EFFECT OF INTERCROPPING AND PLANT POPULATION ON GROWTH, YIELD, COMPETITIVE RELATIONSHIPS AND ECONOMIC RETURN OF PEA AND GARLIC PLANTS

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ABSTRACT

This work was carried out at a farm in Disuq, Kafr El-Sheikh governorate during 2001/2002 and 2002/2003 growing seasons. It aimed to study the effects of intercropping, plant population of pea and their combined interactions on growth, yield and quality, competitive relationships and economic return of pea (Master B cv.) and garlic (Balady cv.). A split plot in a randomized complete blocks design with four replicates was used.

Results indicated that intercropping pea with garlic reduced number of leaves and branches, leaf area, total chlorophyll content and plant fresh weight of both crops compared to sole cropping. Decreasing plant population of pea (64, 500 plants/fed.) led to a favourable effect on the vegetative growth of both crops.

Yield of green pods and number of seeds/pod of pea were decreased by intercropping. Also, garlic yield, bulb diameter and bulb weight were decreased by intercropping, whereas increasing plant population of pea (200,000 plants/fed.) caused an increase in pea pods yield and decrease in garlic bulb yield. In contrast, decreasing plant population of pea (64,500 plants/fed.) decreased pea yield but increased garlic yield and both bulb diameter and weight, as well as, pea pod length and number of seeds/pod.

Pea was dominated whereas garlic was dominant in the intercropping. The aggressivity was decreased by increasing plant population of pea. Intercropping increased relative crowding coefficient which was more pronounced at density of 200,000 pea plants/feddan. Land equivalent ratio and area time equivalent ratio were increased to a maximum of about 45-65% and 11-18%, respectively by intercropping pea with garlic under both pea plant densities (129,000 and 200,000 plants/fed.) compared to sole cropping.

The highest records of both general mean of net return and intercropping monetary advantage were obtained from intercropping pea with garlic under high plant population of pea (200,000 plants/fed.).

INTRODUCTION

In the last two decades, investigators paid intensive attention to intercropping as a way for increasing yield per unit land area. The current status of intercropping research shows that it can give substantial yield advantages, and more stability from season to another than sole cropping. The causes of yield advantages could be due to several factors as suggested by many workers; crops grown in association may utilize water and soil resources efficiently than in sole cropping (Andrews and Kassam, 1976; Ahmed and Gunasena, 1979 and Willey, 1979). In this connection, Abdel-Aal (1990) indicated that a yield advantage under intercropping systems may be due to the differences between crops in their rooting systems, nutrient requirements and photosynthetic cycles, thereby they are able to complement each other and to make better overall use of environmental resources when grown in combination than when grown separately.

Intercropping pea with garlic could be considered one of the successful example. Thus, the pea cultivar used ((Master B) is a short growing period, determinate growth habit and low fertilizer requirements (Fayad, 2004). These characters gave the chance for intercropping with other crops. Moreover, both pea and garlic are considered suitable crops for intercropping with respect to the intensive utilization of nutrients, sunlight and water which are usually wasted in monocropping systems of cultivation. Many investigators stated that the use of vegetables intercropping systems greatly increased land productivity by increasing total yield per unit area (El-Zawily *et al.*, 1993; El-Waraky, 1996 and Abdel-Baky, 2000).

Thus, the main objective of the present study was to investigate the effects of intercropping between pea and garlic plants with different plant populations of pea on growth, yield and quality of both crops as well as the competitive relationships and monetary advantage of the combined intercrop.

MATERIALS AND METHODS

Two field experiments were performed at a farm in Disuq district, Kafr El-Sheikh Governorate, during two winter seasons of 2001/2002 and 2002/2003, to investigate the effect of intercropping between pea and garlic with different plant populations of pea on growth, yield and quality as well as the competitive relationships and economic return of the two crops.

Each experiment included 12 treatments arranged in a split plot system in a randomized complete block design with four replications in which intercropping combinations (pea alone, garlic alone and pea with garlic) were distributed in the main plots. Meanwhile, plant populations of pea at 4 densities, i.e., 64 500, 100 000, 129 000 and 200 000 plants/feddan were arranged within sub-plots.

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Intercropping and plant populations for pea and garlic are listed in Table (1).

Pea seeds were sown on single or double rows in the middle of ridge, while garlic plants were planted with common method at 10 cm. spacing between hills with one plant per hill on both ridge sides in all treatments. Each sub-plot consisted of four ridges of five meters long and 80 cm wide. Thus made an area of 16 square meters.

Table (1): Intercropping and plant population for pea and garlic during 2001/2002 and 2002/2003 seasons.

Treatments	Intercropping and plant populations of pea and garlic					
	No. of pea rows	Hill spacing (cm)	Pea densities (plants/fed.)	No. of garlic rows	Hill spacing (cm)	Garlic densities (plants/fed.)
	Solid pea:			**Solid garlic:**		
1	Double	10	200 000	Double	10	100 000
	Intercropping:			**Intercropping:**		
2	Single	15	64 500	Double	10	100 000
3	Single	10	100 000	Double	10	100 000
4	Double	15	129 000	Double	10	100 000
5	Double	10	200 000	Double	10	100 000

Pea seeds of cv. Master B were sown on 21st of October in both seasons, each hill was allowed to have two plants. Garlic cloves of cv. Balady were sown on 5th and 11th of October in 2001/2002 and 2002/2003 seasons, respectively. The common cultural practices were done whenever needed and as usually conducted by commercial growers. A representative plant sample including 10 plants of pea from each sub-plot was picked at 50 days after sowing, in which plant height, number of branches, number of leaves, leaf area/plant and plant fresh weight were measured. To estimate the yield of green pods, they were picked at intervals of 10 days up to 50 days after sowing. During the harvesting season, three pod samples consisted of twenty-five green pods were taken at random from each sub-plot to estimate the pods quality, i.e. length, diameter and number of seeds/pod.

