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ARAŞTIRMA MAKALESİ **RESEARCH ARTICLE**

Morphological Characterization of Some Hybrid Red Head Cabbage (*Brassica oleracea* L.var. *capitata* subvar. *rubra*) Varieties

Bazı Hibrit Kırmızı Baş Lahana (*Brassica oleracea* L. var. *capitata* subvar. *rubra*) Çeşitlerinin Morfolojik Karakterizasyonu

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Abstract

This research aims to determine the morphological characteristics of different hybrid varieties in red head cabbage varieties, which has an important share in vegetable production, in Samsun province. In this study carried out at the Black Sea Agricultural Research Institute, 15 hybrid varieties were examined in terms of 28 different characteristics. Significant variations were observed in terms of the characteristics studied among hybrid varieties. Plant length varied between 36.33-57.67 cm, plant width varied between 61.67-97.33 cm, head weight varied between 905.0-1693.33 g, length of outer leaf varied between 32.83-46.33 cm, the width of outer leaf varied between 21.5-37.33 cm, length of head varied between 13.67-18.83 cm, the diameter of head ranged from 11.53-14.67 cm, length of interior stem varied between 5.63-8.67 cm and diameter of interior stem varied between 2.33-3.83 cm. It was found that the outer leaves covered the upper part of the head, the hardness of the head was very tight, the shape of the head was broad obovate, and the outer leaves of the heads had a dark violet color. The period from seedling planting to the maturation of the heads varied 68 to 125 days, and all varieties remained in the field for a long time without cracking. Yaldız is determined as the best variety in head weight, head length, and head diameter, traits correlated with cabbage yield. In addition, the highest plant height was observed in Caballero variety, and the highest plant width was observed in Red Taste variety. Remala is determined as the earliest variety, and Red Charisma is determined as the latest variety. It is thought that the varieties that become prominent in terms of head weight, head shape, head color characteristics in red head cabbage can be evaluated in hybridization and variety development studies.

Keywords: Red head cabbage, Morphological characterization, Variety, Yield, Hybrid

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Öz

Bu araştırma ile Samsun ili sebze üretiminde önemli bir paya sahip olan farklı hibrit kırmızı baş lahana çeşitlerinin morfolojik özellikleri belirlenmiştir. Karadeniz Tarımsal Araştırma Enstitüsü'nde yürütülen bu çalışmada 15 adet hibrit kırmızı baş lahana çeşidi 28 farklı özellik yönünden incelenmiştir. Hibrit çeşitler arasında incelenen özellikler bakımından büyük bir varyasyon olduğu tespit edilmiştir. Çeşitlerde bitki boyu 36.33 cm ile 57.67 cm, bitki eni 61.67 cm ile 97.33 cm, baş ağırlığı 905.0 g ile 1693.33 g, yaprak uzunluğu 32.83 cm ile 46.33 cm, yaprak eni 21.5 cm ile 37.33 cm, baş uzunluğu 13.67 cm ile 18.83 cm, baş çapı 11.53 cm ile 14.67 cm, iç sap uzunluğu 5.63 cm ile 8.67 cm, iç sap çapı ise 2.33 cm ile 3.83 cm arasında değişmiştir. Kırmızı baş lahana çeşitlerinde başın üst kısmının dış yapraklar tarafından örtülü, baş sertliğinin çok sıkı, baş şeklinin geniş yumurta ve başlarda dış yaprak renginin koyu menekşe olduğu belirlenmiştir. Fide dikiminden başların olgunlaşmasına kadar geçen sürenin 68 ile 125 gün arasında değiştiği ve hibrit çeşitlerin tamamının arazide uzun süre çatlamadan kaldığı gözlenmiştir. Çalışmada verime etki eden önemli özelliklerden baş ağırlığı, baş uzunluğu ve baş çapı yönünden performansı en iyi olan çeşidin Yaldız olduğu tespit edilmiştir. Ayrıca en yüksek bitki boyu Caballero çeşidinde belirlenirken, en yüksek bitki eni ise Red Taste çeşidinde saptanmıştır. Olgunlaşma süreleri yönünden değerlendirildiğinde Remala çeşidinin erkenci, Red Charisma çeşidinin ise geççi olduğu belirlenmiştir. Kırmızı baş lahana da baş ağırlığı, baş şekli ve baş rengi ve mumsuluk özellikleri bakımından öne çıkan bu çeşitlerin melezlemeler ile çeşit geliştirme çalışmalarında değerlendirilebileceği düşünülmektedir.

