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GROWTH AND YIELDING CAPACITY OF BEAN AND OKRA AS AFFECTED BY INTERCROPPING
BY

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ABSTRACT

Bean (cv. Giza 3) and okra (cv. Balady) plants were grown in sole and intercropping systems at experimental station, Fac. Agric., Fayoum Univ., Egypt in two successive summer seasons of 2005 and 2006, to study the influence of intercropping system on growth and yielding capacity of the two crops. Treatments include: sole cropping of both bean and okra plants and intercropping of bean with okra alternating on the same row. The results could be summarized as follows:

Growth traits;

No. of leaves plant-1, leaf area leaf-1, leaf area plant-1, No. of branches plant-1, fresh and dry weight of leaves plant-1 as well as fresh and dry weights of branches plant-1 for bean were significantly reduced under intercropping treatment as compared to sole cropping of bean. The same growth traits of okra were decreased as affected by intercropping but, did not reach the level of significance as compared to sole cropping of okra.

Yield green pods and its components for bean; No of green pods plant-1, fresh and dry weights pod-1, fresh and dry weights of pods plant-1 as well as yield of green pods feddan-1 were significantly decreased as affected by intercropping system as compared to sole cropping of bean. Intercropping of okra with bean had no a significant effect on the yield of green pods and its components (as mentioned before in bean) as compared to sole cropping pattern.

Intercropping of bean with okra produced lower yield of dry seeds and its components; No. of dry pods plant-1, No. of dry seeds pod-1, weight of seeds pod-1, weight of seeds plant-1, yield of dry seeds feddan-1 and seed index (100-seed weight). This decrease reached the level of significance as compared to sole cropping of bean. Sole cropping of okra gave the highest values for yield of dry seeds and its components (as mentioned in bean) but, without any significance.
Sole cropping of bean recorded the highest values for chemical constituents in leaves, green pods and dry seeds; leaf pigments (chlorophyll a, b and T as well as carotenoids), N, P, K, Fe, Mn, Zn, total sugars (in leavers and green pods only), total soluble carbohydrates (in dry seeds only) and protein as compared to intercropped bean. The differences in the same chemical constituents between

sole cropped and intercropped okra were not significant although the values of sole cropping were higher than intercropped okra.

Data of land equivalent ratio (LER) indicated that intercropping system between bean and okra achieved yield advantage more the sole cropping of both singly. The values of LER in yield of green pods was 1.88 in both seasons while, in dry seeds was 1.79 and 1.76 in 2005 and 2006 seasons, respectively. Results of agressivity revealed that okra was the dominant component in the intercropping system where okra had positive agressivity values and bean had negative values of agressivity.

Thus, Despite of the decrease in bean yield due to intercropping, the process of intercropping is still profitable to farmer because of the yield additional income incurred through okra. Furthermore, these studies could be recommended but more condensed studies are required to minimize the negative effect of intercropping on bean growth and yield (either green pods or dry seeds).

Key words: Bean, Okra, Intercropping, Growth, Yield

INTRODUCTION

It is becoming more important to raise crop productivity in order to meet the increasing food requirements of an increasing population all over the world. Moreover, Crop production per unit area should be increased because of the fixed suitable land for food production (Yildirim and Guvenc, 2005). Crop diversity in sub-tropical and tropical agroecosystems may provide several advantages over sole cropping by providing a higher total return in yield, improved crop quality, land sustainability and acting as an insurance against crop failure or fluctuating market prices of single crops (Ofori and Stern, 1989; Cruz and Sinoqet, 1995; Piepho, 1995 and Skovgard and Pats, 1997). Intercropping, through more effective use of water, nutrients and solar energy, can significantly enhance crop productivity (Midmore, 1993). It has been demonstrated the advantages of intercropping in vegetables which could lead to better land use efficiency as an important component of sustain able farming (Guvenc and Yildirim, 1999). Advantages of intercropping of legumes have been demonstrated in numerous studies; tomato or okra with cowpea (Olasantan, 1991), watermelon with soybean (Sharaiha and Hattar, 1993) and Chili and bean (Costa and Perera, 1998). These studies have indicated that intercropping was more productive than sole cropping because of the complementary effects of intercrops. Under the limited cultivated area of Egypt, the search for maximizing the use of land is of great importance. However, efforts are still needed to increase productivity of limited land resources throughout the use of an intercropping system. Intercropping is becoming one of the most popular phenomena among the small farms in Egypt. Among the many intercropping campanions adopted successfully are those of legumes and non legumes (El-Bana, 1998). In this respect, research work on bean-okra intercropping has not been studied. Therefore, this work aims to evaluate the effect of intercropping on growth and yielding capacity of bean and okra.

MATERIALS AND METHODS

On-farm experiments were conducted for two summer seasons of 2005 and 2006 at experimental station, Fac. Agric., Fayoum Univ., Egypt. Seeds of bean *(Phaselous vulgaris* L. cv. Giza 3) and okra (*Abelmoschus esculentus* L. cv. Balady) used in this study were produced by Ministry of Agriculture, Egypt. Before sowing, soil samples (0-30 cm) depth were taken at each season and were analyzed according to Black (1965). results of soil analysis in both seasons are presented in Table (1). Bean as a main crop was intercropped with okra as follows: 1- Sole cropping of bean on one row. 2- Sole cropping of okra on one row. 3- Bean intercropped with okra in alternating hills on the same row.

