



# Characterization of Newly Introduced Exotic Plum Cultivars for Character Association and Genetic Improvement

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## **Authors' contributions**

*This work was carried out in collaboration between all authors. Authors ASS and SKV designed the study, performed the statistical analysis, wrote the protocol, and the final draft of the manuscript. Authors MKS and AK managed the analyses of the study. Authors NN and AK managed the literature searches. All authors read and approved the final manuscript.*

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## **ABSTRACT**

Exotic plum cultivars have been introduced at Central Institute of Temperate Horticulture, Srinagar in order to broaden the spectrum of existing germplasm and recommendation of better cultivars for their commercial cultivation. The present study consisted of fourteen different plum cultivars of uniform age replicated thrice in a Randomized Complete Block Design (RCBD). The data recorded revealed that the bud swell and tight cluster stage was first in cultivar Beauty on 30<sup>th</sup> March and 2<sup>nd</sup> April, respectively. The early date of first flower bloom was observed in cultivars Frontier, Red Beaut, Tarrol, Au-Rosa, Krassivica Plum and Beauty (7<sup>th</sup> April), while the date of full bloom (10<sup>th</sup> April), first petal fall (12<sup>th</sup> April) and complete petal fall (17<sup>th</sup> April) was reported late in cultivar Beauty. Maximum duration of flowering (15 days) was recorded in cultivars Frontier and Au-Rosa whereas minimum duration of flowering (9 days) was registered in cultivar Red Plum. Highest number of flower per branch was recorded in cultivar Au-Rosa (104.83) whereas, highest

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percentage of fruit set was recorded in cultivar Krassivica Plum (52.85%). Highest percentage of fruit drop was observed in cultivar Frontier (44.21%). Cultivar Red Plum matured earliest among all the cultivars whereas cultivar Grand Duke matured late. Maximum fruit yield (52.54 kg/tree) was registered in cultivar Frontier while minimum (18.07 kg/tree) was recorded in cultivar Kubio Plum. The study conclude on the note that cultivars "Frontier", "Au- Rosa" and "Grand Duke" were of vital importance in relation to their maturity and yield and recommended for used in breeding programme for further improvement of plum.

**Keywords:** Plum; phenology; fruit; leaf; yield.

## 1. INTRODUCTION

Plum (*Prunus salicina* L.) is one of the most important stone fruit of temperate zone. It belongs to family *Rosaceae*, sub family *Prunoideae* and order *Rosales*. This group contains 20-40 species [1], that are distributed in different part of the world. Plum has assumed greater significance as fresh fruit and in processing industries. It is a delicious fruit prized both for its exquisite fresh fruit flavor and aroma. The fruits are fairly attractive but usually are soft, clingstone, round and heart shaped [2]. Plum requires varying type of climate ranging from subtropical plains to the temperate high hills. It thrives well in low hills and in the sub mountain tracts where high chilling fruit crops like apple and cherry not be grown profitably.

The common plum (*P. domestica*) is known for its diversity in fruit size, color, flavor and is one of the most desirable plum species in terms of fruit quality [3]. Presently, Santa Rosa is one of the leading cultivars of plum in hills of Jammu and Kashmir and occupies about 75 per cent of the total area under plum cultivation. But, the predominance of the single cultivar leads to the glut in the market and the farmers do not get remunerative price for their produce and sometimes even they do not get back the cost of production. Hence, there is a need to extend the ripening period to avoid the glut in the market. This is possible, if new exotic introductions are made available and evaluated under the local climatic conditions.

The necessity of improving fruit quality is a main concerned for the modern plum culture. This can achieve only by means of replacing/changing old and senile orchards with new introductions or varieties. When growing the new introductions or varieties, it is essential to determine their various physical and chemical characteristics under local conditions. Recently, few exotic plum cultivars have been introduced at Central Institute of Temperate Horticulture, Srinagar in order to

increase and strengthening the size of existing germplasm and further their recommendation for commercial cultivation. Though, cultivar generally will not flourish well until and unless it is correctly evaluated or characterized, grouped and then recommended for commercial cultivation. Thus, there is a need to have precisely evaluation of such cultivars with the most recent research concerning various phenological characters of fruit and yield in accordance with the local agro climatic conditions. This can be unrivalled through taxonomical studies, which could serve as an index for assigning correct status of a genotype for future research. As such, there is no information available regarding these new introductions under the temperate condition of Kashmir. These varieties exhibit tremendous variability in growth, yield and quality attributes. Therefore, to bring more area under these new exotic varieties, thereby breaking the dominance of lonely cultivar Santa Rosa and to increase the total production of plums is only possible after proper evaluation on each aspect of these exotic cultivars with the objective to characterize the different phenological stages and morphological traits of exotic plum germplasm for their future improvement programme.

