New Zealand Journal of Crop and Horticultural Science, 2005, Vol. 33: 333–341
0014–0671/05/3304–0333

Morphological characterisation of white head cabbage (*Brassica oleracea* var. *capitata* subvar. *alba*) genotypes in Turkey

AHMET BALKAYA
Department of Horticulture
Faculty of Agriculture
University of Ondokuz Mayis
Samsun, Turkey
email: abalkaya@omu.edu.tr

RUHSAR YANMAZ
Department of Horticulture
Faculty of Agriculture
University of Ankara
Ankara, Turkey
email: yanmaz@agri.ankara.edu.tr

AYDIN APAYDIN

HAYATI KAR
Black Sea Agricultural Research Institute
Samsun, Turkey

Abstract Crops belonging to the *Brassica* genus are widely grown in Turkey. Cabbages are one of the most important *Brassica* vegetable crops in Turkey. The aim of this study was to determine similarities and differences regarding morphological variation of white head cabbage (*Brassica oleracea* var. *capitata* subvar. *alba*) genetic resources collected from different eco-geographical regions of Turkey. Data from field experiments conducted between 1999 and 2001 were analysed by multiple variance analysis. Cluster analysis based on 12 quantitative and 10 qualitative variables identified 10 groups. The dendogram was prepared to evaluate morphological similarity between the white head cabbage genotypes. Morphological variability is high among the white head cabbage genotypes of Turkey. As a conclusion, the genotypes evaluated in this study display a wide diversity of characters for selection and combination of interesting genotypes for important characters to obtain improved varieties.

H04076; Online publication date xx October 2005
Received 26 August 2004; accepted 2 March 2005

Keywords cabbage; classification; morphological variation; *Brassica oleracea*; Turkey

INTRODUCTION

Brassica oleracea L. is an important vegetable crop species which includes fully cross-fertile cultivars or form groups with widely differing morphological characteristics (cabbage, broccoli, cauliflower, collards, Brussel sprouts, kohlrabi, and kale). Historical evidence indicates that modern head cabbage cultivars are descended from wild non-heading brassicas originating from the eastern Mediterranean and Asia Minor (Dickson & Wallace 1986). It is commonly accepted that the origin of cabbage is the north European countries and the Baltic Sea coast (Monteiro & Lunn 1998), and the Mediterranean region (Vural et al. 2000). Zhukovsky considered that the origin of the white head cabbage was the Van region in Anatolia and that the greatest cabbages of the world were grown in this region (Bayraktar 1976; Günay 1984).

In Turkey, there are local cultivars of cabbage (*B. oleracea* var. *capitata*) which are open-pollinated populations. Cabbage populations have been improved by farmers through mass selection for centuries. Their cultivation as a percentage of the entire cultivated area for cabbage is reducing. Compared with commercial hybrids, the populations of Turkish cabbage are less productive and their heads lack uniformity and field durability, but they have thinner head leaves that are crisper and juicier. These populations of cabbages are a valuable genetic resource and should either be registered and released as commercial cultivars, after evaluation and selection, or conserved in the Turkey Seed Gene Bank for use in future breeding programmes. Similar collecting studies have also been carried out in different regions of Turkey (Salk 1982; Simsek & Surmeli 1991; Alan & Padem 1995) but a comprehensive collecting programme for the white head cabbage (*B. oleracea* var. *capitata* subvar. *alba*) populations of Turkey began in 1998 with this research (Yanmaz

et al. 2000). The multiplication and evaluation of these genotypes was carried out continuously at the Black Sea Agricultural Research Institute in Samsun, Turkey.

Determination of variation shown by available genetic resources for quantitative and qualitative traits is important for vegetable breeding programmes (Escribano et al. 1998). Objective descriptors based on morphophysiological characters are considered reliable traits to verify or assess genetic distance or conformity among populations (Hunter 1993). These traits have been used commonly for cultivar description and identification by UPOV (The International Union for the Protection of New Varieties of Plants) (Anon. 1998). These characters are expressed according to the principles of numerical taxonomy (Sneath & Sokal 1973), so that similarity or dissimilarity coefficients between cultivars can be estimated. Diversity present in a group of populations can be displayed by means of cluster analysis. In addition, it is used to show the similarity and differences in relationship among populations and it permits the selection of varieties with good qualities for incorporation into breeding programmes (Escribano et al. 1991; Cartea et al. 2002).

