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Growth, Yield and its Components, Chemical Constituents, Correlation Coefficient and Competition Indices of Okra and Cowpea as Influenced by Different Intercropping Systems

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ABSTRACT

This investigation was conducted at the Agriculture Experimental Farm of Faculty of Agriculture, Zagazig University for two successive seasons of 2014 and 2015 aiming to evaluate different intercropping systems between okra and cowpea; viz., 1:1, 1:2, 1:3 and 2:2 as well as sole planting of each crop on growth, yield and its components, chemical constituents and correlation coefficient as well as competitive indices of okra and cowpea plants. Results revealed that in most cases the highest values of all recorded parameters (total dry weight per plant, pod number and green pod yield per plant and nitrogen, potassium, total carbohydrates and total protein percentages of okra plants) were recorded when okra plants were intercropped in the system of 1:1 (okra : cowpea). Also, the same trend were achieved by 2:2 system which followed by 1:1system for cowpea parameters, whereas, intercropping system at 2:2 gave the highest values of total dry weight per plant, dry seed yield per plant, N, P, K, total protein of cowpea followed by 1:1 system. In addition, green pod yield per okra plant as well as dry seed yield per cowpea plant showed positive and highly significant correlation with most parameters of each component under study during both seasons. The highest values of land equivalent ratio (LER), area time equivalent ratio (ATER) and land utilization efficiency (LUE) were belonged to intercropping system of 2:2 okra and cowpea followed by intercropping system of 1:1 treatment without any significant difference between them. These two treatments seemed to be promising for high advantage yield.

Key words: Okra, cowpea, intercropping system, growth, yield, correlation and competitive indices

Introduction

Okra (*Abelmoschus esculentus*, L.; Moench) belongs to Malvaceae family and is an important fruit vegetable crop of the tropical and subtropical regions of the world. Okra is also known as Lady's finger and locally it is called Bamia. It is one of the oldest cultivated crops and presently grown in many countries and is widely distributed from Africa to Asia, southern Europe and America. It has been grown for its edible green pods which can be used as fresh, canned, frozen, or dried food (Kumar *et al.*, 2013).

Cowpea (*Vigna unguiculata*, L.; Walp) is an important grain legume in Egypt. It is commonly cultivated as a nutritious and highly palatable food source in the southern United States, Middle East, Africa, Asia, and throughout the tropics and subtropics. The seed is reported to contain 24% crude protein, 53% carbohydrates, and 2% fat (FAO, 2012). Cowpea grows rapidly, reaching a height of 19–24 inches (48–61 cm) when grown under favorable conditions (Singh *et al.*, 2003). The leaves and flowers can also be consumed.

Multiple cropping has been practiced for centuries by small-scale farmers in Africa to reduce the risk of crop failure, attain higher yields, and to improve soil fertility (Litsinger and Moody, 1976). Intercropping, through more effective use of water, nutrients and solar energy, can significantly enhance crop productivity compared to the growth of sole crops (Midmore, 1993).

In intercropping systems involving a legume and a non-legume, part of the nitrogen fixed in the root nodule of the legume may become available to the non-legume component (Li *et al.*, 2009). Therefore productivity normally is potentially enhanced by the inclusion of a legume in the cropping system (Maingi *et al.*, 2001). Various indices such as land equivalent ratio (LER), area time equivalent

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ratio (ATER), aggressivity (A) and land utilization efficiency (LUE) have been developed to describe the competition and possible economic advantage in intercropping (Mead and Willey, 1980; Hiebesch and McCollum, 1987; Ghosh, 2004). Mathematical indices can help researchers to summarize, interpret, and display the results from plant competition trials (Weigelt and Jolliffe, 2003).

Intercropping of cowpea with okra enhanced for growth and yield of cowpea varieties compared to sole cropping (Odedina *et al.*, 2014). Intercropping ensures efficient utilization of light and other resources, reduces soil erosion, suppresses weed growth and thereby helps to maintain greater stability in crop yield in okra / cowpea intercropping (Susan and Mini, 2005).

Advantages of intercropping with legumes have been demonstrated in numerous studies; tomato or okra with cowpea (Olasantan, 1991). Leguminous plants currently present very good opportunity in sustainable maintenance of soil fertility. Of the various leguminous crops, cowpea appears to be one of the most important crops in playing this role (IITA, 1990).

