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## Plant growth and fruiting behavior of newly introduced plum (*Prunus salicina* Lindl.) cultivars under mid-hills conditions of Himachal Pradesh

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### Abstract

Santa Rosa is the predominant plum cultivar grown over 90 percent of the total area under plum cultivation in Himachal Pradesh and the predominance of single cultivar leads to monoculture like situation and create gluts in the market and the farmers do not get remunerative prices for their produce. To meet ever-changing consumer preferences and spread of harvest season, there is a need for varietal diversification with genetically improved cultivars. The experiment was laid out in Randomized Block Design with five replications of each cultivar planted at a spacing of 5 x 5 m during 2015. Observations were recorded in respect of tree vigour and fruiting parameters of fruits. Analysis of variance showed significant differences among all the cultivars for all the characters under study. Maximum tree vigour was recorded in 'Shiro' with respect to tree spread, tree volume, annual shoot growth and pruning weight. Maximum tree height (3.98 m), leaf area (18.36 cm<sup>2</sup>), earliest bud burst (7<sup>th</sup> February) and flowering (13<sup>th</sup> February) was observed in Red Beaut cultivar. Maximum duration of flowering (16 days) was recorded in 'Red Beaut' while minimum (12 days) in 'Shiro'. The highest fruit set (24.08 %), fruit retention (34.89 %), yield (7.30 kg/tree) and minimum fruit drop was recorded in 'Shiro'. Harvest date was recorded to be earliest (29<sup>th</sup> May) in Red Beaut cultivar with shortest duration of 96 days for maturity. Cultivar 'Frontier' was recorded the maximum fruit size, weight, volume and pulp to stone ratio were found highly desirable in 'Black Amber' and all these fruit quality attributes were in close proximity to 'Duarte'. From the present investigations it can be concluded that out of newly introduced cultivars, 'Black Amber' and 'Duarte' may be suggested for cultivation in mid-hill conditions of Himachal Pradesh and can provide alternative to change the monotony of 'Santa Rosa' in order to stretch the harvest season, fulfill consumer ever-changing taste and better remuneration to the growers. These studies on different cultivars may be continued further at different locations prior to recommendation for commercial cultivation in sub-temperate and mid-hill conditions of Himachal Pradesh.

**Keywords:** Evaluation, growth, plum, yield

### 1. Introduction

Plum (*Prunus salicina* Lindl.) is one of the important and widely cultivated fruit crop of temperate regions of the world. It occupies a unique position amongst the stone fruits in world fruit production and ranks next to peaches in economic importance. The term Japanese plum was applied originally to *Prunus salicina* Lindl and European plums are *P. domestica* L. and these are main plum production species in the world and in our country majority belongs to *P. salicina* group. Japanese group of plum is native to China but was domesticated in Japan and subsequently was introduced to different parts of the world. In India Japanese plums were introduced by European settlers and missionaries. In India area under plum cultivation is 24 thousand hectares with a production of 80 thousand metric tonnes Anon, (2014) <sup>[1]</sup>. In Himachal Pradesh, plums occupy a significant place both in respect of acreage and production next to apple Sharma, (2005) <sup>[2]</sup> and is cultivated in an area of 8556 hectares with a production of 15,991 metric tonnes during 2014 Anon, (2014) <sup>[1]</sup>. Areas ranging from 900 m to 1600 m amsl provide excellent and congenial climatic conditions for plum cultivation.