The aim of this study was to determine similarities and differences in the morphological variation of white head cabbage (*B. oleracea* var. *capitata* subvar. *alba*) genetic resources collected from the different eco-geographical regions of Turkey.

MATERIALS AND METHODS

This study was carried out cooperatively by the Black-Sea Agricultural Research Institute, the University of Ondokuz Mayis and University of Ankara between 1998 and 2001. The 95 cabbage populations used in this study were collected before and during harvest time, between September 1998 and March 1999. The main local white head cabbage populations which are cultivated in Turkey were evaluated in this study. They are mainly used for preparing cooked meals or salads. Their geographical distribution is shown in Table 1 and Fig. 1.

Turkey is located between 36° and 42°N and between 26° and 45°E. It is characterised by mountains in the centre and flat, coastal plains in other locations. The evaluations were carried out in the province of Samsun. This province is situated in the north of Turkey (Fig. 1) and has a humid climate with annual relative humidity of 72.0% and rainfall of c. 708.0 mm (Anon. 2003).

Seeds were collected directly from growers and were sown into plug trays (5.5 cm width and 6 cm depth) on 15 July in 1999 and 2000. Peat, organic manure, and sand at a ratio of 2:1:0.5, respectively, were used as the growing medium. The seedlings were planted in the field at the 4–5 leaf stage in August. Plant spacing within the rows was 1 m. The wide spacing was applied to avoid competition between plants, so that the phenotypic expression and differentiation were maximised (Fasoula 1990). Fertilisation and weed control using standard cultural practices were applied regularly. The plants were harvested for analysis when fully mature. The harvest period started at the end of October and lasted until the end of January of each year, because the investigated populations have different harvest periods.

Morphological analyses were carried out on 100 plants harvested from each population. The morphological characters measured and their scales are presented in Table 2. All characters were measured in the field and at the normal harvest time (mid December–February). The characters are included in the description form developed for *B. oleracea* var. *capitata* subvar. *alba* by UPOV with reference number TG/48 (Anon. 1998).

Statistical analysis of the data was conducted using the statistical programme SPSS (11.0 for Windows). Factor analysis was first applied to data. Oclide distances were calculated by using PC axis separately. After that, a dendogram showing similarities and differences among the genotypes was produced by using the Oclide values. The results of cluster analysis are presented in the form of a dendogram. The dendogram obtained in the study represents “similarities among the groups” (Gil & Ron 1992; Piergiovanni et al. 2000; Duzyaman & Vural 2002).

RESULTS AND DISCUSSION

Ten groups were clustered as a result of the cluster analysis. The resultant groups and their subgroups are shown in Table 3 and the related dendogram is shown in Fig. 2. General characteristics of the investigated white head cabbage populations are as follows.

Group A

This group consisted of three subgroups. These genetic resources were collected from different regions of Turkey (Regions I, II, and III). Subgroup 1

Fig. 1 Regions of Turkey from which white head cabbage (*Brassica oleracea* var. *capitata* subvar. *alba*) genetic resources were collected.

Table 1 Geographical origin and accession number of the 95 white head cabbage (*Brassica oleracea* var. *capitata* subvar. *alba*) genotypes studied.

Geographical origin	Accession number
Region I	
Izmir (11)	G-1, G-2, G-13, G-35, G-38,G-45, G-68, G-81, G-82, G-83, G-92
Manisa (8)	G-53, G-54, G-58, G-65, G-78, G-85, G-90, G-95
Region II	
Bursa (11)	G-37, G-43, G-46, G-50, G-66, G-69, G-73, G-77, G-86, G-87, G-88
Balikesir (2)	G-33, G-59
Sakarya (2)	G-74, G-80
Region III	
Samsun (27)	G-11, G-12, G-14, G-15, G-16, G-17, G-18, G-19, G-20, G-21, G-22, G-31, G-32, G-36, G-39, G-44, G-47, G-49, G-57, G-60, G-62, G-63, G-64, G-72, G-79, G-84, G-89
Tokat (6)	G-48, G-56, G-67, G-70, G-75, G-76
Region IV	
Niğde (12)	G-3, G-4, G-6, G-7, G-8, G-9, G-41, G-42, G-51, G-52, G-91, G-94
Nevşehir (8)	G-23, G-29, G-34, G-40, G-55, G-61, G-71, G-93
Region V	
Muş (1)	G-5
Local cultivars (2)	G-10 (Yalova-1), G-27 (Yalova-Sarmalik)
From Seed Gene Bank in Turkey (5)	G-24, G-25 , G-26 , G-28 , G-30

