Research Article

Characterization of coastal and transitional Chickpea (*Cicer arietinum* L.) populations and evaluation of possible variable

Cetin Sayilgan[1],* (iD)   **Burhan Kara[2]** (iD)

[1]Batı Akdeniz Agricultural Research Institute, Department of field crops, Antalya, Türkiye
[2]Isparta University of Applied Sciences, Agricultural Faculty, Department of field crops, Isparta, Türkiye

*Corresponding Author: cetin.sayilgan@tarimorman.gov.tr

Abstract

This study was conducted on 229 chickpea (*Cicer arietinum* L.) samples collected from coastal and transitional zones with the aim to characterize populations based on 18 qualitative characters, reveal morphological similarities and evaluate the possibility for variable reduction. An augmented experimental design was applied in the study in which a total of 229 samples and 7 control cultivars were characterized. Combined cluster analysis of the experimental material determined 2 main groups that were distributed as 14 subgroups. 131 homogeneous and 98 heterogeneous samples were determined and divided into two groups. Each group was subjected to cluster analysis and the hierarchical distance and genetic differences among the genotypes were determined. The principal component analysis demonstrated that the first 7 main components could explain 69.7% of the total variability in the population. Weighted effect of the seven principal components in explaining the total variation was determined as 20.5%, 15.3%, 7.7%, 7.2%, 6.8%, 6.3% and 5.9%, respectively.

Introduction

The majority of pre-selection is carried out to establish or identify the source of variation to be used in breeding programs. Therefore, individuals seek scientifically valid ways to reduce the heavy workload. One way of doing this is to determine whether the results obtained from the characterization process with a large number of variables can be obtained using fewer. Tatlidil (1992) reported using multivariate analysis methods for the purpose of variable reduction, dependency analysis by measuring the relationships between variables, hypothesis testing, and hypothesis generation, sorting, and scaling. Cluster and principal component analyses are two main methods used for the characterization of chickpeas. Materials in the same cluster formed by cluster analysis are similar to each other. They are also dissimilar to materials outside the

cluster, especially the ones in other clusters (Kayan and Adak, 2012). Principal component analysis is a statistical method to reduce dimensionality and facilitate interpretation by explaining the variance structure of a data set with the help of linear combinations of these variables (Yang and Wang, 1999). It is the most commonly used and easily interpretable statistics aiming to reduce variables and reach meaningful conceptual structures (Buyukozturk, 2007). In principal components analysis, "p" variables with a number of "n" variables (observations) are converted into new "k" variables that are linear, orthogonal, and independent from each other. Components stem from a transformed variability in the original variable and are mutually independent (Kıral and Billor, 2000).

In the present study, the total cultivation area of 15 provinces represented by the chickpea samples was 584,068 decares, while the average yield per unit was 124 kg ha[1], with 63,779 tons of total yield (TUIK, 2020). The Western Mediterranean region, where the experiment was set up, was a sub-region bearing the highest chickpea production in Turkey, but it has now lost its superiority. A national breeding program has been started in the region to increase production. The results will be a pioneer for other studies, both in terms of aiming to reach the first scientific characterization in the region and working with samples from an entire transitional zone similar to the region. Data for the article was obtained from the first-year doctoral thesis.

Materials and Methods

229 local chickpea samples collected from coastal and transitional zones, 4 registered cultivars (Azkan, Çakır, Çağatay and Yaşa 05) and 3 local populations (B7: Elmalı, B9: Korkuteli and B10: Aksu) constituted the experimental material. A total of 236 chickpea samples were cultivated in 5-meter long rows, with a depth of 0.08 m, a plot distance of 0.10 m and row-to-row distance of 1.40 m using a test drill on March 24, 2020, according to the "Augmented Experimental Design". Fertilizers containing 4 kg of pure nitrogen and 6 kg of phosphorus (P_2O_5) were applied before sowing. The harvest was performed by hand between 07-15 July 2020 and the plants were threshed in a trial combine after drying for about 1 week.

Soil of the experimental area was determined to be strongly alkaline (pH=8.5), highly calcareous (22.8%), slightly salty (EC micromhos/cm (25 ℃)=420), silty-clay-loam (Sand=15%-Clay=%). 33-Mil=52%), fine-textured with sufficient organic matter. Between 1930 and 2020, the summer chickpea sowing season (March-August) in Antalya had a record of an average of 196.4 mm of precipitation and an average temperature of 22.0 ℃. In March, April, May, June, July and August 2020, the average rainfall was 22 mm, 27 mm, 53 mm, 1 mm, 0 mm and 1 mm, respectively. A total of 104 mm of precipitation was recorded within the six months covering the 2020 growing season. The amount of precipitation during the 2020 chickpea season accounts for 52% of the long-year averages. In 2020, the average temperature was 14 ℃, 17 ℃, 22 ℃, 24 ℃, 29 ℃ and 28 ℃ in March, April, May, June, July and August, respectively. For the same months in 2021, the average temperature was 13 ℃, 17 ℃, 22 ℃, 25 ℃, 30 ℃ and 28 ℃, respectively (MGM, 2021).

In the research, the morphological characterization was made upon observations on five randomly selected plants in each row, according to the criteria of "The International Union for the Protection of New Varieties of Plants (UPOV, 2021)". Plant: habit (after flowering) (PH): erect (1), semi-erect (3) and prostrate (5). Plant: ramification (R): weak (3), medium (5) and strong (7). Plant: height (when pods fully developed) (PH): short (3), medium (5) and tall (7). Stem: anthocyanin coloration (SAC): absent (1) and present (9). Foliage: intensity of green color (FIGC): light (3), medium (5) and dark (7). Leaflet: size (LS): very small (1), small (3), medium (5), large (7) and very large (9) (Determined on the basis of the largest leaf genotype leaf). Flower color (FC): white (1) and purplish pink (2). Pod: peduncle length (PPL): (according to the genotype with the longest bean stem in the population), short (3) (1/3), medium (5) (2/3), and long (7) (3/3). Pod: size (PS): very small (1), small (3), medium (5), large (7) and very large (9). Pod: intensity of green color (PIGC): light (3), medium (5) and dark (7). Pod: length of beak (PLB): short (1), medium (5) and long (7). Pod: number of seeds (PNS): predominantly one (1), one and two (2) and predominantly two (3). Seed: color (1 month after harvest) (SC): yellow (1), beige (2), yellowish brown (3), brown (4), reddish brown (5), black (6) and mixed color (added observation) (7). Seed: intensity of color (1 month after harvest) (SIC): light (3), medium (5), dark (7) and mixed color (added observation) (9). Seed: shape (SSH): round (1), round to angular (2) angular (3) and mixed shape (added observation) (4). Seed: ribbing (SR): absent or very weak (1), weak (3), medium (5), strong (7), very strong (9) and mixed population (added observation) (10). Time of flowering (80% of plants with at least one flower) (TF): very early (1), early (3), medium (5), late (7) and very late (9). Time of dry seed maturity (TDSM): very early (1), early (3), medium (5) and late (7). Cluster (C) (Table 1).

