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Determination of the Optimum Bulb Sizes and Cultivation Possibilities of Turkish Endemic Allium tuncelianum (KOLLMAN), N.ÖZHATAY, D. MATHEW, S. SİRANECİ

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Abstract
Unconscious collection from nature may lead to the extinction of the Tunceli Garlic plant, which is endemic to Turkey. Preventing this situation can be possible by culturing the plant under field conditions. At the same time, garlic is a plant that requires the use of large amounts of cloves. This is one of the most important factors that increases production costs. The net bulb yield is very important for profitable production. Tunceli garlic, which can also be grown from seeds, can be an alternative to traditional garlic production. This study was conducted to determine the effect of different bulb sizes on some agricultural characteristics of Turkish endemic *Allium tuncelianum* (Kollman), N. Özhatay, D. Mathew, S. Siraneci under the conditions of the Southeastern Anatolia Region of Turkey in 2019-2021. In the research, 4 different bulb sizes (06-08, 08-10, 10-12 and 12-14 cm) were tested according to the Randomized Complete Blocks experimental design with 4 replications. In the research, in addition to phenological observations such as sprouting date, flowering date, flowering period, vegetation period; parameters such as plant height (32.75-118.75 cm), leaf length (26.75-44.75 cm), number of leaves (6.75-9.0 number per plant^{-1}), number of kralens (0-2.94 number per plant^{-1}), bulb yield (1919.0-2460.50 kg/da^{-1}), net bulb yield (1624.50-1748.0 kg/da^{-1}), bulb circumference length (16.52-18.67 cm), bulb weight (50.50-64.75 g), bulb circumference increase rate (143.75-235.75%), total phenolic content (53.75- 64.75 mg/GA) were examined. According to the results obtained in the study, bulbs with a circumference of 12-14 cm showed superior properties in terms of the characteristics examined in different bulb sizes. Although it is seen that bulbs with a circumference of 12-14 cm stand out in bulb yield values; considering the net bulb yield values, it has been determined that it would be more appropriate to use bulbs with a circumference of 06-10 cm in production in Southeastern Anatolia (Sanliurfa) field conditions. In addition, it was determined that Tunceli Garlic has the potential to grow under regional conditions and it was predicted that it could be grown as an alternative plant in regional agriculture.
Keywords: Garlic, Allium, Allium tuncelianum, Bulb, Tunceli garlic
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1. Introduction

More than 1200 geophyte species are naturally distributed in Turkey (Davis, 1988; Güner et al. 2000; Açay, 2018). Of the 1250 Allium species found in the world, 175 are naturally distributed in Turkey and some are used as garlic. Approximately 40% of these Allium species have been reported to be endemic. (Fırat, 2015). Garlic has a significant share in the world agriculture in terms of production area and amount of product obtained (Atik ve Dıraman, 2019). Tunceli Garlic [*Allium tuncelianum* (KOLLMAN), N. ÖZHATAY, D. MATHEW, S. SİRANECİ], an endemic plant species, is distributed in the Eastern Anatolia Region of Turkey and is known as Mountain Garlic (Koyuncu & Güvenç, 1994; Fırat, 2015; Acay, 2018). Tunceli Garlic is a plant that is collected from nature and traded, although it is prohibited (Fırat, 2015; Acay, 2018). In addition to its unique smell and taste, it is similar to cultivated garlic in terms of the active ingredients (Alliin, Allisin) it contains. What distinguishes Tunceli Garlic from cultivated garlic is that it has a single-cloves structure and the ability to reproduce from kralen and seeds. Considering that 100-120 kg/da^{-1} of cloves of garlic are used in cultivated garlic production, it is a known fact that the most important input in garlic production is the seed cost (İbret, 2005). Considering the fact that Tunceli Garlic has the ability to reproduce from seeds and the kralens, this is a factor that can significantly reduce the cost of production. In addition, the fact that it has seeds is one of the factors that can make the breeding of Tunceli Garlic very easy and productive. For these reasons, the cultivation techniques of the plant must be determined and studies must be carried out on the propagation material. In this research, it was aimed to determine the possibility of growing Tunceli Garlic plant under field conditions and some of its agricultural characteristics.

