J. Plant Production, Mansoura Univ., Vol. 5 (7): 1259-1281, 2014

PHYSIOLOGICAL STUDIES ON SUGAR PEA: EFFECT OF PLANT DENSITY AND SOME NATURAL SUBSTANCES AS FOLIAR APPLICATIONS ON GROWTH, POD YIELD AND QUALITY.

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ABSTRACT

Two field experiments were conducted at Private Farm in EL-Salheya, SharKia Governorate, Egypt during winter seasons of 2012/2013 and 2013/2014 to study the effect of plant density and some foliar applications, i.e., moringa leaf extract (MLE), chitosan at 150 ppm and silicon at 200 ppm on vegetative growth, pod yield and quality of snow pea cultivars, i.e. “Compados and Snow Wind” and sugar snap pea cultivar “Sugar Snap”.

The results showed that Compados cultivar had more leaves and branches, longest plant height, heaviest fresh and dry weight, largest leaf area, and gave the highest pod length and pod yield (ton/fed.) compared with other cultivars in the two seasons. Whereas, the least one was Sugar Snap cultivar in both seasons. Moreover, Sugar Snap cultivar was the highest in pod thickness, total soluble solids (TSS) and carbohydrates (%) and the lowest in titrable acidity (%) in both seasons. While, Snow Wind was the superior in vitamin C (mg/100g fw) in both seasons. Meanwhile, plant density (20 cm apart) gave the highest plants and total pod yield/fed. compare with other densities (40 and 60 cm) at the two seasons whereas, (60 cm apart) gave the highest values in all studied parameters except plant height and total pod yield/fed followed by (40 cm apart plants) in both seasons. All foliar applications significantly increased all the studied parameters compared to the control treatment. The superior application was moringa leaf extract (MLE) followed by chitosan and silicon in both seasons, respectively.

From the obtained results it could be concluded that Compados cultivar was the highest pod yield/plant, and total yield/fed. when cultivated on 20 cm apart, meanwhile Sugar Snap cultivar gave the best pod quality when cultivated on 60 cm apart and sprayed with moringa leaf extract three times, i.e., 15 days after planting then repeated each 15 days interval, respectively.

Keywords: Sugar pea, moringa leaf extract, chitosan, silicon, growth, pod yield, quality.

INTRODUCTION

Sugar pea is one of the important newly introduced vegetable crops in Egypt for exporting. Sugar peas contain two types, i.e. the snow peas and the sugar snap peas which they are known as edible podded peas because they don’t have the same cross fiber in the wall of the pod as the common garden pea and pods can be eaten whole. The snow pea (*Pisum sativum var.* macrocarpon) is known by this name in Australia and the USA, but in England and France, it is called “mange-tout” which means “eat-all”. The snow pea is a distinct botanical cultivar or subspecies of pisum sativum. The pod of snow pea is slab sided and is eaten before the string develops and the peas start to swell. While, the sugar snap pea or snap pea (*Pisum sativum* var. saccharatum) is the progeny of a cross between a snow pea and unusual pea that was tightly podded with thick walls. The sugar snap pea is a pea which snaps like a green bean, the pod have thick walls, and are sweet. Unlike the snow pea, the sugar snap pea is picked more mature and is fully rounded (Beckingham, 2001 and Burt, 2008). Pods of sugar pea contain a great amount of protein, carbohydrates, vitamins, minerals and other nutrients, so that sugar pea considered as one of the most important sources in human food nutrition. It can be eaten raw, lightly boiled, steamed or used in stri-frys.

Plant population density is a major determinant of crop yield. In fact, the yield of plant is the result of the competition within and outside of the plant on the environmental factors and the maximum yield will be obtained when, this competition has decreased and the plant has the maximum using of these environmental factors. Increasing the excessive density, prevent the light penetrating into the canopy and increase competition. Therefore, identifying the suitable planting density is the first and the most essential strategies considered for achieving high yield (Rasaei *et al*., 2012). For this reason, managing this new crop is uncertain and knowledge about its agronomic response is required. Clarification of the effect of seeding density on the yield and quality is especially needed. There is no published information on the effect of these factors on the snap pea, but similar studies have been conducted on peas (Azpilicueta *et al*., 2012). In addition, it became important to work on increasing the production and the quality of this crop especially with the increased demand for exporting sugar peas.

One of these strategies for increasing the production and the quality of sugar peas using natural growth stimulating compounds safety to the environment, inexpensive and harmless to humans, i.e., moringa leaf extract and chitosan applications. Moringa (*Moringa oleifera*) is an important plant of Morigaceae family having tremendous allelopathic potential. There are about 13 species of genus Moringa reported in total and among them M. oleifera is the most known and widely cultivated species throughout the world (Fuglie, 1999). Moringa is known as a miracle plant due to its multiple uses. Being rich in amino acids, ascorbate, zeatin, minerals and many other compounds, moringa has several applications in agriculture and medical sciences. Secondary metabolites isolated from this plant promote the plant growth and defense mechanisms against abiotic stresses. Moringa extracts accelerate the growth of plants, strengthen plants, and improve resistance against pests and diseases (Hussain *et al*., 2013). Moringa leaf extract (MLE) being a rich source of amino acids, essential macro- and microplant minerals, vitamins, natural antioxidants and plant growth regulators such as zeatin (cytokinins) and gibberellins; it can be effectively exploited as plant growth enhancer (Makkar and Becker, 1996; Mahmood *et al*., 2010 and Basra *et al*., 2011). Furthermore, foliar spray of leaf extracts of moringa accelerate the growth of plants, improves resistance to pests and diseases, and enhances the yield by 20-35 % in different crops (Fuglie, 2000).

Chitosan is a natural, low toxic and inexpensive compound that is biodegradable and environmentally friendly with various applications in agriculture. Structurally, chitosan is a straight-chain copolymer composed of D-glucosamine and N-acetyl-D-glucosamine being obtained by the partial deacetylation of chitin. It is the most abundant basic biopolymer and it's structurally similar to cellulose, which is composed of only one monomer of glucose (De Alvarenga, 2011). Chitosan is derived from chitin, a polysaccharide found in the exoskeleton of shellfish such as shrimp, lobster, and or crabs and cell walls of fungi (Wojdyla, 2001). Recently, chitosan has been reported to act as a plant growth regulator and considered to elicit the induction of plant defense mechanisms in many plant (Ben-Shalom *et al*., 2003 and Photchanachai *et al*., 2006). Both chitin and chitosan have demonstrated antiviral, antibacterial, and antifungal properites, and have been explored for many agricultural uses. They have been utilized to control disease or reduce their spread, to chelate nutrient and minerals, preventing pathogens from accessing them, or to enhance plant innate defenses (El hadrami *et al*., 2010). Moreover, chitosan has been shown to stimulate plant growth (Kim, 2005 and Mondal *et al*., 2012), to possess antioxidant activity (Xie *et al*., 2001 and Chen *et al*., 2009), act as anti-transpirant compound that has proved to be effective in many crops (Khan *et al*., 2002 and Karimi *et al*., 2012) and to improve storability of postharvest fruits and vegetables (El Ghaouth *et al*., 1991).

Among the tools for increasing productivity and quality of sugar pea using silicon (Si) application. Although silicon is the second most abundant element both on the surface of the Earth's crust and in soils, it has not yet been listed among the essential elements for higher plants. Like salt in food, which itself is not a nutrient or food item but adds to the taste and palatability. Similarly silicon though not essential confers rigidity and strength to plants, protects them from pests, diseases and abiotic tresses (Vasanthi *et al*., 2012). Among all the micronutrients assimilated by plants, silicon alone is consistently present at concentrations similar to those of the macro nutrients. It is also the only beneficial element that does not cause toxicity or serious injury to plants under excessive a mounts (Snyder *et al*., 2007). Its concentrations in different plants range from 0.1% (similar to P and S) to more than 10% of whole plant dry matter (Epstein, 1999). Silicon can alleviate biotic and abiotic stresses in several crops, and it has beneficial effects on plants under nonstressed conditions (Pilon *et al*., 2013). The effective management of Si can offer several potential benefits of crop production including improved plant growth, increased yield, induced resistance to stresses and increased productivity of problem soils (Aziz *et al*., 2002). Moreover, silicon is an element that forms Si-enzyme complex that act as protectors and photosynthesis regulators as well as influencing other enzymatic activities (Toresano-Sanchez *et al*., 2012). Silicon was found to be beneficial to barley, wheat, corn, sugarcane, cucumber, tomato, citrus and other crops (Epstein, 1994).

In the light of above discussions, present study was designed to investigate the effect of plant density and foliar applications, i.e., moringa leaf extract, chitosan and silicon on growth, pod yield and quality of some sugar pea cultivars.

