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Effect of Intercropping of Snap Bean and Pea and Reflection on Growth and Productivity under Different Rates of Mineral Fertilizers

Salwa A. El-Atbany

Vegetables Research Department, Horticulture Research Institute,
Agriculture Research Center, Giza, Egypt

Abstract: Two field experiments were carried out at two successive seasons of 2019 and 2020 at the Experimental Farm of Kaha Station, Qalubia Governorate to study the effect of mono and intercropped pea cv. Indian master as main crop which consider as protector plant while, snap bean cv. Paulista as intercrop under adding three previous fertilizer levels of pea at (100, 75 and 50%). The results indicated that pea plants which fertilized by adding 100% of recommended mineral fertilization + planting snap bean on the other side from pea plants gave highest values which lead to significant increases on most growth parameters, yield and its quality, while 75% of mineral fertilization and intercrop cultivation of pea and snap bean increased significantly the early crop of snap bean yield in both growing seasons, in addition induced the land equivalent ratio (LER). Whereas yield of pea and its components increased with mono crop pea cultivation compared with intercropping pea and snap bean in both growing seasons.

Key words: Intercropping · Protector plant · Pea · Snap bean · Mineral fertilizer

INTRODUCTION

The most important aim of agriculture is the excellent production with high quality, safe and inexpensive food to cover the increasing supply world population. In addition, the system of Intercropping which lead to increase production and achieve maximum benefit from the unit area. Which, plants can be planting at the same time together, but the purpose is that two or more crops are in the same place, during their growing season [1]. Soil fertility increases by using plants of Leguminoseae family, due to the increasing amount of biological nitrogen fixation [2]. Moreover, intercropping maximized the productivity of the unit area compared with mono cropping of the same crops [3, 4]. It also, increased biodiversity and reduces weeds in the field resulting in good yield of crops [5].

In this regard, Abou- El-Hassan *et al*. [6] found that, highest values of all vegetative growth attributes and yield of pea and green onion were recorded under mono cultivation. Application of 50% NPK+ nitrogen fixing bacteria + arbuscular mycorrhizal fungi improved growth, yield and its quality of the two crops also; land equivalent ratio (LER) was greater than 1 in all treatments.

Regarding that, mineral fertilizers are very important for plant growth and yield productivity. They promote the meristemic activity and hence, increase the number of tissues and organs as reported by Ghoneim [7]. Meanwhile chemical fertilizers could improve plant growth parameters due to the role of nitrogen in nucleic acids and protein synthesis and phosphorus as an essential component of the energy compounds and phosphoprotein, also the role of potassium as an activator of many enzymes [8].

In this regard, Abou-El-Hassan *et al*. [6] on pea and Negash *et al*. [9] on snap bean they found that, increasing fertilizer application rates gave the maximum marketable pod yield of snap bean and increased pea plant length as well as highest value of LER. Also, Abebe *et al*. [10] used four rates of N (0, 50, 100 and 150 Kg/ha) and B (0, 2, 4 and 6). The combined application of 100 – 150 Kg/ha N and 2Kg/ha B significantly increased growth attributes. And Abou El -Salehein *et al*. [11] illustrated that adding farmyard manure and NPK fertilizer with half of the recommended dose resulted in significant increments on plant growth, pea pod yield and its components. Also, El-Shimi [12] on sweet pepper intercropped with snap bean indicated that increasing

Corresponding Author: Salwa A. El-Atbany, Vegetables Research Department, Horticulture Research Institute, Agriculture Research Center, Giza, Egypt.

NPK-fertilizer rates caused an increase in the yield and its components as well as total land equivalent ratio in the two seasons.

Snap bean (*Phaseolus vulgaris* L.) is the most important vegetable crops cultivated for local market and exportation in Egypt. It is grown at warm and short season crop relatively sensitive to environmental stresses especially high and low temperature, which may occur in the field which affects negatively its growth, yield and even the quality of pods. Hence, improving tolerance of snap bean plants to the possible environmental stresses by using protection plants is important to enhance its growth, maximize the yield and quality.

Protection plants significantly increases in growth characteristics, pod yield and chemical properties (i.e., N, P and K %) compared with the control [13-16]. While, El-Shimi [17] found that, planting protection treatments broad bean, pea and onion did not effect on growth parameters of snap bean plants, whereas pea and onion protection plants increased significantly fresh, dry pod weight, early, total yield and total sugars compared with the control unprotected plants.

Pea (*Pisum sativum* L.) is not only a member of Leguminoseae family but also it is a critical economic winter crop vegetable which contain high amount of protein and carbohydrates, also it is rich in iron and zinc and thus, could address two of the most common micronutrient deficiencies in the world. It called "poor man's meat" for poorer consumers [18]. This crop also plays a significant role in soil fertility restoration as a suitable rotation crop that fixes atmospheric nitrogen by contents from microorganisms. Also, the pea's crop area registries continue increment yearly in Egypt and this due to its high yield through short season with high stability price and often high economic competitiveness compared with the other cash winter crops.

Therefore, the aim of this investigation was to obtain early pod yield of green snap bean pod yield with the best quality and make the most of the unit area by using intercropping system.

