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Research Article

Intercropping Cowpea with Some Yellow Maize Hybrids Under Different Nitrogen Fertilizer Rates

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Abstract

Field trial was carried out at Sids Agricultural Research Station, Agricultural Research Center (ARC), Beni-Sweif governorate (Lat. 29o 12' N, Long. 31o 01'E, 32 m a.s.l.), Egypt, during 2017 and 2018 summer seasons to study the interaction between three nitrogen (N) fertilizer rates (100, 120 and 140 Kg N fed^{-1}) and three yellow maize hybrids (SC 176, TWC 353 and TWC 360) on maize-cowpea association. Treatments were randomly assigned in a split-plot design with three replications. The main plots were devoted to N fertilizer rates. However, the sub-plots were allocated to hybrids of yellow maize. Sole culture plots of both maize and cowpea were included in each replicate for competitive relationships and economic evaluation essays. The highest values of maize grain yield (22.86 and 23.00 ard fed^{-1}) were recorded for yellow maize hybrid SC 176 when the combination received 140 kg N fed^{-1} whereas the lowest values were recorded for yellow maize hybrid TWC 353 when the combination received 100 kg N fed^{-1} while the highest values cowpea fresh forage yield (18.75 and 15.59 ton fed^{-1}) were recorded for cowpea intercropped with yellow maize hybrid SC 176 when the combination received 140 kg N fed^{-1} whereas the lowest values were recorded for cowpea intercropped with yellow maize hybrid TWC 360 when the combination received 100 kg N fed^{-1} in first and second seasons, respectively. The aggressivity value of maize was positive for all treatments indicating that maize was dominant component whereas the aggressivity value of cowpea was negative for all treatments indicating that cowpea was dominated component in the present study. Results also revealed that intercropping cowpea cv. Cream7 with yellow maize hybrid SC 176 under rate of 140 kg N fed^{-1} for the combination resulted in maximum values of LER estimated to 1.61 and 1.62, gross income of LE 16,598 and 15,717 and net return of LE 8,301 and 7,420 in first and second seasons, respectively. The study recommends the importance of selecting maize variety (the over-story crop), as short hybrid with less leaf area index, which is preferred to provide a better chance for the growth of cowpea (the under-story crop) when planting cowpea with 100% of its sole culture on the other side of maize rows sown at 100% of its density in sole culture in order to achieve the maximum land equivalent ratio, less competition between both crops, and largest income and net return for farmer.

Keywords: *Zea mays* L.; *Vigna unguiculata* L.; Land Equivalent Ratio; Farmer's Benefit

Introduction

Maize is one of the most important crops for food and feed security around the world. It is globally grown on about 193.73 million hectare with a production of 1147.62 million tons of grains in 2018 [1]. In Egypt, the cultivated area of maize grown during 2018 was 0.94 million hectare with a production of 7.30 million tons [1]. The Egyptian government imports about 9 million tons of maize annually with USD 2 billion, to be used in the manufacture of fodder and various production inputs. However, Egypt remains to be the fourth largest grain importer in the world despite government efforts to increase local production. Lower international prices have allowed Egypt to lower its grain import bill from USD 5.4 billion in 2011 to USD 3.4 billion in 2016 [2]. Within the framework of Egypt's tendency to increase the cultivated areas of yellow maize, to work to limit its import and meet the needs of the poultry industry of feed, through early-maturing and high-productivity varieties, as the country is increasingly developing the maize to reduce imports and raise the rate of self-sufficiency in the crop [2].

Growing maize in monoculture is the predominant agriculture in most governorates in Egypt. There are several points that affect the production of yellow maize including farmer profitability compared to another summer crop such as rice, the sustainability of productivity due to the lack of crop rotation, which led to decline in biodiversity of biological systems agribusiness and finally defoliation of maize plants to feed animals due to shortage of summer forage crops in Egypt. This resulted in decreasing maize yield [3]. Hence, intercropping cowpea with maize will provide green fodder in summer, preservation of soil sustainability and keep the sustainable productivity of yellow maize due to increasing profitability for the small-scale farmer. From another angle of view, the principal reasons for farmers to intercrop are flexibility, risk minimization against crop failure, soil conservation and maintenance, weed control and balanced nutrition [4,5]. Maize and cowpea plants can perform and produce better when grown with together than when in sole culture [3,6-13].

