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Evaluation of Morphological and Pomological Diversity of 62 Almond Cultivars and Superior Genotypes in Iran

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Abstract

Identification and selection of promising genotypes of fruit tree are primary steps in breeding programs. The economic importance of almond production in the world has stimulated numerous studies related to breeding, quantitative and qualitative traits, the increase of yield and decrease production costs. In this study, morphological and pomological characteristics of 60 cultivar and superior genotypes from Iran, the European Union and the USA were evaluated. Results indicated that tree habit growth, buds, leaf, flowers and fruit attributes were highly diverse among studied cultivar and superior genotypes and, among the varieties and genotypes studied, significant differences revealed in terms of means comparison. Based on the means comparison, the minimum number of buds on the tree was for genotypes "3_12" and the maximum number of buds was for "14_24". The "Boty" cultivar had the minimum length of nut shell, whereas the "D_99" cultivar had the maximum length. The "Price" cultivar had the minimum width and Marcona had the maximum nutshell width. Cultivars "D_99"and "Marcona" had the minimum and maximum nut shell thickness respectively. Cultivar "2_22" had the minimum kernel length and "D_99" cultivar the maximum. The maximum kernel weight was for "D_99" and the minimum for "SH _15". The minimum kernel hardness was for genotype "D_124" and the maximum of kernel hardness was for genotypes "16 _30" and "3_17". In terms of flowering time, cultivars "Sepid" , "Rabie" and "Mamaie" flowered most early and genotypes "D_5" and "D_11" most late. Also the maximum and minimum weight for almonds buds was seen in cultivars "Perlis" and "Sh _10", respectively. Genotype "D_8" had the maximum bud length and genotype "10_8"the minimum.

Keywords: Almond, Diversity, Morphology, Pomology.

Introduction

Almond (*Prunus dulcis* Mill.) belongs to the rosaceae family, subfamily prunoidea and genus *Prunus*. Almond is one of the treasured perennial woody plants that and is often seen as trees or shrubs in the wild. It has been suggested (Imani 1997, Kester and Gradziel, 1996) that almonds originated in western and central Asia. The culture of almonds in Asia is estimated to go back as far as ten thousand years BC. Some botanists believe that the almond is native to Iran, based on the identification of more than 20 species of wild almonds in Iran. On the other hand, almond is one of the most important and most desirable temperate fruit trees (Kester and Gradziel, 1996). Almond is a diploid species with bisexual flowers of pink to white color. The nut shape is round to ovate (Imani, 1997). Almonds are grown in over 50 countries; the FAO website states that the United States of America, Spain, Iran, Italy, Turkey, Tunisia, Morocco, Syria, Greece and Australia are the ten major producers of almonds. The modern almond industry, needs special commercial cultivars of high quality, and by investigation of the traits and qualitative and quantitative characteristics of fruit trees like almond, one can select the best commercial cultivars for propagatation and commercial promotion (Gradziel and Kester 1998, Ledbetter and Shonnard,1992).

Diversity is necessary, and where there are very rich genetic resources of local almond genotypes, these resources should be investigated for use in almond breeding programs (Kodad *et al.*, 2008).

Almonds can be grown in most regions of Iran. In Iran, superior genotypes have not yet been identified, so there is a need to identify the best cultivars for almond cultivation development (Imani, 1997).

De Giorgio and Polidnano (2001) studied the diversity of 88 almonds cultivars in terms of 20 traits for trees, shell and kernel in southern of Italy. The cluster analysis placed these traits in 7 groups. The most important factors in cluster formation were the percentage of double kernels, followed by nut thickness and the percentage of kernels.

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Later, De Giorgio *et al.,* (2007) evaluated 52 southern Italian almond cultivars and found that these cultivars show the most diversity in terms of traits like kernel doubling, percentage of kernels, weight of nut and kernel, total fat, and the level of alpha-tocopherol. The percentages of kernels and of double kernels had the highest variation and kernel weight the lowest. Chalak *et al.* (2007) evaluated the morphological characteristics of 36 almond cultivars on the basis of 20 quantitative and qualitative traits, mostly for kernels and nuts. They found much diversity among the cultivars and also dis covered two cultivars having the same name.

One of the best ways to study of germplasm and genetic relationships between populations is by use of multivariate statistical methods. Among these methods, the Principal Components Analysis (PCA) and Cluster Analysis techniques have more application than the other available methods. In cluster analysis, the cases within the cluster have the highest similarity and the cases are placed into the separate clusters are more heterogeneous based on these traits. Factor Analysis is one of the other multivariate statistical methods that reduce the number of studied traits and placed them into the effective groups. These methods (Cluster Analysis and Factor Analysis) have been used by De Giorgio & Polidnano (2001), De Giorgio *et al*. (2007) and Chalak *et al*., (2007) in order to grouping and separating of almonds genotypes and cultivars.

The main purpose of this study was the identification and analysis of morphological and pomological special characteristics of almond germplasm in Karaj region almond collection to reach to the promising genotypes with special features of performance, pomolgical and phenological, for almond breeding programs.

