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Productivity, Quality and Profit of Sole or Intercropped Green Bean (*Phaseolus vulgaris* L.) Crop

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Abstract: This study was aimed to determine the effect of different intercropping systems on growth, yield and quality of green bean under field conditions. Land Equivalent Ratio (LER) was determined as an index of intercropping advantage and economic net income to assess the efficiency of different cropping systems. Green bean (*Phaseolus vulgaris* L. cv. Paulista) as a main crop was intercropped with head lettuce (*Lactuca sativa* L. cv. Target) and/or green onion (*Allium cepa* L. cv. Giza 20) as intercrop. Lettuce was planted on the other side of green bean rows in the same time green onion was planted on both sides of the row. All crops were also grown in pure stands. Results indicated that all intercropping systems used in this trail had positive effects on land use efficiency and available growth resources. All intercropping systems used did not affect the yield of green bean. Nitrogen, phosphorus and potassium contents of bean leaves did not vary significantly in response to cropping systems. Under investigation conditions, LER and net income increased when all intercropping systems were used.

Key words: Intercropping, green bean, yield, Land Equivalent Ratio (LER), income, head lettuce, green onion

INTRODUCTION

Intercropping system is a well known technique in vegetable production in some particular areas of Egypt because of the small land ownership. Growers with such small areas are always looking for maximizing their farm income through vertical expansion. Vertical expansion can be achieved by either cultivating the land more than once per year and/or intercropping. Intercropping through more effective use of water, nutrients and solar energy, can significantly enhance land crop productivity compared to the growth of sole crops[1]. It has also a positive effect on soil conservation and improvement of soil fertility[2], more effective use of natural resources[3] and great potential for pest and disease reduction[4]. Intercropping can afford the diminution of the risks of total loss, the better control over erosion, the control of weeds and the potential of greater sources of profits[5].

The advantages of intercropping in better land use efficiency as an important component of sustainable farming has been demonstrated by Guvence and Yildirim[6].

Cultivars suitable for intercropping should enhance the complementary effects between species[7]. Advantages of intercropping with legumes have been demonstrated in numerous studies; tomato or okra with cowpea[8], cabbage with bean ,[9] watermelon with soybean[10] and chilli with bean[11]. These studies have indicated that intercropping was more productive than sole cropping because of the complementary effects of intercrops.

Furthermore, many authors showed favorable aspects of intercropping with non-legume vegetables under field conditions[7,12]. The findings of Resende *et al.*[13] on lettuce and radish intercropping support these results.

In successful intercropping systems, timing of production is an important factor in order to avoid competition among growing crops and conflicts in agricultural practices in particular harvesting.

The objective of this study was to maximize land use efficiency cultivated with green bean by using some intercropping systems different in their time of harvest.

MATERIALS AND METHODS

This study was carried out under field conditions in Kafer Hakeem village, Giza, Egypt, in 2003-2004. The physical and chemical properties of the soil are given in Table 1. Fertilisation was applied per faddan (feddan=4200 m^2) based on the main crop (green bean) as follows: 20 m^3 organic manure, 200 kg of each ammonium sulfate, super phosphate and potassium sulfate. Organic manure and the super phosphate broadcasted uniformly prior to planting on the soil surface and incorporated. Other fertilisers were split and applied to the crop at three equal amounts.

Green bean (*Phaseolus vulgaris* L. cv. Paulista) as main crop was intercropped with lettuce (*Lactuca sativa* L. cv. Target) and/or onion (*Allium cepa* L. cv. Giza 20).

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Table 1: Soil analysis of experimental plots in Kafr Hakim

Depth of soil (cm)	Mechanical analysis (%) Coarse sand	Fine sand	Silt+ clay	Texture	pH	EC (dS m^{-1})	(%) $CaCo_3$	OM
0-20	19.4	39.8	40.8		7.11	1.4	2.3	1.7
20-40	45.7	43.6	10.7	Loamy sand	7.23	0.93	1.2	0.6

Depth of soil (cm)	Cations (meq L^{-1}) N	P	Ca^{++}	Mg^{++}	Na^{++}	K^{+}	Anions (meq L^{-1}) CO_3^{-}	HCO_3^{+}	CL^{-}	SO_4^{-}
0-20	Trace	Trace	3.7	2.8	7.4	0.1	--	4.1	5.8	4.1
20-40	Trace	Trace	2.7	1.3	5.2	0.1	--	3.6	4.0	1.7

Intercropping treatments included green bean: Lettuce; green bean: green onion and green bean: lettuce: greenonion and all these crops in pure stands. The experimental design was a Randomized Complete Block Design with three replicates. Each plot size was 6×8 m. Green bean spacing was 20×50 cm for both sole and intercropped plants.