Cowpea fixed around 60% of its N from the atmosphere amounting to 70 kg fixed N ha^{-1} under sole and 36 kg fixed N ha^{-1} under intercropping [14]. Cowpea-maize association response to N fertilization up to 285.6 Kg N ha^{-1} when planted after berseem as preceding crop and resulted the highest LER = 1.47 compared with LER = 1.45 when the preceding crop was wheat [8].

Relative plant heights of different crops grown in association in an intercrop system are important. Profiles of light intensity and leaf area indices in crop canopies indicate that the taller crop has an advantage over its shorter crop companions [6]. The maximum LER = 1.67 was obtained with shorter maize hybrid (over-story crop), which offer less competition to intercropped crops than taller ones and the yield of cowpea (under-story crop) grown with shorter maize hybrids (SC 168) was higher than that produced with the taller ones TWC 321 [13]. Also, LER=1.65 was recorded when planting cowpea on the other side of maize rows as 100% cowpea: 100% maize as recommended by HamdAlla., *et al*. [3].

Aim of the Study

The aim of this investigation is to find out the optimum N fertilizer rate and suitable yellow maize hybrid when intercropped with cowpea.

Materials and Methods

Field trial was carried out at Sids Agricultural Research Station, Agricultural Research Center (ARC), BeniSweif governorate (Lat.29° 12'N, Long. 31° 01'E, 32 m a.s.l.), Egypt, during 2017 and 2018 summer seasons. The experimental soil texture is loam. Physical and chemical analysis of the soil (0 - 30 cm) was analyzed by Water and Soil Research Institute, ARC (Table 1).

Soil analysis	2017 Season	2018 Season
Physical analysis		
Clay (%)	24.88	24.88
Silt (%)	28.00	30.00
Sand (%)	47.12	45.12
Texture grade	Loam	Loam
Chemical analysis		
pH	8.0	8.0
EC (dSm^{-1})	0.32	0.32
Available N (mg Kg^{-1})	20	40
Available P (mg Kg^{-1})	10	5
Available K (mg Kg^{-1})	328	312

Table 1: Soil physical and chemical analysis of the experimental site during 2017 and 2018 summer seasons.

The experiment included nine treatments, which were the combinations of three N fertilizer rates (100, 120 and 140 Kg N fed^{-1}) (one feddan = 4200m^2) and three hybrids of yellow maize (SC 176, TWC 353 and TWC 360) to study their effects on growth, yield and yield components of maize-cowpea association. Sole cultures of both crops were included in each replicate as check plots for calculating competitive relationships and economic evaluation only, but not included in statistical analysis. A split-plot design with three replications was used. The main plots were devoted to N fertilizer rates. However, the sub-plots were allocated to hybrids of yellow maize. The area of each sub-plot was 10.5m^2 (5 ridges 70 cm apart and 3 m long). Maize (sole or intercropped) was grown one side of ridge with one plant $hill^{-1}$, 25 × 70 cm apart (100% of sole culture). Intercropped cowpea (cv. Cream 7) was grown on the other side of all maize ridges with two plants $hill^{-1}$, 10 cm apart (100% of sole culture). Sole culture of cowpea was grown for comparison on two sides of ridges with two plants $hill^{-1}$, 20 × 70 cm apart.

The experimental field was finely prepared and calcium super phosphate (15.5% P_2O_5) at the rate of 30 Kg P_2O_5 fed^{-1} was applied during soil preparation. The preceding winter crop was wheat in both seasons. N fertilizer for maize-cowpea association or solid maize were added in the form of Urea (46.5% N) in two equal doses, before the first and the second irrigations of maize. In case of solid planting, N fertilizer was applied at the rate of 120 and 20 Kg N fed^{-1} for maize and cowpea, respectively. Potassium (K) fertilizer (potassium sulfate, 48% K_2O) was added at the rate 24 Kg K_2O fed^{-1} before the second irrigation of maize. Both crops were hand sown in the same time on 7th June and 29th May in the first and second seasons, respectively. Plots were kept free of weeds through hand hoeing twice. Other cultural practices were performed as recommended. First cut of cowpea (sole and intercropped) was done after two months of planting date and the second cut was done after one month of the first cut in both seasons. Harvest took place on September 15th and September 10th for maize in both seasons, respectively.