Correlation is a measure of the relationship between two or more variables. Also, the measurement scales used should be at least interval scales, but other correlation coefficients are available to handle other types of data. Correlation coefficients can range from -1.00 to +1.00. Furthermore, the value of -1.00 represents a perfect negative correlation while a value of +1.00 represents a perfect positive correlation but a value of 0.00 represents a lack of correlation. The values < 0.40 means week relationships, the values between 0.40- 0.70 means average relationships and the values > 0.70 means strong relationships between the different parameters. However, this relation some time could be determined very easily, but often must be determined exactly (Zaprianov, 1983).

Therefore, the goal of the present study was to assess the opportunity of introducing okra/cowpea mixed cropping as a means of sustainable intensification of crop production in the farming systems of Egypt. The specific objectives were to compare the growth, yield components, chemical constituents and correlation coefficient of okra/cowpea mixed cropping compared to sole planting, and to examine the competitive indices of okra/cowpea in intercrops by using LER, ATER, LUE and aggressivity measures.

Materials and Methods

The present study was conducted at the Agriculture Research Farm, Faculty of Agriculture, Zagazig University, Egypt during the two successive summer seasons of 2014 and 2015, to investigate the effect of intercropping systems of okra (cv. Balady Ahmer) and cowpea (cv. Cream 7) on growth parameters, yield and its components, chemical constituents and correlation coefficient as well as competitive relationships; i.e.; land equivalent ratio (LER), area time equivalent ratio (ATER) and land utilization efficiency (LUE) and aggressivity (A) in cropped okra and cowpea under Sharkia Governorate conditions.

The soil was clay in texture, it comprised of 43.49% clay, 9.10% silt, 13.52% fine sand and 33.89% coarse sand (average of two seasons). The chemical properties of farm soil were pH (7.82), organic matter (0.52%) and available nitrogen (18.9 ppm) which were determined according to Chapman and Pratt (1978).

The intercropping pattern treatments were sole cropping system of either okra or cowpea which used as control for both components characters, one row of okra alternated with one row of cowpea (1:1), one row of okra alternated with two rows of cowpea (1:2), one row of okra alternated with three rows of cowpea (1:3) and two rows of okra alternated with two rows of cowpea (2:2). The six treatments were arranged in a randomized complete block design with three replicates.

The experimental unit area was 10.8 m^2 included twelve rows. Each row was 60 cm wide and three meters in length. The seeds were sown in hills on one side of the row, and hills spaced 40 cm for okra plants and 30 cm for cowpea plants, a part.

Seeds of okra and cowpea crops were sown on 15th May in both seasons. The seeds were handily sown, then immediately irrigated. After three weeks from planting, plants were thinned to be one plant / hill for each crop. The source of okra cv. Balady Ahmer and cowpea cv. Cream 7 were Mecca Trade Co., Cairo, Egypt. All the plants received normal agricultural practices whenever they needed according to the instruction laid down by the Ministry of Agriculture, Egypt.

Recorded Data

Growth characters:

The outer two rows (1^{st} and 12^{th}) of each experimental unit were considered as a belt. Plant height (cm), number of branches / plant, number of leaves / plant, total plant dry weight (g) of okra and cowpea were estimated at 120 and 90 days after sowing, respectively, by taking 3 random guarded plants from each experimental unit as well as root length (cm) of okra plants.

Yield and its components:

At harvesting stage (60 days after sowing), pods number / plant, average pod weight (g), pod length (cm) and green pod yield per plant (g/plant) were determined, then green pod yield per feddan (kg/fed) was calculated for okra plants. Also, at harvesting stage (120 days after sowing), pods number / plant, 100 seeds weight (g), seed number per pod and dry seed yield per plant (g/plant) were determined, then dry seed yield per feddan (kg/fed) was calculated for cowpea plants (feddan = 0.42 hectar).

Chemical analysis:

A sample of dry pods and seeds was randomly taken from each treatment for chemical analysis for okra and cowpea, respectively. Furthermore, total nitrogen (%) was determined in dry pods and seeds according to the methods described by Chapman and Pratt (1978), carbohydrate percentage was determined according to the method described by Dubois *et al.* (1956). Phosphorus percentage was determined according to the methods adapted by Hucker and Catroux (1980). Potassium percentage was determined by using flame photometer according to the method described by Brown and Lilleland (1946). Total protein percent was calculated as (N % × 6.25).

Correlation coefficient:

Simple correlation coefficients between some growth, yield components as well as carbohydrates percentage and fruit or seed yield per plant of okra and cowpea plants, respectively, under the effect of intercropping system treatments according to Guler *et al.* (2001).