The intercropped lettuce was planted at spacing of 30 cm on the other side of the row whereas the sole crop was planted on both sides. The green onion was planted at spacing of 5.0 cm on both sides of the row; on the other side and on the same side between green bean plants. Lettuce transplants and green onion sets (small bulbs, approximately 0.8-1.0 cm) were planted, while green beans were field seeded. The main crop (green bean) was seeded at a rate of 3 seeds/hill in moist firm soil, 10 days after transplanting of the intercrops. Planting took place on Feb. 1st and 5th in 2003 and 2004, respectively.

Onion and lettuce were harvested after 55 and 50 days from planting, respectively. Meanwhile green beans were harvested after 60 days from sowing and continued for three harvests, which lasted up to 90 days from planting. Data of vegetative growth and yield of lettuce and onion were recorded at harvest of each crop whereas, the growth recorded measurements of green bean: Plant height, number of leaves, shoot fresh and dry weight, dry matter content and pod quality were determined after 60 days. Head diameter, head weight and total yield were determined for lettuce while, plant length, number of leaves, bulb diameter and yield were recorded for green onion.

Chemical analysis of bean leaves was carried out after harvest where they were dried in an oven at 70°C till they reached a constant weight and then they were grounded. Total nitrogen was determined using the micro-Kjeldahl method[14]. Phosphors was determined spectrophotometrically according to Trough and Meyer[15]. Potassium content was determined using an atomic adsorption spectrophotometer[16].

The productivity of the intercropping was evaluated by the LER and economic net income. LER has often been considered to be an index of intercropping advantage and is defined according to Willy and Osiu[17] and Vandermeer[18] as follows:

LER = LA + LB + LC

Where, LA, LB and LC are the individual LERs of three crops A, B and C.

LA = Intercrop yield of bean /sole stand yield of bean
LB = Intercrop yield of onion / sole stand yield of onion
LC = Intercrop yield of lettuce / sole stand yield of lettuce.

Economic net income analysis was undertaken to assess economic feasibility of different intercrops. Material included all cash expense items of fertilizers, seeds or transplants, labor and machine operating costs. Crop prices which farmer had got were estimated as field-gate price.
Data were subjected to statistical analysis[19].

RESULTS AND DISCUSSION

Growth and production of green bean: The plant height of green bean was not significantly affected by any of the intercropping systems (Table 1). Similar results on plant height were reported by Abdel-Gawad *et al.*[20]. Whereas, the number of leaves was significantly lower in any system compared to the sole crop cultivation. Among the intercropping treatments, number of leaves of green bean

Table 2: The effect of sole and intercropping culture on the growth and yield characteristic of green bean plants

Intercropping systems	PH (cm)	Leaf No.	FW (g/plant)	DW (g/plant)	DM (%)	Pod length (cm)	Pod weight (g)	Yield (ton/fed)
First season								
Green bean	38.00	22.00	220.00	26.90	14.19	12.50	4.20	4.60
G. bean: lettuce	36.00	18.00	208.00	25.40	13.42	12.40	4.30	4.45
G. bean: G. onion	38.00	20.00	200.00	25.30	12.90	12.50	4.20	4.48
G. bean: G. onion: lettuce	37.00	17.00	195.00	24.60	12.58	12.20	4.00	4.18
LSD 5%	NS	1.93	8.49	1.04	0.55	NS	NS	0.18
Second season								
Green bean	39.50	22.50	230.50	28.18	14.87	13.10	4.50	5.15
G. bean: lettuce	37.00	20.00	226.20	27.63	14.60	13.49	4.30	4.98
G. bean: G. onion	37.00	21.00	209.10	26.45	13.49	13.07	4.30	5.02
G. bean: G. onion: lettuce	38.00	18.00	205.50	25.92	13.25	12.85	4.40	4.68
LSD 5%	NS	0.87	NS	1.08	0.57	NS	NS	0.20