contained 12 populations (Table 3). The average head weight of this group was 2.23 kg (Table 4). Shape of the head was transverse narrow-elliptic. Average head formation ratio was 66.3%, even though there were no differences among the genotypes for head forming ratio (Table 4). This group had short interior stem lengths (8.3 cm), medium-large leaves, and the internal structure of the head was fine. As a result, they were classified into the group of cabbages for preparing sarmalik (sarma is a traditional Turkish food prepared by wrapping cabbage leaf around rice and other products). In addition, colours of outer leaves were light green and green tones and inner leaves were white, cream, and violet. Populations of this group were harvested between 115 and 129 days and classified as early.

Group B

There was a total of 13 genotypes in Group B. These genotypes were clustered in two subgroups. Most of the genotypes in the first subgroup were collected from Regions I and III. Average head weight of this group was 3.1 kg and for the firmness of head character was rated firm (Table 4). Head shape was narrow-elliptic, leaves were crispy, and juice of leaves was at medium level. Ratio of head formation was 82.2%. This value was higher than for all other groups, except Group E. These genotypes were classified as early (126–128 days).

Group C

This group contains three subspecies. There were two genotypes originating from Regions I and IV in

Table 2 List of morphological characters used in the characterisation of cabbage populations (*Brassica oleracea* var. *capitata* subvar. *alba*).

Observation at maturity (before normal harvest)	
(1)	Head weight (g)
(2)	Plant height (cm)
(3)	Length of head (cm)
(4)	Diameter of head (cm)
(5)	Plant height/diameter ratio
(6)	Height of the head above the ground (cm)
(7)	Length of interior stem (cm)
(8)	Diameter of interior stem (cm)
(9)	Total number of outer leaves (unit)
(10)	Number of outer leaves covering head (unit)
(11)	Ratio of head formation (%) (number of head forming plants/total plant number in the plots)
(12)	Head: internal structure (1, fine; 2, medium; 3, coarse)
(13)	Firmness of head (1, loose; 2, medium; 3, firm)
(14)	Crispy and juicy (1, present; 2, medium; 3, absent)
(15)	Shape of longitudinal section of head (1, transverse narrow elliptic; 2, transverse elliptic; 3, circular; 4, broad elliptic; 5, broad obovate; 6, broad ovate; 7, angular ovate)
(16)	Shape of base in longitudinal section of head (1, flat; 2, rounded; 3, arched)
(17)	Colour of inner leaf (1, white; 2, light cream; 3, light violet)
(18)	Colour of outer leaf (1, yellow-green; 2, light green; 3, green; 4, dark green; 5, blue green)
(19)	Midrib presence (1, present; 2, small; 3, absent)
(20)	Midrib thickness (1, thin; 2, medium; 3, thick)
(21)	Size of outer leaves (1, small; 2, medium; 3, large)
(22)	Time of harvest maturity (days) (1, early (115–140 days); medium (141–169 days); late (>170 days)

Table 3 White head cabbage (*Brassica oleracea* var. *capitata* subvar. *alba*) genotype groups and subgroups obtained by analysis.