For the main crop, ten of garlic plants of each experimental unit were taken at 150 days after sowing and the following growth parameters were measured: Plant height, pseudostem length, number of leaves/plant, leaf area/plant and plant fresh weight. Ten bulb samples of garlic were taken after the harvest for measuring bulb diameter and bulb weight. Total yield (kg/feddan) was also calculated.

Total chlorophyll content was measured at 50 and 120 days in pea and garlic plants, respectively, by using the SPAD-501, a portable leaf chlorophyll meter (Minolta crop) was used for greenness measurements (Marquard and Timpton, 1987) on fully expanded (the fifth from the shoot tip) leaves without destroying them.

In order to determine the nature and degree of competition between pea and garlic and the yield advantage of the intercropping systems, the following parameters were calculated:

1. Aggressivity (A): It was determined according to the formula described by McGilchrist (1965).
2. Relative crowding coefficient (K): It was determined according to the formula described by DeWit (1960).
3. Land equivalent ratio (LER): it was determined according to the formula described by Andrews and Kassam (1976).
4. Area time equivalent ratio (ATER): LER method was modified to include the duration of time (the crop was on the land) from planting to harvest of plants. This method is known as the area time equivalent ratio (ATER), (Hiebsch, 1980).

Net return and monetary advantage of combined intercrop yield:

1. **Net return**: It was calculated by expressing the cost and yield per feddan in monetary terms. This dose, of course, put the two crops on a comparable basis*. The retail prices used in computing cash returns were 500 and 1250 L.E. for each ton of garlic and pea yield, respectively. The costs were negated from the overall case returns in both seasons, as the resulted cash return was the net return.
2. **Monetary advantage:** It was calculated by subtracting the general mean of the cash net return of garlic as a main crop from that of the combined intercrop.

The data obtained were statistically analyzed according to procedures outlined by Snedecor and Cochran (1967). Least significant difference (LSD) test was used for comparing means among treatments.

RESULTS AND DISCUSSION

Garlic plants (main crop) completed their life cycle within 190 days after cloves sowing in this experiment, while pea plants (companion crop) completed their life cycle after about 80 days from

* Average prices of Kafr El-Sheikh Governorate during 202 and 2003 growing seasons.

seeds sowing. Thus both garlic and pea plants remain together after pea planting about 80 days. In this period both crops subjected to inter and intera specific competition, while after harvesting pea plants, garlic plants suffer from intercompetition only.

I. Effect of intercropping:

a. Pea:

Data in Table (2) show that intercropping pea with garlic significantly decreased most of the studied growth characters of pea in terms of number of leaves and branches, leaf area, total chlorophyll content and plant fresh weight compared to pea sole cropping in both seasons. Inversely, the pea plants grown with garlic resulted in the highest average plant height in both seasons. This result may be due to the higher number of plants per feddan with intercropping that caused higher inter and intra competition between plants, light and minerals. This is in harmony with the results of El-Shimi (1983) on tomato and cucumber or beans, Kassem (1991) on cowpea and cucumber, Gawish *et al.* (1992) on pea and tomato, El-Waraky (1996) on cowpea, beans and eggplant or squash and Abdel-Baky (2000) on beans and pepper.

Table (2): Effect of intercropping between pea and garlic on vegetative growth, yield and quality of pea, in 2001/2002 and 2002/2003 seasons.

Intercropping	Vegetative growth						Pod yield and quality			
	Plant height (cm)	Number of leaves/ plant	Number of branches/ plant	Leaf area/plant (cm^2)	Chlorophyll content SPAD unit	Plant fresh weight (g)	Yield of green pods/ (ton/fed.)	Pod length (cm)	Pod diameter (cm)	Number of seeds/pod
2001/2002 season										
Pea alone	55.1 a	35.6 a	3.3 a	1210.9 a	46.38 a	117.3 a	4.845 a	10.6	1.5	9.5 a
Pea with garlic	74.6 b	29.0 b	2.8 b	1136.7 b	43.97 b	104.2 b	2.876 b	10.6	1.4	9.0 b
F-test	**	**	**	**	**	**	**	N.S	N.S	**
2002/2003 season										
Pea alone	48.5	14.5 a	2.5 a	458.3 a	44.00 a	98.2 a	3.771 a	8.5	1.4	7.9
Pea with garlic	51.1	13.0 b	2.3 b	416.5 b	42.00 b	89.3 b	2.145 b	8.4	1.4	7.8
F-test	N.S	**	**	**	**	**	**	N.S	N.S	N.S

*, ** and N.S. indicate $P < 0.05$, $P < 0.01$ and not significant, respectively.
Means designated by the same letter are not significantly different at 5% level according to L.S.D. Test.

Table (2) shows also, that green pods yield of peas (kg/fed.) was significantly decreased in the two growing seasons by intercropping compared to pea sole cropping. The reduction in pea yield was a resultant of the decrease in vegetative growth by intercropping (Table, 2). This result is in agreement with those obtained by Rosset *et al.* (1987) who found that, the yield of intercropped bean with tomato was 75% of monocultural bean production. Similar conclusion was obtained by Gawish *et al.* (1992) on pea and tomato, El-Zawily *et al.* (1993) on cowpea and cucumber, El-Waraky (1996) on cowpea, beans and eggplant or squash and Abdel-Baky (2000) on beans and pepper.

