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Distinctiveness, uniformity and stability testing of apricot genotypes based on morphological traits

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ABSTRACT

Apricot is a stone fruit of the family Rosaceae (order Rosales), closely related to peaches, almonds, plums, and cherries. Apricots are cultivated throughout the temperate regions of the world. In the present study, 17 apricot genotypes were characterized for 32 morphological traits with respect to distinctiveness; uniformity and stability (DUS) test guidelines. The results displayed a high level of variability among all the genotypes. The fruit characteristics such as fruit size, shape, fruit volume, flesh and skin color which determines the quality and marketability of apricot exhibited huge variation. Moreover, the results displayed suggest that description of these varieties based on notes may be used as reference for protection of new varieties under PPV&FRA rules and can be used for comparison against new candidate varieties.

Key words: *Prunus armeniaca*, DUS guidelines, variability, genotypes.

INTRODUCTION

Apricot (*Prunus armeniaca* L.,), is one of the most important temperate fruit grown globally and Turkey, Italy, Greece, Spain, USA and France are the leading producers (Ercisli, 2009). In India, it is mainly grown in the temperate regions of Jammu and Kashmir, Himachal Pradesh and parts of Uttarakhand. In Jammu and Kashmir, it is widely spread over the whole Ladakh with abundance in district Kargil and lower belts of district Leh. As per economic survey report of Jammu and Kashmir (Anonymous, 1) area under the apricot in Jammu and Kashmir has increased to the tune of about 15%, from 2.95 lakh hectare (2007-2008) to 3.38 lakh hectare (2015-2016) and the production has increased from 16.36 Lakh metric tonnes (2007- 2008) to 24.94 Lakh metric tonnes (2015-2016).

Apricot fruits are rich in nutritional value and are good source of fibers, minerals (potassium, calcium, iron, magnesium, zinc, phosphorus and selenium) and vitamins such as vitamin A, vitamin C, thiamin, riboflavin, niacin and pantothenic acid. Apricots fresh as well as dried are rich sources of antioxidants and have been reported to overcome some of the degenerative diseases that affect humans (Hussain *et al*., 9). Moreover, apricots contain number of secondary metabolites such as polyphenols, carotenoids, fatty acids, volatiles and polysaccharides that have been shown to exert various biological activities like antimicrobial activity, antimutagenic activity, cardioprotective activity, hepatoprotective activity, anti-inflammatory, and antinociceptive activity (Bartolini *et al*., 2).

The great variability in apricot varieties assumes a greater significance under PPV&FR Act, 2001 for their protection on a set of relevant characteristics. In 2001, the Indian Government passed the Protection of Plant Varieties and Farmers' Rights (PPV & FR) Act. This provides for the registration of new varieties of agricultural plants if they conform to the criteria of distinctiveness, uniformity and stability (DUS). In 2013, India initiated the procedure with the Council of the International Union for the Protection of New Varieties of Plants (UPOV) in order to become a full member of the Union. The PPV&FR Act uses protocols similar to those for UPOV apricot, with relevant modifications in the morphological descriptors for apricot which is common in India.

Therore, the present study was undertaken to assess the level of uniformity of characteristics and stability of expression of those in different growing locations over the years. The aim of present study was to generate the data of reference varieties as per the DUS descriptor which will be useful for characterization (*Sui generis*) of candidate varieties and their protection through PPV&FRA.

MATERIALS AND METHODS

The present investigation was carried out to study morphological diversity of seventeen genotypes of apricot including 'Balcota', 'Harcot', 'Erani', 'New Castle', 'Turkey', 'Heartly', 'Chinese Apricot', 'Tilton', 'Tokpopa', 'Nimu', 'Australian', 'Nari', 'Rival'

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'Fairmedcester', 'Viva Gold', 'Afghani', 'Communis Holy' and 'Communis', at ICAR-Central Institute of Temperate Horticulture, Srinagar, Jammu & Kashmir, India. The study was carried in a randomized block design with three replications and spacing adopted was 3.0 m ×3.0 m. Thirty-two morphological characters were recorded as per the DUS guidelines recommended by PPV and FRA (2012) for apricot. Characters were classified in different groups and notes were assigned as shown below:

TH: Upright (3), Spreading (5), Drooping (7)
SOB: Obtuse (2), Truncate (3), Cordate (4)
AA: Right angled: 3, Moderately Obtuse (5), Strongly Obtuse (7)
TV: Weak (3), Medium (5), Strong (7)
LA: Extremely Small (1), Small (3), Medium (5), Large (7), Extremely Large (9)
IOM: Crennate (3) Serrate (5), Biserrate (7)
LBL: Short (3), Medium (5), Long (7)
LBLW: Small (3), Medium (5), Large (7)
AC: Weak (3), Medium (5), Strong (7)
FD: Small (3), Medium (5), Large (7)
FSW: Small (3), Medium (5), Large (7)
FW: Narrow (3), Medium (5), Broad (7)
FS: Round (1), Elliptic (3), Ovate (5), Oblong (7)
S: Shallow (3), Intermediate (5), Deep (7)
SA: Flat (3), Round (5), Pointed (7)
FF: Soft (3), Medium (5), Hard (7)
FJ: Less juicy (3), Intermediate (5), Juicy (7)
PL: Short (3), Medium (5), Long (7)
PGN: < 2 (3), 2-4 (5), > 4 (7)
DOB: Early (3), Mid season (5), Late (7)
HM: Early (3), Mid (5), Late (7)
FL: Short (3), Medium (5), Tall (7)
P:S: Small (3), Medium (5), Large (7)
CD: Shallow (3), Intermediate (5), Deep (7)
SAS: Asymmetrical (1), Symmetrical (5)
CS: Green Yellow (1), Yellow (3), Light orange (5), Orange (7), Blush (9)
SC: Brown (3), Creamy (5)
KT: Bitter (3), Sweet (5)
KW: Small (3), Medium (5), Large (7)
SW: Small (3), Medium (5), Large (7)
SS: Round (3), Ovate (5), Elliptic (7), Elongated (9)
SOS: Semi clinging (5), Free (7)

RESULTS AND DISCUSSION

There was considerable variation among 17 genotypes of apricot for all qualitative morphological characters related to vegetative and reproductive stages viz., growth habit, leaf, flower and fruit characteristics. Plant growth habit refers to the overall shape of a plant, and it describes a number of components *such* as stem length and development, branching pattern, and texture. In the present study, the upright growth habit was noted in two varieties, viz., 'Tokpopa Nimu' and 'Harcot'; while spreading growth habit was observed in other 15 genotypes. The leaf characters were also varied among different genotype at young and full grown (mature) leaves. Leaf blade shapes of base (obtuse, truncate and cordate) were recorded and 5 genotypes showed obtuse, 6 genotypes showed truncate and 6 showed cordate shape (Table 1). Leaf blade angle of apex were recorded; 'Tokpoapa Nimu', 'Afghani' and 'Viva Gold' were found right angled; 'Chinese Apricot', 'Rival', 'Communis', 'Turkey', 'Australian' and 'Nari' were found strongly obtuse and other 8 genotypes were having moderately obtuse leaf blade angle of apex. Incisions of margin for leaf blade (crenate, serrate and Biserrate) were recorded as per DUS guidelines recommended by PPV and FRA (2012). In genotypes, 'Afghani', 'Communis Holly', 'Tokpopa Nimu' and 'Viva Gold' showed crenate type of margin, Chinese Apricot and Heartly showed serrate margin whereas other 11 varieties showed biserrate margin.

Anthocyanins are vacuolar flavanoid pigment responsible for orange, red and blue colours in fruits, vegetables, flowers and other storage tissues in plants (Chandra *et al*., 5). These anthocyanins perform diverse biological functions, such as attracting pollinators and seed dispersers, conferring stress resistance, and prolonging fruit life span. Anthocyanins are reported with scavenger activity of free radical and contributors to antioxidant activity (Rapisarda *et al*., 15). One of the most conspicuous developmental changes observed in juvenile leaves as they mature is color change, with young leaves on new growth tips of many species first appearing red, purple, pink, or less commonly blue or white, and becoming greener with leaf age (Choinski *et al*., 6). Anthocyanin coloration of upper side in petiole varied in different apricot varieties ranging from weak to strong. Four apricot genotypes viz., 'Balcot'a', 'Afghani', 'Erani' and T'okpopa Nimu' showed weak coloration; whereas four genotypes viz., 'New Castle', 'Communis', 'Viva Gold' and 'Australian' showed medium coloration and remaining eight varieties showed strong coloration (Fig 1). Blooming time is a very important feature in prunus species may change from year to year, according to the weather conditions before and during bloom. Blooming time is considered as a quantitative trait and it is reported that transmission of blooming time is inherited quantitatively (Kester and Gradziel, 11). Blooming time varied in apricot varieties and only two varieties viz., 'New Castle' and 'Harcot' showed flowering in early season; 'Tokpopa Nimu' showed late season flowering whereas rest of the varieties showed mid season flowering.