Groups	Subgroups	Genotypes	Total no.
A	1	G-33, G-58, G-60, G-61, G-64, G-67, G-70, G-75, G-77, G-80, G-92, G-95	12
	2	G-17, G-25, G-26, G-27	4
	3	G-4, G-11	2
B	1	G-42, G-47, G-63, G-65, G-66, G-78, G-79	7
	2	G-48, G-53, G-57, G-68, G-83, G-85	6
C	1	G-2, G-3	2
	2	G-8, G-10, G-12, G-16, G-18, G-24	6
	3	G-31, G-32, G-34, G-49, G-51, G-55, G-59, G-69, G-72, G-74, G-81, G-82, G-84, G-86, G-87, G-88, G-94	17
D	1	G-1	1
E	1	G-45, G- 90	2
F	1	G-43, G-50, G-56, G-71, G-73	5
	2	G-41, G-44, G-52, G-76	4
	3	G-28	1
G	1	G-39, G-40, G-46, G-54, G-62, G-89, G-91, G-93	8
	2	G-22, G-36	2
	3	G-23	1
H	1	G-13, G-14, G-15, G-19, G-20, G-21, G-29	7
	2	G-38	1
I	1	G-5, G-9	2
	2	G-35, G-37	2
J	1	G-7, G-30	2
	2	G-6	1

Table 4 Average values of the traits used to identify white head cabbage (*Brassica oleracea* var. *capitata* subvar. *alba*) groups.

	Groups									
Trait	A	B	C	D	E	F	G	H	I	J
1	2.23±0.33	3.10±0.30	2.4±0.24	2.4±0.33	2.32±0.43	2.4±0.91	2.3±0.40	2.0±0.20	2.72±0.6	2.45±0.15
2	33.2±1.3	32.2±0.7	32.7±0.8	26.7±2.0	34.0±1.6	32.7±1.1	34.9±5.0	37.8±2.0	35.6±1.5	39.7±2.5
3	19.6±0.53	1 19.7±0.33	19.6±0.94	17.0±1.54	16.3±0.92	19.9±0.83	21.0±1.9	18.0±0.8	20.7±2.1	22.0±2.50
4	23.0±1.4	25.8±1.0	23.7±1.6	27.8±1.7	23.2±2.4	22.5±2.2	24.5±3.2	22.6±1.4	25.5±2.1	24.9±2.5
5	1.44	1.24	1.38	0.96	1.46	1.45	1.42	1.67	1.40	1.59
6	13.6±2.4	12.5±0.25	13.1±0.6	9.7±2.8	17.7±2.5	12.8±1.4	13.9±3.1	19.8±3.2	14.9±0.8	17.7±2.4
7	8.3±1.2	10.0±0.1	8.8±0.3	6.7±1.2	9.2±1.6	11.2±1.5	9.8±2.3	9.6±0.8	10.4±0.2	9.0±1.4
8	3.7±0.16	4.0±0.05	3.8±0.25	3.7±0.20	4.1±0.20	3.9±0.10	3.6±0.20	3.8±0.1	3.8±0.20	3.7±0.10
9	12.1±0.6	12.1±0.6	12.9±0.3	9.7±2.3	12.7±3.8	10.3±3.4	14.8±2.9	15.9±3.1	13.8±0.8	13.8±3.5
10	3.7±0.03	3.6±0.1	3.4±0.05	4.0±0.2	3.5±0.1	3.2±0.2	3.8±0.1	4.2±0.2	4.0±0.1	4.6±0.4
11	66.3±3.6	82.2±5.6	51.1±6.3	33.3±5.0	96.0±2.0	6.2±3.7	29.2±11.6	35.7±2.9	57.5±5.1	13.2±4.2
12	Fine (1)	Medium (2)	Fine (1)	Fine (1)	Fine (1)	Coarse (3)	Fine (1)	Fine (1)	Fine (1)	Coarse (3)
13	Medium (2)	Firm (3)	Medium (2)	Loose (1)	Firm (3)	Firm (3)	Loose (1)	Firm (3)	Loose (1)	Medium (2)
14	Present (1)	Medium (2)	Medium (2)	Present (1)	Present (1)	Absent (3)	Present (1)	Present (1)	Present (1)	Present (1)
15	1	2	1	2	2	1	1	1	1	1
16	1,2,3	1,2	1,2,3	1	2,3	1,2	1	1	1	1
17	1,2,3	1,2	1,2	1	1	1,2,3	1,2,3	1,2	1	1,3
18	2,3	3,4	3,4	5	3,4	4,5	3,4	3,4	3,4	5
19	2,3	1,2	1,2,3	2	1	1	1,2	1,3	1	1
20	2,3	2,3	1,2,3	2	2	2,3	2,3	1,2	2,3	1,2
21	2	2,3	2,3	2	2	2,3	2,3	1,2	2,3	1,2
22	115–129	126–128	115–132	142	126–129	115–128	115–128	126–129	170–175	152–175

