D	208.74 c	18.14 c	4.69 c	15.37 cd
Solid	212.16 a	20 .15 a	5.07 a	15.53 ab
		Combined data of the two seasons		
A	209.88 c	19.31 c	4.92 c	15.43 b
B	206.90 e	16.86 e	4.37e	15.21 d
C	211.79 b	20.34 a	5.17 a	15.63 a
D	208.66 d	18.09 d	4.63 d	15.30 c
Solid	212.11a	20.12 b	5.03 b	15.52 b

A; 100% maize +50% cow pea on other side of the ridge 60 cm (cow pea was sown in hills 20 cm apart 2 plants in hill),
B; 100% maize +50% cow pea on other side of the ridge 60 cm (cow pea was sown in hills 10 cm apart 1 plants in hill),
C;100% maize +50% cow pea on two sides of maize beds 120 cm (cow pea was sown in hills 20 cm apart 2 plants in hill),
D; 100% maize +50% cow pea on two rows on the top of maize beds 120 cm (cow pea was sown in hills 20 cm apart 2 plants in hill).

Table 2: cont.

Intercropping	No. of grains /row	100 grain weight (g)	Grain yield (Ardb)	Crud Protein %
		First season		
A	38.08 c	36.13 c	27.82 b	8.39 b
B	36.69 e	35.09 e	26.73 d	8.52 a
C	39.00 b	36.92 b	28.20 a	8.09 c
D	37.33 d	35.58 d	27.33 c	8.28 b
Solid	40.15 a	38.18 a	29.36 a	8.35.b
		Second season		
A	38.22 c	36.28 c	27.94 b	8.46 ab
B	36.82 e	35.23 e	26.86 d	8.58 a
C	39.18 b	37.08 b	28.36 d	8.13 d
D	37.48 d	35.71 d	27.48 c	8.30 c
Solid	40.15 a	38.17 a	29.42 a	8.38 bc
		Combined data of the two seasons		
A	38.15 c	36.21 c	27.88b	8.43 b
B	36.76 e	35.16 e	26.79 d	8.55 a
C	39.09 b	37.00 b	28.28 a	8.11 d
D	37.41 d	35.64 a	27.41 c	8.29 c
Solid	40.15 a	38.18 a	29.39 a	8.36 bc

A; 100% maize +50% cow pea on other side of the ridge 60 cm (cow pea was sown in hills 20 cm apart 2 plants in hill),
B; 100% maize +50% cow pea on other side of the ridge 60 cm (cow pea was sown in hills 10 cm apart 1 plants in hill),
C;100% maize +50% cow pea on two sides of maize beds 120 cm (cow pea was sown in hills 20 cm apart 2 plants in hill),
D; 100% maize +50% cow pea on two rows on the top of maize beds 120 cm (cow pea was sown in hills 20 cm apart 2 plants in hill).

Results of grain yield/fad showed that intercropping in general decreases this trait as compared with sole cropping (Table 2). Intercropping system (B) 100% maize +50% cowpea at the other side of the ridge produced the lowest yield per feddan (cowpea was sown in hills 10 cm apart 1 plants in hill), These results are mainly due to the effect of distribution of plants for both crops per unit area, which resulted in low or high intra and inter specific competition among maize plants, as well as between maize and cowpea plants when intercropped at high densities. Similar results were reported by El-Hawary (1993), Rana *et al*. (2001), Takim (2012), Muneer *et al.* (2004), Muoneke (2007) and Azraf- *et al*. (2007).

3.1.3. Effect of interaction:

Data recorded in Table 3 indicated that the effect of interaction between maize hybrids and intercropping system was significant effect on all studied except crud protein attained the height values with Sc.168 hybrid when planting under system (C) 100% maize +50% cowpea at the two sides of maize beds (cowpea crop was sow in hills 20 cm apart 2 plants in hill). In both seasons 2019,2020. Similar results were obtained by Abd El-Salam and El Habbasha (2008), Raji (2007), Saban *et al.* (2008). The highest crud protein was recorded with Sc.176 with B intercropping system in both seasons and their combined.

Table 3: Growth, grain yield and components of maize as affected by the interaction between intercropping system and maize hybrids during 2019 and 2020 seasons and combined data.

