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RESEARCH ARTICLE

The Effect of Non-woven Cover and Seedling Techniques on Plant Growth and Bulb Yield of Onion

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ABSTRACT

This study aims to determine the effect of different cultivation techniques on onion plant growth and bulb yield in harsh continental climates and the short vegetation period. Three onion varieties with different dry skin colors were used as plant material. The techniques tried were: direct seed sowing, covering with non-woven fabric after sowing of seeds, planting seedlings, and covering with non-woven fabric after planting seedlings. The study was carried out in open field conditions in the Kayseri province where located in the central Anatolia region for two years. As a result of the study, it was determined that the interaction effects of the cultivar x cultivation technique had a statistically significant effect on all measured parameters. Although germination and emergence were observed in all varieties in both cultivation techniques, which started with direct seed sowing, plant development remained weak. The bulb formation was observed in only one variety in cultivation with seed sowing. In both techniques with seedlings, all varieties formed bulbs. Seedling planting + use of cover material had a positive effect on both yield and quality criteria for the bulbs. When all the results are evaluated together, it is understood that although the degree of effectiveness varies depending on the cultivars, seedling planting is a very effective technique for onions production in these climate conditions.

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Introduction

Onion (*Allium cepa* L.) is one of the oldest known vegetables in the world. It is reported that this vegetable has great importance in terms of its nutritional and medicinal properties, as well as its widespread use in meals (Devi et al., 2014). Bulb onion cultivation in the world could be done in three ways in general: (1) Production by direct seed sowing. (2) Production by seedling. (3) Production with bulblets (small size bulbs) (Vural et al., 2000). Bulb formation physiology in onions is a subject that scientists are interested in intensively. Photoperiodicity (day length) is the most important environmental factor affecting bulb formation (Brewster, 2008). In addition to photoperiodism, the age of the plant and the number of leaves are other important factors affecting the head yield and quality (Rabinowitch & Brewster, 2009). The most important problem in onion cultivation in harsh-terrestrial climate conditions is that the leaf development cannot reach the desired level on the dates when the day length is at its highest level because of late seed sowing. This situation causes the plants to start to form heads when they are not physiologically ready yet, thus leading to a loss of yield. Taller plants provide more photosynthetic areas as a result of the sowing period for all onions, with cooler days being considered for the synthesis of the growth components of the onion stem (Mashayekhi et al., 2022). Farmers try to sow seeds of onion as early as possible to overcome this problem, but due to harsh climatic conditions, this is not always possible compared to other regions.

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Agro-textiles have a long history of use in agriculture. In their simplest form, textiles have been used for thousands of years to protect plants and animals from extreme conditions. With the development of agricultural techniques over time, the development and application of agro-textile production have expanded (Palamutcu & Devrent, 2017). Non-woven fabrics are fabric-like materials obtained by combining fibers of different lengths with various methods (chemical, mechanical, heat, etc.). Nonwoven fabrics (non-woven agro-textiles) are innovative products with special structural performance that can protect the plant against factors such as weeds, wind, and sudden temperature changes. In addition, nonwoven fabrics can be used as shade fabrics to reduce solar radiation and high temperatures. Using natural fibers for new ingredient improvement is one of the Food and Agriculture Organization (FAO) priorities as their use is expected to increase the performance and sustainability of agricultural industries worldwide (Kopitar et al., 2022). All over the world, nonwoven agro-textile applications have been tried in various products and their performance in reducing yield/quality losses has been revealed (Marasovic & Kopitar, 2019).

The study hypothesizes that seedling planting and nonwoven fabric applications will promote bulb formation in onions. This study aimed to compare three different onion cultivars in Central Anatolian conditions with three different methods alternative to direct cultivation from seed.

