J. of Plant Production, Mansoura Univ.,Vol 11 (8): 741-747, 2020

Journal of Plant Production

Journal homepage: www.jpp.mans.edu.eg
Available online at: www.jpp.journals.ekb.eg

Evaluation of Productivity and Quality of Romaine and Iceberg Lettuce (*Lactuca sativa* L.) Under Siwa Conditions

Gomaa, S. S. and M. A. M. Elsagan*

Department of Plant Production, Desert Research Center, Matariya, Cairo, Egypt.

ABSTRACT

The trails were conducted during two consecutive seasons (2017 - 2018 and 2018-2019) in open field at Siwa Experimental Farm Station, at latitude 29º 12' N, longitude 25º 29'E and 18 meters below sea level, Marsa Matrouh Governorate, Egypt, to evaluate the effect of three plant density and spraying of two calcium concentrates on growth, yield and quality of two lettuce types grown at winter seasons. Dark green and Mason cultivars represented of both romaine and iceberg lettuce type were transplanted at plant spacing of 25x20, 25x25 and 25x30 cm to give a plant population about 20, 16 and 13 plants per square meter and treated with 300 or 200 ppm of calcium chelate, as well as control treatment. The results indicated that, in spite of decreasing number of marketable heads per plot, low plant density improved average head weight, head diameter, leaf tip-burn, head compactness, as well as enhancement of nutritional value vs, dry matter, Ascorbic acid, potassium and calcium content. Both calcium treatments have a positive effect on lettuce yield and almost quality characters when compared with control treatment, except, average head weight, head diameter, head compactness, leaf tip-burn and dry matter content, dark green as romaine lettuce type produced highest number of marketable heads per planting area, early yield, highest head of water, ascorbic acid, potassium and calcium content. Egyptian market transplanting showed that romaine lettuce type with high density and calcium foliar spray is recommended.

Keywords: Lettuce, Plant density, Calcium, romaine, Iceberg, Growth, Yield, quality.

INTRODUCTION

Lettuce (*Lactuca sativa* L.) is a leafy vegetable crop, usually use as a raw or as a green salad and considered the main leafy vegetable produced and consumed in the world, especially in the form of salads (Sala and Costa, 2012). lettuce contain a high calcium (68 mg), iron (1.4 mg), potassium (264 mg) and vitamin A (1620 unit /100 g f.w.) also, it consider an excellent source of water and often prescribed for overweight people because of its low kilojoules content (Niederwieser, 2001; Maboko, 2007). Lettuce is a native of Northern Africa, Europe and Asia. Moreover, Lettuce has been cultivated for over 5000 years because it is originated from wild lettuce (*Lactuca serriola* L.) and it was found on Egyptian tomb paintings during the middle kingdom about 4500 years ago. These paintings showed similar to the type of presently cultivated in Egypt (Masarirambi *et al.*, 2012). Although, lettuce production and consumption sharply increased in all over world (FAO, 2018), Egypt production sharply decreased during the last two decades (4294 ha) as compared with production twenty years before (6400 ha), (FAO, 1998 and 2018). The reduction of planting area as despite of iceberg (crisp head) type which is distributed in most planting areas for local and transport markets. So, an attention to give for lettuce production even romaine or iceberg type in terms nutritional value, agricultural practices and marketing.

Calcium is the most plant nutrient related to fruit quality, especially fruit fimenance (Sam, 1999) that's refers to its role as a major component of pectin and in strengthening cell wall and membrane structure (Maas,1998; Sam, 1999; Hepler, 2005; Hepler and Winship, 2010). Calcium deficiency in plants affects the growth of young leaves and triggers symptoms which are associated with cell disruption (Almeida, 2016).Calcium uptake and mobility in plant through phloem are relatively low (Matchima, 2013), also, its transport release on transpiration (Marschner, 1995), leaves content from calcium is higher than fruits (Conway *et al.*, 1994). Moreover, the absence of Ca in plant nutrition occurs in young leaves as a result of low transpiration rates on these sites, which are disrupts the cells of young tissue (White and Broadley, 2003). Low soil moisture, cool, cloudy and humid weather have evident effect on calcium uptake, mobility and distribution in plant (Conway *et al.*, 1994 and Maas, 1998). So, the foliar application of calcium is recommended because it provides the nutrient directly to the organ of interest during critical growth stages (Almeida, 2016). On lettuce, pre harvest times of crop calcium application as foliar spray with calcium chloride and calcium nitrate are common to improve fruit quality and increase calcium content (Matchima, 2013). Calcium content increased with increasing calcium levels from 60 to 180 mg per liter (Yuan, 2018). However, calcium chloride and calcium nitrate may cause phytotoxicity, calcium chelates have been applied as an alternative source (Bramlege *et al.*, 1985). Also, Yuan, (2018) found that, the concentration of calcium in the loose-leaf phenotype was

*** Corresponding author.**
E-mail address: drm_elsagan@yahoo.com
DOI: 10.21608/jpp.2020.114568

2.17, 2.47, and 3.80 percent higher than that in the butter head and romaine phenotypes at 60, 120, and 180 mg per liter respectively. Furthermore, the significant differences in calcium concentration between cultivars ranged from 1.27 to 3.05 percent.

