MORPHOLOGICAL VARIATIONS IN APRICOT (*PRUNUS ARMENIACA*) CULTIVARS GROWN IN GILGIT BALTISTAN PAKISTAN

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ABSTRACT:- Apricot (*Prunus armeniaca* L) belongs to the family Rosacea, genus Prunus L and the section Armeniaca (Lam). Twelve local apricot cultivars (Marghulam, Shakarfo, Shakanda, Charmagzi, Shai Pawand, Nili Pawand, Halman, Habi, Ali Shah Kakas, Astore 1, Narie and Skardu Local) were evaluated for morphological UPOV (International Union for the Protection of New Varieties of Plants) and the International Board for Plant Genetic Resources (IBPGR) characteristics. Three cultivars (Charmagzi, Shai Pawand and Narie) had fruit weight from 39-41 g. Most of the cultivars had small fruit with sweet and large size kernel. Habi and Astore 1 had latest harvest in late June. Nili Pawand, Shai Pawand and Skardu Local were determined to late blossom as compared to others. The cultivars Marghulam, Shakarfo, Charmagzi, Nili Pawand, Habi and Astore1 have firm type of fruit. A statistical tool Principal Component Analysis was used. The eigenvalue was able to represent 84.8% of total variance. Leaf size and leaf blade shape were highly correlated (r = 0.383). Positive correlation found in shape of fruit, weight and percentage of moisture (r = 0.336 and 0.272). Significant correlation was found between fruit weight, percentage of moisture (r = 0.681) shape of stone (r = 0.067). The result of this study may be useful for identification and morphological variations of apricot in Pakistan.

Key Words: Apricot, Gilgit Baltistan, Morphology, Prunus armeniaca.

INTRODUCTION

The apricot *Prunus armeniaca* L. is one of the most cultivated stone fruit in the world (Hurtado et al., 2002; Vilanova et al., 2003; Ercisli, 2009). There were four different species and one naturally occurring interspecific hybrid came under the general term of apricot. These were: *Prunus armeniaca* L., the cultivated apricot; *Prunus sibirica* L., the Siberian apricot; *Prunus mandshurica*, the Mandshurica apricot; *Prunus mume*, the Japanese apricot and Prunus X dasycarpa Ehrh, the black or purple apricot. Among them, *P. armeniaca* is the most widely cultivated (Mehlenbacher et al. 1990; Ercisli 2004; Altindag et al. 2006; Uzun et al., 2007; Yilmaz et al. 2012). The Central Asian apricots is the oldest group with the rich genetic diversity (Mehlenbacher et al., 1990). Pakistan

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is among the top six apricot producing countries in the world with the production, 192,500 metric tons (FAO STAT, 2012). In Pakistan, apricot is cultivated in Khyber Pakhtunkhwa, Balochistan, Upper Punjab, Kashmir and major in Gilgit Baltistan (GB). Thompson (1988) reported that apricot was introduced in Gilgit Baltistan (GB) from central asian countries. Apricot is cultivated on 12,921 hectares and production is 114,286 tons (Department of Agriculture, Gilgit Baltistan). Apricot is at the apex amongst the dry fruits transported to down country that was 4,374.38 mt in 2014 (Department of Agriculture, Diamer). The apricot cultivars investigated in this study are being cultivated for hundreds of years in Gilgit Baltistan and used as fresh and dry fruit as well. Prior to this, no study have been reported concerning to this local group of apricot varieties on morphological and phenotypical traits. Therefore, precious genetic resources of apricot localizing in Gilgit Baltistan are needed to be characterized. Present research work was planned to characterize morphological diversity of genus *Prunus armeniaca* L**.** being a version area with great variability in phenotype and environment and these would be used as reference varieties.

MATERIALS AND METHOD

Plant Material

This study was carried out with12 apricot cultivars (Marghulam, Shakarfo, Shakanda, Charmagzi, Shai Pawand, Nili Pawand, Halman, Habi, Ali Shah Kakas, Astore 1, Narie and Skardu Local). These cultivars were collected from different districts of Gilgit Baltistan during in the year 2005 for the purpose of genetic resource maintenance at Mountain Agriculture Research Centre (MARC) Jaglot, Gilgit. The trees were seven years old and received the same training and pruning practices.

Three vigorous plants of the same age of the each cultivar were selected during the year 2012 and 2013 at the time of flowering, fruit setting and fruit maturity. Main germplasm collection and characterization were performed by describing phenological, pomological, and morphological characteristics. Therefore, for each cultivar a short description in the form of passport data was taken according to points/features with the help of descriptor list for apricot (Leaf Size, leaf blade shape, season of flowering, fruit color, fruit shape, weight of fruit, harvest maturity, uniformity in ripening of fruit, firmness of fruit, percentage of moisture, taste of seed, separation of stone, shape of stone) developed by international board for plant genetic resources IBPGR Secretariat, Rome (1984) and UPOV, 2007 in this study.

Leaf Size (LS)

Five fully developed leaves from tagged plant of each cultivar were selected in 3rd and 4th week of June on one year old shoot from middle part, detached with petiole by pruning shear and packed in moist saw dust to retain freshness and moisture. These were shifted to Oil Seed Research Institute (OSRI) laboratory, NARC. The leaf area was calculated using Delta-T Devices limited, Cambridge, UK. The mean values of five samples were calculated in cm^2

and cultivars were grouped as 1 (extremely small 1-10 cm^2), 3 (small 11-20 cm^2), 5 (medium 21-30 cm^2), 7 (large 31-40 cm^2), 9 (extremely large 41-50 cm^2). All the data were recorded according to IBPGR features genotype identity points.