Anahtar Kelimeler: Kırmızı baş lahana, Morfolojik karakterizasyon, Çeşit, Verim, Hibrit

1. Introduction

Brassica is a genus that belongs to the '*Brassicaceae*' family, known as the mustard family. There are 159 species in the Brassica genus (Zhou, 2001; Zhou et al., 2006). Brassica vegetables consist of *Brassica oleracea* and *Brassica campestris* species (Monteiro and Lunn, 1998). The important Brassica vegetables are listed as; head cabbage (var. *capitata*), acephala, garden cultivars (var. *acephala*), savoy cabbage (var. *sabauda*), cauliflower and romanesco (var. *botrytis*), broccoli (var. *italica*), brussels sprouts (var. *gemmifera*), kohlrabi (var. *gongylodes*), Kai-lan, Chinese leaf sprouts (var. *alboglabra*), Tronchuda cabbage (var. *costata*), curly kale (var. *sabellica*), palm cabbage (var. *palmifolia*), marrow cabbage (var. *medullosa*) and wild cabbage (*B. oleracea* var. *oleracea*). (Song et al., 1988; Song et al., 1990).

Although many different types of cabbage are cultivated worldwide, white cabbage, red head cabbage and leaf cabbage are grown and consumed more commonly in our country (Yağmur et al., 2003). Red head cabbage is a winter vegetable with an important place in human nutrition with its high antioxidants and fiber content. In addition, it is cultivated intensively in our country and has great economic importance. While cabbage is a vegetable consumed primarily in winter in our country, it has been consumed throughout the year except for 1-2 months (Onus and Polat, 2000). Red head cabbage production of our country is 187.948 tons. With 109.570 tons, Samsun is the largest producer of red cabbage, accounting for nearly 57% of its production. Samsun is followed by Konya (12.356 tons), Antalya (11.631 tons) and Bursa (10.477 tons) provinces (TUİK, 2018).

Red head cabbage has a rich genetic diversity because it is a highly cross-pollinated vegetable. For this reason, it can be grown in different ecologies both in the world and in many parts of our country. Today, F1 hybrid varieties are used extensively in vegetable production due to their superior properties such as earliness, yield, quality, homogenous development, resistance to biotic and abiotic stress conditions. In our country, hybrid varieties are mostly used in red head cabbage cultivation.

This research, it is aimed to determine the morphological characteristics, growth habits, earliness, and productivity levels of redhead cabbage hybrid cultivars grown in Samsun ecological conditions.

2. Materials and Methods

This research was carried out at the Black Sea Agricultural Research Institute in 2018 and 2019. 15 hybrid red head cabbage varieties (Pedro, Alex, Anexa, Red Charisma, Yaldız, Huzaro, Davaro, Remala, Caballero, Red Taste, Resima, Bandolero, Klimaro, Ametist and Maestro) were used as plant material.

The seeds of red head cabbage varieties were sown on 16 July 2018 at Black Sea Agricultural Research Institute. Seedlings were grown in an unheated plastic greenhouse. For seedling cultivation, seed trays (45 cells) with a 5.5 x 5.5 cm cell size were used. Growing medium formed from a 3:1 mixture of peat and perlite. Twenty seedlings for each red head cabbage genotypes were planted at the 4 to 5 true leaf stage with a plant spacing of 70x30 cm in the second week of August. The study was carried out according to a randomized block experimental design. During the study, cultural procedures (irrigation, fertilization, weed cleaning, etc.) were carried out regularly.

Morphological characterization of the materials was carried out in the period of head-formation and harvest, and observations and measurements were made according to the criteria of the International Association for the Protection of New Plant Varieties (UPOV, 2004) and the International Institute for Plant Genetic Research (IPGRI, 1990). A total of 28 traits were examined in each variety *(Table 1)*.