Table 1. Materials identification and clustering

No	Sample cod	Sample / province	PH	R	TF	FC	PH	SAC	FIGC	LS	PPL	PS	PIGC	PLB	PNS	SC	SIC	SSH	SR	TDSM	C
1	49713	Isparta	5	3	5	1	5	9	5	7	7	5	5	5	1	2	3	3	9	3	1
2	77122	Manisa	1	5	5	1	5	9	3	9	5	5	3	3	1	2	3	3	9	3	1
3	70295	Hatay	5	5	1	1	5	9	5	7	5	5	3	5	1	1	5	3	7	3	1
4	37418	İzmir	3	5	5	1	3	9	5	5	5	5	3	5	1	1	5	3	7	3	1
5	34860	Denizli	1	3	5	1	5	9	5	7	3	5	3	3	1	1	5	3	7	3	1
6	70299	Hatay	1	3	1	1	5	9	5	7	3	5	3	5	1	1	5	3	7	7	1
7	77323	Denizli	1	5	1	1	7	9	3	5	3	3	3	3	1	1	5	3	5	7	1
8	65815	Burdur	1	5	3	1	3	9	3	7	5	5	3	3	1	1	5	3	7	3	1
9	65130	Muğla	1	5	5	1	3	9	5	5	5	5	5	3	1	1	5	3	7	3	1
10	34853	Burdur	3	3	3	1	5	9	3	7	5	5	5	3	1	1	5	3	7	3	1
11	70250	K. Maraş	1	5	7	1	5	9	3	7	5	5	3	3	1	1	5	3	7	3	1
12	70252	K. Maraş	5	5	5	1	7	9	5	5	5	5	5	3	1	2	3	3	9	3	1
13	34858	Isparta	1	5	3	1	5	9	5	5	5	5	5	5	1	1	5	3	7	3	1
14	35501	Burdur	1	5	5	1	5	9	5	5	5	5	3	3	1	1	5	3	5	3	1
15	49684	Burdur	3	5	7	1	5	9	5	7	5	5	5	3	1	1	5	3	7	3	1
16	77330	Denizli	1	5	3	1	5	9	5	7	5	5	3	3	1	1	5	3	7	3	1
17	42397	Denizli	1	5	5	1	3	9	3	7	5	5	3	3	1	1	5	3	7	3	1

No	Sample cod	Sample / province	PH	R	TF	FC	PH	SAC	FIGC	LS	PPL	PS	PIGC	PLB	PNS	SC	SIC	SSH	SR	TDSM	C
18	65827	Burdur	3	5	3	1	7	9	5	5	5	3	5	5	1	1	5	3	3	3	1
19	35492	Burdur	5	5	5	1	5	9	5	5	5	5	3	3	1	1	5	3	7	3	1
20	35464	Burdur	1	5	3	1	7	9	5	7	5	5	5	3	1	1	5	3	7	3	1
21	79821	Antalya	5	5	1	1	7	9	5	7	5	5	5	3	1	1	5	3	7	7	1
22	79844	Burdur	5	5	1	1	7	9	5	7	5	5	3	3	1	1	5	3	7	7	1
23	49776	Isparta	1	3	5	1	7	9	5	7	7	7	5	5	1	1	5	3	9	5	1
24	78028	Manisa	1	5	3	1	5	9	5	7	5	5	3	3	1	5	5	2	5	3	1
25	79832	Burdur	1	5	3	1	5	9	5	7	7	5	3	5	1	1	5	3	7	3	1
26	34876	Isparta	1	5	3	1	5	9	5	7	5	5	3	3	1	1	5	3	7	3	1
27	42389	Denizli	3	5	3	1	3	9	5	7	5	5	5	3	1	1	5	3	3	3	1
28	49676	Burdur	1	5	5	1	5	9	5	7	3	5	5	3	1	1	5	3	9	3	1
29	63265	Burdur	1	5	3	1	7	9	5	7	5	5	5	3	1	1	5	3	7	3	1
30	47668	Denizli	1	5	3	1	5	9	5	7	5	5	5	3	1	1	5	3	3	3	1
31	66245	Denizli	3	5	3	1	3	9	5	7	5	5	5	3	1	1	5	2	3	3	1
32	87917	Burdur	3	3	7	1	7	9	5	7	5	5	7	3	1	1	5	3	7	3	1
33	70301	Hatay	3	5	3	1	5	9	5	7	5	5	3	5	1	1	5	3	7	3	1
34	47679	Denizli	1	5	1	1	3	9	5	7	7	5	5	3	1	1	5	3	7	3	1
35	82781	Osmaniye	1	5	1	1	7	9	5	7	5	7	5	3	1	1	5	3	7	3	1
36	49660	Burdur	3	5	3	1	7	9	5	7	5	5	5	3	1	1	5	3	7	3	1
37	79820	Antalya	3	5	1	1	7	9	5	7	5	3	5	5	1	1	5	3	7	3	1
38	42400	Denizli	1	5	3	1	5	9	5	7	5	5	3	3	1	1	5	3	7	3	1
39	88018	Manisa	3	5	3	1	3	9	5	7	5	5	5	5	1	1	5	3	7	3	1
40	70266	İçel	3	5	3	2	7	9	5	5	5	3	5	3	1	4	7	1	3	3	2
41	74406	Muğla	5	5	5	1	5	9	5	5	5	5	3	3	1	1	5	1	1	3	2
42	71250	Burdur	5	5	7	1	5	9	5	5	7	5	3	3	1	1	5	1	1	3	2
43	34880	Muğla	1	3	3	1	5	9	7	5	3	3	5	3	1	1	5	1	1	3	2
44	70259	İçel	5	5	7	1	5	9	5	9	7	7	7	3	1	2	3	3	9	7	3
45	42388	Denizli	5	5	5	1	5	9	7	7	5	5	5	3	1	1	5	3	7	3	3
46	65863	Adana	5	5	1	1	5	9	7	7	7	3	5	3	1	1	5	3	7	3	3
47	49726	Isparta	3	5	3	1	7	9	7	7	5	5	5	5	1	1	7	3	7	3	3
48	70280	Osmaniye	5	5	5	1	5	9	7	9	5	5	5	3	1	1	5	3	7	3	3
49	34905	K. Maraş	5	5	5	1	7	9	5	7	7	7	7	5	1	1	5	3	7	5	3
50	79806	Aydın	5	5	3	1	5	9	5	9	5	5	5	3	1	1	5	3	7	3	3
51	42398	Denizli	3	5	1	1	5	9	5	7	5	5	5	3	1	1	5	3	7	3	3
52	70219	Adana	5	5	5	1	5	9	5	7	7	7	5	3	1	1	5	3	9	3	3
53	79816	Antalya	3	5	7	1	7	9	5	7	7	7	7	5	1	1	5	3	9	7	3
54	34867	Muğla	1	5	3	1	5	9	5	9	7	7	7	5	1	1	5	3	9	3	3
55	34916	Burdur	5	5	5	1	5	9	7	7	5	5	5	3	1	1	5	3	7	3	3
56	49847	İçel	5	5	7	1	7	9	7	7	5	5	5	3	1	1	5	3	7	3	3
57	76913	Manisa	1	5	1	1	5	9	5	9	7	7	5	3	1	2	3	3	9	3	3
58	70260	İçel	5	5	7	1	5	9	5	7	5	5	5	3	1	1	5	3	7	7	3
59	44795	Burdur	3	5	5	1	5	9	5	9	7	5	5	3	1	1	5	3	7	3	3
60	65864	Adana	5	5	5	1	7	9	5	5	7	7	7	5	1	2	3	3	9	7	3
61	49703	Antalya	3	5	7	1	7	9	7	9	7	5	7	3	1	2	3	3	9	7	3
62	77320	Denizli	3	5	3	1	5	9	5	7	5	5	5	3	1	1	5	3	9	3	3
63	82002	Isparta	3	5	7	1	7	9	5	9	5	5	5	3	1	1	5	3	9	7	3
64	70239	K. Maraş	5	5	7	1	7	9	5	7	5	5	5	3	1	2	3	3	9	7	3
65	80203	Antalya	3	5	3	1	5	9	5	9	7	7	5	3	1	1	5	3	9	3	3
66	49751	Isparta	3	5	5	1	5	9	7	9	7	7	7	5	1	1	5	3	9	3	3
67	70305	Hatay	1	5	7	1	7	9	5	7	7	7	7	5	1	2	3	3	9	3	3
68	84163	İzmir	5	7	5	1	5	9	5	9	7	7	7	3	1	1	9	4	10	5	3
69	70262	İçel	3	5	3	1	7	9	5	7	7	7	7	3	1	1	5	3	7	3	3
70	34912	K. Maraş	3	5	7	1	7	9	5	7	5	7	3	3	1	1	5	3	9	3	4
71	70242	K. Maraş	1	5	5	1	5	9	5	9	3	7	5	5	1	1	5	3	7	3	4
72	70303	Hatay	3	5	7	1	7	9	5	9	7	7	5	7	1	2	3	3	9	3	4
73	49856	İçel	1	5	7	1	7	9	5	7	5	5	3	5	1	2	3	3	9	7	4
74	34896	Muğla	3	5	5	1	5	9	5	5	5	5	5	5	1	1	5	3	9	3	4
75	49746	Isparta	1	5	5	1	5	9	7	9	5	5	3	7	1	1	5	3	9	3	4
76	70236	K. Maraş	1	5	5	1	7	9	5	7	5	7	5	5	1	1	5	3	9	3	4
77	49857	İçel	1	5	7	1	7	9	5	7	5	7	5	5	1	1	5	3	9	3	4
78	49714	Isparta	1	5	5	1	5	9	3	7	3	5	3	5	1	2	3	3	9	5	4
79	49699	Antalya	3	5	5	1	3	9	5	7	5	5	5	5	1	1	5	3	7	3	4
80	79818	Antalya	1	5	5	1	7	9	5	7	5	5	5	3	1	1	5	3	9	7	4
81	70240	K. Maraş	1	7	7	1	5	9	5	7	5	5	5	5	1	1	5	3	9	3	4
82	77321	Denizli	5	5	3	1	5	9	5	7	5	5	5	5	1	1	5	3	7	3	4