Data in the same Table show also, that intercropping had a significant effect on number of seeds/pod in the first season as pea alone was the superior, but it did not significantly affected both pod length and diameter in both growing seasons.

B. Garlic:

Results presented in Table (3) indicate that intercropping garlic with pea had a significant decreasing effect on all studied garlic vegetative growth parameters i.e., plant height, pseudostem length, number of leaves, leaf area, total chlorophyll content and plant fresh weight compared to sole cropping in both seasons. The depression in plant growth characters was mainly attributed to the shading of pea plants and also from the competition between the two crops for water and minerals as mentioned before. The obtained results are in confirmity with those of El-Mansi *et al.* (1988) on garlic and cowpea.

Table (3): Effect of intercropping between pea and garlic on vegetative growth, yield and quality of garlic, in 2001/2002 and 2002/2003 seasons.

Intercropping	Vegetative growth						Bulb yield and quality		
	Plant height (cm)	Pseudostem length (cm)	Number of leaves/ plant	Leaf area/plant (cm^2)	Chlorophyll content SPAD unit	Plant fresh weight (g)	Total yield (ton/fed.)	Bulb diameter (cm)	Bulb weight (g)
2001/2002 season									
Garlic alone	109.6 a	49.3 a	10.9 a	350.65 a	71.97 a	161.0 a	6.955 a	5.5 a	43.8 a
Garlic with pea	105.1 b	47.2 b	10.2 b	303.84 b	69.97 b	130.9 b	6.211 b	5.1 b	39.2 b
F-test	**	**	**	**	*	**	**	**	**
2002/2003 season									
Garlic alone	103.6 a	48.5 a	10.5 a	310.10 a	70.20 a	135.0 a	6.429 a	5.2 a	39.0 a
Garlic with pea	99.0 b	46.0 b	9.8 b	261.43 b	67.62 b	105.6 b	5.513 b	5.0 b	34.6 b
F-test	**	**	**	**	**	**	**	**	**

*, and ** indicate $P < 0.05$, $P < 0.01$, respectively..
Means designated by the same letter are not significantly different at 5% level according to L.S.D. Test.

The data in the same Table show the effect of intercropping on bulb yield and quality i.e., bulb diameter and bulb weight. Garlic sole cropping enhanced total bulb yield (kg/fed.) and quality compared to garlic intercropped with pea. This might be due to that, the solid planting benefited more from the available nutrients, water and solar radiation. In this concern, El-Beheidi *et al.* (1988) reported that solid cropping improved yield characteristics in garlic and cowpea when compared with intercropping.

II. Effect of plant population of pea:

A. Pea:

Data presented in Table (4), generally, show that the number of leaves, number of branches, leaf area, total chlorophyll content and plant fresh weight of pea plants were significantly increased by increasing the spacing between pea plants up to the highest one (15 cm spacing within single row of pea in the middle of ridge, 64,500 plants/fed.). Therefore, the narrowest spacing (10 cm spacing within double rows of pea in the middle of ridge, 200,000 plants/fed.) resulted in the lowest records of the studied vegetative growth parameters, but it had the longest plants. These results are true in both studied seasons. The noticed increase in plant growth characters of pea plants by increasing the spacing between plants could be due to decreasing the number of plants per unit area and reducing competition between pea and garlic plants for moisture, nutrients and light. These results agreed with those of El-Shimi (1983) on tomato and cucumber or beans plants, El-Waraky (1988) on cucumber and Kassem (1991) on cowpea and cucumber.

Table (4): Effect of plant population of pea intercropped with garlic on vegetative growth, yield and quality of pea, in 2001/2002 and 2002/2003 seasons.

Plant population of pea/fed.	Vegetative growth						Pod yield and quality			
	Plant height (cm)	Number of leaves/ plant	Number of branches/ plant	Leaf area/plant (cm^2)	Chlorophyll content SPAD unit	Plant fresh weight (g)	Yield of green pods (ton/fed.)	Pod length (cm)	Pod diameter (cm)	Number of seeds/pod
2001/2002 season										
64 500	62.6 d	33.1 a	3.2 a	1191.9 a	45.92 a	115.3 a	3.385 d	10.8 a	1.5	9.4 a
100 000	63.8 c	32.6 ab	3.0 b	1182.0 ab	45.51 ab	110.9 bc	3.702 c	10.6 b	1.5	9.3 ab
129 000	64.9 b	31.9 ab	3.0 b	1168.2 b	44.93 ab	109.6 cd	3.948 b	10.6 b	1.5	9.2 b
200 000	68.1 a	31.7 b	2.9 b	1153.1 b	44.36 b	107.2 d	4.407 a	10.5 b	1.4	9.1 b
F-test	**	*	*	*	*	**	**	*	N.S	*
2002/2003 season										
64 500	48.4 b	14.9 a	2.4 a	456.6 a	42.77 a	97.9 a	2.583 d	8.6 a	1.4	7.9
100 000	49.5 b	13.9 bc	2.3 ab	438.4 bc	42.55 a	95.1 bc	2.846 c	8.5 ab	1.4	7.9
129 000	50.3 ab	13.5 c	2.3 ab	429.2 cd	41.47 ab	93.9 c	3.009 b	8.4 b	1.4	7.9
200 000	51.0 a	12.8 d	2.2 b	425.4 d	41.22 b	88.2 d	3.396 a	8.3 b	1.4	7.7
F-test	*	**	*	**	*	**	**	*	N.S	N.S

*, ** and N.S. indicate $P < 0.05$, $P < 0.01$ and not significant, respectively.
Means designated by the same letter are not significantly different at 5% level according to L.S.D. Test.