Hybrids	Intercropping	Plant height (cm.)	Ear Length (cm)	Ear iameter (cm)	No.of rows/ear
		First season			
A_1	**A**	212.13 c	19.63 d	5.13 a	15.17fg
	B	210.73 d	17.00g	4.30 f	15.10 fg
	C	213.50 b	20.43a	5.13 a	15.57 abc
	D	211.67 c	18.30e	4.83 cd	15.10 fg
	Solid	210.57d	19.80cd	5.09a	15.62ab
A_2	**A**	208.30 e	19.60d	4.73 de	15.23 af
	B	204.17 h	17.33f	4.23 f	15.00 g
	C	210.63 d	20.40ab	5.07 a	15.50 bcd
	D	207.00 f	18.47e	4.27 f	15.13 fg
	Solid	210.43d	20.27ab	4.99ab	15.46 bcd
A_3	**A**	208.83 e	18.80e	4.73 de	15.70 a
	B	205.43 g	16.20h	4.30 f	15.37 de
	C	210.77 d	20.10bc	5.13 a	15.73 a
	D	207.07 f	17.37f	4.60 e	15.47 bcd
	Solid	215.17a	20.21ab	4.91bc	15.43cd
		Second season			
A_1	**A**	212.23 c	19.53d	5.20 a	15.37 cdefg
	B	210.70 ef	16.87 g	4.47 ef	15.17 g
	C	213.63 b	20.63 a	5.23 a	15.77 a
	D	211.70 cd	18.53 a	4.93 bc	15.23 fg
	Solid	210.70ef	20.28ab	5.16a	15.65ab
A_2	**A**	209.30 g	19.53 d	4.83 cd	15.33 defg
	B	205.97 d	14.43 f	4.50 ef	15.13 g
	C	211.23 de	20.40 ab	5.20 a	15.63 a
	D	207.40 i	18.40 e	4.47 af	15.27 efg
	Solid	215.27i	19.84cd	5.12ab	15.48bcde
A_3	**A**	208.50 h	18.73 e	4.87 cd	15.80 a
	B	204.40 k	16.33 h	4.43 f	15.50 bcde
	C	211.00 ef	20.07 bc	5.27 a	15.57 abcd
	D	207.13 i	17.50 f	4.67 de	15.60 abc
	Solid	210.50f	20.32ab	4.93bc	15.46 bcdef
		Combined data of the two seasons			
A_1	**A**	212.18 c	19.57 d	5.17 ab	15.27 de
	B	210.72 ef	17.38 g	4.38 g	15.13 ef
	C	213.57b	20.53 a	5.18 ab	15.67 ab
	D	211.68 d	18.50 f	4.88 de	15.17 def
	Solid	210.63 ef	20.28abc	5.13ab	15.64 ab
A_2	**A**	209.07 g	19.58 a	4.80de	15.28 d
	B	205.70 d	16.93h	4.37 g	15.07 f
	C	211.00 e	20.40 ab	5.20 a	15.57 bc
	D	207.23 i	18.35 f	4.63 f	15.20 def
	Solid	215.22a	19.82h	4.92 cd	15.47c
A_3	**A**	208.40 h	18.77e	4.78 e	15.75 a
	B	204.28 k	16.27 i	4.37 g	15.43 c
	C	210.82ef	20.08 c	5.13 ab	15.65 ab
	D	207.07 i	17.43g	4.37 g	15.53 bc
	Solid	210.47f	20.27bc	5.06 bc	15.44 c

A; 100% maize +50% cowpea on other side of the ridge 60 cm (cowpea was sown in hills 20 cm apart 2 plants in hill),
B; 100% maize +50% cowpea on other side of the ridge 60 cm (cowpea was sown in hills 10 cm apart 1 plants in hill),
C;100% maize +50% cowpea on two sides of maize beds 120 cm (cowpea was sown in hills 20 cm apart 2 plants in hill),
D; 100% maize +50% cowpea on two rows on the top of maize beds 120 cm (cowpea was sown in hills 20 cm apart 2 plants in hill).

Table 3: cont.