No	Sample cod	Sample / province	PH	R	TF	FC	PH	SAC	FIGC	LS	PPL	PS	PIGC	PLB	PNS	SC	SIC	SSH	SR	TDSM	C
83	49853	İçel	1	5	5	1	5	9	5	9	3	7	3	5	1	1	5	3	7	3	4
84	70246	K. Maraş	1	5	5	2	7	9	5	7	5	7	5	3	1	1	5	3	9	7	4
85	70235	K. Maraş	3	5	7	1	7	9	5	7	3	7	5	5	1	1	5	3	7	3	4
86	80206	Antalya	1	5	5	1	7	9	5	9	5	7	5	3	1	1	5	3	7	7	4
87	B9	Antalya	5	7	5	1	5	9	7	7	5	5	5	5	1	1	5	3	9	5	4
88	49782	Isparta	3	5	7	1	7	9	5	9	7	5	5	5	1	2	3	3	9	3	4
89	70291	Hatay	3	5	3	1	5	9	5	9	3	7	5	7	1	2	3	3	9	3	4
90	47733	İçel	1	5	7	1	7	9	5	9	5	7	5	3	1	1	5	3	9	3	4
91	49711	Burdur	3	5	5	1	5	9	5	9	5	5	5	5	1	1	5	3	7	3	4
92	Azkan	Eskişehir	1	7	5	1	7	9	5	9	7	5	7	5	1	1	5	3	7	5	5
93	77120	Manisa	1	7	1	1	7	9	5	9	7	7	5	3	1	2	3	3	9	3	5
94	80205	Antalya	1	7	1	1	7	9	5	9	5	5	5	3	1	2	3	3	9	7	5
95	Çağatay	Samsun	1	7	3	1	5	9	5	9	7	5	3	5	1	1	5	3	9	5	5
96	B7	Antalya	1	7	1	1	5	9	5	7	7	7	5	5	1	1	5	3	9	5	5
97	79393	K. Maraş	1	5	5	1	5	9	5	9	7	7	5	5	1	1	9	3	10	5	5
98	70237	K. Maraş	1	7	5	1	7	9	5	7	5	7	5	3	1	1	5	3	7	3	5
99	Yaşa-05	Eskişehir	1	7	1	1	7	9	7	9	5	5	5	5	1	1	5	3	7	5	5
100	B10	Antalya	3	7	3	1	7	9	5	9	7	7	5	7	1	2	3	3	7	5	5
101	82027	Antalya	1	7	5	1	7	9	5	9	7	7	5	5	1	1	5	3	7	7	5
102	70275	Osmaniye	3	5	1	1	5	9	5	9	7	7	5	5	1	2	5	3	9	7	5
103	66252	Denizli	1	7	3	1	7	9	5	7	7	5	5	3	1	1	5	3	9	3	5
104	Çakır	Eskişehir	1	7	1	1	5	9	7	9	5	7	5	3	1	1	5	3	9	5	5
105	76903	Manisa	5	7	3	1	7	9	5	9	7	7	5	3	1	2	3	3	9	3	5
106	49783	Isparta	1	5	3	1	7	9	7	9	5	7	5	5	1	1	5	3	9	7	5
107	81997	Isparta	3	7	1	1	5	9	5	9	5	7	5	5	1	2	3	3	9	3	5
108	80207	Antalya	5	7	3	1	7	9	5	9	5	7	5	3	1	1	5	3	7	3	5
109	70290	Osmaniye	3	7	3	1	7	9	5	9	5	5	5	3	1	2	3	3	9	7	5
110	87924	Burdur	1	7	1	1	7	9	7	7	5	5	7	3	1	1	5	3	7	3	5
111	49702	Antalya	3	7	1	1	7	9	7	9	7	7	7	5	1	2	3	3	9	3	5
112	49693	Burdur	1	7	1	2	7	9	7	5	5	7	5	5	1	1	5	3	9	3	5
113	37415	İzmir	3	5	5	1	7	9	5	5	5	5	5	5	2	1	5	3	7	7	6
114	70268	İçel	5	5	7	1	7	9	5	9	7	7	7	5	2	2	3	3	9	7	6
115	70267	İçel	3	5	5	1	7	9	5	9	7	7	5	3	2	1	5	3	7	7	6
116	49729	Isparta	5	5	5	1	7	9	7	7	5	5	5	5	2	1	5	3	9	3	6
117	34875	Isparta	3	5	3	1	7	9	5	7	7	5	5	3	2	1	5	3	7	3	6
118	34848	İzmir	3	7	5	1	5	9	7	7	5	3	5	3	2	1	5	3	7	3	6
119	70215	Adana	3	5	5	1	5	9	7	7	3	5	3	5	2	2	5	3	9	3	6
120	34897	Isparta	1	5	1	1	5	9	5	7	5	5	5	3	2	1	5	3	7	3	6
121	49732	Isparta	1	5	3	1	5	9	5	5	5	5	3	5	2	1	5	3	9	3	6
122	70226	Adana	1	5	3	1	5	9	7	7	5	5	5	5	2	1	5	3	7	3	6
123	79812	Antalya	5	5	1	1	5	9	5	7	7	7	5	3	2	1	5	3	7	7	6
124	79827	Burdur	3	5	3	1	5	9	5	7	7	5	5	3	2	2	3	3	9	7	6
125	49733	Isparta	1	5	3	1	5	9	5	7	3	5	5	5	2	1	5	3	7	3	6
126	79835	Burdur	5	5	1	1	7	9	5	9	7	5	5	3	2	1	5	3	7	3	6
127	70216	Adana	3	5	5	1	5	9	5	7	3	5	3	5	2	1	5	3	7	3	6
128	70271	İçel	1	5	3	1	7	9	5	9	7	7	7	3	2	1	5	3	9	3	6
129	80204	Antalya	1	7	5	1	7	9	5	7	5	7	5	7	2	1	5	3	9	3	6
130	35376	Antalya	5	5	5	1	3	9	5	3	3	3	5	3	1	7	9	4	10	3	7
131	70296	Hatay	1	3	1	1	5	9	5	5	5	3	3	5	1	7	9	4	10	3	7
132	35475	Isparta	1	5	5	1	3	9	3	7	5	3	3	3	1	7	9	4	10	3	7
133	35468	Denizli	5	5	5	1	3	9	3	7	5	5	5	3	1	7	9	4	10	3	7
134	66119	Manisa	5	5	5	1	7	9	7	7	7	5	5	3	1	7	9	4	10	3	7
135	35373	Antalya	5	5	3	1	3	9	5	5	3	3	5	3	1	7	9	4	10	3	7
136	65730	Aydın	1	5	5	1	5	9	3	7	5	5	5	5	1	7	9	4	10	5	7
137	65830	K. Maraş	1	5	5	2	3	9	3	5	5	5	3	3	1	7	9	4	10	3	7
138	70247	K. Maraş	1	5	5	1	7	9	3	5	5	5	5	3	1	7	9	4	10	3	7
139	77824	Adana	5	5	3	1	7	9	5	7	5	5	3	3	1	7	9	4	10	3	7
140	70238	K. Maraş	5	5	7	1	7	9	5	7	5	3	5	3	1	7	9	4	10	3	7
141	70273	İçel	3	5	5	1	5	9	5	7	7	5	5	3	1	7	9	4	10	3	7
142	66237	Denizli	3	5	3	1	5	9	3	5	5	5	3	3	1	7	9	4	10	3	7
143	49752	Isparta	5	5	5	1	5	9	5	5	7	5	5	3	1	7	9	4	10	3	7
144	88089	Muğla	5	5	1	1	5	9	5	7	7	5	5	5	1	7	9	4	10	3	7
145	34975	İzmir	1	5	7	1	3	9	5	9	5	5	5	3	1	7	9	4	10	3	8
146	88778	Antalya	3	5	7	1	3	9	7	7	5	5	5	5	1	7	9	4	10	3	8
147	47370	Hatay	3	5	1	1	5	9	7	7	3	5	5	3	1	7	9	4	10	3	8

