Influence of Clove Weight on Vegetative Growth and Yield of Garlic (*Allium sativum* L.) Grown under Drip Irrigation

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ABSTRACT

A field trial was carried out during two growing seasons (2005/2006 and 2006/2007) at the Agricultural Research Station, Mu'tah University, Al-Karak, Jordan, to study the influence of clove weight at planting on vegetative growth and yield of garlic. Four clove weights [small (< 1), medium (1.1- 2.0), large (2.1- 3.0) and extra-large (3.1-4) g] were planted in a randomized complete block design with four replicates. Vegetative growth parameters (leaf number, plant height and average plant weight) were significantly higher when large clove weight was planted. Using large clove weight gave significantly the highest garlic yield and average bulb weight compared with small clove weight. However, number of cloves per bulb and bulb neck diameter were not significantly affected by planted clove weight. The percentage of the increase in bulb yield at harvest was 75% and 59% as compared with the smallest clove weight in 2005/2006 and 2006/2007, respectively.

Keywords: Garlic, *Allium sativum* L., Clove weight, Clove size.

INTRODUCTION

Garlic (*Allium sativum* L.) is one of the most important crops worldwide ranking second after onion in order of importance and cultivation (Yamaguchi, 1983). Garlic is rich in sugar, protein, fat, calcium, potassium, phosphorus, sulfer, iodine, fiber, silicon and vitamins (Kilgori *et al.*, 2007; Takagi, 1990). The demand on garlic crop in Jordan as well as worldwide is increasing due to its medicinal value and economic importance. The world average yield of garlic is about 10 tons ha^{-1}, but can be increased up to 19 tons ha^{-1}. Several studies in various parts of the world have shown that garlic production can be improved through appropriate cultural practices (Adekpe *et al.*, 2007; Bhuiya *et al.*, 2003; Castellanos *et al*., 2004; Kilgori *et al.,* 2007; Minard, 1978). The yield potential of garlic plant depends on the extent of vegetative growth attained before the formation of bulbs commences (Ahmed and Haque, 1985). Some growers grade their cloves by size/or weight and plant the largest ones. But most farmers are using cloves varying in sizes/ or weights, which might affect plant stand, vegetative growth and bulb yield and quality. According to Castellanos *et al*. (2004), large clove size produced higher garlic yield and improved bulb quality (bulb weight, bulb diameter and number of cloves per bulb) of the harvested garlic. Therefore, the aim of the present study was to investigate the effect of clove weight at planting on the vegetative growth, bulb yield and bulb quality (bulb weight, bulb diameter, number of cloves per bulb and neck thickness) of garlic grown using drip irrigation.

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MATERIALS AND METHODS

A field trial was carried out during 2005/2006 and 2006/2007 growing seasons at the Agricultural Research Station, Mu'tah University, Al-Karak, Jordan to investigate the responses of garlic vegetative growth and yield to planting of different clove weights. The soil at the experimental site was sandy clay loam with 7.8 pH, 1.45 ds/m electrical conductivity (EC), 31% total $CaCO_3$ and 1.66% organic matter.

The treatments consisted of four clove weights [small (< 1), medium (1.1- 2.0), large (2.1- 3.0) and extra-large (3.1-4) g]. The four cloves were planted in a randomized complete block design (RCBD) with four replicates. The soil was prepared for planting by plowing, disking and leveling. Manual raised-beds with 0.6 m width and 15 cm height were prepared and covered with polyethylene black plastic mulch. The total area of each plot was 12 m^2 consisting of 6 rows of 4 m length. The spacing used was 10 x 40 cm (2 rows per raised bed) with a single clove per hole at 3-4 cm depth. In both years, triple-super phosphate (150 kg ha^{-1}) was incorporated into the soil as basal fertilizer before planting. Nitrogen was applied at the rate of 150 kg urea ha^{-1} in two split doses at 4 and 6 weeks after planting through a drip irrigation system. Cloves of common garlic cultivar "Kiswany" were planted upright with apical tip on 1 and 5 November, 2005/2006 and 2006/2007 growing seasons, respectively. Prior to planting, garlic bulbs were split into the individual cloves (propagating material) and sorted into four clove weights [small (< 1), medium (1.1-2.0), large (2.1- 3.0) and extra-large (3.1-4) g]. Cloves were soaked in water overnight to promote early sprouting before planting on the next day. The plots were irrigated 4 d before planting to provide good clove-soil-water contact and thereafter irrigation was done once a week by using a drip irrigation system. The irrigation water amounts were added based on pan Evaporation (Ep). The total amounts of irrigation water were about 260 mm and 275 mm during the 2005/2006 and 2006/2007 growing seasons, respectively. Weed control has manually taken place and protection measures against thrips were taken by spraying the insecticide Chloropyrifos (Dursban EC 48%) to avoid infestation. Recommended agricultural practices were followed in the experimental field throughout the growing seasons.