2. Materials and Methods

The research was conducted according to the randomized complete block trial design with 4 replications under Southeastern Anatolia Turkey (Sanliurfa) conditions for two years (2019-2021). In order to determine the optimum bulb size, bulbs with a circumference of 6-8, 8-10, 10-12, 12-14 cm were used as seeds. Bulbs were

stored in a temperature-controlled warehouse environment at 16 ℃ until October. The bulbs were sprayed with a mixed solution of 4% Prochloraz and 0.9% Propiconazole, and then they were dried by laying them in 10 cm thick piles in a place out of sunlight before planting. The bulbs were planted by hand in 6 rows in the plots on October 1 in both years. Each plot was arranged in 6 m length and 10×10 cm density. 35 kg/da of 15.15.15 compound fertilizer was applied to the soil before planting. Foliar fertilizer containing 3 kg of pure nitrogen, phosphorus and potassium was applied to the parcels before flowering. Irrigation and manual weed control were carried out when necessary. The data obtained from the research; variance analysis was performed through JMP-SAS, and grouping was carried out by comparing the statistically significant average results according to the LSD test.

3. Results and Discussion

3.1 Phenological Observations

Table 1 shows the phenological observation results determined in the study carried out to determine optimum bulb sizes in Tunceli Garlic.

When the sprouting dates of Tunceli Garlic are examined, it is seen that the size of the bulb significantly affects the sprouting dates and larger bulbs emerge earlier. The data obtained in some studies on bulbous plants supports our study. Özel & Erden (2008) report that as the size of the bulb increases, sprouting occurs earlier in their study on saffron. In their study, Çavuşoğlu & Erkel (2005) reported that sprouting occurred earlier as the corm diameter increased.

When the flowering date values of different bulb sizes were investigated, it was determined that the earliest flowering was seen in bulbs with a size of 12-14 cm and the latest flowering was seen in bulbs with a size of 6-8 cm in both years (Table 1). It has been reported that the development of flower buds is closely related to the amount of nutrients of bulb and that larger tubers form stronger shoots and bloom earlier (Özel & Erden, 2008). In this study, it can be said that the different flowering date values determined in different bulb sizes are related to this character.

When the flowering duration values were investigated, it was determined that the longest flowering period was in bulbs with a size of 12-14 cm (27 days) and the shortest flowering period was in bulbs with a size of 6-8 cm (20 days). Çavuşoğlu & Erkel (2005) report that as corm diameter increases, flowering time also increases. It can be said that the difference in the flowering durations is due to the fact that larger bulbs contain more nutrients. When Table 1 was investigated, it was determined that the longest vegetation period occurred in bulbs with a size of 12-14 cm (274 days) and the shortest vegetation period occurred in bulbs with a size of 6-8 cm (264 days). It can be said that the difference in vegetation periods seen in the bulbs is due to the fact that larger bulbs sprouting earlier and have longer vegetation periods.

Table 1. Some phenological observations of Tunceli Garlic materials used in the research

Characteristics	Planting Date	Sprouting Date	Flowering Date	Flowering Duration (days)	Vegetation Period (days)
2019-2020					
06-08 cm	01.10.2019	23.10.2019	21.05.2020	20	264
08-10 cm	01.10.2019	19.10.2019	18.05.2020	23	268
10-12 cm	01.10.2019	15.10.2019	15.05.2020	25	272
12-14 cm	01.10.2019	13.10.2019	11.05.2020	27	274
2020-2021					
06-08 cm	01.10.2020	26.10.2020	23.05.2021	22	270
08-10 cm	01.10.2020	19.10.2020	20.05.2021	22	271
10-12 cm	01.10.2020	17.10.2020	20.05.2021	24	271
12-14 cm	01.10.2020	16.10.2020	15.05.2021	28	280

3.2 Plant Characteristics

3.2.1 Plant Heights

Plant heights was significantly affected by bulb sizes in both growing seasons. In the research; the plant height values obtained from different bulb sizes in Tunceli Garlic varied between 32.75-118.75 cm according to the combined values of two years. The shortest plant height was found in 6-8 cm, and the highest plant height was found in 12-14 cm bulb circumferences. It is thought that the difference in plant height values is due to the fact that larger bulbs sprout earlier, develop more vegetative parts and perform more photosynthesis. It is reported that as bulb size increases in bulbous plants, plant height also increases (Ozel and Erden, 2008). According to Peker's study (2019) on the Tunceli Garlic plant under similar ecological conditions, plant height values were 39.73-40.59 cm. It can be said that this difference arises from the different sizes of bulbs used in the researchs and the difference in planting dates.