Plant spacing significantly affected lettuce production by changing its architecture, weight and quality (Silva *et al.*, 2000). Small space of lettuce cultivation may increase the net income (Gode and Bobde, 1993; Dubey and Kulvi, 1995). While, Cecilio *et al.* (2007) showed that, small gaps between lettuce rows affected significantly and influenced the fresh yield of the aerial part negatively. Also, Makhadmeh *et al*., (2017) found that, plant density exhibited significant effects on lettuce stem and leaves weight, number of non-consumable leaves, number of outer leaves, number of inner leaves, total number of leaves, marketable head mass, head mass and plant height.

The objective of our study is to determine the assess whether lettuce type which is suitable for local production and consumption facing on nutritional value, productivity per area unit and trying to enhance production and quality by calcium foliar spray and optimum plant density under Siwa Oasis conditions.

MATERIALS AND METHODS

The trails were conducted during two consecutive winter seasons (2017 - 2018 and 2018-2019) in open field at Siwa Experimental farm station, at latitude 29^o 12' N, longitude 25^o 29'E and 18 meters below sea level, Marsa Matrouh Governorate, Egypt, to evaluate the effect of three plant density and spraying of two calcium concentrates on two types of lettuce plants.

Transplants of Dark green lettuce cultivar as romaine type and Mason lettuce cultivar as iceberg type were transplanted on the 1st of December in both seasons. The experimental plot was 10.5 m^2 and transplants were transplanted at plant spacing of 25x30, 25x25 and 25x20 cm to give a plant population of 138, 168 and 210 plant per plot. There were about 13, 16 and 20 plants per square meter, density (1, 2 and 3) respectively. Calcium chelate was added by 300 ppm (calcium 1), 200 ppm (calcium 2) and tap water (control) as foliar spray 30 days after transplanting, then every 10 days up to harvest date. The experiment was laid out as a split-split plot design with five replicates. The plant density were assessed in main plot, while three calcium foliar spray concentrations were assessed in sub plots, but the two lettuce types were assessed in sub-sub plots.

During harvest time, number of days from transplanting to harvest time were calculated and number of marketable lettuce heads were recorded. Then, randomly ten plants of each plot were collected for yield and its component determination. Head weight and diameter were measured. Five heads from each plot collected to measure compactness and tip-burn using a scale of 1-5 and L Ascorbic acid content were determined according to (AOAC, 2005). Heads samples were taken at harvest time and oven-dried at 60 C$^{\circ}$ until constant weight, then dry matter percent was calculated. The powder of samples were ground to pass a 1 mm sieve then 0.1 g of the dry samples was taken and digested using a mixture of sulphuric acid and hydrogen peroxide as described by Thomas *et al*., (1967).

All the studied elements were assayed in the digest of the concerned plant samples. Potassium and calcium were measured by flame photometer as described by Page *et al*. (1982). Data were subjected to statistical analysis by M-STAT C (Russel, 1991). The differences among means were performed using least significant difference (LSD) at 5% level.

RESULTS AND DISCUSSION

Maturity and marketable heads:

Number of days to harvest time and number of marketable heads significantly affected by density of transplants and lettuce types in two seasons, while calcium treatments showed no significant effect on number of days to harvest time, but has significant effect on number of marketable heads in both growing seasons. All interaction effects among densities with calcium application or lettuce types were significant in both growing seasons, while the third interaction (density * calcium * lettuce types) effect on number of days to harvest time in the second season only, Table (1). early yield was obtained with low density of lettuce transplants density 1 (13 p/m²) when compared with medium density density 2 (16 p/m²) followed by high density density 3 (20 p/m²) which was delayed harvesting date in both season. On the contrary, high density of transplants gave the highest number of marketable heads compared with density 2 followed by density 3 in both seasons this results agree with those reported by Cecilio *et al.* (2007).

Foliar spray by calcium chelates at 300 ppm concentrate slightly increased number of marketable heads as compared with 200 ppm concentrate, while the untreated plots (control) produced the lowest number of marketable heads in both seasons. The foliar application of calcium provides the nutrient directly to the organ of interest during critical growth stages (Almeida, 2016). Romine lettuce type evidently had earlier harvest date and number of marketable heads as compared with iceberg type in both seasons.

Regarding, interaction effects of high density transplants with all calcium treatments delayed harvesting date, but the most pronounced effect was when both lettuce types were transplanted with high density without calcium treatment as compared with other densities treated by both calcium concentrates in both seasons. However, high density with high calcium concentrate (300 p.p.m) produced the highest number of lettuce heads when compared with other treatments especially low density plots (density 3) which was untreated with calcium in both seasons. High density of iceberg lettuce type significantly increased number of days to harvest time (delayed harvest) as compared with other treatments, followed by other densities with the same type, while romaine type with all densities had low number of days to harvest (earlier harvest) especially with low density of transplants. Moreover, romaine type gave the highest number of marketable heads with high density when compared with iceberg type which was gave the lowest values especially with low density of transplanting in both seasons.

Table 1. Effect of plant density and calcium foliar spray on No. of days to harvest time and No. of marketable heads/plot of two types of lettuce during 2017/2018 and 2018/2019 growing seasons.