Competitive relationships: Various competition indices were determined as follows:

Land equivalent ratio (LER)

This parameter gives an indication to the relative land area required, as sole cropping, to produce the same yields achieved by intercropping. When the LER is greater than one, the intercropping favors the growth and yield of the species. In contrast, when LER is lower than one the intercropping negatively affects the growth and yield of the intercropped plants. It was determined for okra and cowpea yields recorded per feddan according to Mead and Willey (1980) equation as follows:

$$\text{LER okra. cowpea} = Lo + Lc\ ,$$

$$Lc = \frac{Yoc}{Yoo}\ ,\quad Lf = \frac{Yco}{Ycc}$$

Where:
Lo and Lc are the relative green pod yield of okra and dry seed cowpea, respectively. Yoo and Ycc are the green pod yield per feddan of okra and dry seed cowpea sole crops, respectively. Yoc and Yco are the green pod yield of okra and dry seed cowpea, respectively, as intercrops.

Area time equivalent ratio (ATER)

It was calculated according to Hiebech and McCollum (1987) equation as follows:

$$\text{ATER} = \frac{\text{Yoc}/\text{Yoo}\times \text{to} + \text{Yco}/\text{Ycc}\times \text{tc}}{\text{T}}$$

Where:

Yoc = intercropped green pod yield of okra, Yoo = sole green pod yield of okra, Yco = intercropped dry seed yield of cowpea, Ycc = sole dry seed yield of cowpea, to = the duration of okra in days, tc = the duration of cowpea in days, and T= the total duration of intercropping system in days.

Land utilization efficiency (LUE%)

By using LER and ATER values, the land utilization efficiency (LUE %) was calculated according to Mason *et al.* (1986) equation as follows:

$$\text{LUE} = \frac{\text{LER}\times\text{ATER}}{2}\times 100$$

Aggressivity (A)

Aggressivity value was calculated according to Mc Gilchrist (1965) equation as follows:

1. For combination of 50:50 and 100:100, they were calculated according to the following equations:

$$\text{Aoc} = \text{Lo} - \text{Lc}\ ,\quad \text{Aco} = \text{Lc} - \text{Lo}$$

2. For the other combination ratios, the used equations were:

$$\text{Aoc} = \frac{\text{Yoc}}{\text{Yoo}\times\text{Zoc}} - \frac{\text{Yco}}{\text{Ycc}\times\text{Zco}}$$

$$\text{Aco} = \frac{\text{Yco}}{\text{Ycc}\times\text{Zco}} - \frac{\text{Yoc}}{\text{Yoo}\times\text{Zoc}}$$

Where:

Yoc = green pod yield of okra intercropped with cowpea, Yco = dry seed yield of cowpea intercropped with okra, Yoo = sole green pod yield of okra, Ycc = sole dry seed yield of cowpea, Zoc = sowing proportion of okra and Zco = sowing proportion of cowpea.

Statistical Analysis

All collected data were subjected to analysis of variance and means of treatments were compared with the least significant difference (LSD) test at $P\leq 0.05$. The statistical calculations were performed with statistic software version 9 (Analytical Software, 2008).

Results and Discussion

Effect of intercropping system treatments on okra plants

Growth parameters

Data presented in Table 1 indicate that in most cases using any of applied intercropping system gave higher plant height (cm), number of both branches and leaves per plant total dry weight (g) and root length (cm) than sole crop of okra. The highest values in this regard were recorded with the intercropping system of okra + cowpea (1:1 system) during both seasons. The increases in total dry weight of okra about 28.35 and 24.39 % for the intercropping system at 1:1 over the sole okra in the 1sr and 2nd seasons, respectively. These results are in harmony with those found by Tohura *et al.* (2014) on mungbean intercropped with maize plants, Abd El-Latif (2015) on cowpea when intercropped with maize plants, Adafre (2016) on maize intercropped with haricot bean and Abdelkader and Mohsen (2016) on fennel intercropped with onion.

This may be attributed to the increase in the availability of light to okra plant which increased the production of photosynthates and their reflection on the plant growth, beside the direct transfer of fixed N_2 from cowpea to okra plants.

