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The productivity of garlic plant (*allium sativum*, l.) as affected by plant densities and npk application

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ABSTRACT

Two field experiments were carried out during the two successive seasons of 2008/2009 and 2009/2010 at the horticulture experimental station of the Egyptian agricultural Ministry at Baramon Experimental Farm, Dakahlia Governorate, Egypt. The aim of these experiments were to study the effect of 3 plant densities (one, two and/or three lines/ridges) and 3 NPK fertilizer rates (control, 90 : 90 : 90 and 120 : 120: 120 units/fed., respectively on garlic plant growth characters, head yield and its some physical properties as well as the chemical constituents of garlic cloves.

The important obtained results could be summarized as following:

- Close spacing gained the shortest plant height, which carried the less leaves number and less fresh and dry weight of whole garlic plant and its different organs. On the contrary, the heaviest total garlic yield as tons/fed., with the lowest bulb diameter and lowest values of protein, N, P, K, Fe, Mn, Zn and Cu, all of them recorded with close plant densities (3 lines / ridge).
- Increasing NPK rate for garlic growing resulted the vigor plant growth, the heaviest tonnage yield per fed., the highest garlic head and the highest nutritional values if compared with the lowest NPK rates.
- Growing garlic plants at wide plant density, and applying the higher NPK rate resulted the most vigor plant growth character. The heaviest garlic yield gained with close plant spacing and applying the highest NPK rate, but the lowest nutritional elements vales recorded with close plant spacing (3 lines / ridge) and no NPK addition.

INTRODUCTION

Garlic (*Allium sativum*, L) plant is an important crop grown in Egypt for local consumption and/or for foreign exporting market. Whereas, the total productions are increased slowly in past few years, but its yield did not rise by the same degree. However, the garlic bulb yield could be enhanced by improving the agriculture treatments, i.e. following the better application rate of NPK fertilizer, and/or growing plants at the proper plant intensities. Among the major nutrients, nitrogen is required in the largest amount by plants. It plays an essential role for plant productivity (Marschner, 1999). Phosphorus is an important nutritional element plays its part in regulating many physiological criteria's in the plant which in turn affect the resulted total yield. Potassium plays an important role on promotion of enzymes activity and enhanced the translocation of assimilates. Moreover, it increase root growth,

improve drought resistance, build cellulose, reduce loading and control plant turgidity (Emond *et al*., 1981).

The relationships of garlic plant to NPK rate of applications were studied by many authors such as (Abo-Sedera and Badr (1998); Chattopadhyay *et al*. (2006); Singh and Singh (2006); Gowda *et al*. (2007); and Sud *et al*. (2007)).

Also, the productivity of unit area greatly influenced by the number of plants in units area. However, total yield is associated strongly by the number of growing plants in unit area, on the other side, the yield quality response negatively.

Also, effect to different plant density treatments on the garlic bulb yield and its chemical are reported by (Portela and Dalmasso (2003); Nosraty (2004); Singh and Singh (2006); Gautam *et al*. (2007); Kilgori *et al*. (2007); Rekowska and Skupien (2009) and Temperini *et al*. (2010)).

The objectives of this research were to study the response of growth, yield and its nutritional values of garlic to the different rates of NPK fertilizers and plant densities.

MATERIALS AND METHODS

Two field experiments were carried out at the Horticulture Experimental Station (Ministry of Agriculture) at Baramon Experimental Farm, Dakahlia Governorate, Egypt, during the successive seasons of 2008/2009 and 2009/2010 to study the effect of plant density and fertilization rate of NPK on plant growth, yield and its quality of garlic plant.

The soil of experimental field was clay loam in texture with EC. 2.3 mmhos/cm^3 and pH 8.0, available N was 31.8 ppm, p. 14.6 ppm and exchangeable K was 115 ppm.