Table (1): Physical and chemical properties of the selected soil before sowing in both seasons.

Property	2005	2006	Property	2005	2006
Physical			**Soluble cations (meq 100 mg-1)**		
Clay%	42.6	40.4	Ca^{++}	0.75	0.68
Silt%	31.4	32.3	Mg^{++}	0.67	0.75
Sand%	26.0	27.3	Na^{+}	1.98	2.47
Texture	Clay	Clay	K^{+}	0.03	0.02
Chemical			**Soluble anions (meq 100g-1):**		
pH	7.30	7.34	HCO_3^{-}	0.29	0.28
ECe (dS m-1)	4.40	5.02	Cl^{-}	1.55	1.83
Total N%	0.10	0.07	SO_4^{--}	1.59	2.22
			Available microelements (ppm):		
Organic matter %	2.11	2 12	Fe	35.27	38.16
			Zn	2.06	2.16
CaCO3%	7.17	7 30	Mn	20.95	21.34
			Cu	0.09	0.11

In both sole cropping and intercropping treatments, seeds of bean and okra were field seeded on 4 March and 3 April, respectively in both seasons. Seeds of bean were sown in hills spaced 10 cm on one side of the row. On the other side of the same row, seeds of okra were sown in hills spaced 30 cm. Seeds of each crop were sown in excess and emerged seedlings were thinned prior to the first irrigation leaving one plant hill-1. A randomized complete block design with four replications was adopted. The experimental plot consisted of 6 rows, each 5 m long and 0.7 m apart. All other recommended agronomic practices for both bean and okra were undertaken.

Plant sampling.

At flowering, 10 plants were randomly chosen from each replicate for each crop, carefully cut off at the ground level and the following parameters were recorded: plant height (cm), No. of leaves and branches plant-1, fresh and dry weights of leaves and branches plant-1 (g), leaf area leaf-1 (cm2) and leaf area plant-1 (cm2). At 60 and 75 days from sowing (maturity stage of green pods for bean and okra, respectively); yield green pods and its components were recorded from the whole two middle rows (throughout 21 days at 7 days interval for bean and 2 months at 5 days interval for okra) and the following data for each crop were recorded: No. of green pods plant-1, fresh and dry weights pod-1 (g), fresh and dry weights of pods plant-1 (g) and green pods yield feddan-1 (ton). In each plot, plants of the 5 and 6 rows were left growing till pods approached the dry stage. At this stage, the dry pods of twenty plants of each row were picked and the following parameters were recorded: No. of dry pods plant-1, No. of dry seeds pod-1, weight of dry seeds pod-1 and plant-1 (g), dry seeds yield feddan-1 (kg) as well as seed index (100-seed weight, g).

Competitive relationship.

For the knowledgement about the nature and degree of competition between bean and okra plants, the following parameters were estimated: 1- Land equivalent ratio (LER), was calculated as described by Willy and Osiru (1972) according to the following equation:

$$LER = LERbean + LERokra$$

Where:

$$LERbean = \frac{\text{Intercropped yield of bean}}{\text{Sole yield of bean}}$$

$$LERokra = \frac{\text{Intercropped yield of okra}}{\text{Sole yield of okra}}$$

2- **Agressivity (A),** this index was calculated according to Hall (1974) as follows:

$$Abean = \frac{\text{Intercropped yield of bean}}{\text{Sole yield of bean}} - \frac{\text{Intercropped yield of okra}}{\text{Sole yield of okra}}$$

$$Aokra = \frac{\text{Intercropped yield of okra}}{\text{Soleyield of okra}} - \frac{\text{Intercropped yield of bean}}{\text{Sole yield of bean}}$$

Chemical analysis.

In both seasons, at flowering stage, samples of fresh and dried leaves, fresh and dried green pods of 60 and 75 days old plants as well as powdered dry seeds (at harvesting time) were taken for chemical analysis for bean and okra, respectively. The samples were dried in electric oven at 70oC till constant weight, then well ground for determining the following chemical constituents: 1- in fresh leaves, leaf pigments; chlorophyll a, b and total chlorophyll as well as total carotenoids (mg g-1 fresh weight of leaf) were estimated. They extracted by acetone 80% then determined using colorimetric method as described by Arnon (1949). 2- in dried leaves, the following parameters were determined: N% was colorimetrically determined by using orange G dye according to the method of Hafez and Mikkelsen (1981). For P, K, Fe, Mn and Zn determination; the wet digestion of 0.1 g of ground dry material of leaves of each crop was done with mixture of sulphoric and perchloric acids as described by Piper (1947). P (mg 100-1 g dry matter) was colorimetrically estimated by using chlorostannous molybdophosphoric blue colour method in sulphoric acid system as described by Jackson (1967). K (mg 100-1 g dry matter) was determined using a Perkin-Elmer. Flame-photometer (Page *et al.*, 1982). Fe, Mn and Zn concentrations (mg 100-1g dry matter) were determined using a Perkin-Elmer, Model 3300, Atomic Absorption spectrophotometer according to the method described by Champman and Pratt (1961). 3- in green pods and dried seeds, N, P, K, Fe, Mn and Zn concentrations were determined using the same analytical methods as mentioned before. In addition, total sugars% (in ethanolic extract, 80% of leaves and green pods) and total soluble carbohydrates% (in digestive dry matter with sulphoric acid; 0.1 N of dry seeds) were colorimetrically determined using phenol-sulphoric acid reagent method as outlined by Dubois *et al.* (1956) as well as protein% were estimated by multiplying seed or green pod N% by a factor of 6.25 for conversion of N% to protein% (Kelley and Bliss, 1975).

