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Effect of Planting Pattern on Physico-chemical Properties of Two Garlic Cultivar

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ABSTRACT

Background: Garlic (*Allium sativum* L.) member of the family Alliaceae, quality planting material is one of the major inputs to successful crop production. Planting spacing is the systematic evaluation of the farm area or any growing surface for crop production.

Methods: In order to investigate the effect of planting pattern on morphology and physiology variables of two garlic cultivars an experiments was conducted as a factorial based randomized block design with three replications in research field of Gonbad-e-Kavous University during 2016-2017. The factors were included seven planting patterns (12.5×12.5, 15×15, 17.5×17.5, 20×20, 22.5×22.5, 25×25 and 27.5×27.5 cm) and two garlic cultivars (Tarom and Hamedan) and the measurements were phenology bulb yield, harvest index, biological yield and quality parameters (total phenol, antioxidant activity, total flavonoid and allicin).

Result: The highest bulb yield (19014.4 kg ha^{-1}) was recorded in planting pattern 12.5×12.5 cm that obtained from the Hamedan cultivar. The highest and lowest of total phenol content ranged from 10.43 mg/100 g (27.5×27.5 cm) to 8.50 mg/100 g (12.5×12.5 cm). The antioxidant activity varied from 85.20% (27.5×27.5 cm) to 77.59% (12.5×12.5 cm). The results also showed that Hamedan cultivar had a higher bulb yield, total phenol, Flavonoid and antioxidant activity than Tarom cultivar. The minimum days to 50% leafing (24.16 days), days to 50% bulb initiation (74.50 days) and days to 50% maturation (152.83 days) observed in planting pattern 12.5×12.5 cm treatment.

Key words: *Allium sativum* L.**,** Antioxidant activity, Bulb yield**,** Phenology, Total phenol.

INTRODUCTION

Garlic (*Allium sativum* L.) is one of the medicinal plants in traditional medicine of Iran and it is necessary to evaluate its antimicrobial effects on some food borne bacteria. Resent research indicated that fresh and processed garlic may have some health benefits on human health such as anti-carcinogenic, anti-fungal, anti-bacterial, anti-viral, anti-tumor, hypotensive and hypolipidemic properties (Kavyani *et al*. 2016). The area harvested under garlic cultivation in Iran is about 4,514 hectares, producing quantity 54,247 tonnes and yield 12,016,600 kg ha^{-1} (FAO, 2016).

Cultivar selection and plant density manipulation have been widely used as the most effective agriculture practices in many counties. The great potential benefits mean that there is a need to critically assess harvesting practices that optimize biomass production under different agro ecological conditions. Planting density and frequency of cutting have been identified as critical management that effect yield and quality (Gadzirayi *et al*. 2013).

For increasing garlic production there is a need to check the optical density of garlic. The planting density decrease competition for sunlight, water and nutrient in crops (Geremew *et al*. 2010). Plant spacing was recorded from 20 to 10 cm there was significant increase in cured bulb yield; further reduction to 5 cm reduced the yield, these observations are in agreement with the finding of Kilgori *et al*. (2007). Olfati *et al*. (2016) reported indicate that garlic yield increased when the lower between row spacing and by the reduction in bulb size and some quality indices such as total phenol and antioxidant which severely affects quality value.

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The reason for low yield of garlic is low planting density which is due to wider spacing Total bulb yield can be increased as population density increases (Kantona *et al*. 2003).

The phenology is the study of natural periodic events in the plant life. Changing the era of phenology is the most sensitive reaction of living organisms to climate change and awareness of phenology is important for regeneration and management of farms (Mohammadi *et al*. 2014). For each production system, there is a population that optimizes the use of available resources, allowing the expression of maximum attainable seed yield and growth parameters in that environment. The ideal plant number per area will depend on several factors such as water, plant density and maturity group (Sangoi *et al*. 2002).