Treatments Foliar spr.	Types	Number of days to harvest time								Number of marketable heads/plot							
		First season				Second season				First season				Second season			
		Density1	Density2	Density3	Mean	Density1	Density2	Density3	Mean	Density1	Density2	Density3	Mean	Density1	Density2	Density3	Mean
Calcium 1	Romine	64.38	66.38	69.25	66.67	65.63	66.38	69.25	67.08	132.75	155.50	184.75	157.67	131.75	155.00	182.00	156.25
	Iceberg	70.25	72.00	73.63	71.96	71.75	72.00	73.63	72.46	126.50	147.50	158.50	144.17	125.50	146.75	162.25	144.83
		67.31	69.19	71.44	69.31	68.69	69.19	71.44	69.77	129.63	151.50	171.63	150.92	128.63	150.88	172.13	150.54
Calcium 2	Romine	64.38	66.38	69.50	66.75	65.50	66.38	69.50	67.13	129.50	153.00	183.00	155.17	128.00	154.00	174.75	152.25
	Iceberg	69.88	71.63	74.25	71.92	71.75	71.63	74.25	72.54	126.75	142.50	153.75	141.00	125.75	145.50	155.75	142.33
		67.13	69.00	71.88	69.33	68.63	69.00	71.88	69.83	128.13	147.75	168.38	148.08	126.88	149.75	165.25	147.29
Control	Romine	67.50	69.25	71.75	69.50	67.50	70.00	72.00	69.83	124.00	145.50	170.50	146.67	122.50	150.25	162.25	145.00
	Iceberg	73.25	73.75	76.75	74.58	73.75	75.50	78.00	75.75	124.75	138.00	142.50	135.08	123.00	144.00	145.50	137.50
		70.38	71.50	74.25	72.04	70.63	72.75	75.00	72.79	124.38	141.75	156.50	140.88	122.75	147.13	153.88	141.25
		Dens.1	Dens.2	Dens.3		Dens.1	Dens.2	Dens.3		Dens.1	Dens.2	Dens.3		Dens.1	Dens.2	Dens.3	
Romine		65.42	67.33	70.17	67.64	66.21	67.58	70.25	68.01	128.75	151.33	179.42	153.17	127.42	153.08	173.00	151.17
Iceberg		71.13	72.46	74.88	72.82	72.42	73.04	75.29	73.58	126.00	142.67	151.58	140.08	124.75	145.42	154.50	141.56
		68.27	69.90	72.52		69.31	70.31	72.77		127.38	147.00	165.50		126.08	149.25	163.75	
LSD at 0.05 for Density					0.62				0.75				2.02				2.03
LSD at 0.05 for Calcium					N.S				N.S				1.86				2.30
LSD at 0.05 for Types					0.22				0.22				1.74				1.66
LSD at 0.05 for Density x Calcium					0.35				0.72				3.22				3.98
LSD at 0.05 for Density x Types					0.39				0.39				3.01				2.88
LSD at 0.05 for Culcium x Types					N.S				N.S				N.S				N.S
LSD at 0.05 for Density x Culcium x Types					N.S				0.67				N.S				N.S

Calcium 1 = 300 ppm Calcium 2 = 200 ppm Density 1= 13p/m² Density 2= 16p/m² Density 3= 20p/m²

Average head weight and diameter:

Data presented in Table (2) showed that, low transplants density density 1(13 p/m²) produced the heaviest head weight and highest diameter followed by medium density density 2(16 p/m²) then high density density 3(20 p/m²) produced the lowest head weight and head diameter in both seasons. This agree with those reported by Makhadmeh *et al*., (2017) they found that, plant density exhibited significant effects on lettuce stem and leaves weight, number of non-consumable leaves, number of outer leaves, number of inner leaves, total number of leaves, marketable head mass, head mass and plant height. Also, both calcium treatments increased head weight and diameter as compared with control. Although, iceberg lettuce type produced the heavy head weight than romaine type, but the increasing of diameter in the first season was not significant and slightly increment in the second season was found.

Concerning, interaction effects: low density with calcium as 200 p.p.m produced the heaviest head weight in the first season and both calcium treatments in the second season. Moreover, low density with calcium treatments produced the highest head diameter in both growing seasons. While high density produced the lowest head weight and diameter especially with control of calcium treatment in both seasons.

Table 2. effect of plant density and calcium foliar spray on average head weight and diameter of two types of lettuce during 2017/2018 and 2018/2019 growing seasons.

