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EFFECT OF GREEN ONION, LETTUCE AND SPINACH INTERCROPPING ON GROWTH, PRODUCTIVITY AND ECONOMIC RETURNS

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ABSTRACT

Two field experiments were carried out at the Experimental farm of Hort. Res. Inst. (Qaha farm), Kalubia Governorate, Egypt during 2009/10 and 2010/11 seasons to determine the effect of intercropping of green onion (*Allium cepa L.* cv. Giza 20) with lettuce *(Lactuca sativa L.* cv. Dark Green) and/or spinach (*Spinacia oleracea L.* cv. Saloniki) on growth, yield and quality of the sole and intercropped plants. Land Equivalent Ratio (LER) was evaluated as a real index for intercropping advantages and economic net income to assess the efficiency of different culture systems applied in this study.

The obtained results indicated that growth and yield of green onion intercropped with either lettuce or spinach were significantly decreased compared to the sole cultivation. The least values, however were gained by the intercropping system included green onion + lettuce + spinach. Intercropping of green onion with lettuce gave better results than those of intercropping of it with spinach. A similar trend was also gained concerning N, P and K content in the bulbs. Intercropping of lettuce and spinach with green onion slightly reduced their growth and yield, while intercropping of lettuce with spinach significantly decreased growth and yield of each. On the other hand, LER and net income were increased by all the used intercropping systems over sole crop cultivation. This means that these systems had positive effects on land use efficiency and available growth resources.

So, it could be recommended to intercropping of green onion with lettuce and/or spinach for increasing the income of the small farmers with limited land and resources.

INTRODUCTION

Some leafy vegetable crops are considered a main source for roughage, minerals, vitamins and may have a great culinary and medicinal value. Among of them may be green onion (*Allium cepa L.*, Fam. Alliaceae), lettuce (*Lactuca sativa L.*, Fam. Compositae) and spinach (*Spinacia oleraceae L.*, Fam. Chenopodiaceae). The three species are cool-season crops, grown for its edible leaves. Tender young leaves can be eaten freshly or served raw in salads, but older leaves are usually served as a cooked-vegetable **(Bailey, 1976). Huxley *et al*., (1992)** reported that spinach can tolerate light shade and can therefore be grown as intercrop between other species.

Intercropping system is a well-known way for vegetable production in some particular areas of Egypt because of the small land ownership. Farmers with such small areas are usually looking for maximizing their farm income through vertical expansion, which can be achieved by either cultivating the land many times per year and/or intercropping. Intercropping through more effective use of water, nutrients and solar energy, can greatly enhance land crop productivity compared to the growth of sole crops **(Midmore, 1993).** It has also a positive effect on soil conservation and fertility **(Jarenyama *et al*., 2000),** more effective use of natural resources and great potential for best and disease reduction **(Theunnissen, 1997).** Intercropping can diminute the risks of total loss, the better control over erosion, the control of weeds and the potential of greater sources of profits **(Baumann *et al*., 2001).**

Cultivars suitable for intercropping must enhance the complementary effects between species, such as legumes which improve the yield of other crops intercropped with them due to the improvement in N-use **(Itulya *et al*., 1997),** and that legume can release biologically fixed N to the non-legume crops **(Ofori and Stem, 1987).** This was demonstrated by **Costa and Perera (1998)** who intercropped chilli with bean, and **Abou-Hussein *et al.* (2005)** who concluded that intercropping of green bean with green onion and/or lettuce not only use limited areas for crop production more efficiently, but also increase the income of the small farmers with limited land and resources. Similarly, were those observations of **Olasantan (1991)** on tomato and okra intercropped with cowpea, **Sharaiha and Hattar (1993)** on watermelon intercropped with soybean and **Hussain (2003)** on pea intercropped with cauliflower, lettuce, radish, turnip and spinach.

In addition, favorable effects of intercropping with non-legume vegetables under field conditions were also recorded by **Baumann *et al.***

(2001) on leek-celery, **Resende *et al*. (2003)** on lettuce and radish, and **Hussain (2003)** on tomato with okra, potato, chilli and eggplant.