Statistical analysis.

All measured variables were subjected to analysis of variance by ANOVA (Snedecor and Cochran, 1980). The differences between mean of treatments were tested using t-test at 0.05 level.

RESULTS AND DISCUSSION

1. Vegetative growth.

Data in Table (2) showed the effect of intercropping bean with okra on vegetative growth behavior of bean and okra plants. The intercropping exerted a significant influence on all growth characters of bean under study as compared with sole cropping of bean. It is clear from these data that the growth values were highest in bean plants obtained from sole cropping and the lowest values were obtained from intercropping in both seasons. In the first season, the increases in growth characters which recorded by sole cropped bean as compared to those of sole intercropped ones reached: 46.44%, 25.10%, 26.12%, 57.78%, 43.26%, 34.28%, 55.46%, 75.63% and 125.6%. In the second one, the increases were: 20.17%, 28.32%, 30.15%, 67.02%, 32.56%, 47.11%, 76.72%, 30.64% and 91.11% for plant height, No. of leaves plant-1, leaf area leaf-1, leaf area plant-1, No. of branches plant-1, fresh and dry weights of leaves plant-1 as well as fresh and dry weights of branches plant-1, respectively. The reduction in such traits in intercropped bean plants as compared to sole cropped ones may be due to the increase in competition between bean and okra during growth period, the okra may reduce the light intensity reaching bean canopy by shading and this will lead to a reduction in photosynthesis activity and consequently, the reduction of growth traits were obtained. Also, the competition between plants in intercropping system may be extended to the other environmental factors; soil nutrients and moisture content demand to growth which depend upon the increase in the number of plants unit area. By other means, the ability of competition of okra may be higher than that of bean because of its vigorous vegetative features. Thus, okra, as an intercrop affected adversely growth characters of bean. These results, are in harmony with those obtained by El-Gamili (1994); Galal (1998); El-Nagar *et al.* (2002) and Varghese (2000).

Concerning the effect of intercropping on vegetative growth traits of okra, data in Table (2) revealed that there is no significant effect was observed for intercropping okra with bean on all growth traits under investigation as compared to sole cropping of okra in both seasons. By other means, okra cultivated in only without intercropping produced higher values of traits as compared to that intercropped with bean but the difference was not significant in both seasons. These findings might be attributed to that okra has a vigorous growth in which photosynthesis activity of okra plants is more than that of bean. Consequently, net product of photosynthesis for okra is higher because okra plants utilize the environmental factors (esp. light, soil nutrients and water) more efficiently than bean. This means that okra plants record growth values more than expected as compared to bean. Similar results were obtained by Abd El-Gawad *et al.* (1985); Abdalla *et al.* (1999); El-Gizy (2001) and Yildirim and Guvenc (2005).

2. Yield and its components.

2.1. Green pods yield.

The green pods yield and its components of bean and okra as affected by intercropping in both seasons is shown in Table (3). The variation between intercropped and sole cropped bean was significant for all criteria showed in this Table. In this respect, The increases in No. of green pods plant-1, fresh and dry weights pod-1, fresh and dry weights of pods plant-1 and green pods yield feddan-1 for sole cropped bean as compared to intercropped one in the first season were: 15.79%, 7.86%, 22.95%, 7.37%, 40.43% and 7.38%, respectively. While in the second season reached: 14.29%, 18.94%, 31.67%, 6.91%, 49.65% as well as 11.53%, respectively. Thus, green pods yield and its components of bean were significantly affected by intercropping with okra. The increases in green pods yield and its components of sole cropped beans could be attributed to the increase in growth traits and yield components as compared to intercropped one. Moreover, these results could be due to the interspecific competition between bean and okra for environmental factors; light, nutrients and water, which are important for bean flowering and pod setting in addition to decrease leaf area which is reflected on photosynthetic capacity. These results are in line with those found by Mendoza (1986); Gulah *et al.* (1998) and Teama *et al.* (2000). On the other hand, green pods yield and its components of okra in response to the intercropping with bean had no significant difference as compared to sole cropping of okra. Although, the values of yield and its components of sole cropped okra were more than intercropped ones but did not reach to the level of significance in both seasons. These findings might be attributed to the ability of competition of bean may be lower than that of okra because of its vigorous vegetative growth traits. These results concur with the findings of Brown *et al.* (1985); Eid and El-Gizy (1995); Askar *et al.* (1997).