The experimental design used in the two growing seasons was split plot with three replicates. The plant densities (one, two, three line/ridge) were arranged at random in main plots. While the three level of NPK fertilizer (control, 90: 90: 90 and 120: 120: 120 respectively of N, P, K) were arranged at random in sub plots. Each experimental plot area was 12.8 m^2 consisted of four ridges; each was 0.8 m in width and 4 m in length. Phosphorus as calcium super phosphate (16.5 % P_2O_5) was applied at once time during preparing the soil for planting, whereas nitrogen as ammonium sulphate (20.6 %) and potassium as potassium sulphate (K_2O) added at two equal quantities at 60, 75 days of plant old. The Chinese cv. of garlic cloves was planted on the 15, 13 October month in the seasons of 2008/2009 and 2009/2010 respectively. The gloves were planted 20 cm distances on one, two and/or three lines/ridge.

The normal cultural treatments of growing and irrigation of garlic plant were followed. After 3 months from planting, samples of garlic plants for vegetative growth characters were measured (plant length, number of leaves, fresh and dry weight of whole plant and its leaves, neck and bulb. At harvest and after curing period (15 days), the total yields per feddan as tons were accounted also the average bulb and neck diameter were recorded.

Nitrogen, phosphorus and potassium content in tissues of garlic gloves were determined depending on the method which were described by Jackson (1958); Troug and Mayer (1939) and Brown and Lilleland (1946) respectively. However, Fe, Mn, Zn and cu contents were determined using flame ionization atomic absorption, spectrometer model 1100B of Perkin Elemer and according to the method of Chapmon and Pratt (1978). All data values were subjected to the analysis of variance to Gomez and Gomez (1984).

RESULTS AND DISCUSSION

A. Plant growth characteristics:

Table (1 and 2) shows the response of plant growth characters of garlic plant to the application of 3 plant densities (growing on one, two and/or 3 lines per ridge) and 3 rates of NPK fertilizers (0, 90: 90: 90 and 120: 120: 120 plus control treatment) during the two growing seasons of 2008/2009 and 2009/2010). Whereas, the vigor plant growth measurements (tallest plants which weighted the heaviest fresh and dry weight) were recorded with the wide space of plants (one line/ridge) if compared with that grown at 2 and/or 3 lines/ridge. Moreover, the statistical analysis of the obtained data reveals that, the differences within the 3 plant densities were great enough to reach the 5 % level of significant. This were clear only in 1st season for all plant growth parameters, but was only for total fresh and dry weight of whole plant as well as plant height and dry weight of garlic bulb in 2nd season. The supervisory of wide spacing as express by dry weight of whole plant over the moderate and narrow growing spacing amounted respectively by 31.2, 42.6 % in 1st season and by 11.9, 27.0 % in 2nd seasons.

The reduction in growth characters of plants in the case of increased plant density may be due to increased competition among crop plants and the struggle in an enforced sharing of light, nutrients and water supplies as well as space of the surrounding media. Generally the obtained results are in good accordance with that which reported by the previous investigators such as Gautam *et al*. (2007) and Singh and Singh (2010) on garlic. Their studies indicated that, the garlic characters of plant growth were vegetative correlated with increasing plant density rate.

The presented data in Table (1 and 2) shows that, increasing rates of NPK application caused more vigoursly growth of garlic plant. This increase was gradually and consistant, it means that, the vigor plant growth was associated with that plants which supplied the highest NPK rate, i.e. 120 : 120 : 120. Generally, the addition 120: 120: 120 NPK fertilizers gained superiority in total fresh and dry weight of whole plant if compared with the control treatment (no fertilized). This superiority amounted by 19.6 and 35 % in 1st season and by 12.4 and 15.4% in 2nd season for the above mentioned respective. The statistical analysis of the obtained data reveals that, the NPK application rates had great differences enough to reach the 5 % levels of significance. These were true for all plant growth parameters in both experiments with except average leaves number/plant and neck fresh weight in the second experiment.