MATERIALS AND METHODS

Two field experiments were conducted at Private Farm in EL-Salheya, Sharkia Governorate, Egypt during winter seasons of 2012/2013 and 2013/2014 to study the effect of plant density and some foliar applications, i.e., moringa leaf extract (MLE), chitosan at 150 ppm and silicon at 200 ppm on vegetative growth, pod yield and quality of snow pea cultivars, i.e. “Compados and Snow Wind” and sugar snap pea cultivar “Sugar Snap” grown under drip irrigation system of sandy soil.

The physical and chemical analysis of the experimental soil are shown in Table (1).

Table (1): The physical and chemical analysis of the experimental soil.

Properties	Value	Properties	Value
Physical		Soluble anions (meq/100g soil)	
Soil texture	sand	HCO_3^-	0.40
Organic matter %	1.0085	CL^-	0.33
Chemical		SO_4^{--}	0.04
E.C. (mmohs/cm)	0.15	Macro-elements (ppm)	
pH	9.53	N	23.625
Soluble cations (meq/100g soil)		P	21.00
Ca^{++}	0.33	K	140.00
Mg^{++}	0.25	Micro-elements (ppm)	
Na^+	0.12	Fe^{++}	0.45
K^+	0.07	Mn^{++}	0.62
		Zn^{++}	0.45
		Cu^{++}	0.45

Seeds were sown as two seeds per hill on one side of the irrigation lines in 20th and 27th of November in the first and the second seasons, respectively. The experimental layout was split-split-plot system in a randomized complete blocks design with three replicates. These experiments included 36 treatments which were the combination among 3 cultivars, 3 plant density and 4 foliar applications. The cultivars were randomly arranged in the main plots, while the plant density were randomly distributed in the sub-plots and foliar applications were randomly arranged in the sub-sub-plots. The sub-sub-plot area was 12.0 m^2 (2 dripper lines, each 6 m long and 100 cm width). The normal agricultural practices of sugar pea production were followed according to the recommendations of Egyptian Ministry of Agriculture. The treatments were arranged as follow:

a. Sugar pea cultivars: Compados, Sugar Snap and Snow Wind.

b. Plant density: 20 cm, 40 cm and 60 cm apart.

c. Foliar applications:

1-Moringa leaf extract preparing according to Culver *et al*. (2012).

2-Chitosan (poly-(1.4-B-D-glucopyranosamine);2-Amino-2-deoxy-(1->4)-B-D-glucopyranan) at 150 ppm.

3-Silicon in form of (silicic acid ($Si(OH)_4$) at 200 ppm.

4-Control (sprayed with tap water).

The plants were sprayed three times, 15 days after sowing and repeated each 15 days interval.

Data recorded:

a. Vegetative growth:

At 45 days after sowing five plants were randomly taken from each plot for determining the following data:

Plant height (cm), number of branches/plant, number of leaves/plant, leaf area (cm^2/plant), fresh weight (gm/plant) and dry weight (gm/plant).

b. Pod yield and its components:

Green pods of each plot were harvested at the proper maturing stage, counted and weighted in each harvest and the following parameters were collected:

Number of pods/plant, average weight of pod (gm), pod yield/plant (gm) and total pod yield (ton/fed.).

c. Pod quality:

Pod length (cm), pod diameter (mm), pod thickness (mm), total soluble solids (TSS) was determined by Carl Zeiss refractometer, vitamin C (mg/100gfw) was determined in juice using 2,6-dichlorophenolindophenol dye (A.O.A.C., 1990), titrable acidity (%) was determined by the titration method with 0.1 sodium hydroxide using phenolphthalein indicator (A.O.A.C., 1990) and carbohydrates (%) was determined colorimetrically in dry matter of pods following the method described by Dubois *et al*. (1956).

All collected data on plot basis were subjected to the statistical analysis according to the method mentioned by Snedecor and Cochran (1968). The data of treatment means were compared using least significant difference (LSD) method as mentioned by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Vegetative growth characters:

Effect of cultivars:

Data presented in Table (2) showed that Compados cultivar had highest values than other cultivars in all vegetable growth characters, i.e., plant height, number of leaves and branches/plant, Leaf area and fresh and dry weight followed by Snow Wind cultivar, whereas the least one was Sugar Snap cultivar in both seasons.

Similar results were obtained by Tewfik (2014) who evaluated some sugar pea cultivars and found that Compados cultivar was the best cultivar in all vegetative growth parameters compared with the other studied cultivars. Also, El-Desuki (2006) reported that Snow Wind cultivar gave the highest vegetative growth values compared with Sugar Pearl and Sugar Gem cultivars. The differences among cultivars may due to the genetical variations.

Effect of plant density:

Data in Table (2) indicated that plant density (20 cm apart) gave the highest plants compare with other densities (40 and 60 cm) at the two seasons. Whereas, the plant density (60 cm apart) gave the highest values in number of branches and leaves/plant and leaf area (cm^2)/plant and the heaviest fresh and dry weight of plant at the two seasons. The differences among plant densities were significantly in all studied characters in the two seasons. Theses results were agreed with those of Rasaei *et al.* (2012);

Sajid *et al.* (2012) and Yucel (2013) on pea and Bakry *et al*. (2011) on faba bean, they reported that plant height was increased by increasing plant population. Moreover, Shaukat *et al*. (2012) on pea indicated that row spacing 30 cm gave maximum plant height (93.8 cm), while 50 cm and 60 cm row spacing gave minimum plant height (84.6 and 83.3 cm) and more number of branches plant^{-1} (2.76 and 2.62), compare to 30 cm (1.16), respectively. The increase in number of branches per plant in lower population density may be due to more space availability to plants to spread rather to grow straight. This was the main reason that the plant height in lower population density was less and hence produces more branches, on the other hand, plant height was more in the higher plant population and gave less number of branches per plant and that due to the competition among plants for soil moisture, nutrient, light and carbon dioxide.

Effect of foliar applications:

Data presented in Table (2) showed that all foliar applications significantly increased all studied characters, i.e., plant height, number of branches and leaves/plant, leaf area cm^2/plant and fresh and dry weight/plant compared with the control. The best application in all studied characters was moringa leaf extract followed by chitosan except, the fresh weight in the second season, in which the silicon application followed moringa leaf extract. These results are in harmony with those reported by Culver *et al.* (2012); Yasmeen *et al*. (2012) and Muhamman *et al*. (2013) on tomato all for moringa extract; El Nagar *et al*. (2012) on pea; El-Tanahy *et al*. (2012) on cowpea; Mondal *et al*. (2012) on okra; Mondal *et al*. (2013) on mungbean all for chitosan and Mali and Aery (2009) on cowpea; Abou-Baker *et al.* (2011) on bean and Pilon *et al*. (2013) on potato all for silicon.

The favorable effect of moringa leaf extract on vegetative growth might be due to its role as a plant growth stimulator. It contains zeatin, a cytokinin that plays a role in delaying leaf senescence, in addition to other growth-enhancing-compounds such as ascorbate, phenolics and minerals (Yasmeen *et al*., 2012). Also, Hussain *et al*. (2013) reported that moringa extracts accelerate the growth of plants, strengthen plants and improve resistance against pests and diseases.

Moreover, the effect of chitosan on growth might due to its role in increasing key enzymes activities of nitrogen metabolism (nitrate reductase, glutamine synthetase and protease) and improved the transportation of nitrogen in the functional leaves which enhanced plant growth and development (Qiang *et al*., 2007 and Mondal *et al*., 2012). Also, Chibu and Shibayama (2001) indicated that the positive effect of chitosan may resulted from the greater availability of amino compounds released from chitosan.

Meanwhile, the effect of silicon on plant growth may refer to that Si enhance the growth, improve protection against pathogens (Greger *et al*., 2011) and maintain of photosynthetic activity and that one of the reasons for the increased dry matter production (Agurie *et al*., 1992). In this respect Pilon *et al.* (2013) found that silicon application increased leaf area, specific leaf area, pigment concentration (chlorophyll a and carotenoids) and photosynthesis of potato.

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Effect of interactions:

Data in Tables (3 and 4) indicated that the effect of all interactions were insignificant in plant height in the two seasons except (cultivars × foliar applications) in the second season, number of branches, number of leaves except (cultivars × foliar applications) in the two seasons. Whereas, the effect of interactions was significant in leaf area in the two seasons, fresh weight except (cultivars × density), (density × foliar applications) and (cultivars × density × foliar applications) in the second season and dry weight except (density × foliar applications) and (cultivars × density × foliar applications) in the two seasons.

Table (3): Effect of the dual interaction between cultivar and density, cultivar and foliar applications and density and foliar applications on vegetative growth parameters of sugar pea in the two seasons of 2012/2013 and 2013/2014.