MATERIALS AND METHODS

This present work was carried out during two early summer seasons of 2019 and 2020 at the Experimental Farm of Kaha Station, Qalubia Governorate, Egypt. The soil was clay in texture with 8.11 pH, 1.27% organic matter, 110ppm N, 56ppm P and 98ppm K. The seeds of snap bean cv. Paulista and pea cv. Indian master were obtained from Horticulture Research Institute, Agriculture Research Center, Egypt. A split plot design system with three replicates was adopted. Six treatments, i.e., the combination among three levels from the recommended mineral fertilization (50, 75 and 100% as control) were distributed in the main plots. In addition, three cropping patterns; mono crop of pea, mono crop of snap bean and intercropping of pea with snap bean were arranged in the sub plots. The mineral fertilizers were added in three levels i.e., 50, 75 and 100% from the recommendation of pea plants i.e., 50kg N +73.5 kg P_2O_5 + 60 kg K_2O/ fed.

The seeds of pea were sown on 17th and 19th November in in first and second seasons, respectively in hills on one side of the ridges every 10cm. Snap bean seeds were sown on 6th and 8th January in first and second seasons (about a month before the planting date of snap bean), respectively every 5 cm in hills on the other side of the ridges for both mono and intercropping plants. The area of each experimental plot was 8.4m^2 (4m length, 0.70 m width and 3 ridges). Wooden supports were placed at the corners of the experimental plot and a string was tightened on them to tighten the pea plants on them to act as protector wall for snap bean plants.

The other agricultural practices required for pea and snap bean production were carried out as commonly followed.

Data Recording

Plant Growth Measurements: Representative's samples of 3 plants of pea and snap bean were taken by random at 70 and 50 days after sowing (at flowering stage), respectively from each plot for measuring the plant growth characters, as follows:

Plant length (cm), stem diameter, number of leaves plants and dry weight of plant (deter-mined at 65°C for 72 hours using the standard methods as illustrated by A.O.A.C. [19].

- The leaf area was calculated at flowering stage (after 70 and 50 days from sowing for pea and snap bean, respectively) from the fourth upper leaves according to the following formula of Wallace and Munger [20]:

Leaf area (cm^2) = Leaves dry weight (gm) x disk area / Disk dry weight (gm).

Total Pod Yield and its Components: At harvest stage, green pods were continuously harvested at suitable maturity stage and in the second pickings a random sample of 10 fresh green pods from each plot were taken from snap bean cv. Paulista and pea cv. Indian master to determine the following data:

Pea: Average pod length (cm), average pod diameter (cm), number of seeds/pod, average seeds fresh weight /pod, average 100 seeds fresh and dry weight (g).

Snap Bean: Average pod length (cm), average pod diameter (cm), average pod fresh and dry weight (g), early yield and total green pods yield ton/fed.

Chemical Properties:

- Total nitrogen, phosphorus and potassium were determined in dry pods (snap bean cv. Paulista) and dry seeds (pea cv. Indian master) dried green pods and seeds at edible stage on the basis of dry weight according to the methods described by Bremner and Mulvaney [22], Olsen and Sommers [23] and Jackson [24], respectively.
- Total protein (%); was determined as nitrogen in dry pods and seeds content and converted to its equivalent protein content by multiplying N content x 6.25 [25].

Competitive Relationships

Land Equivalent Ratio (LER): The LER an accurate assessment of the biological efficiency of the intercropping situation, according to Monzon *et al*. [21] using the following equation:

$$Lp = \frac{\text{Intercropping yield of pea}}{\text{Mono cropping yield of pea}}$$

$$Ls = \frac{\text{Intercropping yield of snap bean}}{\text{Mono cropping yield of snap bean}}$$

$$LER = Lp + Ls$$

where:
Lp = LER was estimated for pea pods,
Ls = LER was estimated for snap bean.

LER values >1 indicates an advantage from intercropping in terms of the use of environmental resources for plant growth compared with sole crops.

When LER <1 resources are used more efficiently by sole crops than by intercrops.

Statistical Analysis: Obtained data were subjected to the proper analysis of variance (split-plot design) as described by Snedecor and Cochran [26] using M. stat program. Averages between treatments were differentiated by using LSD at 5% level.

RESULTS AND DISCUSSION

Pea as a Main Crop

Vegetative Growth

Effect of Fertilization Levels: Data in Table (1) revealed that adding level of 100% from the recommended mineral fertilization of pea gave the highest values with significant increases on all vegetative growth except stem diameter followed by adding 50% of the recommended mineral fertilization for plant length, number of leaves/plant, leaf area/plant and plant dry weight in both growing seasons. These results are in the same line with Abou-El-Hassan *et al*. [6] who found that, adding100% NPK increased pea plant length and Abou El -Salehein *et al*. [11] who illustrated that adding farmyard manure and NPK fertilizer with half of the recommended dose resulted in significant increments on plant pea growth.

Effect of the Intercropping Systems: Results recorded in Table (1) clearly show that, all studied plant growth parameters were not reached to significant level by intercropping pea with snap bean or the mono crop pea cultivation. While, monocrop gave the highest values of plant dry weight in both growing seasons. This means that intercropping did not have a direct effect on pea plants as sole crop or when intercropping with snap bean. These increments in dry weight may due to that pea concur more able to improve soil fertility through the fixation of atmospheric nitrogen (N2) in symbiosis with rhizobia and decomposition of its residues [27, 28] to provide optimum conditions nutrient absorption and good plant growth. These results were concluded when pea intercropped with garlic as reported by Qasim *et al*. [4] and when pea intercropped with green onion Abou-El-Hassan *et al*. [6].

