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Performance of Some Japanese Plum (*Prunus salicina*) Cultivars in Mid-hill Condition of Kullu Valley, Himachal Pradesh

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ABSTRACT

A study was conducted during February to July, 2020 and 2021 at the Horticultural Research Station Seobagh, Himachal Pradesh, India to evaluate various attributes of plum under the mid-hill temperate zone. Ten plum cultivars Red Beaut, Au Rosa, Au Amber, Satluj Purple, Kala Amritsari, Shiro, Frontier, Mariposa, Black Amber, Queen Rosa, and Angeleno grafted on wild apricot were evaluated alongside with numerous standards in a high-density experimental orchard, and these types were compared with the "Santa Rosa" variety as a control. According to the findings, Red Beaut ripened first whereas the cultivar Mariposa took 150 days from flowering to harvest, making it the last to be picked. The cv. Au Rosa had the largest trunk girth (44 cm), cv. Mariposa likewise had the longest shoots, measuring 180 cm, cv. Frontier had the highest fruit output per tree (145 kg), closely followed by the cv. Black Amber (140 kg) which also has maximum fruit size (5.4 cm), and weight (130 g). The cv. Frontier (14.1°B) showed the highest TSS, followed by the cv. Mariposa (14.0°B), while the cv. Kala Amritsari showed the lowest TSS. The plum cultivar Kala Amritsari displayed the highest fruit acidity, at 2.3%. Due to their ability to extend the repining period from May through August, the plum cultivars Red Beaut, Frointer, Mariposa, and Black Amber were found to be appropriate for commercial cultivation in Himachal Pradesh.

KEYWORDS: Cultivars, growth, Japanese plum, physico-chemical properties, yield

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1. INTRODUCTION

Plum is one of the most important stone fruits, consumed mainly fresh and dried, although a small quantity is used for canning and beverages (Joshi and Bhutani, 1995). Plums are characterized by variation in many plant characteristics, 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). The fruits may be small or large, round or oval, green, yellow, golden, black, purple, blood red with a variety of flavor aroma, and texture (Joshi and Bhutani, 1995; Rieger, 2006). Plum are rich source of minerals and vitamins. Additionally, plums have chemicals, like sorbitol and dietary fibres, which help control various body processes (Prajapati et al., 2012).

Most of the plums grown commercially fall into one of two groups: European or Japanese, Taxonomically, Japanese plums and European plums belong to the same section, but differ in adaptability, places of origin, and domestication. Japanese plums are believed to have originated in China from where it was spread all over the world and took its name (Faust, 1999; Rieger, 2006). Japanese plum have extremely varied ripening time frames, because of its exceptional tolerance, Japanese plums are grown in both subtropical and temperate climates. Due to their extraordinary potential for climate adaptation, they can withstand various temperature ranges. Areas with Japanese plum orchards are expanding quickly worldwide (Grzyb, 2002). The Japanese plum, *Prunus salicina* Lindl., is mostly grown in China and Japan. It is primarily grown in temperate and sub-temperate regions of various states in India. Japanese plums are mostly consumed fresh (Rieger, 2006).

Earlier in Himalayan states of Jammu & Kashmir and Himachal Pradesh, plum cultivar Santa Rosa dominates 75% of the area. As plum cultivar Santa Rosa is regular bearer and produce quality fruit with high yields. Due to perishable fruit and poor market value Santa Rosa cultivar is becoming less common among orchardists in the valley. So new varieties of Japanese plums must be introduced for commercial production in the valley in order to overcome Santa Rosa's drawbacks, boost varietal variation for greater economic benefits, and solve issues related to climate change. There is need for new exotic introductions 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), Tripathi et al. (1984), Dhatt et al., 1992 , Singh et al. (2002), Kumar et al. (2018).