Leaf Blade Shape (LBS)

According to UPOV, 2007 guidelines leaf blade shape of five leaf samples from tagged plants of each cultivar was recorded as 1 (acute), 2 (right angled), 3 (moderately obtuse), 4 (strongly obtuse).

Season of Flowering (SF)

Apricot plants were weekly visited for a complete month of March in 2012 and 2013. The full flowering date was noted of each cultivar till the end of flowering season. The results were matched with IBPGR 1984 descriptor list according to blooming period of genotypes. On the basis of mean values of flowering dates the cultivars were further divided in five group as 1 (Extremely early), 2 (Very early) 3 Early),4(Early/intermediate), 5 (Intermediate) 6(Intermediate/late), 7 (Late) 8 (Very late), 9 (Extremely late).

Fruit Color (FC)

Five fruits from tagged plant of each cultivar were collected by hand in plastic trays from well exposed branches to sun light and at the time when they got maximum size, time of eating ripeness and changing of color of fruit. The color of fruit was recorded according to the chart of Horticulture Society of London, 2001, (4^{th} edn) and cultivars were separated in seven groups on the basis of their skin ground color which were differentiated visually and given the genotype identity point, 1 (Green-yellowish), 2 (Light cream), 3 (Cream), 4 (Yellow), 5 (Light orange), 6 (Orange) and 7 (Dark orange).

Fruit Shape (FS)

The data were recorded in two consecutive years. Five fruit sample of each cultivar were observed visually according to fruit shape frontal view descriptor list (IBPGR 84). The fruits were classified according to genotype identity points as 1 (Round), 2 (Round/flat), 3 (Elliptic), 4 (Ovate), 5 (Triangular) and 6 (Oblong).

Weight of Fruit (WF)

Fully matured five fruits were collected from the mid of branches on sunny side. The fruit weight was in grams using electric bench scale (range of measurement 1.00 – 500 g) new Mughal scale work Pakistan. The average of five fruit `s weight was determined of each sample group and the cultivars were classified according to IBPGR, 1984 where fruit weight was categorized as 1 (Extremely small < 20 g), 2 (Very small 20-30 g), 3 (Small 31-40 g), 4 (Small/medium 41-45 g), 5 (Medium 46-55 g), 6 (Medium/large 56-60 g), 7 (Large 61-70 g), 8 (Very large 71-85 g) and 9 (Extremely large > 85 g).

Harvest Maturity (HM)

The tagged plants of each cultivar were visually observed during fruit maturity season. Five fruits were selected per genotype keeping in view the time of eating ripeness, when the fruit is most easily removed. The data was recorded on five days intervals during the fruiting season and the harvest dates were noted. The

cultivars were classified for determining maturity by IBPGR, 1984, apricot descriptor list where rating for cultivars as Early (3), Early/ mid-season (4), Mid season (5), Mid season/ late (6) and Late (7).

Uniformity of Ripening of Fruit (URF)

The data pertaining to ripening of fruits at once and the short intervals during the fruiting season was recorded based on the visual observations and were grouped according to IBPGR, 1984 descriptor list as 1 (Not uniform) and 2 (Uniform).

Firmness of Fruit (FF)

Five fruits sample of each cultivar were harvested carefully. The color of fruit, taste and size was kept in mind and readings were recorded in points of firmness tester scale (1-10 in kg/ cm^2). The genotypes were classified by IBPGR, 1984 descriptor list and given the genotype identity point as 3 (Soft), 5 (Medium) and 7 (Firm) and 9 (Extremely firm).

Percentage of Fruit Moisture (PoM)

Fifteen fruits without seed were used from each cultivar. The weight of fresh fruits was measured first and then fruits were opened into two halves and placed in oven. The fruit samples were heated at 60 °C for 24 hours and shifted to horticulture laboratory for weighing. The differences amongst the fresh and dry fruit weight were noted with weighing scale and percentage of fruit moisture was calculated.

$$\text{Percentage of fruit Moisture} = \frac{\text{Dry fruit weight}}{\text{Fresh fruit weight}} \times 100$$

Cultivars were classified on the basis of fruit moisture percentage according to IBPGR, 1984 descriptor list and given the genotype identity point as 3 (Dry 1-7 %), 5 (Intermediate 8-15 %) and 7 (16-22 % Juicy).

Taste of Seed (TS)

Five seeds from the fruits which were used for moisture study were taken from each cultivar to check taste orally. The cultivars were grouped by IBPGR, 1984 and given the genotype identity point as 1 (Sweet) and 2 (Weak bitterness).

Separation of Stone (SE S)

Five fruits were collected in fruiting season from tagged plants of each cultivar. The attachment of seeds to flesh was visually observed by splitting the fruit in two halves manually and cultivars were classified by IBPGR, 1984 and given the genotype identity point as 3 (Clinging), 5 (Semi clinging) and 7 (Free).

Shape of Stone (SH S)

The five stones sample of each cultivar were visually observed. The shape of stones (lateral view) were fixed according to IBPGR, 1984 and given the genotype identity point as 1 (Round), 2 (Ovate), 3 (Oblong), 4 (Elliptic) and 5 (Elongated).

Statistical Analysis

To designate the individualities of local germplasm, a statistical tool principal component analysis (PCA) was used to study the percent variations in data set and establish relationship among the cultivars. PCA helps in determining com-ponents that account for distinction in a reduced data set resultant from a

large number of variables in the data (Hilling and Lezzoni 1988; Perez Gonzales 1992; Badenes et al., 1998; Asma and Ozturk, 2005 and Yilmaz et al., 2012).

