

Plant Growth, Fruit Yield and Mineral Content of Bottle Gourd (*Lagenaria siceraria* M) as Affected by Plant Density and Nitrogen Fertilizer

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Abstract: This experiment was carried out during two successive summer seasons of 2012 and 2013 on bottle gourd landrace El-Arishy (*Lagenaria siceraria* M) at the Experimental Research Farm of the Faculty of Agriculture, Suez Canal University, Ismailia, Egypt to study the effect of plant density and nitrogen fertilizer on plant growth, yield and its components as well as mineral content. The obtained results showed that the low plant population (1750 plant per fad.) gave the highest shoot fresh weight, shoot dry weight, average fruit weight, average fruit length and nitrogen content in shoots and fruits. However, the significant highest fruit yield and fruit number per faddan were associated with the high plant population (3500 plant per faddan). All previous mentioned parameters in addition to shoot and fruit phosphorus contents significantly improved by application of high nitrogen rate (20g/plant). Shoot and fruit potassium and phosphorus contents were not affected significantly by plant spacing. Fruit potassium content did not affect significantly by nitrogen fertilizer. All the above mentioned parameters were significantly higher with the interaction between low plant population (1750 plant per fad.) was combined with high nitrogen rate (20g/plant), except fruit yield (ton/fad.) and fruit number which increased by the combination of high plant population with high nitrogen rate. Potassium content did not affect by the interaction between plant spacing and nitrogen fertilizer.

INTRODUCTION

Bottle gourd (*Lagenaria siceraria* M) is a diploid ($2n = 2x = 22$) belonging to the genus *Lagenaria* of the *Cucurbitaceae* family (Beevy and Kuriachan, 1996). The bottle gourd can be easily distinguished from other pumpkin varieties by its white flowers and characteristic of fruit, seed and leaf shapes (Cutler and Whitaker, 1967). Worldwide, bottle gourd is grown for its young fruit which used as a vegetable. The fresh fruit, which usually has a light green smooth skin and a white flesh, is frequently used in many regions of Asia and Africa as either a stir-fry or soup vegetable ingredient (Morimoto and Mvere, 2004). Furthermore, in India different plant parts, especially the fruit juice can be used as medicine to cure stomach elements (Haque *et al.*, 2009). Another recent utilization of bottle gourd is as rootstocks for watermelon against soil-born diseases and low soil temperature (Yetisir and Sari, 2003).

Bottle gourd was one of the first crops to be domesticated. Based on archaeological evidence, bottle gourd is presumed to have been domesticated in Africa (Decker-Walters *et al.*, 2004; Whitaker, 1971) and might have dispersed to the new world by ocean currents or by human migration in pre-historic times (Erickson *et al.*, 2005; Morimoto *et al.*, 2005). Africa is believed to be the center of genetic diversity for bottle gourd, although wild progenitors of bottle gourd have not been identified there (Whitaker, 1971).

The relationship between crop yield and planting density (number of plant unit area) is of considerable agronomic interest (Holliday, 1960; Thorenley, 1983). It is clear that the density dependent effects on the yield are due to the competition between adjacent plants for the necessary natural resources. There is a basic assumption that a plant located at a given site is constrained to draw nutrients only from its immediate vicinity and this zone may be larger than the size of the actual plant both on the surface and into the ground (Pant *et al.*, 1979). Since competition between plants greatly affect yield (Thorenley, 1983; Willey and Heath,

1969) it is therefore possible to adjust size of the harvested crop to meet the requirements of the market by manipulating density (Cushman *et al.*, 2004). Effect of plant density on the yield and its component in cucurbita crops (Ban *et al.*, 2011; Abd el Hamed and Elwan, 2011; Babayee *et al.*, 2012; Latifi *et al.*, 2012; Baloch *et al.*, 2013) were studied.

Mineral fertilizers application is essential for plant growth, development and productivity of plants. However, the excessive amounts of nitrogen fertilizer would lead to un-favorite effect on the growth and yield of plants and will lead to increase the losses of nitrogen fertilizer. So, the adequate amounts of nitrogen fertilization led to improve growth, yield and quality. There are some supporting studies that N fertilization affects plant growth and yield of cucurbita plants (Heidari and Mohammad, 2012; Ndor and Dauda, 2013; He-xi *et al.*, 2011; Ng'etich *et al.*, 2013).