Plums are rich source of fiber and antioxidants that appear to provide a variety of health benefits related to cardiovascular diseases, tumorogenesis and osteoporosis. Certain health benefiting compounds present in the plum fruits, such as dietary fiber, sorbitol, and isatin are known to help regulate the functioning of the body Prajapati *et al.*, (2012) <sup>[3]</sup>. Plum has assumed greater significance as fresh fruit and in processing industries and it has potential to contribute greatly to human nutrition Kim *et al.*, (2003) <sup>[4]</sup>. Plums are temperate zone fruits, but they are widely grown throughout the world, from the cold climate of Siberia to the sub-

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tropical conditions of the Mediterranean region Son, (2010) [5]. In India plum is grown on commercial scale in mid-hills of Himachal Pradesh, Jammu & Kashmir and Uttarakhand in north India and to a limited extent in Nilgiri hills in South India. Chanana, (2001) [6] suggested that plum can be grown in a wide range of subtropical and warm temperate climate. Plum species and cultivars are quite diverse in fruit characters such as fruit size, shape, color, texture, aroma and other quality characteristics which make their fruits desirable, as compared to other horticultural crops Baden and Byrne, (2012) [7]. On the other hand, plums exhibit limited capacity for adaptation and as a result, in each area only specific cultivars are grown.

This is only possible, if new exotic introductions are made and evaluated under local climatic conditions, however, evaluation studies in mid-hills and subtropical plains of northern India were done by few workers Lal and Mishra, (1980) [8], Tripathi *et al.*, 1984 [9], Dhatt *et al.*, 1992 [10] Singh *et al.*, (2002) [11]. Plum breeding programs throughout the world are focusing on improving fruit quantity and quality, prolonging the harvest season and developing resistance/tolerance to biotic and abiotic stress Hartmann and Petruschke, (2002) [12], Blazek, (2007) [13]. However, these new cultivars of plum have been introduced with an objective of extending the ripening period and to meet the consumer preferences. In Himachal Pradesh more area can be brought under plum cultivation by introducing new cultivars after their proper evaluation. Therefore in the present study four new introductions viz. 'Friar', 'Duarte', 'Black Amber' and 'Shiro' were evaluated and compared with existing cultivars viz. 'Santa Rosa', 'Frontier', 'Red Beaut' and 'Mariposa'. The present study was carried out with the following objectives: - (i) Evaluation of the newly introduced plum cultivars to establish a database for their future use (ii) To compare the suitability of new introductions with the existing cultivars under mid- hills of Himachal Pradesh

## 2. Materials and Methods

### 2.1 Climate and Soil

The experimental orchard lies under the sub-temperate, sub-humid mid-hill agro zone of Himachal Pradesh where, summer is moderately hot during May-June while, winter is quite severe during December-January. The annual rainfall ranges between 110-120 cm and the major amount of which is received during June to September. The soil of the experimental orchard is gravelly loam and have pH range of 6.9.

### 2.2 Plant materials and experimental design

The study was carried out on eight cultivars of plum selected for the present studies namely Black Amber, Duarte, Friar, Shiro, Frontier, Mariposa, Red Beaut and Santa Rosa. The trees selected for the present study were of uniform size belonging to the age group of 8-9 years. In total 40 trees consisting of 5 trees per cultivar were selected for the present studies. All the trees were given uniform cultural practices and recommended nutritional doses during the course of studies. The soil is mountainous alluvial loamy soil and having pH of 6.62, organic carbon 1.58%, available N, P and K were 318.64, 16.62 and 172 kg ha<sup>-1</sup>, respectively. The plantation was composed of 8-9 years trees old plum trees; the trees were spaced 2m apart in the row, with the rows again 2m apart and trained to Modified Central leader system. The experiment was performed on the sample size comprising of

40 trees; the trees being randomly selected. The homogeneity of the experimental area was checked by measuring tree trunk circumferences before the differentiation of the cultivars.

### 2.3 Measurements

The data on tree height (m), tree spread (m), tree volume (m<sup>3</sup>), trunk girth (cm), shoot diameter (mm), graftable scion wood (%), total number of shoots per tree, number of lateral shoots, average shoot length (cm), number of buds per shoot, internodal length (cm), pruning weight (kg/tree) and leaf area (cm<sup>2</sup>) to study the effect of different pruning intensities and benzyladenine were recorded. Procedure suggested by Westwood, (1978) [14] was adopted for fruit set estimation. For taking fruit yield the crop load removed from the trees at the time of harvest season was recorded as kg tree<sup>-1</sup>.