In each region, new cultivars with a good growth pattern should be selected. This study was carried out to investigate the potential of the phonological, morphological and physiology diversity of different plant pattern and two cultivars of garlic. Thus, the aim of this study was also, to identify the phenology (developmental stages) and other physico-chemical properties in a given climatic condition (Iran).

MATERIALS AND METHODS

A factorial experiment based randomized complete block design with three replications was conducted at the research field of University of Gonbad Kavous (37°16′ N latitude, 55°12′ E longitude, elevation of 45 m above sea level, Gonbad Kavous city, Golestan province, Iran) during the growing season of 2016-2017.

Experimental factors consist of different plant patterns (12.5×12.5, 15×15, 17.5×17.5, 20×20, 22.5×22.5, 25×25 and 27.5×27.5 cm) with two garlic cultivars (Tarom and Hamedan). Mean temperature and rainfall in the garlic growing season are presented in (Table 1). The land was prepared by plowing and disking following local farm practices. The cloves were planted on 23 December 2016. Soil characteristics were texture being clay-loam, EC=1.3 $ds.m^{-1}$, pH=7.7 and O.C=1.44%.

The agronomic properties and quality data were collected by sampling plants randomly of each plot, under the replication. Accordingly, the following data were collected. Main phenological stages in garlic plant consist of clove sprouting, leafing, bulb initiation and maturation (Takagi, 1990).

Methanol extracts of sample (1 g sample in 10 cc methanol) were used for determination of total phenolics. Total phenolic content was evaluated by colorimetric analyses using Folin-Ciocaltaue phenol reagent (Singleton and Rossi, 1965). In this way, 0.1 g of dry garlic was mixed with 10 ml of 80% hot ethanol and centrifuged at 1000 rpm for 10 minutes, then 0.5 ml Folin-Ciocaltaue was added and 2 ml of 20% sodium carbonate was added. The resulting solution was then read by a spectrophotometer at the absorption point of 650 nm. The total phenolic content was expressed as mg galic acid equivalent/100 g of sample.

The free radical-scavenging activity against DPPH radical was evaluated with the methods of Larrauri *et al*. (1998) with minor modification. In the presence of an antioxidant, the purple color intensity of DPPH solution decays and the change of absorbance are followed spectrophotometrically at 517 nm. Measurement of total flavonoids was performed according to method Pourmorad *et al*. (2006). Total flavonoids were measured by aluminium colorimetric method. This in way, first 60% solution was prepared with dry garlic in ethanol and then 1 ml of this solution was transferred to a test tube and then 1 ml of 2% aluminium chloride solution and 6 ml of 5% potassium acetate solution were added to it, the absorbance at 415 nm was read with a spectrophotometer. Allicin was measured by Bors and Saran (1987) and the change followed spectrophotometrically at 412 nm.

All the data was subjected to analysis of variance (ANOVA) using SAS version 9.2 Software. Differences among treatment means compared using the least significant difference test (LSD) 5% probability level. Also, Graphs were drawn with Excel 2007.

RESULTS AND DISCUSSION

Phenological parameters

Data presented in (Table 2) showed that planting pattern and cultivar significantly ($p<0.01$) affected 50% leafing bulb initiation and maturation, but plant pattern had no significant effect on clove sprouting of garlic.

The results of the mean comparison showed that the garlic planted in plant pattern 12.5×12.5 cm required minimum number of days to leafing, bulb initiation and maturation. On the other hand, garlic planted in plant pattern 27.5×27.5 cm took maximum number of days for leafing (27.00 days after planting), bulb initiation (76.83 days after planting) and maturation (163.33 days after planting) (Table 3). This might be the reason that in higher plant density (12.5×12.5 cm) and to due competition between plants there was early inter the phenological stages.

Table 1: Temperatures and rainfall during the growing season of 2016-2017.

Month	December	January	February	March	April	May
Rainfall (mm)	39.99	46.10	48.00	46.90	54.80	1.80
Temperature (°C) Max.	15.23	14.35	13.41	19.02	23.00	32.31
Temperature (°C) Min.	3.54	2.08	1.36	6.06	9.68	15.56

Table 2: Analysis of variance (ANOV) for phenological traits of garlic cultivars in different planting patterns.