2.2. Dry seed yield and its components.

Data concerning the effect of intercropping on dry seed yield and its components of both plants in both seasons are shown in Table (4). The comparison among the intercropped bean and sole cropped one showed that the sole cropped bean significantly resulted in high values of No. of dry pods plant-1, No. of dry seeds pod-1, weight of dry seeds pod-1 and plant-1, dry seeds yield feddan-1 as well as seed index than those achieved with intercropped bean. In this respect, the corresponding increments in the above mentioned of yield traits by sole cropped bean over intercropped one were: 13.08%, 44.41%, 7.69%, 21.78%, 21.80% and 22.74%, respectively in the first season. While, in the second one the increase reached: 12.00%, 54.47%, 13.78%, 27.38%, 27.38% and 17.06%, respectively. Higher seed yield of sole cropped bean may be attributed to the increase in No. of branches, No. of pods plant-1, No. of seeds pod-1 and seed yield plant-1 in both seasons. Also, the decrease in yield and its components of intercropped bean may be due to that bean plants exhausted their photosynthates for stem elongation (because of highly specific competition on light) more than for building reproductive organs. Similar results have been reported by Abdalla *et al.* (1999); Nawar and Al-kafoury (2002), Metwally *et al.* (2003) and El-Sherif (2004). On the other hand, the yield of dry seed and its components of okra was not affected when intercropped with bean. In this respect, the differences between them did not reach the level of significance. These results may be due to the lesser competition among sole cropped okra plants on growth factors; light, nutrients and water per area unit to growth, development and maturity than those under intercropping system. This trend was early recorded by Garcia and Lawas (1986); Kamel *et al.* (1990); El-Gergawi *et al.* (1995); Sarma *et al.* (1995); Yildirim and Guvenc (2005) who reported an excess of yield of the sole cropping plants over those grown in intercropping.

3. Chemical constituents.

3.1. In leaves.

Regarding the changes of chemical constituents in leaves of bean and okra as affected by intercropping, data in Tables (5 and 6) show that there is significant differences between intercropped bean and sole cropped one in both seasons for leaf pigments; Chlorophyll a, b and T as well as carotenoids) total sugars (TS), protein, N, P, K, Fe, Mn and Zn concentrations. Under intercropping system in the study, the highest values of those constituents were recorded by the sole cropped bean leaves as compared to the intercropped one. However, the variation among the intercropped and sole cropped bean plants was significant for all chemical constituents for leaves. In this regard, the increases which recorded by the sole cropped bean leaves over intercropped ones reached: 28.30%, 31.06%, 52.82%, 24.07%, 16.49% and 13.98% for Chlorophyll a, b and T as well as carotenoids) total sugars (TS), protein, respectively in the first season. While, in the second one the increases were: 10.83%, 15.51%, 15.02%, 11.27%, 18.64% and 15.55% for the above mentioned parameters as stated before. In a like manner, the highest values of N, P, K, Fe, Mn and Zn concentrations in leaves were recorded with plants produced from sole cropping of bean in both seasons than those of intercropped ones. In this respect, the differences in chemical constituents among sole cropped and intercropped bean leaves were statistically significant in both seasons. The corresponding increase in the above mentioned chemical constituents of bean leaves of sole cropped plants over intercropped ones were: 13.92% in N, 17.79% in P, 32.55% in K, 10.68% in Fe, 9.74% in Mn and 5.83% in Zn concentration in the first season. While, in the second one the increases reached: 15.51% in N, 18.87% in P, 15.30% in K, 6.83% in Fe, 18.47% in Mn, 14.90% in Zn concentration. However, the intercropping of bean with okra did not induce any significant effect on the concentration of chemical constituents in leaves of okra in both seasons as compared to those in leaves produced from sole cropped plants.

Table (2): Effect of intercropping on vegetative growth of bean and okra during both seasons of 2005 and 2006

Treatment	Plant height (cm)	NO. of leaves $plant^{-1}$	Leaf area $leaf^{-1}$ (cm^2)	Leaf area $plant^{-1}$ (cm^2)	NO. of branches $plant^{-1}$	Weight of leaves $plant^{-1}$ (g)		Weight of leaves $plant^{-1}$ (g)	
						Fresh	Dry	Fresh	Dry
1st season									
Sole cropping of bean	39.04	9.17	115.73	1061.24	8.71	21.74	3.70	13.19	2.82
Intercropped of bean	26.66	7.33	91.76	672.60	6.08	16.19	2.38	7.51	1.25
$t_{(0.05)}$	6.13	1.31	18.47	252.68	1.28	4.18	0.97	3.37	1.03
Sole cropping of okra	72.00	9.66	140.50	1357.23	5.00	129.56	11.01	42.03	10.07
Intercropped of okra	69.33	8.33	132.62	1104.72	4.00	106.20	10.05	39.11	9.33
$t_{(0.05)}$	4.72	2.03	9.03	272.13	1.57	26.09	1.32	4.67	1.82
2nd season									
Sole cropping of bean	38.66	9.83	106.92	1051.02	8.02	20.33	3.34	9.21	1.93
Intercropped of bean	32.17	7.66	82.15	629.27	6.05	13.82	1.89	7.05	1.01
$t_{(0.05)}$	5.07	1.89	11.09	292.05	1.81	5.31	0.98	0.92	0.78
Sole cropping of okra	74.33	10.66	141.88	1512.44	6.00	106.06	10.46	40.09	9.12
Intercropped of okra	71.33	9.00	136.71	1230.39	5.00	101.39	9.78	36.93	8.49
$t_{(0.05)}$	4.81	2.22	6.37	298.15	1.38	6.17	1.13	5.42	1.80

Table (3): Effect of intercropping on green pods yield and its components of bean and okra during both seasons of 2005 and 2006