## 2. MATERIALS AND METHODS

The present investigation was carried out at Central Institute of Temperate Horticulture (CITH), Srinagar, Kashmir during the year 2014-15. Twelve-year-old bearing plum trees of different cultivars uniform size and vigour were selected for study. The experimental Farm of Central Institute of Temperate Horticulture (CITH) Srinagar, situated at an altitude of 1588 meter above mean sea level and latitude of 34.8' and longitude 74.83' N. The trees were spaced 5x5 meters in square system of planting and uniform cultural practices as per package and practices were followed during the period of study. The orchard soil was moderately deep with medium fertility status.

## 2.1 Treatments

Fourteen cultivars of plum presented in Table 1 were evaluated for different phenological stages and other traits. Single tree in each cultivar constituted an experimental unit and each cultivar was replicated three times.

## 2.2 Phenological Stages

Four representative branches from each treatment were chosen for the study of different phenological stage. Phenological stages constitute both non reproductive stages viz; bud swell, tight cluster and open cluster and reproductive stages viz; first bloom (10%), full bloom (80 %), first petal fall (10%) complete petal fall (80%). The branches were selected at random, giving due regard to the four directions of the tree canopy, to ensure precision. The dates of various non reproductive stages and reproductive stages were recorded at their appropriate time. Duration of flowering (days) was determined by number of days from the date of opening of first flower to the date of opening of last flower. The total number of flowers per branch of each experimental unit were counted and averaged.

## 2.3 Leaf Characters

Leaf length, leaf breadth, petiole length and petiole thickness of the mature leaf was measured with digital Vernier Calliper and expressed in mm. Leaf area was measured by using leaf area meter and reading was averaged in cm<sup>2</sup>. The leaf margin was examined for the presence or absence of serration in each cultivars.

## 2.4 Yield Characters

Fruit set was measured by counting number of flower buds during full blooming and mature number of fruits at peanut stage after fertilization. The fruit drop was determined by dividing the number of fruits initially set to the number of fruits retained at harvest and multiplied by 100. The fruits retained in all the cultivars were recorded one week before harvesting, averaged and expressed in percentage. The date of maturity was determined by visualizing proper fruit size, colour changes and ease in picking and yield was recorded in kilograms (kg).

## 2.5 Fruit Characters

A random sample of five fruits from each treatment will be taken and individual fruit was judged fruit and flesh colour using the colour chart developed by the Royal Horticultural Society. Stone adherence to flesh of fully ripe fruit were classified into following types:

- Free stone
- Semi-freestone
- Cling stone

## 3. RESULTS AND DISCUSSION

### 3.1 Phenological Stages

The observations pertaining to bud swell, tight cluster, open cluster, first bloom, full bloom, first petal fall, complete petal fall, fruit set and duration of flowering on the exotic plum cultivars are presented in table 2. The earliest bud swell and tight cluster was observed on 30<sup>th</sup> March and 2<sup>nd</sup> April in cultivar Beauty, followed by cultivar Frontier, whereas late was observed in cultivars Kubio Plum on 8<sup>th</sup> April and 11<sup>th</sup> April, respectively. The open cluster stage observed earliest cultivar Beauty, Frontier, Red Beaut, Tarrol, Au-Rosa and Krassicica Plum on 5<sup>th</sup> April, whereas, it was observed late in cultivar Kubio Plum on 14<sup>th</sup> April. The similar variations in different phenological traits was observed by Sud [4], Kumar et al. [5], Aulakh [6] and Josan et al. [7] while working on different plum cultivars and reported that these traits depend on environmental conditions (temperature, altitude, rainfall etc.) and may change every year [8].

