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EFFECT OF PLANT DENSITY ON BULB YIELD AND QUALITY OF ONION (*Allium cepa L.*) UNDER NEWLY RECLAIMED SOIL CONDITIONS

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ABSTRACT

Two field experiments were carried out at Nubaria Agriculture Research Station farm (calcareous soil) during the two successive seasons of 2002/2003 and 2003/2004 to investigate the effect of four planting densities i.e., 40, 60, 80 and 100 plants per squre meter on plant growth, bulb yield and its components as well as economical income per feddan (fed = 4200 m^2).The obtained results showed that:

1. Plant growth expressed as plant length and number of leaves per plant were significantly affected by number of plants/ m^2 where increasing planting rate from 40 to 60, 80 and 100 plants/ m^2 increased plant length and decreased number of produced leaves/plant.
2. The highest total and marketable bulbs yield were connected with the higthest plant density i.e., planting five rows per ridge 50 cm in width and 10 cm a part between transplants (100 plants/ m^2). At the same time no significant differences were noticed among the studied plant densities in number of days elapsed from planting to maturiety, percentage of single, double and bolter bulbs.
3. The average bulb weight was decresaed with increasing plant density.
4. In view of the economical study, the profitability assessment on produced total and marketable yield showed clearly that the best rate of plant density was 100 plants/ m^2 followed by 80 plants/ m^2. Also, the highest net income values (11072 and 4339 L.E./fed) and investiment ratio (3.58 for both) were obtained under plant densities100 and 80 plants/ m^2, respectively.

INTRODUCTION

Onion (*Allium cepa L.*) is one of the most important bulb crops grown all over the world. In Egypt, it is grown as a regetable crop at a large scale either for exportation or local consumption. In the last decates the average Egyption exportable yield was increased, this might be caused to increase the onion price in local markets. Moreover, Egypt faced a national problem due to the fact that the population increasing rate is grater than that of crops production. Increasing crop production can be achived either within increasing the cultivated area or by increasing the yield per unit area. Increasing the yield per unit area can be done through the application of proper agricultural practices, amonmg them

transplanting on the proper plant density. In this respect, it was found that plant density as number of plants /unit area, number of rows/plot, the distance between rows or number of rows/ridge affected on plant growth experssed as plant length, and number of leaves/plant (Moustafa, 1979; El-Habbasha *et al.*, 1984; Koriem *et al.*, 1990; El-Sheekh *et al.*, 1994; El-Gamili, 1996; Rizk, 1997; Naik and Hasamani, 2003 and Karam, 2005) as well as total produced yield and its components; (Shaheen and El-Habbash, 1985; Staofella 1996; Abd El-Rahim *et al.*, 1997; Qukal, 1999; Rumpel and Felczycnshi, 2000 and Karam, 2005). Therefor, this study was carried out to investigate the effect of increasing plant density on plant growth, total produced bulb yield and its components as well as to assese and compare of farm profitability of all tested variables under Nubaria area conditions (calcareous soil).

MATERIALS AND METHODS

Two field experiments were carried out at the Farm of Nubaria Agricultural Research Station in North Tahrir area, during the two winter successive seasons of 2002/03 and 2003/04 to elucidate the effect of plant density on growth, yield and bulb quality of Onion (*Allium cepa L*). The soil of the experimental field was a calcareous sandy loam in texture with pH 8.3 and total $CaCO_3$ percentage was about 22%. Data for chemical and physical analysis of the experimental fields are shown in Table (1).

Seeds of onion cv. Giza 20 were sown in the nursery on 5th and 6th of October during the two growing seasons of study, respectively. Seventy days after seeds sowing seedlings were transplanted in the permenant field according to the tested plant density i.e., 40, 60, 80 and 100 plants/ m^2 as follows.

1- Seedlings were transplanted on both sides of ridge at 10 cm a part, i.e., two rows/ridge in case of 40 plants/ m^2.
2- Seedlings were transplanted on both sides and top of ridges at 10 cm a part, i.e., three rows/ridge in case of 60 plants/ m^2.
3- Seedlings were transplanted on both sides of ridges in two rows per each side of ridge at 10 cm a part, i.e., four rows/ridge in case of 80 plants/ m^2.
4- Seedlings were transplanted on top and both sides of ridges in two rows per each side of ridge at 10 cm a part, i.e., five rows/ridge in case of 100 plants/m^2.