Average head weight (g)										Average head diameter (cm)							
Treatments		First season				Second season				First season				Second season			
Foliar spr.	Types	Density1	Density2	Density3	Mean	Density1	Density2	Density3	Mean	Density1	Density2	Density3	Mean	Density1	Density2	Density3	Mean
Calcium 1	Romine	626.03	674.88	669.07	656.66	729.36	726.98	693.83	716.72	15.33	15.64	14.96	15.31	15.38	15.77	15.00	15.38
	Iceberg	974.16	753.37	709.05	812.19	1021.79	772.87	753.55	849.40	16.46	15.21	14.47	15.38	17.05	15.71	14.44	15.73
		800.09	714.12	689.06	734.42	875.57	749.92	723.69	783.06	15.90	15.42	14.71	15.34	16.21	15.74	14.72	15.56
Calcium 2	Romine	692.95	661.06	620.93	658.32	709.85	660.39	674.32	681.52	15.58	15.09	15.08	15.25	15.48	15.73	14.94	15.38
	Iceberg	956.92	714.92	643.23	771.69	1012.84	757.39	687.68	819.30	16.19	14.65	14.58	15.14	17.18	16.21	14.85	16.08
		824.94	687.99	632.08	715.00	861.34	708.89	681.00	750.41	15.88	14.87	14.83	15.19	16.33	15.97	14.90	15.73
Control	Romine	683.13	561.31	587.89	610.77	699.97	580.23	617.56	632.58	15.60	15.01	15.05	15.22	15.28	15.07	14.86	15.07
	Iceberg	884.18	658.18	584.66	709.00	903.68	703.47	629.44	745.53	16.19	14.62	14.43	15.08	17.03	15.12	14.69	15.61
		783.65	609.75	586.27	659.89	801.83	641.85	623.50	689.06	15.89	14.82	14.74	15.15	16.15	15.09	14.78	15.34
		Density1	Density2	Density3		Density1	Density2	Density3		Density1	Density2	Density3		Density1	Density2	Density3	
Romine		667.37	632.42	625.96	641.92	713.06	655.86	661.90	676.94	15.50	15.25	15.03	15.26	15.38	15.52	14.93	15.28
Iceberg		938.42	708.82	645.64	764.29	979.44	744.57	690.22	804.74	16.28	14.83	14.49	15.20	17.08	15.68	14.66	15.81
		802.89	670.62	635.80		846.25	700.22	676.06		15.89	15.04	14.76		16.23	15.60	14.80	
LSD at 0.05 for Density					45.30				46.83				0.22				0.23
LSD at 0.05 for Calcium					33.22				31.66				0.15				0.21
LSD at 0.05 for Cultivars					31.89				24.22				0.12				0.19
LSD at 0.05 for Density x Calcium					N.S				N.S				0.25				0.36
LSD at 0.05 for Density x Cultivars					55.24				41.95				0.21				0.32
LSD at 0.05 for Culcium x Cultivars					N.S				N.S				N.S				N.S
LSD at 0.05 for Density x Culcium x Cultivars					N.S				N.S				N.S				N.S

Other interactions effect were not significant, except the effect of transplants density with lettuce types, where, iceberg type with low density gave the highest head weight and diameter as compared with other treatments. While romaine type with all transplants density and iceberg with high density gave the lowest values in this respect in both seasons. From previous data, we notice that, iceberg lettuce type had increasing size head compare with romaine lettuce type as a results of genetic improvements in lettuce growth, head weight and head diameter. Similar results were found by Yuan, 2018 on loose-leaf, romaine and butter head phenotypes. Although iceberg lettuce type had increment of average head weight and diameter, romaine lettuce type increased total number of heads per plot and consequently increased yield/plot especially when lettuce have being marketing as units not as bulk weight.

Increasing growth rate of romain type was higher with high density of transplants may be due to vertical growth for romaine lettuce type and this led to maximize growth with limited distances compared with iceberg lettuce type (rounded head shape) which need more area to give maximize head growth. Moreover, iceberg genetically need more time to form compact when compared with romaine lettuce type which was a relatively loose heads and may be harvested early before heads has full compacted.

Tip-burn and compactness:

Transplants density, calcium treatments and their interaction effects on leaf tip-burn and head compactness of two lettuce types were shown in Table (3). Presented data showed that, low density transplants (density 1) significantly decreased tip-burn and increased head compactness as compared with other densities , followed by medium density (density 2), while high density (density 3) sharply increased tip-burn and decreased head compactness in both seasons this results in the same line with those reported by (Silva *et al.*, 2000) they plant spacing significantly affected lettuce production by changing its architecture, weight and quality. Regarding calcium treatments effect, there were slightly decreasing of leaf tip-burn disorder and slightly increasing of head compactness when compared with control treatment which was gave the highest tip-burn and lowest head compactness. Iceberg lettuce type gave the lowest tip-burn and highest head compactness when compared with romaine type which was gave the highest tip-burn and lowest head compactness in both seasons.

Table 3. effect of plant density and calcium foliar spray on tip-burn and head compactness of two types of lettuce plants during 2017/2018 and 2018/2019 growing seasons.