Materials and Methods

This study was performed during 2 growth session (2010 & 2011) In Meshkindasht region at south of Alborz province. The desired region is between the geographical coordinates with 35.7521^{0} N Latitude and 50.9535^{0} E Longitude with temperate climate (cold winters and hot summers).

The average annual rainfall was between 300-400 mm and average temperature was 7.4°C, -20 °C minimum and 38°C maximum temperatures. The relative humidity of air varied between 60 to 85%. The almond superior genotypes and cultivars were planted in 2006.

The identification, comparison and genotype selection for further studies were performed based on the morphological traits by using almond descriptor (Gulcan, 1985). The important traits studied with physical and chemical parameters would include the following items:

Fruit appearance (skin and kernel color)

Each genotype was classified into the following groups according to almond descriptor and based on the kind of fruit colors:

A) Skin color: 1= cream, 2= Bright orange, 3= Green to White, 4= White, 5= Dark Orange;

B) Kernel color (based on the color intensity and kind of color): 1= Bright yellow, 2= Brown yellow, 3=Yellow, 4= Brown

Information on the fruit taste was registered based on the test panel of five horticultural experts.

The fruit shapes were divided into the following groups based on descriptor (Gulcan, 1985):

1= Round shape, 2= Oval shape, 3=Narrow shape, 4=wide shape

Fruit Weight (FW) and Kernel Weight (PW)

Measurements on the fruit were performed immediately after fruit harvest. Fruit weight divided into the following groups:

1: Very small 2: Small 3: Medium 4: Big 5: Very Big

Also measurements based on the pit weight, divided them into following groups:

1: Very small (PW<0.9 grams) 2: Small (Between 0.9-1.8 grams) 3: Medium (Between 1.8-2.7 grams) 4: Big (Between 2.7-3.6 grams) 5: Very Big (PW>3.6 grams)

Yield (Y)

The fruit yield was measured for each tree alone.

Flowering date

This index was calculated at the end of the winter and early spring for each genotype and cultivar. On this basis, genotypes and cultivars were grouped by flowering date (Table 1).

Table 1. Indices for full flowering, during 2010 to 2011

Code	Description
1	Extremely Early
2	Early
3	Intermediate
4	Late
5	Extremely Late

Harvest date

Number of days from full balloon stage until fruit ripening was calculated and registered based on the individual genotypes. Fruit was harvested when the 90 percent of fruits had splitting hulls. Thus, genotypes and cultivars were grouped as Table 2.

Table 2. Classification of studied genotypes based on harvest date

Code	Description
1	Extremely Early
2	Early
3	Intermediate
4	Late
5	Extremely Late

Generally, in this experiment 62 Almond's genotypes and cultivars were evaluated for the 72 traits and characteristics of almond trees, leaves, kernels and shells. All of traits measurements were performed during 2010 and 2011 at Meshkin - Dasht Horticulture Research Station of Seed and Plant Improvement Institute (SPII) in Alborz province of Iran.

Analysis of data

All data analysis was performed by SPSS 20 software. The data analysis included analysis of variance and means comparison for all traits. Also the descriptive statistics, simple correlation between traits, factor analysis and cluster was performed by using this software. Data rotation method and maximum variance method was used for data separation. Cluster analysis and grouping the varieties and genotypes using Ward's Method or minimum variance based on the Euclidean distance was used as a criterion for standard interval.

Results

Results from study of the cultivars and genotypes indicate differences among the cultivars and genotypes. In this study the different data was evaluated and for this reason, in Table 3 has been shown the all stated traits with its descriptions. Also numerical averages and some important measured traits are shown in Table 4. The traits in which had with high variation, have a wider range of quantitative traits, and this wider range has provided more choice for the trait.

Discussion

Among the varieties and genotypes, significant differences revealed in terms of studied traits. Based on the means comparison the properties of some cultivars and genotypes are as follows: The minimum number of buds on the tree was for genotypes "3_12" and the maximum number of buds was for "14_24"The minimum length of nut shell in "Boty" cultivar and the maximum length were seen in"D_99" cultivar. "Price" cultivar had the minimum width and Marcona had the maximum nut shell width. Cultivars "D_99"and "Marcona" had the minimum and maximum nut shell thickness respectively. The minimum kernel length in cultivar "2_22" and the maximum of it was seen on "D_99" cultivar. The maximum kernel weight was for "D_99" and the

Minimum of kernel weight was for "SH _15". The minimum kernel hardness was for genotype "D_124" and the maximum of kernel hardness were for genotypes, "16 _30" and "3_17".In terms of flowering time, cultivars "Sepid" , "Rabie" and "Mamaie"were the most early flowering and genotypes "D_5" and "D_11"was the most late flowering genotypes. Also the maximum and minimum weight for almonds buds was seen in cultivars "Perlis" and "Sh _10". The maximum bud length in genotype "D_8" and the minimum value was seen in genotype "10_8" (Table 4).