The fruit maturity has been divided into two categories, viz. physiological maturity and harvest

Table 1. Characterization of apricot varieties based on DUS descriptor.

Character / Variety	Tree habit. (*) (+) (TH)	Tree Vigour (TV)	Leaf area (cm2) (LA)	Leaf blade: Length (cm) (LBL)	Leaf blade: ratio length/width (LBLW)	Leaf blade :shape of base (*) (+) (SOB)	Leaf blade: Angle of apex (excluding tip) (*+)(AA)	Leaf blade: incisions of margin (*) (+) (IOM)	Petiole: Length(cm) (PL)	Petiole: gland number (PGN)	Petiole: Anthocyanin coloration of upper side (AC)	Flowering: duration of blooming (days) (DOB)	Flower :diameter(mm) (FD)	Fruit: harvest maturity(days) (HM)	Fruit size: weight(g) (+) (FSW)	Fruit :length(mm) (FL)	Fruit :width(mm) (FW)	Fruit shape (*) (+) (FS)	Fruit :ratio weight of pulp/weight of stone (P:S)	Fruit :cavity depth(mm) (CD)	Fruit: suture (S)	Fruit: Symmetry along the suture (SAS)	Fruit: Shape of apex (*) (+) (SA)	Fruit :ground colour of skin (CS)	Fruit firmness of flesh (FF)	Fruit: flesh juiciness (FJ)	Stone: Weight (SW)	Stone :shape (*) (+) (SS)	Separation of stone (SOS)	Stone :colour (ST)	Kernal taste (KT)	Kernal: weight (KW)
Balcota	5	5	5	5	5	3	5	7	5	7	3	5	5	7	3	5	5	1	3	3	5	5	5	3	3	5	7	3	7	3	3	7
Harcot	3	5	5	5	5	2	5	7	5	5	7	3	5	7	7	7	5	3	5	3	5	5	3	3	5	5	5	7	7	3	3	5
Erani	5	5	5	5	5	3	5	7	5	7	3	5	5	5	5	5	7	1	3	7	5	5	5	3	5	3	5	3	5	3	3	7
New Castle	5	5	3	3	3	4	5	7	3	3	5	3	5	3	3	3	5	1	3	5	7	3	3	3	5	5	5	3	5	3	5	5
Turkey	5	7	5	5	5	3	7	7	3	7	7	5	5	3	3	5	5	1	3	3	7	5	5	3	3	7	3	3	7	3	5	5
Heartly	5	7	3	5	7	2	5	5	5	5	7	5	5	5	7	3	3	5	3	3	5	5	5	9	7	3	3	7	7	3	3	5
Chinese Apricot	5	5	9	7	5	4	7	5	7	7	7	5	5	7	5	5	7	3	3	5	7	5	5	7	5	7	5	7	7	3	3	7
Tilton	5	5	1	3	5	4	5	7	3	5	7	5	5	7	3	3	3	7	3	3	5	5	3	5	5	5	3	9	7	3	5	3
Tokpopa Nimu	3	7	7	5	7	3	3	3	5	3	3	7	5	7	5	5	5	1	5	5	5	5	5	1	5	5	5	5	7	3	3	7
Australian	5	5	5	5	3	3	7	7	7	5	5	5	7	7	3	5	5	1	3	5	5	5	5	1	3	5	5	3	7	3	3	7
Nari	5	5	9	5	7	3	7	7	5	5	7	5	5	7	3	5	5	1	3	5	5	5	5	7	5	7	3	3	7	3	5	5
Rival	5	7	3	3	3	4	7	7	3	5	7	5	5	7	3	5	5	7	3	5	3	5	5	7	5	7	3	7	5	3	5	7
Fairmedcester	5	7	3	3	3	4	5	7	5	5	7	5	7	7	5	3	3	1	3	3	5	5	7	9	7	5	3	5	7	3	5	5
Viva Gold	5	5	3	5	3	2	3	3	5	5	5	5	3	7	3	5	5	5	3	3	3	5	5	5	7	5	5	5	7	3	5	7
Afghani	5	5	3	5	3	2	3	3	5	7	3	5	5	7	3	3	3	1	5	5	7	5	5	1	5	5		7	7	3	3	5
Communis Holy	5	5	5	3	5	2	5	3	5	5	7	5	5	7	3	5	5	7	3	3	3	5	5	9	5	5	5	5	7	3	3	7
Communis	5	5	3	3	3	4	7	7	3	5	5	5	5	7	5	5	7	1	5	3	3	5	5	1	7	7	3	3	7	3	5	5