The first bloom was observed earliest on 7<sup>th</sup> April in cultivars Frontier, Red Beaut, Tarrol, Au-Rosa, Krassivica Plum and Beauty and cultivars Kubio Plum on 17<sup>th</sup> April and Monarch (13<sup>th</sup> April) were late blooming. Cultivars Beauty and Tarrol were earliest in completion of full bloom (10<sup>th</sup> April) followed by Frontier, Red Beaut, Au-Cherry, Au-Rosa and Krassivica Plum (12<sup>th</sup> April). Cultivar Kubio Plum (21<sup>th</sup> April) and Grand Duke (16<sup>th</sup> April) were late in completion of full blooming. Duration of flowering among the different cultivars was ranges from 9 to 15 days among the different cultivars. Maximum duration of flowering of 15 days was recorded in cultivars Frontier and Au-Rosa and minimum of 9 days was recorded in cultivar Red Plum. Rest of the cultivars are in between them. Gonez-Pleza and Ledbetter [9] stated that 'flowering time duration'

is a feature which is influenced both by climatic as well as genetic factor.

The earliest petal fall was observed in cultivar Beauty on 12<sup>th</sup> April and late in Monarch on 19<sup>th</sup> April. The complete petal fall was observed earliest in cultivar Beauty (17<sup>th</sup> April) followed by Tarrol (18<sup>th</sup> April), Red Beaut and Au-Cherry (19<sup>th</sup> April), whereas, Grand Duke and Monarch had late complete petal fall on 23<sup>th</sup> April. Variability in duration of flowering in different plum cultivars were also reported by Jovancevic and Milosevic and Milosevic [10,11] concluded that high variation in flowering period pave the way for developing late flowering plum to avoid damage due to spring frost under mid hill conditions. Similar variation in duration of flowering in plum has been observed by Gonzales [12] and Josan et al. [13] further reported that these variations in blooming, petal fall and their duration are due to the genetic makeup of the cultivars and response to existing soil and agro-climatic conditions of the specific location as reported by Kaur and Kaundal [14].

### 3.2 Leaf Characters

The largest leaf length was observed in cultivar Frontier (116.13 mm) which was statistically at par with cultivar Krassivica Plum (115.80 mm) and Monarch (115.66 mm). The minimum leaf length was recorded in cultivar Red Beaut (92.33 mm) which was statistically at par with cultivar Burbank (94.16 mm) and Kanto-5 (97.70 mm).

The maximum mean leaf breadth (49.66 mm) was recorded in cultivar Au- Rosa and it is significantly higher than all the other cultivars, whereas, the minimum mean leaf breadth (33.26 mm) was observed in cultivar Burbank. Leaf area of cultivar Krassivica Plum (52.27 cm<sup>2</sup>) was statistically higher than cultivars Frontier (51.28 cm<sup>2</sup>) and Red Plum (50.90 cm<sup>2</sup>), whereas, the minimum mean leaf area (31.24 cm<sup>2</sup>) was observed in cultivar Burbank which was significantly lower than cultivar Kubio Plum (37.98 cm<sup>2</sup>). The maximum petiole length was recorded in cultivar Grand Duke (21.17 mm), whereas minimum petiole length was recorded in Burbank (13.96 mm). The petiole thickness was recorded maximum in cultivar Frontier (1.67 mm) and minimum in cultivars Au- Cherry and Au- Rosa (1.17 mm). Leaf margin was categorized as crenate to serrate type (Table 2). Only cultivars viz; Grand Duke had crenate type of leaf margin, whereas it was serrate type in rest of the plum cultivars understudy. Kumar [15] in cherry, Liverani [16] in peach and Mehraj [17] also reported similar type of variation in different leaf characters (leaf length, leaf breadth, leaf area, petiole length and petiole thickness). The results obtained in present studies are in accordance with the findings of Okie and Hancock [18] and Rozpara [19] who reported that the traits viz, leaf length, leaf breadth, leaf area, petiole length and petiole thickness are genetically inherited characters which varied from variety to variety, age of tree, location and fertility status of the soil.