Correlation coefficients between traits

For quantitative and qualitative traits, Spearman's correlation was used. One of the reasons for the existence of correlation between traits can be settle of traits controller genes on one chromosome. (Mirzaei Nadoshan, 1990)

The result between quantitative traits indicate that, was seen between number of buds and nut weight; lamina length and weight.; kernel weight and green fruit thickness; dried length and kernel weight; kernel weight and dried fruits with and thickness; dried fruit thickness and kernel thickness; green fruit weight and kernel length; green fruit length and its weight; green fruit length and kernel length; bearing sign and bearing type; trees blood aphids pest contamination and kernel hardness; kernel main color and kernel color intensity; extra edge in shell and Anther color and softness of shell and softness of kernel there was a positive and significant correlation r=+0.33; r=+0.33; r=+10.6; r=+0.41; r=+0.58; r=+0.37; r=+0.26; r=+0.72; r=+0.40; r=+0.44; r=+0.33; r=+0.50; r= -0.34; r= -0.33 respectively

Table 3. Some of the registered characters of studied traits in 62 almonds cultivar evaluation (Gulcan,1985)

No.	Traits	Symbol	No.	Traits	Symbol
1	Number of Buds	Code1	23	Number of Bud Scales	CODE23
2	Bearing Type	Code2	24	Number of Bud Layers	CODE24
3	Bearing Rate	Code3	25	Bud Scale Color	CODE25
4	Bud Shape	Code4	26	Bud Scale Shape	CODE26
5	Bud Color	Code5	27	Bud fuzz Distribution Location	CODE27
6	Bud Growth Stage	Code6	28	Bud fuzz Density Location	CODE28
7	Tree Kirk Cover	Code7	29	Ovary Color	CODE29
8	Tree Bearing Density	Code8	30	Anther Color	CODE30
9	Tree Blood Aphid	Code9	31	Flower Size	CODE31
10	Tree Habit	Code10	32	Number of Stamens	CODE32
11	Lamina Length	CODE11	33	Genonecium Length	CODE33
12	Lamina Width	CODE12	34	Petal Shape	CODE34
13	Leaf Tail Length	CODE13	35	Flower Buds Density	CODE35
14	Length to Width Ratio (Lamina)	CODE14	36	Bearing distribution in canopy	CODE36
15	Number of Gland in Leaf	CODE15	37	Flower Bud Shape	CODE37
16	Margin Shape	CODE16	38	Flower Color	CODE38
17	Stipule Existence	CODE17	39	Cuts in Petal	CODE39
18	Folding In Leaf	CODE18	40	Leaf Emergence Stage	CODE40
19	Leaf Color	CODE19	41	Flowering Date	CODE41
20	Bud Length	CODE20	42	Flower Stage	CODE42
21	Bud Width	CODE21	43	Green Fruit Length	CODE43
22	Bud Weight	CODE22	44	Green Fruit Width	CODE44

Continue of table 3

45	Green Fruit Thickness	CODE45	59	Shell Hardness	CODE59
46	Green Fruit Weight	CODE46	60	Sture Opening of the Shell	CODE60
47	Green Fruit Shape	CODE47	61	Nut Extra Edge	CODE61
48	Green Fruit fuzz Cover	CODE48	62	Double Kernel Percentage	CODE62
49	Nut Length	CODE49	63	Kernel Length	CODE63
50	Nut Width	CODE50	64	Kernel Width	CODE64
51	Nut Thickness	CODE51	65	Kernel Thickness	CODE65
52	Nut Weight	CODE52	66	Kernel Weight	CODE66
53	Precocity of Bearing	CODE53	67	Kernel Weight to total weight Percentage	CODE67
54	Nut Shape	CODE54	68	Kernel Shape	CODE68
55	Nut Tip Shape	CODE55	69	Kernel Color	CODE69
56	Shell Thickness	CODE56	70	Kernel Color Density	CODE70
57	Making of Outer Shell	CODE57	71	Kernel Hardness	CODE71
58	Shell Retention	CODE58	72	Kernel Taste	CODE72

Table 4. The Minimum, Maximum, Means and Coefficient of Variation of some most important Traits in 62 almonds cultivar evaluation