The studied traits

Maize traits

Ten plants were chosen randomly from inner rows of each sub-plots to determine: Plant height (cm), leaf area index (LAI), number of ears $plant^{-1}$, ear length (cm), number of rows ear^{-1} and 100-kernel weight (g). Grain yield of maize fed^{-1} (ardab) was estimated from the whole sub-plot area (kg $plot^{-1}$) and it was adjusted per fed (one ardab = 140 kg).

Cowpea traits

Ten plants were chosen randomly at the first and the second cuts from inner rows of each sub-plots to determine: Plant height (cm) and no. of branches $plant^{-1}$. Fresh forage yield fed^{-1}(ton) was estimated from the whole sub-plot area (kg $plot^{-1}$) and it was adjusted per fed.

Competitive relationships

Land equivalent ratio (LER)

LER defines as the ratio of area needed under sole cropping to one of intercropping at the same management level to produce an equivalent yield [15]. It is calculated as follows: LER = Relative Yield (RY_a) for crop a (maize) + Relative Yield (RY_b) for crop b (cowpea), $RY_a = (Y_{ab}/Y_{aa})$, $RY_b = (Y_{ba}/Y_{bb})$, where Y_{aa}= Pure stand yield of crop a (maize), Y_{bb}= Pure stand yield of crop b (cowpea), Y_{ab}= Intercrop yield of crop a (maize) and Y_{ba}= Intercrop yield of crop b (cowpea). The values of LER were estimated by using data of recommended sole cultures of both crops. When LER of more than unity indicates yield advantage, equal to unity indicates no gain or no loss and less than unity indicates yield loss [16].

Aggressivity (A)

Aggressivity (A) represents a simple measure of how much the relative yield increase in one crop is greater than the other in an intercropping system [17] was calculated as follows: $A_{ab}=[Y_{ab} / (Y_{aa} \times Z_{ab})]-[Y_{ba} / (Y_{bb} \times Z_{ba})]$; $A_{ba}=[Y_{ba} / (Y_{bb} \times Z_{ba})]-[Y_{ab} / (_{Yaa} \times Z_{ab})]$. Aggressiveness tests the disparity in competitive ability of crops under intercropping. Positive signs of aggressivity indicates the dominant crop and the negative sign indicates the dominated crop. Higher numerical aggressiveness values signify a greater difference in competition as well as a greater difference in both crops between real and predicted production.

Economic evaluation

It was calculated by determining the net return of intercropping culture as compared to recommended sole culture of maize.

Gross income of intercropping cultures = Price of maize yield + Price of cowpea yield in Egyptian pound (LE). To calculate the gross income, the average of maize and cowpea prices presented by Bulletin of Statistical Cost Production and Net Return [18] were

used. The maize price was LE 480 ard^{-1} of grains, meanwhile cowpea price was LE 300 ton^{-1} of fresh forage.

Net return fed^{-1} = Gross income – Production costs (fixed costs of maize + fixed costs of cowpea + variable costs of N fertilization rates).

Production costs were LE 7797, 8047 and 8297 fed^{-1} for intercropping cultures fertilized with 100, 120 and 140 Kg N fed^{-1}, respectively, and LE 7535 fed^{-1} for sole culture of maize.

The statistical analysis

Analysis of variance of the obtained data of each season was performed. The measured variables were analyzed by ANOVA using MSTAT-C statistical package [19]. Mean comparisons were performed using the least significant differences (L.S.D) test with a significance level of 5% [20].

Results and Discussion

Maize traits

Effect of N fertilization rates

Effect of N fertilizer on maize traits in the intercrop was presented in table 2. Results obtained evidenced that there were increases in all traits, namely, plant height, LAI, No. of ears plant^{-1}, ear length, 100-kernel weight and grain yield fed^{-1} with increasing N fertilizer dose up to 140 Kg N fed^{-1}. Increases were significant among the treatments imposed in both seasons, except in case of no. of rows ear^{-1} where differences failed to reach 5% level of significance. It could be concluded that the increase in yield components and maize grain yield due to increased use of N is mainly attributable to stimulating metabolite production, which leads to the increase in the amount of metabolites, which is used in dry matter accumulation.