Tip-burn (1-5)										Head compactness (1-5)							
Treatments		First season				Second season				First season				Second season			
Foliar spr.	Types	Density1	Density2	Density3	Mean	Density1	Density2	Density3	Mean	Density1	Density2	Density3	Mean	Density1	Density2	Density3	Mean
Calcium 1	Romine	2.25	3.50	4.25	3.33	2.25	3.25	4.00	3.17	2.75	2.50	1.50	2.25	2.25	2.75	1.75	2.25
	Iceberg	1.00	1.25	1.50	1.25	1.00	1.25	1.50	1.25	4.50	4.75	3.75	4.33	4.75	4.50	3.25	4.17
		1.63	2.38	2.88	2.29	1.63	2.25	2.75	2.21	3.63	3.63	2.63	3.29	3.50	3.63	2.50	3.21
Calcium 2	Romine	2.50	3.50	4.25	3.42	2.75	3.50	4.25	3.50	3.75	2.25	2.50	2.83	2.75	2.50	1.75	2.33
	Iceberg	1.00	1.25	1.25	1.17	1.00	1.50	1.75	1.42	4.50	4.75	3.75	4.33	4.25	4.50	3.75	4.17
		1.75	2.38	2.75	2.29	1.88	2.50	3.00	2.46	4.13	3.50	3.13	3.58	3.50	3.50	2.75	3.25
Control	Romine	3.25	4.25	4.75	4.08	3.50	3.75	4.50	3.92	3.75	2.50	2.25	2.83	3.00	3.00	2.50	2.83
	Iceberg	1.50	1.50	1.75	1.58	1.50	1.25	1.75	1.50	4.75	5.00	4.00	4.58	4.75	4.75	4.25	4.58
		2.38	2.88	3.25	2.83	2.50	2.50	3.13	2.71	4.25	3.75	3.13	3.71	3.88	3.88	3.38	3.71
		Density1	Density2	Density3		Density1	Density2	Density3		Density1	Density2	Density3		Density1	Density2	Density3	
Romine		2.67	3.75	4.42	3.61	2.83	3.50	4.25	3.53	3.42	2.42	2.08	2.64	2.67	2.75	2.00	2.47
Iceberg		1.17	1.33	1.50	1.33	1.17	1.33	1.67	1.39	4.58	4.83	3.83	4.42	4.58	4.58	3.75	4.31
		1.92	2.54	2.96		2.00	2.42	2.96		4.00	3.63	2.96		3.63	3.67	2.88	
LSD at 0.05 for Density					0.39				0.42				0.58				0.26
LSD at 0.05 for Calcium					0.22				0.29				0.27				0.32
LSD at 0.05 for Types					0.26				0.24				0.21				0.25
LSD at 0.05 for Density x Calcium					N.S				N.S				N.S				N.S
LSD at 0.05 for Density x Types					0.45				0.41				0.37				N.S
LSD at 0.05 for Calcium x Types					N.S				N.S				0.37				N.S
LSD at 0.05 for Density x Calcium x Types					N.S				N.S				N.S				N.S

Calcium 1 = 300 ppm Calcium 2 = 200 ppm Density 1= 13p/m² Density 2= 16p/m² Density 3= 20p/m²

Regarding, interaction treatments had no significant differences among them, except density with lettuce types on tip-burn in both growing seasons. Romine type which is growing in high transplants density showed high tip-burn values when compared with other treatments, while iceberg type showed less values especially when growing in low transplants density in both seasons.

Dry matter content and L. Ascorbic acid:

Data presented in Table (4) showed that, transplants density, calcium application treatments and two lettuce types significantly affected on dry matter percent and L. ascorbic acid content in both growing seasons. Interaction treatments have no significant effects on dry matter content, while the effects of interaction treatments on L.

ascorbic acid have significant effect with density and lettuce types in the both growing seasons, while density* types and denisity * calcium and denisity * calcium * types showed significant effect in second season only. Low density of transplants produced the highest head dry matter content (lowest water percent content) followed by medium density as compared with high density which was produced the lowest dry matter content and subsequently, highest water content in both growing seasons. Both calcium application treatments slightly increased dry matter content when compared with control in both seasons, while the most pronounced effect on dry matter content were obtained with iceberg lettuce type as compared with was romaine type which produced low dry matter content.

Regarding, L. ascorbic acid content, low transplants density increased L. ascorbic acid content followed by medium density as compared with high density in the first season, while in the second seasons, the effect was not significant. Moreover, both calcium application treatments in the first season significantly increased L. ascorbic acid as compared with control, while in the second season, calcium 2 only had a significant effect when compared with calcium 1 or control treatments. The most important and shocked data were noticed by lettuce type L. ascorbic acid content, since romaine type had about double amounts of ascorbic acid as compared with iceberg lettuce type in both seasons.

Potassium and calcium content:

Data in Table (5) showed that, transplants density significantly affected on both head potassium and calcium content in both growing season. Low density (density 1) in the first season or with medium density (density 2) in the second season which was produced the highest head potassium as compared with high density (density 3). Moreover, low density gave the highest calcium content as compared with other densities in both seasons. Concerning, calcium treatments presented in Table (5), showed that, no significant effect was found on potassium content of lettuce, while the effect on lettuce calcium content was significant. Both calcium treatments increased lettuce head calcium content as compared with control treatment in both growing seasons. Regarding, the results of tow lettuce types potassium and calcium content showed the similar results with L. Ascorbic acid content. Romaine type showed high superiority in this respect.

The interaction effect of density with calcium treatments showed significant increases on lettuce transplanting with low density and calcium 1 or calcium 2 treatment. While, all transplants density with control of calcium treatments gave the lowest values in this respect. Also, transplants density with lettuce types had a significant effect, since romaine type gave the highest potassium and calcium content especially with low density as compared with iceberg type, especially with transplanting on high density. Other interactions effect were not significant in both seasons. From the previous data we can notice that, calcium content and tip-burn disorder attributed to transpiration effects which are led to calcium element reach to and distribution throw young leaves, so the older leaves can transpire rabidly and more than youngest on the same plant which are suffer calcium deficit and consequently showed tip-burn disorder (Collier and Tibbitts, 1982 and 1984).

Table 4. Effect of plant density and calcium foliar spray on dry matter percent and L. Ascorbic acid of two types of lettuce during 2017/2018 and 2018/2019 growing seasons.