Tree Habit	Kernel Length (mm)	Kernel Width (mm)	Kernel Thickness (mm)	Kernel Weight (gr)	Nut Length(mm)	Nut Width (mm)	Nut Thickness (mm)	Nut Weight (gr)	Nut Shape	Kernel Percentage	Full Flower Date
3	26.37	13.12	6.99	1.58	37.61	24.55	16.14	4.35	2	36.32	8
4	21.75	12.02	6.85	1.28	31.04	22.2	13.87	3.58	3	41.15	6
4	24.48	13	10.25	1.52	32.27	22.08	17.83	3.4	4	44.7	7
4	25.11	13.15	6.7	1.05	36.95	23.13	13.76	2.85	2	36.84	7
4	26.77	14.58	5.93	1.17	37.2	22.64	15.17	5.01	6	23.35	5
2	21.54	9.94	7.13	0.78	27.99	16.86	13.01	1.85	2	42.16	6
3	25.04	15.51	7.89	1.34	35.5	28.09	15.31	5.99	2	22.37	9
2	16.09	11.22	8.7	0.76	19.32	16.44	13.04	2.21	4	34.38	7
2	21.09	10.79	6.53	0.71	29.5	19.12	13.96	2.53	4	28.06	5
4	24.65	11.32	6.78	0.88	33.63	19.58	12.57	1.52	2	57.89	5
4	25.17	11.78	11.9	1.5	37.32	22.46	16.64	4.33	4	34.64	6
1	22.64	11.46	6.28	0.79	32.95	19.01	12.37	1.46	2	54.1	5
4	21.33	13.96	7.93	1.06	29.4	22.64	12.98	1.86	2	56.98	3

Continue of table 4

16-30	4	24.99	13.12	6.53	1.12	35.12	22.64	15.89	4.62	5	24.24	6
10-8	4	18.27	10.88	7.47	1.1	38.22	18.54	13.22	3.31	5	33.23	6
Marcona	3	23.24	16.87	6.81	1.33	33.97	27.39	17.76	6.47	1	20.55	4
Supernova	2	27.88	15.4	7.16	1.37	38.49	24.59	15.52	4.69	4	29.21	7
D-101	4	19.36	9.34	6.24	0.52	27.23	15.13	11.6	1	2	52	8
Rabi	2	26.9	13.92	9.93	1.46	36.9	22.48	16.61	3.96	3	36.86	4
3-12	4	20.39	9.71	6.69	0.62	28.95	14.49	9.62	1.04	4	59.61	8
Sh-6	4	25.21	12.91	7	1.03	30.5	21.29	13.26	2.54	2	40.55	6
13-40	4	25.45	10.17	7.05	0.82	32.43	18.7	12.64	2.81	2	29.18	7
Sh-8	4	23.99	16.43	7.5	1.39	35.44	23.24	14.59	4.68	1	29.7	8
Sh-15	4	21.45	9.25	6.43	0.73	28.81	14.49	12.62	1.19	2	61.34	5
Carmel	4	29.27	9.86	7.05	0.99	38.13	16.57	12.94	1.86	5	53.22	3
3-17	4	27.61	12.32	11.23	1.84	42.33	20.17	15.89	4.24	5	43.39	8
2-22	4	26.67	14.68	10.56	1.50	33.08	23.64	16.23	3.00	1	50.00	3
10-11	4	28.44	12.92	6.95	1.09	38.39	21.64	13.17	2.43	2	44.85	7
Azar	4	25.85	13.06	7.8	1.22	31.93	21.91	15.77	2.99	2	40.8	6
1-25	4	25.6	13.86	8.83	1.43	31.05	21.34	16.19	2.91	2	49.14	5
8-6	4	22.5	11.78	7.08	0.93	32.24	21.79	15.69	2.85	2	32.63	8
9-7	4	20.28	11.04	6.58	0.67	26.4	17.74	10.7	1.02	2	65.68	6
Flipceo	4	26.45	15.13	11.67	1.88	34.06	23.08	18.39	5.29	2	35.53	7
6-5	3	22.7	14.11	7.66	1.22	32.19	22.74	15.45	2.88	1	40.00	3
D-11	4	22.23	10.08	7.4	1.91	30.48	16.94	11.01	5.2	2	36.73	9
P2	4	25.21	13.25	6.72	1.04	36.85	23.23	13.16	2.80	2	36.80	5
F3	3	25.23	10.28	7.19	0.81	32.23	18.87	12.87	2.81	2	29.10	6
12-24	3	25.41	12.61	6.86	0.98	33.31	22.6	14.28	3.67	4	26.7	7
4-6	3	29.29	14.09	9.21	1.48	42.64	24.36	16.76	5.66	2	26.14	5
D-5	2	21.56	10.59	6.6	0.68	28.84	18.51	12.68	1.25	2	54.4	9
Sahand	2	22.69	14.44	6.88	1.1	34.56	22.64	15.05	4.13	5	26.63	8
8-9	2	21.01	11.32	8.53	1.09	30.23	19.51	14.82	4.28	2	25.46	8
4-14	4	24.82	13.38	6.99	1.08	33.22	22.22	13.64	2.17	2	49.76	5
9-24	4	23.22	11.8	6.22	0.75	32.69	21.62	12.83	3.86	5	19.94	8
Falsa	3	24.9	14.63	8.63	1.48	32.27	22.44	15.51	4.3	4	34.41	7
8-24	3	23.16	16.2	7.31	1.24	31.37	27.26	15.52	3.84	2	32.29	5
Nep Plus Ultra	3	28.25	10.82	6.19	0.99	37.72	19.58	14.01	2.38	6	41.59	5
16-23	3	26.21	11.91	6.69	0.99	34.41	19.82	13.56	2.37	4	41.77	7
2-27	3	18.31	9.4	7.76	0.69	23.44	16.71	12.81	1.48	2	46.62	6
Boty	3	25.13	10.27	7.15	0.81	32.33	18.67	12.84	2.80	2	29.10	7
9-2	3	25.37	12.49	6.37	0.94	34.27	22.51	15.76	3.2	1	29.37	7
D-99	3	28.92	9.41	6.56	0.85	45.18	17.84	13.81	2.15	2	39.53	7
D-8	3	27.9	1.48	7.14	1.02	34.94	20.61	14.02	2.36	2	43.22	5
Mission	3	23.44	11.24	8.52	1.1	30.3	19.77	14.3	2.54	4	43.3	5
Roby	3	23.06	11.25	6.18	0.78	29.74	17.3	12.76	1.69	4	46.15	7
Genco	3	20.08	12.94	7.51	0.88	28.65	20.91	15.86	3.23	1	27.24	7
D124	3	23.34	12.6	7.05	1.01	34.22	14.06	13.93	3.9	4	28.2	7
3-16	4	24.33	12.71	8.13	1.27	37.34	19.95	13.09	3.16	2	40.18	6
Shokufeh	4	22.76	11.79	7.8	0.97	28.74	20.02	12.22	1.53	2	63.39	8
3-19	4	27.25	11.48	5.93	0.9	37.27	20.23	13.73	3.78	5	23.8	8
A200	4	25.41	11.47	6.91	0.69	28.75	18.31	12.57	2.23	3	30.94	7
Mamaee	4	25	10.4	6.42	1.15	35.15	19.18	13.12	3.42	3	33.62	4
Min.	1	16.09	1.48	5.93	0.52	19.32	14.06	9.62	0.86	1	19.94	3
Max.	4	29.29	16.87	11.9	1.91	45.18	28.09	18.39	6.47	6	65.68	9
Mean	3.34	23.89	11.96	7.54	1.08	32.86	20.42	14.06	3.06	2.89	40.62	6.26