A few literatures were found on the interaction effect between the plant density and nitrogen fertilizer on the yield and its components of cucurbitaceae (Rieners and Riggs, 1997; Goreta *et al.*, 2005; Sabo *et al.*, 2013) and there is only one publication was found on bottle gourd (Jan *et al.*, 2000).

This study was done with the objective of testing the hypothesis whether the interaction between nitrogen fertilizer and plant density will affect plant growth, yield and mineral contents of bottle gourd plants (*Lagenaria siceraria* M) landrace El-Arishy collected from Sinai region under the condition of Ismailia Governorate or not.

MATERIALS AND METHODS

Plant materials and treatments

This investigation was carried out during two successive summer seasons of 2012 and 2013 on bottle gourd plants (*Lagenaria siceraria* M) landrace El-Arishy grown on sandy soil at the Experimental Research Farm of the Faculty of Agriculture, Suez Canal University, Ismailia, Egypt to study the effect of

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different plant density and nitrogen fertilization levels on vegetative growth, yield and plant mineral content.

The soil of the experimental site was sandy in texture (85.21% sand, 11.5% silt and 3.29% clay) with EC 1.5 dsm⁻¹ and pH 7.31 (average the two seasons). The soil was prepared by adding 20 m³ per faddan of farmyard manure. Afterward, the ridges were completed and drip lines were placed. During the growing season, weeds, pests, and diseases were controlled periodically and all the experimental units received the normal cultural practices.

Seeds of bottle gourd landrace El-Arishy were sown in 84-cell styrophom trays under greenhouse conditions from the beginning of March. The trays were filled with soil mixture (Peat moss and vermiculite mixes in 1:1 v/v, enriched with different nutrients). After emerging, seeds were watered regularly with diluted fertilizer solution (0.2g/L of 6:6:6, N: P: K composite fertilizer). At four true leaves stage, the seedlings were transplanted to the open field in the middle of April.

Two factors, plant density and nitrogen level were studied. Plant densities were 60cm (3500 plant/faddan), 90cm (2350 plant/faddan) and 120cm (1750 plant/faddan). For nitrogen fertilizer factor, two rates was applied, the first was 10g N/ plant which equal to 35, 23.5 and 17.5kg N per faddan for tested plant densities, respectively. The second one was 20g N/plant which equal to 70, 47 and 35kg N per faddan for tested plant densities, respectively. Ammonium nitrate (33.5%) as nitrogen source was used and the application started after one month from transplanting.

Experimental design

The experiment involved three plant densities and two rates of nitrogen fertilizer. Consequently, the experiment comprised of six combinations of treatments, arranged in a complete randomized blocks, laid out in split plot design and each treatment was replicated three times. Each experimental unit contained 41, 27 and 20 plants for each plant density, respectively. The main plots represented the plant density, while the nitrogen fertilizer was devoted to the sub plot. The experimental unit represented by a single ridge of 25m length and 2m width. Drip irrigation system was used in this district.

Recorded data

Plant growth and yield:

Fresh and dry weights of the vegetative growth were determined after 4 months from transplanting. At maturity stage, four harvests were taken to calculate fruit yield characters such as average fruit weight (kg/fruit), average fruit length (cm), average fruit number per faddan and average fruit yield per faddan.

Mineral contents:

Samples of shoots and fruits were taken at the end of the experiment (after 4 months from transplanting), oven dried at 70°C till constant weight. Dried samples were pulverized separately and samples of 0.5gm each were digested with a mixture of sulfuric acid and hydrogen peroxide. The percentage (%) of nitrogen was estimated using semi-micro-Kjeldahl method as described by Bremner (1996). The percentage (%) of

potassium was determined by flame photometer according to Page (1982). Also, phosphorus percentage (%) was analyzed by a vanadate-molybdate method at 660 nm using spectrophotometer (Chapman and Pratt, 1982).