Table 1: Effect of intercropping system treatments on vegetative growth parameters of okra during 2014 and 2015 seasons

Intercropping system treatments	Plant height (cm)	Number of branches / plant	Number of leaves / plant	Total dry weight / plant (g)	Root length (cm)
	Season 2014				
Sole okra	131.83C	5.67 BC	49.00 B	60.90 C	41.00 C
1 row okra :1 row cowpea	145.83A	7.67 A	65.33 A	78.17 A	48.93 A
1 row okra :2 rows cowpea	136.00BC	6.33 B	55.00 B	70.70 B	42.90BC
1 row okra :3 rows cowpea	139.33B	6.33 B	54.67 B	69.75 B	45.57AB
2 rows okra :2 rows cowpea	136.67BC	5.00 C	49.33 B	63.76 C	41.00 C
	Season 2015				
Sole okra	133.72 C	5.33 B	50.00 C	62.07 D	39.17 B
1 row okra :1 row cowpea	138.83 A	7.33 A	66.67 A	77.21 A	45.87 A
1 row okra :2 rows cowpea	135.67 BC	6.67 A	58.33 B	70.04 B	45.42 A
1 row okra :3 rows cowpea	137.33 AB	6.33 AB	53.33 BC	68.37BC	46.00 A
2 rows okra :2 rows cowpea	134.33 C	5.33 B	50.67 C	65.02CD	40.77 B

** Means having the same letter (s) within the same column are not significantly different according to LSD for all-pairwise comparisons test at 5% level of probability.*

Yield and its components

As shown in Table 2, all intercropping applied systems were more effective in enhancing the average number of green pod /plant, average of green pod weight, pod length and green pod yield / plant than sole planting system of okra.

Table 2. Effect of intercropping system treatments on green pod yield and its components of okra during 2014 and 2015 seasons

Intercropping system treatments	Green pod number / plant	Average green pod weight (g)	Pod length (cm)	Green pod yield / plant (g)	Green pod yield / fed. (ton)
	Season 2014				
Sole okra	58.48 C	5.72 C	4.16 B	323.10D	5.67 A
1 row okra :1 row cowpea	90.53 A	6.17 A	5.13 A	535.97A	4.69 B
1 row okra :2 rows cowpea	81.47 B	6.33 A	4.53 AB	516.01B	3. 01 D
1 row okra :3 rows cowpea	78.72BC	5.97 B	4.03 B	472.23C	2.11 E
2 rows okra :2 rows cowpea	75.81 B	6.28 A	4.10 B	461.50C	4.04 C
	Season 2015				
Sole okra	58.53 D	5.48 AB	4.33 B	349.77 D	6.12 A
1 row okra :1 row cowpea	88.20 A	5.75 A	5.20 A	542.63 A	4.75 B
1 row okra :2 rows cowpea	78.12 B	5.63 AB	4.20 B	502.70 B	2.93 D
1 row okra :3 rows cowpea	75.87 B	5.55 AB	4.17 B	485.57 B	2.12 E
2 rows okra :2 rows cowpea	70.44 C	5.22 B	4.23 B	464.83 C	4.07 C

** Means having the same letter (s) within the same column are not significantly different according to LSD for all-pairwise comparisons test at 5% level of probability.*

The highest significant values in this connection were observed with intercropping system of okra: cowpea (1:1) in most cases. On the other side, the highest green pod yield of okra/fed. was recorded with sole okra planting during both seasons. Maffei and Mucciarelli (2003) on peppermint when intercropped with soybean, Abdelkader and Mohsen (2016) on coriander intercropped with onion, also, HongJiao *et al.* (2011) on cabbages when intercropped with garlic, Abdelkader and Hassan (2016) on dill intercropped with fenugreek and Raei *et al.* (2017) on soybean intercropped with maize came to similar results.

Concerning green pod yield/fed., it was found that pure stand yield of okra gave the highest yield of green pod per feddan. The decreases in gre en pod yield of okra were about 17.29 and 22.39 % for intercropping system at 1:1, 46.92 and 52.13 % for intercropping system at 1:2, 62.79 and 65.33 % for intercropping system at 1:3 and 28.75 and 33.50 % for intercropping system at 2:2 over the sole okra in the 1st and 2nd seasons, respectively. This result seems to be conflicted with the above mentioned result which suggested that intercropping system of okra + cowpea (1:1) produced the highest values of growth parameters as well as yield components. These paradoxical results can be interpreted in the light of that the higher population of okra plants within area unit (feddan) in sole okra system could be compensated the lack of fruit yield/plant in these treatments compared with 1:1 row ratio.