RESULTS AND DISCUSSION

Description of Apricot Cultivars

Leaf size

The apricot cultivars exhibited quantitative diversity in foliar dimensions and differences in leaf size were found among them. Large (7) size leaf was recorded in Charmagzi, Shai Pawand and Narie (36.8 - 40.0 cm^2) followed by Marghulam, Shakarfo Shakanda, Nili Pawand, Habi, Halman, Astore1 and Skardu local had a medium (5) leaf size (20.4 - 26.6 cm^2) while Ali Shah Kakas had extremely small (1) leaf size (10.0 cm^2). In the current study it was recorded that large size leaf plants produced large size fruits and vice versa. Charmagzi, Shai Pawand and Narie had small/medium size fruit and Ali Shah Kakas due to extreme small leaf size have a fruit weight 7.7 g. Leaf is very important part of plant which serves as source of food to the plant and plays a vital role in plant growth and fruit develop-ment. In previous studies significant diversity in leaves and flowers of rosaceous fruits were reported. Environmental as well as genetic factors are responsible for the diversity and growth of plant species. Leaf area and their specific mass were found highly correlated with light intensity received. Garriz et al., 1998 reported significant difference in leaf area having 18.31 cm^2 in shade and 21.98 cm^2 in light. In the present research work, this diversity might be partly due to variations in local environment such as sunlight, soil conditions, climate, topography, rainfall, and direction of fruit plants and other salient features of the area. The leaf size may be considered as indicator for cultivar identification, our findings are supported by Perez-Gonzalez (1992), he found that apricot fruit weight correlated with growth habit, and both bud and leaf size (Table 1).

Table 1. Qualitative and Quantitative description of apricot cultivars.

Varieties	LS	LBS	SF	FC	FS	WF	HM	URF	FF	PM	TS	SES	SHS
Marghulam	5	3	5	1	2	30.27	5	2	7	7	1	7	2
Shakarfo	5	2	5	3	1	20.02	5	2	7	5	1	7	3
Shakanda	5	4	4	4	1	26.25	4	2	5	5	1	7	2
Charmagzi	7	2	5	2	2	39.40	3	2	7	7	1	7	1
Shai Pawand	7	4	7	2	1	41.71	4	2	3	7	1	5	1
Nili Pawand	5	4	7	2	1	33.45	5	1	3	5	1	7	2
Halman	5	3	4	4	3	26.25	5	1	5	3	1	7	3
Habi	5	4	5	2	1	27.56	6	1	7	3	1	7	1
Ali Shah Kakas	1	4	6	3	1	7.17	5	2	3	3	1	7	1
Astore 1	5	4	6	3	4	23.30	6	1	7	3	1	7	1
Narie	7	4	6	2	1	39.97	5	2	5	5	1	5	3

Leaf blade shape (angle of apex)

There was a variation in leaf blade shape of cultivars. Shakanda, Shai Pawand, Nili Pawand, Habi, Ali Shah Kakas, Astore1, Narie and Skardu Local were identified as strongly obtuse (4). Marghulam and Halman belonged to moderately obtuse group (3), while Shakarfo and Charmagzi were right angled (2), leaves prepare food for plants, the sizes of leaves and shapes are very important vegetative organs responsible for development of the plants. To absorb sufficient sun light energy, the size of leaves must be large and wide as possible which assist the important gases exchange process (CO_2, O_2), it is suggested that leaves must be smooth and thin as possible. However, it was observed that if leaves are large with thin surface, desiccation will be occur due to high temperature. Thus, leaf size and thickness were dependent on water availability. The plants showed elasticity in the leaf shape either because of environmental conditions such as sunlight, temperature and shade, Genard and Bruchou (1992). Variation in leaf blade shape might be due to genetic makeup of cultivar (Table 1).

Season of flowering

Blossom period of targeted cultivars in Jaglot, Gilgit is generally from early March to mid-late of March. The cultivars Nili Pawand, Shai Pawand and Skardu Local exhibited late flowering dates (7) as compared with others. Ali Shah Kakas, Astore 1 and Narie were bloomed in Intermediate/ late in March (6). Marghulam, Shakarfo, Charmagzi and Habi were bloomed in mid of March (5). Shakanda and Halman bloomed in Early/inter-mediate period (4). Results of this research work are in good agreement with the findings of Asma and Ozturk (2005). They observed full blossom of 128 apricot germplasm between early March and early April. This difference in flowering periods of the germplasm under the same climatic conditions attributed to the fluctuations in total exposure temperature required during flowering season. Late flowering of cultivars is important character to protect flowers from damages of early spring frost under the same climatic condotion (Guleryuz 1988; Unal et al. 1999). In Gilgit Baltistan the flowering time may be lengthy or shortened by cold spell in the region. There was a great difference shown by different cultivars in their flowering response. The cultivars blossomed before mid of March were exposed to the risk of spring frost damage but the late season flowering cultivars (Nili Pawand, Shai Pawand and Skardu Local) were found under the minimum spring frost damages to flowers (Table 1).