Statistical analysis:

Data were organized in split plot design in a completely randomized block (CRBD) and three replications, in which each replication was considered as a block. Experimental data were analyzed by analysis of variance (ANOVA) using CoStat. LSD test was used to compare the treatments means at 0.05% significance level of probability.

RESULTS AND DISCUSSION

1- Foliage fresh and dry weight:

Results presented in Table (1) regarding the main effects of plant density and nitrogen fertilizer level as well as their interaction on fresh and dry weight after four months from transplanting. The results show that the fresh and dry weights of bottle gourd were significantly decreased with increasing plant population (high plant density). This decrement was 15.25% and 19.33% for fresh weight and 21.09% and 12.50% for dry weight in the two seasons, respectively. The wider plant spacing gave the highest fresh and dry weight of bottle gourd in both seasons, this increment due to less competition for nutrients and other essential factors such as light and CO₂. Our results are supported by the results of Babayee *et al.* (2012) who indicated that the dry weight of *Cucurbita pepo* was increased by increasing plant density.

Regarding the main effect of nitrogen fertilizer level, the results showed that fresh and dry weight were increased significantly with increasing nitrogen level from 10 to 20g N/plant in both seasons. This increase was 20.73% and 15.05% for fresh weight and 42.9% and 7.25% for dry weight in the first and second seasons, respectively. It is well known that, nitrogen is one of the most important nutrients in crop production, because it affects photosynthetic efficiency and leaf development, which leads to dry matter production (Dordas and Sioulas, 2008). Also, nitrogen has a vital importance for plant growth due to being a part of amino acids, proteins, enzymes and chlorophyll molecules (Devlin and Witham, 1986). These results, regarding to a positive correlation between higher nitrogen level and higher fresh and dry weight are in accordance with the results of (Swaidar *et al.*, 1994; Olaniyi and Akanbi, 2007; Ng'etich *et al.*, 2013 and Oloyede *et al.*, 2013a, b) who reported that dry weight was increased with increasing nitrogen fertilization levels.

Concerning the interaction effects of plant population and nitrogen fertilizer, the presented data Table (1) proved that plants cultivated at low plant population (1750 plants/fad.) and fertilized with the higher nitrogen level (20g N/fad.) produced bottle gourd plants with high fresh and dry weights and this effect was significant in both seasons.

2- Fruit yield characters:

Main effects of plant population and nitrogen fertilizer and their interactions on average fruit weight (kg/fruit), average fruit length (cm), total fruit number and total fruit yield (ton/fad.) are presented in Table (2) and 3. The presented data reveal that significant highest

average fruit weight and average fruit length were associated with plants cultivated at low plant population.

However, fruit yield as well as fruit number per faddan were markedly increased by increasing number of plants per faddan (low plant density) in both seasons.

Table (1): Effect of plant population, nitrogen levels and their interactions on fresh and dry weight of El-Arishy bottle gourd landrace during the two seasons of 2012 and 2013.

Treatments		Fresh weight (g)		Dry weight (g)	
Plant population/fad	N-rates (g/plant)	2012	2013	2012	2013
1750		2658.50 a	3021.83 a	426.00 a	466.16 a
2350		2441.33b	2696.00 b	360.16 b	433.50 b
3500		2253.16c	2437.66 c	336.16 c	407.91 c
	10	2220.77 b	2528.22b	308.00 b	420.41 b
	20	2681.22a	2908.77a	440.22 a	451.30 a
1750	10	2445.00 b	2599.66 bc	374.66 b	443.94 b
	20	2872.00 a	3444.00 a	477.33 a	488.39 a
2350	10	2438.66 b	2650.00 b	299.33 c	411.05 c
	20	2444.00 b	2742.00 b	421.00 ab	455.94 b
3500	10	1778.66 c	2335.00 c	246.33 c	406.23 c
	20	2727.66 a	2540.33 bc	418.66 b	409.59 c

Values are the means of 3 plants per replicate (from 3 replicates). Values followed by the same letter within a column are not significantly different at the 0.05 level of probability according to LSD test.