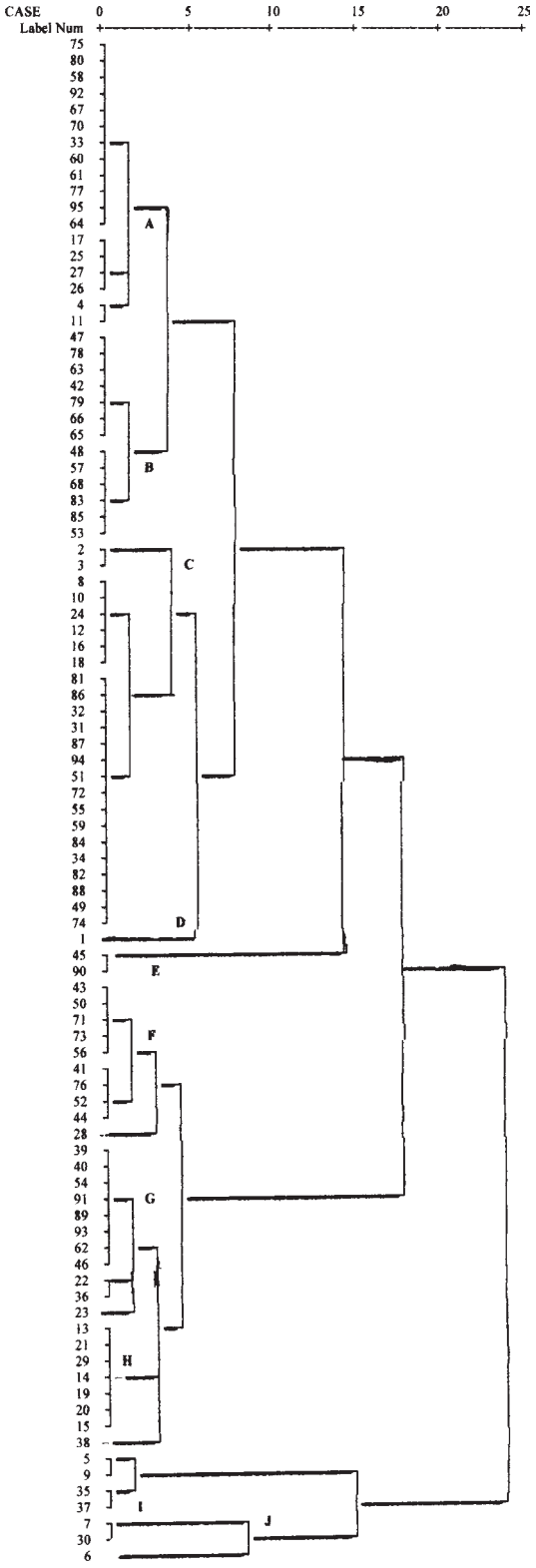

Fig. 2 Genetic groupings of white head cabbage (*Brassica oleracea* var. *capitata* subvar. *alba*) according to Cluster analysis.

the first subgroup. A population obtained from the Turkey Seed Gene Bank and a commercial cultivar, 'Yalova 1' were included in the second subgroup. There were 17 populations collected from different regions in the third subgroup. Average head weight of the cabbages was 2.4 kg and the shape was transverse narrow-elliptic (Table 4). Internal structure of the heads was fine. These populations were suitable for sarmalik production. Colour of outer leaves was green or dark green tones, and the inner leaf colour was light cream or white tones. Size of outer leaves was medium or large. Time of harvest maturity of populations was between 115 and 132 days.

Group D

There was only one population (Region I) in Group D. The head diameter value of this population was the largest of all groups (Table 4). Head firmness was rated loose and they have been named "rough cabbage" by farmers because of this trait. Shape of the head base was flat. The colour of outer leaves was blue-green tones. Midrib presence was determined to be small and midrib thickness was rated medium. Ratio of head formation was low (33.3%) (Table 4). The quality traits of this population were not very good. Finally, general development characteristics of this genotype made it unsuitable for fresh consumption and hence this population was not selected for hybrid cabbage breeding. It was harvested on day 142 and was classified as medium.