These results were in agreement with several investigators such Hafez and Abdelaal [21] and Ewis., *et al*. [22] reported that maize grain yield increased significantly with increasing N fertilization up to 150 Kg N fed^{-1} sole culture of maize under Egyptian condition, whereas Abdel-Wahab., *et al*. [8] reported that maize-cowpea association can save 15 Kg N fed^{-1} of the recommended mineral N fertilizer for maize sole culture (120 Kg N fed^{-1}) in addition to N fertilizer of cowpea in sole culture when the preceding crop was berseem compared to planting after wheat crop.

Effect of yellow maize hybrids

Results in table 3 indicated that maize yellow hybrids expressed significant difference, whereas the maize yellow hybrid TWC 360 gave the tallest plants, the biggest LAI and the highest weight of

N rate	Plant height (cm)	LAI	No. of ears plant^{-1}	Ear length (cm)	No. of rows ear^{-1}	100-kernel weight (g)	Grain yield fed^{-1} (ard)
2017 Season							
100 Kg N fed^{-1}	219	3.77	1.08	22.24	13.37	34.98	21.00
120 Kg N fed^{-1}	228	5.36	1.26	22.87	13.50	35.49	21.56
140 Kg N fed^{-1}	233	6.12	1.49	23.06	13.66	35.64	21.96
LSD at 0.05	6	0.46	0.16	0.56	NS	0.38	0.37
2018 Season							
100 Kg N fed^{-1}	221	4.16	1.21	22.86	14.05	35.21	21.64
120 Kg N fed^{-1}	233	5.53	1.40	23.51	14.41	36.06	22.09
140 Kg N fed^{-1}	239	6.25	1.56	23.57	14.63	36.52	22.46
LSD at 0.05	8	0.69	0.12	0.45	NS	0.22	0.47

Table 2: Effect of N fertilization rates on growth, yield and its components of maize in 2017 and 2018 seasons.

100-kernel as compared with other hybrids during both cropping seasons. Maize yellow hybrid SC 176 gave the highest values of no. of ears plant^{-1}, ear length, no. of rows ear^{-1} and grain yield fed^{-1} during both seasons.

These results were agree with those reported by Hassaan [23] who tested four yellow maize hybrids, i.e. SC 168, SC 176, TWC 353 and TWC 360 in sole cultures and concluded that sown SC 176 hybrid successfully improving production of maize yield and its components compared with TWC 353 or TWC 360. These results are also supported by El-Ghobashy., *et al.* [13].

Yellow maize hybrid	Plant height (cm)	LAI	No. of ears plant^{-1}	Ear length (cm)	No. of rows ear^{-1}	100-kernel weight (g)	Grain yield fed^{-1} (ard)
2017 Season							
SC176	218	4.63	1.54	23.72	13.84	33.57	22.04
TWC 353	230	5.20	1.12	21.59	13.31	35.54	21.11
TWC 360	232	5.41	1.17	22.86	13.38	37.00	21.41
LSD at 0.05	6	0.34	0.14	0.72	0.15	0.54	0.32
2018 Season							
SC176	223	4.84	1.69	23.99	15.06	34.64	22.56
TWC 353	233	5.40	1.21	22.62	13.86	36.01	21.51
TWC 360	238	5.70	1.28	23.32	14.18	37.14	22.11
LSD at 0.05	5	0.51	0.11	0.27	0.48	0.43	0.34

Table 3: Effect of yellow maize hybrids on growth, yield and its components of maize in 2017 and 2018 seasons.

Interaction effect between N fertilization rates and yellow maize hybrids

The interaction between N fertilization rates and yellow maize hybrids significantly influenced plant height, LAI, no. of ears plant^{-1}, ear length, 100-kernel weight and grain yield fed^{-1} in both seasons (Table 4). The highest maize values of plant height, LAI and 100-grain weight were recorded when fertilized the maize-cowpea association with the rate of 140 Kg N fed^{-1} and growing cowpea under yellow maize hybrid TWC 360, while the highest maize values of no. of ears plant^{-1}, ear length and grain yield fed^{-1} were recorded when fertilized the maize-cowpea association with the rate of 140 Kg N fed^{-1} and growing cowpea under yellow maize hybrid SC 176 in both seasons. These results are also supported by Hassaan [23] and El-Ghobashy., *et al*. [13].

Cowpea traits

Effect of N fertilization rates

Results in table 5 indicated that cowpea values increased with increasing N fertilization rates for the combination (100% maize + 100 cowpea) up to 140 Kg N fed^{-1}.