In successful intercropping schemes, timing of production is one of the most important factors to avoid competition among intercropped crops and conflicts in agricultural practices in particular harvesting.

This trial, however aims to increase profit through maximize land use efficiency cultivated with green onion by using some intercropping systems included lettuce and spinach.

MATERIALS AND METHODS

An investigation was consummated under field conditions at the Experimental Farm of Hort. Res. Inst. (Qaha farm), Kalubia Governorate, Egypt during the two successive season of 2009/10 and 2010/11 to find out the positive effects of green onion intercropping with lettuce and/or spinach in some combinations.

Before planting in both seasons, soil sample was taken from the experimental plots at a depth of 0-30cm to determine some physical and chemical properties according to the standard methods of Richards (1954) and given in Table (1).

Table (1) Some physical and chemical properties of the experimental soil sample from Qaha farm in the two seasons.

Depth of soil (cm)	Particle size distribution (%)				Texture	pH	Organic matter (%)	EC (ds/m)	Available mineral content (%)			
	Coarse sand	Fine sand	Silt	Clay					N	P	K	SO_4^-
0-30	8.85	24.23	28.10	38.82	Clayey loam	7.9	1.9	0.68	0.91	0.62	2.8	1.3

Moreover, farm yard manure and the time superphosphate (on the basis of $20m^3$ and 200kg/fed., respectively) were uniformly distributed on the soil surface and incorporated, while ammonium sulphat and potassium sulphate (at the arte of 200kg/fed. for each) were divided and applied at three equal batches.

Green onion (*Allium cepa L*. cv. Giza 20) as a main crop was intercropped with lettuce (*Lactuca sativa L*. cv. Dark Green) and/or spinach (*Spinacia oleraceae L*. cv. Saloniki) to form the following combinations: green onion + lettuce, green onion + spinach, lettuce +

spinach, and green onion + lettuce + spinach, besides each crop in pure stand (as control). Layout of the experiments in the two seasons was a completely Randomized Blocks with three replicates **(Das and Giri, 1986).** The area of each plot was 11.2m^2 (as each plot contained 4 ridges at 4m long X 0.7m width). Green onion spacing was 10x70cm for both sole and intercropped plants. The intercropped lettuce was planted at 30cm apart on the other side of the ridge, but solely was planted on both sides. The spinach was planted on both sides of the ridge (in sole cultivation), on the other side (in the double combination) and on the top of the ridge between green onion and lettuce (in the triple combination). Small bulblets of green onion and transplants of lettuce were planted on November, 15th for the two seasons, while spinach was seeded three days before that. Green onion and lettuce were harvested after 60 and 55 days from planting, respectively, while spinach was harvested after 60 days from sowing.

At harvest time of each crop, the following data were recorded: plant height (cm), number of leaves/plant (only for green onion and spinach), bulb diameter (cm) for green onion, and total yield (ton/fed.). Moreover, plant fresh weight (g) was determined only for both lettuce and spinach. In dry samples of green onion bulbs, the percentages of nitrogen (using micro-kjeldahle method indicated by **Pregl, 1945),** phosphorus (using a colorimetric method of **Luatanab and Olsen, 1965)** and potassium (using the flame photometer set as explained by Jackson, 1973) were evaluated.

The productivity of the intercropping was evaluated by the Land Equivalent Ratio (LER) and economic net income. LER is considered a real index of intercropping advantage, and is defined according to **Vandermeer (1989)** as follows:

$$LER = LA + LB + LC \text{ (A, B and C: the three used crops).}$$

Where: LA = Intercrop yield of green onion/sole stand yield of it
LB = Intercrop yield of lettuce/sole stand yield of it
LC = Intercrop yield of spinach/sole stand yield of it

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.

SAS program (1994) was used for statistical analysis and **Duncan's** Multiple Range Test **(1955)** was applied to compare the differences among means of sole and intercropping treatments.