Interaction Between Intercropping Systems and Mineral Fertilization Levels: As shown in Table (1) the data indicate that interaction between mono cropping system and 100% of pea recommended mineral fertilizer rates on vegetative growth increased significantly number of branches/plant, number of leaves/plant and plant dry weight . On the other hand, the interaction had no significant effect on plant length, stem diameter and leaf area in both growing seasons. These results are supported by the studies of Abou-El-Hassan *et al*. [6] when pea intercropped with green onion and El-Shimi [12] when planting sweet pepper intercropped with pea.

Table 1: Effect of fertilization levels, intercropping system between pea as main crop and snap bean as intercrop and their interaction on vegetative growth of pea plants during the two seasons of 2019 an d 2020

Treatments		Plant length (cm)		No. of leaves/plant		No. of. brunches/plant		Stem diameter (cm)		Dry weight g/plant))		Leaf area (cm^2)	
		2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
Fertilization levels													
100% (cont)		85.75	86.75	56.96	58.48	2.69	2.85	0.43	0.45	15.59	16.01	649.49	683.05
75%		79.12	80.38	42.28	50.51	2.74	2.87	0.46	0.46	14.44	15.02	481.15	509.69
50%		83.63	84.69	45.04	52.65	2.59	2.79	0.43	0.43	14.82	16.13	575.50	628.88
L.S.D at 5 % level		1.41	1.13	0.65	2.36	0.12	0.01	N.S	N.S	0.14	0.07	6.54	11.35
Cropping system													
Monocrop		83.21	84.25	47.89	54.11	2.71	2.86	0.44	0.45	15.08	15.95	568.07	607.84
Intercrop		82.45	83.62	48.29	53.64	2.63	2.82	0.44	0.44	14.82	15.48	569.36	606.56
L.S.D at 5 % level		N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	0.09	0.04	N.S	N.S
Fertilization levels * cropping system													
100%	Monocrop	86.50	88.00	57.00	59.00	2.83	2.92	0.43	0.45	15.62	16.25	652.53	685.38
	Intercrop	85.00	85.50	56.91	57.96	2.56	2.78	0.42	0.45	15.57	15.77	646.44	680.71
75%	Monocrop	79.13	80.00	41.33	50.17	2.64	2.82	0.46	0.47	14.73	15.58	474.69	511.37
	Intercrop	79.11	80.75	43.22	50.84	2.83	2.92	0.46	0.45	14.15	14.45	487.62	508.01
50%	Monocrop	84.00	84.75	45.33	53.17	2.67	2.84	0.42	0.44	14.90	16.03	576.99	626.78
	Intercrop	83.25	84.62	44.75	52.13	2.50	2.75	0.43	0.42	14.73	16.22	574.01	630.97
L.S.D at 5 % level		N.S	N.S	0.23	0.24	0.05	0.01	N.S	N.S	0.05	0.02	N.S	N.S

Yield and its Components

Effect of Fertilization Levels: Results recorded in Table (2) clearly show that, the highest values of yield and its components i.e., seeds number/pod, seeds weight/pod, pod fresh weight and dry weight of 100 and the fresh weight of 100 seeds as well as the total yield were obtained by adding 100% of recommended rate from mineral NPK in both growing seasons. It can say that these treatments as shown in Table (1) showed obvious, increasing in plant growth which that reflect on yield and its components. Chemical fertilizers could improve plant growth parameters to the role of nitrogen in nucleic acids and protein synthesis and phosphorus as an essential component of the energy compounds and phosphoprotein, also potassium plays as an activator of many enzymes [8].

These results are in agreement with Abou El-Salehein *et al*. [11] who found that adding Farmyard manure and NPK fertilizer with half of the recommended dose resulted in significant increments on green pea pod yield and its components. This may be due to increase soil fertility by using plants of Leguminoseae family, due to the increasing amount of biological nitrogen fixation [2].

On the other hand, pod length and diameter did not reach to the significant level and this may be due to that the green pod length and diameter of pea cultivars controlled by genetic factors.

Effect of the Intercropping Systems: As shown in Table (2) the data show that, total yield of pea and its components i.e., seeds number/pod, seeds weight/pod and the fresh weight of 100 seeds as well as total yield significantly increased by mono crop pea cultivation compared with intercropping between pea and snap bean in both growing seasons. Concerning dry weight of 100 seeds gave highest values in the first season and did not reach to the significant level at the second season. These results may be due to the increasing in plant growth (this increase did not reach to the significant level) which that reflects on yield and its components as shown in Table (1). These results are in the same line with El-Shimi [12] who indicates that sole plants followed by the treatment which snap bean was planted on the other side of sweet pepper plants and between them produced the highest yield compared to other intercropping system.