Chemical constituents

Data in Table 3 reveal that the differences in N, P, K, total carbohydrates and total protein percentages of okra dry pods among intercropping systems were significant. In addition, the highest values in this regard were obtained with the system of okra + cowpea (2:2 system) which followed by 1:1 system during both seasons in most cases. It is worth to mention that all intercropping systems surpassed the sole crop of okra concerning these parameters. These results are in accordance with those found by Nawar and Abdel-Galil (2008) when intercropped sunflower with soybean, Megawer *et al.* (2010) on barley intercropped with lupine or chickpea and Nurbakhsh *et al.* (2013) on sesame intercropped with bean.

Table 3: Effect of intercropping system treatments on chemical constituents of okra dry pods during 2014 and 2015 seasons

Intercropping system treatments	Nitrogen percentage	Phosphorus percentage	Potassium percentage	Protein percentage	Total carbohydrates percentage
	Season 2014				
Sole okra	1.95 D	0.417 D	1.86 D	12.19 D	29.93 B
1 row okra :1 row cowpea	2.44 B	0.536 B	2.30 B	15.25 B	31.93 AB
1 row okra :2 rows cowpea	2.36 C	0.489 C	2.15 C	14.75 C	30.47 B
1 row okra :3 rows cowpea	2.46 B	0.515 B	2.20 C	15.37 B	31.90 AB
2 rows okra :2 rows cowpea	2.62 A	0.595 A	2.42 A	14.12 A	33.10 A
	Season 2015				
Sole okra	2.02 C	0.417 B	1.96 C	12.62 C	30.60 C
1 row okra :1 row cowpea	2.48 A	0.512 A	2.27 A	15.50 A	32.27 AB
1 row okra :2 rows cowpea	2.30 B	0.496 A	2.13 B	14.37 B	31.13 C
1 row okra :3 rows cowpea	2.42 A	0.501 A	2.27 A	15.12 A	31.23 BC
2 rows okra :2 rows cowpea	2.26 B	0.518 A	2.35 A	14.12 B	32.43 A

** Means having the same letter (s) within the same column are not significantly different according to LSD for all-pairwise comparisons test at 5% level of probability.*

Correlation coefficient

The results of simple correlation coefficients between some characters of okra plants viz., green pod yield per plant, number of both branches and leaves per plant, total dry weight per plant, pod diameter and length as well as total carbohydrates percentage are presented in Table 4. It is clear that green pod yield per okra plant showed positive and insignificant correlation with pod length, whereas, it showed positive and highly significant correlation with number of both branches and leaves per plant and total dry weight per plant. Also, there was positive and highly significant relation between number of branches and number of leaves per plant as well as total dry weight per plant. But it recorded positive and insignificant pertinence with total carbohydrates percentage during both seasons. In addition, total dry weight per plant exhibited highly significant and positive correlation with pod diameter. However, these results are in agreement with those stated by Meawad *et al.* (2004) on roselle intercropped with guar.

Table 4: Simple correlation coefficients between green pod yield per okra plant and some growth parameters, green pod yield as well as total carbohydrates under the effect of intercropping system treatments during 2014 and 2015 seasons

Parameters	1	2	3	4	5	6
	Season 2014					
Y. Green pod yield per plant (g)	0.479	0.591*	0.825**	0.710**	0.443	0.383
1. Number of branches / plant		0.884**	0.802**	0.421	0.599*	0.178
2. Number of leaves / plant			0.820**	0.402	0.690**	0.122
3. Total dry weight / plant (g)				0.660**	0.578*	0.137
4. Pod diameter (cm)					0.118	0.169
5. Pod length (cm)						0.061
6. Total carbohydrates percentage						
	Season 2015					
Y. Green pod yield per plant (g)	0.661**	0.708**	0.842**	0.689**	0.401	0.503*
1. Number of branches / plant		0.844**	0.778**	0.646**	0.417	0.071
2. Number of leaves / plant			0.882**	0.771**	0.713**	0.251
3. Total dry weight / plant (g)				0.772**	0.716**	0.472
4. Pod diameter (cm)					0.734**	0.589*
5. Pod length (cm)						0.503*
6. Total carbohydrates percentage						

*** = Highly significant at 0.01. * = Significant at 0.05.*

Effect of intercropping system treatments on cowpea plants

Growth parameters

It is quite clear from the data in Table 5 that in most cases using of 2:2 cropping system followed by using of 1:1 cropping system (okra + cowpea) resulted in significant increase in number of both leaves and branches per plant and total dry weight per plant compared with sole cowpea planting pattern and other intercropping treatments. Furthermore, all intercropping system increased the abovementioned parameters compared to sole planting system of cowpea. The increases in total dry weight per plant of cowpea were about 33.80 and 17.90 % for intercropping system at 2:2 and 27.08 and 13.57 % for intercropping system at 1:1 over the sole cowpea in the 1st and 2nd seasons, respectively. These results are in similar with those stated by Sarkar and Raghav (2010) on capsicum when intercropped with maize and Abdelkader and Hamad (2015) on safflower intercropped with fenugreek.