RESULTS AND DISCUSSION

Effect of culture system on:

1) Growth and production of the main crop (green onion):

Data in Table 2 clear that plant height (cm), No. of leaves/plant, bulb diameter (cm) and total yield (ton/fed.) of green onion intercropped with either lettuce or spinach were significantly decreased compared to the sole crop cultivation in the two seasons, except for total yield parameter of green onion combined with lettuce in the first season, which was slightly reduced with non-significant differences. In general, the least records in both seasons was gained by green onion + lettuce + spinach intercropping system. It was also noticed that growth and yield of green onion intercropped with lettuce were better than those of intercropping of it with spinach. This may be attributed to that spinach is able to tolerate competition and light shade, thus all its needs can be taken from the soil on account of other crops **(Bailey, 1976).** Because of the different timing of maturity and harvesting of the intercrops (57 and 55 days for spinach and lettuce, respectively) non-interference with the growth of the main crop was observed.

Table (2) Effect of sole and intercropping culture on growth and yield of green onion (*Allium cepa L.* cv. Giza 20) plants during 2009/10 and 2010/11 seasons.

Culture system	Plant length (cm)		Leaf No./plant		Bulb diameter (cm)		Total yield (ton/fed.)	
	2009/10	2010/11	2009/10	2010/11	2009/10	2010/11	2009/10	2010/11
Green onion (G.O.)	56.0a	58.4a	9.8a	10.9a	1.9a	2.0a	3.75a	4.02a
G.O. + lettuce (L)	51.1b	55.5b	9.0b	8.7b	1.7b	1.9b	3.31ab	3.45b
G.O.+ spinach (S)	52.2b	54.1b	8.2c	7.9c	1.6b	1.8b	3.00b	3.28c
G.O. + L + S	50.2b	51.0c	7.5d	7.0d	1.4c	1.6c	2.50c	2.61d

Means within a column having the same letters are not significantly different according to Duncan's Multiple Range Test (DMRT) at 5% level.

The reduction in growth and yield of intercropped plants may be due to the reduction in plant population per unit area. In addition, a slight competition may be another reason for decrement growth and yield of the intercrops. These findings are supported by the results of **Resende *et al.* (2003)** on lettuce and radish, **Hussain (2003)** on tomato intercropped with okra, potato, chilli and eggplant, and **Abou-Hussein *et al.* (2005)** on green bean intercropped with green onion and/or lettuce.

2) Chemical composition of green onion bulb:

Similar observation to those obtained in case of vegetative growth and yield were also gained regarding the chemical composition of the main crop bulbs (Table,3), as the percentages of N, P and K were significantly declined, with few exceptions compared to those of the sole crop in both seasons. Also, the least content of the previous nutrients in the two seasons was scored by the intercropping scheme included green onion, lettuce and spinach. This may ascribed to that depth and spread of the root systems of the three cultivated crops were greatly near together, therefore a high competition for nutrients was happened. Moreover, an overlapping in growth duration among the three crops may existe so that their maximum requirements for growth resources may occur at near times, and this may exceed the strength of competition.

Table (3) Effect of sole and intercropping culture on N, P and K content in green onion (*Allium cepa L.* cv. Giza 20) leaves during 2009/10 and 2010/11 seasons.

Culture system	N (%)		P (%)		K (%)	
	2009/10	2010/11	2009/10	2010/11	2009/10	2010/11
Green onion (G.O.)	2.21a	2.41a	0.320a	0.301a	1.94a	2.10a
G.O. + lettuce (L)	2.13ab	2.21b	0.307a	0.293ab	1.92a	1.94b
G.O.+ spinach (S)	1.93b	2.01c	0.300ab	0.278ab	1.89ab	1.90b
G.O. + L + S	1.90b	1.98c	0.281b	0.270b	1.80b	1.89b

Means within a column having the same letters are not significantly different according to Duncan's Multiple Range Test (DMRT) at 5% level.

On the same trend, those results were attained by **Midmore (1993), Baumann *et al.* (2001)** on leek-celery and **Hussain (2003)** on tomato combined with okra and/or eggplant. On the contrary, **Abou-Hussein *et al.* (2005)** mentioned that the mineral content was not significantly different in leaves of intercropped green bean plants compared to those of the sole crop.