Treatment	NO. of green pods plant^{-1}	Weight pod^{-1} (g)		Wight of pods plant^{-1} (g)		Yield of green pods feddan^{-1} (ton)
		Fresh	Dry	Fresh	Dry	
			1st season			
Sole cropping of bean	14.67	10.83	0.75	146.16	11.01	8.352
Intercropped of bean	12.67	10.04	0.61	136.13	7.84	7.778
$t_{(0.05)}$	**1.87**	**0.53**	**0.11**	**8.13**	**2.92**	**0.801**
Sole cropping of okra	28.66	4.92	0.93	143.50	23.31	3.272
Intercropped of okra	27.67	4.83	0.84	135.76	20.68	3.095
$t_{(0.05)}$	**1.23**	**0.17**	**0.21**	9.15	3.05	**0.225**
			2nd season			
Sole cropping of bean	16.00	10.36	0.79	150.43	12.69	8.506
Intercropped of bean	14.00	8.71	0.60	140.71	8.48	8.040
$t_{(0.05)}$	**1.79**	**0.89**	**0.14**	**8.32**	**3.13**	**0.632**
Sole cropping of okra	26.66	5.15	0.89	135.07	23.73	3.100
Intercropped of okra	25.00	5.11	0.82	127.07	20.57	2.897
$t_{(0.05)}$	**1.92**	**0.08**	**0.09**	**11.17**	**3.37**	**0.272**

Table (4): Effect of intercropping on dry seed yield and its components of bean and okra during both seasons of 2005 and 2006

Treatment	NO. of dry pods plant^{-1}	NO. of dry seeds pod^{-1}	Weight of dry seeds pod^{-1} (g)	Weight of dry seeds plant^{-1} (g)	Dry seeds yield feddan^{-1} (kg)	Seed index (100-seed wt., g)
			1st season			
Sole cropping of bean	13.57	4.39	0.98	13.30	759.98	50.41
Intercropped of bean	12.00	3.04	0.91	10.92	623.98	41.07
$t_{(0.05)}$	**1.13**	**0.69**	**0.07**	**1.11**	**67.15**	**6.21**
Sole cropping of okra	10.30	81.50	5.94	61.18	1352	8.34
Intercropped of okra	10.00	80.50	5.93	59.30	1395	8.23
$t_{(0.05)}$	**0.72**	**0.19**	**0.07**	**2.13**	**13.02**	**0.17**
			2nd season			
Sole cropping of bean	12.69	397	0.99	12.56	717.69	50.15
Intercropped of bean	11.33	2.57	0.87	9.86	563.41	43.13
$t_{(0.05)}$	**0.86**	**0.93**	**0.09**	**1.93**	**82.13**	**4.28**
Sole cropping of okra	10.20	93.83	5.85	59.67	1322	6.68
Intercropped of okra	10.00	92.93	5.80	58.00	1360	6.52
$t_{(0.05)}$	**0.28**	**1.05**	**0.08**	**1.89**	**41.15**	**0.24**

Table (5): Effect of intercropping on leaf pigments (chlorophyll a, b, T and carotenoids), total sugars (TS) and protein concentration in leaves of bean and okra during both seasons of 2005 and 2006

Treatment	Leaf pigments ($mg\ g^{-1}$ fresh wt. of leaves)				TS	Protein
	Chlorophyll			Carotenoids	(%)	
	A	B	T			
1st season						
Sole cropping of bean	1.632	1.384	3.220	0.263	3.25	16.88
Intercropped of bean	1.272	1.056	2.107	0.212	2.79	14.81
$t_{(0.05)}$	**0.217**	**0.103**	**0.687**	**0.027**	**0.40**	**1.18**
Sole cropping of okra	2.428	1.764	4.253	0.257	4.46	16.25
Intercropped of okra	2.287	1.730	4.112	0.234	4.10	15.00
$t_{(0.05)}$	**0.182**	**0.076**	**0.173**	**0.031**	**0.247**	**1.63**
2nd season						
Sole cropping of bean	1.310	1.691	3.079	0.286	3.50	17.69
Intercropped of bean	1.182	1.464	2.677	0.257	2.95	15.31
$t_{(0.05)}$	**0.071**	**0.198**	**0.356**	**0.020**	**0.31**	**1.67**
Sole cropping of okra	2.321	1.853	4.301	0.230	3.87	17.75
Intercropped of okra	2.287	1.644	3.979	0.209	3.57	15.94
$t_{(0.05)}$	**0.049**	**0.284**	**0.411**	**0.032**	**0.45**	**2.85**

Table (6): Effect of intercropping on nitrogen (N), potassium (K), phosphorus (P), iron (Fe), manganese (Mn) and Zinc (Zn) concentration in leaves of bean and okra during both seasons of 2005 and 2006

Treatment	N	P	K	Fe	Mn	Zn
	(%)	($mg\ 100^{-1}$ g dry matter of leaves)				
1st season						
Sole cropping of bean	2.70	38.67	261.00	19.89	6.42	9.44
Intercropped of bean	2.37	32.83	196.90	17.97	5.85	8.92
$t_{(0.05)}$	**0.21**	**3.17**	**51.19**	**0.93**	**0.27**	**0.36**
Sole cropping of okra	2.60	38.79	167.92	60.29	10.80	14.34
Intercropped of okra	2.40	34.78	121.10	58.53	10.65	14.19
$t_{(0.05)}$	**0.28**	**4.43**	**51.13**	**1.92**	**0.09**	**0.22**
2nd season						
Sole cropping of bean	2.83	31.5	255.00	17.83	6.67	10.95
Intercropped of bean	2.45	26.5	221.17	16.69	5.63	9.53
$t_{(0.05)}$	**0.19**	**4.03**	**19.11**	**0.87**	**0.17**	**0.61**
Sole cropping of okra	2.84	37.37	196.78	61.47	12.28	15.47
Intercropped of okra	2.55	34.81	174.13	60.72	12.00	15.16
$t_{(0.05)}$	**0.36**	**2.78**	**28.01**	**0.89**	**0.34**	**0.35**

