Bull. Fac. Agric., Cairo Univ., 59 (2008): 231-235.

EFFECT OF PLANTING DATE, PLANT SPACING AND CLOVE SIZE ON GARLIC (*Allium sativum* L .) YIELD UNDER SEMI-ARID CONDITIONS IN JORDAN

(Received: 21. 2. 2008)

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ABSTRACT

A field experiment was conducted in 2006/2007 growing season at the Agricultural Research Station, Mu'tah University, Jordan, to study the effect of planting date, spacing and clove size on garlic yield. A factorial combination of three planting dates, three plant spacings and three clove sizes were laid out in a randomized complete block design with three replications. Results indicate that early planting date (Nov. 15) produced higher yield, average bulb weight and clove number per bulb. Close spacing of 10 cm resulted in significantly ($P< 0.05$) higher garlic bulb yield. Moreover, using large cloves gave the highest yield compared with medium and small cloves. Number of cloves per bulb and bulb weight were mainly affected by planting date. However, plant spacing and clove size had little effect on these parameters in each planting date. Maximum bulb weight (54.62 gm bulb $^{-1}$) was produced when large cloves (2-3 gm) were planted on Nov. 15 at 20 cm plant spacing. In conclusion, to produce the maximum yield, large garlic cloves should be planted early in the growing season with 10 cm spacing.

***Key words*:** *Allium sativum* L., *clove size, garlic, planting date, plant spacing.*

1. INTRODUCTION

Garlic (*Allium sativum* L.) is an annual bulb crop and ranks second after onion in order of importance and cultivation (Yamaguchi, 1983). It is an erect annual herb that can reach a height of 75-90 cm and grows during dry and mild winter season (Brewester, 1994). The world average yield of garlic is about 10 tons ha^{-1}, but can be increased up to 19 tons ha^{-1}. Garlic is rich in sugar, protein, fat, calcium, potassium, phosphorus, sulfer, iodine, fiber, silicon and vitamins (Kilgori *et al.*, 2007). Increased awareness of the medicinal values of garlic and its economic importance has increased the demand for garlic crop in Jordan as well as worldwide. A number of studies in various parts of the world has shown that garlic production can be improved through appropriate cultural practices (Adekpe *et al.*, 2007; Bhuiya *et al.*, 2003; Kilgori *et al*., 2007; Minard, 1978). In the Mediterranean areas, the garlic crop is exposed to great seasonal fluctuations of temperature and photoperiod, both having a strong influence on garlic growth (Takagi, 1990). Time of planting influences the growth and yield of garlic (Kilgori *et al.*, 2007; Poldma *et al*., 2005). The yield potential of garlic plant depends on the extent of vegetative growth attained before bulbing commences (Ahmed and Haque, 1985). Yet, the available data and information obtained under different climatogical conditions and with different cultivars, though invaluable, can not be adopted for local conditions. The aim of this study was to find out the best combination of planting date, plant spacing and clove size for maximizing garlic yield under local management considerations.

2. MATERIALS AND METHODS

A field experiment was conducted at the Agricultural Research Station, Mu'tah University, Jordan, during the growing season of 2006/2007. The soil used was sandy clay loam with the following characteristics: pH 7.78, electrical conductivity (EC) 1.28 ds/m, total $CaCO_3$ 32%, organic matter 1.63%. The region has a Mediterranean climate (semi-arid, with cold rainy winters and hot dry summers) with annual mean rainfall of 350 mm, most of the rain fall occurs from December to February.

The treatments consisted of three planting dates at two week interval (Nov. 15, Dec. 1 and Dec. 15), three inter-plant spaces (10, 15 and 20 cm) and three clove sizes by weight (< 1.0, 1.0- 2.0 and 2.1- 3.0 gram). Experimental treatments were arranged as factorial in a randomized complete

block design with three replicates. The soil was prepared for planting by plowing, disking and leveling. Manual raised-beds with 0.6 m width, 15 cm height were prepared and covered with black plastic mulch. Cloves of local garlic cultivar (Syrian cultivar called Kiswany) were planted upright with apical tip. Prior to planting, garlic bulbs were split into the individual cloves (planting material) and sorted into three sizes as required. Cloves of each size were soaked in water overnight to promote early germination and sprouting before planting the next day for each date. The plots were irrigated two days before planting to provide good clove-soil-water contact and thereafter irrigation was done only for one month (about 4 times) by drip irrigation system.