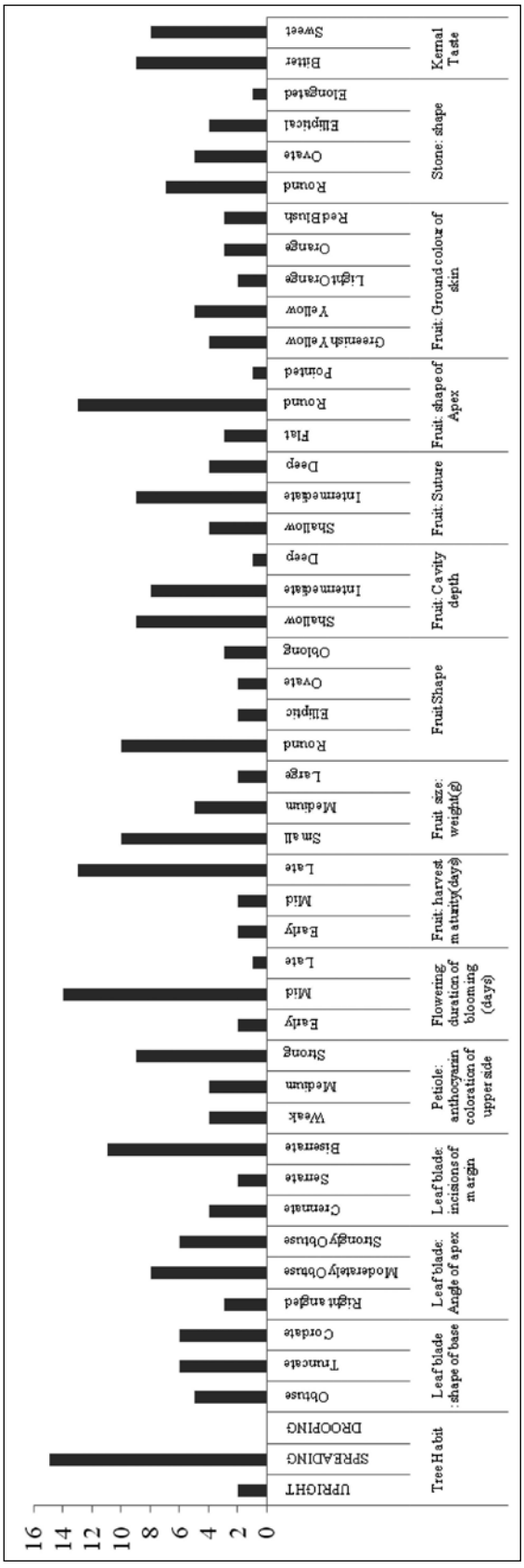

Fig. 1. Frequency distribution of 17 apricot varieties based on morphological characters.

maturity. Physiological maturity is the stage when a fruit is capable of further development or ripening when it is harvested, i.e. ready for eating or processing. Harvest maturity refers to the stage of development when plant and plant part possesses the prerequisites for use by consumers for a particular purpose, i.e. ready for harvest. Determination of maturity indices helps us to ensure sensory quality like flavor, colour, aroma and texture as well as nutritional quality to ensure an adequate shelf life (Pal and Babu 13). 'New Castle' and 'Turkey' were found to show early maturity with less than 100 days, 'Erani' and 'Heartly' showed mid harvesting usually ranging from 100-115 days whereas rest of the varieties showed late harvesting with more than 115 days.