Hybrids	Intercropping	No. of grains /row	100 grain weight (g)	Grain yield (ardb)	Crud Protein %
			First season		
A_1	**A**	37.67 d	37.17b	28.53b	8.63 ab
	B	36.13 g	36.30d	27.43de	8.30 cdef
	C	39.10b	37.37b	29.03a	8.70 a
	D	36.53 f	36.73c	28.20c	8.37 cde
	Solid	40.31a	37.99a	29.37j	8.25def
A_2	**A**	38.23 c	35.87e	27.63d	8.43 bcd
	B	36.63 f	34.80g	26.67g	8.83 a
	C	39.03b	37.13b	28.07c	8.03 g
	D	37.63 d	35.20f	27.13f	8.17 efg
	Solid	40.09a	38.32d	29.79i	8.33cde
A_3	**A**	38.33 c	35.37f	27.30ef	8.10 fg
	B	37.30 e	34.17h	27.10h	8.43 bcd
	C	38.87 b	36.27d	27.50de	7.53 h
	D	37.83 d	34.80g	26.67g	8.30 cdef
	Solid	40.04a	38.24a	28.93 k	8.47bc
			Second season		
A_1	**A**	37.83 e	37.33 b	28.63 a	8.64 bc
	B	36.27 h	36.43 d	27.53 de	8.31 de
	C	39.20 c	37.53 b	29.23 a	8.72 ab
	D	36.73 g	36.83 c	28.40 bc	8.39 de
	Solid	40.35a	38.01a	29.38 j	8.27ef
A_2	**A**	38.37 d	36.00 e	27.77 d	8.52 bcd
	B	36.80 g	34.93 g	26.77 f	8.90 a
	C	39.20 c	37.30 b	28.17 c	8.08 f
	D	37.73 e	35.37 f	27.27 e	8.20 ef
	Solid	40.9ab	38.26a	29.94 k	8.63de
A_3	**A**	38.47 d	35.50 f	27.43 de	8.22 ef
	B	37.40 f	34.33 h	26.27 g	8.53 bcd
	C	39.13 c	36.40 d	27.67 d	7.59 g
	D	37.97 e	34.93 g	26.77 f	8.32 de
	Solid	40.01b	38.26a	28.95j	8.49cd
			Combined data of the two seasons		
A_1	**A**	37.75 ef	35.93 f	28.58 b	8.64 b
	B	36.20 i	34.87 k	27.48 de	8.31 de
	C	39.15 c	37.22c	29.13a	8.71 b
	D	36.63 h	35.28 g	28.30 c	8.38 cd
	Solid	40.33a	38.29a	29.37j	8.26de
A_2	**A**	38.30 d	35.43 g	27.70 d	8.48 c
	B	36.72 h	34.25 i	26.72 g	8.87 a
	C	39.12 c	36.33 e	28.12 c	8.06 f
	D	37.68 f	34.87 k	27.20 f	8.18 ef
	Solid	40.09b	38.25a	29.897i	8.35cd
A_3	**A**	38.40 d	37.25 c	27.37 ef	8.16 ef
	B	37.35 g	36.37 e	26.18 h	8.48 c
	C	39.00 c	37.45 c	27.58 de	7.56 g
	D	37.90e	36.78 d	26.72 g	8.31 de
	Solid	40.03b	37.99b	28.94 k	8.49c

A; 100% maize +50% cowpea on other side of the ridge 60 cm (cow pea was sown in hills 20 cm apart 2 plants in hill),
B; 100% maize +50% cowpea on other side of the ridge 60 cm (cow pea was sown in hills 10 cm apart 1 plants in hill),
C;100% maize +50% cowpea on two sides of maize beds 120 cm (cowpea was sown in hills 20 cm apart 2 plants in hill),
D ; 100% maize +50% cow pea on two rows on the top of maize beds 120 cm (cow pea was sown in hills 20 cm apart 2 plants in hill).

3.2. Cowpea

3.2.1. Effect of maize hybrids

Data in table (4) showed that maize hybrids had a significant effect on all studied characters in both seasons. planting cowpea intercropped with Giza168 hybrid attained the highest values in plant height, number of leaves, stem diameter and seed yield/fed while crud protein were not significantly affected by maize hybrids as shown in tables 4 recorded the highest value in two seasons 2019and 2020 respectively.

Differences in seed yield due to the effect of intra and inter specific competition between cow pea plants and between cowpea and maize plants. Similar results were obtained by Gouda *et al.* (1992), Hassan (2000), Nofal and Mobarak (2003) and Nofal and attalla (2006).

Table 4: Effect of maize hybrids in plant height, No. of leaves/ plant, Stem diameter, Seed yield/fed and Crud protein of cowpea in the two growing seasons.