Regarding the effect of plant population on pea yield, results in Table (4) indicate that decreasing the spacing between pea plants (10 cm within double rows of pea in the middle of ridge, 200,000 plants/fed.) caused a significant increase in yield of green pods/fed. in both seasons. This might be due to increasing the number of plants per unit area at close spacings. This result is in agreement with the findings of other workers on several crops such as Rey and Zandstra (1976) who obtained greater bean yields per hectare at higher plant densities. Also, El-Zawily *et al.* (1993) reported that the seed yield of cowpea per feddan was increased remarkably with decreasing the spacing between plants.

Table (4) shows also, that each of pod length, pod diameter and number of seeds/pod were increased by increasing the distance between plants up to the highest one. Therefore, the highest values of these parameters were obtained from the widest spacing (15 cm) and the lowest plant population of pea per unit area (single row of pea, 64,500 plants/fed.), while the lowest values were of the narrowest spacing (10 cm) and the highest plant population per unit area (double rows of pea, 200,000 plants/fed.). However, the differences in these parameters were significant only in pod length in both seasons and number of sees/pod in the first season.

B. Garlic:

The data in Table (5) show that decreasing plant density of pea gradually increased all studied garlic plant growth characters, so the most vigorous growth of garlic was obtained when pea plants planted at 15 cm spacing within single rows of pea in the middle of ridge (64,500 pea plants/fed.). In contrast, significant decrease in number of leaves, leaf area and plant fresh weight of garlic was produced from pea plants grown at the narrowest spacing (10 cm) with double rows of pea in the middle of ridge (200,000 pea plants/fed.). These results are true in both studied seasons. Results may be due to the positively effect of low plant population of pea on growth characters of garlic plants which was adequate to supply the nutrients, water and light needed for maximum garlic plant growth. These results agreed with those of El-Mansi *et al.* (1988) on garlic and cowpea.

Table (5): Effect of plant population of pea intercropped with garlic on vegetative growth, yield and quality of garlic, in 2001/2002 and 2002/2003 seasons.

Plant population of pea/fed.	Vegetative growth						Bulb yield and quality		
	Plant height (cm)	Pseudostem length (cm)	Number of leaves/ plant	Leaf area/plant (cm^2)	Chlorophyll content SPAD unit	Plant fresh weight (g)	Total yield (ton/fed.)	Bulb diameter (cm)	Bulb weight (g)
2001/2002 season									
64 500	108.3	49.1	10.9 a	338.96 a	71.63	152.6 a	6.762 a	5.4 a	42.8 a
100 000	107.6	48.4	10.7 a	337.53 a	71.17	149.3 ab	6.670 a	5.3 ab	41.9 ab
129 000	107.1	47.9	10 6ab	329.41 a	70.90	142.5 b	6.580 ab	5.3 ab	41.1 ab
200 000	106.4	47.6	10.5 b	303.08 b	70.19	139.5 b	6.400 b	5.2 b	40.3 b
F-test	N.S	N.S	*	**	N.S	*	*	*	*
2002/2003 season									
64 500	102.7	47.7	10.3 a	294.40 a	69.41	128.8 a	6.143 a	5.2 a	38.5 a
100 000	102.1	47.3	10.2 ab	289.08 ab	69.08	124.1 b	6.042 ab	5.2 a	37.1 b
129 000	100.9	47.2	10.2 b	282.46 ab	68.93	115.6 cd	5.946 b	2.1 bc	36.3 c
200 000	99.7	45.3	10.0 b	277.13 a	68.23	112.8 d	5.752 c	5.0 c	35.5 d
F-test	N.S	N.S	*	*	N.S	**	**	*	**

*, ** and N.S. indicate $P < 0.05$, $P < 0.01$ and not significant, respectively.
Means designated by the same letter are not significantly different at 5% level according to L.S.D. Test.

Regarding the effect of plant population of pea on garlic yield and quality data in Table (5) indicate also, that decreasing plant population of pea, gradually increased garlic yield (ton/fed.) and both bulb diameter and weight, so the spacing of 15 cm between plants within single row of pea in the middle of ridge (64,500 pea plants/fed.) gave the highest values of these parameters in the two growing seasons. The noticed increase in bulb yield of garlic by decreasing the plant population of pea could be due to reducing competition between garlic and pea plants as mentioned before. These results agreed with those of El-Beheidi *et al.* (1988) on garlic and cowpea.

III. Effects of the combined interaction between intercropping and plant population of pea:

A. Pea:

Data in Table (6) indicate that the greatest values of vegetative growth parameters of pea plants were obtained from low plant population of pea under both intercropping and sole cropping with superiority for the later on the former. On the other hand, plants which planted at high plant population (200 000 pea plants/fed.) showed the least growth of pea plants.

The interaction of intercropping along with plant population density caused significant variation in yield of green pods at both growing seasons. The lowest value of peas total yield was obtained from intercropped pea plants which planted at low plant population. On the other hand, the high plant population density gave the highest values of total yield of pea whether under intercropping or sole cropping with superiority for the later on the former. The combined interaction of intercropping and plant density of peas did not show any significant differences in pod dimensions of peas (length and diameter) in both seasons.