Group E

This group consisted of two populations collected from the first region (originating from Izmir and Manisa/Alaşehir provinces). Populations in this group were transverse elliptic in shape and average head weight was 2.32 kg (Table 4). They were found to have uniform head formation ratio (96%). Average height of heads above the ground was greater than for other groups. This could be an advantage for white head cabbage growing by protecting them from plant diseases. It was suitable for sarmalik production because of its leaf characteristics. Colour of outer leaves was green or dark green tones and inner leaf colour was white. Size of outer leaves was medium. Time of harvest maturity of populations was between 126 and 129 days. This group was found to be promising for breeding studies.

Group F

Genotypes in this group were clustered into three subgroups. There were populations collected from Region II (Bursa province), mostly in the first subgroup. There were four populations originating from Regions III and IV in the second subgroup. There was one population obtained from the Turkey Seed Gene Bank in the third subgroup. Cabbages were transverse elliptic in shape (Table 4) and shape of base of head was flat or rounded. Internal structure of these populations was coarse and crispy and juice was absent from their leaves. Ratio of head formation was very low (6.2%). We consider that these genotypes are more suitable for pickled consumption.

Group G

Most of the populations consisted of genetic materials collected from Regions III and IV. Average head weight of populations was 2.3 kg (Table 4) and head shape was transverse narrow-elliptic. Total number of outer leaves was higher than for other groups, except for Group H. Internal structure of heads was fine, but head firmness was loose. These populations were not selected for the hybrid cabbage breeding study because the ratio of head formation was very low (29.2%). Size of outer leaves was between medium or large. Midrib thickness was found to be medium or thick. This group was harvested between 115 and 128 days and was classified as early.

Group H

This group included seven genotypes in the first subgroup and one genotype in the second subgroup. Average head weight was 2.0 kg. This value was the lowest among all groups (Table 4). Height of the harvested heads from the ground was greater than for the other groups, which can be an advantage against plant diseases in humid regions. In addition, plant height/diameter ratio was the highest among all groups (Table 4). The head formation ratio was 35.7%. Heads were suitable for sarmalik production even though their head formation ratio was low. Especially, internal structure of heads was fine and plant density was firm. Colour of outer leaves was green or dark green tones, and the colour of inner leaves was light cream or white tones. Time of harvest maturity of populations was between 126 and 129 days and was classified as early.

Group I

This group was clustered into two subgroups. Each of the genotypes in both subgroups was collected from a different region. Head shape was transverse narrow elliptic and average head weight was 2.72 kg. Head formation ratio (57.5%) was not very uniform. Shape of the base of head was flat. Outer leaves were medium or large and suitable for sarmalik production. This group was harvested between 170 and 175 days and was classified as late.

Group J

There were two populations in the first subgroup which were collected from Region IV and one population in the second subgroup. The population in the second subgroup was provided from the Turkey Seed Gene Bank. The plant height value was the highest of any group (Table 4). Ratio of head formation was very low (13.2%). This group was not selected for the hybrid cabbage studies because leaf midribs were thick and internal structure of heads was coarse. This group is suitable for pickling consumption.

DISCUSSION

Turkey is one of the most important countries in the world for plant genetic resources and genetic diversity. It is also a domestication centre where ancient agriculture started. Vavilov (1951) described two important genetic centres (Near East and Mediterranean) in the country. Turkey's natural environment is very diverse, ranging from subtropical to the cold temperate zones. This ecological diversity has contributed to high genetic diversity and has allowed the successful introduction and cultivation of a great number of vegetable species. Over 50 vegetables species are grown in Turkey (Agaoglu et al. 1997). These include a range of native and imported vegetables belonging to the *Brassica* genus (kale, cabbage, cauliflower, brussel sprouts, kohlrabi, broccoli).