Fruit Color (ground color of skin)

The apricot fruit color plays an important role for distinguishing two cultivars or group of cultivars. The quality and maturity of fruits are dependent on fruit color of genotype, each cultivar exhibited specific color at maturity stage. A large variation was found in fruit color of different cultivar. The skin ground color of Skardu local apricot cultivars were orange (6). The fruit color of Shakanda and Halman cultivars was found yellow (4). Shakarfo, Ali Shah Kakas, Astore1 had cream color fruit (3). The fruit color of Charmagzi, Nili Pawand, Shai Pawand, Habi and

Narie was light cream (2). Marghulam had green-yellowish shades till ripening on fruit (1). To study the fruit character, color is an important parameter and it has direct correlation with the environmental conditions in the area. On the other hand interaction between environment and genotypes, growth and development of plant canopy, leaves and location of the fruit also effect the color of fruits. Mostly fruit colors are same as Irano-Cacuasian apricot group studied by Asma and Ozturk, (2005) proved the travel route of apricot from Central Asia to these countries having similitaries in fruit color (Table 1).

Fruit Shape

Fruit shapes of apricot cultivars were different from each other. The cultivar Astore1 had ovate type fruit (4). Elliptic type fruit shape was recorded in Halman (3), Charmagzi and Marghulam fruits were round/flate shape (2). Round fruit shape rating 1 was recorded in seven apricot (Shakarfo, Shakanda, Shai Pawand, Nili Pawand, Habi, Ali Shah Kakas, Narie and Skardu local) Thompson et al., (1988) in a study found that cross pollination might be responsible to cause variability in morphological traits, especially in fruit shapes. The results of present study are closely related to fruit shapes of Irano Caucasian apricots group studied by (Asma and Ozturk; 2005, Yilmaz. et al., 2012). Table 1.

Fruit Weight (g)

The native cultivars exhibited diversity in weight of fruit. The small/medium size fruit (41.71 g) was determined belongs to native cultivar Shai Pawand (4), followed by Narie, Charmagzi and Nili Pawand (3) with small fruit (39.97, 39.40 and 33.45 g respectively). Seven apricot types Marghulam, Shakarfo, Shakanda Halman, Habi Astore1 and Skardu local had $\leq$ 30 g of fruits very small (2). An important character of Ali Sha Kakas cultivar was that fruit dried on branch and not dropped until harvesting used for dry purpose had fruit weight 7.17 g extremely small (1). This shows that native cultivars of Gilgit Baltistan are composed of low fruit weight. Fruit size is considered important trait to select the superior genotypes in apricot (Westwood and Blaney, 1963). The space between plants to plant of same genus as well as other species can also affect the weight of fruit and size due to competition for sun light, water and nutrition uptake and also increases chances of diseases and insects attack. Low radiation and stress condition by water in plants decreases the supply of nutrients (cabohydrates) available for fruit enlargement and resulted in small size and weight of fruit. (Caspari et al., 1994; Behboudian et al., 1994). Large size of fruit might be the genetic character of a cultivar to consume the available nutrients competently to attain a certain fruit size (Stanley et al., 2000). The fruit plants with heavy crop load commonly resulted in small fruit size. High cropping load resulted in small fruit size and vice versa thus thining of fruit in initial stage may favor large sized fruits (Lotze and Bergh, 2004). These results are in strong agreement with the findings of Asma and Ozturk (2005). In which they studied the Irano-Caucasian group apricot having small weight fruit cultivars. The fruit weight of 49

cultivars was determined below ≤ 30g. In a study on genotypes from Kargil (Sofi et al., 2001) found Positive correlations between kernel and stone weight, fruit diameter, fruit cheek, length, and fruit weight in apricot (Table1).

Harvest Maturity

Each cultivar have different signs for harvesting in fruiting season, like apricot fruit got optimum size, the ground color becomes yellow or yellow orange or cream on the tree, it is ready for harvesting. In the local market, fruit appears in early June when harvesting starts and lasts till late August. In the present study, ripening dates were noted in each cultivar based on size of fruit, changes in color from green to light cream, yellow, orange, cream, firmness of fruit. Table 1. shows harvest maturity of different cultivars. Habi and Astore1 had latest harvest in last week of June (6) are important cultivars for late ripening fruits followed by cultivar Mar-ghulam, Shakarfo, Nili Pawand, Halman, Ali Shah Kakas and Narie were harvested on mid -June (5). Shakanda and Shai Pawand were harvested on early mid –June (4). The early harvest was made for Charm-agzi and Skardu local on 1st week of June (3). Some of Irano-Cacausian also harvested in mid-June, studied by Asma and Ozturk (2005). In the cultivars studied, fruit maturity and ripening was attributed to genetic makeup as well as local environ-mental conditions. Thus native genotypes fruits matured at different times under same climatic condition (Erez and Flore, 1986). The fruit plants grown on southern site and exposed direct to sunlight, fruit matured in early season as compared to those plants located on north direction and shady places (Marini et al., 1991; Genard and Bruchou, 1992).

Uniformity Ripening of Fruit

Uniformity ripening of fruit plays an important role in commercial production of apricot. As shown in Table 1, eight apricot cultivars (Marghulam, Shakarfo, Shakanda, Charmagzi, Shai Pawand, Ali Shah Kakas, Narie and Skardu local) fell in uniform ripening of fruit (2). However Nili Pawand, Halman, Habi and Astore1 were not uniform in ripening (1). This may be due to genetic make-up of cultivars. Selection of scion wood and rootstock for development of cultivars are important factors affect the composition of raw fruit, shipment and response to fruit processing. Prevailing temperature, sunlight, growth habit might be have strong impact on uniformity of ripening of fruit. Intensity of sunlight considerably affects the concentration of vitamins and temperature stimuli the transpiration rate, which results in the nutrient uptake and physiology of plants. (Marini et al., 1991).