Bulbs were harvested (June, 5) when the leaves turned yellowish green and had started withering. At harvesting time, the total yield per ha, average bulb weight and number of cloves per bulb were recorded. Data were subjected to analysis of variance (ANOVA) by MSTATC-program and means were separated using Duncan's Multiple Ranges Test (DMRT) with $P< 0.05$ (Lentner and Bishop, 1993).

3. RESULTS AND DISCUSSION

3.1.Separate effects of planting date, plant spacing and clove size

Data of the separate effects of planting date, plant spacing and clove size on garlic yield and its components are presented in Table 1. Planting date had significantly ($P< 0.05$) affected yield of garlic and its components. There are significant ($P< 0.05$) declines in garlic yield/ha, average bulb weight and the number of cloves per bulb with delaying date of planting. The highest yield (11.93 ton ha $^{-1}$) was produced with the earliest planting date (Nov. 15), while the lowest yield (8.11 ton ha $^{-1}$) was produced with the latest planting date (Dec. 1). Moreover, average bulb weight and the number of cloves per bulb had similar trend. The earliest planting date gave the highest garlic yield and its components, properly due to the plant attained high vegetative growth, as a result the plants gave high number of leaves and highest plant height (Adekpe *et al*., 2007; Bhuiya *et al*., 2003). Our results are in agreement with the findings of many researchers (Adekpe *et al.*, 2007; Bhuiya, *et al.*, 2003 and Rahim *et al*., 1984). They indicated that garlic plants attained high vegetative growth in the early planting, which possibly led to the development of large bulbs and high yield.

Plant spacing had significant ($P< 0.05$) effect on bulb yield per ha (Table 1). It is evident that increasing plant spacing from 10 to 15 cm significantly ($P< 0.05$) decreased bulb yield, further an increase to 20 cm resulted in a significant decline in bulb yield of garlic. The highest yield (10.92 ton ha $^{-1}$) was recorded at 10 cm spacing compared with the lowest yield (8.91 ton ha $^{-1}$) was recorded at 20 cm spacing. On the other hand, plant spacing had no significant ($P< 0.05$) effect on bulb weight and the number of cloves per bulb. It means that interplant competition was not found even at small plant spacing (10 cm). Kilgori *et al.* (2007) reported that

Table (1): Separate effects of planting date, plant spacing and clove size on yield and yield components of garlic grown in semi-arid conditions in Jordan .

Treatment	Yield (ton/ha)	Average bulb weight (gm)	Number of cloves/bulb
Planting date			
Nov. 15	**11.93 a**	**49.64 a**	**37.24 a**
Dec. 1	**9.26 b**	**39.10 b**	**35.03 b**
Dec. 15	**8.11 c**	**32.00 c**	**33.25 c**
Plant spacing (cm)			
10	**10.92 a**	**40.61 a**	**36.00 a**
15	**9.48 b**	**40.28 a**	**35.10 a**
20	**8.91 c**	**39.86 a**	**35.35 a**
Clove size (gm)			
< 1	**9.18 c**	**37.27 c**	**34.52 a**
1-2	**9.78 b**	**40.74 b**	**35.85 a**
2-3	**10.34 a**	**44.12 a**	**36.00 a**

*****Means having different letters within each column of each factor are significantly different at 5% level of probability according to DMRT

close spacing of 10 cm had optimum effect on cured bulb yield. Moreover, they reported that an improvement in individual plants at wider spacing did not compensate for the reduction in yield due to a decrease in plant population. According to El-Gamili, (1996) the increase in weight of total onion bulb yield under the high plant densities may be due mainly to the increase in the number of bulbs per unit area.