Yield and its components

Results under discussion in Table 6 indicate that, in many cases alternating two rows of okra with two rows of cowpea treatment (2:2) followed by intercropping system (1:1) significantly increased pods number per plant, weight of 100 seeds, seed number per pod and seed yield per plant compared with the other ones under study during both seasons. However, dry seed yield of cowpea per feddan significantly decreased with intercropping system treatments compared to sole crop system in the first and second seasons, where sole crop gave the highest values of dry seed yield / fed. Followed by intercropping system 2:1. The decrease in dry seed yield of cowpea were about 39.15 and 40.28 % for intercropping system at 1:1, 66.06 and 65.56 %% for intercropping system at 1:2, 70.99 and 71.38 %% for intercropping system at 1:3 and 34.47 and 37.45 % for intercropping system at 2:2 over the sole cowpea in the1st and 2nd seasons, respectively. Odhiambo and Ariga (2001) reported that, when maize intercropped with beans in different row ratios, the production was increased due to reducing competition between the two species compared competition within specie. These results are in line with those found by Megawer, *et al.* (2010) on barley intercropped with lupin. These results are in accordance with those reported by Agegnehu, *et al.* (2008) when wheat intercropped with faba bean.

Table 5: Effect of intercropping system treatments on vegetative growth parameters of cowpea plant during 2014 and 2015 seasons

Intercropping system treatments	Plant height (cm)	Number of branches / plant	Number of leaves / plant	Total dry weight / plant (g)
	Season 2014			
Sole cowpea	53.97 B	6.67 C	46.67 C	22.37 D
1 row okra :1 row cowpea	59.53 A	8.67 AB	53.00 AB	29.70 A
1 row okra :2 rows cowpea	57.97 A	7.33 BC	49.33 BC	25.17 C
1 row okra :3 rows cowpea	58.03 A	7.33 BC	50.67 BC	27.22 B
2 rows okra :2 rows cowpea	59.53 A	9.67 A	56.33 A	31.27 A
	Season 2015			
Sole cowpea	56.30 A	6.33 D	48.33 D	27.03 B
1 row okra :1 row cowpea	57.73 A	8.33 AB	54.67 B	30.70 A
1 row okra :2 rows cowpea	56.30 A	7.00 CD	50.67 B	24.50 C
1 row okra :3 rows cowpea	59.03 A	7.67 BC	52.00 BC	28.55 B
2 rows okra :2 rows cowpea	58.87 A	9.33 A	58.67 A	31.87 A

** Means having the same letter (s) within the same column are not significantly different according to LSD for all-pairwise comparisons test at 5% level of probability.*

Table 6: Effect of intercropping system treatments on dry seed yield and its components of cowpea plant during 2014 and 2015 seasons

Intercropping system treatments	Pods number / plant	100 seeds weight (g)	Dry seeds number/ pod	Dry seed yield / plant (g)	Seed yield / fed. (Kg)
	Season 2014				
Sole cowpea	80.00 C	16.50 C	7.67 D	49.37 C	1152 A
1 row okra :1 row cowpea	111.67A	18.33 B	10.67AB	60.07 B	701 C
1 row okra :2 rows cowpea	97.67 B	17.33 BC	8.67 CD	50.33 C	391 D
1 row okra :3 rows cowpea	101.67B	17.67 BC	9.67 BC	57.30 B	340 E
2 rows okra :2 rows cowpea	113.33A	20.33 A	11.33 A	64.73 A	755 B
	Season 2015				
Sole cowpea	86.67 D	17.67 B	8.33 B	50.03 C	1167 A
1 row okra :1 row cowpea	109.00B	19.00 B	10.00A	59.73 A	697 B
1 row okra :2 rows cowpea	96.33 C	17.67 B	8.33 B	51.67BC	402 C
1 row okra :3 rows cowpea	103.67B	17.67 B	9.33AB	57.30AB	334 D
2 rows okra :2 rows cowpea	115.33A	20.67 A	10.67A	62.53 A	730 B

** Means having the same letter (s) within the same column are not significantly different according to LSD for all-pairwise comparisons test at 5% level of probability.*

Chemical constituents

Table 7 pointed out that, the highest values of nitrogen, phosphorus percentages and total protein in cowpea seeds was achieved by alternating one or two rows of okra with one or two rows of cowpea (1:1 and 2:2 systems) in the two seasons compared with the other ones under study. However, the highest values of potassium and total carbohydrates percentages in cowpea seeds was achieved by alternating two rows of okra with two rows of cowpea (2:2 system) followed by intercropping system at 1:1 compared with the other ones under study during both seasons.