S.O.V.	DF	Mean square			
		Clove sprouting	Leafing	Bulb initiation	Maturation
Replication	2	3.16*	1.78*	0.85^{ns}	3.50^{ns}
Cultivar	1	754.38**	486.88**	1394.38**	298.66**
Planting pattern	6	1.53^{ns}	6.96**	4.07**	117.10**
Interaction	6	0.60^{ns}	0.26^{ns}	0.38^{ns}	2.05^{ns}
Error	26	16.33	9.76	12.28	35.66
CV (%)	-	0.74	0.90	2.41	8.76

ns,* and **: non-significant difference, significant difference at 0.05 and 0.01 probability levels, respectively.

Similar results were reported by Seyed Sharifi and Namvar (2016) that the increase of plant density from 7 to 9 and 11 plants m^{-2} induced a statistically significant increase of the days to tasseling of maize from 40.86 to 42.53 and 43.66 days, respectively.

The observed in (Fig 1), that among the cultivars the minimum number of days to clove sprouting (4.80 days after planting), leafing (21.95 days after planting), bulb initiation (70.09 days after planting) and maturation (154.76 days after planting) of Tarom cultivar. And (Fig 1) shows that the beginning of bulb initition in Hamedan was about 81.61 days after planting and Hamedan cultivar took maximum number of days (160.09 days after planting) for maturation. Therefore, these results need more serious attention to climate adaptation and conditions impact as one of the strategies to optimal growth. Agriculture is strongly influenced by weather and climate. The nature of agriculture and farming practices in any particular location are strongly influenced by the short and long term mean climate (Dhawan *et al*. 2017).

Physical properties

The results showed that there were significant differences interaction between cultivar and planting patterns effects on bulb yield, total yield and harvest index (Table 4). According to mean comparison results the data in (Fig 2), the highest bulb yield belonged to Hamedan cultivar (19014.4 kg ha^{-1}) that obtained planting pattern 12.5×12.5 cm and the lowest obtained from planting pattern 27.5× 7.5 cm of Tarom cultivar (7572.1 kg ha^{-1}). As it is shown in Fig 3, maximum mean comparison total yield (Biological yield) was observed at 12.5×12.5 cm (29100.3 kg ha^{-1}) of Hamedan garlic and the planting pattern 27.5×27.5 cm (10837.3 kg ha^{-1}) lead to the lowest total yield. The total yield increased by increasing plant density. The highest harvesting index for two cultivars obtained from planting pattern 27.5×27.5 cm and the lowest harvesting index was observed in planting pattern 12.5×12.5 cm (Fig 4). Bulb

Table 3: Mean comparison of phenological traits of garlic cultivars in different planting patterns.

Planting patterns (cm)	Leafing	Bulb initiation	Maturation
12.5×12.5	24.16^{d}	74.50^{c}	152.83^{e}
15 ×15	24.33^{d}	75.33^{b}	153.00^{ed}
17.5×17.5	24.50^{d}	75.66^{b}	154.33^{d}
20×20	25.50^{c}	75.83^{b}	159.33^{c}
22.5×22.5	25.66^{bc}	76.00^{b}	159.66^{b}
25×25	26.33^{ab}	76.83^{a}	162.50^{a}
27.5×27.5	27.00^{a}	76.83^{a}	163.33^{a}
LSD (5%)	0.72	0.81	1.54

Means in each column followed by the similar letters are not significantly different at 5% of probability level.