PH = Plant Height, FW = Fresh Weight, DW = Dry Weight, DM = Dry Matter, Fed. Feddan (4200 m^2)

Table 3: The effect of sole and intercropping culture on N, P and K (%) in leaves of green bean plants

	1st season			2nd season		
Intercropping systems	N	P	K	N	P	K
Green bean	3.70	0.69	2.2	3.69	0.68	2.19
G. bean: lettuce	4.04	0.64	2.1	3.93	0.53	1.99
G. bean: G. onion	3.90	0.64	2.2	3.80	0.54	2.10
G. bean: G. onion: lettuce	3.82	0.67	2.3	3.72	0.57	2.20
LSD 5%	NS	NS	NS	NS	NS	NS

was significantly the highest in green bean intercropped with onion than that intercropped with lettuce or in bean:onion:lettuce intercropping system. The same results were observed in the fresh and dry weights of individual plants, where they were significantly lower than sole green bean crop. In green bean: lettuce: onion intercropping, plant fresh weight of green bean was significantly lower than that of all intercropping treatments. Dry matter content showed a similar trend to the previous results. Lower number of leaves per plant may result in a lower leaf area per plant which is supported by Abdel-Gawad *et al.*[20].

Concerning yield and quality, the total yield of green bean was not significantly affected by intercropping treatments except with that of green bean: lettuce: green onion where yield was significantly lower than all other intercropping and sole crop treatments (Table 2). Pod quality, in terms of pod length and average individual pod weight was significantly not affected by any of the intercropping treatments in both seasons. Other studies reported the same findings that the production of the main crop was not affected by intercropping in tomato: lettuce[21] and in cabbage: spinach[22]. Because of the different and early timing of maturity and harvesting of the intercropping crops (55 and 50 for green onion and lettuce, respectively), there was no interference with the growth of the main crop (green bean). This is also confirmed by the findings of Splitstoesser[23].

The mineral content was not significantly different in leaves of intercropped bean plants compared to those of the sole crop (Table 3). This was previously reported by Varghese and Santos *et al.*[24,25]. This can be explained by the efficient use of available resources per unit areas for different crops[10,26].

Growth and yield of intercropped plants: Growth characteristics of green onion and lettuce as shown in Table 4 and 5, respectively were significantly affected by intercropping where average plant length, number of leaves and bulb diameter of green onion as well as diameter and weight of individual lettuce head tended to be lower than the sole green onion or lettuce crop, respectively. However, the reduction in total yield of the intercrops was mainly because of the reduction in plant population per unit area. The significant reduction of total yield per unit area in all intercrops is far beyond to be caused by the reduction observed in the previous growth parameters. This can be explained on the basis of the advantages of intercropping with legumes observed in previous studies[8-11], where, growth of all intercrops was not affected. The intercropping with a legume crop may improve the yield of other crops due to the improvement in N-use[27] and that legume can release biologically fixed N to the non-legume crops[28]. The other possible reason for yield reduction in intercropping treatments is that a possibly slight competition for growth resources by the end of the growing season of the lettuce and green onion. This is supported by Fukai and Trenbath[29]. According to them, intercropping is most productive when intercrops differ greatly in growth duration so that their maximum requirements for growth resources occur at different times. In this study an overlapping in growth duration among crops existed where onion and lettuce were harvested after 55 and 50 days, respectively, meanwhile green bean harvesting stared after 60 days from sowing. Hence, a slight competition could be expected to reduce yield of the intercrops. Cultivation of intercrops on the other side of the raw of green bean may contribute to the reduction of that competition for light. Furthermore, because of the different depth and spread of the root systems of the cultivated crops, serious competition for water and nutrients was minimal. This is confirmed by mineral content of bean leaves (Table 3) that were not significantly different in all intercropping systems in this study. Baumann *et al.*[7] Stressed the point of complementary effects of cultivars suitable for intercropping.