No	Sample cod	Sample / province	PH	R	TF	FC	PH	SAC	FIGC	LS	PPL	PS	PIGC	PLB	PNS	SC	SIC	SSH	SR	TDSM	C
148	66213	Denizli	3	5	1	1	5	9	5	7	5	5	5	3	1	7	5	4	7	3	8
149	49845	İçel	1	5	5	1	7	9	5	9	1	3	3	3	1	7	9	4	10	7	8
150	42175	K. Maraş	1	5	1	1	3	9	7	5	5	5	5	3	1	7	9	4	10	3	8
151	34976	İzmir	1	5	5	1	3	9	5	7	5	5	5	3	1	7	9	4	10	3	8
152	34869	İçel	1	5	1	1	3	9	7	5	3	1	5	3	1	7	9	4	10	3	8
153	49730	Isparta	1	5	5	1	7	9	5	7	3	5	5	5	1	7	9	4	10	3	8
154	70230	K. Maraş	1	5	5	1	5	9	5	5	5	5	5	3	1	7	9	4	10	3	8
155	70203	Adana	3	5	1	1	3	9	5	7	5	5	5	3	1	7	5	4	10	3	8
156	49745	Isparta	1	5	5	1	7	9	5	7	3	5	3	5	1	7	5	4	10	3	8
157	4757	Denizli	1	5	1	1	5	9	5	5	3	3	3	5	1	7	9	4	10	3	8
158	70218	Adana	3	3	7	2	5	9	7	5	3	5	7	3	1	7	9	4	10	3	9
159	49734	Isparta	3	3	7	1	5	9	7	7	7	5	5	7	1	7	9	4	10	3	9
160	79822	Burdur	5	3	7	2	7	9	7	5	5	5	5	5	1	7	9	4	10	3	9
161	34889	Manisa	5	3	7	1	5	9	7	9	5	5	5	5	1	7	9	4	10	7	9
162	34854	Denizli	1	5	5	1	7	9	5	7	7	5	5	5	1	7	9	4	10	3	10
163	53904	Isparta	1	5	5	1	7	9	5	7	5	7	5	3	1	7	9	4	10	3	10
164	70258	İçel	1	5	5	1	7	9	5	9	7	3	5	3	1	7	9	4	1	3	10
165	76901	Manisa	1	5	5	1	7	9	5	9	5	5	5	3	1	7	9	4	10	5	10
166	70217	Adana	1	5	5	1	7	9	5	7	5	5	5	3	1	7	9	4	10	3	10
167	70225	Adana	1	5	5	1	5	9	7	7	7	5	5	5	1	7	9	4	10	3	10
168	70261	İçel	3	5	5	1	7	9	7	9	5	5	5	3	1	7	9	4	10	3	10
169	70224	Adana	3	5	5	1	7	9	7	7	7	5	7	3	1	7	9	4	10	3	10
170	66227	Denizli	3	5	3	1	7	9	5	9	5	5	5	3	1	7	9	4	10	3	10
171	49747	Isparta	3	5	3	1	5	9	7	9	7	7	7	5	1	7	9	4	10	3	10
172	80202	Muğla	1	5	3	1	7	9	5	9	5	7	5	3	1	7	9	4	10	3	10
173	70220	Adana	3	5	5	1	7	9	7	7	7	7	5	5	1	7	9	4	10	3	10
174	88751	Antalya	3	5	3	1	7	9	7	7	5	5	7	5	1	7	9	4	10	3	10
175	49605	İzmir	3	5	7	2	5	9	7	7	5	5	7	3	1	7	9	4	10	3	10
176	77827	Adana	3	5	7	1	7	9	5	7	7	7	5	3	1	7	9	4	10	7	11
177	70228	Adana	1	5	5	1	7	9	7	7	7	7	7	3	1	7	9	4	10	7	11
178	65831	K. Maraş	5	5	3	1	7	9	5	7	7	7	7	3	1	7	9	4	10	7	11
179	49849	İçel	3	5	7	1	7	9	5	5	5	5	5	5	1	7	9	4	10	7	11
180	76911	Manisa	3	5	5	1	7	9	5	7	5	7	5	3	1	7	9	4	10	7	11
181	35362	Antalya	3	5	5	1	7	9	5	5	5	5	5	5	1	7	9	4	10	7	11
182	49834	İçel	1	5	7	1	7	9	5	7	7	5	5	5	1	7	9	4	10	7	11
183	70222	Adana	1	5	5	1	7	9	7	7	7	5	3	5	1	7	9	4	10	7	11
184	40753	İçel	5	5	5	1	7	9	5	7	5	5	5	7	1	7	9	4	10	7	11
185	70257	K. Maraş	3	5	5	1	5	9	5	7	7	5	5	5	1	7	9	4	10	7	11
186	70227	Adana	1	5	5	1	7	9	5	7	5	7	5	3	1	7	9	4	10	7	11
187	70210	Adana	3	5	5	1	7	9	5	7	3	5	5	5	2	7	9	4	10	3	12
188	37483	İzmir	3	5	5	1	5	9	5	7	5	7	5	3	2	7	9	4	10	7	12
189	34878	Denizli	1	5	3	1	7	9	5	7	5	5	3	5	2	7	9	4	10	3	12
190	49832	İçel	3	5	5	2	7	9	5	7	7	3	5	5	2	7	9	4	10	3	12
191	81998	Isparta	1	5	3	1	7	9	5	9	5	7	5	3	2	7	9	4	10	3	12
192	34868	Muğla	1	5	5	1	5	9	5	7	5	3	5	3	2	7	9	4	10	3	12
193	49425	Hatay	1	5	5	1	7	9	5	7	7	5	5	3	2	7	9	4	10	7	12
194	79826	Burdur	5	5	3	1	7	9	5	9	7	7	7	3	2	7	9	4	10	3	12
195	34901	Denizli	3	5	3	1	7	9	7	9	7	5	5	5	2	7	9	4	10	7	12
196	37429	İzmir	5	5	5	1	7	9	5	5	5	5	5	3	2	7	9	4	10	7	12
197	66552	Adana	3	5	1	2	5	9	5	9	5	5	5	3	2	7	9	4	10	3	12
198	66117	Manisa	3	5	3	1	5	9	7	7	7	5	5	3	2	7	9	4	10	7	12
199	70272	İçel	1	5	1	1	7	9	5	7	3	5	5	3	2	7	9	4	10	3	12
200	70223	Adana	1	5	3	1	7	9	5	9	5	5	5	3	2	7	9	4	10	3	12
201	70253	K. Maraş	5	5	5	2	5	9	5	7	7	5	3	3	1	7	9	4	10	3	13
202	70251	K. Maraş	5	5	5	2	5	9	3	7	5	5	5	3	1	7	9	4	10	3	13
203	77841	K. Maraş	5	5	5	2	7	9	5	7	5	5	5	3	1	7	9	4	10	3	13
204	66543	Adana	3	5	7	2	7	9	5	7	5	3	5	3	1	7	9	4	10	3	13
205	70255	K. Maraş	5	5	5	2	5	9	5	7	5	7	5	3	1	7	9	4	10	3	13
206	34988	İzmir	5	5	5	2	7	9	5	9	5	7	5	3	1	7	9	4	10	7	13
207	70241	K. Maraş	1	5	7	2	7	9	5	9	5	5	5	3	1	7	9	4	10	3	13
208	70249	K. Maraş	3	5	5	2	5	9	5	7	7	7	7	3	1	7	9	4	10	3	13
209	37452	İzmir	5	5	3	2	7	9	5	9	5	5	5	5	1	7	9	4	10	3	13
210	65668	Burdur	3	5	3	2	5	9	5	7	7	5	5	3	1	7	9	4	10	3	13
211	70270	İçel	3	5	5	2	7	9	5	9	5	5	5	7	1	7	9	4	10	3	13
212	49833	İçel	1	5	5	2	7	9	5	7	5	7	7	3	2	7	9	4	10	3	13