Treatments		Plant height (cm)		No of branches/ plant		No of leaves/ plant		Leaf area/plant (cm^2)		Fresh weight/plant (gm)		Dry weight/ plant (gm)	
		S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
Cvs X Density													
Compados	20 cm	62.75	77.66	4.33	3.50	42.41	36.25	3407.85	3042.64	214.24	177.49	28.48	25.71
	40 cm	56.33	75.33	5.16	3.83	45.75	38.33	3896.43	3789.35	220.04	182.79	31.07	30.56
	60 cm	55.50	74.00	5.16	4.00	49.33	41.75	4258.53	3905.95	227.57	187.76	36.33	32.69
Sugar Snap	20 cm	54.00	55.08	3.66	2.83	34.75	32.00	1830.74	1743.69	137.78	108.76	21.30	20.46
	40 cm	52.50	54.16	4.00	3.16	38.00	33.58	2102.32	2051.54	161.45	114.09	23.17	22.40
	60 cm	50.08	52.83	4.25	3.33	42.00	34.58	2569.02	2367.02	166.70	117.47	25.30	24.37
Snow Wind	20 cm	57.08	64.66	3.83	2.83	37.66	33.83	2484.95	1848.83	159.54	128.51	21.20	21.49
	40 cm	54.00	60.58	4.08	3.25	38.66	34.83	2843.94	2459.64	161.58	131.85	23.72	23.76
	60 cm	51.08	58.50	5.16	3.75	40.16	36.16	2137.83	2553.59	165.46	133.76	26.34	24.70
L.S.D at 5 %		NS	NS	NS	NS	NS	NS	25.679	41.018	4.989	NS	1.782	1.666
Cvs X Foliar applications													
Compados	MLE	62.55	81.33	5.55	4.66	54.22	43.44	4480.11	4067.51	236.36	187.21	36.59	33.63
	Chitosan	60.44	76.55	4.88	3.66	45.22	38.88	3959.50	3753.76	223.84	181.08	34.33	30.27
	Silicon	57.88	73.88	4.77	3.55	45.55	36.88	3815.72	3589.52	224.57	186.71	31.71	29.90
	Control	51.88	70.88	4.33	3.22	38.33	35.88	3160.75	2906.46	197.53	175.72	25.22	24.81
Sugar Snap	MLE	55.44	55.88	4.22	3.66	43.22	35.11	2318.67	2186.78	168.85	120.95	27.15	25.38
	Chitosan	53.00	54.44	4.00	3.22	38.44	34.22	2299.37	2131.37	162.38	118.62	23.30	23.81
	Silicon	51.88	53.33	4.11	2.88	37.88	33.11	2227.36	2118.25	160.43	116.61	22.36	20.93
	Control	48.44	52.44	3.55	2.66	33.44	31.11	1824.06	1779.94	129.59	97.59	20.21	19.51
Snow Wind	MLE	57.44	63.66	5.00	3.77	42.22	38.11	2763.22	2561.74	184.99	134.18	25.98	24.98
	Chitosan	54.77	60.22	4.66	3.33	40.33	36.44	2684.53	2438.25	167.89	132.96	24.69	24.10
	Silicon	54.33	61.00	4.00	3.11	38.22	34.77	2635.64	2331.37	164.80	132.69	23.03	23.86
	Control	49.66	60.11	3.77	2.88	34.55	30.44	1872.24	1818.05	131.09	125.65	21.32	20.34
L.S.D at 5 %		NS	2.493	NS	NS	2.642	1.881	30.447	26.539	4.979	3.234	1.576	1.453
Density X Foliar applications													
20 cm	MLE	63.33	70.00	4.55	3.66	43.77	36.33	3132.55	2492.86	189.49	144.41	27.42	25.09
	Chitosan	59.11	64.88	4.00	3.11	37.66	35.33	2608.93	2254.28	170.71	139.68	24.75	23.22
	Silicon	57.44	65.33	3.88	2.88	39.11	33.44	2574.66	2216.36	176.53	142.43	22.15	21.88
	Control	51.88	63.00	3.33	2.55	32.55	31.00	1981.93	1883.39	145.36	126.49	20.34	20.03
40 cm	MLE	57.22	66.00	4.88	4.00	45.66	39.00	3268.28	3074.78	198.50	147.08	29.45	28.30
	Chitosan	55.66	64.00	4.44	3.44	41.77	36.00	3210.23	2922.97	187.02	144.19	26.91	26.70
	Silicon	54.33	61.77	4.22	3.22	40.33	34.77	3030.83	2810.23	183.87	145.22	25.48	25.78
	Control	49.88	61.66	4.11	3.00	35.44	32.55	2280.92	2259.38	154.70	135.15	22.10	21.52
60 cm	MLE	54.88	64.88	5.33	4.44	50.22	41.33	3161.93	3248.40	202.37	150.85	32.65	30.60
	Chitosan	53.44	62.33	5.11	3.66	44.55	38.22	3124.50	3146.12	196.37	148.80	30.87	28.26
	Silicon	52.33	61.11	4.77	3.44	42.22	36.55	3073.23	3012.55	189.41	148.35	29.47	27.02
	Control	48.22	58.77	4.22	3.22	38.33	33.88	2594.18	2361.68	158.16	137.32	24.31	23.11
L.S.D at 5 %		NS	NS	NS	NS	NS	NS	30.447	26.539	4.979	NS	NS	NS

S1: 2012/2013 season, S2: 2013/2014 season, MLE: moringa leaf extract and NS: not significant at 0.05 level of significance.

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In general, the best interaction was in plant height was (Compados × 20 cm × moringa leaf extract) in the two seasons respectively. While, the lowest one was (Sugar Snap × 60 cm × control) in the two seasons. Concerning the number of branches and leaves, leaf area and fresh and dry weight, (Compados × 60 cm × moringa leaf extract) was the best interaction and the lowest one was (Sugar Snap × 20 cm × control). That is true in the two seasons. Similar results were obtained by Bakry *et al.* (2011) on faba bean, they found that the interaction between varieties and plant density had significant effect in plant height and number of branches/plant in both seasons.

Yield and its components:

Effect of cultivars:

Data in Table (5) showed that Compados cultivar was the highest one in number of pods/plant (55.52 and 51.17), heaviest in pod yield/plant (173.25 and 169.60 gm) and total pod yield/fed. (4.173 and 4.095 ton) at the two seasons, respectively. On the other hand, Sugar Snap cultivar was the heaviest in average pod weight (4.40 and 4.88 gm), while the lowest one was Snow Wind (3.03 and 3.20 gm) in the both seasons, respectively. These results are harmony with those reported by El-Desuki (2006) and Tewfik (2014) on sugar pea; Bozoglu *et al*. (2007) and Singh and Singh (2011) on pea.

Table (5): Effect of cultivars, plant density and foliar applications on yield parameters of sugar pea in the two seasons of 2012/2013 and 2013/2014.

Treatments		No of pod/plant		Average Pod weight (gm)		Pod yield/plant (gm)		Total pod yield (ton/fed.)	
		S1	S2	S1	S2	S1	S2	S1	S2
Cvs.	Compados	55.52	51.17	3.11	3.31	173.25	169.60	4.173	4.095
	Sugar Snap	35.00	30.91	4.40	4.88	154.33	151.30	3.658	3.597
	Snow Wind	53.17	49.00	3.03	3.20	161.69	157.00	3.870	3.753
L.S.D at 5 %		0.381	0.585	0.064	0.022	2.567	1.864	0.056	0.036
Density	20 cm	46.97	42.63	3.36	3.67	153.37	150.72	6.135	6.028
	40 cm	47.83	43.98	3.53	3.74	163.74	158.46	3.274	3.169
	60 cm	48.88	44.47	3.64	3.98	172.15	168.72	2.293	2.247
L.S.D at 5 %		0.420	0.368	0.047	0.025	1.920	0.922	0.057	0.020
Foliar	MLE	49.84	45.59	3.58	3.87	173.05	169.51	4.132	4.049
	Chitosan	48.50	44.34	3.55	3.82	166.61	162.55	3.979	3.885
	Silicon	47.98	44.01	3.53	3.80	163.76	160.40	3.917	3.841
	Control	45.35	40.83	3.40	3.68	148.92	144.74	3.575	3.483
L.S.D at 5 %		0.478	0.372	0.033	0.029	1.644	1.265	0.042	0.036

S1: 2012/2013 season, S2: 2013/2014 season and MLE: moringa leaf extract.

Effect of plant density:

Data presented in Table (5) showed the effect of plant density on yield and its components. It is clear that all plant densities significantly affected all studied characters. The plant density (60 cm apart) was the best in number of pods/plant, average pod weight, pod yield/plant, followed by 40 cm and 20 cm in the two seasons, respectively. Though, 20 cm apart gave the highest pod yield/fed. Results show that average pod weight, number of pods/plant and pod yield /plant were gradually reduced by increasing plant population density. Similar results were obtained by Munakamwe *et al*. (2012); Rasaei *et al*. (2012); Sajid *et al*. (2012); Shaukat *et al.* (2012) on pea and El Naim *et* *al*. (2011) on cowpea. Moreover, Azpilicueta *et al*. (2012) on sugar snap pea found that the effect of plant density on the number of pods m^{-2} was significant in the first season but was less clear in the second. The increase in the number of pods per plant in lower population density may be due to vigorous plants as in lower population density; plant grew vigorously and produced more branches which resulted in high number of pods $plant^{-1}$. On the other hand, higher plant population, the plant growth was decreased which resulted in less number of pods $plant^{-1}$ (Sajid *et al*., 2012). The total pods yield/fed. was increased in higher plant population compare to lower population density and that may be attributed to the highest number of plants per unit area.