3.2. In green pods.

Changes in N, P, K, Fe, Mn, Zn, TS and protein concentrationin green pods of bean and okra plants produced from intercropping and sole cropping under this study are shown in Table (7). It is clear that the sole cropping of bean resulted in a marked increase in green pods of those chemical constituents over that of intercropped ones. This finding seems to indicate that chemical constituents of green pods affected were by intercropping of bean and okra. However, the increases recorded by the green pods of sole cropped bean plants over intercropped ones were: 12.43% in N, 10.98% in P, 7.38% in K, 7.32% in Fe, 19.61% in Mn, 16.70% in Zn, 27.67% in TS and 12.50% in protein in the first season. Meanwhile, in the second one increases reached: 14.53% in N, 9.56% in P, 11.02% in K, 8.64% in Fe, 15.79% in Mn, 18.03% in Zn concentration. Under the effect of intercropping, it was found that, no significant differences could be detected in the concentrations of N, P, K, Fe, Mn, Zn, TS and protein in the green pods of sole cropped and intercropped of both crops in both seasons.

3.3. In dry seeds.

Data presented in Table (8) clearly show that the chemical constituents concentration in dry seeds of bean was significantly affected by the intercropping of bean and okra in both seasons (Table 8). In this respect, sole cropping of bean resulted in a marked increase in the concentration of N, P, K, Fe, Mn, Zn, Total soluble carbohydrates (TSC) and protein in dry seeds of bean over than those of intercropped ones in both seasons. These increases, in the first season, reached: 12.87% in N, 20.32% in P, 21.89% in K, 13.02% in Fe, 8.48% in Mn, 12.19% in Zn, 6.45% in TSC and 12.84% in protein. Whereas, the increases in the second season were: 17.15% in N, 24.58% in P, 24.27% in K, 2.49% in Fe, 6.34% in Mn, 9.63% in Zn, 8.45% in TSC and 17.16% in protein. With respect to, the effect of intercropping on the chemical constituents; N, P, K, Fe, MN, Zn, TSC and protein in dry seeds of okra, it was found that no significant differences could be recorded between the mean values of those constituents in dry seeds produced from intercropped plants and sole cropped ones. However, the increases in the chemical constituents of leaves, green pods and dry seeds of sole cropped bean over intercropped ones may be due to the increase in competition between bean and okra on the environmental factor; light, where the okra may lower the light intensity reaching bean canopy by shading and this will lead to the reduction in photosynthesis activity, this will reduce dry matter production. The reduction in dry matter was accompanied by a reduction in the above mentioned chemical constituents in leaves, green pods and dry seeds of intercropped bean. In addition, the competition on the soil nutrients will lead to the decrease of nutrients absorption from the soil by roots of intercropped plants. These results are in agreement with those reported by Teama *et al.* (2000) and El-Nagar *et al.* (2002). On the other hand, the insignificant differences between intercropped and sole cropped okra in the chemical constituents in leaves, green pods and dry seeds may be attributed to the vigorous vegetative growth features of okra as compared to bean and consequently has a high ability of competition on environmental factors (light, soil nutrients and water), this lead to the increase in photosynthesis activity, dry matter and nutrients uptake which make the differences between intercropped and sole cropped plants in their chemical constituents did not reach the level of significance. In this respect, Varghese (2000) indicated that intercropping with six different vegetables did not affect on N, P and K concentration of cabbage compared to sole cropped one. Similarly, Santos *et al.* (2002) reported that concentration of N, P and K of intercropped broccoli with cauliflower and bean were similar to the sole cropping. This could be explained by the efficient use of available resources per unit area for different crops (Sharaiha and Hattar, 1993). Also, Yildirim and Guvenc (2005) reported that the concentration of N, P, K, Fe in cauliflower in different cropping systems produced no significant response as compared to sole cropping of cauliflower.

4. Competitive relationships.

4.1. Land equivalent ratio (LER).

When the values of LER appear to be greater than 1 under intercropping system, this usually indicates the efficiency of this system over the sole cropping (Vandermeer, 1989). LER as an indicator of biological efficiency in intercropping system was always greater than I with intercropping in this study (Table 9). In the study the value of LER was obtained in the bean intercropped with okra reached 1.88 for green pods yield feddan-1 in both seasons. For dry seeds yield feddan-1, LER values were: 1.79 and 1.76 in the first and second seasons, respectively. This indicates that yield advantages was obtained and land usage was increased by intercropping bean with okra. It could be concluded that planting bean on the other side of row produced the best yield advantage and the highest land use. In addition, these results indicate that okra had more competitive abilities than bean. The compatibility of okra and bean, in mixture which resulted in yield advantage over sole cropped okra or bean might be due to different rooting systems of bean and okra plants. On the other hand, the growth behavior of okra show its ability to utilize higher light intensities might explain the maximizing benefits of land per unit area, especially when tall growing okra plants were associated with short bean plants. The high efficiency of intercropping found in this study agreed with the findings of Prabhakar and Shukla (1990); Malhotra and Kumar (1995); Costa and Perera (1998); Baumann *et al.* (2001) and Yildirim and Guvenc (2005), they explained this phenomenon by the complementary use of growth resources in vegetables production. An explanation for the beneficial effect of intercropping might be the more efficient use of available resources per unit area.