In order to address all these concerns, to expand the germplasm and to choose the varieties that are most suited to the Kullu valley of Himachal Pradesh, eleven new varieties of plum were introduced at Regional Horticultural Research and Training Station Bajaura and the current study was carried out to identify suitable varieties out of these that may be grown in the Kullu area of Himachal Pradesh. These varieties should have good physicochemical characteristics that could lengthen or spread the harvesting season. The selection of an appropriate cultivar is the main challenge an orchardist encounters before planting an orchard as there is little systematic and thorough information in the literature about the performance of several Japanese plum cultivars in Himachal Pradesh and other hill regions of the nation. Therefore this study is focused on the evaluation of performance of these cultivars in the Mid-hills of Kullu valley.

2. MATERIALS AND METHODS

A study was conducted during February to July, 2020 and 2021 at the Horticultural Research a Station, Seobagh, Himachal Pradesh, India. The experimental orchard was planted in the month on January at Horticultural Research Station, Seobagh. Plum cvs. Red Beaut, Au Rosa, Au Amber, Satluj Purple Kala Amritsari, Shiro, Frontier, Mariposa, Black Amber, Queen Rosa and Santa Rosa grafted on wild apricot were planted at a spacing of 3m×6m (3m between the rows and 6 m between trees) in randomized block design with 3 trees per replication. Climatic conditions of Bajaura are characterized by the average maximum temperature of 17.3–33.1°C, minimum temperature of 3.0–19.3°C and the average annual rainfall of 918 cm. The orchard was located at the altitude of 1090 m amsl. Experimental trees were trained as modified Leader System training. Contact herbicides and manual weeding were used to maintain clean strips beneath trees, while routinely cut sod was maintained in the alleyways between tree rows. Soil analyses were used to determine how much fertiliser to use. According to the guidelines used for commercial orchards, pest and disease control spraying was carried out. The following observations on plum cultivars' flowering behaviour, flowering period, ripening time, and fruit characteristics were made. The fruits' taste, colour development, and picking ease were used to measure their maturity. Ten cm above the graft union was used to measure the trunk's girth, and 10 randomly chosen shoots of the tree's current season's growth were measured to determine the tree's yearly extension growth. With the help of an Erma hand refractometer, the total soluble solids were calculated. By utilizing a phenolphthalein indicator to titrate a fruit pulp solution against N/10 NaOH, the titratable acidity of the solution was calculated. The AOAC technique was used to determine the content of reducing sugars and total sugars (1980). Data were pooled and statistically analyzed using OPSTAT software.

3. RESULTS AND DISCUSSION

3.2. Time and duration of flowering

The cultivar Red Beaut was first flower to open flower, displayed full bloom, and experienced petal fall first (on March 2, March 14, and March 19, respectively). Au amber and Frontier were the next cultivars to do so. Shiro and Queen Rosa, on the other hand, were the latest to have their first flower open, show full bloom, and petal fall, respectively, on March 14, March 26, and March 30. Flowering duration in different cultivars varies from 10 to 17 days, similar variation in flowering duration is observed by Thakur et al. (2014) and Sharma et al. (2018) where the duration of flowering varies from 12 to 16 days. In comparison to other cultivars, cv. Red Beaut had the longest flowering duration, lasting 17 days, whereas Au Rosa and Frontier had shorter blooming periods of 10 days. According to climatic factors (such as height, temperature and others), the timing and length of flowering can vary from year to year (Woznicki et al., 2019). According to Rimpika and Sharma (2021), the timing and length of flowering are characteristics that are controlled by both genetic and climatic factors (Table 1).

Table 1: Time and duration of flowering and days from flowering to harvesting time of different plum cultivars

Cultivar	Date of bud burst	Date of first flower open	Date of full bloom	Date of petal fall	Duration of flowering (Days)	Days from flowering to harvest	Date of harvest
Red Beaut	21st Feb	2nd March	14th March	19th March	17	77	28th May
Au Rosa	3rd March	10th March	15th March	20th March	10	99	19th June
Au Amber	4th March	9th March	14th March	20th March	11	98	18th June
Kala Amritsari	3rd March	8th March	15th March	22th March	14	90	14th June
Satluj Purple	3rd March	7th March	15th March	23rd March	16	89	12th June
Shiro	4th March	14th March	26th March	30th March	16	79	30th June
Frontier	2nd March	9th March	15th March	19th March	10	117	4th July
Mariposa	28th Feb	10th March	21th March	26th March	16	150	28th July
Black Amber	1st March	11th March	20th March	26th March	15	121	10th July
Queen Rosa	3rd March	14th March	25th March	30th March	16	121	13th July
Santa Rosa	3rd March	10th March	15th March	20th March	10	92	12th June