Firmness of Fruit

Firmness of fruit is an important trait for transportation of fresh fruit to market. Firm and mature apricot fruit fetch good market values results in more income to apricot growers. Most of apricot germplasm studied were firm type fruit. This included Marghulam, Shakarfo, Charmagzi, Nili Pawand, Habi and Astore1 (7). Medium type fruit readings were recorded in Shakanda, Halman, Skardu Local and Narie (5), while

Shai Pawand and Ali Shah Kakas had soft type fruit (3). Bourne (1979) classified the temperate fruits into two groups on the basis of their keeping quality with respect to texture. The soft melting texture fruits have a relatively short shelf life than those with moderately soft and firm fruits. Adding to this, many factors like type of fruits, harvesting stage, micro climate and genetic makeup also have impact on firmness and perishability of temperate fruits.

In various studies it was concluded that fruit size is negatively correlated to firmness. In apple, straw berry and blue berry (Blanpied et al., 1978; Ourecky and Bourne, 1968; Ballinger et al., 1973), it was observed that small fruit are firmer than large fruit. This might be due to factor that fruit size is dependent on both size and cell number. Texture of fruits relied directly on genetic factors in fruits and controlling the fruit texture. Our findings are in good agreement with Yilmaz et al., (2012) they described the average firmness of mostly Turkish apricot fruit ranged between 1.00 to 5.99 kg/cm^2.

Percentage of Moisture

Apricot cultivars were different from each other regarding percentage of fruit moisture showed in Table 1. The apricot cultivars consumed as fresh Marghulam, Charmagzi and Shai Pawand had maximum percentage of moisture (7). The cultivars Shakarfo, Shakanda, Nili Pawand and Narie were intermediate type (5). Halman, Habi, Ali Shah Kakas and Astore1 were dry type fruit (3) as they consumed as dry apricot in winter season Values ranged between 5% and 20% which was also recorded in previous research work done on apricot (David Ruiz and Jose Egea 2008; Witherspoon and Jackson 1996; Witherspoon 1999). Cultivar Shai Pawand showed the highest percentage of moisture (20.4%), while the lowest value (5.5%) occurred for Ali Sha Kakas. Most of the apricot genotype showed values higher than 15 %, which is a good trait for drying apricot. These values are closer to the results of David Ruiz and Jose Egea (2008) on Spanish apricot cultivars. Moisture content has a good impact on dried apricot. Adding to this, color of dried apricot were correlated with moisture content, as the light and yellow color values increased with moisture percentage, whereas the red color values decreased at all moisture levels in apricot (Ozkan et al., 2003).

Taste of Kernel

Fresh apricots contained the seeds found inside the pits (stones) named kernels. Worldwide apricot kernels were classified into main two groups, bitter and sweet. Apricot with bitter kernels taste comprised naturally compound called amygdalin, results in cyanide when eaten by humans. Small amounts of cyanide are reclaimed by the human body but high amounts can be toxic. Instead, apricot with sweet kernels and the fruit have positive effects on health because they contained low levels of amygdalin.

In the target group of cultivars kernels taste of all native cultivars were sweet as presented in Table 1, which is of great economic value used for direct consumption and confectioneries. Large kernel size is desirable for apricot growers. Our findings are close to research work carried by

Asma and Ozturk (2005) in which they found kernel taste of 86 apricot cultivars located in Malatya belonging to Irano-Cacausian apricot group were sweet.

Separation of Stone

Data on separation of stone from flesh is shown in Table 1. Most of the cultivars had free stone in the flesh when opened in halves (7). Shai Pawand and Narie had semi clinging properties (5). Free stone from flesh characteristic of germplasm studied is an important factor in apricot drying. Easily separation of stone from flesh result in less physically damages to fruit texture. There is need of commercialization of such cultivars to compete in the international apricot dry fruit market. Akpinar et al., (2010) studied 25 Turkish and 4 exotic cultivars of apricot. They found 15 cultivars had free pit character.

Shape of Stone

There was large variation in shape of stone. Shakarfo, Halman and Narie had oblong type stone (3). Ovate shapes of stone were found in Marghulam, Shakanda and Nili Pawand (2). The round type stones were found in Charmagzi, Shai Pawand, Habi, Ali Shah Kakas, Astore1 and Skardu Local (1). There is no literature available regarding apricot shape of stone of these cultivars. But the different cultivars showed great diversity regarding apricot seed. This variation easily to observe by glass magnifier, however it is not easy to describe exactly shape in a quantitative way. For this purpose international standard (UPOV 2007, IPGRI 1984) is based on morphological comparison with important cultivars, the results are given in genotype identity point. This information can be used for differentiating two sample sets. Sofi et al., 2001 reported that stone weight, fruit weight and stone diameter showed the greatest positive association with fruit weight in germplasm from Kargil area Jammu and Kashmir, India. The selection of this parameter for evaluation of local cultivars stone shape was the first study under the international standers of native cultivars of GB.

Correlation among Variables

There were significant correlation in phenological variables (Table 2) such as leaf size and leaf blade shape were highly correlated (r = 0.383) this implies that leaf size and leaf blade shape is variable that depends on cultivar. A positive correlation was found between leaf size, season of flowering, weight of fruit, uniform ripening of fruit, flesh juiciness r = 0.404, 0.833, 0.297, 0.594 respectively. The cultivars with large size of leaf were determined to have large size of fruit and juiciness. The results showed that the cultivars with large size leaves may have large size of fruit in apricot.