The increase reached 5% of significance with traits of plant height and no. of branches plant^{-1} for the first cut in both seasons and fresh forage yield fed^{-1} for first, second and total cuts in both seasons, respectively. These results might be due to the higher inter and intra-specific competition under maize-cowpea association (100% maize + 100% cowpea), which reduce the capacity of cowpea to fix N from atmosphere amounting to 50% in intercropping culture reflecting to more utilization of extra N fertilization compared to sole culture of cowpea [14].

Effect of yellow maize hybrids

Results in table 6 indicated that plant height, no. of branches and fresh forage yield affected significantly by maize yellow hybrids. The tallest and less branched plants, which reflected in a low fresh forage yield were recorded when cowpea intercropped with tallest yellow maize hybrid TWC 360, while the shortest and more branched plants, which reflected in a high fresh forage yield were recorded when cowpea intercropped with shortest yellow maize hybrid SC 176. These results might be due to genetic makeup of

Yellow maize hybrid	Plant height (cm)	LAI	No. of ears plant^{-1}	Ear length (cm)	No. of rows ear^{-1}	100-kernel weight (g)	Grain yield fed^{-1} (ard)
2017 Season							
100 Kg N fed^{-1}	SC176	210	3.34	1.17	22.90	33.23	21.37
	TWC353	221	3.85	1.03	21.70	35.33	20.73
	TWC360	225	4.11	1.06	22.13	36.37	21.04
120 Kg N fed^{-1}	SC176	219	4.86	1.59	23.83	33.90	21.88
	TWC353	231	5.50	1.07	21.80	35.43	21.26
	TWC360	234	5.72	1.12	22.97	37.13	21.54
140 Kg N fed^{-1}	SC176	225	5.69	1.87	24.43	33.57	22.86
	TWC353	237	6.25	1.28	21.27	35.87	21.35
	TWC360	238	6.41	1.34	23.47	37.50	21.66
LSD at 0.05		11	0.59	0.24	1.25	0.93	0.56
2018 Season							
100 Kg N fed^{-1}	SC176	214	3.68	1.37	23.80	34.27	22.18
	TWC353	222	4.23	1.10	22.23	35.23	21.11
	TWC360	227	4.57	1.16	22.53	36.13	21.63
120 Kg N fed^{-1}	SC176	224	5.07	1.76	24.07	34.79	22.50
	TWC353	234	5.60	1.19	22.73	35.97	21.66
	TWC360	239	5.91	1.26	23.73	37.43	22.12
140 Kg N fed^{-1}	SC176	230	5.78	1.94	24.10	34.87	23.00
	TWC353	242	6.36	1.33	22.90	36.83	21.77
	TWC360	247	6.62	1.41	23.70	37.87	22.60
LSD at 0.05		8	0.89	0.19	0.47	0.74	0.58

Table 4: Effect of N fertilization rates and yellow maize hybrids on growth, yield and its components of maize in 2017 and 2018 seasons.

N rate	Plant height (cm)		No. of branches plant^{-1}		Fresh forage yield fed^{-1}(ton)		
	1st Cut	2nd Cut	1st Cut	2nd Cut	1st Cut	2nd Cut	Total
	2017 Season						
100 Kg N fed^{-1}	107.00	59.78	3.34	1.98	11.42	2.39	13.81
120 Kg N fed^{-1}	125.00	62.00	3.92	2.28	12.60	2.62	15.22
140 Kg N fed^{-1}	129.89	63.67	4.57	2.39	13.91	2.71	16.62
LSD at 0.05	3.26	NS	0.55	NS	0.37	0.14	1.39
	2018 Season						
100 Kg N fed^{-1}	92.11	53.67	2.78	1.30	9.51	1.80	11.31
120 Kg N fed^{-1}	103.22	56.00	3.10	1.63	10.91	2.05	12.96
140 Kg N fed^{-1}	106.56	57.44	3.39	1.88	11.92	2.16	14.08
LSD at 0.05	3.22	NS	0.27	NS	0.17	0.12	0.23

Table 5: Effect of N fertilization rates on intercropped cowpea in 2017 and 2018 seasons.