No	Sample cod	Sample / province	PH	R	TF	FC	PH	SAC	FIGC	LS	PPL	PS	PIGC	PLB	PNS	SC	SIC	SSH	SR	TDSM	C
213	70248	K. Maraş	1	5	5	2	7	9	5	7	7	7	7	3	1	7	9	4	10	3	13
214	77322	Denizli	1	5	3	2	5	9	5	7	5	5	3	3	1	7	9	4	10	3	13
215	70245	K. Maraş	1	5	3	2	7	9	5	7	5	5	5	3	1	7	9	4	10	7	13
216	70243	K. Maraş	3	5	3	2	7	9	5	5	5	5	5	3	1	7	9	4	10	3	13
217	70269	İçel	3	7	5	2	7	9	5	7	7	7	5	3	1	7	9	4	10	5	13
218	70254	K. Maraş	1	5	5	2	5	9	5	7	5	5	5	3	1	7	9	4	10	7	13
219	70256	K. Maraş	1	5	3	2	7	9	5	7	3	5	5	3	1	7	9	4	10	7	13
220	37494	K. Maraş	5	5	3	2	5	9	5	5	3	3	5	5	1	7	9	4	10	7	13
221	70221	Adana	1	5	3	2	5	9	5	7	5	5	5	3	1	7	9	4	10	3	13
222	70232	K. Maraş	1	5	1	2	7	9	5	5	7	7	5	1	1	7	9	4	10	3	13
223	70190	Adana	1	5	1	2	7	9	5	5	5	5	5	5	1	7	9	4	10	7	13
224	49698	Antalya	1	5	5	2	7	9	5	7	5	5	5	5	1	7	9	4	10	3	13
225	82086	Denizli	1	5	3	2	7	9	5	7	5	5	5	3	1	7	9	3	10	3	13
226	71252	Denizli	1	5	7	2	5	9	5	5	5	1	3	3	1	4	7	3	9	3	14
227	71251	Denizli	3	5	5	2	5	9	5	5	5	5	5	3	1	4	7	3	9	3	14
228	71248	Burdur	1	5	5	2	5	9	5	5	5	5	3	3	1	4	7	3	9	7	14
229	70234	K. Maraş	1	5	5	2	5	9	5	7	5	5	5	3	1	1	5	3	7	3	14
230	49424	Hatay	1	5	3	2	5	9	5	9	5	5	5	3	1	4	7	3	9	3	14
231	26432	Manisa	1	5	5	2	7	9	7	5	3	1	3	3	1	4	7	3	9	3	14
232	71249	Burdur	1	5	5	2	5	9	5	5	3	3	3	3	1	4	7	3	9	3	14
233	71247	Isparta	1	5	5	2	7	9	5	5	3	1	5	3	1	4	7	3	9	3	14
234	71246	Isparta	1	5	5	2	5	9	5	5	5	1	5	3	2	4	7	3	9	3	14
235	70206	Adana	3	5	3	2	5	9	5	7	5	3	5	3	1	1	5	3	7	3	14
236	66551	Adana	1	5	3	2	5	9	5	9	7	5	5	3	1	1	5	3	7	3	14

Plant: habit (after flowering) (PH), Plant: ramification (R), Plant: height (PH), Stem: anthocyanin coloration (SAC), Foliage: intensity of green color (FIGC), Leaflet: size (LS), Flower: color (FC), Pod: peduncle length (PPL), Pod: size (PS), Pod: intensity of green color (PIGC), Pod: length of beak (PLB), Pod: number of seeds (PNS), Seed: color (SC), Seed: intensity of color (SIC), Seed: shape (SSH), Seed: ribbing (SR), Time of flowering (80% of plants with at least one flower) (TF), Time of dry seed maturity (TDSM), Cluster (C).

Statistical analyses were performed using the JUMP package program. Material clustering analysis was performed according to the observation garden data. Samples were divided into two main groups based on their heterogeneous (population) and homogeneous (local cultivar/old cultivar/village cultivar) qualities. Hierarchical clustering was performed for both groups and the genetic distance and similarity of each sample was determined. Principal component analysis was performed to see whether variable reduction was possible and the obtained results were evaluated.

Results and Discussion

Combined clustering analysis determined 2 main groups distributed into 14 subgroups (Table 1). Chickpea is known to transmit seed characteristics to the next generations perfectly, therefore, seed shape and seed size, surface texture, color, coarseness and size are considered as the main characteristics in determining chickpea varieties (Zhukovsky, 1933; Genckan, 1958; Sing, 1971; Altınbas and Sepetoğlu, 2002; Upadhyaya et al.., 2011), while they exhibit differences in seed color and seed coat content (Jomov et al., 2005; Upadhyaya et al., 2007), which are considered as the optimal features to be utilized for selection studies.