3) Growth and yield of intercropped plants (lettuce and spinach):

Growth characteristics of lettuce and spinach as shown in Tables 4 and5, respectively were significantly affected by intercropping systems, where mean plant length (cm), plant fresh weight (g) and total yield (ton/fed.) of both crops, as well as leaf No./plant of spinach tended to be lower than the means of sole lettuce and spinach crops, respectively. However, intercropping of lettuce or spinach with green onion caused a slight reduction in their growth and yield with non-significant differences in most cases of the two seasons, while intercropping lettuce with spinach significantly decreased growth and yield of them. The highest decrement, however was noticed when the three crops used in study were intercropped together.

Table (4) Effect of sole and intercropping culture on growth and yield of lettuce (*Lactuca sativa L.* cv. Dark green) plants during 2009/10 and 2010/11 seasons.

Culture system	Plant length (cm)		Plant F.W. (g)		Total yield (ton/fed.)	
	2009/10	2010/11	2009/10	2010/11	2009/10	2010/11
Lettuce (L)	47.3a	46.6a	550.3a	536.6a	13.41a	11.24a
L + green onion (G.O.)	46.3a	47.0a	485.0ab	485.0a	13.20a	11.10a
L + spinach (S)	45.0a	45.6ab	418.0b	451.6b	9.38b	9.41b
L + G.O. + S	44.6a	43.7b	416.5b	336.3b	9.07b	6.87b

Means within a column having the same letters are not significantly different according to Duncan's Multiple Range Test (DMRT) at 5% level.

Table (5) Effect of sole and intercropping culture on growth and yield of spinach (Spinacia oleracea L. cv. Saloniki) plants during 2009/10 and 2010/11 seasons.

Culture system	Plant length (cm)		Leaf No./plant		Plant F.W. (g)		Total yield (ton/fed.)	
	2009/10	2010/11	2009/10	2010/11	2009/10	2010/11	2009/10	2010/11
Spinach (S)	18.1a	17.4a	7.6a	7.3a	44.7a	40.9a	6.31a	5.25a
S + green onion (G.O.)	17.4ab	16.9ab	7.1b	6.9a	40.3b	33.5b	5.25b	4.69b
S + lettuce (L)	16.5bc	16.0bc	6.7c	6.3b	33.9c	31.9b	4.86c	4.50b
S + G.O. + L.	16.0c	15.5c	6.1d	6.2b	27.3d	28.2c	3.11d	3.75c

Means within a column having the same letters are not significantly different according to Duncan's Multiple Range Test (DMRT) at 5% level.

The reduction in total yield of the intercrops may be due to the reduction in plant population per unit area, and the significant diminution of total yield per unit area in all intercrops is for beyond to be caused by the decrement observed in the previous growth parameters. This is confirmed by **Baumann *et al.* (2001) and Abou-Hussein *et al.* (2005)** who reported that growth traits of green onion and lettuce as intercrops significantly declined by intercropping systems.

4) Intercropping efficiency:

It is evident from data averaged in Table 6 that the value of LER was greater the sole cultivation under all intercropping systems. This is a real indicator for the biological efficiency of these systems over the sole cropping system which was previously indicated by **Vandermeer (1989).** The highest LERs registered in the two seasons were obtained from intercropping of green onion with both lettuce and spinach. LER of green onion intercropped with lettuce was higher than that of intercropping it with spinach in the first and second seasons,. Net income (L.E.) was also increased due to all intercropping systems used in this trial, with the superiority of green onion + lettuce + spinach intercropping system, which gave the utmost high income in both seasons. That was true concerning the percentage of income increases (Table, 6).

Table (6) Effect of sole and intercropping culture on LER, net income and income increases in 2009/10 and 2010/11 seasons.