**Table 1. Plum cultivar used in present study**

S. No.	Name of cultivars	Species	Origin
1	Frontier	<i>Prunus salicina</i>	USA
2	Red Beaut	<i>Prunus salicina</i>	California
3	Tarrol	<i>Prunus salicina</i>	China
4	Grand Duke	<i>Prunus domestica</i>	England
5	Black Amber	<i>Prunus salicina</i>	USA
6	Burbank	<i>Prunus salicina</i>	Burbank
7	Au-Cherry	<i>Prunus salicina</i>	USA
8	Au-Rosa	<i>Prunus salicina</i>	USA
9	Kanto 5	<i>Prunus salicina</i>	China
10	Kubio Plum	Unknown	Unknown
11	Red Plum	Inter species	USA
12	Krassivica Plum	Inter species	USSR
13	Monarch	<i>Prunus domestica</i>	England
14	Beauty	<i>Prunus salicina</i>	Burbank

**Table 2. Phenological stages of exotic plum cultivars**

<b>Cultivars</b>	<b>Bud swell</b>	<b>Tight cluster</b>	<b>Open cluster</b>	<b>First bloom</b>	<b>Full bloom</b>	<b>First petal fall</b>	<b>Complete petal fall</b>	<b>Duration of flowering</b>
Frontier	1 <sup>st</sup> April	4 <sup>th</sup> April	5 <sup>th</sup> April	7 <sup>th</sup> April	12 <sup>th</sup> April	15 <sup>th</sup> April	21 <sup>th</sup> April	15 Days
Red Beaut	2 <sup>nd</sup> April	4 <sup>th</sup> April	5 <sup>th</sup> April	7 <sup>th</sup> April	12 <sup>th</sup> April	15 <sup>th</sup> April	19 <sup>th</sup> April	13 Days
Tarrol	2 <sup>nd</sup> April	4 <sup>th</sup> April	5 <sup>th</sup> April	7 <sup>th</sup> April	10 <sup>th</sup> April	14 <sup>th</sup> April	18 <sup>th</sup> April	12 Days
Grand Duke	5 <sup>th</sup> April	7 <sup>th</sup> April	9 <sup>th</sup> April	12 <sup>th</sup> April	16 <sup>th</sup> April	19 <sup>th</sup> April	23 <sup>th</sup> April	12 Days
Black Amber	4 <sup>th</sup> April	7 <sup>th</sup> April	9 <sup>th</sup> April	11 <sup>th</sup> April	14 <sup>th</sup> April	17 <sup>th</sup> April	21 <sup>th</sup> April	11 Days
Burbank	4 <sup>th</sup> April	7 <sup>th</sup> April	9 <sup>th</sup> April	11 <sup>th</sup> April	14 <sup>th</sup> April	17 <sup>th</sup> April	21 <sup>th</sup> April	11 Days
Au-Cherry	3 <sup>rd</sup> April	5 <sup>th</sup> April	7 <sup>th</sup> April	9 <sup>th</sup> April	12 <sup>th</sup> April	16 <sup>th</sup> April	19 <sup>th</sup> April	11 Days
Au-Rosa	2 <sup>nd</sup> April	4 <sup>th</sup> April	5 <sup>th</sup> April	7 <sup>th</sup> April	12 <sup>th</sup> April	15 <sup>th</sup> April	21 <sup>th</sup> April	15 Days
Kanto 5	4 <sup>th</sup> April	7 <sup>th</sup> April	9 <sup>th</sup> April	11 <sup>th</sup> April	14 <sup>th</sup> April	17 <sup>th</sup> April	22 <sup>th</sup> April	12 Days
Kubio Plum	8 <sup>th</sup> April	11 <sup>th</sup> April	14 <sup>th</sup> April	17 <sup>th</sup> April	21 <sup>st</sup> April	24 <sup>th</sup> April	28 <sup>th</sup> April	11 Days
Red Plum	4 <sup>th</sup> April	7 <sup>th</sup> April	9 <sup>th</sup> April	12 <sup>th</sup> April	15 <sup>th</sup> April	17 <sup>th</sup> April	20 <sup>th</sup> April	9 Days
Krassivica Plum	1 <sup>st</sup> April	4 <sup>th</sup> April	5 <sup>th</sup> April	7 <sup>th</sup> April	12 <sup>th</sup> April	15 <sup>th</sup> April	20 <sup>th</sup> April	14 Days
Monarch	3 <sup>rd</sup> April	6 <sup>th</sup> April	9 <sup>th</sup> April	13 <sup>th</sup> April	17 <sup>th</sup> April	19 <sup>th</sup> April	23 <sup>th</sup> April	11 Days
Beauty	30 <sup>th</sup> March	2 <sup>nd</sup> April	5 <sup>th</sup> April	7 <sup>th</sup> April	10 <sup>th</sup> April	12 <sup>th</sup> April	17 <sup>th</sup> April	11 Days