Interaction Between Intercropping Systems and Fertilization Levels: Data presented in Table (2) showed that the effect of interaction between cropping systems and mineral fertilizer rates on the yield of pea, led to increasing the total yield of pea and its components except pod diameter, pod length, fresh weight of 100 seeds in both growing seasons and the seeds weight/pod in the first season only, while all treatments have non-significant effect on them. Adding 100% of the recommended mineral fertilization + cultivation of mono pea gave the highest values of the average pod fresh weight, dry weight of 100 seeds, total yield in both growing seasons, seeds number/ pod in the first season and seeds weight/pod in the second season.

Table 2: Effect of fertilization levels, intercropping system between pea as main crop and snap bean as intercrop and their interaction between them on pea pods yield and its component during the two seasons of 2019 an d 2020

Treatments		Pod length (cm)		Pod diameter (cm)		Pod fresh weight (g)		Number of seeds/pod		Seeds weight/pod (g)		Fresh weight of 100seeds (g)		Dry weight of 100seeds (g)		Pod yield/fed t/fed	
		2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
Fertilization levels																	
100% (cont)		11.35	11.75	1.29	1.31	9.46	9.14	9.85	10.63	4.47	4.87	53.58	56.60	13.15	14.72	10.30	10.41
75%		11.49	11.57	1.27	1.31	8.87	8.74	9.43	9.37	4.39	4.79	52.38	53.28	11.16	14.30	9.59	9.67
50%		11.37	11.48	1.29	1.30	8.03	8.29	7.88	8.34	4.25	4.42	48.20	51.54	10.19	12.50	8.16	8.44
L.S.D at 5 % level		N.S	N.S	N.S	N.S	0.14	0.01	0.27	0.07	0.12	0.07	1.31	1.30	0.56	0.59	0.19	0.11
Cropping system																	
Monocrop		11.43	11.60	1.29	1.31	8.94	8.77	9.44	9.50	4.36	4.82	52.48	54.51	11.78	14.37	9.72	9.84
Intercrop		11.37	11.59	1.28	1.30	8.62	8.68	8.66	9.39	4.37	4.57	50.29	53.10	11.22	13.31	8.98	9.18
L.S.D at 5 % level		N.S	N.S	N.S	N.S	0.10	0.01	0.01	N.S	N.S	0.04	0.94	0.94	0.46	0.42	0.12	0.05
Fertilization levels * cropping system																	
100%	Monocrop	11.39	11.77	1.29	1.31	9.47	9.15	10.29	10.46	4.46	4.94	54.03	57.40	13.90	15.60	10.86	10.94
	Intercrop	11.31	11.72	1.28	1.30	9.44	9.14	9.40	10.79	4.47	4.80	53.13	55.80	12.40	13.84	9.74	9.88
75%	Monocrop	11.44	11.46	1.27	1.30	8.89	8.78	9.75	9.43	4.37	4.90	53.80	54.16	11.40	14.90	9.73	9.75
	Intercrop	11.53	11.67	1.27	1.31	8.84	8.69	9.10	9.30	4.42	4.69	50.95	52.40	10.92	13.70	9.44	9.59
50%	Monocrop	11.46	11.58	1.30	1.31	8.47	8.39	8.27	8.60	4.26	4.62	49.60	51.98	10.05	12.60	8.57	8.83
	Intercrop	11.27	11.38	1.29	1.30	7.58	8.20	7.49	8.08	4.23	4.22	46.80	51.10	10.34	12.40	7.75	8.06
L.S.D at 5 % level		N.S	N.S	N.S	N.S	0.05	0.03	0.03	0.07	N.S	0.02	N.S	N.S	0.23	0.21	0.06	0.02

Table 3: Effect of fertilization levels, intercropping system between pea as main crop and snap bean as intercrop and their interaction on some chemical characters of pea seeds and leaf chlorophyll concentration during the two seasons of 2019 and 2020

Treatments		N%		P%		K%		Protein %		Leaf chlorophyll SPAD	
		2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
Fertilization levels											
100% (cont)		3.65	3.65	0.28	0.37	1.94	2.11	22.79	22.81	57.80	65.31
75%		3.45	3.38	0.32	0.31	1.96	2.24	21.58	21.12	55.16	59.43
50%		3.36	3.41	0.39	0.44	1.85	1.86	20.97	21.30	51.22	51.43
L.S.D at 5 % level		0.15	0.11	0.07	0.01	N.S	N.S	0.92	0.71	1.31	1.73
Cropping system											
Monocrop		3.50	3.52	0.34	0.39	1.91	2.02	21.88	21.99	54.76	59.24
Intercrop		3.47	3.44	0.32	0.36	1.92	2.12	21.67	21.50	54.69	58.20
L.S.D at 5 % level		N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
Fertilization levels * cropping system											
100%	Monocrop	3.64	3.69	0.29	0.38	1.92	2.08	22.75	23.06	57.20	65.80
	Intercrop	3.65	3.61	0.27	0.35	1.95	2.15	22.83	22.56	58.40	64.81
75%	Monocrop	3.50	3.43	0.33	0.35	1.94	2.11	21.89	21.44	55.81	60.13
	Intercrop	3.40	3.33	0.32	0.28	1.97	2.36	21.25	20.81	54.50	58.72
50%	Monocrop	3.36	3.44	0.41	0.43	1.85	1.88	21.00	21.48	51.28	51.78
	Intercrop	3.35	3.38	0.36	0.46	1.85	1.85	20.94	21.13	51.16	51.07
L.S.D at 5 % level		N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S

Chemical Characters of Pea Seeds and Total Chlorophyll Concentration in the Leaves of Plants

Effect of Fertilization Levels: Data registered in Table (3) showed that adding 100% of the recommended mineral fertilization on pea increased N% and protein% in pea seeds. Meanwhile, adding 75% of the recommended mineral fertilization of pea gave the best values of K% in pea seeds .While as adding 50% of the recommended mineral fertilization of pea gave the highest values of P % components in pea seeds. These results are true in both growing seasons.