Each experimental plot consisted of four ridges 50 cm in width and 3.5 m in length with an area about 7 m^2.A completely randomized block design with four replicates was adopted. Recommended doses of nitrogen, phosphorus and potussium fertilizers were added at rate of 90 kg N, 45 kg P_2O_5 and 48 kg K_2O fed^{-1} as ammonium sulphate, calcium super phosphate and potassium sulfate used as a source of nitrogen, phosphorus and potussium, respectively. The amounts of fertilizers were divided into two equal portions.The first part was added one month after transplanting and the other one was added one month later. Other agricultural practices required for onion prduction were done as commonly followed in the district. Also, evaluation of the farm profitability of all used variable in this study was conducted.

Table (1): Some physical and chemical properties of the experimental soil

Soil characteristics	2002/2003		2003/2004	
Soil depth (cm)	**0 – 20**	**20 - 40**	**0 - 20**	**20– 40**
Soil pH (1:2.5)	8.19	8.22	8.20	8.23
EC, dS/m	2.11	2.24	1.84	1.96
Soil texture	S.L.*	S.L.	S.L.	S.L.
$CaCO_3$ %	23.16	25.42	24.31	26.52
Organic matter %	0.31	0.19	0.38	0.27
Availa. maro.				
N, ppm	46.38	33.72	52.71	41.16
P, ppm	4.14	3.65	4.42	3.74
K, ppm	91.36	84.31	102.26	89.24
Availa. micro.				
Zn, ppm	0.21	0.17	0.24	0.16
Fe, ppm	3.40	2.60	4.10	2.80
Mn, ppm	0.94	0.83	1.10	0.87
Soluble cations				
Ca, meq/l	7.68	7.10	6.68	7.17
Mg, meq/l	2.13	2.46	1.85	2.11
Na, meq/l	8.63	9.73	7.98	8.34
K, meq/l	2.66	3.11	1.89	1.98
Soluble anions				
CO_3, meq/l	--	---	---	---
HCO_3, meq/l	4.52	4.78	3.25	3.62
Cl, meq/l	10.11	11.35	9.16	9.85
SO_4, meq/l	6.47	6.27	5.99	6.13

* S.L.: Sandy loam

During both seasons of the experiment, the following data were recorded ...

1) Vegetative growth characters :-

During the growing season, 120 days after transplanting, 15 plants were taken as a representative sample from each experimental plot to measure both plant length and number of tubular leaves per plant..

2) Days to maturity:-

Number of days from transplanting to maturity was recorded. Maturity was determined by both neck softening and 5o% topsdown.

3) Bulb yield and its components:-

At harvest, all plants in each experimental plot were pulled and the following data were recorded.:

a- Total yield:-

It was calculated on basis of yield for the experimental plot as tons/ fed.

b- Marketable yield:-

Weight of single bulbs as tons/fed.

c- Average weight of single bulb :-

It was calculated by dividing weight of single bulbs by its number.

d- Percentage of single, double and bolter bulbs :-

It was estimated by dividing number of single, double or bolters bulbs by the total number of bulbs per plot X100.

All the obtained data were subjected to the statistical analysis according to Gomez and Gomez (1984). Farthermore, the whole tested variables were economically analyzed by calculating the inputs and outputs of production as an average for the two experimental seasons. The net income and investment ratios for all variables were compared to evaluate the farm profitability of all tested variables. Means were separated according to Duncan's Multiple Range Test using Costat Software (1985).