To make better use of the descriptive scale and distinguish the homogeneous (local cultivar/old cultivar/registered cultivar) and non-homogeneous (population) samples during seed observation, additional scaling variables such as seed color (7), seed color intensity (9), seed shape (4), and seed ribbing (10) were included for non-homogeneous samples. All material properties and distributions of clustering (C) analysis in the material set are shown in Table 1. 98

population (Figure 1) and 131 local cultivar (Figure 2) distributions were determined. In the experiment, all 7 cultivars and lines used as controls were grouped into the cluster where homogeneous samples were collected following the cluster analysis. The fact that all controls were in the homogeneous clusters supports that the new groupings are more homogeneous and healthier in terms of characterization.

As determined by morphological observations, the cluster analysis of populations revealed two main hierarchical clusters. Genotypes sampled from İzmir (84163), Kahramanmaraş (79393) and Denizli (82086) were in the first cluster, whereas the other 95 genotypes were in the second cluster (Figure 1). Genotype 84163 (İzmir) in the first group and genotype 35376 (Antalya) in the second group were the two genotypes showing the least genetic similarity (11.99) to each other. Genotypes with the highest similarity (0.82) were those numbered 49849 (Icel) and 35362 (Antalya) in the second group (Table 2).

Clustering analysis for homogenous samples (131 varieties, 7 cultivars) revealed 2 main groups and 18 subgroups (Figure 2). All control cultivars were clustered in the homogeneous group. B9 local cultivar and registered genotypes 42388 (Denizli), 34916 (Burdur), 70280 (Osmaniye), 49847 (Icel), 65863 (Adana), 49726 (Isparta) are in the same sub-cluster, whereas Azkan, Çağatay, B10 and B7 cultivars and 82027 (Antalya), 70275 (Osmaniye) and 49783 (Isparta) genotypes were in the same sub-cluster, and Yasa-05 and Cakir cultivars and 87924 (Burdur), 49702 (Antalya) and 49693 (Burdur) genotypes were in the same sub-cluster. In the homogeneous group, genotype 49713 (Isparta) and 70295 (Hatay) hierarchically exhibited the least genetic similarity

(16.61). In the homogeneous group, no hierarchical distance (0.00) was found between registered genotypes 77330 (Denizli) and 34876 (Isparta), 35464 (Burdur) and 63265 (Burdur), 77330 (Denizli) and 42400 (Denizli), 42388 (Denizli) and 34916 (Burdur) (Table 3).

The wide range of population-specific variations among the samples collected from the coastal and transitional zones exhibit consistency with the previous studies and is also a significant result that can help increase the success of breeding programs for self-pollinated plants. Characterizations of *Cicer* varieties are important in terms of forming the first phase of studies to develop varieties in breeding programs and evaluate existing genetic resources (Sehirali and Ozgen, 1987). In available characterization studies with genetic materials collected from different ecological environments, materials were also clustered in different groups, which is consistent with our study. In this respect, different cluster distributions determined by the clustering analysis are expected positive results.
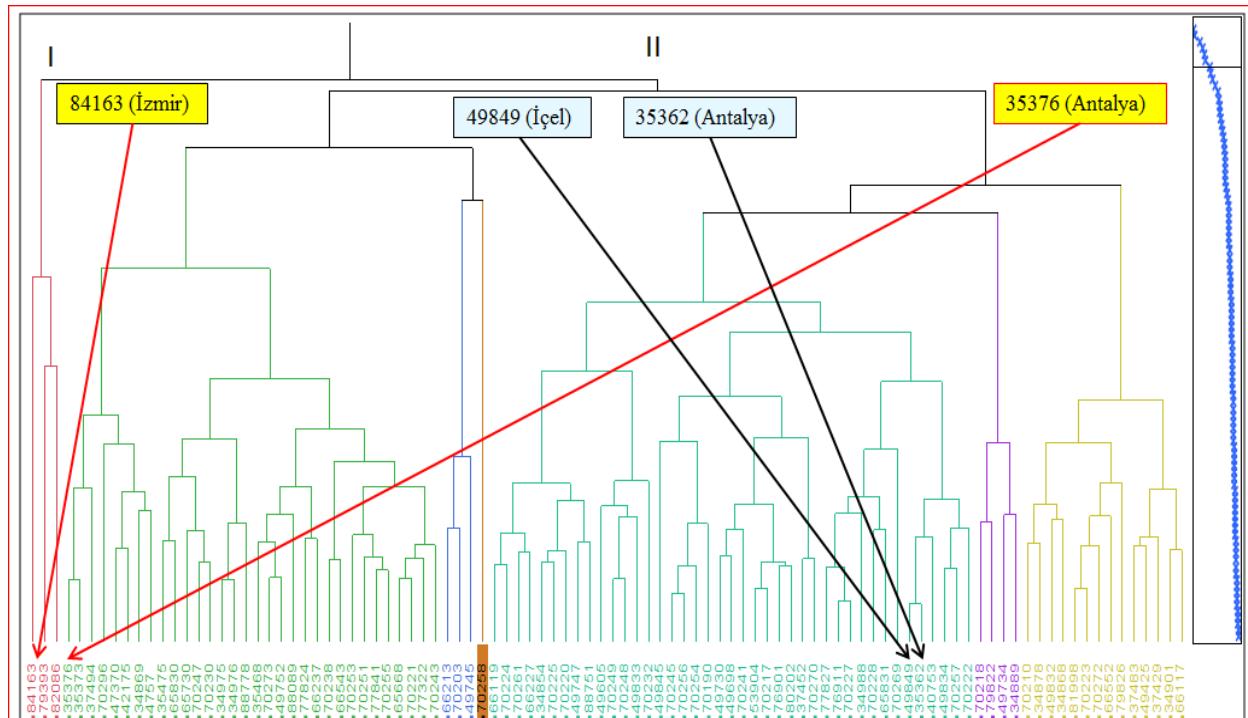
Figure 1. Cluster analysis of heterogeneous experimental material.
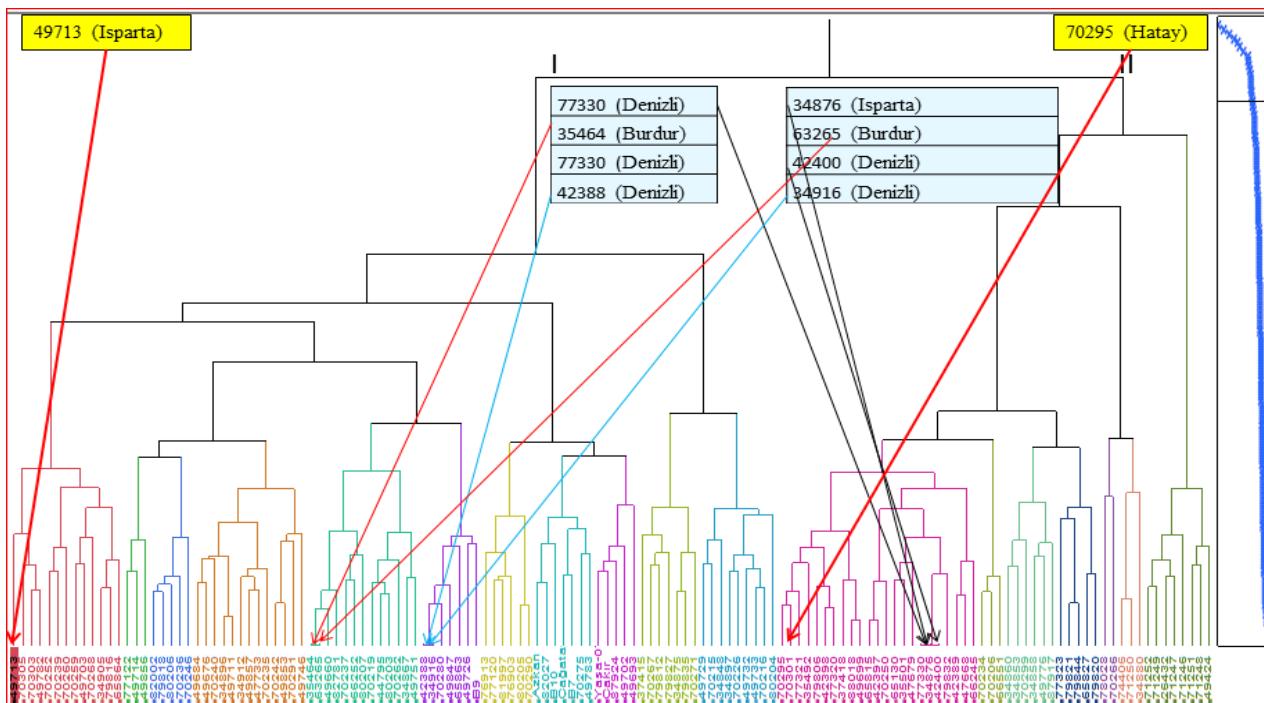
Figure 2. Cluster analysis of homogeneous experimental materials.