Effect of foliar applications:

Data in Table (5) indicated that all foliar applications, i.e., moringa leaf extract, chitosan and silicon significantly affected on all studied parameters, i.e., number of pods/plant, average pod weight, pod yield/plant and total pod yield/fed. compared with the control in the two seasons. The highest number of pods/plant (49.84 and 45.59) and heaviest average pod weight (3.58 and 3.87 gm), pod yield/plant (173.05 and 169.51 gm) and total pod yield/fed (4.132 and 4.049 ton) were obtained when sugar pea plants treated with moringa leaf extract followed by chitosan and silicon foliar applications in both seasons, respectively. These results are in accordance with those obtained by Culver *et al.* (2012) they found that moringa leaf extract increased the yield of tomato by 20 – 150 %. Also, Hussain *et al*. (2013) reported that moringa leaf extract application enhanced the productivity of several arable crops such as soybean, sugarcane, corn, sorghum, black bean, coffee, bell pepper and onion ranging from 6.57 to 47.88 %. The effect of moringa leaf extract on yield might be connected with the role of plant growth regulators in improving crop growth and hence yield (Muhamman *et al*., 2013).

The effect of chitosan on yield may be due to its effects in stimulating physiological processes, improving vegetative growth, followed by active translocation of photoassimilates from source to sink tissues. The increases in plant biomass may be due to improving photosynthetic machinery (Khan *et al*., 2002).

Moreover, effects of silicon on yield are related to the deposition of the element under the leaf epidermis which results a physical mechanism of defense, reduces lodging, increases photosynthesis capacity and decreases transpiration losses (Korndörfer *et al*., 2004). Also, Matichenkov and Bocharnikova (2004) reported that numerous experiments were conducted with silicon in cucumber over a nine-year period and there was 6 to 16 % increase in production with regard to the number of fruits and a 11 to 33 % increase in relation to total production. Similar results were obtained by Toresano-Sanchez *et al.* (2012) on tomato.

Effect of interactions:

It is clearly in Tables (6 and 7) that all interactions insignificantly affected number of pods/plant except (cultivars × density) in the second season and (cultivars × foliar applications) in both seasons. Whereas, the effect was significantly in average pod weight, except (cultivars × foliar applications), (density × foliar applications) and (cultivars × density × foliar applications) in the first season, pod yield/plant except (cultivars × foliar applications) in the first season. Belong on, total pod yield/fed. responded significantly to all combinations, in both seasons. Generally, the best interaction in number of pods and total pod yield/plant was (Compados × 60 cm × moringa leaf extract), whereas the lowest was (Sugar Snap × 20 cm × control) in both seasons. As for average pod weight the best one was (Sugar Snap × 60 cm × moringa leaf extract) and the lowest was (Snow Wind × 20 cm × control). The superior interaction in total pod yield/fed. was (Compados × 20 cm × moringa leaf extract) and the less one was (Sugar Snap × 60 cm × control) in both seasons. These results are in accordance with those obtained by Turk *et al*. (2011); Munakamwe *et al*. (2012) and Yucel (2013) on pea; Bakry *et al.* (2011) on faba bean and El Naim *et al*. (2011) on cowpea.

Table (6): Effect of the dual interaction between cultivar and density, cultivar and foliar applications and density and foliar applications on yield parameters of sugar pea in the two seasons of 2012/2013 and 2013/2014.

Treatments		No of pod/plant		Average Pod weight (gm)		Pod yield/plant (gm)		Total pod yield (ton/fed.)	
		S1	S2	S1	S2	S1	S2	S1	S2
Cvs X Density									
Compados	20 cm	54.64	50.56	3.04	3.24	166.33	164.00	6.653	6.560
	40 cm	55.15	51.16	3.14	3.31	173.66	169.56	3.473	3.391
	60 cm	56.77	51.77	3.16	3.38	179.75	175.25	2.394	2.334
Sugar Snap	20 cm	34.15	30.38	4.15	4.63	141.91	140.91	5.676	5.636
	40 cm	34.77	31.07	4.39	4.74	153.07	147.58	3.061	2.961
	60 cm	36.07	31.29	4.65	5.27	168.00	165.41	2.237	2.203
Snow Wind	20 cm	52.11	46.95	2.91	3.13	151.88	147.25	6.075	5.890
	40 cm	53.58	49.70	3.06	3.18	164.48	158.25	3.289	3.165
	60 cm	53.81	50.34	3.13	3.28	168.70	165.50	2.247	2.204
L.S.D at 5 %		NS	0.638	0.081	0.044	3.326	1.597	0.099	0.035
Cvs X Foliar applications									
Compados	MLE	57.72	53.46	3.17	3.35	183.55	179.55	4.424	4.338
	Chitosan	56.69	52.62	3.13	3.31	177.66	174.55	4.287	4.214
	Silicon	55.77	52.22	3.13	3.31	175.11	172.86	4.224	4.177
	Control	51.89	46.37	3.01	3.26	156.66	151.44	3.758	3.650
Sugar Snap	MLE	36.46	32.28	4.48	4.99	163.77	161.44	3.856	3.808
	Chitosan	35.38	31.11	4.43	4.93	157.02	153.55	3.713	3.639
	Silicon	34.97	30.81	4.41	4.90	154.63	151.11	3.665	3.597
	Control	33.19	29.46	4.27	4.72	141.88	139.11	3.399	3.343
Snow Wind	MLE	55.34	51.02	3.10	3.28	171.84	167.55	4.115	4.002
	Chitosan	53.42	49.29	3.09	3.23	165.14	159.55	3.936	3.802
	Silicon	53.19	49.01	3.03	3.20	161.55	157.22	3.862	3.751
	Control	50.72	46.67	2.92	3.07	148.22	143.66	3.567	3.457
L.S.D at 5 %		0.826	0.644	NS	0.050	NS	2.192	0.073	0.062
Density X Foliar applications									
20 cm	MLE	48.60	44.27	3.44	3.74	162.11	159.44	6.484	6.377
	Chitosan	47.52	43.06	3.38	3.68	155.84	152.66	6.233	6.106
	Silicon	47.10	42.99	3.37	3.67	154.11	151.88	6.164	6.075
	Control	44.65	40.20	3.27	3.57	141.44	138.88	5.657	5.555
40 cm	MLE	49.51	45.95	3.61	3.80	173.00	167.88	3.460	3.357
	Chitosan	48.42	44.82	3.58	3.78	168.00	162.88	3.360	3.257
	Silicon	48.11	44.23	3.53	3.74	164.18	159.20	3.283	3.184
	Control	45.30	40.91	3.41	3.66	149.77	143.88	2.995	2.877
60 cm	MLE	51.41	46.53	3.70	4.09	184.06	181.22	2.451	2.413
	Chitosan	49.55	45.14	3.68	4.01	175.98	172.11	2.344	2.292
	Silicon	48.73	44.81	3.68	3.99	173.00	170.11	2.304	2.265
	Control	45.85	41.38	3.51	3.82	155.55	151.44	2.072	2.017
L.S.D at 5 %		NS	NS	NS	0.050	2.848	2.192	0.073	0.062

S1: 2012/2013 season, S2: 2013/2014 season, MLE: moringa leaf extract and NS: not significant at 0.05 level of significance.

Table (7): Effect of the triple interaction among cultivars, plant density and foliar applications on yield parameters of sugar pea in the two seasons of 2012/2013 and 2013/2014.