Emergence percentage, number of leaves per plant and plant height were recorded during the growing seasons. Bulbs were harvested (10 June 2005/2006 and 13 June 2006/2007) when the leaves had turned pale green and started falling. At harvest time, total bulbs yield per ha, average bulb weight, neck diameter, plant 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 Least Significant Differences (LSD) with $P< 0.05$ (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Effects of Clove Weight on Garlic Vegetative Growth

Percentage of seedlings emergence was significantly *(P*< 0.05) increased by using cloves with weights of more than 1g compared with clove weights less than 1g in both seasons (Table 1). Number of leaves per plant, plant height and plant weight were significantly *(P*< 0.05) affected by planted clove weight (Table 1). Generally, in both seasons, using extra-large clove weight (3.1-4.0g) significantly *(P*< 0.05) produced higher number of leaves per plant, taller plant and higher plant weight than using other clove weights. There were no significant differences between using clove weights of 3.1-4.0g and 2.1-3.0g in both seasons. The highest leaf number (13.8) was obtained when extra-large (3.1-4.0g) cloves were used, while the least leaf number was

obtained when small cloves (<1g) were used. This indicated that planting large clove weight produced higher vegetative growth as estimated by number of leaves, plant height and plant weight. In general, number of leaves per plant, plant height and average plant weight were significantly *(P*< 0.05) increased by using large clove weight and extra-large clove weight in both seasons (Table 1). This could be a result of the positive effect of available food reserves in large cloves, which may improve crop establishment and consequently increased with the leaf number, plant height and plant weight. This was in agreement with results reported by Ahmed *et al.* (2007), Castellanos *et al*. (2004) and Stahlschmidt *et al.* (1997). Availability of food reserves for the new young cloves allowed them to be more vigorous in their growth and development. According to Danna *et al*. (2000), large-sized cloves produced plants which were taller and had more leaves per plant.

Effects of Clove Weight on Garlic Yield and Yield Components

In both seasons, clove weight significantly affected bulb yield of garlic. Higher bulb yield was achieved when large and extra-large cloves were used compared with other clove weights (Table 2). In the first growing season (2005/2006), higher bulb yield per hectare was obtained when extra-large clove weights (3.1-4.0g) were planted compared with other clove weights. However, in the second year (2006/2007), using extra-large (3.1-4.0g) and large (2.1-3.0g) clove weights was not significantly *(P*< 0.05) different in bulb yield, but both clove weights had significantly *(P*< 0.05) higher bulb yields than other clove weights. The percentage of the increase in bulb yield by using the extra-large clove weights (3.1-4.0g) compared with the small clove weights (<1g) was 75% and 59% in 2005/2006 and 2006/2007, respectively.

Maximum garlic yield values (19.2 and 18.4 tons ha $^{-1}$) were achieved by using large clove weights (3.1-4.0 g) in 2005/2006 and 2006/2007 growing seasons, respectively. This could be a result of the positive effect of higher vegetative growth which was obtained by planting large clove weight, possibly lending to the development of larger bulbs and higher yield (Ahmed *et al.*, 2007; Stahlschmidt *et al.*, 1997). This confirmed the earliest findings of Minard (1978) who reported that best garlic yield resulted from using large cloves. According to Adekpe *et al*. (2007) and Bhuiya *et al*. (2003), the highest garlic yield and its components were produced with early planting date, which may be due to higher vegetative growth as a result of higher number of leaves and higher plant height. Our results are in agreement with the findings of other researchers (Adekpe *et al.*, 2007; Bhuiya *et al.*, 2003; Rahim *et al*., 1984), who indicated that garlic plants which attained higher vegetative growth in early planting possibly had developed larger bulbs and higher yield.

In regard to bulb quality traits such as bulb diameter and average bulb weight, these were significantly *(P*< 0.05) higher when the largest clove weights (3.1-4.0g) were used as compared with the smallest clove weights (<1g) (Table 2). In 2005/2006, the least bulb diameter and average bulb weight were achieved by using the small clove weights (<1g); however, there were no significant differences between using 1.0-2.0 and 2.1-3 g clove weights. In 2006/2007, bulb diameter was significantly higher by using the extra-large clove weights (3.1-4.0g) than by using the other clove weights. Number of cloves per bulb was not significantly affected by different clove weights in 2005/2006. However, the least number of cloves per bulb was significantly produced by using the smallest seed clove weights (<1g) in 2006/2007. In general, number of cloves per bulb was not significantly affected by different clove weights except for the small clove weights (<1g) in 2006/2007,

which agreed with data obtained by Danna *et al*. (2000) and Reghin *et al*. (2004), and disagreed with those obtained by Ahmed *et al.* (2007) and Minard (1978). The only significant reduction in neck diameter was observed in 2005/2006 when the small clove weights (<1g) were used as planting material.