B. Garlic:

The combined interaction of intercropping and plant population density of pea show that, the lowest plant population density of pea i.e., 64,500 plants/fed. resulted in a significant increase in vegetative growth parameters of both intercropped and monocrop garlic with superiority for the later on the former. Reversely, the highest plant population density of pea i.e., 20,000 plants/fed. reduced plant height, pseudostem length, number of leaves, leaf area, total chlorophyll content and plant fresh weight of garlic plants.

In regard to the effect of the combined interaction between intercropping and plant population density of pea on bulb yield and quality of garlic, the same data in Table (7) indicate that, the low plant population density of pea i.e., 64,500 plants/fed. resulted in a significant increase in total yield of both intercropped and monocrop garlic with superiority for the later on the former. However, the effect of the combined interaction on bulb quality (bulb diameter and weight) was not significant in mot cases.

IV. Competitive relationships between pea and garlic:

The results in Table (8) show the competitive relationships i.e., aggressivity, relative crowding coefficient, land equivalent ratio and area time equivalent ratio as affected by intercropping pea with garlic.

The aggressivity value was positive for garlic and negative for pea, indicating that garlic was the dominant intercrop component and pea was the dominated one. Exception being at pea density (200 000 plants/fed.) in the second season, though the reverse was the right. This means that competitive ability of garlic was greater than of pea. However, El-Beheidi *et al.* (1988) found in intercropping garlic with cowpea, that cowpea was dominant and garlic was dominated. In contrast, Gawish *et al.* (1992) found in, intercropping tomato with pea, that tomato was dominant and pea was dominated.

Table (6): Effect of intercropping plant population of pea interaction on vegetative growth, yield and quality of pea, in 2001/2002 and 2002/2003 seasons.

Intercropping	Plant population of pea/fed.	Vegetative growth						Pod yield and quality			
		Plant height (cm)	Number of leaves/ plant	Number of branches/ plant	Leaf area/plant (cm^2)	Chlorophyll content SPAD unit	Plant fresh weight (g)	Yield of green pods (ton/fed.)	Pod length (cm)	Pod diameter (cm)	Number of seeds/pod
2001/2002 season											
Pea alone	200 000	55.1 d	35.6	3.3	1210.9	46.38	117.3 a	4.845 a	10.6	1.5	9.5 a
Pea with garlic	64 000	70.0 c	30.5	3.1	1172.8	45.45	113.3 b	1.925 e	10.9	1.5	9.3 b
Pea with garlic	100 000	72.5 bc	29.6	2.7	1153.0	44.52	104.5 cd	2.559 d	10.5	1.4	9.1 c
Pea with garlic	129 000	74.8 b	28.2	2.7	1125.5	43.47	101.9 d	3.052 c	10.5	1.4	8.9 cd
Pea with garlic	200 000	81.0 a	27.7	2.5	1095.3	42.33	97.0 e	3.969 b	10.3	1.4	8.7 d
F-test		*	N.S	N.S	N.S	N.S	**	**	N.S	N.S	*
2002/2003 season											
Pea alone	200 000	48.5	14.5 a	2.5	458.3 a	44.00	98.2 a	3.771 a	8.5	1.4	7.9
Pea with garlic	64 000	48.3	15.3 a	2.4	454.9 a	42.77	97.6 a	1.394 e	8.6	1.4	7.9
Pea with garlic	100 000	50.4	13.2 bc	2.3	418.4 b	42.55	91.9 bc	1.920 d	8.5	1.4	7.8
Pea with garlic	129 000	52.0	12.4 c	2.2	400.4 cd	41.47	89.5 c	2.247 c	8.2	1.4	7.8
Pea with garlic	200 000	53.5	11.1 d	2.1	392.4 d	41.22	76.2 d	3.020 b	8.1	1.4	7.5
F-test		N.S	**	N.S	**	N.S	**	**	N.S	N.S	N.S

*, ** and N.S. indicate $P < 0.05$, $P < 0.01$ and not significant, respectively.
Means designated by the same letter are not significantly different at 5% level according to L.S.D. Test.

Table (7): Effect of intercropping plant population of pea interaction on vegetative growth, yield and quality of garlic, in 2001/2002 and 2002/2003 seasons.

Intercropping	Plant population of pea/fed.	Vegetative growth						Pod yield and quality		
		Plant height (cm)	Pseudostem length (cm)	Number of leaves/ plant	Leaf area/plant (cm^2)	Chlorophyll content SPAD unit	Plant fresh weight (g)	Total yield (ton/fed.)	Bulb diameter (cm)	Bulb weight (g)
2001/2002 season										
Garlic alone	-	109.6	49.3	10.9	350.65 a	71.97	161.0 a	6.995	5.5	43.8
Garlic with pea	64 000	107.0	48.9	10.8	327.26 b	71.28	144.1 b	6.529 b	5.3	41.8
Garlic with pea	100 000	105.6	47.4	10.4	324.41 b	70.36	137.6 bc	6.345 bc	5.1	40.0
Garlic with pea	129 000	104.6	46.5	10.3	308.16 b	69.82	124.0 c	6.165 c	5.1	38.3
Garlic with pea	200 000	103.1	45.9	10.1	255.51 c	68.41	118.0 c	5.805 d	4.9	36.7
F-test		N.S.	N.S	N.S	**	N.S	*	*	N.S	N.S
2002/2003 season										
Garlic alone	-	103.6	48.5	10.5 a	310.10 a	70.20	135.0 a	6.429 a	5.2 a	39.0
Garlic with pea	64 000	101.7	46.9	10.1 bc	278.70 c	68.62	122.5 b	5.857 bc	5.2 a	37.9
Garlic with pea	100 000	100.5	46.0	9.9 c	268.06 bc	67.96	113.2 b	5.655 c	5.1 ab	35.1
Garlic with pea	129 000	98.1	45.8	9.8 c	254.81 c	67.65	96.2 c	5.463 c	4.9 bc	33.5
Garlic with pea	200 000	98.8	45.1	9.5 d	244.16 c	66.25	90.5 d	5.075 d	4.7 c	32.0
F-test		N.S	N.S	*	*	N.S	**	*	*	N.S