Table 2. Distance/similarity of heterogeneous materials

No	Distance	Leader	Joiner	No	Distance	Leader	Joiner
97	0.82	49849	35362	48	2.67	70249	49833
96	0.89	76911	70227	47	2.69	81998	66552
95	1.04	70245	70256	46	2.72	49734	34889
94	1.15	53904	70217	45	2.72	35468	88089
93	1.15	81998	70223	44	2.75	77827	34988
92	1.34	35376	35373	43	2.82	34869	4757
91	1.34	34975	34976	42	2.91	49605	70249
90	1.36	70249	70248	41	2.94	70210	49832
89	1.37	65668	70221	40	2.94	49730	53904
88	1.39	70273	49752	39	3.02	34854	49747
87	1.54	77841	70255	38	3.06	49849	49834
86	1.59	49834	70257	37	3.11	77827	70228
85	1.61	77827	76911	36	3.20	47370	34869
84	1.63	70245	70254	35	3.27	37483	34901
83	1.63	76901	80202	34	3.30	35376	37494
82	1.65	66119	70224	33	3.31	70253	65668
81	1.71	53904	76901	32	3.32	35468	77824
80	1.72	70247	70230	31	3.39	66119	34854
79	1.72	34854	70225	30	3.41	81998	79826
78	1.76	70238	66543	29	3.44	49605	70232
77	1.78	37452	70270	28	3.54	35475	65730
76	1.79	65668	77322	27	3.85	70238	70253
75	1.83	70251	77841	26	3.97	66213	49745
74	1.84	49730	49698	25	4.11	77827	70269
73	1.92	70261	66227	24	4.24	70296	47370
72	1.95	34854	70220	23	4.24	70210	81998
71	1.97	34901	66117	22	4.25	70218	49734
70	2.01	47370	42175	21	4.29	49845	70245
69	2.06	37483	49425	20	4.34	35475	34975
68	2.07	81998	70272	19	4.37	49730	37452
67	2.07	65668	70243	18	4.56	35468	70238
66	2.12	70210	34878	17	4.83	35376	70296
65	2.14	49747	88751	16	5.16	70210	37483
64	2.14	35468	70273	15	5.24	49845	49730
63	2.18	35475	65830	14	5.55	77827	49849
62	2.21	77824	66237	13	5.62	35475	35468
61	2.25	37483	37429	12	5.78	66119	49605
60	2.25	49849	40753	11	5.89	79393	82086
59	2.29	70253	70251	10	6.60	49845	77827
58	2.34	66119	70261	9	7.24	66119	49845
57	2.38	65730	70247	8	7.79	84163	79393
56	2.40	70228	65831	7	7.96	35376	35475
55	2.41	49730	70241	6	9.14	66119	70218
54	2.45	66213	70203	5	9.42	66213	70258
53	2.45	49834	70222	4	9.74	66119	70210
52	2.53	70245	70190	3	10.53	35376	66213
51	2.55	34975	88778	2	11.73	35376	66119
50	2.56	70218	79822	1	11.99	84163	35376
49	2.63	49832	34868				

Table 3. Distance/similarity of homogeneous materials

No	Distance	Leader	Joiner	No	Distance	Leader	Joiner
137	0.00	77330	34876	68	2.65	70237	80207
136	0.00	35464	63265	67	2.66	34897	49732
135	0.00	77330	42400	66	2.69	70275	49783
134	0.00	42388	34916	65	2.70	70267	79827
133	0.74	65815	42397	64	2.72	34875	70271
132	0.74	88018	49699	63	2.73	76913	77120
131	0.83	34896	49711	62	2.86	70252	70260
130	1.05	35464	49660	61	2.86	70295	79806
129	1.11	42398	77320	60	2.89	Yasa-07	49702
128	1.17	70295	70301	59	2.90	71251	49424
127	1.17	80205	70290	58	2.90	42388	65863
126	1.21	42388	70280	57	2.97	49726	B9
125	1.24	79821	79844	56	2.98	Azkan	B10
124	1.24	70242	49853	55	2.99	34858	87917
123	1.36	74406	71250	54	3.03	70242	70291
122	1.48	42389	47668	53	3.08	34860	70299
121	1.52	44795	80203	52	3.09	49729	34848
120	1.56	70234	70206	51	3.09	77122	49856
119	1.57	82002	79818	50	3.14	70259	70268
118	1.57	34875	79835	49	3.15	82002	70246
117	1.58	70295	77321	48	3.17	65130	77330
116	1.60	35464	82781	47	3.20	42388	49726
115	1.62	70303	49782	46	3.22	37415	70267
114	1.63	49857	47733	45	3.24	71252	71246
113	1.68	34905	79816	44	3.25	70242	49746
112	1.70	49733	70216	43	3.26	49713	70305
111	1.71	71252	71249	42	3.31	70219	34867
110	1.72	79806	42398	41	3.33	70295	37418
109	1.74	42388	49847	40	3.34	35464	70237
108	1.78	82002	80206	39	3.40	Cağatay	70275
107	1.82	70219	44795	38	3.59	49684	34912
106	1.83	49684	49676	37	3.71	77323	79821
105	1.84	Azkan	82027	36	3.74	Azkan	Cağatay
104	1.86	65815	70250	35	3.77	76913	80205
103	1.90	70237	66252	34	3.81	34897	80204
102	1.91	65130	35501	33	3.98	49729	34897
101	1.92	37418	88018	32	3.99	65815	65130
100	1.92	77120	81997	31	4.02	70259	34905
99	1.97	34867	49751	30	4.03	37415	34875
98	2.00	34912	49857	29	4.04	77323	65827
97	2.00	70234	66551	28	4.09	Yasa-07	49693
96	2.01	26432	71247	27	4.19	34860	34858
95	2.03	82002	70236	26	4.35	78028	70266
94	2.03	77120	76903	25	4.46	74406	34880
93	2.06	Cağatay	B7	24	4.56	49684	70242
92	2.07	77330	79832	23	4.57	65815	42389
91	2.09	65827	79820	22	4.59	71252	71251
90	2.15	34897	70226	21	4.60	70252	70259
89	2.16	Yasa-05	Cakır	20	5.04	70295	65815
88	2.18	77122	49714	19	5.11	35464	70219
87	2.18	70252	70239	18	5.18	49713	70252
86	2.24	34912	70235	17	5.51	77122	82002
85	2.25	49732	49733	16	5.54	Azkan	Yasa-07
84	2.32	34860	34853	15	5.78	34860	77323
83	2.33	71251	71248	14	5.92	76913	Azkan
82	2.33	70267	79812	13	5.98	77122	49684
81	2.34	70305	70303	12	6.00	70295	70234
80	2.39	49729	70215	11	6.05	78028	74406
79	2.40	70259	49703	10	6.49	35464	42388
78	2.41	70295	35492	9	6.78	37415	49729
77	2.42	65130	47679	8	6.84	70295	34860
76	2.45	42389	66245	7	8.27	77122	35464
75	2.47	Yasa-05	87924	6	9.47	49713	77122
74	2.49	70219	70262	5	10.02	49713	76913
73	2.49	71252	26432	4	11.44	49713	37415
72	2.51	34905	65864	3	12.84	70295	78028
71	2.53	49684	70240	2	14.90	70295	71252
70	2.60	49684	34896	1	16.61	49713	70295
69	2.62	34858	49776				