Dry matter percent										L. Ascorbic acid mg/100g F.W							
Treatments		First season				Second season				First season				Second season			
Foliar spr.	Types	Density1	Density2	Density3	Mean	Density1	Density2	Density3	Mean	Density1	Density2	Density3	Mean	Density1	Density2	Density3	Mean
Calcium 1	Romine	8.09	7.70	7.15	7.65	7.47	7.11	6.51	7.03	53.03	51.63	46.83	50.49	49.50	50.32	49.72	49.84
	Iceberg	10.21	9.65	9.49	9.78	10.31	10.03	9.65	10.00	26.05	26.65	24.35	25.68	24.72	25.81	25.99	25.51
		9.15	8.67	8.32	8.71	8.89	8.57	8.08	8.51	39.54	39.14	35.59	38.09	37.11	38.06	37.86	37.68
Calcium 2	Romine	8.01	7.67	6.99	7.56	7.62	6.86	6.28	6.92	53.35	52.08	48.68	51.37	53.45	49.99	50.67	51.37
	Iceberg	10.25	9.86	9.37	9.83	10.57	9.97	9.57	10.04	26.93	27.00	25.33	26.42	25.70	27.34	25.22	26.09
		9.13	8.77	8.18	8.69	9.10	8.41	7.92	8.48	40.14	39.54	37.00	38.89	39.58	38.67	37.94	38.73
Control	Romine	7.80	7.24	6.62	7.22	7.43	6.67	6.30	6.80	49.38	49.15	46.73	48.42	50.20	48.51	48.82	49.17
	Iceberg	10.13	9.60	9.39	9.71	10.43	9.70	9.45	9.86	25.53	23.63	24.40	24.52	24.62	25.12	26.20	25.31
		8.97	8.42	8.01	8.46	8.93	8.19	7.88	8.33	37.45	36.39	35.56	36.47	37.41	36.81	37.51	37.24
		Density1	Density2	Density3		Density1	Density2	Density3		Density1	Density2	Density3		Density1	Density2	Density3	
Romine		7.97	7.53	6.92	7.47	7.51	6.88	6.36	6.92	51.92	50.95	47.41	50.09	51.05	49.60	49.73	50.13
Iceberg		10.19	9.70	9.42	9.77	10.44	9.90	9.55	9.96	26.17	25.76	24.69	25.54	25.01	26.09	25.80	25.64
		9.08	8.62	8.17		8.97	8.39	7.96		39.04	38.36	36.05		38.03	37.85	37.77	
LSD at 0.05 for Density					0.22				0.21				0.40				N.S
LSD at 0.05 for Calcium					0.16				0.14				0.86				0.67
LSD at 0.05 for Types					0.16				0.21				0.61				0.55
LSD at 0.05 for Density x Calcium					N.S				N.S				N.S				1.16
LSD at 0.05 for Density x Types					N.S				N.S				1.05				0.95
LSD at 0.05 for Culcium x Types					N.S				N.S				N.S				N.S
LSD at 0.05 for Density x Culcium x Types					N.S				N.S				N.S				1.65

Calcium 1 = 300 ppm Calcium 2 = 200 ppm Density 1= 13p/m² Density 2= 16p/m² Density 3= 20p/m²

Table 5. effect of plant density and calcium foliar spray on potassium and calcium content of two types of lettuce during 2017/2018 and 2018/2019 growing seasons.

Potassium content mg/g of d.w.										Calcium content mg/g of d.w.							
Treatments		First season				Second season				First season				Second season			
Foliar spr.	Types	Density1	Density2	Density3	Mean	Density1	Density2	Density3	Mean	Density1	Density2	Density3	Mean	Density1	Density2	Density3	Mean
Calcium 1	Romine	32.50	31.75	30.75	31.67	31.00	31.00	28.00	30.00	8.50	8.00	7.00	7.83	8.00	7.25	6.25	7.17
	Iceberg	22.50	22.25	21.75	22.17	21.00	21.25	21.75	21.33	6.00	5.75	5.00	5.58	5.50	5.00	4.75	5.08
		27.50	27.00	26.25	26.92	26.00	26.13	24.88	25.67	7.25	6.88	6.00	6.71	6.75	6.13	5.50	6.13
Calcium 2	Romine	32.50	31.25	31.00	31.58	31.25	31.00	28.75	30.33	8.50	6.75	7.25	7.50	7.75	7.50	7.00	7.42
	Iceberg	22.25	22.50	21.75	22.17	20.50	21.00	20.50	20.67	5.75	5.25	5.00	5.33	5.50	4.75	5.00	5.08
		27.38	26.88	26.38	26.88	25.88	26.00	24.63	25.50	7.13	6.00	6.13	6.42	6.63	6.13	6.00	6.25
Control	Romine	32.25	31.75	31.00	31.67	30.50	30.25	28.50	29.75	6.50	5.00	6.25	5.92	5.75	5.25	5.50	5.50
	Iceberg	22.50	22.00	21.50	22.00	21.25	21.25	20.25	20.92	4.00	4.00	4.25	4.08	3.50	4.25	4.00	3.92
		27.38	26.88	26.25	26.83	25.88	25.75	24.38	25.33	5.25	4.50	5.25	5.00	4.63	4.75	4.75	4.71
		Density1	Density2	Density3		Density1	Density2	Density3		Density1	Density2	Density3		Density1	Density2	Density3	
Romine		32.42	31.58	30.92	31.64	30.92	30.75	28.42	30.03	7.83	6.58	6.83	7.08	7.17	6.67	6.25	6.69
Iceberg		22.42	22.25	21.67	22.11	20.92	21.17	20.83	20.97	5.25	5.00	4.75	5.00	4.83	4.67	4.58	4.69
		27.42	26.92	26.29		25.92	25.96	24.63		6.54	5.79	5.79		6.00	5.67	5.42	
LSD at 0.05 for Density					0.44				0.48				0.37				0.50
LSD at 0.05 for Calcium					N.S				N.S				0.31				0.30
LSD at 0.05 for Cultivars					0.28				0.50				0.26				0.21
LSD at 0.05 for Density x Calcium					N.S				N.S				0.53				0.53
LSD at 0.05 for Density x Cultivars					0.48				0.87				0.45				N.S
LSD at 0.05 for Culcium x Cultivars					N.S				N.S				N.S				0.36
LSD at 0.05 for Density x Culcium x Cultivars					N.S				N.S				N.S				N.S