*, ** and N.S. indicate $P < 0.05$, $P < 0.01$ and not significant, respectively.
Means designated by the same letter are not significantly different at 5% level according to L.S.D. Test.

Increasing plant population of intercropped pea per feddan gradually decreased the aggressivity value of garlic, as it reached the lowest at density of 200 000 pea plants/feddan. From these results, it could be suggested that the enhancement of pea productivity by increasing plant population of pea might lead to higher pea aggressivity.

The results obtained in Table (8) reveal that, relative crowding coefficient calculated for both intercropped pea and garlic was almost higher than one being of advantage. Therefore, total relative crowding coefficient exceeded than one under all plant population densities of pea. These indicate that intercropping resulted in a yield advantage compared to pea or garlic sole cropping. Similar results were obtained by El-Beheidi *et al.* (1988) in intercropping garlic with cowpea, Gawish *et al.* (1992) in intercropping tomato with pea and El-Waraky (1996) in intercropping eggplant or squash with cowpea and beans.

Table (8): Effect of intercropping plant population of pea interaction on the competitive relationships of pea intercropped with garlic plants, in 2001/2002 and 2002/2003 seasons.

Plant population of pea/fed.	2001/2002 season				2002/2003 season			
	64 500	100 000	129 000	200 000	64 500	100 000	129 000	200 000
Competitive relationships								
Aggressivity (A)								
Pea	-0.54	-0.38	-0.25	-0.01	-0.54	-0.37	-0.25	+0.02
Garlic	+0.54	+0.38	+0.25	+0.01	+0.54	+0.37	+0.25	-0.02
Relative crowding coefficient (k)								
Pea	0.66	1.12	1.70	3.48	0.59	1.04	1.47	4.02
Garlic	14.01	9.76	7.43	4.88	14.01	4.12	7.43	4.88
Combined	9.23	10.92	12.64	16.96	8.21	4.28	10.94	19.61
Land equivalent ratio (LER)								
Pea	0.40	0.53	0.63	0.82	0.37	0.51	0.60	0.80
Garlic	0.93	0.91	0.88	0.83	0.91	0.88	0.85	0.79
Combined	1.33	1.44	1.51	1.65	1.28	1.39	1.45	1.59
Area time equivalent ratio (ATER)	1.10	1.13	1.15	1.18	1.07	110	1.11	1.13

The data in the same Table indicate that, the land equivalent ratios (LER) under intercropping were greater than 1 in both seasons. These results are true for all plant population densities of pea. This means that yield advantage was produced and land usage was increased by all plant population densities of pea under intercropping pea with garlic. In another words, intercropping was more efficient than sole cropping at all pea plant population densities tested, based on the land equivalent ratio. Similar results were obtained by Gawish *et al.* (1992) who found that LER values were higher than two by intercropping tomato with pea. Likewise, were the results of El-Waraky (1996) in intercropping eggplant or squash with cowpea and beans.

Using LER to estimate the productivity may be in accurate since, it dose not take into consideration the duration time of the crops in the land from planting to harvest. To correct this deficiency, the LER was modified by area time equivalent ratio (ATER) which included the time of the crops in the land; i.e. duration of land occupancy by crops (Hiebsch and Mecollum, 1987).

The data in Table (8) indicate that, the productivity of unit area increased by 10, 13, 15 and 18% in 2001/2002 season and by 7, 10, 11 and 13% in 202/2003 season using different pea plant population densities under intercropping compared to sole cropping. From these results it could be concluded that, intercropping pea with garlic at pea plant population densities (129, 000 and 200, 000 plants/fed.) produced the best yield advantage and the highest productivity in the unit land area. These results are in agreement with those obtained by Gawish *et al.* (1992) and El-Waraky (1996).

V. Net return and monetary advantage of the combined intercrop yield:

Data in Table (9) show that, the highest net return was produced from solid garlic or pea compared to each of both when intercropped together which recorded the lowest values in both seasons. In contrast, the highest net return of both crops were detected from the densities of 129,000 and 200,000 pea plants/fed. of pea with garlic whereas, the lowest value was by densities of 64, 500 and 100 000 pea plant/fed. in both seasons. The highest general means of net return for both crops under the effects of the different plant population densities of pea under intercropping was produced by densities of 129,000 and 200,000 pea plants/fed. as the estimated values were 6230.0 and 7090.0 L.E./fed., respectively.

As shown in Table (9), intercropping monetary advantage showed a similar trend as that obtained from general means of net return under the effects of combined interactions, as the highest value was achieved with density of 200, 000 pea plants/fed.

followed by density 129,000 pea plants/fed. as they were 3730 and 2870 L.E./fed., respectively.