### 3.3 Yield Characters

The number of flowers per branch among the cultivars under studied ranged from 64.91 to 104.84. The cultivar Au- Rosa (104.84) had maximum no. of flowers per branch followed by cultivars Red Plum (103.98), Au-Chery (102.55) and Monarch (101.65). The minimum number of flowers per branch was recorded in cultivar Kanto 5 (64.91). Maximum fruit set was recorded in cultivar Frontier (52.44) which was statistically at par with cultivar Red Plum (51.78) and Beauty (50.74). The minimum fruit set was recorded in cultivar Black Amber (40.88) which was differs significantly from rest of the plum cultivars under studies. The fruit drop was recorded maximum in cultivar Frontier (44.21) and minimum in cultivar Burbank (32.14). The maximum fruit retains (67.86 %) was observed in cultivar Burbank followed by Au- Cherry (65.48 %), Monarch (64.91 %) and Red Beaut (61.48 %). However minimum number of fruits retain in cultivar Frontier (55.59 %) followed by Grand Duke (56.56 %) and Red Plum (56.92 %) respectively. Higher fruit set under present investigation may be better due to more nutrient availability and weed control. These results are in accordance with the findings of Sharma and Josan [20], Sharma [21] and Singh [22], who reported that an adequate nitrogen supply to the first leaf emerging in the spring as well as to the flower was critical for fruit set. Higher fruit drop in the present study may be due to decrease in soil moisture and nutrient losses which resulted in low fruit retention and higher fruit drop leading to lower yield. These results are in accordance with the findings of Sharma [21], Sud [23] and Teskey and Shoemaker [24].

Fruits of Red Plum cultivar were the earliest to mature (28<sup>th</sup> May), it was closely followed by fruits of Frontier, Tarrol and Au- Rosa on 2<sup>nd</sup> June. The cultivar Kubio Plum and Grand Duke were mature late from 20<sup>th</sup> June to 26<sup>th</sup> June respectively. Similar type of variation has also been reported by Thakur [25] and Tondon [26] who reported that the time of maturity of plum cultivars ranged from the middle of June to the first week of September whereas, plum cultivar Autumn Giant, T.C Sun and Angeleno were the late ripening cultivars and matured in the first week of September Vitanova [27]. These different findings are most likely attributed to the characteristics of different species of fruit. Also the differences in date may be the result of different ecological conditions.

Yield per tree in different cultivars ranged from 18.07 kg to 52.54 kg per tree. The highest yield per tree was recorded in Frontier (52.54 kg) which was statistically higher of all other cultivars. Minimum fruit yield was recorded in cultivar Kubio Plum (18.07 kg). The yield potential of a plum crop is inherently dependent upon their adaptation to agro-climatic conditions and management practices. The ultimate objective of the grower is to have high yield, which is highly variable among the different cultivars and is genetically controlled. However, yield generally depends on the health of tree, nutrition, age of plants, cultural practices adopted, pest and disease incidence and finally climatic conditions of cultivated area.

### 3.4 Fruit Characters

Fruit colour varied greatly among the different plum cultivars. Red purple colour possessed by cultivars viz; Grand Duke, Black Amber, Au-Rosa, Kubio Plum and Krassivica Plum, red colour by cultivars Red beaut, Tarrol, Burbank, Red Plum and Beauty, grey purple by only plum cultivar Frontier, yellow colour in cultivars Au-Cherry, Kanto 5 and Monarch, respectively. Data on the fruit flesh colour among the different plum cultivars revealed that yellow orange colour is dominant with the traces of the other colour depending upon their genetic constitution and pigmentation. Yellow orange colour was dominant in seven cultivars (Frontier, Red Beaut, Tarrol, Grand Duke, Red Plum, Burbank and Beauty), dark red flesh was observed in three cultivars (Black Amber, Kubio Plum and Krassivica Plum), red flesh only cultivar Au-Rosa, yellow flesh in three cultivars (Au- Cherry, Kanto 5 and Monarch), respectively. The colour characteristics of plum depends upon the genetic constitution and anthocynin pigmentation of the cultivars and further variation in them is related fruit position on tree and direction of the tree. Such traits are highly genetically inherent and control by polygene's and such similar variations in the fruit and flesh colour characters have been reported by Wang [28] in peach and Billini [5] in plum.