Materials and Methods

The study was carried out in the laboratories and open fields of Erciyes University Faculty of Agriculture during 2019-2020. Three commercial onion varieties were used as plant material. Among these varieties, “Çorum moru” is a long-day onion variety. Dry skin color is dark red/purple. It is especially well adapted to high altitudes and harsh climatic conditions. Gordion is an onion variety that leads to long/mid-day conditions. The dry skin color of this variety is yellow. "Snow-white" is a variety that binds the head in long-day conditions. The outer dry skin color is bright white. The flesh color is slightly more greenish-white. The sowing period for all varieties is indicated by the developers as January - March. The treatments were planned as direct sowing (control), seedling planting, non-woven fabric covering on the seed sowed area, and non-woven fabric covering on the seedling planted area. In seed sowing and seed sowing+covering with non-woven fabric applications, the seeds were sown on April 14, 2019, in 2 m2 plots with 7x30 cm row spacing. White-colored non-woven fabric with a density of 50 g/m2 was covered after seed sowing on the same day. On May 20, 2019, the cover was completely removed from the plants. In applications based on the use of seedlings, seeds were sown in plastic viols on 25.01.2019. The seedlings were planted on April 14, 2019, in 2 m2 plots with 7x30 cm row spacing. White-colored non-woven fabric with a density of 50 g/m2 was covered on seedlings. On May 20, 2019, the cover was completely removed from the plants. At the end of the study; pseudo-stem diameter (mm), leaf diameter (mm), pseudo-stem length (cm), bulb diameter (cm), bulb length (cm), bulb-neck diameter (cm), bulb diameter/height ratio (value), bulb weight (g), soluble dry matter (%), dry skin amount (number) were measured in the harvested plants. In addition to these, leaf length (cm) and leaf number (piece) values were measured in 10-day periods on four different dates. The study was planned in a randomized plot design with three replications. The averages were calculated by measuring 6 plants from each replication. The obtained data were subjected to analysis of variance (ANOVA) and LSD (minimum significant difference) test was used to determine the differences between applications.

Results

According to the results of the variance analysis, the effect of the double interaction of the cultivation techniques and varieties was found to be significant for all parameters examined. Leaf lengths were measured just before transplanting in seedling planting applications. At this stage, approximately 15 cm long seedlings were used for all cultivars. Two months after the establishment of the field trial, the leaf lengths were measured for the first time. Three more measurements were made in the following 10-day periods. While evaluating the results, all four measurements were statistically compared within themselves. Accordingly, in the first measurement, seedling planting and seedling planting + Non-woven cover applications had a significant positive effect on leaf lengths in all varieties (Table 1). This effect was also observed in other measurements, but differences were observed between the maximum lengths reached due to the variety effect. In the last measurement, the highest value was determined at 79.33 cm in the seedling planting application of the “Gordion” cultivar. The positive effect was observed in the "Kar beyaz" variety in the application where the non-woven cover was combined with the seedling planting. Leaf lengths remained remarkably small in applications starting with direct seed sowing. The number of leaves is one of the most important factors that indirectly affect the head tying in onions. To achieve the ideal head size, the plants should have a large number of leaves during the maximum day length period when bulb forming is physiologically triggered. In the applications that started with the seedling planting, three leafy plants were used as starting material. As with the leaf length values, the first counts were made two months after the establishment of the field trial. Three more counts were made in the following 10-day periods. While evaluating the results, all four counts were statistically compared within themselves. Accordingly, in the first count, seedling planting and seedling planting + non-woven cover applications had a significant positive effect on the number of leaves in all varieties (Table 2). This effect was also observed in ongoing counts. In the last count, the highest value was determined in the seedling planting application of the

"Gordion" variety with 9.17 units/plant. In the applications that started with direct seed sowing, the number of leaves decreased significantly.

Table 1. The effect of treatments on the length of leaves

Variety	Treatment	Start (cm)	1. Count (cm)	2. Count (cm)	3. Count (cm)	4. Count (cm)
Çorum moru	Seedling	15.00	67.83 a	74.50 ab	74.50 ab	74.50 ab
	Seedling + Non-woven cover	15.00	67.67 a	70.00 bc	73.67 ab	76.17 ab
	Seed sowing	0	17.33 b	26.00 d	28.00 d	32.17 e
	Seed sowing + Non-woven cover	0	10.00 c	10.00 ef	10.00 f	10 f
Gordion	Seedling	15.00	69.50 a	78.33 a	79.17 a	79.33 a
	Seedling + Non-woven cover	15.00	66.83 a	71.17 bc	71.17 b	71.17 bc
	Seed sowing	0	14.50 b	16.17 e	19.17 e	30.17 e
	Seed sowing + Non-woven cover	0	0 d	0 f	0 g	0 g
Kar beyaz	Seedling	15.00	67.83 a	70.67 bc	70.67 bc	70.67 c
	Seedling + Non-woven cover	15.00	67.00 a	68.67 c	73.67 ab	73.67 b
	Seed sowing	0	14.17 b	19.50 e	21.83 e	43.00 d
	Seed sowing + Non-woven cover	0	0 d	0 f	0 g	0 g