Calcium 1 = 300 ppm Calcium 2 = 200 ppm Density 1= 13p/m² Density 2= 16p/m² Density 3= 20p/m²

In this study romaine lettuce type had the highest tip-burn disorder in spite of that is a relatively loose head (semi-open leaves) which are enhance in transpiration rate and consequently hard competition between old and young leaves. Moreover, vertical head growth of romaine lettuce type might it difficult for calcium reach to leaves apical. On the contrary, although iceberg lettuce type (closed head) have a less respiration rate, closed heads led to young leaves to obtain its calcium requirements. In addition that, horizontal growth may be useful in this respect. Similar results were found by (Barta and Tibbitts, 1991). Moreover, there were a significant variation in nutritional values (water percent, L. ascorbic acid, calcium and potassium content) among lettuce phenotypes, since romaine type had great amount of water, L. ascorbic acid, potassium and calcium content as compared with iceberg type. Also, romaine type gave the highest lettuce yield represented in average heads per unit area when transplanted on high density, as well as calcium application as a foliar spray by 300 or 200 ppm. enhanced lettuce yield and quality of both lettuce types.

REFERENCES

Almeida, P. H., Mogor, A. F., Ribeiro, A. Z., Heinrichs ,J.and E. Amano. (2016) Increase in lettuce (*Lactuca sativa* L.) production by foliar calcium application Aust. J.of Basic and Appl. Sci., 10(16) P. 161-167.

AOAC (2005). Official Methods of Analysis. 18th edn., eds.: W. Hortwitz, G. W. Latimer, AOAC-Int. Suite 500, 481 North Frederick Avenue, Gaithersburg, Maryland, USA.

Barta, D.J. and T.W. Tibbitts. (1991). Calcium localization in lettuce leaves with and without tip-burn: Comparison of controlled-environment and field-grown plants. J. Amer. Soc. Hort. Sci.116:870–875.

Bramlage, W. G., Drake, M. and S. A. Weis. (1985). Comparisons of calcium chloride, calcium phosphate, and a calcium chelate as foliar sprays for 'McIntosh' apple trees. Journal of the American Society for Horticultural Science 110: 786-789.

Cecilio Filho, A. B., Rezende, B. L. A. and G. H. D.Canato. (2007). Produtividade de alface e rabanete em cultivo consorciado estabelecido em diferentes épocas e espaçamentos entre linhas. Horticultura Brasileira 25: 15-19.

Collier, G.F. and T.W. Tibbitts. (1982). Tipburn of lettuce. Hort. Rev. 4:49–65.

Collier, G.F. and T.W. Tibbitts. 1984. Effects of relative humidity and root temperature on calcium concentration and tipburn development in lettuce. J. Amer. Soc. Hort. Sci. 109:128.

Conway, W. S., Sams, C. E. and A. Kelman. (1994). Enhancing the natural resistance of plant tissues to postharvest disease through calcium applications. HortScience 29: 751-754.

Dubey, D. and G. S. Kulvi. (1995). Performance of sorghum (Sorghum bicolor) as influenced by intercropping and planting geometry. Indian J. Agron. 9 : 353-56.

FAO, FAOSTAT/Statistical database (1998 and 2018). http:// faostat.fao. org/site / 535 / desk top Default. aspx? Page ID=535#ancor.

Gode, D. B. and G. N. Bobde. (1993). Intercropping of soybean sorghum. PKV Res. J. 17 : 128-29.

Hepler, P.K. and J.L. Winship, (2010). Calcium at the Cell Wall-Cytoplast Interface. J Integr Plant Biol., 52(2): 147-160.

Hepler, P.K., (2005). Calcium: A Central Regulator of Plant Growth and evelopment. Plant Cell, 17(8): 2142-2155.

Maas, J. L. (1998). Compendium of strawberry diseases. St. Paul, Minnesota, USA, APS Press.

Maboko MM (2007). Leafy lettuce grown in a hydroponics system. 1st Floor, AGRISETA building, 529 Belvedere street, Arcadia, Pretoria, South Africa. Undercover Farming 3 (3): 8.