In conclusion, planting large clove weights (3.1-4.0 g) produced higher vegetative growth parameters (emergence, leaf number per plant, plant height and plant weight) and maximum garlic bulb yield. Bulb quality (bulb diameter and average bulb weight) was considerably improved by using large clove weight. Therefore, it is suggested that planting large and extra-large clove weights produces higher bulb yield and enhances the quality of garlic.

Table 1. Effect of clove weight on vegetative growth of garlic grown under drip irrigation.

Clove weight (g)	Emergence (%)	Leaf number/plant	Plant height (cm)	Plant weight (g)
		2005/2006		
3.1-4.0	99 a	13.8 a	105.7 a	63.5 a
2.1-3.0	98 a	13.2 ab	94.4 ab	51.3 b
1.0-2.0	98 a	11.9 bc	81.9 bc	41.7 bc
< 1	91 b	11.4 c	78.3 c	38.3 c
LSD	5.8	1.6	13.0	10.0
		2006/2007		
3.1-4.0	98 a	14.6 a	98.2 a	61.2 a
2.1-3.0	98 a	13.8 ab	95.3 ab	52.4 b
1.0-2.0	97 ab	12.2 b	82.9 b	42.6 c
< 1	92 b	10.5 c	77.8 c	35.4 c
LSD	4.6	2.1	11.0	8.5

*****Means having different letters within each column for each growing season are significantly different at 5% level of probability according to LSD.

Table 2. Effect of clove weight on garlic yield and yield components under drip irrigation.

Clove weight (gm)	Yield (ton/ha)	Bulb diameter (cm)	Average bulb weight (gm)	Number of cloves/bulb	Neck diameter (cm)
2005/2006 growing season					
3.1-4.0	19.2 a	5.2 a	47.2 a	38.1 a	1.5 a
2.1-3.0	14.5 b	4.5 ab	35.1 ab	37.2 a	1.3 ab
1.0-2.0	11.4 bc	4.4 ab	33.9 ab	38.8 a	1.1 ab
< 1	11.0 c	4.2 b	29.8 b	36.2 a	1.0 b
LSD	3.4	0.9	17.8	6.9	0.4
2006/2007 growing season					
3.1-4.0	18.4 a	5.4 a	45.3 a	38.3 a	1.6 a
2.1-3.0	16.6 a	4.6 b	39.7 ab	38.1 a	1.4 a
1.0-2.0	12.3 b	4.3 b	34.5 ab	36.2 a	1.4 a
< 1	11.6 b	4.1 b	29.6 b	32.6 b	1.3 a
LSD	3.6	0.7	15.6	5.8	0.35

*****Means having different letters within each column for each growing season are significantly different at 5% level of probability according to LSD.

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تأثير وزن فصوص الثوم على نمو وإنتاجية محصول الثوم تحت الري بالتنقيط

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ملخـص

أجريت التجربة في محطة البحوث الزراعية/ كلية الزراعة/ جامعة مؤتة/ الكرك- الأردن خلال موسمي 2006/2005 و 2007/2006 لدراسة تأثير أربعة أوزان لفصوص الثوم على نمو وإنتاجية الثوم. تم استخدام أربعة أوزان لفصوص الثوم (أقل من 1.0 ، 1.0-2.0، 2.1-3.0، 3.1-4.0 غرام)، حيث استخدم تصميم القطاعات العشوائية الكاملة وبأربعة مكررات. أدى استخدام الفصوص الكبيرة إلى زيادة النمو الخضري معنوياً مقارنة بأوزان الفصوص الأصغر. فقد ازداد عدد الأوراق وطول النبات ومعدل وزن النبات الكلي. كما ازداد محصول الثوم ومعدل وزن البصلة الواحدة بشكل معنوي بزيادة وزن الفصوص المستخدمة في الزراعة. بينما لم يتأثر كل من عدد الفصوص للبصلة الواحدة وقطر عنق البصلة معنوياً نتيجة لوزن الفصوص المستخدمة في الزراعة. بلغت نسبة الزيادة في محصول الثوم نتيجة استخدام الفصوص الأكبر حجماً (3.1-4.0 غرام) مقارنة باستخدام الفصوص الصغيرة (أقل من 1.0 غرام) حوالي 75% و 59%خلال موسمي الزراعة على التوالي.

الكلمات الدالة: الثوم، وزن فصوص الثوم، إنتاجية محصول الثوم.

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