Means within a column that has a different small letter are significantly different from each other ($p< 0.01$). The lettering was made according to the results of variance analyses.

Table 2. The effect of treatments on the number of leaves

Variety	Treatment	Start (cm)	1. Count (cm)	2. Count (cm)	3. Count (cm)	4. Count (cm)
Çorum moru	Seedling	3.00	7.67 bc	8.50 abc	8.50 ab	8.83 ab
	Seedling + Non-woven cover	3.00	7.50 c	8.16 c	8.50 ab	8.50 abc
	Seed sowing	0.00	3.33 d	3.50 d	3.83 d	7.00 bc
	Seed sowing + Non-woven cover	0.00	3.00 d	4.00 d	4.00 d	4.67 d
Gordion	Seedling	3.00	8.33 ab	9.00 a	9.17 a	9.17 a
	Seedling + Non-woven cover	3.00	7.83 abc	8.17 c	8.67 ab	8.67 ab
	Seed sowing	0.00	3.17 d	3.50 d	3.50 d	6.33 c
	Seed sowing + Non-woven cover	0.00	0 e	0 e	0 e	0 f
Kar beyaz	Seedling	3.00	8.50 a	8.50 abc	8.67 ab	8.67 ab
	Seedling + Non-woven cover	3.00	8.50 a	8.83 ab	8.83 ab	8.83 ab
	Seed sowing	0.00	3.00 d	3.50 d	4.67 c	4.67 d
	Seed sowing + Non-woven cover	0.00	0 e	0 e	0 e	0 f

Means within a column that has a different small letter are significantly different from each other ($p< 0.01$). The lettering was made according to the results of variance analyses.

While investigating the bulbs, data from a diameter of less than 2 cm were not taken into consideration because they did not have any economic importance. Accordingly, while all three varieties formed bulbs in seedling and seedling + non-woven cover applications, only the "Gordion" variety was able to form a bulb with seed application (Table 3). In this variety, there was no statistical effect of the non-woven application on the diameter of the heads, while the diameter values increased with the application of seedling + non-woven cover in the other two varieties. This effect occurred mostly in "Çorum moru" variety (18.4%). No bulb could be obtained from any of the seed + non-woven cover applications. When the effects of the treatments on the length of the bulb heads were examined, it was seen that the non-woven cover application made a statistically positive contribution to the "Kar beyaz" and "Çorum moru" varieties after the seedling planting. In Gordion variety, there was no statistical difference between the results obtained from seedling and seedling + non-woven cover applications.

The diameter/length ratio is not an independent variable in onion bulbs. It is data obtained using previous measurement results. However, because there is numerical data about the bulb shape, which is a very important character in terms of quality in onions, it has been examined under a separate heading. If this value is close to "1", it means spherical heads, if it is larger than "1", it indicates a flattened sphere, and if it is

less than “1”, it indicates a cylindrical shape. According to the findings, the bulb shape was slightly cylindrical in the "Kar beyaz" variety and no effect of non-woven cover application was observed. The bulbs of the “Gordion” variety obtained from the seed were also cylindrical as in the “Kar beyaz” variety, but the bulb shape changed to slightly flattened in two different applications made with seedlings. In the “Çorum moru” variety, on the other hand, spherical bulbs were obtained in cultivation with seedlings, while more flat-shaped bulbs emerged in cultivation with seedlings + non-woven cover. Among all the cultivars, the water-soluble dry matter content of the "Çorum moru" variety was higher than the other varieties. Non-woven cover application increased the amount of water-soluble dry matter in all three varieties. This increase was more pronounced in the “Çorum moru” variety (17.6%). It was observed that the seedling planting + non-woven cover applications caused a serious weight increase in the "Kar beyaz" and "Çorum moru" varieties. This increase was 58% in “Çorum purple” variety and 38% in “Kar beyaz” variety. The amount of dry skin in onion bulbs is an important quality criterion, especially in terms of storage period. The treatment seedling planting caused an increase in the number of dry skin on the bulbs. The cover material used harmed the number of dry skin in all varieties.