### 2.4 Statistical analysis

Data on growth parameters characteristics of apple to determine the significance of differences were analyzed by using Randomized Block Design (RBD)- one way analysis of variance (ANOVA) as suggested by Gomez and Gomez, (1984) [15]. In addition to show the interrelationships between pruning intensities in combination with benzyladenine and mean values of each studied plant growth parameters statistical analysis program (SPSS) was used. The level of significance was tested for different variables at 5 percent level of significance.

## 3. Results and Discussion

### 3.1 Tree characters

It is evident from the perusal of data presented in Table 1 that the evaluation of newly introduced plum cultivars significant effect on plant growth parameters. Tree height in all the eight plum cultivars studied ranged between 2.04 m in 'Friar' and 3.98 m in 'Red Beaut', followed by 'Santa Rosa' (3.65 m) and 'Mariposa' (3.48 m). The overall mean for tree height was recorded as 3.06 m. Cultivar Red Beaut was found statistically at par with 'Santa Rosa'. The plant height of 'Red Beaut' (3.98 m) was 1.95 times more as compared to that observed in the cultivar Friar (2.04 m). The maximum trunk girth (20.46 cm) was recorded in the cultivar Santa Rosa which was statistically at par with 'Red Beaut' (20.16 cm), 'Frontier' (19.86 cm) and 'Shiro' (18.98 cm), whereas, the minimum girth (13.06 cm) was attained by the cultivar Friar which showed significantly lower trunk girth as compared to the rest of the cultivars. Maximum tree spread (2.14 m) was recorded in the cultivar Shiro which was statistically higher than all other cultivars. Minimum tree spread (1.06 m) was, however, recorded for the cultivar Friar which was found to be statistically at par with cultivars Black Amber and Duarte. The highest tree volume (7.20 m<sup>3</sup>) was recorded for the cultivar Shiro which was statistically at par with 'Santa Rosa' (6.78 m<sup>3</sup>), 'Frontier' (6.54 m<sup>3</sup>) and 'Red Beaut' (6.48 m<sup>3</sup>). Minimum tree volume (1.41 m<sup>3</sup>) was observed in the cultivar Friar which was at par with 'Black Amber' and 'Duarte'. The maximum annual shoot growth (99.6 cm) was registered for the cultivar Shiro which was at par with 'Red Beaut' (95.2 cm). However minimum annual shoot growth (72.1 cm) was observed in 'Friar' and was at par with the values of 'Black Amber', 'Duarte', 'Frontier', 'Mariposa' and 'Santa Rosa'. The maximum pruned wood weight 2.22 kg was recorded in cultivar Shiro which was found to be significantly higher than rest of the cultivars. The minimum value of pruning weight was 1.13 kg in 'Friar' which was statistically at par with

cultivars 'Black Amber', 'Duarte', 'Frontier', 'Mariposa' and 'Santa Rosa'. Maximum leaf area was observed in 'Red Beaut' (18.36 cm<sup>2</sup>) and minimum leaf area was recorded in cultivar Black Amber (12.53 cm<sup>2</sup>). Cultivars Santa Rosa

(15.79 cm<sup>2</sup>), Mariposa (14.79 cm<sup>2</sup>) and Duarte (14.71 cm<sup>2</sup>) were found to be statistically at par with each other in terms of average leaf area.

**Table 1:** Tree characters of different plum cultivars

Cultivars	Tree Height (m)	Trunk girth (cm)	Spread (m)	Tree volume (m <sup>3</sup> )	Annual shoot growth (cm)	Pruning weight (kg)	Average leaf area (cm <sup>2</sup> )
Duarte	2.70	16.92	1.19	2.23	77.8	1.18	14.71
Black Amber	2.45	15.54	1.07	1.59	76.5	1.16	12.53
Friar	2.04	13.06	1.06	1.41	72.1	1.13	13.18
Shiro	2.84	18.98	2.14	7.20	99.6	2.22	13.08
Frontier	3.32	19.86	1.77	6.54	79.6	1.31	14.38
Santa Rosa	3.65	20.46	1.86	6.78	81.2	1.62	15.79
Red Beaut	3.98	20.16	1.68	6.48	95.2	1.80	18.36
Mariposa	3.48	15.82	1.47	4.17	80.9	1.38	14.79
C.D <sub>0.05</sub>	0.29	1.78	0.22	1.34	10.10	0.59	1.17