Treatments			No of pod/plant		Average Pod weight (gm)		Pod yield/plant (gm)		Total pod yield (ton/fed.)	
			S1	S2	S1	S2	S1	S2	S1	S2
Compados	20 cm	MLE	56.38	52.56	3.13	3.31	176.66	174.00	7.066	6.960
		Chitosan	55.87	52.11	3.06	3.23	171.33	168.66	6.853	6.746
		Silicon	55.10	51.85	3.06	3.23	169.00	167.66	6.760	6.706
		Control	51.19	45.73	2.90	3.18	148.33	145.66	5.933	5.826
	40 cm	MLE	57.20	53.53	3.20	3.35	183.33	179.33	3.666	3.586
		Chitosan	56.31	52.50	3.16	3.33	178.33	175.00	3.566	3.500
		Silicon	55.45	52.20	3.15	3.30	174.66	172.26	3.493	3.445
		Control	51.63	46.43	3.06	3.26	158.33	151.66	3.166	3.033
	60 cm	MLE	59.58	54.29	3.20	3.41	190.66	185.33	2.539	2.468
		Chitosan	57.89	53.25	3.16	3.38	183.33	180.00	2.442	2.397
		Silicon	56.77	52.60	3.20	3.39	181.66	178.66	2.419	2.379
		Control	52.85	46.96	3.09	3.34	163.33	157.00	2.175	2.091
Sugar Snap	20 cm	MLE	35.04	31.30	4.23	4.71	148.33	147.66	5.933	5.906
		Chitosan	34.55	30.44	4.14	4.65	143.33	141.66	5.733	5.666
		Silicon	34.27	30.35	4.13	4.65	141.66	141.33	5.666	5.653
		Control	32.76	29.44	4.10	4.51	134.33	133.00	5.373	5.320
	40 cm	MLE	35.60	32.28	4.48	4.80	159.66	155.00	3.193	3.100
		Chitosan	35.19	31.54	4.43	4.76	156.06	150.33	3.121	3.006
		Silicon	35.07	31.01	4.42	4.74	155.23	147.00	3.104	2.940
		Control	33.23	29.46	4.25	4.68	141.33	138.00	2.826	2.760
	60 cm	MLE	38.73	33.25	4.73	5.46	183.33	181.66	2.442	2.419
		Chitosan	36.40	31.36	4.71	5.37	171.66	168.66	2.286	2.246
		Silicon	35.56	31.07	4.69	5.31	167.00	165.00	2.224	2.197
		Control	33.58	29.46	4.46	4.96	150.00	146.33	1.998	1.949
Snow Wind	20 cm	MLE	54.38	48.95	2.96	3.20	161.33	156.66	6.453	6.266
		Chitosan	52.14	46.63	2.93	3.16	152.86	147.66	6.114	5.906
		Silicon	51.92	46.78	2.92	3.13	151.66	146.66	6.066	5.866
		Control	50.02	45.44	2.83	3.03	141.66	138.00	5.666	5.520
	40 cm	MLE	55.73	52.05	3.15	3.25	176.00	169.33	3.520	3.386
		Chitosan	53.75	50.43	3.15	3.24	169.60	163.33	3.392	3.266
		Silicon	53.80	49.49	3.02	3.20	162.66	158.33	3.253	3.166
		Control	51.03	46.83	2.93	3.03	149.66	142.00	2.993	2.840
	60 cm	MLE	55.92	52.06	3.18	3.39	178.20	176.66	2.373	2.353
		Chitosan	54.36	50.80	3.18	3.30	172.96	167.66	2.303	2.233
		Silicon	53.87	50.76	3.16	3.28	170.33	166.66	2.268	2.220
		Control	51.11	47.74	3.00	3.16	153.33	151.00	2.042	2.011
LSDat 5 %			NS	NS	NS	0.087	4.934	3.797	0.126	0.108

S1: 2012/2013 season, S2: 2013/2014 season, MLE: moringa leaf extract and NS: not significant at 0.05 level of significance.

Pod quality:

Effect of cultivars:

Data in Tables (8 and 11) show the effect of cultivars, plant density and foliar applications on pod quality of sugar peas. It is clear in table (8) that Compados cultivar was the superior in pod length in both seasons, whereas Snow Wind cultivar was the superior in pod diameter and Sugar Snap cultivar was the superior in pod thickness in both seasons. In table (11) it could observed that Sugar Snap cultivar was the superior in total soluble solids (TSS) and carbohydrates (%) and the lowest in titrable acidity (%) in both seasons. While, Snow Wind was the superior in vitamin C (mg/100g fw) in both seasons. Similar results were obtained by El-Desuki (2006) and Tewfik (2014).

Table (8): Effect of cultivars, plant density and foliar applications on pod parameters of sugar pea in the two seasons of 2012/2013 and 2013/2014.

Treatments		Pod length (cm)		Pod diameter (mm)		Pod thickness (mm)	
		S1	S2	S1	S2	S1	S2
Cvs.	Compados	9.09	9.64	17.56	18.26	3.23	3.58
	Sugar Snap	8.11	8.35	15.11	15.43	8.47	10.50
	Snow Wind	8.75	8.70	18.17	18.90	3.05	3.32
L.S.D at 5 %		0.131	0.121	0.274	0.173	0.288	0.251
Density	20 cm	8.41	8.73	16.45	17.27	4.64	5.55
	40 cm	8.64	8.86	17.04	17.52	4.95	5.78
	60 cm	8.91	9.10	17.35	17.80	5.17	6.07
L.S.D at 5 %		0.176	0.138	0.181	0.193	0.240	0.167
Foliar	MLE	9.00	9.15	17.10	17.87	5.12	6.05
	Chitosan	8.72	8.97	17.30	17.57	5.02	5.98
	Silicon	8.64	8.91	16.93	17.65	5.00	5.95
	Control	8.26	8.56	16.45	17.03	4.53	5.23
L.S.D at 5 %		0.180	0.146	0.219	0.244	0.192	0.175

S1: 2012/2013 season, S2: 2013/2014 season and MLE: moringa leaf extract.

Effect of plant density:

Data in Tables (8 and 11) indicated that all tested densities were affected pod length, pod diameter, pod thickness, total soluble solids (TSS), vitamin C, titrable acidity (%) and carbohydrates (%) in both seasons. The superior density was 60 cm among plants, while the lowest was 20 cm among plants in both seasons. Similar results were obtained by Shaukat *et al*. (2012) on pea, they reported that maximum pod length was recorded in (50 cm) row spacing while minimum pod length was measured in (30 cm) row spacing.

Effect of foliar applications:

Also, Tables (8 and 11) showed that all foliar applications, i.e., moringa leaf extract, chitosan and silicon significantly affected pod length, pod diameter, pod thickness, total soluble solids (TSS), vitamin C, titrable acidity (%) and carbohydrates (%) in both seasons. The best application in all studied parameters was obtained when sugar pea plants sprayed with moringa leaf extract followed by chitosan and silicon, respectively except pod diameter in the first season whereas chitosan was the best one. Concerning vitamin C, foliar spray with moringa leaf extract was the superior in the first season while silicon was the superior in the second season followed by moringa leaf extract and chitosan, respectively. The lowest application in all studied parameters was control except titrable acidity where it was higher compare with other applications.

Table(9): Effect of the dual interaction between cultivar and density, cultivar and foliar applications and density and foliar

applications on pod parameters of sugar pea in the two seasons of 2012/2013 and 2013/2014.

Treatments		Pod length (cm)		Pod diameter (mm)		Pod thickness (mm)	
		S1	S2	S1	S2	S1	S2
Cvs X Density							
Compados	20 cm	8.86	9.43	17.35	17.85	3.13	3.33
	40 cm	9.08	9.60	17.55	18.18	3.29	3.58
	60 cm	9.34	9.89	17.78	18.74	3.26	3.83
Sugar Snap	20 cm	7.81	8.24	14.59	15.36	7.90	10.28
	40 cm	8.04	8.28	15.27	15.39	8.48	10.45
	60 cm	8.49	8.53	15.47	15.55	9.04	10.79
Snow Wind	20 cm	8.57	8.52	17.41	18.60	2.89	3.05
	40 cm	8.79	8.71	18.29	19.00	3.07	3.32
	60 cm	8.91	8.89	18.80	19.11	3.21	3.60
L.S.D at 5 %		NS	NS	0.313	NS	0.416	NS
Cvs X Foliar applications							
Compados	MLE	9.39	9.95	17.71	18.75	3.36	3.75
	Chitosan	9.23	9.69	17.80	18.33	3.25	3.77
	Silicon	9.18	9.61	17.59	18.34	3.25	3.69
	Control	8.58	9.31	17.13	17.62	3.05	3.12
Sugar Snap	MLE	8.34	8.60	15.45	15.77	8.80	10.84
	Chitosan	8.19	8.51	15.42	15.40	8.66	10.83
	Silicon	8.07	8.31	15.04	15.51	8.67	10.63
	Control	7.86	7.98	14.53	15.05	7.76	9.72
Snow Wind	MLE	9.26	8.90	18.15	19.10	3.19	3.55
	Chitosan	8.74	8.72	18.67	18.99	3.14	3.35
	Silicon	8.68	8.82	18.15	19.12	3.09	3.54
	Control	8.33	8.39	17.69	18.41	2.79	2.86
L.S.D at 5 %		NS	NS	NS	NS	0.333	NS
Density X Foliar applications							
20 cm	MLE	8.74	8.89	16.58	17.63	4.81	5.88
	Chitosan	8.41	8.82	16.84	17.44	4.72	5.82
	Silicon	8.43	8.75	16.39	17.37	4.63	5.74
	Control	8.07	8.46	15.99	16.65	4.40	4.77
40 cm	MLE	8.95	9.08	17.25	17.78	5.12	6.00
	Chitosan	8.67	8.92	17.39	17.50	5.13	5.92
	Silicon	8.64	8.93	17.03	17.65	5.07	5.89
	Control	8.28	8.53	16.48	17.16	4.47	5.33
60 cm	MLE	9.30	9.48	17.48	18.22	5.43	6.25
	Chitosan	9.08	9.18	17.67	17.79	5.20	6.21
	Silicon	8.86	9.05	17.37	17.94	5.30	6.23
	Control	8.42	8.69	16.88	17.27	4.73	5.60
L.S.D at 5 %		NS	NS	NS	NS	NS	NS

S1: 2012/2013 season, S2: 2013/2014 season, MLE: moringa leaf extract and NS: not significant at 0.05 level of significance.