Culture system	L (1)		LER(2)		Net income		N(3)		Income increases	
	2009/10	2010/11	2009/10	2010/11	2009/10	2010/11	2009/10	2010/11	2009/10	2010/11
Green onion (G.O.)	1.00	1.00	1.00	1.00	4810	5020				
G.O. + lettuce (L)	0.88	0.85	1.86	1.83	6982	6910	1.45	1.37	45.1	37.6
G.O.+ spinach (S)	0.80	0.81	1.57	1.66	6766	6806	1.41	1.35	40.1	35.5
G.O. + L + S	0.66	0.64	1.86	1.96	7671	8150	1.59	1.62	59.4	62.3
Lettuce	0.71	0.61			4180	4646	0.86	0.92		
Spinach	0.49	0.71			3940	4310	0.81	0.85		

(1) Yield of sole or intercropped/sole crop.
(2) Land Equivalent Ratio.
(3) Percentage of net income due to sole or intercropping crops compared to sole main crop, L, LER, N and net income(L.E=Egyptian pound).

The high efficiency of intercropping found in this work may explained by the complementary use of growth resources in vegetable production. In this concern, **Sharaiha and Hattar (1993)** explained the beneficial effect of intercropping on the basis that intercropping might be more efficient in using the available resources per unit area.

From the aforementioned results, it could be concluded that intercropping of green onion with lettuce and/or spinach is one of the best ways for increasing the income of the small farmers with limited land and resources.

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تأثير تحميل البصل الأخضر، الخس والسبانخ علي النمو والإنتاجية والعائد الاقتصادي

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أجريت تجربتان حقليتان بالمزرعة التجريبية لمعهد بحوث البساتين (مزرعة قها)، محافظة القليوبية، مصر خلال موسمي 2010/2009، 2011/2010 وذلك لتحديد تأثير تحميل محصول البصل الأخضر (Allium cepa L. cv. Giza 20) بمحصول الخس (Lactuca sativa L. cv. Dark Green) أو السبانخ (Spinacia oleracea L. cv. Saloniki) أو بهما معاً علي نمو، إنتاج وجودة كل محصول عند زراعته منفرداً أو محملاً مع المحصول الآخر ولقد تم تقدير نسبة مكافئ الأرض (LER) كأحد المؤشرات الحقيقية لمميزات أنظمة التحميل، كما قدر متوسط العائد أو الدخل النهائي، وذلك لتقييم كفاءة أنظمة الزراعة المختلفة التي طبقت بهذه الدراسة.

ولقد أوضحت النتائج المتحصل عليها أن النمو والمحصول الكلي لنباتات البصل الأخضر المحملة مع نباتات الخس أو السبانخ قد انخفضت معنوياً مقارنة بالنباتات المنزرعة بمفردها. إلا أن أقل قيم للنمو والمحصول تم الحصول عليها عند تحميل المحاصيل الثلاثة معاً (البصل الأخضر + الخس + السبانخ). ولقد أعطي تحميل البصل الأخضر مع الخس نتائج أفضل عن تحميلة مع السبانخ. نفس الإتجاة تم الحصول عليه أيضاً فيما يتعلق بمحتوي الأبصال من النيتروجين، الفوسفور والبوتاسيوم. كما أوضحت النتائج أن تحميل الخس أو السبانخ مع البصل الأخضر لم يؤثر إلا تأثيراً طفيفاً علي نموها والمحصول الكلي الناتج منها، بينما أدي تحميل الخس مع السبانخ إلي خفض نمو ومحصول كل منهما معنوياً. علي الجانب الآخر، فإن نسبة مكافئ الأرض (LER) والعائد أو الدخل النهائي (Net income) قد زادت في جميع أنظمة التحميل التي طبقت بهذه الدراسة عند مقارنتها بزراعة كل محصول علي حدة (منفرداً). وهذا يعني أن هذه الأنظمة لها تأثيرات إيجابية علي كفاءة استخدام الأرض ومصادر النمو المتاحة بها.

لذلك، يمكن التوصية بتحميل محصول البصل الأخضر (صنف جيزة – 20) إما بالخس أو السبانخ أو بهما معاً لزيادة دخل صغار المزراعين محدودي الملكية والموارد.