Each increment in clove size resulted in a significant ($P< 0.05$) increase in garlic yield and average bulb weight (Table 1). Maximum garlic yield (10.92 ton ha $^{-1}$) was produced by using large cloves (2-3 gm). This could be as a result of positive effects of available food reserves in large size cloves, which makes the crop to be established better and increased crop vigor (Ahmed *et al.*, 2007 and Stahlschmidt *et al.*, 1997). This confirmed the earliest findings of Minard, (1978) who reported that the best garlic yield resulted from using large cloves. Number of cloves per bulb was not significantly affected by different clove sizes which disagreed with the data obtained by Ahmed *et al.* (2007) and Minard, (1978).

3.2. Interactive effects of planting date, plant spacing and clove size

Data of the interactive effects of planting date, spacing and clove size on garlic yield and its components are presented in Table 2. Bulb yield of garlic was significantly ($P< 0.05$) affected with the different combinations of planting date, plant

Table (2): Interactive effects of planting date, plant spacing and clove size on yield and yield components of garlic grown in semi-arid conditions in Jordan.

Plant spacing (cm)	Clove size (gm)	Planting date		
		Nov. 15	Dec. 1	Dec. 15
		Yield (ton ha $^{-1}$)		
10	< 1	13.02 bc	9.50 ghij	8.00 klmno
	1-2	13.82 ab	10.60 efg	9.00 ijkl
	2-3	14.60 a	10.30 fgh	9.40 hij
15	< 1	10.08 ghi	8.93 ijkl	7.64 mno
	1-2	11.40 def	9.00 ijkl	7.80 lmno
	2-3	12.39 c	9.20 hijk	8.84 jklm
20	< 1	10.2 ghi	8.41 jklmn	6.94 o
	1-2	10.40 fgh	9.00 jklm	7.40 no
	2-3	11.54 de	9.40 jklm	8.20 klmno
		Average bulb weight (gm bulb $^{-1}$)		
10	< 1	49.17 abc	38.00 efg	28.25 ij
	1-2	50.42 ab	41.75 cde	31.30 ghij
	2-3	54.62 a	40.25 def	34.75 efghi
15	< 1	42.58 bcde	33.25 fghij	29.30 hij
	1-2	49.00 abc	41.00 def	31.73 ghij
	2-3	54.45 a	43.12 bcde	38.37 efg
20	< 1	47.90 abcd	37.23 efgh	26.25 j
	1-2	47.73 abcd	37.75 efg	31.50 ghij
	2-3	52.88 a	40.50 def	36.88 efgh
		Number of cloves/bulb		
10	< 1	37.17 abcde	36.75 abcde	32.00 cde
	1-2	41.00 a	35.47 bcde	34.63 bcde
	2-3	36.70 abcde	37.78 abcd	31.40 de
15	< 1	35.05 bcde	31.40 de	34.05 bcde
	1-2	38.00 abc	33.32 bcde	34.25 bcde
	2-3	36.02 abcde	36.83 abcde	35.37 bcde
20	< 1	38.73 ab	33.05 bcde	31.15 de
	1-2	35.40 bcde	36.78 abcde	31.50 de
	2-3	36.75 abcde	36.35 abcde	34.70 bcde

*****Means having different letters for each parameter are significantly different at 5% level of probability according to DMRT.

spacing and clove size. In general, early plantation of large clove at closed plant spacing gave the highest bulb yield. Maximum garlic bulbs yield (14.60 ton ha $^{-1}$) was obtained from early planting date with closer plant spacing with large cloves. On the other hand, the least bulb yield was obtained from planting small cloves on Dec. 15 at 20 cm plant spacing. Within each planting date each increased in clove size resulted in an increase in bulb yield regardless of plant spacing. Also, each increase in plant density (decreased plant spacing) over all planting dates resulted in higher bulb yields compared with low plant density. Higher bulbs yield was recorded in large sized cloves than in small sized cloves which had the least bulb yield at all planting dates and plant spaces. To produce high yield of garlic, large cloves (2-3 gm) must be planted at early time (Nov. 15) that allowed for the development of large vegetative parts (Adekpe *et al.*, 2007; Maksoud, *et al.*, 1983; and 1984) and close spacing (10 cm). Bulb yield declined gradually with delaying planting date, increasing plant spacing and decreasing cloves size. Similar results were obtained by several workers as Rahim *et al*. (1984); Bhuiya *et al.* (2003); Adekpe *et al.* (2007); Kilgori *et al.* (2007). Kilgori *et al.* (2007) who reported that significant reduction in cured bulb yield with every two weeks delay in planting date from Nov. 29 to Dec. 27.