Factor Analysis

Factor Analysis primarily used for data reduction or structure detection. The purpose of data reduction, eliminated the additional variance (with high correlation) of obtained data; and the purpose of structure detection was examining the hidden relationships among the variables. Due to the lot number of obtained data from morphological studies, it's not possible for easy conclusions using Analysis of variance or one variable. Factor Analysis was used as a method to reduce number of data in order to reveal the relationships between two or more variables and justify the total changes of main and primary data by the limited number of new independent and orthogonal variables, called main component data reduction was done by linear converting of main data to new independent variables. So that, the first component (component 1) justified the maximum amount of raw data changes and the next components descript the remaining changes after the component 1. Because, each component was independent from the others and every component indicated the different properties of main data, should be interpreted independently (Lansari *et al.*, 1994).

The result of Factor Analysis is indicated in Table 5. The results of Factor analysis for 72 traits, were included of 24 main components, among of these component, component 1, 2 and 3 were most important to justify the variance.

Table 5. The result of factor analysis. Total variance explained including initial eigenvalues, extraction sums of squared loadings, cumulative percentage and percentage of variance

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	5.697	7.913	7.913	5.697	7.913	7.913
2	5.277	7.329	15.242	5.277	7.329	15.242
3	4.241	5.891	21.133	4.241	5.891	21.133
4	3.626	5.036	26.169	3.626	5.036	26.169
5	3.430	4.764	30.933	3.430	4.764	30.933
6	3.135	4.354	35.287	3.135	4.354	35.287
7	2.916	4.050	39.337	2.916	4.050	39.337
8	2.655	3.688	43.025	2.655	3.688	43.025
9	2.577	3.579	46.604	2.577	3.579	46.604
10	2.444	3.394	49.998	2.444	3.394	49.998
11	2.214	3.075	53.073	2.214	3.075	53.073
12	2.165	3.007	56.080	2.165	3.007	56.080
13	1.990	2.764	58.844	1.990	2.764	58.844
14	1.977	2.746	61.590	1.977	2.746	61.590
15	1.870	2.597	64.188	1.870	2.597	64.188
16	1.841	2.557	66.745	1.841	2.557	66.745
17	1.783	2.476	69.221	1.783	2.476	69.221
18	1.545	2.145	71.366	1.545	2.145	71.366
19	1.533	2.129	73.495	1.533	2.129	73.495
20	1.391	1.932	75.427	1.391	1.932	75.427
21	1.254	1.741	77.169	1.254	1.741	77.169
22	1.143	1.588	78.757	1.143	1.588	78.757
23	1.118	1.552	80.309	1.118	1.552	80.309
24	1.086	1.509	81.818	1.086	1.509	81.818
25	1.044	1.450	83.268	1.044	1.450	83.268

The relative value of variance for each component explained the importance of that component in total variance of all studied traits. In this case study in Factor Analysis, total of 25 main and independent components, could justify 83 percent of total variance. Some of traits just like, Bearing Rate, and Tree Bearing Density were grouped in component 1.