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It could be concluded that, supplying NPK for garlic plant gained an enhancement in plant growth characters and with increasing rates of NPK application resulted the highest vigor in plant growth of garlic. The obtained results are in good accordance with that where obtained by Abo-Sedera and Badr (1998); Gowda *et al*. (2007) and Singh and Singh (2010) on garlic plant, as well as that of Madan and Saimbhi (1984); Ali-Aisha *et al*. (2007) and Shaheen *et al*. (2010) on onion plant, all of them reported that, the best plant growths were recorded with the higher NPK rate of fertilization.

The interaction treatments within the two factors, i.e. 3 plants densities and 3 rates of NPK application had no significant effect on the plant growth measures of garlic. These findings are true in both seasons with except total dry weight of whole plant (in two seasons), and dry weight of neck and bulb (in 2nd season). Generally, the best plant growth as expressed by total dry weight of whole plant was recorded with that plants which grow as wide space, i.e. one line per ridge and supplied the highest NPK rate (120 : 120 : 120).

B. Cloves yield and its physical properties:

Table (3) shows clearly that the two treatments factors, i.e. plant densities and NPK fertilizer had a significant effect on the total garlic yield as ton/fed., as well as its physical properties(diameter garlic head and its neck).These results were true in both experiments of 2008/2009 and 2009/2010. Whereas, the obtained data reveals that the close planting, i.e. 3 lines on the same ridge resulted the heaviest tonnage of garlic yield, followed in descending order by that plants which grown on the medium space (2 lines/ridges) and lastly that of widest space planting (one line/ridge). It could be concluded that the superiority of close planting over the widest one amounted by 37.7 % in 1st season and by 23.5 % in second season. This findings are in good accordance of that published before by many workers (Portela and Dalmasso (2003); Nosraty (2004); Kilgori *et al*. (2007) and Singh and Singh (2010)) on garlic plant, whereas their recorded results detected that the higher plant densities produced high bulb yield but poor quality.

Concerning to the diameter of garlic head and its neck the presented results shows that, the biggest diameter of garlic head and its neck recorded with that plants which grown at the wide space (one line/ridge). It means that, the heaviest garlic yield was estimated by the close spacing, but with the small head diameter. These findings are good accordance in the two experimental seasons. The poor heads quality of garlic yield are associated with the high plant densities whereas, the close spacing gained small head and neck diameter (Gautam *et al*. (2007) and Kilgori *et al.* (2007)).

The application of NPK fertilizer for garlic plant caused a significant increase in total garlic yield as tons/fed., as well as its physical properties during the two experimental seasons. The recorded data in Table (3) clearly demonstrated that, with increasing the level of NPK application the total garlic yield increased. It means that, the heaviest yield was associated with the heaviest dose of NPK (120: 120: 120). By short words the superiority of yield as ton/fed., when the highest NPK level application over the control treatment amounted by 37 % in 1st experiment and by 41.1 % in 2nd one.

The average diameter of garlic bulb and its neck followed the same pattern of change similar that which mentioned before.

It could be summarized that the total garlic yield as ton/fed., as well as its physical properties, i.e. diameter of garlic bulb and its neck, all of them recorded their highest peack with the addition of NPK at rate of 120: 120: 120 for the same respective. Results of this script are in the same trend of that which reported before by Abo-Sedera and Badr (1998); Gautam *et al*. (2007); Subrata Chand *et al*. (2010) and Singh and Singh (2010) on garlic.

The interaction treatments within the two experimental factors gained no significant effect on the total garlic bulbs yield as well as its physical properties in both experiments. It means that, each one of the two factors act as individually.

Table (3): Effect of different plant densities and NPK treatments on total yield of garlic heads and its some physical properties during the two experimental seasons 2008/2009 and 2009/2010.