In this study there was positive correlation between season of flowering and weight of fruit (r = 0.336) and negative correlation found between season of flowering and harvest maturity (r = -0.408). It is may be due to effect of micro climatic condition on apricot in the specific area. Badenes et al. (1998) found correlation between bud break and blossom season (r = 0.87) and also a correlation in between bud break and harvest

season (r = 0.79). The apricot cultivars in their study were from European ecogeographical group.

Fruit color was also correlate with weight of fruit, harvest maturity, and highly with firmness of fruit (r = 0.580) fruit color can play an important role in harvest maturity and juiciness of fruit, harvesting of fruit depends on fruit color. A high correlation found in shape of fruit, firmness of fruit and separation of stone (r = 0.277 and 0.316). It may be due to genetic makeup of cultivars. A high significant correlation was found between fruit weight, flesh juiciness, (r = 0.681) shape of stone (r = 0.067). This might be due to fruits with larger in size would also have larger stone and also higher flesh juiciness. Harvest maturity have a significant correlation with firmness of fruit and separation of stone (r = 0.277) and (r = 0.079) respectively. There was significant correlation between firmness of fruit and separation of stone (r = 5.00). It entails that firm fruit have free separation of stone. It may be due

Table 2. Correlation matrix among variables studied.

	LS	LBS	SF	FC	FS	WF	HM	URF	FF	PFM	SES	SHS
LS	L	-	-	-	-	-	-	-	-	-	-	-
LBS	0.383 0.219	-	-	-	-	-	-	-	-	-	-	-
SF	0.404 0.192	0.225 0.481		-	-	-	-	-	-	-	-	-
FC	-0.113 0.727	0.151 0.639	-0.052 0.873	-	-	-	-	-	-	-	-	-
FS	0.000 1.000	-0.230 0.472	-0.204 0.525	-0.174 0.589	-	-	-	-	-	-	-	-
WF	0.833 0.001	0.011 0.972	0.336 0.285	0.115 0.723	-0.090 0.782	-	-	-	-	-	-	-
HM	-0.594 0.042	-0.506 0.093	0.408 0.188	0.300 0.343	0.156 0.628	0.333 0.290	-	-	-	-	-	-
URF	0.297 0.348	0.368 0.239	0.000 1.000	-0.253 0.428	0.438 0.155	0.064 0.843	-0.625 0.030	-	-	-	-	-
FF	-0.000 1.000	0.116 0.719	0.258 0.418	0.580 0.048	0.277 0.384	0.136 0.674	0.277 0.384	-0.395 0.203	-	-	-	-
PM	0.594 0.042	0.000 1.000	0.272 0.392	-0.063 0.84	0.125 0.699	0.681 0.015	0.625 0.030	0.500 0.098	0.000 1.000	-	-	-

LS: Leaf Size
LBS: Leaf Blade Shape
SF: Season of Flowering
FC: Fruit Colour
FS: Fruit Shape
WF: Weight of Fruit
HM: Harvest Maturity
URF: Uniformity in Ripening of Fruit
FF: Firmness of Fruit
PoM: Percentage of Fruit Moisture
TS: Taste of Seed;
SES: Separation of Stone
SHS: Shape of Stone.

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TS: Taste of Seed
SE S: Separation of Stone
SH S: Shape of Stone
Note; Taste of seed remained constant in correlation matrix because all the cultivars have had sweet kernel taste.

to genetic makeup of cultivars. There was a negative correlation between flesh juiciness and separation of stone (r = - 0.316) and positive relation with shape of stone (r = 0.142).

Principal Component Analysis

The five (5) components which had eigenvalues equal to or of greater than 1 were retained as meaningful and worthy of interpretation (Table 3).

These five components accounted for 84.8% of the total variation in the data set. The principal component analysis indicated that the first component analysis (PC1) had an eigenvalue of 3.89 and explains 32.5% of the total variation in the data set (Table 3), this suggests that PC1 represents mainly leaf size, harvest maturity and flesh juiciness account for 32.5% of the variance. The second component (PC2) had eigenvalue of 1.96 and accounting for 48.9% of the total variation; the value suggest that PC2 represents the equivalent of three individual variables which are fruit color and firmness of fruit. Principal components 3 to 5 had more than 1 eigenvalue, thus they represent equivalent of two or more variables each and accounted for 63.7%, 74.3%, 84.8%, respectively of the total variation in data set.

Table 3. Eigen values and proportion of total variability among apricot genotypes explained by the first 05 principal components.

PC	Eigenvalue	percent var	Cumulative
1	3.89	32.5	32.5
2	1.96	16.4	48.9
3	1.78	14.9	63.7
4	1.27	10.6	74.3
5	1.25	10.5	84.8

In (Table 4): PC1 represents the variables reflecting phenological characters and some pomological variables in apricot. Leaf size with larger blade shape produces more chlorophyll and absorbs more sunlight results in better shape of fruit, weight, and flesh juiciness. PC^2 could be reflecting fruit color, uniformity ripening of fruit and shape of stone. PC^3 represents the weight of fruit and shape of stone. PC^4; season of flowering, fruit color, weight of fruit, harvest maturity and shape of stone. The fifth principal component showed that fruit color, fruit shape and harvest maturity.

CONCLUSION

The native apricot cultivars in Gilgit Baltistan were evaluated for morphological variation and it was concluded that

- Three apricot cultivars Charmagzi, Shai Pawand and Narie produced small/medium size fruits.
- Habi and Astore1 ripened late as compared to other cultivars under same climatic condition.
- The cultivars Nili Pawand, Shai Pawand, Astore1 and Skardu Local were determined to late blossom, escaped from spring frost.
- The cultivars Marghulam, Shakarfo, Charmagzi, Nili Pawand, Habi and Astore1 have firm type of fruit suitable for fresh apricot marketing.
- Kernel taste of all cultivars under study was sweet.