Component 2 included the following traits: Flower Buds Density, Flowering Date, Green Fruit Length, Green Fruit Width, Nut Length, Nut Width, Nut Weight, Kernel Length, Kernel Width, and Kernel Weight.

These traits grouped in component

3: Lamina Length, Margin Shape, Number of Bud Layers and Shell Retention.

Also other traits grouped in these following components

Component 4: Bud Length, Bud Width, Bud Weight, Number of Bud Scales, Flower Size, Green Fruit Shape, Nut Shape and Kernel Color.

Component 5: Nut Thickness, Shell Thickness, Shell Hardness, and Kernel Color Density.

Component 6: Cuts in Petal, Sture Opening of the Shell and double Kernel Percentage.

Component 7: Lamina Width, Bud Scale Shape, Green Fruit Thickness, Green Fruit Weight and Kernel Shape.

Component 8: Number of Buds, Bearing Rate, Tree Habit, Leaf Tail Length and Length to Width Ratio (Lamina).

Component 9: Precocity of Bearing and Kernel Taste.

Component 10: Bearing Type, Stipule Existence and Flower Bud Shape.

Component11: Bud Scale Color, Genonecium Length and Leaf Emergence Stage.
Component 12: Tree Blood Aphid, Petal Shape, Making of Outer Shell and Kernel Weight to total weight Percentage.
Component13: None
Component 14: Flower Color.
Component 15: None
Component 16: Number of Gland in Leaf and Kernel Thickness.
Component17: None.
Component 18: Folding In Leaf, Anther Color and Nut Tip Shape.
Component 19: Kernel Hardness.
Component 20: sture opening of the shell.
Component 21: None
Component 22: None
Component 23: Leaf Color
Component 24: Number of Stamens
Component 25: None

Cluster Analysis

Identifying groups of individuals or objects that are similar to each other but different from individuals in other groups can be intellectually satisfying, profitable, or sometimes both. Cluster analysis was done based on the all measured traits, by using Wards' method. In general, the traits, divided in to the 2 main groups at 25 Euclidean distance, and the notable factors in this cluster separation was included some traits like kernel shape, flowering time, kernel weight, bud Shape, bearing rate and nut shape with reducing the scale of distance (squared Euclidean) the genotypes and cultivar were divided into 9 major groups (Fig. 1).

Group 1: At this group some cultivars like: "Carmel", "4_6", "Azar", "3_17" , "8_9", and "8_24"placed based on the same characteristics such as kernel narrow shape, kernel light brown color, kernel sweet taste, ovate nut shape, round nut tip shape, existence of extra edge in nut, leaf emergence stage and intermediate date of flowering.

Group 2: Cultivars "Sh _6" and "Shokufeh"placed in similar grouped based on the, bud ovate shape, tree intermediate / high bearing density, lamina length, shorter leaf tail and late of flowering.

Group 3: Based on the more kernel hardness and intermediate data of flowering, cultivars "Sh_10", "Perlis", "Supernova", "Ruby", "Touno", "10_11" and "4_4", placed in this group.

Group 4: Cultivars like, "D_101", "D_5", "12_24", "4_12", "16_ 30"and "D_11"based on the similar traits like, low number of flower buds placed in group 4.

Group 5: Cultivars "A230", "Sahand", "Sh_8", "16_ 25", "Marcona", "Rabi", "4_14" and "FlipCeo" based on the similar traits like more kernel relative weight and very high bearing rate.

Group 6: Consists genotype "8_6", "9_24" and "FalsaBarese" cultivar based on the bud cream color and high relative bearing rate.

Group 7: Cultivars/genotype", "14_24", "Genco", "7_24", "Sh_16", "Sh_7", "13_40", "D_124", "A200", "2_27", "Boty" and "Price" based on the similar traits like high number of flower buds. Extremely hard softness of shell and relative high relative bearing rate placed in this group.

Group 8: Cultivars/gynotype "8_39", "Mamaee", "Ne Plus Ultra", "16_ 10", "3_4", "3_16" and "9_7" based on these similar traits: inter mediate data of flowering, spread tree growth habit and intermediate twin kernel percentage.

Group 9: Cultivars/genotype "Nonpareil", "1_25", "Sh _15" and "2_22" placed in the last group based on these similar traits, inter mediate data of flowering, shell softness and harvest date.