Yellow maize hybrid	Plant height (cm)		No. of branches plant^{-1}		Fresh forage yield fed^{-1} (ton)		
	1st Cut	2nd Cut	1st Cut	2nd Cut	1st Cut	2nd Cut	Total
2017 Season							
SC 176	112.67	57.78	4.47	2.74	13.90	2.92	16.82
TWC 353	123.00	62.67	3.80	2.08	12.46	2.50	14.96
TWC 360	126.22	65.00	3.57	1.83	11.58	2.29	13.87
LSD at 0.05	2.58	3.11	0.23	0.18	0.33	0.11	0.55
2018 Season							
SC 176	95.67	51.22	3.54	2.00	11.37	2.51	13.88
TWC 353	102.33	56.67	2.94	1.52	10.71	1.89	12.60
TWC 360	103.89	59.22	2.78	1.29	10.27	1.61	11.88
LSD at 0.05	1.28	2.87	0.18	0.16	0.12	0.07	0.13

Table 6: Effect of yellow maize hybrids on intercropped cowpea in 2017 and 2018 seasons.

yellow maize hybrid SC 176, which appeared in shorter plants and less LAI than yellow maize hybrid TWC 360 resulted in a less inter-specific competition and more yield for cowpea.

This result was consistent with Abou-Keriasha., *et al*. [6] who found that yield of under-story crop grown with taller over-story crop was lower than that produced with the shorter ones due to low availability of light for the under-story crop in the mixture, which reduced the photosynthesis rate and crop growth rate and eventually limited lighting leads to drastic reduction in dry matter accumulation in the under-story crop. This result was also supported by El-Ghobashy., *et al*. [13].

Interaction effect between N fertilization rates and yellow maize hybrids

Results in table 7 indicated that the interaction between N fertilization rates and yellow maize hybrids significantly affected plant height for the first cut in first season only, no. of branches plant^{-1} for the second cut in second season only and fresh forage yield fed^{-1} for the first and total cuts in both seasons.

The highest values of plant height were recorded when cowpea intercropped with yellow maize hybrid TWC 360 and the combination received 140 Kg N fed^{-1}, as well as the highest values of no. of branches plant^{-1} and Fresh forage yield fed^{-1} were recorded when cowpea intercropped with yellow maize hybrid SC 176 and the combination received 140 Kg N fed^{-1} in both seasons. These results might be due decreases in inter and intra-specific competition when intercropping of cowpea with yellow maize hybrid SC 176 compared with other yellow maize hybrids. This result was also supported by El-Ghobashy., *et al*. [13].

Competitive relationships

Land equivalent ratio (LER)

Results in table 8 indicate interesting trends of the relative yield of both crops with yellow maize hybrids under different nitrogen fertilization rates. RY_m of maize (the over-story crop) was higher than those of cowpea (the under-story crop), indicating higher and heavy competitive pressure of maize crop.

Results also indicate high values of LER in all the intercropping treatments, their values exceed the unit and ranged from 1.39 to 1.61 and from 1.41 to 1.62 in the first and second seasons, respectively. However, there were gradual increases in LER with increasing N fertilization rate up to 140 Kg N fed^{-1}, whatever, the hybrid used of maize indicating the pronounced effect of maize in increasing the land use efficiency. Results indicate also that intercropping cowpea with yellow maize hybrid SC 176 with adding 140 Kg N fed^{-1} for the combination resulted in highest LER, whereas minimum

N rate	Yellow maize hybrid	Plant height (cm)	No. of branches plant^{-1}	Fresh forage yield fed^{-1} (ton)	
		1st Cut	1st Cut	1st Cut	Total
2017 Season					
100 Kg N fed^{-1}	SC 176	102	3.8	12.02	14.67
	TWC 353	109	3.3	11.28	13.62
	TWC 360	110	3.0	10.97	13.15
120 Kg N fed^{-1}	SC 176	115	4.6	14.04	17.04
	TWC 353	128	3.7	12.43	14.97
	TWC 360	132	3.4	11.34	13.67
140 Kg N fed^{-1}	SC 176	121	5.0	15.63	18.75
	TWC 353	132	4.4	13.67	16.30
	TWC 360	137	4.3	12.42	14.80
LSD at 0.05		4.47	NS	0.57	0.95
2018 Season					
100 Kg N fed^{-1}	SC 176	87	3.0	9.80	11.97
	TWC 353	94	2.7	9.47	11.18
	TWC 360	95	2.7	9.27	10.79
120 Kg N fed^{-1}	SC 176	98	3.6	11.47	14.06
	TWC 353	105	3.0	10.80	12.72
	TWC 360	107	2.7	10.47	12.10
140 Kg N fed^{-1}	SC 176	102	4.0	12.83	15.59
	TWC 353	108	3.2	11.87	13.90
	TWC 360	110	3.0	11.07	12.76
LSD at 0.05		NS	0.31	0.29	0.41

Table 7: Effect of N fertilization rates and yellow maize hybrids on intercropped cowpea in 2017 and 2018 seasons.