Hybrids	Plant height (cm)	No. of leaves	Stem diameter (cm)	Seed yield /fed (kg)	Crud protein %
			First season		
A_1	158.10 a	60.76 a	1.63 a	402.87 a	14.51 a
A_2	155.61 b	54.16 b	1.43 b	397.17 b	14.50 a
A_3	143.95 c	50.15 c	1.33 c	373.70 c	14.54 a
			Second season		
A_1	158.29 a	61.01 a	1.66 a	406.20 a	14.78 a
A_2	155.84 b	54 .31 b	1.45 b	398.87 b	14.61 a
A_3	144.37 c	50.32 c	1.35 c	374.97 c	14.68 a
			Combined data of the two seasons		
A_1	158.20 a	60.89 a	1.65 a	404.53a	14.65 a
A_2	155.73b	54.23 b	1.44 b	398.02 b	14.55 a
A_3	144.16c	50.24 c	1.34 c	374.33 c	14.61 a

Means followed by the some letter in the some column are not significantly different at the 5 % probability level.
A_1 = S. c 168 A_2 = S. c 176 A_3 = T.w.c. 352
Solid seed yield/fed in first, second and combined seasons ; 775.23 ،780.42 ،777.825 kg .

3.2.2. Effect of intercropping systems:

Data in Table (5) showed that intercropping systems had a significant effect on all studied characters in two seasons. Plant height, number of leaves, stem diameter and seed yield/fed recorded the highest values when grown cowpea under intercropping system (C). These results mainly attributed to more light use efficiency of solar radiation utilized by cowpea plants, which resulted in minimizing competition between cowpea plants as well as between cowpea and maize plants for light, which in turn enhances the conversion of light energy to chemical energy and consequently encourages the dry matter accumulation, while the higher crud protein obtained its under system (B)100% maize +50% cowpea at the other side of the ridge (cowpea crop was sown in hills 10 cm apart 1 plants in hill) in both seasons. Regarding cowpea seed yield/fad. (Table 5). Intercropping system (C) 100% maize +50% cowpea at the two sides of maize beds120cm (cowpea was sown in hills 20 cm apart 2 plants in hill) out yielded the other system in both seasons. These results may be due to the differences of distribution for both crops per unit area under intercropping systems, which resulted in maximizing the effect of intra and inter specific competition among cowpea plants, also between Cowpea and maize plants, which lead to low light use efficiency of solar radiation utilized by Cowpea, which in turn low in the conversion of light energy to chemical energy and consequently low dry matter accumulation. Similar results were reported by Mohta and R. De (1980) , Galal and Metwally (1982) and Nofal and Attalla (2006).

Table 5: Effect of intercropping system in plant height, No. of leaves/plant, stem diameter, seed yield/fed and crud protein of cowpea in the two growing seasons.

Intercropping	Plant height (cm)	No. of Leaves/ plant	Stem diameter (cm)	Seed yield/fed (kg)	Crud protein %
			First season		
A	152.24 c	54.48 c	1.40b	383.78 b	14.51 b
B	148.07 d	53.86 d	1.35c	366.58 c	14.50 b
C	155.87 a	56.54 a	1.60a	409.16 a	14.54 b
D	154.04 b	55.21 b	1.49b	405.47 a	14.85 a
			Second season		
A	152.63c	54.65c	1.43c	386.84 c	14.58 c
B	148.49 d	54.02d	1.37d	368.89d	15.33 a
C	156.00a	56.78 a	1.63a	411.16a	13.91 d
D	154.22b	55.40 b	1.52b	406.49b	14.93 b
			Combined data of the two seasons		
A	152.44c	54.57c	1.41c	385.31c	14.55 b
B	148.28d	53.94d	1.36d	367.73d	14.92 a
C	155.93a	56.66a	1.62a	410.16a	14.23 c
D	154.13b	55.30b	1.51b	405.98b	14.89 a

A; 100% maize +50% cowpea on other side of the ridge 60 cm (cow pea was sown in hills 20 cm apart 2 plants in hill),
B; 100% maize +50% cowpea on other side of the ridge 60 cm (cowpea was sown in hills 10 cm apart 1 plants in hill),
C;100% maize +50% cowpea on two sides of maize beds 120 cm (cow pea was sown in hills 20 cm apart 2 plants in hill),
D; 100% maize +50% cow pea on two rows on the top of maize beds 120 cm (cow pea was sown in hills 20 cm apart 2 plants in hill).