The canopy spread varied from 1.07 × 1.16 m to 2.14 × 2.19 m, and such variations in growth characters has also been observed by Kumar *et al.*, (2013) [16]. In the present study tree height and trunk girth varied from 13.06 to 20.46 cm which was observed to be in accordance with the work of Kuden *et al.*, (1994) [17]. In annual shoot growth the cultivar Shiro excelled with highest shoot extension (99.6 cm). Similar result was observed by Sosna and Kortylewska, (2010) [18] and they found that the cultivar Shiro had significantly longer annual shoots. Further the corresponding pruning weight also depends on the growth character of the cultivars. Cultivar Shiro had the maximum annual shoot growth as well as the maximum pruning weight. Among the four introduced cultivars (Duarte, Black Amber, Friar, Shiro), 'Shiro' exhibited a strong growth in overall tree characters. Such strong growth has also been reported by Grzyb, (2002) [19] in the same cultivar. Average leaf area showed a difference from 12.53 cm<sup>2</sup> to 18.36 cm<sup>2</sup> in the current study which is supported by the findings of Kuden *et al.*, (1994) [20] who reported leaf area in seven Japanese plum cultivars ranging from 10.75 cm<sup>2</sup> to 23.09 cm<sup>2</sup>. Further Sharma, (1999) [21] reported leaf area in 'Frontier', 'Red Beaut' and 'Santa Rosa' to be 14.76 cm<sup>2</sup>, 17.51 cm<sup>2</sup> and 15.72 cm<sup>2</sup> respectively, which supports the results observed in the present study.

### 3.2 Foliage characters

Data presented in Table 2 showed that the time of bud burst

varied quite significantly in different cultivars under study and it was found that bud burst observations varied between first week of February to second week of March. The cultivar earliest to show leaf emergence was Red Beaut on 7th February which was remarkably earlier than the rest of the cultivars, whereas, the cultivar last to do so was Shiro on 10<sup>th</sup> March. The time of leaf fall was recorded between first week of November to third week of November. The cultivar Red Beaut had earliest leaf fall on 2nd November which was quite earlier than the rest of the cultivars, whereas, the cultivar last to do so was Duarte on 24<sup>th</sup> November. The average leaf area of 'Red Beaut' (18.36 cm<sup>2</sup>) was 1.47 times more as compared to the cultivar Black Amber (12.53 cm<sup>2</sup>). First flower opening ranged from 13th February to 12th of March. Cultivar Red Beaut was the earliest to flower on 13th February, followed by 'Black Amber' (15<sup>th</sup> February), whereas, the cultivar Friar was last to flower on 12th of March. All the studied cultivars took 5-11 days to attain full bloom from the start of flowering. Cultivar Frontier attained peak flowering in the shortest span of five days, whereas, cultivar Black Amber took 11 days to attain peak flowering. It was earliest in the cultivar Red Beaut (1st March) followed by Black Amber (3<sup>rd</sup> March) while cultivars Duarte, Shiro and Friar showed a late trend in reaching the end of flowering i.e. 21<sup>st</sup> March, 22<sup>nd</sup> March and 25<sup>th</sup> March respectively. Cultivar Red Beaut and Black Amber had the longest flowering period of 16 days, whereas, cultivar Shiro had the shortest flowering period of 12 days.