Size of the fruits were observed and recorded as small, medium and large and the size of apricot genotypes varied from varieties to varieties. Large size fruit was observed in 'Harcot' and 'Heartly' whereas smaller fruit size was reported in 'New Castle', 'Viva Gold', 'Afghani', 'Communis Holly', 'Australian', 'Balcota', 'Nari', 'Turkey', 'Tilton' and 'Rival'. Fruit shape was observed and tabulated as round, elliptical, ovate and oblong and the most dominant fruit shape was rounded – in 10 varieties, followed by oblong (3 varieties), elliptical (2 varieties) and ovate (2 varieties). Significant variability has been found in cavity depth of different apricot varieties ranging from shallow to deep. 'Erani' variety only showed deep cavity depth, 'Afghani', 'Chinese Apricot', 'Nari', 'New Castle', 'Rival', 'Tokpopa Nimu' and 'Australia'n variety showed intermediate depths whereas remaining eight varieties showed shallow depths.

Fruit shape depends on many characteristics such as stem cavity depth, the suture between two halves and the apex shape (Rahovic *et al*., 14). The trait suture depth was evaluated in all apricot varieties and four varieties viz., 'New Castle;, ;Turkey;, ;Chinese Apricot; and ;Afghani; have deep suture, ;Rival;, ;Viva Gold;, ;Communis; and ;Communis Holly; showed shallow suture whereas other nine apricot varieties showed intermediate suture.

There was a variation in apex shape among different apricot varieties. 'Fairmedcester' was only variety identified with pointed apex; 'New Castle', 'Harcot' and' 'Tilton' were found with flat apex whereas other thirteen varieties were reported with round apex. The apricot fruit color plays an important role for distinguishing group of varieties. The quality and maturity of fruits are dependent on fruit color of genotype, and each variety exhibited specific color at maturity stage (Shakir *et al*., 16). A large variation was found in fruit color of different

varieties. 'Afghani', 'Tokpopa Nimu', 'Australian,' 'Communis' were found Greenish yellow; 'New Castle', 'Turkey', 'Erani', 'Harcot', 'Balcot'a' were found Yellow; whileas, 'Tilton' and 'Viva Gold' were found with light orange in colour. It was also found that 'Rival', 'Chinese Apricot' and 'Nari' were having orange coloured fruits; whereas, 'Fairmedester', 'Heartly' and 'Communis Holly' were having red blush coloured fruits. It is reported that the fruit character, color is an important parameter and has direct correlation with the environmental conditions in the area. Further it is reported that interaction between environment and genotypes, growth and development of plant canopy, leaves and location of the fruit also affect the color of the fruits (Shakir *et al*., 16). Genotypes showed variation in stone shape ranging from round to elongate. 'Erani', 'Nari', 'New Castle', 'Communis', 'Australian', 'Balcota' and 'Turkey' showed round shape; 'Harcot', 'Rival', 'Chinese Aprico't', 'Afghani' and 'Heartly' showed elliptical shape; 'Tilton' showed elongated, whereas other four varieties showed stone ovate shape. Bhatia *et al*. (4) also reported the presence of round oval, round compressed, oblong ovate and ovate stones in apricots of Ladakh. There are reports mentioning the effect of environmental factors on stone shape in stone fruits. Bernhardt (3) reported effect on low temperature on stone shape in plum. Thus genetic stability of this character is influenced by genetic and environmental interaction.

In the present study apricot kernels were classified into two main groups, bitter and sweet on the basis of taste. It was found that nine varieties showed bitter taste and eight varieties were sweet in taste. In very small amounts, the toxic hydrogen cyanide present in bitter apricot kernels has been recommended for asthma, cough, and constipation (*Hyta* and Alpaslan (10). Furthermore, apricot kernel has been a good source of dietary protein as well as oil and fiber. The apricot kernels are also reported to have high antioxidant and antimicrobial activities. Similar kind of description of reference varieties has been done in walnut. This kind of work is useful for generating the reference database for comparison with new candidate varieties applied for protection through PPV&FRA. Apricot being perennial crop occupies large area during plantation and also bears fruit after 3-4 years of planting and therefore DUS testing in such crops is done on-site.

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