These results were agreed with those obtained by Farouk and Ramadan (2012) on cowpea; El-Miniawy *et al*. (2013) on strawberry and Abu-Muriefah (2013) on common bean for chitosan and Toresano- Sanchez *et al*. (2010) on watermelon for silicon. In this respect Ghoname *et al*. (2010) on pepper found that chitosan application improved pepper quality and increased TSS and vitamin C contents. Moreover, Jia *et al*. (2011) reported that silicon fertilizer could enhance hardness and pressure-resistance of tomato and increase vitamin C of strawberry and eggplant. The possible mechanisms of silicon-improvement of crop quality were summarized in the following aspects: silicon provision, improvement of micro-nutrient supply, coordination of nutrition supply and enhancement of resistance to stressful conditions.

Table(10): Effect of the triple interaction among cultivars, plant density and foliar applications on pod parameters of sugar pea cultivars in the two seasons of 2012/2013 and 2013/2014.

Treatments			Pod length (cm)		Pod diameter (mm)		Pod thickness (mm)	
			S1	S2	S1	S2	S1	S2
Compados	20 cm	MLE	9.20	9.49	17.57	18.29	3.21	3.58
		Chitosan	8.77	9.52	17.50	18.10	3.20	3.63
		Silicon	9.05	9.45	17.32	17.74	3.16	3.46
		Control	8.41	9.26	17.00	17.28	2.94	2.66
	40 cm	MLE	9.27	9.81	17.76	17.48	3.41	3.68
		Chitosan	9.24	9.73	17.88	18.13	3.33	3.66
		Silicon	9.20	9.62	17.61	18.43	3.45	3.65
		Control	8.61	9.27	16.96	17.67	2.99	3.35
	60 cm	MLE	9.70	10.56	17.81	19.47	3.46	4.00
		Chitosan	9.66	9.82	18.01	18.75	3.22	4.02
		Silicon	9.28	9.76	17.85	18.85	3.13	3.96
		Control	8.73	9.41	17.44	17.91	3.23	3.36
Sugar Snap	20 cm	MLE	7.94	8.51	14.75	15.71	8.20	10.67
		Chitosan	7.83	8.38	14.78	15.30	8.03	10.64
		Silicon	7.83	8.22	14.58	15.41	7.77	10.39
		Control	7.64	7.84	14.23	15.02	7.59	9.43
	40 cm	MLE	8.27	8.56	15.61	15.75	8.78	10.83
		Chitosan	8.04	8.42	15.72	15.35	8.71	10.91
		Silicon	7.96	8.25	15.15	15.40	8.82	10.51
		Control	7.90	7.90	14.61	15.05	7.62	9.53
	60 cm	MLE	8.81	8.74	15.97	15.85	9.43	11.02
		Chitosan	8.72	8.73	15.77	15.56	9.24	10.93
		Silicon	8.41	8.45	15.39	15.71	9.41	10.99
		Control	8.04	8.20	14.74	15.10	8.08	10.20
Snow Wind	20 cm	MLE	9.07	8.67	17.42	18.88	3.01	3.40
		Chitosan	8.63	8.56	18.23	18.91	2.91	3.18
		Silicon	8.41	8.57	17.26	18.97	2.97	3.38
		Control	8.16	8.27	16.75	17.66	2.67	2.24
	40 cm	MLE	9.32	8.88	18.37	19.10	3.17	3.50
		Chitosan	8.73	8.61	18.58	19.01	3.37	3.19
		Silicon	8.76	8.93	18.32	19.11	2.93	3.50
		Control	8.33	8.42	17.87	18.77	2.80	3.10
	60 cm	MLE	9.38	9.14	18.67	19.33	3.40	3.74
		Chitosan	8.86	8.99	19.22	19.05	3.16	3.69
		Silicon	8.88	8.94	18.86	19.27	3.36	3.75
		Control	8.51	8.48	18.45	18.80	2.90	3.24
LSD at 5 %			NS	NS	NS	NS	NS	NS

S1: 2012/2013 season, S2: 2013/2014 season, MLE: moringa leaf extract and NS: not significant at 0.05 level of significance.

Table (11): Effect of cultivars, plant density and foliar applications on pod quality parameters of sugar pea in the two seasons of 2012/2013 and 2013/2014.

Treatments		TSS		Vitamin C (mg/100gfw)		Acidity (%)		Carbohydrates (%)	
		S1	S2	S1	S2	S1	S2	S1	S2
Cvs.	Compados	7.88	10.01	68.57	75.23	0.434	0.413	44.23	45.65
	Sugar Snap	8.72	10.02	74.83	79.03	0.349	0.361	57.33	58.61
	Snow Wind	7.79	9.28	78.90	96.30	0.388	0.405	46.34	49.12
L.S.D at 5 %		0.239	0.274	2.194	1.047	0.010	0.020	0.348	0.223
Density	20 cm	7.65	9.25	72.57	87.35	0.417	0.416	46.05	47.73
	40 cm	8.20	9.86	74.40	82.66	0.382	0.390	49.87	51.54
	60 cm	8.54	10.21	75.32	89.37	0.371	0.373	51.98	54.12
L.S.D at 5 %		0.152	0.157	1.204	2.069	0.008	0.011	0.345	0.141
Foliar	MLE	8.42	10.05	77.33	86.84	0.378	0.383	52.53	54.43
	Chitosan	8.24	9.85	76.28	85.37	0.386	0.389	50.26	51.75
	Silicon	8.17	9.80	75.91	87.26	0.381	0.388	49.39	50.97
	Control	7.70	9.39	66.86	74.60	0.416	0.412	45.02	47.35
L.S.D at 5 %		0.158	0.152	1.658	1.442	0.008	0.012	0.400	0.178

S1: 2012/2013 season, S2: 2013/2014 season and MLE: moringa leaf extract.

Effect of interactions:

The effect of interactions on pod length, pod diameter, pod thickness, vitamin C, titrable acidity (%) and carbohydrates (%) was presented in Tables (9, 10, 12 and 13). The effect of interactions was insignificant on pod length, pod diameter except (cultivars × density) in the first season and pod thickness except (cultivars × density) and (cultivars × foliar applications) in the first season. Concerning, total soluble solids (TSS), vitamin C, titrable acidity (%) and carbohydrates (%), Tables (12 and 13) indicated that the effect of interactions was insignificant on total soluble solids (TSS) except (cultivars × density) in the second season and (cultivars × foliar applications) in the first season,

Table (12): Effect of the dual interaction between cultivar and density, cultivar and foliar applications and density and foliar applications on pod quality parameters of sugar pea in the two seasons of 2012/2013 and 2013/2014.

Treatments		TSS		Vitamin C (mg/100gfw)		Acidity (%)		Carbohydrates (%)	
		S1	S2	S1	S2	S1	S2	S1	S2
Cvs X Density									
Compados	20 cm	7.36	9.49	66.70	72.09	0.455	0.437	42.93	44.39
	40 cm	8.03	10.12	68.81	74.35	0.429	0.415	44.38	45.58
	60 cm	8.24	10.43	70.20	79.25	0.419	0.386	45.38	46.99
Sugar Snap	20 cm	8.27	9.31	73.71	77.05	0.376	0.392	51.28	51.60
	40 cm	8.61	10.25	74.69	78.16	0.339	0.349	58.32	59.53
	60 cm	9.29	10.50	76.09	81.88	0.331	0.344	62.40	64.70
Snow Wind	20 cm	7.31	8.94	77.30	92.50	0.420	0.420	43.95	47.20
	40 cm	7.97	9.20	79.71	95.49	0.380	0.407	46.91	49.50
	60 cm	8.10	9.70	79.68	100.91	0.365	0.390	48.16	50.67
L.S.D at 5 %		NS	0.272	NS	NS	NS	NS	0.598	0.245
Cvs X Foliar applications									
Compados	MLE	8.07	10.43	71.38	78.78	0.430	0.404	47.80	53.77
	Chitosan	7.91	10.05	70.57	76.42	0.431	0.409	44.39	48.48
	Silicon	7.94	9.96	70.32	78.73	0.428	0.409	44.28	47.46
	Control	7.58	9.61	62.00	67.00	0.448	0.429	40.45	43.44
Sugar Snap	MLE	9.18	10.27	77.85	81.25	0.340	0.353	60.22	74.66
	Chitosan	8.97	10.08	76.56	80.81	0.347	0.355	59.09	71.81
	Silicon	8.76	10.10	77.24	81.79	0.341	0.356	58.07	69.82
	Control	7.97	9.63	67.66	72.27	0.368	0.383	51.96	64.03
Snow Wind	MLE	8.00	9.45	82.77	100.50	0.366	0.394	49.58	58.74
	Chitosan	7.83	9.41	80.60	98.88	0.382	0.404	47.28	51.61
	Silicon	7.81	9.33	81.28	101.27	0.373	0.400	45.84	49.64
	Control	7.54	8.94	70.93	84.54	0.431	0.424	42.66	49.25
L.S.D at 5 %		0.273	NS	NS	2.498	0.014	NS	0.693	0.309
Density X Foliar applications									
20 cm	MLE	7.94	9.47	75.22	83.55	0.410	0.407	48.22	49.64
	Chitosan	7.72	9.28	73.37	81.37	0.415	0.413	46.93	48.34
	Silicon	7.72	9.23	74.60	83.88	0.412	0.412	46.45	48.71
	Control	7.22	9.00	67.08	73.38	0.432	0.433	42.61	44.22
40 cm	MLE	8.45	10.10	77.78	85.54	0.370	0.380	53.14	55.01
	Chitosan	8.34	9.98	76.80	84.92	0.378	0.388	51.14	52.31
	Silicon	8.24	9.92	76.37	86.10	0.369	0.383	49.50	50.62
	Control	7.78	9.44	66.66	74.11	0.413	0.411	45.70	48.21
60 cm	MLE	8.86	10.58	79.01	91.44	0.355	0.363	56.23	58.66
	Chitosan	8.65	10.27	77.56	89.82	0.367	0.367	52.69	54.61
	Silicon	8.55	10.24	77.87	91.82	0.362	0.370	52.24	53.57
	Control	8.10	9.74	66.88	76.32	0.402	0.393	46.76	49.63
L.S.D at 5 %		NS	NS	NS	2.498	NS	NS	0.693	0.309