**Table 2:** Floral characters of different plum cultivars

Cultivars	Time of bud burst	Time of leaf fall	First flower opening	Full bloom	End of flowering	Duration of flowering
Duarte	03-03-2015	24-11-2015	07-03-2015	15-03-2015	21-03-2015	14
Black Amber	18-02-2015	11-11-2015	15-02-2015	26-03-2015	03-03-2015	16
Friar	07-03-2015	15-11-2015	12-03-2015	20-03-2015	25-03-2015	13
Shiro	10-03-2015	17-11-2015	10-03-2015	17-03-2015	22-03-2015	12
Frontier	16-02-2015	18-11-2015	25-02-2015	02-03-2015	12-03-2015	15
Santa Rosa	15-02-2015	13-11-2015	20-02-2015	01-03-2015	06-03-2015	14
Red Beaut	07-02-2015	02-11-2015	13-02-2015	22-02-2015	01-03-2015	16
Mariposa	14-02-2015	19-11-2015	20-02-2015	02-03-2015	07-03-2015	15
C.D <sub>0.05</sub>	-	-				14

The time of bud burst in the studied cultivars extended from first week of February to second week of March. Similar trend was observed by Thakur *et al.*, (2014) [22] where time of bud burst extended from second week of February to the second week of March. Time of leaf fall in the above cultivars ranged from 2nd to 24th of November and was in line with study conducted by Kumar *et al.*, (2013) [16]. A similar variation in leaf fall extending from 23<sup>rd</sup> October to 28<sup>th</sup>

November was also recorded by Sharma, (1999) [21] and the slight variation could be attributed to the varietal characteristics. From the above data it was observed that the flowering in cultivars under study started in the first week of February and continued till second week of March. Similar observations with slight variation in flowering trend was observed by Randhawa and Nair, (1960) [23] where it extended from first week of February to third week of March under

Delhi conditions. The overall average duration of flowering was 14.56 days. Similar results were obtained by Thakur *et al.*, (2014) [24] who observed overall average flowering duration of 15.37 days under Solan conditions. In the present work narrow range of variation regarding duration of flowering was observed in different cultivars ranged from 12 to 16 days. These findings are in line with the work of Thakur, (2012) [25] who reported flowering duration of 18 days but is in contradiction with the work of Chung *et al.*, (1998) [26] who indicated short duration blooming period of 6 to 7 days, while Kemp, (1996) [27] recorded prolonged flowering duration of 37 days. These variations could be assigned to the varied nature of the cultivars as well as to the effect of environmental or ecological conditions.

**3.3 Flowering characters**

The highest fruit set of 24.08 percent was recorded in ‘Shiro’ which was significantly higher than the rest of the cultivars, while minimum fruit set of 9.62 percent was recorded in ‘Red Beaut’. Maximum fruit drop of 80.47 percent fruit drop was recorded in the cultivar Red Beaut, while minimum fruit drop of 61.05 percent was observed in ‘Shiro’ which was statistically at par with cultivar Black Amber (62.70 %). The maximum fruit retention of 34.89 percent was recorded in the cultivar Shiro which was statistically at par with ‘Black Amber’ (34.11 %) and the minimum fruit retention (11.63 %) was observed in ‘Santa Rosa’ which was at par with cultivar ‘Red Beaut’ (14.23 %). The cultivar Red Beaut was ready for harvesting on 29<sup>th</sup> May which was significantly early than the rest of studied cultivars. While, ‘Mariposa’ was the last to reach harvesting on 12<sup>th</sup> July. The cultivar which matured earliest was Red Beaut (96 days) followed by ‘Shiro’ (98 days), whereas, ‘Mariposa’ took longest time of 127 days to attain maturity.

Maximum fruit firmness (2.42 kg/cm<sup>2</sup>) was recorded in the cultivar Black Amber which as statistically at par with ‘Friar’ (2.36 kg/cm<sup>2</sup>), ‘Mariposa’ (2.18 kg/cm<sup>2</sup>) and ‘Frontier’ (2.16 kg/cm<sup>2</sup>). The minimum fruit firmness (1.76 kg/cm<sup>2</sup>) was observed in the cultivar Duarte which was found statistically at par with ‘Red Beaut’ (1.98 kg/cm<sup>2</sup>), ‘Santa Rosa’ (2.06 kg/cm<sup>2</sup>) and ‘Shiro’ (2.08 kg/cm<sup>2</sup>). The highest fruit yield (7.30 kg/tree) was recorded in the cultivar Shiro followed by