Regarding, the total chlorophyll concentration in pea leaf tissues increased significantly by increasing fertilization rates up to 100% of pea recommended mineral fertilization.

These results were in the same line with Abou-El-Hassan *et al.* [6] who obtained the highest values of N and P content by adding 50% NPK + Rhizobium (NFB) + Arbuscular mycorrhizal fungi (AMF), while adding 100% +NFB + AMF increased K% but it can't reach to significant level. Moreover, Abou El Salehein *et al*. [11] who found that adding Farmyard manure and NPK

fertilizer with half of the recommended resulted in significant increments on pea seeds quality. On the other hand El-Shimi [12] noticed that, the highest values with significant increase of V.C concentration, P (%) and K (%) in fruits as well as the chlorophyll content in the leaves of sweet pepper plants were obtained when sweet pepper plants fertilized by the addition 100% of the mineral fertilization of sweet pepper +50% mineral fertilization of snap bean except the chlorophyll content in the leaves in the second season.

Effect of the Intercropping System: The obtained data in Table (3) revealed that, N, P, K% and protein components in pea seeds were obtained from mono pea cultivation but these increases did not reach to the significance level in the two growing seasons.

According to total chlorophyll concentration in leaf tissues were not affect with cropping system (mono pea cultivation or inter crop pea with snap bean plants). These results were true in both seasons. These results were in harmony with those obtained by Qasim *et al.* [4]; Abou-El-Hassan [6] and El-Shimi [12] reported that, mono cropping plants significantly increased nutritional status and quality compared to intercropping plants.

Interaction Between Intercropping Systems and Fertilization Levels: Data in Table (3) illustrated that, the interaction between mineral fertilizer rates (100, 75 and 50%) and intercropping systems (mono pea cultivation or intercrop snap bean with pea plants) had non-significant effect on N, P , K (%) and protein components in pea seeds in the two growing seasons.

Also total chlorophyll concentration in leaf tissues were not affected with interaction treatments between mineral fertilizer rates and cropping system. These results were true in both seasons.

Snap Bean as Intercrop

Vegetative Growth

Effect of Fertilization Levels: Results recorded in Table (4) cleared that, all studied growth attributes i.e., plant length, leaves and branches number, plant dry weight and leaf area were increased significantly by adding 100% of the recommended mineral fertilization in both growing seasons except stem diameter in the second season which not reach to significant level. These increments could be due to the effect of nitrogen which promotes the meristemic activity and hence, increase the number of tissues and organs as reported by Ghoneim [7]. Meanwhile, chemical fertilizers could improve plant growth parameters and this due to the role of nitrogen in nucleic acids and protein synthesis and phosphorus as an essential component of the energy compounds and phosphoprotein, also the role of potassium as an activator of many enzymes [8]. In this regard, Abebe *et al*. [10] reported that, using four rates of N (0, 50, 100 and 150 Kg/ha) and B (0, 2, 4 and 6). The combined application of 100 – 150 Kg/ha N and 2Kg/ha B significantly increased growth attributes.

Effect of the Intercropping Systems: Data registered in Table (4) showed that the treatment which planting snap bean on the other side of pea plants gave the best growth attributes, i.e., plant length, leaves and branches number and plant dry weight in both growing seasons except leaf area data revealed that monocrop was the best treatment in the second season. These results are supported by Turky [13] on sunflower or maize with snap bean, Dahmardeh *et al*. [15], Eskandari *et al*. [16] on cowpea and maize and Abdel-Aziz and Gaafer [14] on sunflower or maize with snap bean but are in the contrary with El-Shimi [17] found that, planting protection treatments broad bean, pea did not effect on growth parameters of snap bean plants c.v, Poulista. On the other hand, Abou-El-Hassan *et al*. [6] recorded significantly decrease in growth attributes when pea intercropped with green onion.

Interaction Between Intercropping Systems and Mineral Fertilizer Rates: Results recorded in Table (4) cleared that, all studied growth attributes i.e., plant length, leaves and branches number and plant dry weight as well as leaf area were increased significantly by the addition100% of mineral fertilization and intercrop cultivation of pea and snap bean except stem diameter which did not reach to significant level in the two seasons. While, the highest values of leaf area were obtained by the addition 100% and monocrop treatment. These increases may be due to the interaction between intercropping systems and mineral fertilizer rates this, might be attributed to the reduction in inter and intra competition between the two crops for nutrients especially NPK elements as reported by Abdelkader and Hamad [29]. These results were in the same line with Abou-El-Hassan *et al*. [6] and El-Shimi [12] which they found that, adding 100% of the recommended mineral fertilization of sweet pepper + 50% of the recommended mineral fertilization of snap bean and sole cultivation of snap bean followed by snap bean was planted on the other side of sweet pepper increased the most snap bean growth attributes.