Principal component analysis successfully used to study variations in the morphological data formed five

Table 4. Correlation between original variables and the first five PC

Variable	Pc^1	Pc^2	Pc^3	Pc^4	Pc^5
Leaf Size(LS)	0.424*	-0.240	0.147	0.016	-0.155
Leaf Blade Shape(LBS)	0.185	-0.212	-0.506	-0.177	0.046
Season of Flowering(SF)	0.268	-0.099	-0.134	0.505*	0.122
Fruit Color(FC)	-0.120	-0.528*	-0.122	0.102*	0.461*
Fruit Shape(FS)	-0.175	-0.151	0.183	-0.024	0.727*
Weight of Fruit(WF)	0.354*	-0.317	0.383*	0.102*	0.052
Harvest Maturity(HM)	-0.399*	0.002	0.285	0.221	0.284*
Uniformity Rip.Fr.(URF)	0.323*	0.258*	-0.246	-0.381	0.172
Firmness of Fruit(FF)	-0.179	-0.571	0.119	-0.349	0.044
Percentage Fruit moisture	0.381*	-0.122	-0.203	-0.275	-0.041
Separation of Stone(SE S)	-0.320*	-0.179	-0.307	-0.326	-0.265
Shape of S tone(SH S)	-0.026	0.215*	0.468*	-0.441*	0.176

different components envisaged 84.8% variability. Present study indicated the morphological diversity in apricot cultivars grown in different districts of Gilgit Baltistan.

LITERATURE CITED

Asma, B.M., and K. Ozturk. 2005. Analysis of morphological, pomological and yield\char-acteristics of some apricot germplasm in Turkey. Genetic Resources and Crop Evolution. 52: 305–313.

Anonymous., 2011-12. Pakistan Bureau of Statistics, Ministry of National Food Security and Research, Islamabad.

Altindag, M., M. Şahin, A. Eşitken, S. Ercişli, M. Güleryüz. 2006. Biological control of brown rot (Moniliana laxa Ehr.) on apricot (Prunus armeniaca L. cv. Hacihaliloglu) by Bacillus, Burkholdria., and Pseudomonas application under in vitro and in vivo conditions. Biological Contol. 38: 369-372.

Ari N. 1999. Apricot Kernel Oil (Kayisi tohum yagi) Effective Compounds and its Used. Master of Science Thesis, Ankara Universitesi, Saghk Bilimleri Enstitusu, in Turkish.

Behboudian, M. H., G. S. Lawes, K. M. Griffiths. 1994. The influence of water deficit on water relations, photosynthesis and fruit growth in Asian pear (Pyrus serotina Rehd.). Scientia Horticulturae, 60: 89-99.

Badenes, M. L., J. Martine;z-Calvo, G. Llacer. 1998. Analysis of apricot germplasm from the European ecogeographical group, Euphytica. 102: 93-99.

Battcock, M., 1989. Report on apricot drying consultancy in Northern Areas-Pakistan. FAO.

Caspari, H.W., M.H. Behboudian, D. G. Chalmers. 1994. Water use, growth, and fruit yield of 'Housi'

Asian pears under deficit irrigation. Journal of the American Society for Horticultural Science. 119: 383-388.

Dussi, M. C., M. Huysamer. 1995. Severe postharvest summer pruning of mature 'Forelle' pear trees influences canopy light distribution and fruit and spur leaf characteristics in the following season. Journal of the African Society for Horticultural Science. 5: 57-60.

Erez, A., J.A. Flore. 1986. The quantitative effect of solar radiation on “Red heaven” peach fruit skin colour. Hort. Scie. 21: 1424-1426.

Ercisli, S. 2009. Apricot culture in Turkey. Scientific Research and Essays. 4: 715-719.

Ercisli, S. 2004. A short review of the fruit germplasm resources of Turkey. Genetic Research Crop Evaluation. 51: 419-435.

Guleryuz, M. 1988. A study on breeding by selection of wild apricots quality and resistance to spring frosts in Erzincan plain. Professor thesis, Ataturk University Faculty of Agriculture, Erzurum Turkey.

Goffreda, J. C. 1999. White-fleshed peach and apricot breeding. Proceedings of the 42nd Annual International Dwarf Fruit Tree Association Conference, 20–24 February 1999, Hamilton, Ontario, Canada. p. 4–6.

Genard, M., and C. Bruchou. 1992. Multivariate analysis of within three factors accounting for the variation of peach fruit quality. Scientia Horticulturae. 52: 37-51.

Garriz, P. I., G. M. Colavita, H.L. Alvarez. 1998. Fruit and spur leaf growth and quality as influenced by low irradiance levels in pear. Scientia Horticulturae. 77: 195-205.

Hurtado, M. A., C. Romero, G Abbot, G. Llacer, M.L. Badenes. 2002. Genetic linkage maps of two apricot cultivar (*prunus arminiaca* L.) and mapping of PPV (Sharka) resistence. Theor Appl Genet. 105: 182-191.

Jasra, A. W., M. A. Rafi. 2003. Cash crop farming in northern Pakistan; the importance of pollination diversity and managed pollination in apricots. A Report.

Jackson, J. E., A. B. Beakbane. 1970. Structure of leaves growing at different light intensities within mature apple trees. Annual Report of East Malling Research Station. p. 87-89.