‘Frontier’ (7.02 kg/tree). However, minimum yield (3.76 kg/tree) was recorded in ‘Red Beaut’ which was found to be statistically at par with cultivars Friar (4.01 kg/tree), Duarte (4.13 kg/tree), Black Amber (4.51 kg/tree) and Mariposa (4.20 kg/tree). The maximum pulp to stone ratio (48.31) was recorded in the cultivar Frontier closely followed by ‘Red Beaut’ (45.84). The minimum pulp to stone ratio (20.17) was recorded in cultivar Shiro which was significantly lower than rest of the cultivars. Observations on adherence of pulp to stone are presented in Table 4. The cultivars Duarte and Santa Rosa were clingstone while ‘Shiro’, ‘Red Beaut’, and ‘Mariposa’ were semi-clingstone, whereas, ‘Black Amber’, ‘Friar’ and ‘Frontier’ were found to be of freestone nature.

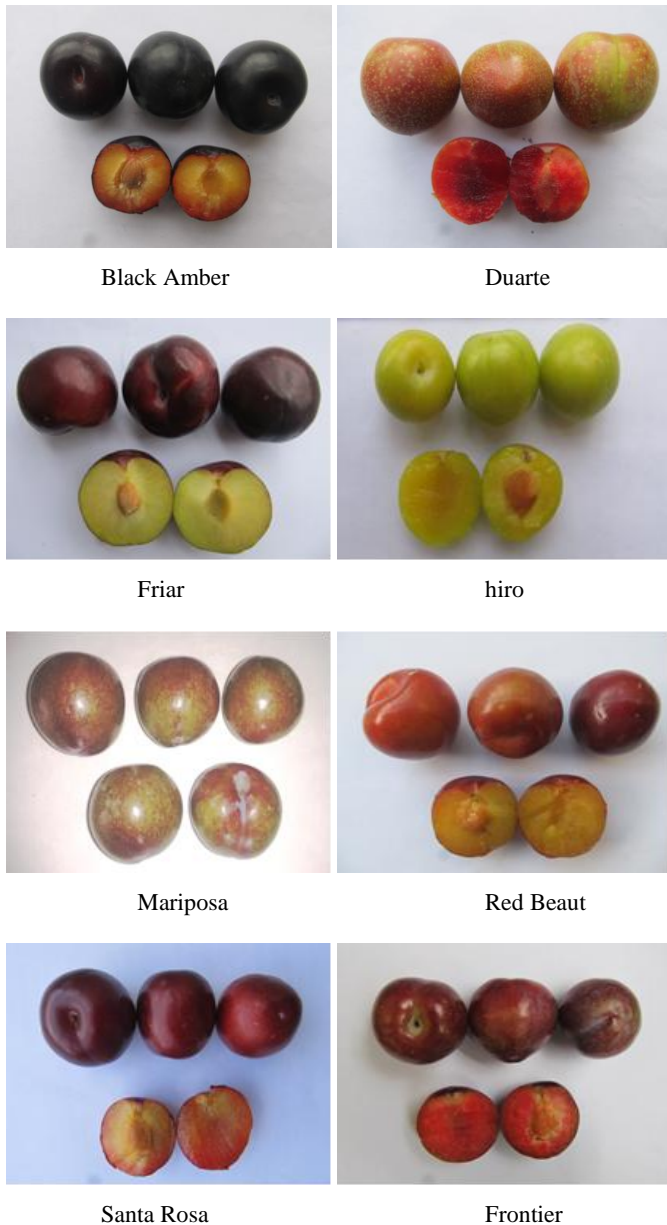
The findings of Bist and Sharma, (2002) [28] also supported our results where fruit set ranged from 6.26 to 18.71 percent. Variation in fruit drop was low i.e. ranging from 61.05 to 80.47 percent as compared to the findings of Mishra and Sud, (1977) [29] who recorded fruit drop of 96 percent in cultivar Green and 77 percent in Mariposa. Gupta, (2014) [30] recorded more than 86.41 percent total fruit drop in ‘Satluj Purple’ plum under various irrigation and mulch treatments, while less initial fruit drop of 75 percent and 64 percent was reported by Sattar *et al.*, (2013) [31] in ‘Hollywood’ plum during their study. Extending the duration of harvest time is important for sending the adequate supply of fresh fruits to the market due to their high demand and price. Kemp *et al.*, (1986) [32] suggested growing early, medium and late plum cultivars considering the climatic conditions in targeted areas to reduce market risks, expand harvest time and to increase the supply of fresh fruits to market. A high variability in average fruit weight and size has also been reported in plum by Dhatt *et al.*, (1982) [33] in different parts of Punjab state. One of the important characteristics of the plum fruit is its size. These findings on fruit weight is supported by the work of Thakur *et al.*, (2014) [24] where the variation was between 29.20 g (Florida 1-2) and 80.51 g (Fortune), while Bist and Sharma (1996) [28] reported greater variation in fruit weight which ranged from 17.32 g in ‘Methley’ to 66.50 g in ‘Frontier’. Fruit colour variations observed during the current study was also supported by Thakur *et al.*, (2014) [24] and Kumar *et al.*, (2013) [16].