Table 4: The effect of sole and intercropping culture on the growth and yield characteristic of green onion

	1st season				2nd season			
Intercropping systems	Plant length (cm)	Leaf No.	Bulb diameter	Yield (ton/fed.)	Plant length (cm)	Leaf No.	Bulb diameter	Yield (ton/fed)
G. bean: G. onion	53.00	9.80	1.68	2.10	53.00	10.20	1.92	2.35
G. bean: G. onion: lettuce	53.00	9.80	1.65	1.52	51.00	9.90	1.80	1.70
Green onion	55.00	10.20	1.75	4.65	57.00	10.50	2.10	5.21
LSD 5%	0.61	0.11	0.02	0.37	0.48	0.08	0.02	0.41

Table 5: The effect of sole and intercropping culture on the growth and yield characteristic of lettuce

Intercropping systems	1st season Head diameter (cm)	Weight (g/head)	Yield (ton/fed)	2nd season Head diameter (cm)	Weight (g/head)	Yield (ton/fed)
G. bean: lettuce	12.10	415.00	5.60	12.90	428.40	6.27
G. bean: G. onion: lettuce	11.60	380.00	4.45	12.30	396.10	4.98
Lettuce	12.30	430.00	11.30	13.60	444.60	12.66
LSD 5%	0.08	1.80	0.80	0.09	1.84	0.89

Table 6: The effect of sole and intercropping culture on LER, net income and income increases

	1st season L*	LER	Net income	N**	Income increases (%)
Green bean	1.00	1.00	2464.00	1.00	
G. bean: lettuce	0.97	1.46	4214.00	1.71	71.02
G. bean: G. onion	0.97	1.43	3624.00	1.47	47.08
G. bean: G. onion: lettuce	0.91	1.86	4375.00	1.78	77.56
Green onion	0.45		1664.00	0.68	
Lettuce	0.50		2584.00	1.05	
	2nd season				
Green bean	1.00	1.00	3016	1.00	
G. bean: lettuce	0.94	1.42	4771	1.58	58.20
G. bean: G. onion	0.91	1.36	4050	1.34	34.27
G. bean: G. onion: lettuce	0.83	1.76	4676	1.55	55.03
Green onion	0.45		2110	0.68	
Lettuce	0.48		3036	1.05	

* Yield of sole or intercropped/sole crop

** Percentage of net income due to sole or intercropping crops compared to sole main crop, L*; LER, N**; Net inocme

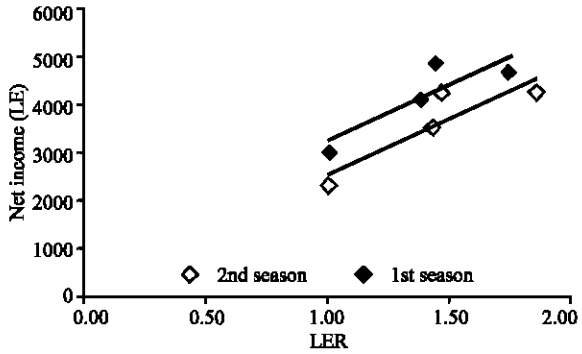

Fig. 1: Relationship between net income of intercropping systems and their relative Land Equivalent Ratio (LER.). For the first season (Y= 2279.2 X + 398.17 with R^2 = 0.85) and for the second season (Y= 2264.9 X + 985.89 with R^2 = 0.76). LE = Egyptian pound

Intercropping efficiency: The value of LER appears to be greater than unity under all intercropping systems (Table 6). This is an indicator of the biological efficiency of these systems over the sole cropping system which was previously reported by Vandermeer[18]. LER continued to rise with intercropping with the highest LER recorded here was obtained in green bean intercropped with both onion and lettuce. LER of bean intercropped with lettuce was higher than that of bean intercropped with onion although differences were only 0.03 and 0.06 in 2003 and 2004, respectively. Willey[30] reported that the practical significance of LER could only be assessed when related to the actual economic yield. Indeed Fig.1 shows the positive relationship between LER and income of a farm in both season of 2003 and 2004. The high efficiency of intercropping found in this study agreed with the findings of many other previous studies[7,11,31-33] explained this phenomenon by the complementary use of growth resources in vegetable production. Sharaiha and Hattar[10] explained the beneficial effect of intercropping on the basis that intercropping might be more efficient in using the available resources per unit area.

CONCLUSIONS

It can be concluded that intercropping of green bean with other crops such as green onion and/or lettuce not only use limited areas for crop production more efficiently but also increase the income for the small farmers with limited land and resources.

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