Table 4: Effect of fertilization levels, intercropping system between pea as main crop and snap bean as intercrop and their interaction on vegetative growth of snap bean plants during the two seasons of 2019 and 2020

Treatments		Plant length (cm)		No. of leaves/ plant		No. of. brunches/plant		Stem diameter (cm)		Dry weight g/plant))		Leaf area (cm^2)	
		2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
Fertilization levels													
100% (cont)		30.36	32.80	14.62	15.11	7.79	8.25	0.61	0.62	8.18	8.77	314.45	347.65
75%		26.50	27.99	13.58	15.20	7.64	8.25	0.57	0.59	6.29	6.49	265.02	277.00
50%		25.44	29.78	13.79	14.38	7.56	8.00	0.53	0.60	7.80	7.95	237.37	263.42
L.S.D at 5 % level		1.31	1.26	0.08	0.59	0.07	0.14	0.07	N.S	0.06	0.12	13.72	22.39
Cropping system													
Monocrop		25.75	27.57	13.15	13.90	7.24	7.69	0.61	0.63	6.83	7.08	273.48	306.44
Intercrop		29.11	32.81	14.84	15.88	8.09	8.64	0.53	0.58	8.02	8.39	271.08	285.61
L.S.D at 5 % level		1.33	0.59	0.20	0.59	0.05	0.10	N.S	N.S	0.04	0.03	N.S	9.42
Fertilization levels * cropping system													
100%	Monocrop	27.71	29.60	14.25	14.71	7.33	7.50	0.68	0.68	7.39	7.96	315.86	361.51
	Intercrop	33.00	36.00	15.00	15.50	8.26	9.00	0.54	0.56	8.97	9.58	313.03	333.80
75%	Monocrop	28.33	25.43	12.50	13.50	7.28	8.25	0.58	0.60	6.29	6.32	257.04	265.02
	Intercrop	24.67	30.56	14.66	16.89	8.00	8.25	0.56	0.58	6.30	6.65	273.01	288.99
50%	Monocrop	24.88	27.67	14.87	13.50	7.12	7.33	0.56	0.61	6.80	6.97	247.53	292.79
	Intercrop	26.00	31.88	12.71	15.25	8.00	8.67	0.50	0.59	8.80	8.93	227.21	234.04
L.S.D at 5 % level		0.67	0.29	0.10	0.30	0.03	0.05	N.S	N.S	0.02	0.01	4.28	4.72

Yield and its Components

Effect of Fertilization Levels: Data recorded in Table (5) showed that, fertilizing with 100% or 75% of the recommended rate of NPK increased pod fresh and dry weight, early yield and total yield. While, pod length and pod diameter did not reach to the significant level and this may be due to that the green pod length and pod diameter of pea cultivars controlled by genetic factors. It can say that these treatments as shown in Table (4) showed obvious that, increasing in plant growth which that reflects on yield and its components. The same trend was obtained by Negash *et al*. [9] which found that, increasing fertilizer application rates gave the maximum marketable pod yield. Moerover, Abebe *et al*. [10] on snap bean and El-Shimi [12] on sweet pepper intercropped with snap bean which cleared that increasing NPK-fertilizer rates caused an increase in the yield and its components.

Effect of the Intercropping Systems: Data registered in Table (5) showed that the treatment which snap bean was planted on the other side of pea plants gave the highest values of pod fresh, dry weight and early yield as well as total yield while, pod length and diameter did not reach to the significant level, these results were true in both growing seasons. These results were agreement with those obtained by Turky [13], Abdel-Aziz and Gaafer [14] on bean with sunflower or maize, Dahmardeh *et al*. [15], Eskandari *et al*. [16] cowpea and maize, El-Shimi [17] showed that, on snap bean with broad bean, pea and onion as same result. This cleared that planting protection treatments (sunflower, maize, broad bean and pea) increased significantly pod fresh, dry weight, early and total yield compared with the control unprotected plants and El-Shimi [12] who indicated that sole plants followed by intern crop systems produced the highest yield.

Interaction Between Intercropping Systems and Mineral Fertilizer Rates: Data in Table (5) noticed that, the highest values of pod fresh and dry weight as well as total yield/fed were recorded by adding 100% of mineral fertilization and intercrop cultivation of pea with snap bean, while 75% of mineral fertilization and intercrop cultivation of pea with snap bean increased significantly the early snap bean yield. On the other hand, pod length and pod diameter did not reach to the significant level. These results were true in both growing seasons and w These results were ere agreements with those obtained by Abou-El-Hassan [6] and El-Shimi [12] who indicates that, interaction between cropping systems and fertilizer treatments had a significant effect on yield of inter crop yield (pea pods and snap bean) when mineral fertilization was increased.

Chemical Characters of Pea Seeds and Chlorophyll in the Leaves of Plants

Effect of Fertilization Levels: Data recorded in Table (6) showed that, adding mineral fertilization rates at100% increased significantly N% and protein content in snap been pods. While, adding mineral fertilization rates (100, 75 and 50%) had no significant effect on the percent of P and K in snap been pods. These results are true in the two seasons.