Table 1. Morphological characterization criteria examined in red head cabbage varieties

Traits and Descriptions
Plant length (cm)
Plant width (cm)
Weight of head (g)
Length of head (cm)
Diameter of head (cm)
The shape of the head (transverse narrow elliptic, elliptic, round, broad elliptic, broad obovate, broad ovate, angular ovate, cylindrical)
The internal color of the head (pink, dark pink, red, dark red, violet, light violet, dark violet)
Top leaf color of the head (dark green, blue-green, light green, violet, dark violet)
Covering of head (not covered, partially covered, covered)
The hardness of the head (very loose, loose, medium, tight, very tight)
Length of the interior stem (cm)
Diameter of the interior stem (cm)
Length of the outer leaf (cm)
Width of the outer leaf (cm)
Outer leaf angle (vertical angle (87º<), open (~67°), half slant (~45°), slant (<30°), drooping (<-10°)
The shape of the outer leaf (circular, elliptic, circular, broad ovate, spatula, spear, long)
Outer leaf teeth (absent, present)
Outer leaf end shape (pointed, medium, round and narrow round)
Blistering of the outer leaf (absent or very weak, medium, strong)
Size of blisters in outer leaf (small, medium, large)
Waxiness on the outer leaf (absent or very weak, weak, medium, strong, very strong)
Color of the outer leaf (dark green, blue-green, light violet, violet, dark violet)
The color intensity of the outer leaf (light, medium, dark)
Maximum width region of the head (at the top, in the middle, at the bottom)
The shape of the base in longitudinal section (rounded, flat and arched)
Time of harvest maturity (days) (early, medium, late, too late)
Resistance to cracking (low, medium, high)
Duration of mature heads in the field (short, medium, long)

Analysis of variance was performed using the (ANOVA) package program of the obtained data. Duncan's multiple comparison test determined P=0.01 significance levels.

3. Results and Discussion

In the study, the plant length value of varieties varied between 36.33 and 57.67 cm. The lowest plant length was determined in Maestro, and the highest plant length was determined in Caballero varieties *(Table 2).* Among the redhead cabbage varieties, the lowest plant width was 61.67 cm in the Alex variety, and the highest plant width was 97.33 cm in the Red Taste variety. Acar and Paksoy (2006) determined the plant length as 25.02 cm in ACN-33 F1 red head cabbage variety and 24.99 cm in Royal F1 variety. Aşçıoğul (2009) was determined that the plant length was 74.00 cm and width of the plant was 79.33 cm in redhead cabbage. The plant length of redhead cabbage was reported by Thapa and Prassad (2012) as 69.5 in Red Quen variety by Maltaş et al. (2017) as 23.06 cm and by Salwa et al. (2019) as 27.51 cm.

The length of the outer leaf varied between 32.83 cm and 46.33 cm, and the width of the outer leaf varied between 21.50 cm and 37.33 cm in the examined varieties *(Table 2).* While Aşçıoğul (2009) determined the length of outer leaf as 29.2-33 cm and the width of outer leaf as 30.33 cm in redhead cabbage, Salwa et al. (2019) were found the length of outer leaf as 21.24 cm and the width of outer leaf as 13.43 cm. It was determined that the cultivars had mostly spatula leaf shapes. However some of the varieties had broad ovate and circular leaf shapes *(Table 3).* Outer leaf end shape is determined as narrow rounded in Resima and Caballero varieties and is determined as broadly rounded in other varieties. In most of the red head cabbage varieties, blistering of the outer

leaf could not be detected. Size of blisters in outer leaf characteristic, which was determined as the medium in the leaves of the Klimaro cultivar and as large in the leaves of the Anexa, Remala, and Huzaro cultivars, could not be detected among the other red head cabbage cultivars. Waxiness is a desired feature in red head cabbage leaves and heads. Moreover, it was determined as strong in Klimaro and Red Charisma varieties *(Table 3).*