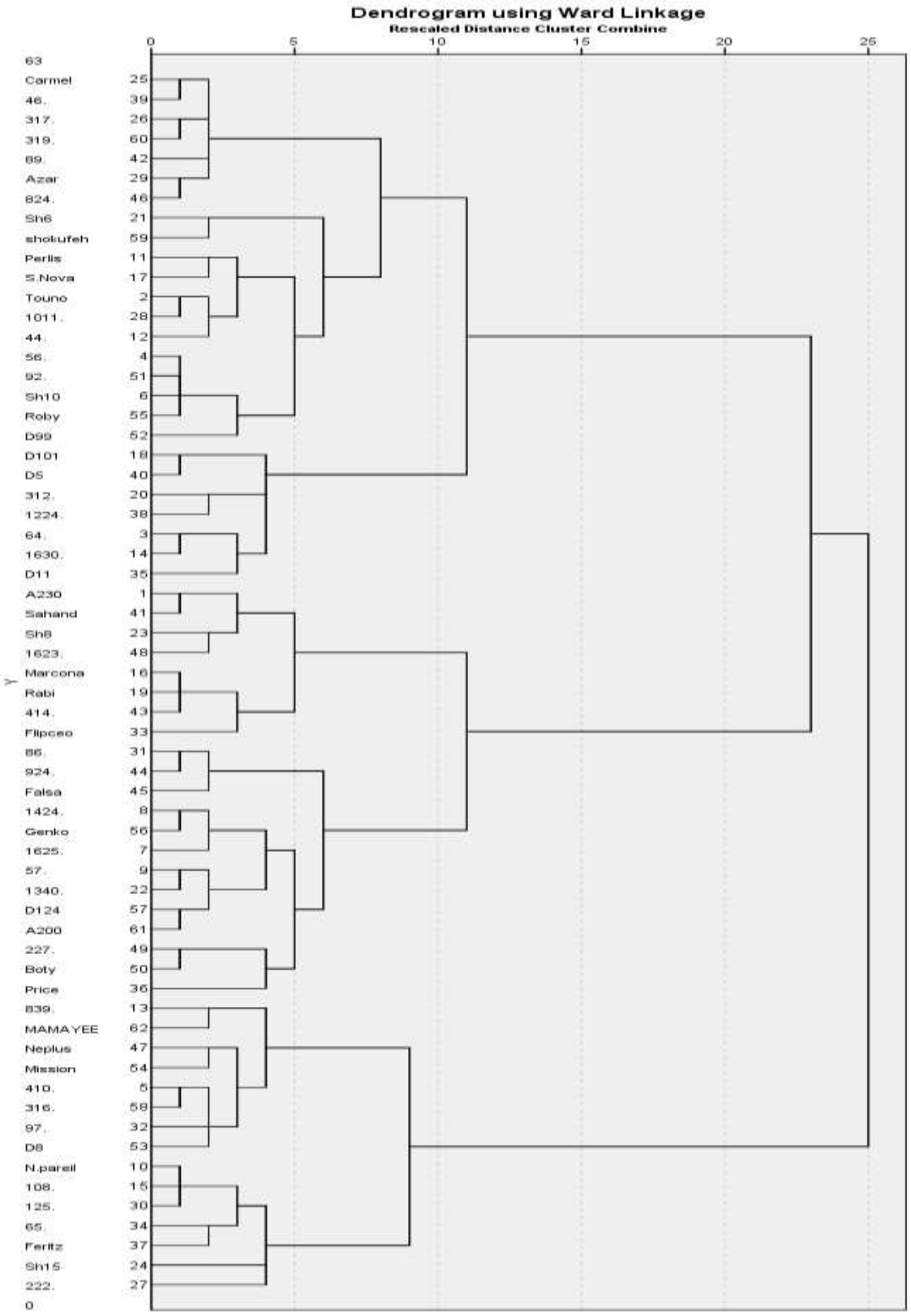

Fig.1. The dendrogram of 62 almond cultivars and genotype, using ward linkage

Plot Analysis

Plot Analysis can provide the 2-D or 3-D picture of the traits distribution and each demination consists of the major discriminator major component. So the distribution of genotypes and cultivars and the range of these major components can help to better determination of cultivars and genotypes distance and differences between them.

Di- Plot Analysis

At this study the Di- plot was done with using of just components 1 and 2. These components justify of 15.24 percent of total variance (Fig. 2).

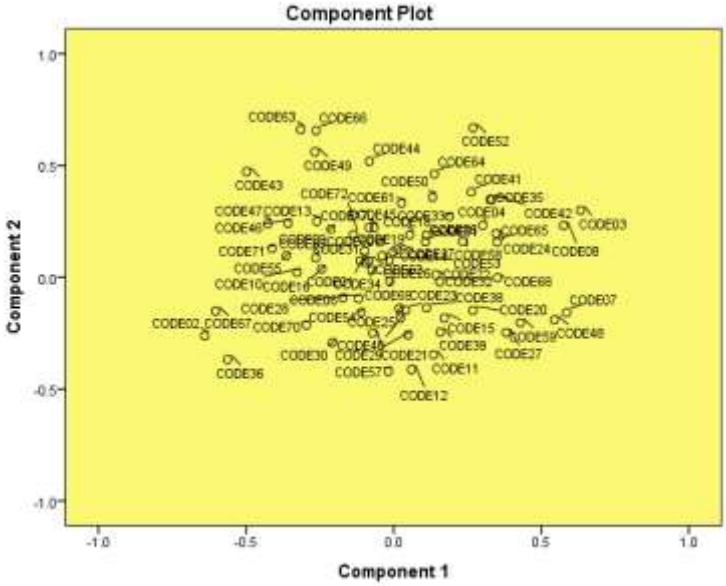

Fig. 2 .The Di-Plot analysis (2-D Picture). Distribution of studied traits in 62 almonds cultivar and genotyp evaluation, based on the effective traits in Component1=%7.91 and Component2=%7.32