Table 3. The effect of treatments on the bulb characters

Variety	Treatment	BL (cm)	BD (cm)	BLD	DMC (%)	BW (g)	NDS
Çorum moru	Seedling	6.25 d	6.25 c	1.01 ab	9.33 ab	112.00 c	4,67 abc
	Seedling + Non-woven cover	6.83 c	7.40 a	1.08 a	11.33 a	177.33 a	5,00 ab
	Seed sowing	0 f	0 e	0 c	0 g	0 e	0 d
	Seed sowing + Non-woven cover	0 f	0 e	0 c	0 g	0 e	0 d
Gordion	Seedling	6.90 c	7.12 ab	1.03 a	6.50 ef	183.67 a	4,50 bc
	Seedling + Non-woven cover	6.85 c	7.32 ab	1.07 a	7.00 de	184.33 a	5,17 a
	Seed sowing	4.40 e	4.07 d	0.93 b	6.00 f	27.00 d	5,00 ab
	Seed sowing + Non-woven cover	0 f	0 e	0 c	0 g	0 e	0 d
Kar beyaz	Seedling	7.45 a	6.78 bc	0.93 b	7.67 cd	143.50 b	4,17 c
	Seedling + Non-woven cover	8.25 a	7.60 a	0.93 b	8.50 bc	199.00 a	4,33 c
	Seed sowing	0 f	0 e	0 c	0 g	0 e	0 d
	Seed sowing + Non-woven cover	0 f	0 e	0 c	0 g	0 e	0 d

Means within a column that has a different small letter are significantly different from each other ($p< 0.01$). The lettering was made according to the results of variance analyses. BL: Bulb Length, BD: Bulb Diameter, BLD: Bulb Lenght/Diameter, DMC: Dry Matter Content, BW: Bulb Weight, NDS: Number of Dry Skin

Discussion

Soil preparation and seed sowing were only possible in the second week of April under harsh climatic conditions. Germination and plant growth was observed in all cultivars in seed sowing application. However, the biodegradable non-woven cover laid on the seed sowing areas adversely affected the germination of two varieties (Gordion and Kar beyaz). Marketable bulbs were obtained in all three varieties in cultivation with seedlings. This proved that bulb formation can be achieved by planting seedlings even at a late period. Significant increases were observed in the yield and quality characteristics of the heads with the use of seedling planting and non-woven cover material together. In particular, head weight, water-soluble dry matter ratio, and dry skin number were positively affected by the use of the cover material.

Lee et al. (2019) investigated the effects of different mulch types (non-woven polypropylene cover, clear plastic mulch, black plastic mulch, or bare ground) and different planting times on the growth and yield of two onion varieties. It has been demonstrated that marketable head yields can be increased with a nonwoven polypropylene cover covering, especially in onions grown with black plastic mulch or planted without mulch. In our study, it was observed that seedling planting + mulch cover applications caused a significant increase in the weight of onion heads in "Kar beyaz" and "Çorum moru" varieties.

Although in addition to some positive effects, some researchers have reported that mulching or coating applications cause bolting or double bulbing in onion heads (Suh & Kim, 1991; Varina & Roka, 2000) no head bolting or deformity was observed in our study. Suh and Kim's (1992) study, which reported significant differences in bolting and double bulb formation levels for onions depending on planting dates, varieties, and year (possibly weather-related), explains this difference.

Conclusion

In conclusion, when all results are considered together, it has been understood that although there are partial differences between onion genotypes and cultivation techniques, seedling planting instead of direct seed sowing provides a great advantage in terms of bulb formation, yield, and quality criteria

in harsh continental climate conditions. In addition to planting seedlings, it was concluded that the use of biodegradable non-woven cover material can be recommended especially because of its positive effects on quality.

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Conflict of Interest

The authors declare that they have no conflict of interest.

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