Table 2. Morphological characterization parameters of red head cabbage varieties

Variety	Plant length	Plant width	Weight of head	Length of outer leaf	Width of outer leaf	Length of head	Diameter of head	Length of interior stem	Diameter of interior stem
Kaberola	57.67 a	92.33 b	973.33 e	43.70 bc	23.00 h	15.50 fg	11.53 f	6.43 fgh	3.23 bc
Red Taste	54.33 b	97.33 a	1131.67 d	46.33 a	31.67 cde	15.00 g	12.00 ef	5.87 hı	2.60 fg
Resima	54.00 b	92.00 b	1223.33 c	43.93 bc	37.33 a	15.50 fg	11.97 ef	7.60 bc	3.00 c-f
Anexa	51.00 c	92.00 b	1381.67 b	46.00 b	33.00 c	18.73 ab	13.07 bcd	6.73 ef	3.07 b-e
Yaldız	50.33 c	92.67 b	1693.33 a	45.67 b	29.83 e	18.83 a	14.67 a	8.17 ab	3.83 a
R.Charisma	49.83 cd	76.33 cd	1403.33 b	35.73 gh	30.27 de	18.13 ab	13.17 bcd	7.17 cde	3.23 bc
Bandolero	47.00 de	93.00 b	1325.00 b	42.33 cd	27.33 f	17.90 bc	12.53 def	6.80 def	3.23 bc
Huzaro	46.83 e	91.00 b	1208.33 cd	43.00 cd	32.33 cd	17.07 cd	12.33 def	6.90 def	2.87 c-f
Davaro	45.33 ef	77.33 cd	1323.33 b	40.67 de	33.33 c	16.10 ef	12.87 b-e	6.60 efg	3.17 bcd
Klimaro	42.67 fg	80.33 c	905.00 e	41.00 d	33.67 bc	14.00 h	13.83 ab	8.67 a	3.43 ab
Pedro	41.33 gh	73.33 d	1195.00 cd	33.50 hı	21.83 h	15.83 efg	13.27 bcd	6.83 def	3.00 c-f
Remala	40.10 ghı	77.07 cd	1147.00 cd	38.33 ef	35.90 ab	15.07 g	13.77 abc	5.63 ı	3.03 b-e
Ametist	39.33 hı	65.33 e	1175.00 cd	32.83 ı	21.50 h	16.50 de	12.77 cde	7.40 cd	2.67 efg
Alex	37.33 ıj	61.67 e	970.00 e	33.67 hı	23.33 gh	13.67 h	12.73 cde	7.00 c-f	2.33 g
Maestro	36.33 j	64.67 e	1216.67 cd	36.90 fg	25.33 fg	16.67 de	13.20 bcd	6.07 ghı	2.80 d-f
Significant	**	**	**	**	**	**	**	**	**
CV	**3.7**	**3.2**	**4.3**	**3.7**	**4.6**	**3.3**	**4.8**	**5.3**	**7.9**

The color of the outer leaf varied between green, dark green, and dark violet. The color of the outer leaf was determined as green in the varieties of Resima, Caballero, Klimaro; dark green in the Bandolero, Anexa, Remala, and Huzaro varieties; and dark violet in the other varieties *(Table 3).* It was determined that the color intensity of the outer leaf was mainly in dark tones. Except for Bandolero, Remala, Pedro, and Red Charisma cultivars, the leaf margins of the other varieties were found to have a teethed structure *(Table 3).*

The outer leaf angle of the cultivars was examined as vertical angle (87º <), open (~ 67 °), half slant (~ 45 °), slant (<30 °) and drooping (<-10 °). The outer leaf angle is determined as the half slant in Anexa variety; as slant in Klimaro, Ametist, Pedro and Maestro varieties; as open in Bandolero, Remala, Alex, Davaro, Huzaro and Red Taste varieties; as the vertical angle in Yaldız, Resima, Caballero and Red Charisma varieties *(Table 3).*