These results are in agreed with those found by Nawar and Abdel-Galil (2008) on sunflower intercropped with soybean, Megawer, *et al.* (2010) when intercropped barley with lupine or chickpea and Nurbakhsh, *et al.* (2013) on sesame when intercropped with bean.

Table 7: Effect of intercropping system treatments on chemical constituents of dry seeds of cowpea during 2014 and 2015 seasons

Intercropping system treatments	Nitrogen percentage	Phosphorus percentage	Potassium percentage	Protein percentage	Total carbohydrates percentage
	Season 2014				
Sole cowpea	3.50 C	0.388 D	1.257 E	21.87 C	41.50 E
1 row okra :1 row cowpea	3.86 A	0.564 A	1.533 B	24.12 A	50.91 B
1 row okra :2 rows cowpea	3.55 C	0.477 C	1.377 D	22.18 C	43.78 D
1 row okra :3 rows cowpea	3.80 B	0.492 B	1.492 C	23.75 B	47.34 C
2 rows okra :2 rows cowpea	3.92 A	0.566 A	1.653 A	24.50 A	53.17 A
	Season 2015				
Sole cowpea	3.40 B	0.381 E	1.263 D	21.25 B	43.16 C
1 row okra :1 row cowpea	3.76 A	0.534 B	1.467 BC	23.50 A	49.24 AB
1 row okra :2 rows cowpea	3.38 B	0.467 D	1.410 C	21.12 B	44.44 C
1 row okra :3 rows cowpea	3.75 A	0.491 C	1.527 AB	23.43 A	48.01 B
2 rows okra :2 rows cowpea	3.82 A	0.573 A	1.587 A	23.87 A	50.50 A

** Means having the same letter (s) within the same column are not significantly different according to LSD for all-pairwise comparisons test at 5% level of probability.*

Correlation coefficient

It is evident from the obtained data in Table 8 that dry seed yield per plant of cowpea exhibited positive and strong relationship with each of number of leaves and branches per plant, total dry weight per plant, pods number per plant, weight of 100 seeds and total carbohydrates percentage. Also, fruit yield per okra plant showed positive and highly significant correlation with abovementioned parameters during both seasons.

These results are in harmony with those stated by Meawad *et al.* (2004) on roselle intercropped with guar.

Table 8: Simple correlation coefficients between dry seed yield per cowpea plant and some growth parameters, dry seed yield as well as total carbohydrates under the effect of intercropping system treatments during 2014 and 2015 seasons

Parameters	1	2	3	4	5	6
	Season 2014					
Y. Dry seed yield per plant (g)	0.759**	0.800**	0.895**	0.854**	0.807**	0.943**
1. Number of branches / plant		0.942**	0.833**	0.847**	0.902**	0.839**
2. Number of leaves / plant			0.834**	0. 875**	0.896**	0.832**
3. Total dry weight / plant (g)				0.921**	0.822**	0.962**
4. Pods number / plant					0.835**	0.911**
5. Weight of 100 seeds (g)						0.820**
6. Total carbohydrates percentage						
	Season 2015					
Y. Dry seed yield per plant (g)	0.748**	0.907**	0.778**	0.881**	0.677**	0.806**
1. Number of branches / plant		0.813**	0.763**	0.834**	0.622**	0.871**
2. Number of leaves / plant			0.734**	0. 926**	0.793**	0.829**
3. Total dry weight / plant (g)				0.777**	0.616**	0.810**
4. Pods number / plant					0.723**	0.916**
5. Weight of 100 seeds (g)						0.606**
6. Total carbohydrates percentage						

*** = Highly significant at 0.01. * = Significant at 0.05.*

Effect of intercropping system treatments on competition Indices

Many scientists calculate the land equivalent ratio (LER), area time equivalent ratio (ATER) and land utilization efficiency percentage (LUE%) to evaluate over yielding. It is the total land required by a sole crop to produce the yield achieved in intercropping.