Table 5: Effect of fertilization levels, intercropping system between pea as main crop and snap bean as intercrop and their interaction on snap bean yield and its component during the two seasons of 2019 and 2020

Treatments		Pod length (cm)		Pod diameter (cm)		Pod fresh weight (g)		Pod dry weight (g)		Early yield t/fed		Total yield ton/fed	
		2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
Fertilization levels													
100% (cont)		12.71	12.88	0.52	0.60	5.83	6.03	0.53	0.54	1.65	1.92	6.94	7.28
75%		13.32	13.52	0.46	0.47	5.56	5.83	0.45	0.46	2.26	2.34	5.73	7.51
50%		13.32	13.75	0.56	0.56	4.69	4.97	0.38	0.44	0.95	1.17	4.19	4.06
L.S.D at 5 % level		N.S	N.S	N.S	N.S	0.08	0.07	0.08	0.06	0.44	0.19	0.26	0.59
Cropping system													
Monocrop		13.28	13.50	0.49	0.54	5.17	5.48	0.42	0.46	1.34	1.49	4.95	5.45
Intercrop 12.95		13.26	0.52	0.54	5.54	5.74	0.49	0.50	1.90	2.14	6.29	6.45	
L.S.D at 5 % level		N.S	N.S	N.S	N.S	0.05	0.05	0.05	0.04	0.31	0.06	0.05	0.47
Fertilization levels * cropping system													
100%	Monocrop	12.90	12.95	0.51	0.59	5.56	5.81	0.47	0.47	1.42	1.53	6.30	6.78
	Intercrop	12.51	12.80	0.52	0.61	6.09	6.24	0.59	0.61	1.87	2.32	7.57	7.79
75%	Monocrop	13.45	13.55	0.43	0.46	5.45	5.77	0.45	0.47	1.68	1.74	5.12	5.51
	Intercrop	13.19	13.49	0.48	0.47	5.68	5.89	0.45	0.46	2.84	2.95	6.34	7.50
50%	Monocrop	13.49	14.00	0.54	0.56	4.51	4.85	0.34	0.43	0.91	1.19	3.43	4.06
	Intercrop	13.14	13.50	0.55	0.55	4.87	5.09	0.42	0.44	0.98	1.15	4.96	4.06
L.S.D at 5 % level		N.S	N.S	N.S	N.S	0.03	0.02	0.02	0.02	0.16	0.03	0.02	0.23

Table 6: Effect of fertilization levels, intercropping system between pea as main crop and snap bean as intercrop and their interaction on some chemical characters of snap bean plants and leaf chlorophyll concentration during the two seasons of 2019 and 2020

Treatments		N%		P%		K%		Proten %		Leaf chlorophyll SPAD	
		2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
Fertilization levels											
100% (cont)		2.38	2.56	0.63	0.66	2.69	2.71	14.88	16.00	57.80	65.31
75%		1.94	2.17	0.63	0.64	2.65	2.68	12.13	13.53	55.16	59.43
50%		1.85	1.99	0.56	0.57	2.73	2.76	11.56	12.44	51.22	51.43
L.S.D at 5 % level		0.07	0.14	N.S	N.S	N.S	N.S	0.45	0.88	1.31	1.73
Cropping system											
Monocrop		1.94	2.13	0.61	0.63	2.69	2.71	12.13	13.29	54.76	59.24
Intercrop		2.17	2.35	0.59	0.61	2.68	2.72	13.58	14.69	54.69	58.20
L.S.D at 5 % level		0.05	0.01	N.S	N.S	N.S	N.S	0.32	0.06	N.S	N.S
Fertilization levels * cropping system											
100%	Monocrop	2.24	2.47	0.65	0.66	2.71	2.72	14.00	15.44	57.20	65.80
	Intercrop	2.52	2.65	0.61	0.65	2.69	2.69	15.75	16.56	58.40	64.81
75%	Monocrop	1.76	2.00	0.64	0.65	2.69	2.71	11.00	12.50	55.81	60.13
	Intercrop	2.12	2.33	0.62	0.63	2.62	2.65	13.25	14.56	54.50	58.72
50%	Monocrop	1.82	1.91	0.56	0.59	2.69	2.70	11.38	11.94	51.28	51.78
	Intercrop	1.88	2.07	0.56	0.55	2.76	2.82	11.75	12.94	51.16	51.07
L.S.D at 5 % level		0.03	0.01	N.S	N.S	N.S	N.S	0.16	0.03	N.S	N.S

Concerning, chlorophyll concentration in leaf tissues were increased significantly by increasing mineral fertilization at the rate of 100%. These results were in the same line with El-Shimi [12] who showed that added100% of the recommended mineral fertilization of sweet pepper + 50% of the recommended mineral fertilization of snap bean gave the highest values of the percent of N, protein and Total sugar content in the green pods of snap bean, but the percent of K and P did not reach to significant level.

Effect of the Intercropping Systems: The obtained data in Table (6) revealed that, intercropping systems increased the percent of N and protein in pea seeds. While as. the percent of P and K in pea seeds were not affected by intercropping systems whereas, mono snap bean gave higher values than intercrop system but did not reach to the significant level in the two growing seasons.