Feng, J., W. WeiDong, W. HuaLei, X. Lin, Y. XianKe J. Yan. 2008. Evaluation for juicing adaptability of the leading apricot cultivars cultivated in Xinjiang. Journal-of-Fruit-Science. 25(5): 747-750.

Faust, M., D. Suranyi, F. Nyujto. 1998. Origion and dissemination of Apricot. In J.Janick, Horticulure review, Vol.22.John Wiley and sons Inc., New York. 225-266.

Faqir, M. A., A. Saeed and D. Maqam. 2004. Storage effect on physiochemical and sensory characteristics of dried apricot jam. Pakistan Journal of Food. Science. 14(1-2): 43-47.

Hilling, K. W., A. Lezzoni. 1988. Multi-variate analysis in a sour cherry germplasm collection. Journal of American Society of

Science.113: 928-934.

Hussain, K. S. 1994. A focus on the dynamic of apricot as an emerging commodity. AKRSP, A Report.13 p.

Lone., A. F., and B. A. Wafal. 2000. Va-rietal diversity in the germplasm of cherries under cultivation in Kashmir. In: Khan, M. A. and Farooq, S. (eds.). Environmental Biodiversity and Conservation, A. P. H. Publishing Corporation, New Delhi. p. 319-340.

Layne, R. E. C., C. H. Bailey, L. F. Hough. 1996. Apricots. In: J. Janick J. N. Moore . Fruit breeding: tree and tropical fruits, vol.1 John Wileyand and sons Inc., New York. p.79-111.

Lotze, E., and O. Bergh. 2004. Early prediction of harvest fruit size distribution of an apple and pear cultivar. Scientia Horticulturae, 101: 281-290.

Marini, R. P., D. Sowers, M.C. Marini. 1991. Peach fruit quality is affected by shade during final swell of fruit growth. Journal of the American Society for Horticultural Science. 116: 383-389.

Mehlenbacher, S.A., V. Cociu, L.F Hough, 1990. Apricots (*Prunus*). Acta Hort 290: 63-109.

Özkan, M., A. Kirca, B. Cemeroğlu, 2003. Effect of moisture content on CIE color values in dried apricots. European Food Research Technology, 216:217-219.

Parmer, C., and M.K. Kaushal, 1982. Wild fruits of Sub-Himalayan Region. Kalyani Publishers, New Delhi, India. 403 p.

Perez-Gonales, S. 1992. Association among morphological and phenological characters representing apricot germplasm in central Mexico. Journal of American Society Science. 117(3): 486-490.

Perez-Gonales, S., S. Montens, C. Majia. 1993. Analysis of peach germplasm in Maxico. Journal of American Society Science. 118 (4): 519-524.

Rehder, A. 1967. Manual of Cultivated Trees and Shrubs, 2nd edition. Macmillan, New York.

Ruiz, D. and J. Egea. 2008. Phenotypic diversity and relationships of fruit quality traits in apricot (*Prunus armeniaca* L.) germplasm. Euphytica. 163:143-158.

Stanley, C. J., D. S. Tustin, G.B. Lupton, S. McArthney, W.M. Cashmore, H.N. De Silva. 2000. Toward understanding the role of temperature in apple fruit growth responses in three geographical regions within New Zealand. Journal of Horticultural Science and Biotechnology. 5: 413-422.

Sultana, R. 1996. Some promising varieties of apricot in Skardu. AKRSP, Skardu.

Thompson, M. 1993. Exploration and exploitation of new fruit and nut germplasm. In: J. Janick and J.E. Simon (eds.), New crops. Wiley, New York. p. 155-160.

Thompson, M., D. Brenner, R. Anwer , Z. Ahmed, and S. Bhatti. 1988. Biogeographic survey and collection of temperate fruit and nut genetic resources in Northern Pakistan. 105 p.

Unal, M.S., M. Sahin, H. Olmez, B. Celik, B. M. Asma, M. Bas. 1999. The Breeding of Late Flowering and Resistance to Late Spring Frosts Apricots through Crossing (First Phase). Tagem /IY/96–06–02–014, Fruit Research

Institute, Malatya Turkey.
Uzun, A., O. Gülşen, Y. Aka-Kaçar, V. Aras, A. Demirel, M. Bircan, S. Paydaş, A. Yıldız. 2007. Characterization of new apricot cultivars by RAPD markers. J Appl Hort. 9: 132-135.
Vilanova, S., C. Romero, A.G. Abbot, G. Llacer, M.L. Badenes. 2003. An apricot (Prunus arminiaca L.) F2 progeny linkage based on SSR and AFLP markers, mapping PlumPoxVirus resistence and self incompitability Traits.Theor Appl Genet.107: 239-247.
Westwood, M. N., L. T. Blaney. 1963. Non-climatic factors affecting the shape of apple fruits. Nature. 200: 802-803.
Yilmaz, K.U., S. Paydas-Kargi, Y. Dogan and S. Kafkas. 2012. Genetic diversity analysis based on ISSR, RAPD and SSR among Turkish Apricot Germplasms in Iran Caucasian eco-geographical roup. Sci. Hort. 138. 138–143.
Vavilov, N.I. 1951. Phytogeographical basis of plant breeding. In: CHESTER, K. S. (trans): The origin, variation, immunity and breeding of cultivated plants Chronical Botany. 13: 13–54.
Zafar, I. 1992. Baltistan Apricot Marketing Association. Skardu (BAMA). AKRSP, Commercial and Industrial Development Division.

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