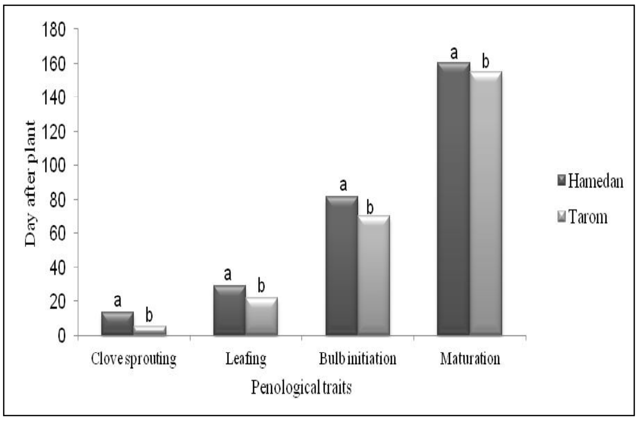

Fig 1: The effects of cultivars on phenological traits of garlic. (Means in each column followed by the similar letters are not significantly different at 5% of probability level).

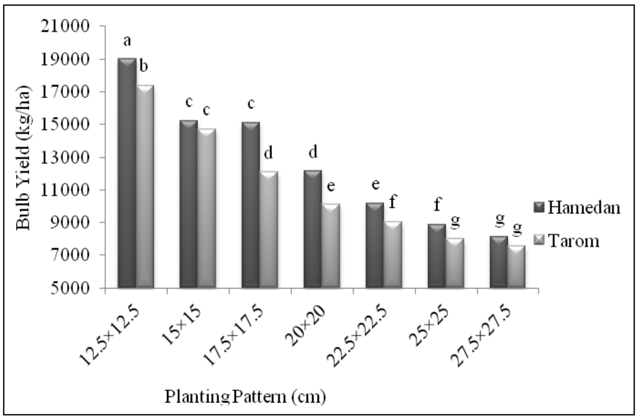

Fig 2: Interaction effects between cultivar and planting patterns on bulb yield of garlic. (Means in each column followed by the similar letters are not significantly different at 5% of probability level).

Table 4: Analysis of variance (ANOVA) of effects of planting patterns and cultivar on agronomy properties of garlic.

S.O.V.	DF	Mean square		
		Bulb yield	Harvest index	Biological yield
Replication	2	103225.6^{ns}	0.0018*	578303^{ns}
Cultivar	1	20365382.5**	0.18**	37083005**
Planting pattern	6	86302764.2**	0.0055**	281385224**
Interaction	6	1256791.5**	0.0042**	16170383**
Error	26	140309.9	0.0004	150228
CV (%)		3.12	3.27	1.98

ns, * and **: non-significant difference, significant difference at the levels of 5% and 1% probability, respectively.

Table 5: Analysis of variance (ANOVA) of effects of planting patterns and cultivars on chemical properties of garlic.

S.O.V.	DF	Mean square			
		Total phenolic	Allicin	Flavonoid	Antioxidant activity
Replication	2	0.10^{ns}	3.54^{ns}	0.51^{ns}	0.09^{ns}
Cultivar	1	27.83**	19.54**	32.54**	12.08**
Planting pattern	6	5.47**	5.99^{ns}	6.16**	4.24**
Interaction	6	1.06*	2.21^{ns}	1.92*	1.51*
Error	26	0.13	2.05	0.22	0.06
CV (%)		1.11	7.91	4.06	3.17

ns, * and **: non-significant difference, significant difference at the levels of 5% and 1% probability, respectively.

Table 6: Mean comparison of chemical properties (Allicin) of different garlic cultivars.

Cultivar	Allicin (%)
Tarom	5.13^{b}
Hamedan	7.32^{a}
LSD (5%)	1.39

Mean in each column followed by the similar letters are not significantly different at 5% of probability level.