The average fruit weight reduction associated with increasing plant population was compensated by the increasing in the number of fruits due to the increase in number of plants which resulted in overall increase in yield (Abd El Hamid and Elwan, 2011). These results are in conformity with those of Jan *et al.* (2000) on bottle gourd, Cushman *et al.* (2001) on pumpkin, Edelstein and Nerson (2001) on watermelon and Nerson (2002) on muskmelon, who reported that increasing plant population decreased the average fruit weight.

Fruit yield (number and ton/fad.) decreased in low plant population probably due to the environmental factors including light, space, water and soil which are not optimally used (Cormark and Smith, 1998; Rassam *et al.*, 2007) and the decrease in number of fruit per area at low population could be attributed to reduction in number of plants per hectare and this consequently, reduce the number of fruitful branches (Knavel, 1988; Walters and Schultheis, 2000). These results are in a good line with those reported by Shukla and Prabhakar (1987) on bottle gourd, Maynard and Scott, 1998 on muskmelon, Jan *et al.* (2000) on bottle gourd, Kultur *et al.* (2001), Goreta *et al.* (2005), Ban *et al.* (2006), Ban *et al.* (2011) on watermelon, who reported that total yield and numbers of fruit per hectare were linearly increased with the increase in plant population.

Regarding to the main effect of nitrogen fertilizer, the results in Tables 2 and 3 illustrate that significantly the highest average fruit weight, average fruit length,

total fruit yield and total fruit number per faddan were obtained in plants received higher nitrogen level (20g N/plant), in both seasons. The increment in nitrogen fertilization lead to vigorous growth which increased the net photosynthetic capacity of plants, and thus the plants produced more fruits per plant and per hectare (Kultur *et al.*, 2001). The obtained results are in harmony with some studies which reported that increasing nitrogen application, increased fruit yield, fruit number per ha and average fruit weight (Jan *et al.* (2000) on bottle gourd; Ansary *et al.* (2004) and Harrelson *et al.* (2008) on pumpkin; Ahmed *et al.* (2007) and He-xi *et al.* (2011) on cucumber).

Interaction effect between plant population and nitrogen fertilizer on fruit characters are presented in Tables 2 and 3. Results show that (Table 2), in most cases, the highest values of average fruit weight and average fruit length were observed in fruits of bottle gourd plants cultivated at low plant population and fertilized with high nitrogen rate (20g N/plant). However, the highest fruit yield and fruit number per faddan were noticed when higher plant population (3500 plants per faddan) interacted with high nitrogen rate (20g N/faddan).

3- Plant mineral elements content:

The effect of plant population and nitrogen rate and their interaction on the content of NPK percentage in shoots (leaves + stems) and fruits of Al-Arishy bottle

gourd genotype in the two seasons are presented in Tables 4 and 5. The results of plant population show that nitrogen percentage in shoots and fruits significantly decreased with increasing number of plants per faddan in both seasons. However, the percentage of phosphorus and potassium contents were not significantly affected by plant population in both seasons (Tables 4 and 5). The percentage of nitrogen

and phosphorus were increased significantly by increasing nitrogen level from 10g N/plant to 20g N/plant. However, shoots and fruits potassium content did not significantly change by increasing nitrogen rate in both seasons (Tables 4 and 5). The higher N content in nitrogen fertilized plants could be connected with the positive effect of nitrogen in some important physiological processes (Chaturved, 2005).

Table (2): Effect of plant population nitrogen levels and their interactions on average of fruit weight and fruit length of El-Arishy bottle gourd landrace, during the two seasons of 2012 and 2013.