Concerning, total chlorophyll concentration in leaf tissues were not affect with cropping system (mono pea cultivation or inter crop pea with snap bean plants).

These results were true in both seasons. In this regard El-Shimi [12] revealed that the sole cultivation of snap bean treatment followed by the treatment which snap bean was planted on the other side of sweet pepper induced significant increases in the percent of total sugar content in the green pods of snap bean but cropping systems had no effect on N and protein

Interaction Between Intercropping Systems and Mineral Fertilizer Rates: Data in Table (6) illustrated that, the interaction between mineral fertilizer rates (100, 75 and 50%) and intercropping systems (mono pea cultivation or intercrop snap bean with pea plants) increased the percent of N, protein and had no significant effect on P and K (%) components in pea seeds in the two growing seasons.

Also total chlorophyll concentration in leaf tissues were not affected with interaction treatments between mineral fertilizer rates and cropping system. These results were true in both seasons.

Land Equivalent Ratio (LER)

Effect of Fertilization Levels: Land equivalent ratio LER is the most important factor used to determine the efficiency of intercropping system. When the value of LER is greater than one, that is mean it is a good efficiency indicator of land productivity. Data in Table (7) showed that, LER of pea was less than one with significant difference between fertilizers levels rates in both growing seasons put it is found that, adding 75% of the recommended mineral fertilization increased LER which gave the best values followed by adding 100% and 50% of the recommended mineral fertilization in the first season and followed by 100%then 50% in the second season. Regarding to LER of snap bean, it was more than one in both growing seasons. Adding 100% of the recommended mineral fertilization increased LER significantly followed by 75% of the recommended mineral fertilization in the first season on the other hand, adding 75% of the recommended mineral fertilization followed by 100% of the recommended mineral fertilization increased LER significantly in the second season. Meanwhile, total land equivalent ratio increased by increasing mineral fertilization with significant difference, by adding 100% and 75% of the recommended mineral fertilization in the first and second season respectively. These results are in the same line with Abou - El-Hassan *et al.* [6] who cleared that the highest value of LER was obtained by using 50% NPK+ NFB+ AMF, but are in the contrary with El-Shimi [12], who found that total land equivalent ratio increased by increasing fertilization rates in the two seasons.

Table 7: Effect of fertilization levels, intercropping system between pea as main crop and snap bean as intercrop and their interaction on Land Equivalent Ratio (LER) during the two seasons of 2019 and 2020

		LER pea		LER snap bean		LER	
Treatments		2019	2020	2019	2020	2019	2020
Fertilization levels							
100% (cont)		0.94	0.95	1.17	1.00	2.12	1.95
75%		0.98	0.99	1.09	1.15	2.08	2.15
50%		0.95	0.96	1.08	1.06	2.04	2.02
L.S.D at 5 % level		0.01	0.01	0.06	0.07	0.05	0.06
Cropping system							
Monocrop	1.00	1.00	1.00	1.00	2.00	2.00	
Intercrop	0.92	0.93	1.24	1.15	2.16	2.08	
L.S.D at 5 % level		0.01	0.01	0.07	0.06	0.06	0.05
Fertilization levels * cropping system							
100%	Monocrop	1.00	1.00	1.00	1.00	2.00	2.00
	Intercrop	0.89	0.90	1.35	1.00	2.24	1.90
75%	Monocrop	1.00	1.00	1.00	1.00	2.00	2.00
	Intercrop	0.97	0.98	1.19	1.31	2.17	2.29
50%	Monocrop	1.00	1.00	1.00	1.00	2.00	2.00
	Intercrop	0.90	0.91	1.17	1.13	2.08	2.04
L.S.D at 5 % level		0.002	0.004	0.03	0.03	0.03	0.02

Effect of the Intercropping Systems: Results in Table (7) revealed that the LER of pea was one or less than one (resources are used more efficiently by sole crops than by intercrops). Where, mono pea cultivation show increased more than intercrop cultivation (pea+ snap bean). Though intercrop cultivation of snap bean and pea increased significantly and was greater than one compared with mono snap bean cultivation. Moreover, total LER of intercropped systems which snap bean was planted on the other side of pea plants was greater than mono one. These results were true in both growing seasons. In this regard Abou-El-Hassan *et al*. [6] when pea intercropped with green onion and EL-Shimi [12] when sweet pepper intercropped with snap bean indicated that, Land equivalent ratio of all intercrops was greater than one and indicated an advantage from intercropping in terms of the use of environmental resources for plant growth compared with sole crops.

Interaction Between Intercropping Systems and Mineral Fertilization Levels: Data in Table (7) indicated that the all intercrop systems increased total LER except LER of pea mono pea cultivate outperform crop cultivate and it was one or less than one. Regarding LER of snap bean and total LER increased by adding 100% of the recommended mineral fertilization and intercrop cultivation of pea and snap bean in the first season. Whereas, adding 75% of the recommended mineral

fertilization and intercrop cultivation of pea and snap bean which gave the highest LER values of snap bean and total LER in the second season increased. This means that the efficiency of using land increased. This result is in agreement with those found by Abou -El-Hassan *et al*. [6] when pea intercropped with green onion and EL-Shimi [12] when sweet pepper intercropped with snap bean.

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