3.2.3. Effect of interaction:

Data recorded in Table (6) indicated that the effect of interaction between intercropping systems and maize hybrids was significant for plant height, number of leaves/ plant , stem diameter and yield/fad, which attained the highest values when planting cowpea intercropped with Giza 168 hybrid under system(C) 100% maize +50% cowpea at the two sides of maize beds (cowpea was sown in hills 20 cm apart 2 plants in hill) in both seasons also Sc. 168 recorded the highest value of crud protein % but with (B) intercropping system. Similar results were obtained by Galal and Metwalley (1982), Adeniyan and Ayoola (2007) and Naveed *et al*. (2000).

3.3. Competitive relationships and yield advantage

Competitive relationships and total income of intercropping maize hybrids with cow pea cleared its results as in Table 7:

Intercropping maize (Singel cross 168 with cowpea) produced the highest values of land equivalent ratio (1.57, 1.53, and 1.53) and total income (24990.4, 23118.3, and 24057.85LE) in the first and second seasons and their combined respectively, under system (C) 100% maize + 50% cowpea at the two sides of maize beds (cowpea was sown in hills 20 cm apart, 2 plants in a hill).

Similar results were obtained by Moursi *et al*. (1983) and Nawar and Al-kafoury (2002), willey (1979) and Ghosh (2004).

Table 6: Effect of interaction between maize hybrids and Intercropping system in plant height, No. of leaves/plant, Stem diameter, Seed yield/fed and Crud protein of cowpea in the two growing seasons.

Hybrids	Intercropping	Plant height (cm.)	No. of Leaves/ plant	Stem diameter (cm)	Seed yield /fed (kg)	Crud protein %
			First season			
	A	157.75c	60.31b	1.52 cd	395.60 c	14.35 d
A_1	**B**	155.04d	59.35c	1.49 cs	377.87cf	15.39 a
	C	160.28a	62.48a	1.81a	420.13a	13.41c
	D	159.34ab	60.90b	1.70 b	417.87 a	14.91 bc
	A	155.27d	53.21f	1.38 ef	383.87 dc	14.51 cd
A_2	**B**	151.54c	52.70f	1.31 fg	378.53ef	15.19 ab
	C	158.45bc	56.18d	1.55 c	418.93 a	13.57 c
	D	157.20c	54.56c	1.49 cd	407.33 b	14.73 bcd
	A	143.71h	49.92h	1.31 fg	371.87f	14.56 cd
A_3	**B**	137.63i	49.54h	1.25 g	343.33g	15.12 ab
	C	148.87f	50.97g	1.45 dc	388.40cd	13.57c
	D	145.58g	50.17gh	1.29 g	391.20cd	14.92 abc
			Second season			
A_1	**A**	157.98c	60.52b	1.56 cd	399.60 c	14.48 cdef
	B	155.33d	59.54c	1.52 cd	382.13 fg	15.49 a
	C	160.34a	62.78a	1.84 a	421.87 a	14.17 def
	D	159.50ab	61.21b	1.73 b	421.20 a	14.97 abcd
A_2	**A**	155.64d	53.33 f	1.40 c	386.00 cf	14.60 bcde
	B	151.73c	52.83 f	1.33 cf	379.33 gh	15.31 ab
	C	158.57c	56.45 d	1.57 c	419.73 c	13.71 f
	D	157.44c	54.61c	1.51 cd	410.40 b	14.81 abcd
A_3	**A**	144.27g	50.11h	1.32 f	374.93 b	14.67 bcd
	B	138.42h	49.69 h	1.27 f	345.20 i	15.19 abc
	C	149.07f	51.11g	1.49 d	391.87d	13.86 cf
	D	145.71g	50.38 gh	1.32 f	387.87 dc	15.01 abc
			Combined data of the two seasons			
A_1	**A**	157.87cd	60.42c	1.54cd	397.60c	14.42c
	B	155.19c	59.45d	1.51dc	380.00f	15.44a
	C	160.31a	62.63a	1.83a	421.00a	13.79f
	D	159.42ab	61.05b	1.71b	419.53a	14.94bcd
A_2	**A**	155.45c	53.27g	1.39f	384.93e	14.55de
	B	151.63f	52.77g	1.32g	378.93f	15.25ab
	C	158.51bc	56.32g	1.56g	419.33a	13.64f
	D	157.32d	54.59f	1.50de	408.87b	14.77cde
A_3	**A**	143.99i	50.02ij	1.31gh	373.40g	14.62dc
	B	138.03j	49.61j	1.26h	344.27h	15.16abc
	C	148.97g	51.04h	1.47e	390.13d	13.72f
	D	145.65h	50.27i	1.31gh	389.53de	14.96bcd

Table 7: Effects of maize hybrids and intercropping system with cowpea on LER and Economic evaluation.