Treatments		Average fruit weight (kg/fruit)		Average fruit length (cm)	
Plant population/fad	N-rates (g/plant)	2012	2013	2012	2013
1750		0.79 a	0.62 a	28.55 a	26.33 a
2350		0.73 b	0.52 b	27.93 a	25.63 b
3500		0.60 c	0.46 c	26.15 b	24.58 c
	10	0.69 b	0.50 b	27.06 b	25.22 b
	20	0.72 a	0.56 a	28.02 a	25.81 a
1750	10	0.78 b	0.57 b	28.26 ab	26.06 b
	20	0.81 a	0.66 a	28.83 a	26.60 a
2350	10	0.72 d	0.50 c	27.80 ab	25.43 bc
	20	0.74 c	0.53bc	28.06 ab	25.83 b
3500	10	0.57 f	0.43 d	25.13 c	24.16 d
	20	0.63 e	0.49 c	27.16 b	25.00 c

Values are the means of 3 plants per replicate (from 3 replicates). Values followed by the same letter within a column are not significantly different at the 0.05 level of probability according to LSD test.

Table (3): Effect of plant population, nitrogen levels and their interactions on fruit yield and numbers of El-Arishy bottle gourd landrace, during the two seasons of 2012 and 2013.

Treatment		Total fruit No./fad.		Total fruit yield (Ton/fad.)	
Plant population/fad.	N-rates (g/plant)	2012	2013	2012	2013
1750		6006 c	4277 c	4.79 c	2.69 c
2350		9534 b	8736 b	6.97 b	4.56 b
3500		12768 a	12467 a	7.76 a	5.84 a
	10	8596 b	7401b	5.72 b	3.54 b
	20	10276 a	9585a	7.30 a	5.18 a
1750	10	5124 f	2912 f	3.99 e	1.68 d
	20	6888 e	5642 e	5.59 d	3.71 c
2350	10	8904 d	7644 d	6.42 c	3.88 c
	20	10164 c	9828 c	7.53 b	5.24 b
3500	10	11760 b	11648 b	6.75 c	5.06 b
	20	13776 a	13286 a	8.76 a	6.61 a

Values are the means of 3 plants per replicate (from 3 replicates). Values followed by the same letter within a column are not significantly different at the 0.05 level of probability according to LSD test.

These results are in conformity with Aroiee and Omidbaigi (2004) on pumpkin, Goreta *et al.* (2005) on watermelon, Olaniyi and Akanbi (2007) on pumpkin and Herdari and Mohammad (2012) on bitter melon who reported that mineral elements contents in the shoots and fruits increased as application of nitrogen increased.

Concerning the interaction effect of plant population and nitrogen fertilizer, the results show that there was no clear trend for nitrogen and phosphorus percentage, in bottle gourd shoots and fruits in both seasons. In

addition the highest nitrogen and phosphorus values were found in shoots and fruits of plants obtained from low population (1750 plant per faddan) combined with high nitrogen level (Tables 4 and 5). The presented results showed generally that potassium content in shoots and fruits did not affect significantly by any interaction treatments in both seasons (Tables 4 and 5).

In conclusion, the results showed that the higher fruit yield (ton/fad.) and fruit number were found in the combination of high plant population (3500 plant/fad.) with high nitrogen rate (20g N/plant).

Table (4): Effect of plant population, nitrogen levels and their interactions on foliage NPK percentage of El-Arishy bottle gourd landrace, during the two seasons of 2012 and 2013.

Treatment		N%		P%		K%	
Plant population/fad.	N-rates (g/plant)	2012	2013	2012	2013	2012	2013
1750		2.02 a	2.11 a	0.28 a	0.28 a	3.08 a	2.22 a
2350		1.83 b	2.06 a	0.27 a	0.30 a	3.03 a	2.27 a
3500		1.76 b	1.79 b	0.24 a	0.25 a	3.28 a	2.63 a
	10	1.73 b	1.81 b	0.24 b	0.24 b	3.10 a	2.29 a
	20	2.01 a	2.16 a	0.29 a	0.31 a	3.16 a	2.45 a
1750	10	1.59 b	2.00 bc	0.25 c	0.24 b	3.03 a	2.22 a
	20	1.94 a	2.22 ab	0.30 ab	0.31 ab	3.14 a	2.22 a
2350	10	2.07 a	1.87 c	0.23 c	0.26 ab	3.14 a	2.22 a
	20	1.60 b	2.25 a	0.25 bc	0.35 a	2.92 a	2.33 a
3500	10	2.00 a	1.58 d	0.25 bc	0.23 b	3.30 a	2.44 a
	20	2.04 a	2.00 bc	0.32 a	0.27 ab	3.25 a	2.82 a

Values are the means of 3 plants per replicate (from 3 replicates). Values followed by the same letter within a column are not significantly different at the 0.05 level of probability according to LSD test.