S1: 2012/2013 season, S2: 2013/2014 season, MLE: moringa leaf extract and NS: not significant at 0.05 level of significance.

vitamin C except (cultivars × foliar applications) and (density × foliar applications) in the second season and titrable acidity (%) except (cultivars × foliar applications) in the first season. On the other hand, the effect of all interactions on carbohydrates (%) was significant in both seasons. Generally, the superior interaction in pod length and pod diameter was (Compados × 60 cm × moringa leaf extract) in both seasons except pod diameter in the first season which (Compados × 60 cm × chitosan) was the superior. Moreover, (Sugar Snap × 60 cm × moringa leaf extract) was the best interaction in pod thickness, total soluble solids (TSS), titrable acidity (%) and carbohydrates (%) in both seasons. Meanwhile, the best one in vitamin C was (Snow Wind × 60 cm × moringa leaf extract) in both seasons.

Table (13): Effect of the triple interaction among cultivars, plant density and foliar applications on pod quality parameters of sugar pea in the two seasons of 2012/2013 and 2013/2014.

Treatments			TSS		Vitamin C (mg/100g fw)		Acidity (%)		Carbohydrates (%)	
			S1	**S2**	**S1**	**S2**	**S1**	**S2**	**S1**	**S2**
Compados	**20 cm**	**MLE**	7.43	10.00	69.16	76.22	0.446	0.430	45.63	46.46
		Chitosan	7.40	9.46	67.83	71.33	0.456	0.433	43.12	43.61
		Silicon	7.56	9.33	68.13	75.67	0.450	0.433	43.60	46.23
		Control	7.06	9.16	61.66	65.16	0.470	0.453	39.36	41.26
	40 cm	**MLE**	8.26	10.46	71.85	77.46	0.430	0.404	48.10	49.38
		Chitosan	8.03	10.20	71.73	76.60	0.420	0.411	44.16	45.72
		Silicon	8.06	10.16	70.33	77.33	0.420	0.410	44.50	45.01
		Control	7.76	9.66	61.33	66.00	0.446	0.436	40.76	42.24
	60 cm	**MLE**	8.53	10.83	73.13	82.66	0.413	0.380	49.66	51.53
		Chitosan	8.30	10.50	72.16	81.33	0.416	0.383	45.89	47.02
		Silicon	8.20	10.40	72.50	83.20	0.416	0.384	44.75	46.64
		Control	7.93	10.00	63.00	69.83	0.430	0.400	41.23	42.77
Sugar Snaps	**20 cm**	**MLE**	8.73	9.40	75.70	78.26	0.375	0.386	53.63	53.63
		Chitosan	8.46	9.33	73.63	77.46	0.365	0.389	53.08	53.57
		Silicon	8.30	9.36	75.66	78.98	0.376	0.389	51.92	52.43
		Control	7.60	9.16	69.86	73.49	0.388	0.403	46.48	46.75
	40 cm	**MLE**	9.00	10.50	78.23	80.50	0.324	0.340	60.93	62.34
		Chitosan	8.96	10.43	77.66	80.50	0.342	0.340	60.70	61.24
		Silicon	8.66	10.43	77.26	80.80	0.326	0.340	58.00	59.17
		Control	7.83	9.66	65.60	70.86	0.362	0.378	53.66	55.38
	60 cm	**MLE**	9.83	10.93	79.63	85.00	0.320	0.330	66.10	68.69
		Chitosan	9.50	10.50	78.40	84.46	0.333	0.336	63.50	66.60
		Silicon	9.33	10.50	78.80	85.60	0.320	0.340	64.29	65.05
		Control	8.50	10.06	67.53	72.46	0.353	0.370	55.73	58.45
Snow Wind	**20 cm**	**MLE**	7.66	9.03	80.80	96.16	0.410	0.406	45.40	48.83
		Chitosan	7.30	9.06	78.66	95.33	0.423	0.416	44.60	47.84
		Silicon	7.30	9.00	80.00	97.00	0.410	0.414	43.83	47.47
		Control	7.00	8.66	69.73	81.50	0.440	0.443	41.98	44.66
	40 cm	**MLE**	8.10	9.33	83.26	98.66	0.356	0.396	50.41	53.31
		Chitosan	8.03	9.33	81.00	97.66	0.371	0.413	48.56	49.98
		Silicon	8.00	9.16	81.53	100.16	0.361	0.400	46.01	47.69
		Control	7.76	9.00	73.06	85.46	0.432	0.420	42.66	47.01
	60 cm	**MLE**	8.23	10.00	84.26	106.66	0.333	0.380	52.93	55.76
		Chitosan	8.16	9.83	82.13	103.66	0.353	0.383	48.70	50.21
		Silicon	8.13	9.83	82.33	106.66	0.350	0.386	47.68	49.03
		Control	7.86	9.16	70.00	86.66	0.423	0.410	43.33	47.68
LSD at 5 %			**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**1.200**	**0.535**

S1: 2012/2013 season, S2: 2013/2014 season, MLE: moringa leaf extract and NS: not significant at 0.05 level of significance.

CONCLUSION

It could be concluded that Compados cultivar was the highest pod yield/plant, and total yield/fed. when cultivated on 20 cm apart, meanwhile Sugar Snap cultivars gave the best pod quality when cultivated on 60 cm apart and sprayed with moringa leaf extract three times, i.e., 15 days after planting then repeated each 15 days interval, respectively.

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دراسات فسيولوجية على البسلة السكرية: تأثير الكثافة النباتية و معاملات الرش ببعض المواد الطبيعيه على النمو والمحصول وجودة القرون.

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أجريت تجربتان حقليتان بمزرعة خاصة فى الصالحية - محافظة الشرقية – مصر خلال موسمى الزراعة الشتويين ٢٠١٢- ٢٠١٣ و ٢٠١٣ – ٢٠١٤ بهدف دراسة تأثير الكثافة النباتية ومعاملات الرش ببعض المواد الطبيعيه (مستخلص المورينجا ، الشيتوزان بتركيز ١٥٠ جزء فى المليون و السيليكون بتركيز ٢٠٠ جزء فى المليون) على صفات النمو ، ومحصول وجودة القرون لبعض أصناف البسلة السكرية (كومبادوس ، سنو ويند و شوجر سناب).

أوضحت النتائج أن صنف كومبادوس أعطى أكبر عدد للأوراق والأفرع للنبات وأطول ارتفاع للنبات وأثقل وزن طازج وجاف وأكبر مساحة ورقية ، كما أعطى أطول قرن وأكبر محصول قرون للفدان مقارنة ببقية الأصناف ، وكان أقل الأصناف فى هذه الصفات صنف شوجر سناب خلال موسمى الزراعة. بينما كان صنف شوجر سناب أفضل الأصناف من حيث سمك القرن ، نسبة المواد الصلبة الذائبة الكلية والكربوهيدارت كما سجل أقل القيم من حيث محتوى الحموضة ، فى حين أن صنف سنو ويند كان أعلى الأصناف فى نسبة فيتامين سى. كما سجلت مسافة الزراعة (٢٠ سم بين النباتات) أطول النباتات وأكبر محصول للفدان مقارنة بمسافة الزراعة (٤٠ و ٦٠ سم بين النباتات) فى حين أن مسافة الزراعة (٦٠ سم بين النباتات) أعطت أعلى القيم فى كل الصفات المدروسة ما عدا صفة ارتفاع النبات والمحصول الكلى للفدان تليها المسافة (٤٠سم بين النباتات) فى كلا الموسمين. وأوضحت النتائج أيضا أن جميع معاملات الرش المختلفة أثرت معنويا فى جميع الصفات المدروسة مقارنة بمعاملة الكونترول ، وكانت أفضل المعاملات الرش بمستخلص المورينجا يليها الرش بالشيتوزان ثم السيليكون على التوالى. من خلال النتائج السابقة يمكن القول بأن صنف كومبادوس أعطى أعلى محصول للفدان عند الزراعة على مسافة ٢٠ سم بين النباتات ، كما أعطى صنف شوجر سناب أفضل جودة عند الزراعة على مسافة ٦٠سم بين النباتات وذلك مع الرش بمستخلص المورينجا ثلاث مرات الأولى بعد ١٥ يوم من الزراعة ثم تكرر كل ١٥ يوم.