Eight plum cultivar viz; (Frontier, Red Beaut, Tarrol, Burbank, Kanto 5, Kubio Plum, Monarch and Beauty) had rounded, two plum cultivars (Red Plum and Krassivica Plum) had ovate, two cultivar (Black Amber and Au- Cherry) had elliptic, cultivar (Grand Duke) had oblong and cultivar (Au- Rosa) had heart shape. Of the total cultivars, nine cultivars (Red Beaut, Tarrol, Black

Table 3. Leaf characteristics of exotic plum cultivars

Cultivars	Leaf length (mm)	Leaf breadth (mm)	Leaf area (cm <sup>2</sup> )	Petiole length (mm)	Petiole thickness (mm)	Leaf margin
Frontier	116.13	43.33	51.28	19.57	1.67	Serrate
Red Beaut	92.33	35.46	32.42	19.52	1.60	Serrate
Tarrol	112.50	41.66	47.12	15.78	1.43	Serrate
Grand Duke	102.76	47.83	48.92	21.17	1.50	Crenate
Black Amber	111.96	39.00	44.14	16.79	1.19	Serrate
Burbank	94.16	33.26	31.24	13.96	1.56	Serrate
Au-Cherry	102.33	42.40	42.84	20.33	1.17	Serrate
Au-Rosa	112.56	49.66	56.22	18.31	1.17	Serrate
Kanto 5	97.70	41.80	41.02	21.00	1.36	Serrate
Kubio Plum	105.93	36.00	37.98	14.58	1.21	Serrate
Red Plum	107.06	47.90	50.90	16.73	1.44	Serrate
Krassivica Plum	115.80	44.70	52.27	19.58	1.28	Serrate
Monarch	115.66	37.50	43.34	18.75	1.29	Serrate
Beauty	112.46	41.20	47.10	16.96	1.58	Serrate
<b>CD<sub>(0.05)</sub></b>	<b>1.61</b>	<b>1.58</b>	<b>0.88</b>	<b>2.44</b>	<b>0.23</b>	-
<b>CV</b>	<b>5.89</b>	<b>10.82</b>	<b>4.11</b>	<b>7.97</b>	<b>9.65</b>	-

**Table 4. Fruit set, fruit drop and fruit retention in exotic plum**

<b>Cultivars</b>	<b>No. of flower/branch</b>	<b>Fruit set (%)</b>	<b>Fruit drop (%)</b>	<b>Fruit retention (%)</b>	<b>Date of maturity</b>	<b>Yield/tree (kg)</b>
Frontier	91.44	52.44	44.21	55.59	2 <sup>nd</sup> June	52.54
Red Beaut	88.89	47.54	37.85	61.48	6 <sup>th</sup> June	32.24
Tarrol	85.53	45.28	42.85	56.15	2 <sup>nd</sup> June	35.00
Grand Duke	81.46	48.14	43.44	56.56	26 <sup>th</sup> June	42.49
Black Amber	99.35	40.88	38.73	60.27	7 <sup>th</sup> June	22.66
Burbank	89.02	45.40	32.14	67.86	10 <sup>th</sup> June	35.18
Au-Cherry	102.55	43.84	34.52	65.48	5 <sup>th</sup> June	44.13
Au-Rosa	104.84	45.98	41.20	58.80	2 <sup>nd</sup> June	22.95
Kanto 5	64.91	48.92	40.01	59.99	12 <sup>th</sup> June	40.35
Kubio Plum	98.44	45.56	37.00	62.63	20 <sup>th</sup> June	18.07
Red Plum	103.98	51.78	43.08	56.92	28 <sup>th</sup> May	30.57
Krassivica Plum	74.39	49.92	42.24	57.76	5 <sup>th</sup> June	26.56
Monarch	101.65	49.28	35.09	64.91	8 <sup>th</sup> June	37.55
Beauty	96.87	50.74	42.16	57.84	9 <sup>th</sup> June	45.31
<b>CD<sub>0.05</sub></b>	<b>2.07</b>	<b>1.88</b>	<b>0.26</b>	<b>1.08</b>	-	<b>1.43</b>
<b>CV</b>	<b>5.36</b>	<b>9.11</b>	<b>3.40</b>	<b>4.00</b>	-	<b>6.83</b>