LER was obtained when intercropping cowpea with yellow maize hybrid TWC 360 with adding 100 Kg N fed^{-1} for the combination. These results are in accordance with those obtained by Gadallah and Shams [7], HamdAlla., *et al*. [3], Abdel-Wahab., *et al*. [8], Hassan., *et al*. [9], Olowolaju and Okunlola [10] and El-Ghobashy., *et al*. [11,13] who showed that intercropping cowpea with maize had the highest LER values compared with sole culture of maize.

Aggressivity (A)

Results in table 8 showed that maize was the dominant crop and cowpea was the dominated crop in all treatments in both seasons. The highest numeric values for aggressivity were achieved by intercropping cowpea with yellow maize hybrid TWC 360 with adding of 120 Kg N fed^{-1} for the combination in the first season with light difference than treatment, which received only 100 Kg N fed^{-1} in the second season showing that TWC 360 was the most aggressive yellow maize hybrid. Sole culture yields in 2017 were 22.97, 21.55 and 21.86 ard fed^{-1} for yellow maize hybrids SC176, TWC353

N rate	Yellow maize hybrid	Yield fed^{-1}		Land Equivalent Ratio (LER)			Aggressivity (A)	
		Maize (ard)	Cowpea (ton)	RY_m	RY_c	LER	A_m	A_c
2017 Season								
100 Kg N fed^{-1}	SC176	21.37	14.67	0.93	0.48	1.41	0.90	-0.90
	TWC353	20.73	13.62	0.96	0.44	1.41	1.04	-1.04
	TWC360	21.04	13.15	0.96	0.43	1.39	1.07	-1.07
120 Kg N fed^{-1}	SC176	21.88	17.04	0.95	0.56	1.51	0.79	-0.79
	TWC353	21.26	14.97	0.99	0.49	1.47	1.00	-1.00
	TWC360	21.54	13.67	0.99	0.45	1.43	1.08	-1.08
140 Kg N fed^{-1}	SC176	22.86	18.75	1.00	0.61	1.61	0.77	-0.77
	TWC353	21.35	16.30	0.99	0.53	1.52	0.92	-0.92
	TWC360	21.66	14.80	0.99	0.48	1.47	1.02	-1.02
2018 Season								
100 Kg N fed^{-1}	SC176	22.18	11.97	0.93	0.50	1.43	0.85	-0.85
	TWC353	21.11	11.18	0.96	0.47	1.43	0.99	-0.99
	TWC360	21.63	10.79	0.96	0.45	1.41	1.01	-1.01
120 Kg N fed^{-1}	SC176	22.50	14.06	0.94	0.59	1.53	0.70	-0.70
	TWC353	21.66	12.72	0.99	0.53	1.52	0.91	-0.91
	TWC360	22.12	12.10	0.98	0.51	1.49	0.95	-0.95
140 Kg N fed^{-1}	SC176	23.00	15.59	0.96	0.65	1.62	0.61	-0.61
	TWC353	21.77	13.90	0.99	0.58	1.58	0.82	-0.82
	TWC360	22.60	12.76	1.00	0.54	1.54	0.93	-0.93

Table 8: Effect of N fertilization rates and yellow maize hybrids on competitive relationships of maize-cowpea association in 2017 and 2018 seasons.

- Sole culture yields in 2017 were 22.97, 21.55 and 21.86 ard fed^{-1} for yellow maize hybrids SC 176, TWC 353 and TWC 360, respectively and 30.70 ton fed^{-1} for cowpea.
- Sole culture yields in 2018 were 23.92, 21.92 and 22.53 ard fed^{-1} for yellow maize hybrids SC 176, TWC 353 and TWC 360, respectively and 23.82 ton fed^{-1} for cowpea.

and TWC360, respectively and 30.70 ton fed^{-1} for cowpea. Sole culture yields in 2018 were 23.92, 21.92 and 22.53 ard fed^{-1} for yellow maize hybrids SC 176, TWC 353 and TWC 360, respectively and 23.82 ton fed^{-1} for cowpea.