RESULTS AND DISCUSSION

1- Vegetative growth characters :-

Data presented in Table (2) show the effect of different studied plant densities on vegetative growth aspects expressed as plant height and number of leaves per plant during both seasons of study.Such data reveal that there were differences among the tested plant densities in plant lenght and number of produced tubular leaves per plant during both seasons of study. In this respect increasing the plant density from 40 plant/m^2 (planting two rows/ridge) up to100 plant/ m^2 (planting five rows/ridge) resulted increasing plant length. On the contrarly, increasing plant density per unit area by transplanting at rate of 60, 80 and 100 plants/m^2 led to a decrease in number of produced leaves/plant.Obtained results are true during both seasons of growth. Such results may be due to the competetion on the light and nutrients as well as between plants which inturn affect on plant lenght and number of leaves produced by plants. In this regard, Muostafa (1979), Mc-Geary (1985) and Vasets-kii and Ostroverkhov (1986) repoted that growth rate of onion plants varied greatly according to the number of plants per unit area. In addition, El-Habbasha *et al.* (1984), Koriem *et al.* (1990), El-Sheekh *et al.* (1994), El-Gamil (1996), Rizk (1997) and Karam (2005) repoted Simular results on plant growth aspects under different planting densities.

Table (2): Effect of plant density on vegetative growth characters of onion plant in the two seasons.

No. of plants per m^2	Plant height (cm)		No. of leaves/plant	
	Seasons		Seasons	
	2002/03	2003/04	2002/03	2003/04
40	63.63 b	53.33 b	8.13 a	7.05 a
60	65.63 ab	54.73 b	7.73 ab	6.85 a
80	66.57 ab	58.03 ab	7.30 b	6.95 a
100	67.70 a	62.67 a	7.25 b	6.18 b
LSD at 0.05	2.96	6.67	0.54	0.65

2- Days to maturity :-

Data recorded in Table (3) reveal that increasing plant density through planting at a rate of 60, 80 or 100 plant/m^2 hastened the maturity of bulbs by decreasing the number of days elapsed from transplanting to maturity during both seasons of experiments. Such decrements in number of days from transplanting to maturity among the tested rates of plant density did not reach the level of 0.05 significancy during the two seasons of growth. Such delaying in maturity as a result of widest planting, i.e., growing the plants in two rows on ridges 50 cm apart (40 plant/m^2) may be attributed to the abundance of nutrients and water as well as higher photo- assimilation rate which in turne affect and increase the period of vegetative phase of plant growth and concequently delatied bulbing and maturity time. Obtained results are confermed with those reported by Brewster (1994). On the other hand, Weerasinghe *et al.* (1994, used 100 – 600 plant/m^2) and Rumpel and Felczynski (1997, used 140 plant/m^2) reported opposite results in this respect.

Table (3): Effect of the plant density on days to maturity character of onion plant in the two seasons

No. of plants/m^2	Seasons	
	2002/03	2003/04
40	152.75	139.00
60	160.00	136.50
80	148.52	137.75
100	153.75	134.00
LSD at 0.05	NS	NS

3- Bulbs yield and its components :-

Data recorded in Table (4) shows the effect of plant density on total bulb yield and its components.

a- Total and marketable yield :-

Such data indicate that there were significant differences among the tested planting densities in total and marketable bulb yield as well as average weight of bulb during the two seasons of study. In this regard, the higher plant density i. e., transplanting at rate of five rows per ridge (100 plant/m^2) reflected the highest values for both total and marketable bulb yields during the two seasons of growth. On the other hand, the lowest values in such traits were obtained as a result of transplanting two rows per ridge (40 plant/m^2). In this respect, Abd El-Rehim *et al.* (1997); Rizk (1997); Rumpel and Felczynski (1997); Visser and Berg (1998); Dellacecca *et al.* (2000); Rumpel and Felczynski (2000); Kanton *et al.* (2002) and Karam (2005), all working on onion, repoted that total bulb yield and its components were affected by tested plant densities either as plant spacing, number of rows per ridge or number of plants per unit area.

b- Average weight of bulb: -

As for the effect of plant density on the average bulb weight, the same data in Table (4) show that increasing the rate of planting from 40 plants/ m^2 up

to100 plants/ m^2 led to a significant and continous decrease in average weight of produced bulb. Such results are true during the two seasons of growth. Decreasing the average bulb weight with increasing planting rate may be expected due to the competion on different growing factors (nutrients and water) between plants which in turne affec plant growth. In this respect, such decrease in bulb weright with increasing the plant density was repoted by Abd El-Rehim and *et al.* 1997; Dellacecca and *et al.*, 2000, and Kanton and *et al.*, 2002).