With the increasing world population, it has come to the fore to increase efficiency to get more efficiency from the unit area (Çay and Aykaş, 2013). The yield is directly related to the size of the head and firmness, and the head size of the redhead cabbage is generally between 1-2 kg (Kar and Karaağaç, 2016). In the research, the head weights of varieties varied between 905.0 g and 1693.33g. The highest head weight was determined in the Yaldız variety, and the lowest head weight was determined in the Klimaro variety *(Table 2).* The hardness of the head was determined as tight in all varieties. Acar and Paksoy (2006) reported that the head weight was 625.08 g cm in the ACN-33 F1 variety and 678.5 g in the Royal F1 variety. Padem and Güvenç (2007) reported the head weight as 820 g to 2142.0 g among red head cabbage varieties; Tıraşçı (2016) determined the head weight as 907.50 g in Mohrenkopf variety. Similarly, Demirboğa (2016) determined the head weight as 814.0 g; Salwa et al. (2019) reported as 1.12 g. They reported that different varieties might come to the fore in changing environments depending on the adaptability of the varieties and the environmental conditions in which they are grown (Ece and Güler, 2017).

In the study, the head diameters of the cultivars showed relative values, with the lowest in Caballero (11.53 cm) and the highest in Yaldız (14.67 cm) varieties. Head length values ranged from 13.67 cm to 18.83 cm. The lowest head length is determined in Alex and the highest head length in Yaldız varieties *(Table 2).* In studies conducted by different researchers, head diameter values were between 6.83 cm to 22.8 cm; head lengths were found to be between 10.65 cm to 19.7 cm (Onus and Polat, 2000; Padem and Güvenç, 2007; Thapa and Prasad, 2012; Demirboğa 2016; Tunc and Sahin, 2016; Maltaş et al. 2017).

Table 3. Morphological characterization criteria of red head cabbage varieties

Traits	Variety							
	Yaldız	**Pedro**	**Caballero**	**Bandolero**	**Anexa**	**Remala**	**Huzaro**	**Resima**
Covering of head	Covered	Covered	Covered	Partially covered	Covered	Partially covered	Covered	Covered
Shape of head	Broad obovate	Broad obovate	Broad obovate	Elliptic	Elliptic	Broad obovate	Elliptic	Broad obovate
Top leaf color of the head	Dark violet	Dark violet	Dark violet	Dark violet	Dark violet	Dark violet	Dark violet	Dark violet
Hardness of head	Very tight	Very tight	Very tight	Very tight	Very tight	Very tight	Very tight	Very tight
Outer leaf angle	Vertical angle	Slant	Vertical angle	Open	Half slant	Open	Open	Vertical angle
The shape of the outer leaf	Spatula	Spatula	Spatula	Broad ovate	Broad ovate	Circular	Broad ovate	Spatula
Outer leaf end shape	Round	Round	Narrow round	Round	Round	Round	Round	Narrow round
Blistering of the outer leaf	-	-	-	-	Very weak	Weak	Very weak	-
Size of blisters in the outer leaf	-	-	-	-	Large	Large	Large	-
Waxiness on the outer leaf	Weak	Weak	Weak	Weak	Weak	Weak	Weak	Weak
Color of the outer leaf	Dark violet	Dark violet	Green	Dark green	Dark green	Dark green	Dark green	Green
The color intensity of the outer leaf	Dark	Dark	Dark	Dark	Dark	Dark	Dark	Medium
Outer leaf teeth	Available	Absent	Available	Absent	Available	Absent	Available	Available
The internal color of the head	Violet	Dark violet	Violet	Dark violet	Dark violet	Dark violet	Dark violet	Dark violet
Maximum width region of the head	in the middle	in the middle	in the middle	in the middle	in the middle	in the middle	in the middle	in the middle
The shape of the base in the longitudinal section	Rounded	Rounded	Rounded	Rounded	Rounded	Rounded	Rounded	Rounded
Time of harvest maturity	95	87	115	115	115	68	115	115
Resistance to cracking	High	High	High	High	High	High	High	High
Duration of mature heads in the field	Long	Long	Long	Long	Long	Long	Long	Long

Table 3 (continued)