Whereas the lowest numeric value for aggressivity was achieved by intercropping cowpea with yellow maize hybrid SC 176 with adding of 140 Kg N fed^{-1} for the combination in both seasons indicating clearly that the inter-specific competition of yellow maize hybrid SC 176 to cowpea is less than the inter-specific competition of other yellow maize hybrids. These results could be due to the shortness of the yellow maize hybrid SC 176 and the small size of its LAI compared to other hybrids, which enhanced cowpea plants to greatly benefit from basic growth resources especially solar radiation to produce more dray matter resulted from shorter cowpea plants with more branches. The reverse was true when intercrop cowpea with TWC 360. These results were supported by Abou-Keriasha., *et al*. [6], Gadallah and Shams [7], HamdAlla., *et al*. [3], Abdel-Wahab., *et al.* [8], Hassan., *et al.* [9], Olowolaju and Okunlola [10] and El-Ghobashy., *et al*. [11,13].

Economic evaluation

Results in table 9 provided the gross income and net return of intercropping cowpea with maize compared to sole culture of yellow maize hybrids. Gross income and net return of intercropped cowpea with maize were higher than those of sole cultures of maize, indicating the advantages from intercropping legumes (cowpea) with cereal (maize). Net return recorded the highest values of LE 8301 and 7420 fed^{-1} by intercropping cowpea under yellow maize hybrid SC 176 with adding N fertilizer of 140 Kg N fed^{-1} for the combination compared with LE 3491 and 3947 fed^{-1}, which obtained from growing yellow maize hybrid SC 176 as a sole culture in the first and second seasons, respectively. The differences in net return of intercropping cowpea with yellow maize hybrid SC 176 compared with the sole culture were LE 4810 and 3473 fed-1, in the first and second seasons, respectively, indicating more profitable than maize sole culture for Egyptian farmers. Farmer profitability in the maize-cowpea association was significantly higher than sole maize culture [3,6-8,11,13].

N rate	Yellow maize hybrid	Income fed^{-1} (LE)		Gross income fed^{-1} (LE)	Net return fed^{-1} (LE)
		Maize	Cowpea		
2017 Season					
100 Kg N fed^{-1}	SC 176	10258	4401	14659	6862
	TWC 353	9950	4086	14036	6239
	TWC 360	10099	3945	14044	6247
120 Kg N fed^{-1}	SC 176	10502	5112	15614	7567
	TWC 353	10205	4491	14696	6649
	TWC 360	10339	4101	14440	6393
140 Kg N fed^{-1}	SC 176	10973	5625	16598	8301
	TWC 353	10248	4890	15138	6841
	TWC 360	10397	4440	14837	6540
Sole maize (SC 176)		11026	-	11026	3491
Sole maize (TWC 353)		10344	-	10344	2809
Sole maize (TWC 360)		10493	-	10493	2958
2018 Season					
100 Kg N fed^{-1}	SC 176	10646	3591	14237	6440
	TWC 353	10133	3354	13487	5690
	TWC 360	10382	3237	13619	5822
120 Kg N fed^{-1}	SC 176	10800	4218	15018	6971
	TWC 353	10397	3816	14213	6166
	TWC 360	10618	3630	14248	6201
140 Kg N fed^{-1}	SC 176	11040	4677	15717	7420
	TWC 353	10450	4170	14620	6323
	TWC 360	10848	3828	14676	6379
Sole maize (SC 176)		11482	-	11482	3947
Sole maize (TWC 353)		10522	-	10522	2987
Sole maize (TWC 360)		10814	-	10814	3279

Table 9: Effect of N fertilization rates and yellow maize hybrids on economic evaluation of maize-cowpea association in 2017 and 2018 seasons.

Conclusion

It could be concluded that intercropping cowpea (cv Cream 7) on the other side of maize rows at 100% of its sole culture with yellow maize hybrid SC 176 at 100% density of its sole culture gave highest LER of 1.62, gross income of LE 16,158 fed^{-1} and net return of LE 7,861 fed^{-1} for farmers as average of both seasons.

Conflict of Interest

No declare for financial interest or any conflict of interest exists.

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