Table (4): Effect of plant density on the total and marketable yield and average bulb weight in the two seasons

No. of plants per m^2	Total yield (ton/fed.)		Marketable yield (ton/fed.)		Average bulb weight (g)	
	Seasons		Seasons		Seasons	
	2002/03	2003/04	2002/03	2003/04	2002/03	2003/04
40	19.99 c	19.12 c	19.71 c	18.73 d	139.10 a	120.00 a
60	25.13 b	23.29 b	24.85 b	22.37 c	98.95 b	95.75 b
80	25.42 b	26.40 b	24.99 b	25.38 b	69.48 c	76.25 b
100	31.56 a	29.87 a	31.27 a	29.13 a	76.13 c	75.50 b
LSD at 0.05	4.39	3.26	4.77	2.46	15.10	23.94

c-The Percentage of single, double and bolters:

The presence of double bulbs ad bolters in onion is an undesirable characters. Data on the percentage of single, double and bolter bulbs as affected by plant densities were recorded in Table (5). Such data show that there were no significant differences among the tested plant densities in the percentage of each of single bulbs, double and bolters bulbs during both seasons of the experiment. This might be related to the stable in the environmental conditions among the different plant density rates in the two seasons of growth.In this respect, Karam (2005) reported that the highest percentage and weight of culls bulbs were recorded in the case of wide spacing i.e. growing the plants in two rows per ridge 50 cm wide.

Table (5): Effect of plant density on the percentage of single, double bulbs and bolters of onion bulbs in the two seasons.

No. of plants per m^2	% of single bulbs		% of double bulbs		% of bolters	
	Seasons		Seasons		seasons	
	2002/03	2003/04	2002/03	2003/04	2002/03	2003/04
40	98.00	97.75	1.00	2.25	1.00	0.00
60	98.50	96.70	0.00	3.05	1.50	0.25
80	99.00	96.60	0.50	2.90	0.50	0.50
100	99.25	97.25	0.50	2.50	0.25	0.25
LSD at 5%	NS	NS	NS	NS	NS	NS

*** Profitability assessment:**

Data in Table (6) shown profitability calculations for the input values for different treatments under study, considering the appraisal of all costs and gains of cultivation process. Total input costs, outputs, net income and the investment ratio (IR) for all tested treatments were presented in Table (7). The obtained results and their discussion will be handled as follows:

1- The values of net income indicate the highest net income value (11072 L.E. fed^{-1}) was incorporated with the highest plant density rate (100 plants/m^2), followed by 80.60.
2- The increasing income (L.E. fed^{-1}) were by about 68.42 and 32% at 100, 80 and 60 plants/m^2 respectively.
3- The highest values of investment ration (I.R) were 3.58 and 3.582 and are attributed to 80 and 100 plants/m^2, respectively with insignificant different between them.

Table (6): Input production items and output of the experimental work (average of two seasons 2002/03 and 2003/04)

Items	Treatments/ fed.	Treatment Unit	Unit price (L.E.)
	(A) Inputs		
Land Preparation*	---	Per fed.	45
Mineral Fertilizers:			
N-Fertilizer	90 unit fed^{-1}	Kg N	1.79
P-Fertilizer	45 unit fed^{-1}	Kg P_2O_2	2.58
K-Fertilizer	48 unit fed^{-1}	Kg K_2O	4.17
Pesticides and Fungicides	---	Per fed.	710
Seeds: 40 Plants/m^2	3.0 Kg/fed.	Kg/fed.	60
60 Plants/m^2	4.5 Kg/fed		
80 Plants/m^2	6.0 Kg/fed		
100 Plants/m^2	7.5 Kg/fed		
Labour: 40 Plants/m^2	24 man+44 boy	Man	12
60 Plants/m^2	24 man+ 52 boy	Boy	8
80 Plants/m^2	24 man+58 boy		
100 Plants/m^2	28 man+79 boy		
Other Costs**			
-40 Plants/m^2	---	Per fed	1002
-60 Plants/m^2	---	Per fed	1032
Total yield:	(B) Outputs		
40 Plants/m^2	19.56	Ton/fed	500
60 Plants/m^2	24.21	Ton/fed	500
80 Plants/m^2	25.91	Ton/fed	500
100 Plants/m^2	30.72	Ton/fed	500

*Rent of agricultural machines.