Treatments		Yield (ton / fed.)	Diameter (cm)		Yield (ton / fed.)	Diameter (cm)	
Plant density	Fertilizers		Bulb	Neck		Bulb	Neck
		2008/2009			2009/2010		
Wide one line / ridge	0	1.25	2.97	1.18	0.92	2.73	1.23
	90:90:90	1.33	3.76	1.34	1.28	3.23	1.34
	120:120:120	1.47	4.13	1.61	1.24	4.07	1.57
Mean		**1.35**	**3.62**	**1.37**	**1.15**	**3.34**	**1.38**
Moderate two lines / ridge	0	1.44	2.90	1.24	0.99	2.17	1.20
	90:90:90	1.94	3.43	1.49	1.41	2.97	1.25
	120:120:120	2.11	3.93	1.59	1.49	3.10	1.41
Mean		**1.83**	**3.42**	**1.44**	**1.30**	**2.74**	**1.29**
Narrow 3 lines / ridge	0	1.54	2.40	1.01	1.15	2.00	1.05
	90:90:90	1.82	2.57	1.07	1.49	2.63	1.23
	120:120:120	2.23	3.00	1.27	1.60	2.83	1.35
Mean		**1.86**	**2.66**	**1.12**	**1.42**	**2.49**	**1.21**
Averages	0	1.41	2.76	1.14	1.02	2.30	1.16
	90:90:90	1.69	3.25	1.30	1.39	2.94	1.27
	120:120:120	1.93	3.69	1.49	1.44	3.33	1.44
L.S.D. at 5%	Plant density	**0.22**	**0.25**	**0.10**	**0.17**	**0.18**	**0.05**
	Fertilizers	**0.21**	**0.36**	**0.09**	**0.07**	**0.27**	**0.07**
	Interactions	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**

C. Nutritional values of garlic bulbs:

Tables (4 and 5) shows the response of nutritional value, of garlic yield as influenced by the plant densities (one, two and three lines/ridge) and NPK application (0, 90: 90: 90 and 120: 120: 120 NPK respectively) during the two experimental seasons of 2008/2009 and 2009/2010. Whereas, growing garlic cloves as wide spacing (one line/ridge) gave the best nutritional values, i.e. protein, N, P and K percentages as well as Fe, Mn, Zn and Cu contents. However, statistical analysis of the obtained values showed that, the differences within the 3 plants densities were great enough to be significantly

for all nutritional values in both two seasons. The obtained results are in good accordance with that which reported before by Gautam *et al*. (2007); Fikreyahannes Gedamu *et al*. (2008); Rekowska and Skupien (2009) and Temperini *et al*. (2010) on garlic.

Table (4): Effect of different plant densities and NPK treatments on the nutritional values of garlic cloves during 2008/2009 season.

Treatments		%				ppm			
Plant density	**Fertilizers**	**Protein**	**N**	**P**	**K**	**Fe**	**Mn**	**Zn**	**Cu**
Wide one line / ridge	**0**	3.04	0.49	0.09	0.77	0.78	18.30	13.97	13.97
	90:90:90	4.52	0.72	0.13	0.82	0.91	19.23	14.30	14.50
	120:120:120	5.10	0.82	0.17	0.87	0.94	19.77	14.93	15.57
Mean		**4.22**	**0.68**	**0.13**	**0.82**	**0.88**	**19.10**	**14.40**	**14.68**
Moderate two lines / ridge	**0**	2.96	0.47	0.08	0.72	0.74	18.10	13.77	13.70
	90:90:90	4.44	0.71	0.13	0.78	0.81	17.80	13.90	13.80
	120:120:120	5.17	0.83	0.13	0.81	0.83	18.87	15.10	13.90
Mean		**4.19**	**0.67**	**0.11**	**0.77**	**0.79**	**18.26**	**14.26**	**13.80**
Narrow 3 lines / ridge	**0**	2.71	0.43	0.07	0.65	0.67	17.90	13.33	13.37
	90:90:90	4.04	0.65	0.13	0.67	0.77	18.73	13.53	12.60
	120:120:120	4.15	0.66	0.12	0.68	0.78	18.60	14.20	13.27
Mean		**3.63**	**0.58**	**0.11**	**0.67**	**0.74**	**18.41**	**13.69**	**13.08**
Averages	**0**	2.90	0.46	0.08	0.71	0.73	18.10	13.69	13.68
	90:90:90	4.33	0.69	0.13	0.76	0.83	18.59	13.91	13.63
	120:120:120	4.81	0.77	0.14	0.79	0.85	19.08	14.74	14.24
L.S.D. at 5%	**Plant density**	**0.34**	**0.05**	**0.01**	**0.01**	**0.02**	**0.28**	**0.30**	**0.27**
	Fertilizers	**0.28**	**0.04**	**0.01**	**0.02**	**0.01**	**0.31**	**0.34**	**0.33**
	Interactions	**N.S.**	**N.S.**	**N.S.**	**0.03**	**0.02**	**0.53**	**N.S.**	**0.57**