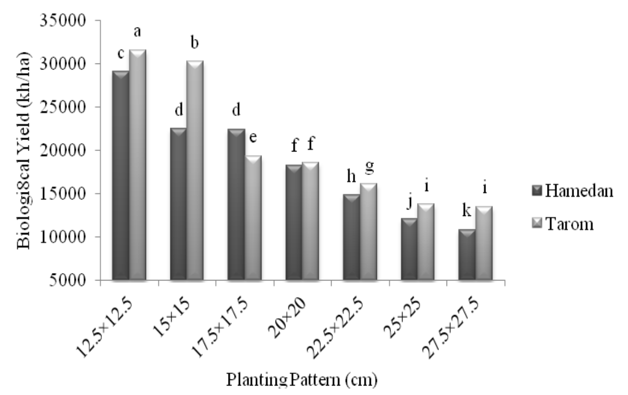

Fig 3: Interaction effects between cultivar and planting patterns on biological yield of garlic. (Means in each column followed by the similar letters are not significantly different at 5% of probability level).

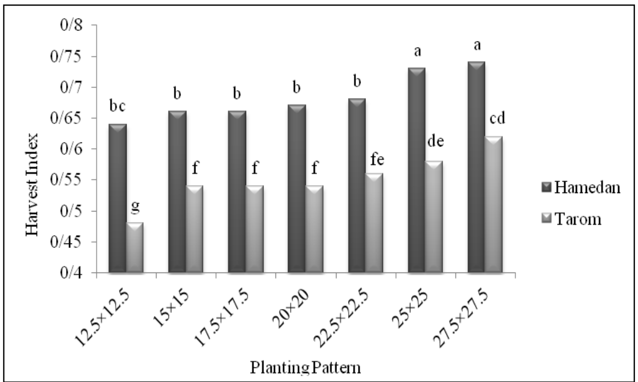

Fig 4: Interaction effects between cultivar and planting patterns on harvest index of garlic. (Means in each column followed by the similar letters are not significantly different at 5% of probability level).

yield increased in high plant density (12.5×12.5 cm), this might be due to high number plant per area.

Previous studies carried out on plant density indicate its direct influence on difference crop yield (Lima *et al*. 2012; Zhang *et al*. 2012; Souza *et al*. 2013). Observation of results for various planting pattern showed that the wider spaced plants (27/5×27/5 cm) have the higher harvest index in Hamedan cultivar. These results are also similar with the result of Olfati *et al*. (2016). The higher plant density resulted in competition nutrient, water and light thus resulting in plant that were short while the wider spaced plants had adequate space for their growth and development (Biru, 2015). Noorbakhshian *et al*. (2006) reported that there were significant differences among genotypes for garlic yield per plant and per plot. Observation of results for various plant spacing showed that almost all plant spacing under study responded positively for bulb yield. These results are also similar with the results of Bosekeng and Gesin (2015). Olfati *et al*. (2016) reported that wider spaced plant showed high harvest index and biological yield due to the high potential of plants.

Chemical analysis

The results showed that there are significant differences interaction between planting patterns and cultivar effects on total phenol, flavonoid and antioxidant activity, but effects of planting pattern on allicin was not significant (Table 5).

The highest total phenol of Hamedan cultivar obtained from 27.5×27.5 cm (12.30 mg/g DW) while the lowest total phenol was observed in 12.5×12.5 cm (7.94 mg/g DW) Tarom cultivar (Fig 5). The highest antioxidant capacity for two cultivar obtained from 27.5×27.5 cm, but the highest antioxidant capacity except Hamedan that it related to 27.5×27.5 cm planting pattern (96.85% DPPH reduction) and the lowest antioxidant capacity (75.91% DPPH) of Tarom cultivar obtained from planting pattern 12.5×12.5 cm (Fig 6). In Fig 7, using of planting pattern to 27.5×27.5 cm led to increase in flavonoid of Hamedan cultivar (5.25 mg/100g DW), which decreased at plant density 12.5×12.5 cm of Tarom cultivar (2.78 mg/100g DW). More bulb size obtained from wider spacing (27.5×27.5 cm) may be due to vigorous plant, dues bulb store more food for vegetative as well as reproductive growth and quality of garlic. Light is important source of photosynthesis for crop, wider spaced plant get proper light intensity and nutrient (Kahsay *et al*. 2014; Muneer *et al*. 2017). Olfati *et al*. (2016) reported that in closer row spacing total phenol in garlic was less.