4.2. Agressivity.

Agressivity data in Table (10) revealed that okra was always the dominant intercrop component over bean. These results indicate that okra had more competitive abilities than bean which may be due to the vigor of growth of okra consequently, a high photosynthetic activity by okra leaves will occurs in which the net product of photosynthesis is higher because these plants utilize the environmental factors more efficiently than bean. Thus, okra crop produce yield (green pods and dry seed yield) than expected as compared to bean. By other means, intercropping is considered to be an effective method to increase the use efficiency of land. Similar results were obtained by many investigators such as El-Hawary (1993); El-Douby *et al.* (1996); El-Nagar *et al.* (2002) and El-Sherif (2004).

Table (7): Effect of intercropping on nitrogen (N), potassium (K), phosphorus (P), iron (Fe), manganese (Mn) and Zinc (Zn), total sugar (TS) and protein concentration in green pods of bean and okra during both seasons of 2005 and 2006

Treatment	N (%)	P	K	Fe	Mn	Zn	TS	Protein
		(mg 100^{-1} g dry matter of green pods)					(%)	
1[st] season								
Sole cropping of bean	1.90	112.83	329.83	0.88	1.22	18.87	3.33	11.88
Intercropped of bean	1.69	101.67	307.17	0.82	1.02	16.17	2.53	10.56
$T_{(0.05)}$	**0.11**	**5.67**	**9.13**	**0.035**	**0.112**	**1.03**	**.52**	**0.72**
Sole cropping of okra	0.78	64.33	335.67	0.84	1.63	20.22	6.38	4.88
Intercropped of okra	0.75	59.33	329.67	0.80	1.57	19.00	5.95	4.69
$T_{(0.05)}$	**0.047**	**7.32**	**8.17**	**0.062**	**0.089**	**2.39**	**0.74**	**0.31**
2[nd] season								
Sole cropping of bean	1.97	106.33	363.58	0.88	1.32	18.59	3.04	12.31
Intercropped of bean	1.72	96.17	327.50	0.81	1.14	15.75	2.57	10.75
$T_{(0.05)}$	**0.14**	**4.01**	**19.15**	**0.041**	**0.145**	**1.11**	**.38**	**0.96**
Sole cropping of okra	0.82	78.67	326.00	0.79	1.70	19.91	6.98	4.50
Intercropped of okra	0.75	73.67	317.33	0.74	1.57	18.33	6.70	4.69
$T_{(0.05)}$	0.0.18	7.03	**10.63**	**0.081**	**0.181**	**1.87**	**0.351**	**0.242**

Table (8): Effect of intercropping on nitrogen (N), potassium (K), phosphorus (P), iron (Fe), manganese (Mn) and Zinc (Zn), total soluble carbohydrates (TSC) and protein concentration in dry seed of bean and okra during both seasons of 2005 and 2006

Treatment	N (%)	P	K	Fe	Mn	Zn	TS	Protein
		(mg 100^{-1} g dry matter of dry seed)					(%)	
1[st] season								
Sole cropping of bean	3.77	73.00	232.00	85.52	83.17	52.17	60.92	23.56
Intercropped of bean	3.34	60.67	190.33	75.65	76.67	46.50	57.23	20.88
$t_{(0.05)}$	**0.271**	**4.71**	**27.52**	**4.61**	**3.19**	**2.83**	**1.62**	**1.18**
Sole cropping of okra	2.82	41.33	384.00	101.15	27.00	20.66	60.19	17.63
Intercropped of okra	2.62	38.00	353.66	97.33	23.66	17.67	58.77	16.38
$t_{(0.05)}$	**0.037**	**4.05**	**37.16**	**6.15**	**5.19**	**4.11**	**3.82**	**3.16**
2[nd] season								
Sole cropping of bean	4.03	72.67	242.33	88.19	83.66	55.00	59.05	25.19
Intercropped of bean	3.44	58.33	195.00	86.05	78.67	50.17	54.45	21.50
$t_{(0.05)}$	**0.265**	**7.13**	**31.10**	**1.78**	**2.97**	**2.57**	**1.86**	**1.69**
Sole cropping of okra	2.62	43.00	399.00	106.09	25.00	21.83	63.09	16.38
Intercropped of okra	2.58	38.67	370.67	103.11	23.00	19.00	60.66	16.13
$t_{(0.05)}$	**0.062**	**6.22**	**32.03**	**5.07**	**2.48**	**3.11**	**4.01**	**0.292**

Table (9): Comparative relationships of intercropped bean and okra (for green pods yield) during both seasons of 2005 and 2006.

Treatment	Land equivalent ratio (LER)			Agressivity (A)	
	LER bean	LER okra	LER	Abean	AOkra
First season					
Sole cropping of bean	1.00	----	1.00	0.00	-----
Sole cropping of okra	---	1.00	1.00	----	1.00
Intercropped bean and okra	0.931	0.946	1.877	-0.014	+0.014
Second season					
Sole cropping of bean	1.00	---	1.00	1.00	----
Sole cropping of okra	---	1.00	1.00	----	1.00
Intercropped bean and okra	0.945	0.935	1.880	-0.01	+0.01

Table (10): Comparative relationships of intercropped bean and okra (for dry seed yield) during both seasons of 2005 and 2006.