Table (2): Effect of cultivars, plant density and foliar applications on vegetative growth parameters of sugar pea in the two seasons of 2012/2013 and 2013/2014.

Treatments		Plant height (cm)		No of branches/ plant		No of leaves/plant		Leaf area/plant (cm^2)		Fresh weight/plant (gm)		Dry weight/plant (gm)	
		S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
Cvs.	Compados	58.19	75.66	4.88	3.77	45.83	38.77	3854.27	3579.31	220.62	182.68	31.96	29.65
	Sugar Snap	52.19	54.02	3.97	3.11	38.25	33.38	2167.36	2054.08	155.31	113.44	23.26	22.41
	Snow Wind	54.05	61.25	4.36	3.27	38.83	34.94	2488.91	2287.35	162.19	131.37	23.76	23.32
L.S.D at 5 %		2.269	0.965	0.166	0.353	1.379	1.727	25.493	13.568	4.019	4.196	0.868	1.864
Density	20 cm	57.94	65.80	3.94	3.05	38.27	34.02	2574.52	2211.72	170.52	138.25	23.66	22.55
	40 cm	54.27	63.36	4.41	3.41	40.80	35.58	2947.57	2766.84	181.02	142.91	25.99	25.57
	60 cm	52.22	61.77	4.86	3.69	43.83	37.50	2988.46	2942.19	186.58	146.33	29.32	27.25
L.S.D at 5 %		1.883	1.566	0.392	0.218	1.353	1.283	14.825	23.682	2.880	2.599	1.029	0.962
Foliar	MLE	58.48	66.96	4.92	4.03	46.55	38.88	3187.59	2938.68	196.79	147.45	29.91	28.00
	Chitosan	56.07	63.74	4.51	3.40	41.33	36.51	2981.22	2774.46	184.70	144.22	27.44	26.06
	Silicon	54.70	62.74	4.29	3.18	40.55	34.92	2892.90	2679.71	183.27	145.33	25.70	24.89
	Control	50.00	61.14	3.88	2.92	35.44	32.48	2285.68	2168.15	152.74	132.99	22.25	21.55
L.S.D at 5 %		1.829	1.439	0.319	0.285	1.525	1.086	17.579	15.322	2.874	1.867	0.910	0.839

S1: 2012/2013 season, S2: 2013/2014 season and MLE: moringa leaf extract.

Table (4): Effect of the triple interaction among cultivars, plant density and foliar applications on vegetative growth parameters of sugar pea in the two seasons of 2012/2013 and 2013/2014.

Treatments			Plant height (cm)		No of branches/ Plant		No of leaves/plant		Leaf area/plant (cm^2)		Fresh weight/plant (gm)		Dry weight/plant (gm)	
			S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
Compados	20 cm	MLE	71.00	85.33	5.00	4.33	52.00	39.66	4488.29	3722.53	231.49	183.84	34.19	31.36
		Chitosan	65.00	77.00	4.33	3.33	38.66	36.66	3080.22	2883.56	212.35	173.19	30.78	24.71
		Silicon	60.66	75.66	4.33	3.33	43.33	34.66	3164.63	2845.17	220.63	182.40	25.71	24.45
		Control	54.33	72.66	3.66	3.00	35.66	34.00	2898.26	2719.29	192.51	170.51	23.25	22.34
	40 cm	MLE	59.66	80.00	5.66	4.66	53.00	43.33	4451.11	4187.05	238.03	187.01	35.43	33.76
		Chitosan	58.00	77.33	5.00	3.66	47.00	37.33	4334.09	4164.09	219.62	181.20	32.66	31.89
		Silicon	56.66	73.33	5.00	3.66	46.33	36.66	3920.69	3904.02	224.47	185.94	31.84	31.32
		Control	51.00	70.66	5.00	3.33	36.66	36.00	2879.83	2902.22	198.05	177.03	24.34	25.28
	60 cm	MLE	57.00	78.66	6.00	5.00	57.66	47.33	4503.94	4292.96	240.08	190.79	40.15	35.79
		Chitosan	58.33	75.33	5.33	4.00	50.00	42.66	4464.19	4213.62	239.56	188.86	39.53	34.22
		Silicon	56.33	72.66	5.00	3.66	47.00	39.33	4361.83	4019.37	228.62	191.78	37.58	33.92
		Control	50.33	69.33	4.33	3.33	42.66	37.66	3704.14	3097.86	202.04	179.63	28.06	26.82
Sugar Snap	20 cm	MLE	57.66	56.66	4.00	3.33	38.33	32.66	1887.11	1832.78	153.65	118.28	25.72	22.01
		Chitosan	55.00	55.66	3.66	3.00	34.66	33.66	2058.88	1922.67	133.81	115.69	21.32	22.47
		Silicon	53.33	54.33	4.00	2.66	36.33	31.66	1845.74	1764.74	149.30	114.74	19.64	19.16
		Control	50.00	53.66	3.00	2.33	29.66	30.00	1531.25	1454.58	114.38	86.35	18.53	18.20
	40 cm	MLE	55.33	56.33	4.33	3.66	42.33	35.66	2210.25	2196.58	173.18	119.12	27.24	25.77
		Chitosan	53.00	54.66	4.00	3.33	38.00	34.33	2115.33	1963.88	173.22	118.00	22.68	23.41
		Silicon	52.33	53.33	4.00	3.00	36.66	33.33	2168.94	2133.28	164.35	117.01	22.10	21.27
		Control	49.33	52.33	3.66	2.66	35.00	31.00	1914.77	1912.41	135.05	102.25	20.66	19.16
	60 cm	MLE	53.33	54.66	4.33	4.00	49.00	37.00	2858.66	2531.00	179.71	125.44	28.50	28.37
		Chitosan	51.00	53.00	4.33	3.33	42.66	34.66	2723.90	2507.57	180.10	122.17	25.91	25.55
		Silicon	50.00	52.33	4.33	3.00	40.66	34.33	2667.39	2456.72	167.66	118.09	25.33	22.36
		Control	46.00	51.33	4.00	3.00	35.66	32.33	2026.15	1972.81	139.35	104.17	21.46	21.18
Snow Wind	20 cm	MLE	61.33	68.00	4.66	3.33	41.00	36.66	3022.25	1923.27	183.35	131.10	22.35	21.90
		Chitosan	57.33	62.00	4.00	3.00	39.66	35.66	2687.68	1956.61	165.99	130.15	22.14	22.49
		Silicon	58.33	66.00	3.33	2.66	37.66	34.00	2713.60	2039.16	159.65	130.16	21.11	22.02
		Control	51.33	62.66	3.33	2.33	32.33	29.00	1516.29	1476.29	129.19	122.61	19.23	19.56
	40 cm	MLE	56.66	61.66	4.66	3.66	41.66	38.00	3143.47	2840.71	184.28	135.12	25.70	25.39
		Chitosan	56.00	60.00	4.33	3.33	40.33	36.33	3181.27	2640.95	168.24	133.36	25.38	24.79
		Silicon	54.00	58.66	3.66	3.00	38.00	34.33	3002.86	2393.39	162.80	132.73	22.50	24.77
		Control	49.33	62.00	3.66	3.00	34.66	30.66	2048.17	1963.50	131.00	126.18	21.31	20.12
	60 cm	MLE	54.33	61.33	5.66	4.33	44.00	39.66	2123.94	2921.25	187.33	136.32	29.90	27.66
		Chitosan	51.00	58.66	5.66	3.66	41.00	37.33	2184.65	2717.18	169.45	135.36	26.55	25.02
		Silicon	50.66	58.33	5.00	3.66	39.00	36.00	2190.46	2561.57	171.96	135.18	25.49	24.79
		Control	48.33	55.66	4.33	3.33	36.66	31.66	2052.26	2014.38	133.09	128.17	23.43	21.33
LSD at 5 %			NS	NS	NS	NS	NS	NS	52.737	45.967	8.624	NS	NS	NS

S1: 2012/2013 season, S2: 2013/2014 season, MLE: moringa leaf extract and NS: not significant at 0.05 level of significance.