**Table 5. Qualitative characteristics of exotic plum cultivars**

Cultivars	Fruit colour	Flesh colour	Fruit shape	Stone adherence
Frontier	Grey purple	Yellow orange	Round	Free stone
Red Beaut	Red	Yellow orange	Round	Cling stone
Tarrol	Red	Yellow orange	Round	Cling stone
Grand Duke	Red purple	Yellow orange	Oblong	Free stone
Black Amber	Red purple	Dark red	Elliptic	Cling stone
Burbank	Red	Yellow orange	Round	Cling stone
Au-Cherry	Yellow	Yellow	Elliptic	Cling stone
Au-Rosa	Red purple	Red	Heart shape	Free stone
Kanto 5	Yellow	Yellow	Round	Cling stone
Kubio Plum	Red purple	Dark red	Round	Semi cling stone
Red Plum	Red	Yellow orange	Ovate	Cling stone
Krassivica Plum	Red purple	Dark red	Ovate	Cling stone
Monarch	Yellow	Yellow	Round	Cling stone
Beauty	Red	Yellow orange	Round	Semi cling stone

Amber, Burbank, Au- Cherry, Kanto 5, Red Plum, Krassivica Plum and Monarch) were cling stone type, three cultivars (Frontier, Grand Duke and Au- Rosa) were free stone type and two cultivar Kubio Plum and Beauty was semi cling stone type. Similar results have been reported by workers like Jovancevic [10] and Milosevic and Milosevic [11]. The variation in fruit shape might be due to difference in agro-ecological and adaphic conditions, genetic makeup of plum cultivars and most important is the nature and place of origin.

#### 4. CONCLUSION

The study summarized on the affirmative note that cultivars "Beauty, Frontier, Red Beaut, Tarrol, Au-Rosa and Krassivica Plum" were earlier in their blooming and grouped as early ones.. The Cultivars "Frontier", "Au- Rosa" and "Grand Duke" were of vital importance in relation to their maturity and yield. Cultivar "Red Plum" matures and harvest much earlier and best in fruit size and colour than all other cultivars. These cultivars had potential in replacing the low quality and old existing cultivars and further recommended for their utilization in framing breeding programme for further improvement of plum.

#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

#### REFERENCES

1. Aulakh PS. Evaluation of plum cultivars under arid and irrigated region of Punjab.

Journal of Applied Horticulture. 1991;1:48-50.

2. Autio WR, Greene DW, Cooley DR, Schupp JR. Improving the growth of newly planted apple tree. Horticulture Science. 1991;26:840-843.
3. Bajawa GS, Bindra AS, Bal JS, Minhas PPS. Problems of pollination and fertilization in plum. Acta Horticulturae 1991;283:157-162.
4. Balik S. Studies on new table Japanese Plum (*Prunus salicina* Lind.) cultivars growing for export in Kahramanmaras. M.Sc. Thesis submitted to Institute of Natural Science, University of Kahramanmaras, Turkey. 2004;74:137-142.
5. Billini E, Giordini E, Nencetti V. Behaviour of new early plum selections grafted on two rootstocks. Acta Horticulturae. 1992;317:133-39.
6. Caliskan T, Eken M, Bircan M. Studies on the adaptation of new Japanese plum cultivars to the different regions of Turkey. Horticulture Research Institute of Alata, Mersin, Turkey. 2006;18-22.
7. Cosmulescu S, Baci A, Cichi M, Gruia M. The effect of climate changes on phenological phases in plum tree (*Prunus domestica* L.) in South-Western Romania. South Western Journal of Horticulture. 2010;1(1):9-20.
8. Fathia H, Dejampourb J, Jahanic U, Zarrinbald M. Tree and fruit characterization of peach genotypes grown under Ardabil and East Azerbaijan environmental conditions in Iran. Crop Breeding Journal. 2013;3(1):31-42.