It would be very beneficial to complete the description of white head cabbage genotypes grown in Turkey and to identity populations with desirable characters for white head cabbage breeding. Multivariate statistical analysis was necessary for better understanding the diversity of white head cabbage populations from Turkey, as well as useful characters which could be used in breeding programmes. As a result, the 95 white head cabbage genotypes have been clustered into 10 groups. All genotypes included in this research belong to the same group (*B. oleracea* var. *capitata* subvar. *alba*). However, it was possible to distinguish those genotypes useful traits for breeding because they possess a great range of morphological variation.

Further successful results could have been obtained by using DNA markers and molecular techniques for the determination of genetic traits for cabbage improvement in recent years (King 1990). Many reports conclude that relationships among genotypes obtained from morphological and agronomic characters are different from those obtained from isozyme and allozyme, RFLPS and RAPD markers. There are similar reports for cabbage (Dias et al. 1993; Kennard et al. 1994; Santos et al. 1994; Koutsos& Koutsika 2001). It would be possible to reach more conclusive results by using these techniques, even if cabbage genotypes were very similar to each other in their morphological traits.

The clustering of white head cabbage genetic resources of Turkey on the dendogram in 10 separate groups resulted from their different morphological structure and special characteristics. This study shows that there is considerable morphological variability, because of the introduction of diverse white head cabbage genetic materials to Turkey from different countries. Cabbage seeds are collected from the best plants open-pollinated in Turkey. Cross-pollination is common in cabbages because of flower morphology and self-incompability (Oraman & Günay 1971). Inter-crossing among different local *Brassica* varieties in Turkey has increased the genetic variability of populations in the same areas. The geographical distribution of the cluster groups was more random than expected. The origin of the collected material, mainly the coast and inland area, had no effect on the grouping in the cluster. Cluster groups were not associated with the geographical origin of the genotypes. There is no clear relationship between clusters and coastal or inland areas (Table 1; Fig. 2). In other research, it was found that there were many significant morphological differences between landraces (Yanmaz et al. 2000). When the genotypes were evaluated, three main groups (cluster A, cluster B, and cluster C) were revealed in the dendogram. There are many populations which are important for sarmalik production**.** Additionally, in the other cluster groups, a wide diversity for all traits enables us to select and combine useful traits for improved populations. It was determined that most of this type of cabbage were in the same group in the dendogram. The local cultivar 'Yalova 1' is grown in the third and fourth regions.

In conclusion, we have presented some characteristics of white head cabbage genotypes grown in Turkey, which is the origin of the cabbage. The potential for the use of Turkey's white head cabbage genotypes as new genetic sources in breeding programmes was shown. Some of these unique gene resources may not be suitable for standard cultivars in productivity and plant characteristics, but they should be saved from extinction. We must consider that conservation and maintenance of these valuable genetic resources are necessary, because these populations are an important source of diversity which could be used in future breeding programmes.

ACKNOWLEDGMENTS

We gratefully acknowledge the support of Ministry of Agriculture, Agricultural Research Project (Tarim Bakanliği Tarimsal Araştirmalar Projesi (TAP)) and partial funding by the Black Sea Agricultural Research Institute in Turkey. We also appreciate comments on this manuscript by Gregory T. Sullivan of Ondokuz Mayis University, Turkey.

REFERENCES

Agaoglu YS, Celik H, Celik M, Fidan Y, Gulşen Y, Gunay A, et al. 1997. General Horticulture. AUZF 4: 394. (In Turkish.)

Alan R, Padem H 1995. Breeding cabbage varieties suitable for eastern Anatolia by mass selection. The Scientific and Technical Research Council of Turkey. Project No. TOAG-803. 59 p. (In Turkish.)

Anonymous 1998. Descriptors for cabbage. Guidelines for the conduct tests for distinctness, homogeneity and stability of new varieties of plants. Tarim ve Köyişleri Bakanliği Tohumluk Tescil ve Sertifikasyon Merkezi Müdürlüğü.

Anonymous 2003. Meteorology Office Records of Samsun Province, Turkey.

Bayraktar K 1976. Vegetable growing. Vol. III Seed production of vegetables. Ege Ziraat Fakültesi Yayinlari No. 244.356, Izmir, Turkey. (In Turkish.)