Table (5): Effect of plant densities, nitrogen levels and their interaction on fruit NPK percentage of El-Arishy bottle gourd landrace, during the two seasons of 2012 and 2013.

Treatment		N%		P%		K%	
Plant population/fad.	N-rates (g/plant)	2012	2013	2012	2013	2012	2013
1750		1.76 a	1.60 a	0.33 a	0.30 a	2.98 a	3.22 a
2350		1.57 b	1.27 b	0.36 a	0.30 a	3.16 a	3.08 a
3500		1.33 c	1.09 c	0.33 a	0.31 a	3.06 a	3.01 a
	10	1.29 b	1.19 b	0.32 b	0.29 b	2.96 a	3.07 a
	20	1.82 a	1.44 a	0.36 a	0.31 a	3.18 a	3.14 a
1750	10	1.52 ab	1.52 ab	0.32 b	0.29 a	2.87 a	3.14 a
	20	2.04 a	1.68 a	0.34 b	0.31 a	3.09 a	3.30 a
2350	10	1.30 b	1.17 c	0.33 b	0.28 a	3.08 a	3.08 a
	20	1.68 ab	1.36 bc	0.39 a	0.31 a	3.25 a	3.08 a
3500	10	1.17 b	0.88 d	0.33 b	0.29 a	2.92 a	2.98 a
	20	1.61 ab	1.29 bc	0.34 b	0.32 a	3.20 a	3.03 a

Values are the means of 3 plants per replicate (from 3 replicates). Values followed by the same letter within a column are not significantly different at the 0.05 level of probability according to LSD test.

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تأثير الكثافة النباتية ومعدل التسميد النتروجيني على النمو الخضري والمحصول ومحتوى النبات من العناصر المعدنية في اليقطين

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اجريت هذه الدراسة خلال صيف موسمي ٢٠١٢ و ٢٠١٣ على نبات اليقطين (صنف العرايشي) وذلك في مزرعة قسم البساتين كلية الزراعة - جامعة قناة السويس، لدراسة تأثير الكثافة النباتية ومعدل التسميد النتروجيني على نمو النبات و المحصول وتركيز العناصر المعدنية. اظهرت النتائج المتحصل عليها ان الكثافة النباتية المنخفضة (١٧٥٠ نبات/فدان) اعطت اعلى وزن طازج وجاف للنبات واعلى متوسط وزن وطول للثمار واعلى تركيز للعناصر المعدنية (ن، فو ، بو) في كلا من المجموع الخضري والثمار. بينما اعطت الكثافة النباتية العالية (٣٥٠٠ نبات/فدان) اعلى محصول للفدان واعلى عدد من الثمار للفدان. تأثرت جميع القياسات سابقة الذكر بالإضافة الى محتوى المجموع الخضري والثمار من الفوسفور معنويا بزيادة معدل التسميد النتروجيني (٢٠ جرام نتروجين/النبات). لم يتأثر محتوى المجموع الخضري والثمار من عنصر البوتاسيوم والفوسفور بالكثافة النباتية وايضا لم يتأثر محتوى الثمار من عنصر البوتاسيوم معنويا بالتسميد النتروجيني. تأثرت معنويا جميع القياسات تحت الدراسة عند تفاعل الكثافة النباتية المنخفضة (١٧٥٠ نبات/الفدان) مع معدل التسميد النتروجيني العالي (٢٠ جرام/النبات) باستثناء كل من المحصول (طن/الفدان)، وعدد الثمار للفدان حيث تأثرا معنويا عند تفاعل الكثافة النباتية العالية مع معدل التسميد النتروجيني العالي، اما عنصر البوتاسيوم فلم يتأثر معنويا بالتفاعل بين الكثافة النباتية مع التسميد النتروجيني.