Table (5): Effect of different plant densities and NPK treatments on the nutritional values of garlic cloves during 2008/2009 season.

Treatments		%				ppm			
Plant density	**Fertilizers**	**Protein**	**N**	**P**	**K**	**Fe**	**Mn**	**Zn**	**Cu**
Wide one line / ridge	**0**	3.23	0.52	0.08	0.67	0.78	17.17	12.70	13.40
	90:90:90	3.88	0.62	0.12	0.87	0.85	18.07	13.40	13.87
	120:120:120	4.25	0.68	0.14	0.91	0.88	18.67	13.87	14.57
Mean		**3.78**	**0.61**	**0.11**	**0.81**	**0.84**	**17.97**	**13.32**	**13.94**
Moderate two lines / ridge	**0**	3.08	0.49	0.08	0.62	0.72	16.57	12.47	13.10
	90:90:90	3.77	0.60	0.09	0.82	0.83	16.10	12.80	12.77
	120:120:120	3.94	0.63	0.11	0.84	0.86	17.37	13.60	13.60
Mean		**3.60**	**0.58**	**0.09**	**0.76**	**0.80**	**16.68**	**12.96**	**13.16**
Narrow 3 lines / ridge	**0**	2.92	0.47	0.07	0.59	0.72	16.07	12.20	12.83
	90:90:90	3.50	0.56	0.07	0.74	0.77	15.03	12.90	12.60
	120:120:120	3.56	0.57	0.11	0.83	0.83	16.47	13.13	12.97
Mean		**3.33**	**0.53**	**0.08**	**0.72**	**0.77**	**15.86**	**12.75**	**12.80**
Averages	**0**	3.08	0.49	0.07	0.63	0.74	16.60	12.46	13.11
	90:90:90	3.72	0.59	0.09	0.81	0.82	16.40	13.03	13.08
	120:120:120	3.92	0.63	0.12	0.86	0.86	17.50	13.53	13.71
L.S.D. at 5%	**Plant density**	**0.05**	**0.01**	**0.01**	**0.02**	**0.03**	**0.16**	**0.24**	**0.31**
	Fertilizers	**0.12**	**0.02**	**0.01**	**0.02**	**0.02**	**0.29**	**0.18**	**0.20**
	Interactions	**N.S.**	**N.S.**	**0.01**	**N.S.**	**0.03**	**0.51**	**N.S.**	**0.35**

The application of compound fertilizer, i.e. NPK gained a great effect on the nutritional values of garlic yield. Whereas the presented results (Table 4 and 5) indicated that, addition NPK fertilizer caused an enhancement in nutritional values if compared with the control treatment. Moreover, with increasing the applied rate of NPK addition, the best nutritional values were obtained. It could be abstracted that the best chemical properties of protein, N, P, K, Fe, Mn, Zn and Cu were associated with the highest NPK application rate. The studies of Abo-Sedera and Badr (1998) and Sud *et al*. (2007) on garlic are supported that results which written herein in this script.

The interaction treatments between plant densities and NPK application had no significant effect on the nutritional values of garlic cloves. These findings are true for all nutritional elements except Fe, Mn and Zn in both seasons. Whereas, the best chemical consistuent were recorded with that plants which grown on widest space (one line/ridge) and supplied the heaviest NPK rate.