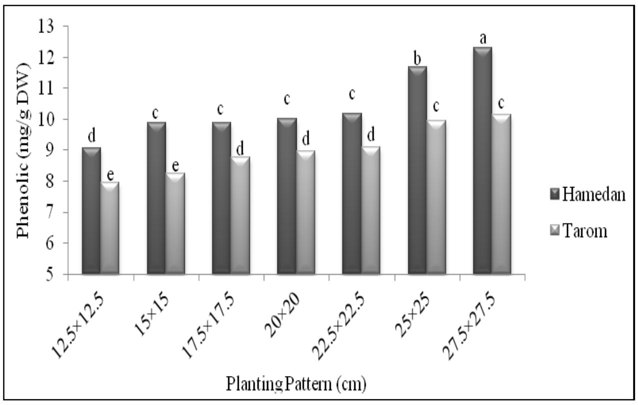

Fig 5: Interaction effects between cultivar and planting patterns on total phenolic of garlic. (Means in each column followed by the similar letters are not significantly different at 5% of probability level).

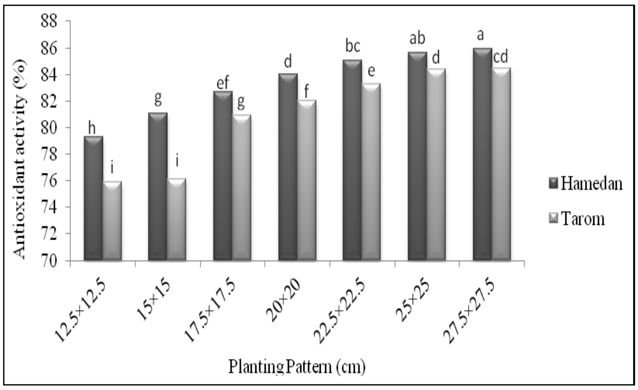

Fig 6: Interaction effects of cultivar and different planting patterns on antioxidant activity of garlic. (Means in each column followed by the similar letters are not significantly different at 5% of probability level).

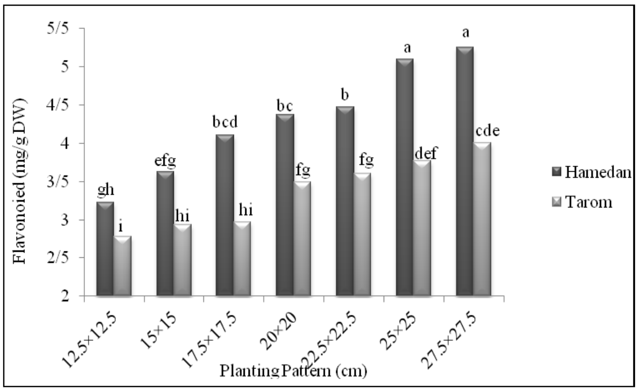

Fig 7: Interaction effects of cultivar and different planting patterns on flavonoid of garlic. (Means in each column followed by the similar letters are not significantly different at 5% of probability level).

The result in Table 6 showed that the Hamedan cultivar was the best accession of allicin (7.32%). These results are also similar with the results of Sedaghati, (2016). Castellanos *et al*. (2004) in their experiments on garlic, they concluded that qualitative traits change with changing density. At high densities, plants are weakened by competition and reduce photosynthesis and such conditions reduce product quality (Moravcevic *et al*. 2011).

CONCLUSION

The most suitable planting density is very important management practices in garlic production. Planting pattern 12.5×12.5 cm gave best result for bulb yield, while planting pattern 27.5×27.5 cm gave more total phenol, flavonoid and antioxidant capacity. Thus, moderate planting density for fresh market garlic and closer planting pattern and high plant density for higher yield is proposed according our results. The minimum of days to 50% maturation was obtained from plant density 12.5×12.5 cm of Tarom cultivar and plant pattern 12.5×12.5 cm occurred due to competition between the early plants.

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