It was observed from data reported in Table 9 that, studied treatments of intercropping system have significant effect on LER, ATER and LUE%. However, although the intercrop green pod yield of okra (Lo) as well as of cowpea dry seed yield (Lc) crop in the okra / cowpea cropping system was decreased in mixed relative to pure stands, the combined intercrop yield of both crops yielded in some cases more than respective pure stand yields. Indeed, intercropping of okra and cowpea at 2:2 systems followed by 1:1 system were more productive than growing them separately, as can be seen from the total competition indices values which were greater than 1.00 or 100%. This result was true for LER, ATER and LUE% determinations in both seasons. Since, intercropping of okra with cowpea resulted in LER, ATER and LUE% determined from total yield /fed. ranged from 1.401 to 1.375, 1.314 to 1.290 and 135.75% to 133.21% in the first and second seasons, respectively, when okra and cowpea were intercropped at 2:2. These LERs indicated that 0.401% to 0.375% more land would require to planting the sole crops to produce the same quantities of intercrop yield of okra and cowpea. On the assumption that photosynthesis under field conditions, and consequently total dry matter assimilation, is limited by the amount leaf canopy of the intercrops may make better use of light in this respect. In the same time, the beneficial effects of combined leaf canopy of the intercrops, as reported in literature can be achieved through more efficient use of light rather than greater light interception. While, 1:2 and 1:3 systems produced lower significant value of LER, ATER and LUE compared with the above mentioned systems.

Table 9: Effect of intercropping system treatments on some competitive indices between okra and cowpea under intercropping system treatments during 2014 and 2015 seasons

Intercropping system treatments	Land equivalent ratio (LER)	Area time equivalent ratio (ATER)	Land utilization efficiency (LUE %)	Aggressivity (A)
	Season 2014			Aoc*
1 row okra :1 row cowpea	1.401 A	1.314 A	135.75 A	+ 0.184 B
1 row okra :2 rows cowpea	0.847 B	0.799 B	82.30 B	+ 1.086 A
1 row okra :3 rows cowpea	0.644 C	0.602 C	62.31 C	+ 1.068 A
2 rows okra :2 rows cowpea	1.370 A	1.276 A	132.30 A	+ 0.058 C
	Season 2015			Aco**
1 row okra :1 row cowpea	1.375 A	1.290 A	133.21 A	- 0.184 B
1 row okra :2 rows cowpea	0.824 C	0.775 C	79.94 C	- 1.086 A
1 row okra :3 rows cowpea	0.634 D	0.593 D	61.37 D	- 1.068 A
2 rows okra :2 rows cowpea	1.292 B	1.202 B	124.67 B	- 0.058 C

** Means having the same letter (s) within the same column are not significantly different according to LSD for all-pairwise comparisons test at 5% level of probability.*
***Aoc = Aggressivity values of okra ***Aco = Aggressivity values of cowpea*

Furthermore, the advantage of growing species (okra and cowpea) in association depends primarily on the degree of inter-crop versus intra-crop competition. Lower inter-crop comparison with intra-crop competition occurs when companion crops differ in their use of growth resources (for example nitrogen element).

Since, Willey (1979) showed that probably the main way that complementarily occurs is when growth patterns of the component crops differ in time so that the crops make their major demands on resources at different times. Also, Natarajan and Willy (1980) reported that, the most commonly suggested reason for utilize growth resources rather differently, so that when grown together they "complement" each other and make better overall use of resources than when grown separately.

It is known that an aggressivity value of zero indicates that the component crops are equally competitive. For any other situation, two crops will have the same numerical value by positive for the dominant crop and negative for the dominated one. The greater the numerical value, the larger the difference in competitive abilities.

It is evident from data in Table 9 that, the competitive ability of the component crops in an intercropping system is determined by its aggressivity value. Regardless of the planting systems, there was a positive sign for okra and a negative sign for the intercropped cowpea, indicating that okra was dominant while cowpea was dominated. Results showed the highest positive aggressivity for okra at 1:2 system, while it proved less competitive at 2:2 planting system during both seasons.

However, Dua *et al.* (2015) found that aggressivity values indicated that maize was a dominant specie whereas potato was dominated specie. Also, Abdelkader and Hamad (2015) indicated that positive aggressivity values for safflower demonstrate that safflower was the dominant specie whereas the negative values for fenugreek indicate that it was the dominated one.

Conclusion

Intercropping advantage indices (LER, ATER and LUE %) supported 1:1 system and 2:2 system which were more advantageous without significant differences between them than other treatments and seems promising in the development of sustainable both crops production with a limited use of external inputs.

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