This method was used to show the 2-dimensional pictures of studied traits based on the components 1 and 2 and accumulation of traits in a region of plot shows the genetic similarity of studied traits. So, based on the Di-plot analysis, traits that are together in a close range, shows the more similarities based on the component 1 and component 2 and placed in one group.

For example the traits like Bud Scale Color, Flower Color and Leaf Emergence Stage (CODES 25, 38 and 40) show more similarities based on the major components and placed together.

Kernel Length (CODE 63) and Kernel Weight (CODE 66) traits placed at the upper and positive side of components 2(O to+1.0) and negative side of components 1 (0 to -0.5) and the Making of Outer Shell (CODE 57) at the lowest and negative side of components 1 and 2. (0 to -0.5) and this one indicates that these traits have many differences with each other based on the major components in constitution of traits.

Tri- Plot Analysis

Also Tri- Plot Analysis was performed with using three components (Fig.3). These three components justify of 21.13 percentage of total variance.

The traits distribution based on the Tri-Plot analysis indicate that the Kernel Weight to total weight Percentage trait (CODE 67) placed at the positive section of component 3 and the components 1 (-0.6) and 2 (-0.1) placed at the negative section and indicate that, to constitution of Kernel Weight to total weight Percentage trait.

Kernel weight trait (CODE 66) based on the component 1 was placed at the negative section (0 to - 0.5) and also based on the components 2 (+0.6) and component 3(+0.05) placed at the positive sections of these components, and indicate that the components 2 is most effective for kernel weight trait.

Kernel length (CODE 63) placed at the positive section (0 to + 0.1) based on the components 2 and 3 but component 1 placed at the negative section (0 to -0.5) and because the value of component 2 (+0.661), higher than component 3(+0.262), the component 2 is much more effective for kernel weight trait.

Kernel length (CODE 63) placed at the positive section (0 to + 0.1) based on the components 2 and 3 but component 1 placed at the negative section (0 to -0.5) and because the value of component 2 (+0.661), higher than component 3(+0.262), the component 2 is much more effective.

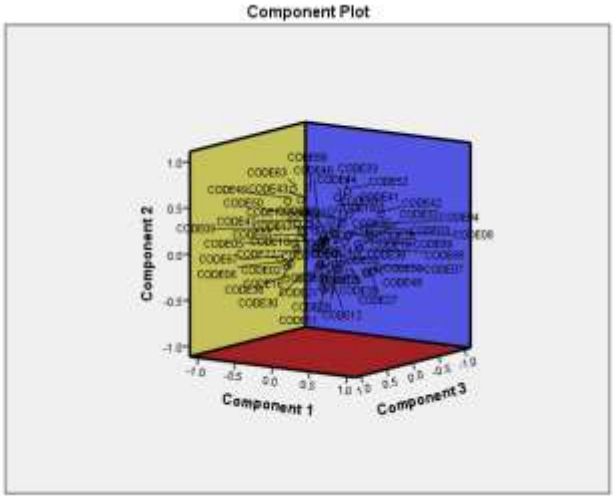

Fig. 3. The Ti-Plot analysis (3-D Picture). Distribution of studied traits in 62 almonds cultivar and genotypes evaluation, based on the effective traits in Component1=%7.91 and Component2=%7.32 and Component3=%5 (The complete name of traits is given in Table 3)

The traits such as kernel width and kernel weight (CODES 64, and 66) placed at the positive section of components 2 and 3, but because the value of component 2 (+0.461, +0.656) was higher than the component 3 (+0.180, +0.055) and component 1(+0.138, -0.263) component 2 was much more effective.

Conclusion

In this study, morphological and pomological characteristics of 60 cultivar and superior genotypes from Iran and European Union and USA were evaluated. Results of morphopomilogical traits indicated that tree habit growth, buds, leaf, flowers and fruit attributes were from a high diversity among studied cultivar and superior genotypes. Also time of flowering among almond genotypes and cultivars varied widely and as early flowering, middle flowering and late. Performances of almond genotypes and cultivars based on their quantity and quality characteristics were different. Similar results have been repored by. Karl *et al*.(1998), Lansari *et al.* (1994) , Talhouk (2000), De Giorgio & Polidnano (2001), Fatahi *et al.*, (2004), Sarkhosh (2006), De Giorgio *et al.*, (2007), Asma *et al*. (2007), and Chalak *et al*., (2007), in order to grouping and separating of almonds genotypes and cultivars.

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