Treatment	Land equivalent ratio (LER)			Agressivity (A)	
	LER bean	LER okra	LER	A bean	A Okra
First season					
Sole cropping of bean	1.00	----	1.00	0.00	-----
Sole cropping of okra	---	1.00	1.00	----	1.00
Intercropped bean and okra	0.821	0.969	1.790	-0.172	+0.172
Second season					
Sole cropping of bean	1.00	---	1.00	1.00	----
Sole cropping of okra	---	1.00	1.00	----	1.00
Intercropped bean and okra	0.785	0.972	1.757	-0.116	+0.116

Finally, Despite of the decrease in bean yield, under this study, due to intercropping, the process of bean and okra intercropping is sill profitable to farmer because of the yield additional income incurred through okra and produce bean for self sufficient without any major change in Egyptian prevailing agricultural crop structure. Furthermore, these studies could be recommended but more condensed studies are required to minimize the negative effect of intercropping on bean yields (green pods and dry seed).

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تأثير التحميل على النمو والقدرة المحصولية للفاصوليا والباميا

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أجريت هذه الدراسة بمزرعة كلية الزراعة-جامعة الفيوم-مصر، وذلك خلال موسمى الصيف لعامى ٢٠٠٥-٢٠٠٦. بهدف دراسة تأثير التحميل على النمو والقدرة المحصولية لكل من الفاصوليا والباميا. لإنجاز هذا الهدف فقد تم زراعة الفاصوليا (صنف جيزة ٣) والباميا (صنف بلدى) على النحو التالى:

١- زراعة الفاصوليا والباميا بصورة منفردة (غير محملة)

٢- زراعة الفاصوليا والباميا بصورة متبادلة على جانبى نفس الخط (كل محصول على أحد جانبى الخط).

وكانت أهم النتائج المتحصل عليها على النحو التالى:

- أدى التحميل إلى حدوث نقص معنوى- مقارنة بالزراعة المنفردة (غير المحملة)- فى صفات النمو لنباتات الفاصوليا التى تم دراستها (ارتفاع النبات- عدد الأوراق للنبات- مساحة الورقة - المساحة الورقية للنبات - عدد الأفرع النبات - الوزن الطازج والجاف لأوراق النبات والفروع).

- لم يلاحظ وجود فرق معنوى فى صفات النمو سالفة الذكر بين نباتات الباميا المحملة وغير المحملة على الرغم من زيادة قيم هذه الصفات للباميا غير المحملة عن مثيلتها المحملة.
- كان للتحميل تأثير معنوى واضح - مقارنة بالزراعة المنفردة (غير المحملة) - فى نقص محصول القرون الخضراء ومكوناته للفاصوليا (عدد القرون الخضراء للنبات -وزن القرن الطازج والجاف - وزن القرون الطازجة والجافة للنبات- محصول القرون الخضراء للفدان).
- لم يظهر أى فرق معنوى بين محصول القرون الخضراء ومكوناته للباميا المحملة وغير المحملة، على الرغم من زيادة قيمته للباميا غير المحملة عن مثيلتها المحملة.
- أدى التحميل الى حدوث نقص معنوى - مقارنة بالزراعة المنفردة (غير المحملة) - فى محصول البذرة الجافة ومكوناته (عدد القرون الجافة للنبات - عدد البذور للقرن - وزن بذور القرن - وزن بذور النبات - محصول البذرة للفدان - وزن ١٠٠ بذرة).
- لم يلاحظ حدوث تأثير معنوى على المحصول ومكوناته ما بين الباميا المحملة وغير المحملة، على الرغم من زيادة قيمته للباميا غير المحملة عن مثيلتها المحملة.
- كان للتحميل أثر واضح معنويا فى نقص المكونات الكيماوية التى تم دراستها فى كل من الأوراق والقرون الخضراء والبذور الجافة (الصبغات النباتية: كلوروفيل ا، ب، الكلى، الكارتينويدات (فى الأوراق فقط)- النتروجين- البوتاسيوم- الفوسفور- الحديد-المنجنيز- الزنك- السكريات الكلية (الكربوهيدرات الذائبة الكلية فى البذور الجافة فقط) - البروتين) مقارنة بمثيلتها فى الفاصوليا غير المحملة.
- لم يظهر التحميل أى تأثير معنوى على المكونات الكيماوية مابين الباميا المحملة وغير المحملة، على الرغم من زيادة قيمته للباميا غير المحملة عن مثيلتها المحملة.
- أظهرت نتائج المكافىء الأرضى أن نظام التحميل المستخدم فى هذه الدراسة سجل أعلى قدر من الاستفادة من الأرض المنزرعة (حيث بلغت قيمته ١,٨٨ للمحصول الأخضر فى كلا موسمى الدراسة و فى فى حالة محصول البذرة الجافة بلغ ١,٧٩، ١,٧٦ فى كلا الموسمين على التوالى). وكما أظهرت النتائج أيضا سيادة محصول الباميا على الفاصوليا خلال موسمى الدراسة.
- وهكذا، وعلى الرغم من حدوث نقص فى محصول الفاصوليا تحت تأثير التحميل، فان نظام التحميل المستخدم فى هذه الدراسة يعتبر مربح للمزارع بسبب الدخل الاضافى لمحصول الباميا المحملة مع الفاصوليا.

ومن هنا - وفى ضوء نتائج هذه الدراسة- يمكن التوصية باستخدام هذا النظام فى تحميل الفاصوليا والباميا ولكن مع إجراء المزيد من الدراسات فى محاولة لتقليل التأثيرات السلبية للتحميل على نمو ومحصول الفاصوليا (القرون الخضراء والبذور الجافة).