Generally, the average bulb weight was significantly high by planting garlic on Nov. 15 at all plant spacings and by using different clove sizes. Maximum bulb weight (54.62 gm bulb $^{-1}$) was produced when large cloves (2-3 gm) were planted on Nov. 15 at 20 cm plant spacing, but the differences between bulb weights produced by different plant spacing and clove size combinations within Nov. 15 planting date were not significant. The least bulb weight (26.25 gm) was obtained by planting small cloves (< 1) on late planting date (Dec. 15) at wide plant spacing (20 cm). It appears that the average bulb weight was mainly affected by planting date. However, plant spacing and clove size had little effect on bulb weight in each planting date. In general, planting large cloves on different planting dates and plant spaces produced larger bulb weights compared with other clove sizes, but the differences among large sized cloves were not significant.

Number of cloves per bulb was mainly affected by planting date (Table 2), however, plant spacing and clove size had little effect on this parameter in each planting date. The highest number of cloves per bulb (31.15) was obtained by planting medium sized cloves on Nov. 15 at 10 cm plant spacing, while the least number of cloves was obtained by planting small sized cloves at 10 cm plant spacing on Dec. 15.

Based on the results obtained from this study, it is suggested that large garlic cloves (2-3 gm) should be planted early in the growing season (Nov. 15) and use inter-plant spacing of 10 cm for the maximum yield at semi-arid conditions of Jordan.

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تأثير مواعيد ومسافات الزراعة وأحجام الفصوص على إنتاجية محصول الثوم تحت ظروف الزراعة البعلية في المناطق شبه الجافة من الأردن

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ملخـص

أجريت التجربة في محطة البحوث الزراعية/ كلية الزراعة/ جامعة مؤته خلال موسم 2007/2006 لدراسة تأثير ثلاثة مواعيد للزراعة وثلاث مسافات للزراعة وثلاثة أحجام للفصوص على محصول الثوم. رتبت المعاملات في تجربة عامليه حيث استخدم تصميم القطاعات العشوائية الكاملة وبثلاثة مكررات. أدى التبكير في موعد الزراعة (15 تشرين الثاني - نوفمبر) إلى زيادة كمية محصول الثوم ومتوسط وزن البصلة ومتوسط عدد الفصوص في البصلة الواحدة. كما أدت الزراعة على مسافات قصيرة (10 سم) إلى زيادة كمية المحصول وكذلك أدى استخدام الفصوص الكبيرة إلى زيادة كمية المحصول. لم يتأثر عدد الفصوص للبصلة الواحدة معنويا نتيجة مسافات الزراعة وحجم الفصوص المستعملة في الزراعة وإنما تأثر بشكل رئيس نتيجة التبكير في موعد الزراعة. لقد تم الحصول على اكبر كمية من محصول الثوم عند زراعة الفصوص كبيرة الحجم (2-3 جرام) مبكرا في موسم الزراعة (15تشرين الثاني - نوفمبر) وعلى مسافات زراعة قصيرة (10 سم). ويمكن الاستنتاج من خلال هذه الدراسة بأنه للحصول على أعلى إنتاجية يفضل زراعة الفصوص الكبيرة خلال منتصف تشرين الثاني وعلى مسافات زراعة قصيرة.

المجلة العلمية لكلية الزراعة – جامعة القاهرة – المجلد 59 العدد الثالث (يوليو 2008): 231-235.