**Table 3: Physical characters of different plum cultivars**

Cultivars	Duration of flowering	Fruit set	Fruit drop (%)	Fruit retention (%)	Harvest date	Time for maturity
Duarte	14	12.44 (3.67)	66.67(57.72)	27.73(31.73)	8-07-2015	115
Black Amber	16	17.52 (4.30)	62.70(52.34)	34.11(35.71)	26-06-2015	116
Friar	13	15.67 (4.08)	70.02(56.81)	17.53(17.53)	10-07-2015	112
Shiro	12	24.08 (5.01)	61.05(51.40)	34.89(36.18)	23-06-2015	98
Frontier	15	21.89 (4.78)	72.00(58.06)	15.60(23.19)	16-06-2015	106
Santa Rosa	14	16.55 (4.19)	72.33(58.27)	11.63(19.93)	17-06-2015	108
Red Beaut	16	9.62 (3.25)	80.47(63.75)	14.23(22.13)	29-05-2015	96
Mariposa	15	17.75(4.33)	77.26(58.00)	18.70(22.59)	12-07-2015	127
C.D <sub>0.05</sub>	14	0.16	5.26	2.22	-	-

**Table 4: Fruit characters of different plum cultivars**

Cultivars	Fruit firmness (kg/cm <sup>2</sup> )	Fruit Yield (kg)	Pulp/stone ratio	Adherence to stone
Duarte	1.76	4.13	38.57	Clingstone
Black Amber	2.42	4.51	26.94	Freestone
Friar	2.36	4.01	34.72	Freestone
Shiro	2.08	7.30	20.17	Semi-cling
Frontier	2.16	7.02	48.31	Freestone
Santa Rosa	2.06	5.60	37.01	Clingstone
Red Beaut	1.98	3.76	45.84	Semi-cling
Mariposa	2.18	4.20	40.42	Semi-cling
C.D <sub>0.05</sub>	0.31	1.57	1.98	



**Fig 1:** Photographs showing old standard plum cultivars under study

#### 4. Conclusion

From the preliminary study conducted on different plum cultivars, it can be concluded that the plum cultivar Shiro was found to be vigorous. Some while ‘Black Amber’ and ‘Duarte’ were found to be promising with respect to fruit biochemical characters and matures in mid and late season, respectively. Therefore, it can be suggested that ‘Black Amber’ and ‘Duarte’ may be suitable for cultivation under mid-hills condition of Himachal Pradesh and can be better alternatives to change the monotony of ‘Santa Rosa’ in order to stretch the harvesting season, fulfill consumer ever-changing taste and provide better remuneration to the growers.

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