**Rent or depreciation rate of irrigation machine, seed transporting, fertilizers, pesticides, fungicides, packing, tax, rent of land,....etc.

Table (7): Profitability assessment of the tested variable for onion crop under the present investigation (average of two seasons 2002/03 and 2003/04)

Plant density/m^2	Yield (ton/fed)			Inputs LE/fed	Outputs LE/fed	Net income LE/fed	Income increase LE/fed	Increase %	*IR
	1st Season	2nd Season	Average						
40	19.99	19.12	19.56	3192	9780	6588	—	—	3.064
60	25.13	23.29	24.21	3396	12105	8709	2121	32.19	6.564
80	25.49	26.10	25.91	3616	12955	9339	2751	41.76	3.583
100	31.56	29.87	3072	4288	15360	11072	4484	68.06	3.582

* I.R = Investment ratio = output / Input

Generally, the investment ratio values were incorporated with the highest net income in the descending order 80≥100>60>40 plants/m^2.

General Conclusion

On the light of the present data and under calcareous soil condition, it seems evident that addition of NPK mineral fertilizer at the rate of 90Kg N fed^{-1}, 45Kg P_2O_2 fed^{-1} and 48Kg K_2O fed^{-1} under plant density of 80 plants/m^2 markedly enhanced onion total and marketable yield.

Data, also revealed that the highest net income values (11072 and 93391 LE fed^{-1}) and investment ratio (3.58 for the both) were obtained under plant density of 100 and 80 plants/m^2, respectively.

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تأثير الكثافة النباتية للبصل على محصول الأبصال كما ونوعا تحت ظروف الأراضي الجديدة

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أجرى هذا البحث بمزرعة محطة البحوث الزراعية بالنوبارية (الأراضي المستصلحة حديثا) خلال موسمي زراعة ٢٠٠٢-٢٠٠٣، ٢٠٠٣-٢٠٠٤، بغرض دراسة تأثير أربع معدلات كثافة (٤٠، ٦٠، ٨٠، ١٠٠ نبات/م^2) على صفات النمو و المحصول و مكوناتة للابصال للصنف جيزة ٢٠.و كذلك العائد الأقتصادى من الفدان ويمكن تلخيص النتائج في النقاط الآتية:

١. حدوث تأثير طفيف للمعدلات المختلفة من الكثافة النباتية على صفات النمو (طول النبات، عدد الأوراق لكل نبات). وفي نفس الوقت لم يكن لمعدلات الكثافة أي تأثير يذكر على فترة النضج، أوالنسبة المئوية للأبصال المفرد والمزدوجة والحنبوط (التزهير الحولي).
٢. لوحظ زيادة المحصول الكلي والمحصول الصالح للتسويق من الأبصال بزيادة معدل الكثافة النباتية حيث حقق المعدل ١٠٠ نبات/م^2.أعلى محصول كلى
٣. كان هناك علاقة عكسية بين زيادة معدل الكثافة النباتية و متوسط وزن البصلة حيث كان أعلى متوسط وزن للبصلة عند الكثافة النباتية ٤٠ نبات/م^2.

ومن خلال دراسة تقييم الأربحية، وجد أن الأعلى أربحية حققه معدل ٨٠ نبات/م^2. بينما كانت أعلى قيم لصافي الدخل المزرعي (١١٠٧٢، ٩٣٣٩ جنيه/فدان)، وأعلى نسبة لصافي ربح الجنيه (٣,٥٨) تم الحصول عليها تحت الكثافة النباتية ١٠٠، ٨٠ نبات/م^2 على التوالي.