Cartea ME, Picoaga A, Soengas P, Ordas A 2002. Morphological characterization of kale populations from north-western Spain. Euphytica 129: 25–32.

Dias JS, Monteiro AA, Lima, M.B. 1993: Numerical taxonomy of Portuguese Tronchuda cabbage and Galega kale landraces using morphological characters. Euphytica 69(1–2): 51–68.

Dickson MH, Wallace DH 1986. Cabbage breeding. In: Bassett MJ ed. Breeding vegetable crops. 395–432.

Duzyaman E, Vural H 2002. A study on morphological variability in okra genotypes from different eco-geographic origin. The Journal of Agricultural Faculty of Ege University 39(2):17–24. (In Turkish.)

Escribano MR, Ron AM, Santalla M, Ferreira JJ 1991. Taxonomical relationship among common bean populations from northern Spain. Euphytica 76: 1–6.

Escribano MR, Santalla M, Casquero PA, Ron ADE 1998. Patterns of genetic diversity in landraces of common bean (*Phaseolus vulgaris* L.) from Galicia. Plant Breeding 117: 49–56.

Fasoula DA 1990. Correlation between aoto-allo and nil competition and their implications in plant breeding. Euphytica 50: 57–62.

Gil J, Ron ADE 1992: Variation in *Phaseolus vulgaris* in the northwest of the Iberian Peninsula. Plant Breeding 109: 313–319.

Günay A. 1984. Special vegetable growing (Brassica crops). Vol. 3. Ankara, Turkey. (In Turkish.)

Hunter BR 1993. Science based identification of plant genetic material. CSSA, Intellectual Propert Rights: Protection of Plant Materials. Special Publication No. 21: 93–99.

Kennard WC, Slocum MK, Figdore SS, Osborn TC 1994. Genetic analyses of morphological variation in *Brassica oleracea* using molecular markers. Theoretical Applied Genetics 87: 721–732.

King JG 1990. Molecular genetics and breeding of vegetable brassicas. Euphytica 50: 97–112.

Koutsos TV, Koutsika-Sotiriou M 2001. Genetic diversity in four cabbage populations based on UPOV and IPGRI description forms and allozyme variation. Journal of Agricultural Science 136: 309–318.

Monteiro A, Lunn T 1998. Trends and perspectives of vegetable brassica breeding. World Conference on Horticultural Research, 17–20 June 1998, Rome, Italy.

Oraman N, Gunay A 1971. Lahanalarda çiçek tomurcuklarinin ayrim zamanindan tohumlarin oluşumuna kadar geçen safhalarin tesbiti üzerinde araştirmalar. Ankara Ziraat Fakültesi Yilliği. Yil 20: 597–631. (In Turkish.)

Piergiovanni AR, Cerbino D, Brandi M 2000. The common bean populations from Basiliciata (Southern Italy). An evaluation of their variation. Genetic Resources and Crop Evolution 47: 489–495.

Salk A 1982. Breeding cabbage varieties suitable for Aegean region by mass selection. Ege Ziraat Fakültesi Yayinlari 470. Izmir, Turkey. (In Turkish.)

Santos JB, Nienhuis J, Skroch P, Tivang J, Slocum MK 1994. Comparison of RAPD and RFLP genetic markers in determining genetic similarity among *Brassica oleracea* L. genotypes. Theoretical Applied Genetics 87: 909–915.

Simsek G, Sürmeli N 1991. White head cabbage variety breeding. Yalova Bahçe Kült. Araş. Sonuç Raporu. (In Turkish.)

Sneath PHA, Sokal RR 1973. Numerical taxonomy. The principles and practise of numerical classification. San Fransisco, W.F. Freeman.

Vavilov NI 1951. The origin, variation, immunity and breeding of cultivated plants. The Chronica Botanica 176: 13.

Vural H, Eşiyok D, Duman I 2000. The culture vegetables (vegetable growing). 440 p. Izmir, Turkey. (In Turkish.)

Yanmaz R, Kaplan N, Balkaya A, Apaydin A, Kar H 2000. Investigation on the identification of cabbage (*Brassica oleracea* var. *capitata* subvar. *alba*) gene sources of Turkey. III. Vegetable Growing Symposium 160–166. (In Turkish.)