Treatments		Relative yield (RY)		LER	Gross return For maize	Gross return For cow pea	Total return	Net return
Hybrids	**Intercropping system**	**Maize**	**Cow pea**					
				First season				
S.c. 168	**A**	0.97	0.51	1.48	21397.5	11516.1	32913.6	23563.6
	B	0.93	0.49	1.42	20572.5	11355.9	31928.4	22578.4
	C	1.01	0.56	1.57	21772.5	12567.9	34340.4	24990.4
	D	1.03	0.54	1.55	21150	12219.9	33369.9	24019.9
S.c 176	**A**	0.94	0.5	1.44	20722.5	11868	32590.5	23240.5
	B	0.94	0.49	1.43	20002.5	11336.1	31338.6	21988.6
	C	0.95	0.56	1.51	21052.5	12603.9	33656.4	24306.4
	D	0.92	0.53	1.45	20347.5	12536.1	32883.6	23533.6
T.w.c.352	**A**	0.93	0.48	1.41	20475	11156.1	31631.1	22281.1
	B	0.9	0.44	1.34	20325	10299.9	30624.9	21274.9
	C	0.98	0.5	1.48	20625	11652	32277	22927
	D	0.91	0.52	1.43	20002.5	11736	31738.5	22388.5
				Second season				
S.c. 168	**A**	0.97	0.49	1.47	19468.4	11580	31048.4	21698.4
	B	0.94	0.49	1.42	18720.4	11379.9	30100.3	20750.3
	C	0.99	0.54	1.53	19876.4	12591.9	32468.3	23118.3
	D	0.97	0.53	1.49	19312	12312	31624	22274
S.c 176	**A**	0.93	0.51	1.44	18883.6	11988	30871.6	21521.6
	B	0.89	0.49	1.38	18203.6	11463.9	29667.5	20317.5
	C	0.94	0.54	1.48	19155.6	12656.1	31811.7	22461.7
	D	0.91	0.54	1.45	18543.6	12636	31179.6	21829.6
T.w.c.352	**A**	0.95	0.48	1.43	18652.4	11247.9	29900.3	20550.3
	B	0.91	0.44	1.35	17863.6	10356	28219.6	18869.6
	C	0.96	0.5	1.46	18815.6	11756.1	30571.7	21221.7
	D	0.92	0.5	1.42	18203.6	11636.1	29839.7	20489.7
				Combined data of the two seasons				
S.c. 168	**A**	0.97	0.5	1.47	20434.7	11547.9	31982.6	22632.6
	B	0.94	0.49	1.42	19648.2	11367.9	31016.1	21666.1
	C	0.99	0.54	1.53	20827.95	12579.9	33407.85	24057.85
	D	0.96	0.53	1.49	20234.5	12266.1	32500.6	23150.6
S.c 176	**A**	0.93	0.51	1.44	19805.5	11928	31733.5	22383.5
	B	0.89	0.49	1.38	19104.8	11400	30504.8	21154.8
	C	0.94	0.54	1.48	20105.8	12630	32735.8	23385.8
	D	0.91	0.54	1.45	19448	12585.9	32033.9	22683.9
T.w.c.352	**A**	0.95	0.48	1.43	19569.55	11202	30771.55	21421.55
	B	0.9	0.44	1.35	18718.7	10328.1	29046.8	19696.8
	C	0.95	0.5	1.45	19719.7	11703.9	31423.6	22073.6
	D	0.92	0.5	1.42	19104.8	11685.9	30790.7	21440.7

Total income for solid crops: maize S.c. 168 , S.c 176, T.c.352 : LE 22342.5, 22027.5 and 21697.5 respectively in 2019 season LE120359.2, 19978.4and 19686 respectively in 2020 season LE 21376.36, 20999.55 and 20692.1 respectively in Combined data of the two seasons.. Cowpea LE 22500, 20400 and 21450 respectively in two seasons and combined.

Conclusion

From the previous results, we observed that intercropping maize (Single Cross 168 hybrid) with cowpea under system (C) 100% maize +50% cowpea at the two sides of maize beds 120 cm (cowpea was sown in hills 20 cm apart 2 plants in hill) attained the highest values of yield and components, land equivalent ratio and total income for in 2019 and 2020 seasons.

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