3.2.2 Leaf Lenght

In this study on Tunceli Garlic, leaf length values varied between 26.75-44.75 cm. The lowest leaf length was detected in bulbs with a size of 6-8 cm, and the highest leaf length was detected in bulbs with a size of 12-14 cm. It can be said that the difference in the leaf length data in question is due to the fact that large bulbs have more plant nutrients, develop more vegetative parts because they sprout earlier, and start photosynthesis earlier. Jones & Man (1963) reported that the size of the bulb used in garlic production also contributed to the good development of the above-ground parts of the plant. Peker (2019), in his study in Diyarbakır, reported leaf length values as 32.05-33.99 cm. The values we found in the research were above the reported values. It is thought that this difference is due to the cultivation technique, genotypic difference, the different circumference of the bulbs used as seeds and the difference in planting dates.

Table 2. Mean values of plant heights (cm), leaf lenghts (cm), leaf number per plant (leaf plant $^{-1}$), kralen number per plant (kralen plant $^{-1}$), bulb yield (kg da $^{-1}$) of Tunceli Garlic for different bulb sizes

Characteristics	Plant Heights	Leaf Lengths	Leaf Number per Plant	Kralen Number per Plant	Bulb Yield
Two Years Combined					
06-08 cm	32.75^{d}	26.75 ^{d}	6.75 ^{b}	0.00 ^{c}	1919.00 ^{c}
08-10 cm	85.50 ^{c}	33.75 ^{c}	7.50 ^{b}	1.11 ^{c}	2166.00 ^{b}
10-12 cm	112.50^{b}	42.75 ^{b}	8.50 ^{a}	2.31 ^{b}	2413.00 ^{a}
12-14 cm	118.75^{a}	44.75 ^{a}	9.00 ^{a}	2.94 ^{a}	2460.50 ^{a}
Mean	**87.88**	**37**	**7.94**	**0.62**	**2239.60**
LSD (%1)	**1.09**	**0.78**	**0.76**	**1.64**	**2.40**

3.2.3 Leaf Number per Plant

When the number of leaves determined in Tunceli Garlic according to different bulb sizes are examined, the lowest number of leaves comes from bulbs with a size of 6-8 cm (6.75 number per plant), and the highest number of leaves comes from bulbs with a size of 12-14 cm (9.00 number per plant) was found to be obtained. The garlic plant has a pseudostem type formed by intertwining leaves. Therefore, it is an expected result that the number of leaves increases as the plant grows taller. When plant height values are examined, it can be seen that plants with high plant height values reach high leaf number values (Table 2). Peker (2019), in his study in Diyarbakır, reported the number of leaves as 7.87-7.88 number per plant. The data obtained as a result of this study exceeded the values reported by other researchers. It can be said that this difference is due to the different sizes of bulbs used as seeds and the different planting dates.

3.2.4 Kralen Number per Plant

The number of kralens determined according to different bulb sizes varied between 0-2.94 number per plant, and it was determined that the lowest value was obtained from bulbs with a size of 6-8 cm, and the highest value was obtained from bulbs with a size of 12-14 cm. The information obtained from studies on geophytes supports our study. Çavuşoğlu & Erkel (2005), in their research in Northwestern Anatolia, reported that the number of cormels increased due to the increase in corm diameter. Peker (2019), in his study in Diyarbakır, found the number of bulbils to be between 1.0-1.2 number per plant^{-1}. The findings obtained as a result of our research were above the reported values. It can be said that this difference is due to the different sizes of bulbs and genotypic differences.

3.2.5 Bulb Yield

Bulb yield was significantly affected by bulb sizes in both growing seasons. Bulb yield values in Tunceli Garlic varied between 1919.00 and 2460.50 kg da^{-1}. The lowest bulb yield was found in bulbs with a size of 6-8 cm, and the highest bulb yield was found in those with a size of 12-14 cm. Data show that bulb yield increases in direct proportion to the increase in the size of bulbs used as seeds. Arslan et al. (2007) reported that corm yield increased due to the increase in corm size in saffron plants. Beşirli et al. (1999), in their research in Central Anatolia conditions, reported that large cloves provided a significant increase in bulb yield in garlic cultivation. Peker (2019), in his study, found bulb yield findings to be between 350-430 kg da^{-1}. The bulb yield values obtained as a result of our study were above the reported values. It can be said that this difference arises from the difference in the amount of bulb used per decare and ecological differences.