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تـأثير مسـافات الزراعـة والسـماد الكيمـاوي (نيتـروجين، فوسـفور، بوتاسـيوم) علـي إنتاجية نبات الثوم

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إجريـت تجربتـان حقليتـان خـلال موسـمي الزراعـة ٢٠٠٨/٢٠٠٩ ، ٢٠٠٩/٢٠١٠ فـي محطة التجارب الزراعة التابعة لوزارة الزراعة بمزرعة البارامون (محافظـة الدقهليـة). تهدف هذه التجارب الي دراسة تاثير ٣ معاملات للكثافة النباتية (خط واحد / المصطبة، ٢ خط / المصطبة، ٣ خطوط / المصطبة) وثلاثة معدلات للتسميد المركب (صفر، ٩٠:٩٠:٩٠ ، ١٢٠:١٢٠:١٢٠ وحدة نيتـروجين، فوسفور، بوتاسيوم) علـي انتاجيـة نبـات الثـوم (النمـو الخضـري، المحصـول ومكوناتـة، المحتوي الغذائي لفصوص الثوم).

وتضمنت اهم النتائج مايلي:

- الزراعة الكثيفة (٣ خط / المصطبة) اعطت اقل النباتات طولا، وعدد للاوراق، اقل وزن غض وجاف لنبات الثوم ولاجزائه المختلفة. وعلي العكس من ذلك حيث سجلت الزراعـة الكثيفـة اعلـي محصـول (طـن / فدان) واقل حجم وقطـر لـرؤوس الثـوم وكـذلك اقل قيمـة غذائيـة معبـرا عنهـا بمحتوي البروتين، النيتروجين، الفوسفور، البوتاسيوم، الحديد، المنجنيز، الزنك، النحاس.
- أدي اضـافة السـماد المركـب بالمعـدل العـالي (١٢٠:١٢٠:١٢٠ مـن النيتـروجين والفوسـفور والبوتاسيوم) الي الحصول علي افضل صفات للنمو الخضـري للنبـات معبـرا عنـه بطـول النبـات وعدد الاوراق والوزن الغض والجاف للنبات ولاجزائـه المختلفـة – بالاضـافة الـي ذلـك الحصـول علي اعلي محصول من الثوم (طن / فدان) ذو القيمة الغذائية العالية.
- بصـفة عامـة الزراعـة الواسـعة (خـط واحـد / المصـطبة) والمعـدل العـالي مـن السـماد المركـب (١٢٠:١٢٠:١٢٠) سجل افضل نمو خضري لنبات الثوم بينما الزراعة الكثيفة ادت الي الحصول علـي اعلـي محصـول (طـن / فـدان) – واقـل قـيم للمحتـوي الغـذائي (البـروتين، النيتـروجين، الفوسفور، البوتاسيوم، الحديد، المنجنيز، الزنك، النحاس).

قام بتحكيم البحث

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Table (1): Effect of different plant densities and NPK treatments on plant growth characters of garlic during 2008/2009 season.