Gençkan (1958) obtained 34 different clusters from their observations with respect to seed morphology on 319 samples obtained from 52 different provinces of Turkey. Ghaffari et al. (2014) used 60 samples consisting of 29 local cultivars and 31 cultivars from different environments in Iran, in which they determined 5 different groups as a result of the morphological and molecular characterization carried out to reveal genetic variations. Cinsoy et al. (1997) analyzed 125 samples collected from the Aegean

region in terms of 11 qualities; Atikyilmaz Cinsoy et al. (1997) analyzed 125 samples collected from the Aegean region in terms of 11 qualities; Atikyilmaz and Acikgoz (2001) analyzed 7 cultivars and 1 Spanish genotype with a total of 327 samples from different regions (47 from Eastern Anatolia, 93 from Central Anatolia, and 187 from Southeastern Anatolia) in terms of 28 agronomic and morphological characteristics. Karagul (2016) characterized 230 chickpea samples collected from the Aegean Region and 250 samples obtained from the National Gene Bank, reporting that the materials were all clustered under different groups.

Principal component analysis was performed for 18 qualities (variables) of 236 samples to reduce the dimensionality and facilitate interpretation. In principal component analysis, components with an eigenvalue greater than 1 are accepted as a principal component. The present study demonstrated that the first 7 principal components with an eigenvalue greater than 1 could explain 69.7% of the total variation in the population. Mohammadi and Prasanna (2003) found it sufficient for the first two or three principal components to explain more than 25% of the total variation for an accurate and effective assessment. In our study, determination of the additive variance of the first two principal components as 35.3% enables accurate and effective interpretation. Variables of the first principal component such as seed color, seed color intensity, seed shape, and seed coat content were able to explain 20.5% of the total variation. Pod size, pod peduncle length, leaf size, pod foliage and plant height, variables of the second principal component, explained 15.3% of the total variation. Time of flowering, plant habit and foliage (intensity of green color), variables of the third principal component, explained 7.7% of the total variation. Time of flowering, seed maturation time and pod beak length, variables of the fourth principal component, explained 7.2% of the total variation. Foliage, pod beak length and number of seeds per pod, variables of the fifth principal component, explained 6.8% of the total variation. Plant height, time of seed maturation and number of seeds per pod, variables of the sixth principal component, explained 6.27% of the total variation. Flower color and foliage, variables of the seventh principal component, explained 5.9% of the total variation (Table 4).

Table 4. Principal Components

	PC1	PC2	PC3	PC4	PC5	PC6	PC7
Eigenvalue	3.4946	2.5962	1.3136	1.2159	1.1591	1.0673	1.0097
Percent of cumulative variance (%)	**20.556**	**15.272**	**7.727**	**7.152**	**6.818**	**6.278**	**5.94**
Cumulative variance (%)	20.556	35.828	43.555	50.707	57.525	63.804	69.743
Eigenvectors							
Seed color	**0.50251**	-0.0308	-0.0222	-0.03972	0.0106	-0.0449	-0.05204
Seed color intensity	**0.48625**	-0.06421	0.00055	-0.08776	0.03166	-0.02707	-0.0279
Seed shape	**0.48346**	0.07926	-0.09921	-0.0027	0.04568	-0.17701	-0.12812
Seed coat contend	**0.40924**	0.17889	-0.14248	0.11841	0.03171	-0.1709	-0.01377
Pod size	-0.07247	**0.45366**	-0.08949	0.07295	-0.20374	-0.19351	-0.05988
Pod peduncle length	-0.01378	**0.39012**	0.13632	-0.2369	-0.21468	-0.11291	-0.16246
Leaf size	-0.09324	**0.38718**	-0.21189	-0.03056	-0.04129	-0.24728	-0.0379
Pod foliage	0.08128	**0.3857**	0.25453	-0.3085	-0.04789	0.11427	0.14338
Plant height	0.0649	**0.31448**	-0.09187	0.21812	0.04212	**0.52287**	0.26647
Time of flowering	0.09154	0.0529	**0.42556**	**0.46649**	-0.25337	-0.019	0.1083
Plant habit	0.00262	0.11656	**0.58652**	-0.15766	-0.04632	0.06093	-0.30635
Foliage (intensity of green color)	0.02704	0.16129	**0.31475**	-0.24464	**0.55915**	0.04601	**0.39349**
Time of seed maturation	0.04361	0.231	-0.03526	**0.45059**	-0.07087	**0.41258**	-0.18497
Pod beak length	-0.04268	0.15751	0.03767	**0.4247**	**0.46345**	-0.36179	0.24529
Number of seeds per pod	0.03255	0.07814	-0.12799	-0.06019	**0.47971**	**0.36889**	-0.53532
Flower color	0.24352	-0.13038	-0.03886	-0.14856	-0.26792	0.29888	**0.42734**
Anthocyanin coloration	0	0	0	0	0	0	0
Branching	-0.10808	0.23958	-0.42417	-0.24528	-0.04159	0.07872	0.18153

Bold numbers indicate have higher eigenvalue than 0.30

Conclusion

As expected, both heterogeneous and homogeneous samples formed different clusters as shown by the clustering analysis performed on 236 characterized samples. The number of subclusters formed out of heterogeneous genotypes is fewer, whereas a higher number of subclusters is formed out of homogeneous genotypes, which is closely linked with the average of five randomly selected plants from the rows during observation. Difference in the average of five plants is considered to be the final determinant.

Testing the homogeneity of material and separation of genotypes and cultivar/line quality samples from each other during chickpea identification together with seed reproduction will facilitate prospective single plant selection activities. Proper identification will facilitate future studies by preventing the collection of too many samples from materials with similar homogeneous plants. Again, it will eliminate the risks of selection with the same material as the registered cultivar/old cultivar grown in the production area, as demonstrated by the detection of genotypes with no genetic distance in the homogeneous group, whose hierarchical distances were determined.

Total variance of the first two of the seven principal components (total variance > 25%) determined by the principal component analysis is sufficient for interpretation. However, total variance of the first two or three principal components (total variance > 80-90%) must be greater for a precise reduction of dimensionality (Alkan, 2008). However, our results show that the variable of anthocyanin coloration and the variable of branching, which have a weighted contribution of 0 in the formation of the principal component, can be ignored in the characterization of homogeneous chickpea samples.

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