Makhadmeh, I.,M.; AL-Tawaha, A.; Edaroyati, P.; AL-Karaki, G.; AL Tawaha, A. ; S. Hassan. (2017). Effects of different growth media and planting densities on growth of lettuce grown in a closed soilless system Res. on Crops 18 (2) : 294-298

Marschner, H., 1995. Mineral nutrition of higher plants. Academic Press, London, p: 889.

Masarirambi, M. T.; P. Dlamini; P. K. Wahome and T. O. Oseni. (2012). Effects of Chicken Manure on Growth, Yield and Quality of Lettuce (Lactuca sativa L.) ‘Taina’ Under a Lath House in a Semi-Arid Sub-Tropical Environment. American-Eurasian J. Agric. & Environ. Sci., 12 (3): 399-406.

Matchima, N. (2013). Effect of calcium nutrition on fruit quality and postharvest diseases. ijsid, 3 (1), 8-13

Niederwieser JG (2001). Guide to hydroponic vegetable production (2nd ed.). Agricultural Research Council, Roodeplaat, Vegetable and Ornamental Plant Institute. Pretoria, South Africa. p. 140.

Page, A.L., R.H. Miller and D.R. Keeney. (1982). Methods of soil analysis-chemical and microbiology properties, SSSA Inc., Mad., WI., USA.

Russell, D. F., (1991). In “ MSTATC, Directory crop soil science Department” Michigan Universty.USA.

Saber, M.S.M. (1993). Multi-strainn biofertilizer. The Sixth International Symbosiumon Nitrogen Fixation with Non-Legumes. Ismailia, Egypt 6-10 September.

Sala, F. C., and Costa, C. P. (2012). Retrospectiva e tendência da alfacicultura brasileira. Horticultura Brasileira 30, 187 - 194. https :// doi .org /10 .1590 /S0102-05362012000200002.

Sams, C. E. (1999). Preharvest factors affecting postharvest texture. Postharvest Biology and Technology, 15: 249-254.

Silva, V. F., Bezerra Neto, F., Negreiros, M. Z. and Pedrosa, J. F. (2000). Comportamento de cultivares de alface em diferentes espaçamentos sob temperatura e luminosidade elevadas. Horticultura Brasileira 18 : 183-87.

Thomas, R.L., R.W. Sheard and J.R. Moyer, (1967). Comparison of conventional and automated procedures for nitrogen, phosphorus and potassium analysis of plant materials using a single digestion. Agron. J., 59: 240-243.

White, P.J. and M.R. Broadley, (2003). Calcium in plants. Ann Bot., 92(4): 487-511.

Yuan, W., (2018). Effect of Foliar Application of $CaCl_2$ on Lettuce Growth and Calcium Concentrations with Organic and Conventional Fertilization. Hort. Sciences 53(6):891–894.

تقييم الانتاجية والجودة لخس الرومين والايسبرج تحت ظروف سيوة

سيد سعد جمعة و محمد عبد المعطى عبد اللطيف السجان

قسم الانتاج النباتى – مركز بحوث الصحراء – المطرية – القاهرة – مصر

أجريت التجارب خلال موسمين شتويين متتاليين (2017-2018 ، 2018-2019) فى الحقل المكشوف بمحطة بحوث سيوة ، خط عرض ’12 °29 ، خط طول ’29 °25 ، 18 متر تحت مستوى سطح البحر ، محافظة مرسى مطروح ، مصر ، لتقييم تأثير ثلاث كثافات نباتية ومستويين من الرش الورقى بالكالسيوم المخلبى على نمو ومحصول وجودة اثنين من طرز الخس. الاصناف دارك جرين و ماسون الممثلين لكلى طرز الخس الرومين والايسبرج تم شتلهما على مسافات زراعية 25 x 20 ، 25 x 25 و 25 x 30 سم لاعطاء كثافة نباتية فى حدود 20 ، 16 ، 13 نبات لكل متر مربع وتم معاملتها بالرش الورقى بالكالسيوم المخلبى بتركيز 300 ، 200 جزء بالمليون بالاضافة الى معاملة المقارنة. وقد أظهرت النتائج أنه بغض النظر عن نقص عدد الرؤوس القابلة للتسويق لكل حوض فان الكثافة النباتية المنخفضة حسنت من متوسط وزن الرأس ، قطر الرأس ، حواف الأوراق المحترقة ، صلابة الرؤوس، بالاضافة الى تحسين مكونات القيمة الغذائية مثل نسبة المادة الجافة ، حامض الاسكوربيك ومحتوى الرؤوس من البوتاسيوم والكالسيوم. كما اوضحت النتائج ان معاملتى الرش بالكالسيوم كان لهما تأثير ايجابى على محصول الخس ومعظم صفات الجودة بالمقارنة مع عدم الرش. باستثناء متوسط وزن الرأس، قطر الرأس ، صلابة الرأس ، احتراق حواف الأوراق ونسبة المادة الجافة فان الصنف دارك جرين ممثلا للطراز رومين أعطى أعلى عدد من الرؤوس القابلة للتسويق فى وحدة المساحة ، اعلى محصول مبكر، اعلى محتوى للرؤوس من الماء ، حامض الأسكوربيك ، البوتاسيوم والكالسيوم. يوصى بزراعة شتلات الخس طراز الرومين بكثافة عالية (20 نبات/م^2) مع الرش الورقى بالكالسيوم المخلبى.