3.2.6 Bulb Size

It has been determined that bulb circumference values in Tunceli Garlic vary between 16.52-18.67 cm (Table 3). The lowest bulb circumference was found in bulb with a size of 6-8 cm, and the highest bulb circumference was found in bulb with a size of 12-14 cm. In general, as the size of the bulb used as seed increased, the size of the bulb obtained also increased. However, since the values are very close to each other, it can be said that bulbs with a circumference of 6-8 cm should be used for cultivation. Thus, seed costs can be greatly reduced.

Table 3. Mean values of bulb sizes (cm), bulb weights (g), bulb circumference increase rate (%), net bulb yield (kg da $^{-1}$) and total phenolic content (mg GA $^{-1}$) of Tunceli Garlic for different bulb sizes

Characteristics	Bulb Sizes	Bulb Weights	Bulb Circumference Increase Rate	Net Bulb Yield	Total Phenolic Content
Two Years Combined					
06-08 cm	16.53 ^{c}	50.50 ^{c}	235.75 ^{a}	1748.00 ^{a}	64.75 ^{a}
08-10 cm	17.70 ^{b}	57.00 ^{b}	197.00 ^{b}	1820.00 ^{a}	63.50 ^{b}
10-12 cm	18.63 ^{a}	63.50 ^{a}	169.25 ^{c}	1653.00 ^{b}	58.50 ^{c}
12-14 cm	18.68 ^{a}	64.75 ^{a}	143.75 ^{d}	1624.50 ^{b}	53.75 ^{d}
Mean	**17.88**	**58.93**	**186.43**	**1711.25**	**60.12**
LSD (%1)	**4.63**	**1.99**	**1.77**	**2.40**	**0.46**

3.2.7 Bulb Weight

Bulb weights obtained in the research varied between 50.50-64.75 g. It has been determined that as the size of the bulb used as seed increases, the weight of the bulb obtained also increases. Brewster (1994) reported that bulb weight in garlic production increases in direct proportion to the size of the seed materials used for planting. It was determined that the data obtained in this study were higher than the data in the literature [Yanmaz et al. (2006) 14.8-32.0 g, Ağbaş et al. (2014) 10.89-14.08 g, Peker (2019) 17.91-18.84 g]. This difference may be due to the different sizes of bulbs used as seeds, climatic factors, different planting dates and cultivation techniques.

3.2.8 Bulb Circumference Increase Rates

The bulb circumference increase rate is measured to reveal the difference between the planted bulb and the harvested bulb. When the increase rates in bulb circumference length of Tunceli Garlic are examined in Table 3, it is seen that the lowest increase rate from bulbs with a size of 12-14 cm (143.75%), and the highest increase rate from bulbs with a size of 6-8 cm (235.75%) was found to be obtained. Considering that each bulb has a maximum bulb size value that it can reach; it can be said that small bulbs have a greater potential for development. According to the obtained values, it can be said that bulbs with a circumference of 6-10 cm are suitable for use in bulb production, and bulbs with a circumference of 12-14 cm are suitable for use in seed production.

3.2.9 Net Bulb Yield

Garlic is a plant that requires the use of large amounts of cloves. This is one of the most important factors that increases production costs. The net bulb yield is very important for profitable production. The net bulb yield values obtained in the research varied between 1624.50-1820.0 kg/da^{-1}, the lowest net bulb yield was found in those with a size of 12-14 cm, and the highest net bulb yield was found in those with a size of 8-10 cm.

3.2.10 Total Phenolic Content

It was determined that the total phenolic content values detected in Tunceli Garlic bulbs varied between 53.750-64.750 mg GA-1. The total phenolic content values obtained in this study are higher than the values of Ağbaş et al.. (16.21-54.25 mg GA^{-1}) and Gün (16.70 mg GA^{-1}). Our data was below the 154.79 mg GA^{-1} value obtained by Takım (2015) in his research under Eastern Anatolia conditions. It can be said that this difference is due to the different sizes of bulbs used in the research and different ecology.

4. Conclusion

According to the results obtained in the study, it can be said that it would be more appropriate to use bulbs with a circumference of 6-10 cm in field conditions in Şanlıurfa province. In this way, it will be possible to obtain higher net bulb yield. The results obtained in the study revealed that endemic Tunceli garlic can be grown successfully under field conditions. It can be said that a study should be conducted on the production of Tunceli garlic from seeds and the determination of planting time. Additionally, the possibilities of using kralens in production can also be chosen as the subject of study in the future.

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