The obtained results of net return and monetary advantage under the effects of plant population density of peas under intercropping of both crops showed somewhat similar results as that of yield of both crops. These results are in accordance with those of Sharaiha and Haddad (1985) on cabbage with broad bean and El-Waraky (1996) on eggplant or squash with cowpea and bean and El-Zawily *et al.* (2000) on cabbage and lettuce and Badr and Masoud (2004) on cowpea and cotton.

Table (9): Effect of intercropping and plant population of pea on net return and monetary advantage of combined intercrop yield, in 2001/2002 and 2002/2003 seasons.

Intercropping	Plant population of pea/fed.	Net return of combined intercrop yield (L.E./fed.)						General means of net return (L.E./fed.)		Intercropping monetary advantage (L.E./fed.)
		2001/2002 season			2002/2003 season					
		Garlic	Pea	Both crops	Garlic	Pea	Both crops	Garlic	Pea	
Solid crop		3500.0	6060.0	-	3210.0	4710.0	-	3360.0	5390.0	-
G* with P	64 500	3260.0	2410.0	5670.0	2930.0	1740.0	4670.0	5170.0		1810.0
G with P	100 000	3170.0	3200.0	6370.0	2830.0	2400.0	5230.0	5800.0		2440.0
G with P	129 000	3080.0	3820.0	6900.0	2730.0	2810.0	5540.0	6230.0		2870.0
G with P	200 000	2900.0	4960.0	7860.0	2540.0	3780.0	6320.0	7090.0		3730.0

* G = Garlic P = Pea

Thus, it could be recommended that densities of 200,000 pea plants/fed. under intercropping peas with garlic was more profitable than sole cropping under Kafr El-Sheikh Governorate conditions.

REFERENCES

Addel-Aal, S.M. 1990. Studies on the effect of intercropping some maize varieties with cotton on growth, yield, competitive relationships and yield advantage of the two crops. Menofiya J. Agric. Res. 15: 671-687.

Abdel-Baky, M.M. 2000. Productivity of some vegetable crops as affected by intercropping system. Ph.D. Thesis, Fac. Agric. Ain Shams Univ., Egypt.

Ahmed, S. and H.P. Gunasena 1979. N utilization and economics of some intercropped system in tropical countries. Trop. Agric. 56: 115-123.

Andrews, D.J. and A.H. Kassam 1976. The importance of multiple cropping in increasing world food supplies. pp. 1-10. In popendick, R.I.; .A. Sanchez and G.B. Triplett (eds.) Multiple cropping Spec. Publ. No. 27 Am. Soc. of Agron., Madison, Wis.

Badr, S.S. and A.M. Masoud 2004. Studies on the effect of intercropping systems on new cowpea genotypes with cotton. J. Agric. Res. Tanta Univ. 30(2): 437-453.

DeWit, C.T. 1960. On competition. Verslage Landourwkundige Onderzoek 66(88): 1-82 (C.F. Willey, R.W. 1979). Intercropping, its importance and research needs. Part 1. Competition and yield advantages. (Field Crop Abstr. 32: 1-10).

El-Beheidi, M.A.; A.A. El-Mansi; S.A. Foda; M.H. El-Sawah; A.A. Gad and A.H. Shaheen 1988. Effect of planting data and intercropping on garlic. 2- Effect on yield and its components. Proc. 2nd Hort. Sci. Conf. Tanta Univ., Sept. Vol. (II): 506-520.

El-Mansi, A.A.; M.A. El-Beheidi; S.A. Foda; A.A. Gad; M.I. Khalil and A.H. Shaheen 1988. Effect of planting data and intercropping on garlic. 1- Growth. Proc. 2nd Hort. Sci. Conf. Tanta Univ., Sept. Vol. (II): 489-505.

El-Shimi, E.Z. 1983. Effect of inter and intra-specific competition among tomato and cucumber or phaseolus plants. M.Sc. Thesis, Fac. Agric. Zagazig Univ., Egypt.

El-Waraky, Y.B. 1988. Effects of nitrogen fertilizer and plant population on growth yield and quality of cucumber. M.Sc. Thesis, Fac. Agric. Alex. Univ., Egypt.

El-Waraky, Y.B. 1996. Studies on the effect of intercropping systems and nitrogen fertilization levels on growth, yield and quality of some vegetable crops. Ph.D. Thesis, Fac. Agric. Alex. Univ., Egypt.

El-Zawily, A.I.; A.A. Etman; M.H. Kassem and E.I. Metwally 1993. Productivity of cucumber under different intercropping systems and spacings of cowpea. J. Agric. Res. Tanta Univ., 19(2): 439-447.

El-Zawily, A.I.; A.Y. Mazrouh; N.A. Hassan and D.K. Farrag 2000. Effect of intercropping on yield, head quality and economic return of cabbage and lettuce crops. J. Agric. Res., Tanta Univ. 26(2): 278-294.

Fayad, A.M. 2004. Studies of breeding and improvement pea crop (*Pisum sativum* L.). Ph.D. Thesis, Fac. Agric. Tanta Univ., Egypt.

Gawish, R.A.; M.A. Fattahallah and F.A. Ali 1992. Effect of intercropping tomato with pea on growth, yield, quality and land productivity in relation to N, P and K fertilization. Menofiya J. Agric. Res. 17: 743-764.

Hiebsch, C.K. 1980. Principles of intercropping: Effect of nitrogen fertilization, plant population and crop duration on equivalency ratios in intercrop versus monoculture comparisons. Ph.D. Diss. North Carolina State Univ., Raleigh, N.C. (Diss. Abstr. 41 B; 4337).