9. Gonez-Pleza E, Ledbetter C. Handbook of fruits, vegetables and flowers: In: Y.H. Hui (ed), John Wiley & sons Inc. 2010;10- 45.
10. Jovancevic, R. Biological and economic properties of some outstanding prune cultivars grown in the River Valley. *Acta Horticulturae* 1977;129-136.
11. Milosevic T, Milosevic N. Quantitative analysis of the main biological and fruit quality traits of F<sup>1</sup> Plum genotypes (*Prunus domestica*). *Acta Science Hortorum Culture*. 2011;10(2):95-107.
12. Gonzales SP. Associations among morphological and phenological characters representing apricot germplasm in Central Mexico. *Journal of American Society of Horticultural Science*. 1992;117:486-90.
13. Josan JS, Sharma JN, Mehrotra NK, Monga PK. Performance of some plum cultivars under arid-irrigated region of Punjab. *Indian Journal of Horticulture*. 1999;56:299-303.
14. Kaur K, Kaundal G. Efficacy of herbicide, mulching and sod cover on control of weeds in plum orchards. *India Journal of Weed Science*. 2009;104:110-112.
15. Kumar K, Sonali T, Dinesh S, Vikas KS. Evaluation of promising Japanese plum genotypes for mid-hills of Himachal Pradesh. *Indian Journal of Horticulture*. 2013;70(2):283-286.
16. Liverani A, Giovannini D, Versari N, Sirri S, Brandi F. Japanese and European plum cultivars evaluation in the valley of Italy: yield and climate influence. *Acta Horticulturae* 2010;874:327-336.
17. Mehraj S, Farooq AP, Bilal AP, Bisati IA, Ganai IH. Effect of organic and inorganic mulches on growth, yield and quality attributes of plum cv. Santa Rosa under temperate conditions. *Green Farming*. 2014;5(6):1048-1051.
18. Okie WR, Hancock JF. Plum. In: *Temperate Fruit Crop Breeding Germplasm to Genomics* (Ed. J.F. Hancock). Michigan State University. 2008;337-357.
19. Rozpara E, Grzyb Z, Bielicki P. Influence of various soil maintenance methods in organic orchard on the growth and yield of sweet cherry in the first years after planting. *Journal of Fruit and Ornamental Plant Research*. 2008;16:17-24.
20. Sharma JN, Josan JS. Varietal performance of plum under arid irrigated region of Punjab. *Indian Journal of Horticulture*. 1993;50(4):301-305.
21. Sharma VK. Studies on flowering, pollination and fruit characteristics in some plum cultivars. MSc. Thesis submitted to Department of Fruit Science, Dr. YS Parmar University of Horticulture and Forestry, Nauni, Solan Himachal Pradesh, India. 1999;62-65.
22. Singh, D, Sharma VK, Kumar K. Evaluation and characterization of some exotic plum germplasm accessions for fruit quality traits. *Journal of Hill Agriculture*. 2011;2(1):59-62.
23. Sud G. Studies on the pollination requirement of plum cultivar 'Climax'. *Indian Journal of Horticulture*. 1979;36: 423-26.
24. Teskey JE, Shoemaker JS. Peach. In: *Tree Fruit Production*. AVI Publications, Westport, Connecticut, Ireland. 1978;187-201.
25. Thakur GC, Chadha TR, Verma HS, Kumar J. Effect of soil management systems on bearing and fruit quality of apple cv. Red Delicious. *Indian Journal of Horticulture*. 1993;50(1):10-13.
26. Tondon S. Studies on evaluation of some apricot, peach and plum introductions. M.Sc. Thesis submitted to Department of Fruit Science, Dr. YS Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, India. 2006;102-110.
27. Vitanova IM, Dimkova SD, Ivanova DA. Chemical and technological characteristics of plum cultivars. *Acta Horticulturae*. 1998;478:309-312.
28. Wang L, Zhu GM, Fang WC. The evaluation criteria of some botanical quantitative characters of peach genetic resources. *Agriculture Science in China*. 2006;5:905-10.

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