Traits	Variety						
	Maestro	**Red Taste**	**Red Charisma**	**Alex**	**Davaro**	**Ametist**	**Klimaro**
Covering of head	Partially covered	Covered	Covered	Partially covered	Covered	Covered	Covered
Shape of head	Broad obovate	Broad obovate	Elliptic	Broad obovate	Broad obovate	Broad obovate	Round
Top leaf color of the head	Dark violet	Dark violet	Dark violet	Dark violet	Dark violet	Dark violet	Dark violet
Hardness of head	Very tight	Very tight	Very tight	Very tight	Very tight	Very tight	Very tight
Outer leaf angle	Slant	Open	Vertical angle	Open	Open	Slant	Slant
The shape of the outer leaf	Broad ovate	Spatula	Spatula	Circular	Circular	Spatula	Circular
Outer leaf end shape	Round	Round	Round	Round	Round	Round	Round
Blistering of the outer leaf	-	-	-	-	-	-	Medium
Size of blisters in the outer leaf	-	-	-	-	-		Large
Waxiness on the outer leaf	Weak	Medium	Strong	Weak	Weak	Weak	Strong
Color of the outer leaf	Dark violet	Dark violet	Dark violet	Dark violet	Dark violet	Dark violet	Green
The color intensity of the outer leaf	Dark	Dark	Dark	Dark	Dark	Dark	Dark
Outer leaf teeth	Available	Available	Absent	Available	Available	Available	Available
The internal color of the head	Dark violet	Dark violet	Dark violet	Dark violet	Dark violet	Dark violet	Light violet
Maximum width region of the head	in the middle	in the middle	in the middle	in the middle	in the middle	in the middle	in the middle
The shape of the base in the longitudinal section	Rounded	Rounded	Rounded	Rounded	Rounded	Rounded	Rounded
Time of harvest maturity	87	95	125	87	87	87	115
Resistance to cracking	High	High	High	High	High	High	High
Duration of mature heads in the field	Long	Long	Long	Long	Long	Long	Long

The length of the head stem varied between 5.63 cm and 8.67 cm, and the diameter of the head stem varied between 2.33 cm and 3.83 cm among all varieties. The shortest length of the head stem was measured in the

Remala variety, and the highest length of the head stem was measured in the Klimaro variety. The lowest diameter of the head stem was found in the Alex variety, and the highest diameter of the head stem was found in the Yaldız variety *(Table 2).* Aşçıoğul (2009) determined the length of head stem as 11.0 cm and the diameter of the head stem as 4.0 cm in the redhead cabbage.

The shape of the head varied between broad obovate, elliptic and round in red head cabbage varieties. The head shape of the Klimaro variety was determined as round. The head shape was determined as elliptic in Bandolero, Anexa, Huzaro and Red Charisma varieties. In other varieties, it was observed as broad obovate *(Table 3).*

Covering the upper part of the head with outer leaves is a desirable feature as it protects the head from external factors. (Kar and Karaağaç, 2016). It was determined that the heads were covered with outer leaves in most of the cultivars. One of the characteristics examined in the heads was the interior color of the head. The dark violet interior color of the head was the most common among the varieties. Also, it was determined that the interior color of the head was light violet in the Klimaro variety and violet in the Caballero and Yaldız varieties *(Table 3).*

It was determined that the maximum width region of the head was in the middle in all varieties and the base shape in the longitudinal section was round. The top leaf colors of the head varieties were determined visually. As a result of the observation, it was determined that the top leaf color of the head varieties was dark violet *(Table 3).*

The time from seedling planting of varieties to the harvest maturity of the heads varied between 68 and 125 days. Remala was the earliest variety, while the latest was Red Charisma. Also, it was observed that all varieties remained on the field for a considerable time without cracking *(Table 3).*

4. Conclusions

Red head cabbage is among the significant winter vegetables produced mainly in various parts of the world and Turkey. Vegetable growers prefer to use hybrid seeds due to their advantages. In Turkey, hybrid seeds are used in the production of red head cabbage. In the study, morphological characterization of 15 different hybrid red cabbage varieties was made. It was determined that the varieties showed great variety in terms of the characteristics examined. The study revealed that the variety with the best performance in terms of head weight, head length, and head diameter, traits affecting yield was Yaldız. In addition, Caballero has become prominent in terms of plant height. On the other hand, Red Taste has become prominent in terms of plant width features. It was determined that the earliest variety was Remala while the latest variety was Red Charisma. It was determined that the heads in all varieties could remain in the field for a long time without cracking.

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