Hiebsch, C.K. and R.E. McColum 1987. Area-X-time equivalency ratio: A method for evaluating the productivity of intercrops. Agron. J. 79: 15-22.

Kassem, M.H. 1991. Studies on vegetables intercropping in summer season. M.Sc. Thesis, Fac. Agric. Tanta Univ., Egypt.

Marquard, R.D. and J.L. Timpton 1987. Relationship between extractable chlorophyll and an in situ method to estimate leaf green. Hort. Sci. 22(6): 1327.

McGillchrist, C.A. 1965. Analysis of competition experiments. Nebraska Agric. Exp. Sta. Ann. Rep. 24: 108-159.

Rey, A.G. and H.G. Zandstra 1976. Studies on the yield of 2 potato and bean cultivars grown in association at different densities. Revista Instituta Colombiano Agropecuario. 71: 305-314. (Hort. Abstr. 48: 5542).

Rosset, P.; I. Diaz; R. Ambrose; P. Cano; Var-Rela and A. Snook 1987. Evaluation of validation of the polycultural system of tomatoes and beans as a part of an integrated pest management programme for tomatoes, in Nicaragua. Turrialba. 37: 85-92. (Hort. Abstr. 59: 111).

Sharaiha, R.K. and N.I. Haddad 1985. Potential of row intercropping of cabbage, broad bean and corn under Jordan Valley Conditions. Dirasat, 12(4): 45-56.

Snedecor, G.W. and W.G. Cochran 1967. Statistical methods, sixth edition. The Iowa State College Press, Ames. Iowa, U.S.A.

Willey, R.W. 1979. Intercropping-its importance and research needs. Part 1, Competition and yield advantages. (Field Crop Abstr. 32: 1-10).

الملخص العربى

تأثير التحميل والكثافة النباتية على النمو والمحصول والعلاقات التنافسية والعائد الاقتصادى لنباتات البسلة والثوم

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أجرى هذا البحث فى مزرعة بمنطقة دسوق محافظة كفرالشيخ فى موسمى ٢٠٠١/٢٠٠٢م ، ٢٠٠٢/٢٠٠٣م بهدف دراسة تأثير تحميل البسلة (صنف مستربى) على الثوم (صنف بلدى) ، وكذلك تأثير أربع كثافات نباتية للبسلة والتفاعل بينهما على النمو والمحصول ومكوناتـه ، وكذلك العلاقات التنافسية ، والعائد الاقتصادى لكلا المحصولين ، وكان التصميم المستخدم هو نظام القطع المنشقة فـى تـصميم قطاعـات عشوائية كامله باستخدام اربع مكررات وكانت مساحة الوحدة التجريبية ١٦ مترا مربعا.

ولقد وجد من النتائج أن تحميل البسلة على الثوم أدى إلى نقص فى كل من عدد الأوراق وعـدد الأفـرع والمـساحة الورقيـة/نبـات والكلوروفيل الكلى ووزن النبات الكامل للبسلة إذا ما قورن بالزراعة المنفردة للبسلة. كما أدى التحميل أيضا إلى نقص قيم النمو بنبات الثوم.

أما بالنسبه لتأثير الكثافة النباتية للبسلة فقد أدت قلتها (٦٤,٥٠٠ نبات/فدان) إلى زيادة النمو لكلا المحصولين.

وأدى التحميل إلى نقص فى محصول القرون الخضراء للبسلة وعدد البذور بالقرن ، وكذلك نقص محصول الثوم وقطر ووزن الرأس.

أدت زيادة الكثافة النباتية للبسلة (٢٠٠,٠٠٠ نبات/فدان) إلى زيادة محصول البسلة ونقص محصول الثوم ، وعلى العكس من ذلك أدى صغر الكثافة النباتية للبسلة (٦٤,٥٠٠ نبات/فدان) إلى نقص محصول البسلة وزيادة محصول الثوم ، وكذلك زيادة المكونات الخاصـة بهـم (طول القرن للبسلة وعدد البذور بالقرن، وكذلك قطر ووزن رأس الثوم) زيادة تدريجية بصغر الكثافة النباتية للبسلة.

تشير النتائج كذلك إلى أن قيم العدوانية للثوم كانت موجبة ، بينما قيم العدوانية للبسلة سالبة وهذا يعنى أن الثوم هو السائد والبسلة هـى المتنحية ، وكانت قيم العدوانية للثوم تقل تدريجيا بزيادة الكثافة النباتية للبسلة. كما أدى أيضا تحميل البسلة على الثوم إلى زيادة قـيم معامـل الحشد النسبى ، وكذلك زيادة معدل كفاءة الأرض ، ونسبة المكافئ الزمنى للمساحة ، واقد تم الحصول على أعلى قيمة لكل منهما عند كثافة نباتية للبسلة (١٢٩,٠٠٠ ، ٢٠٠,٠٠٠ نبات/فدان) ، وهذا يعنى زيادة الإنتاجية الفعلية عن الإنتاجية المتوقعة بتحميل البسلة على الثوم بمقـدار ٤٥-٦٥% ، ١١-١٨% مقارنة بزراعة كل محصول على حده.

تحققت أعلى قيمة نقدية لكل من المتوسط العام لصافى العائد والفائدة النقدية من التحميل/فدان مـن أعلـى كثافـة نباتيـة للبـسلة (٢٠٠,٠٠٠ نبات/فدان) عند تحميلها مع الثوم. ولذلك يوصى باستخدام هذه الكثافة عند تحميل البسلة مع الثوم تحت ظروف محافظة كفرالشيخ.