Treatments		Plant height (cm)	No. of leaves	Fresh wt. (g)				Dry wt. (g)			
Plant density	Fertilizers			Leaves	Neck	Bulb	Total	Leaves	Neck	Bulb	Total
Wide one line / ridge	0	46.67	7.47	56.63	10.10	11.87	78.60	7.14	3.17	5.30	15.60
	90:90:90	61.87	8.60	60.85	12.66	13.83	87.34	8.29	4.22	5.50	18.01
	120:120:120	74.63	9.13	63.62	13.33	14.74	91.69	9.32	5.05	5.95	20.32
Mean		**61.06**	**8.40**	**60.37**	**12.03**	**13.48**	**85.88**	**8.25**	**4.14**	**5.58**	**17.98**
Moderate two lines / ridge	0	44.73	6.63	46.89	9.23	11.47	67.59	6.30	2.63	4.30	13.23
	90:90:90	56.27	7.77	53.17	10.80	12.53	76.51	7.91	3.83	4.63	16.38
	120:120:120	64.50	7.90	55.79	11.20	14.23	81.22	8.00	4.03	4.77	16.80
Mean		**55.17**	**7.43**	**51.95**	**10.41**	**12.74**	**75.10**	**7.40**	**3.50**	**4.57**	**15.47**
Narrow 3 lines / ridge	0	43.00	6.07	43.40	8.70	9.77	61.87	5.67	1.97	3.30	10.93
	90:90:90	51.53	6.90	48.30	11.70	12.00	72.00	7.47	3.83	3.93	15.23
	120:120:120	59.83	7.40	51.80	11.83	12.33	75.97	7.80	4.55	4.23	16.59
Mean		**51.46**	**6.79**	**47.83**	**10.74**	**11.37**	**69.94**	**6.98**	**3.45**	**3.82**	**14.25**
Averages	0	44.80	6.72	48.97	9.34	11.03	69.35	6.37	2.59	4.30	13.26
	90:90:90	56.56	7.76	54.11	11.72	12.79	78.62	7.89	3.96	4.69	16.54
	120:120:120	66.32	8.14	57.07	12.12	13.77	82.96	8.37	4.54	4.98	17.90
L.S.D. at 5%	Plant density	**2.71**	**0.50**	**3.18**	**0.79**	**0.63**	**3.59**	**0.58**	**0.28**	**0.41**	**0.71**
	Fertilizers	**4.13**	**0.26**	**2.20**	**0.64**	**0.71**	**2.13**	**0.46**	**0.41**	**0.49**	**0.49**
	Interactions	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**0.84**

Table (2): Effect of different plant densities and NPK treatments on plant growth characters of garlic during 2009/2010 season.

Treatments		Plant height (cm)	No. of leaves	Fresh wt. (g)				Dry wt. (g)			
Plant density	Fertilizers			Leaves	Neck	Bulb	Total	Leaves	Neck	Bulb	Total
Wide one line / ridge	0	58.80	7.20	48.90	10.70	15.60	75.20	6.77	3.63	4.90	15.30
	90:90:90	64.50	7.97	51.83	13.70	16.62	82.15	7.29	4.54	5.16	16.99
	120:120:120	66.87	9.03	57.55	14.49	16.75	88.79	8.41	5.23	5.30	18.94
Mean		**63.39**	**8.07**	**52.76**	**12.96**	**16.32**	**85.05**	**7.49**	**4.47**	**5.12**	**17.08**
Moderate two lines / ridge	0	58.00	7.13	46.77	11.53	13.90	72.20	6.60	3.30	4.40	14.30
	90:90:90	59.83	7.77	49.07	11.05	13.49	73.60	6.83	3.63	4.70	15.17
	120:120:120	63.80	7.80	51.25	12.27	14.90	78.42	7.48	4.10	4.72	16.31
Mean		**60.54**	**7.57**	**49.03**	**11.62**	**14.10**	**74.74**	**6.97**	**3.68**	**4.61**	**15.26**
Narrow 3 lines / ridge	0	50.83	7.23	40.97	10.73	12.53	64.23	6.20	4.13	2.80	13.13
	90:90:90	54.97	6.53	44.21	12.09	12.70	68.99	6.31	3.13	3.73	13.18
	120:120:120	61.90	7.17	45.87	11.30	13.57	70.74	6.33	3.53	4.17	14.03
Mean		**55.90**	**6.98**	**43.68**	**11.37**	**12.93**	**67.99**	**6.28**	**3.60**	**3.57**	**13.45**
Averages	0	55.88	7.19	45.54	10.99	14.01	70.54	6.52	3.60	4.03	14.24
	90:90:90	59.77	7.42	48.37	12.28	14.27	74.91	6.81	3.77	4.53	15.11
	120:120:120	64.19	8.00	51.56	12.69	15.07	79.31	7.41	4.29	4.73	16.43
L.S.D. at 5%	Plant density	**3.48**	**N.S.**	**5.17**	**N.S.**	**1.04**	**3.94**	**0.77**	**0.35**	**0.13**	**0.79**
	Fertilizers	**3.60**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**4.91**	**N.S.**	**N.S.**	**0.27**	**0.63**
	Interactions	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**0.89**	**0.47**	**1.10**