3.2. Fruit maturity

With only 77 days between flowering and harvest, Red Beaut was the earliest to ripen. Mariposa required 150 days from flowering to harvest and was the last variety. From a marketing perspective, Red Beautearly ripening was favourable because it occurs when no other plum varieties were ready for harvest. The different cultivars' maturation dates ranged from 28 May to 15 September.The genetic make-up of each cultivar, the growing environment, and geographic locations all affect fruit maturity. Pre-harvest techniques include managing the canopy, floor, nutrients, and water as well as plant growth regulators have been shown to influence crop phenology and fruit maturity (Table 2).

3.3. Growth and yield

The results on growth and yield are shown in Table 3, which showed that the cv. Au Rosa had the maximum trunk girth (44 cm), followed by the cv. Red Beaut (43 cm), and the cv. Shiro had the lowest trunk girth (33 cm). The maximum shoot growth of 172 cm was recorded with cvs. Mariposa, Red Beaut, Shiro, Queen Rosa, and Santa Rosa whereas cv. Satluj Purple had the shortest shoot length (120 cm). The annual season shoot growth may be affected by a variety of applied treatments, but genotype is the primary factor (Arzani et al., 2009, Elshihy et al., 2004). According to Loreti et al. (2000) and Wertheim (2000), genotype has an impact on tree size, therefore sufficient shoot growth and vigour were required for optimal photosynthesis to provide enough carbohydrates for a strong fruit sink and high yield Arzani (1994).

The cv. Frontier had the highest fruit output per tree (145 kg), followed closely by the cv. Black Amber (140 kg), and the cv. Satluj purple had the lowest fruit yield (100 kg tree^{-1}). The final yield may be impacted by a number of factors, including appropriate and optimum pollination, hormone levels, sufficient vegetative growth, and orchard management, but genotype has a significant impact on plant performance (Lezzoni et al., 1991, Arzani, 1994)

3.4. Fruit character

The data presented in the Table 3 revealed that maximum

Table 2: Growth, yield and fruiting characters of different plum cultivars

Cultivar	Fruit								Stone	
	Trunk girth (cm)	Shoot length (cm)	Fruit yield kg tree^{-1}	Skin colour	Flesh colour	Size	Shape	Taste	Stone weight	Flesh adherence
Red Beaut	43	172	121	Reddish purple with bloom	Reddish yellow	Medium	Globose to ovate	Sweet with acid blend	0.6	Cling stone
Au Rosa	44	125	104	Dark Red with bloom	Saffron yellow	Medium	Round	Sweet	0.9	Cling stone
Au Amber	40	131	101	Red with Golden strips	Reddish	Medium	Round	Sweet with acid blend	1.4	Semi Cling Stone
Kala Amritsari	34	120	121	Purplish Black	Yellowish	Small	Flat round/ round oblate	Acidic	0.7	Cling Stone
Satluj Purple	37	121	100	Reddish Purple with bloom	Yellowish	Medium	Elongated heart	Sweet with acid blend	1.2	Cling Stone
Shiro	33	172	131	Yellowish	Yellowish	Small-Medium	Globose to heart shape	Sweet with acidic blend	0.7	Cling Stone
Frontier	38	165	145	Purplish Red with bloom	Reddish	Large	Flat round	Sweet	1.0	Free Stone
Mariposa	39	180	121	Mottled moron over green skin	Blood Red	Large	Heart shape	Sweet	1.7	Free Stone
Black Amber	35	140	140	Purplish Black with Bloom	Yellowish	Large	Round	Sweet with acidic blend	0.8	Semi cling Stone
Queen Rosa	40	172	131	Reddish	Yellowish	Large	Heart shape	Sweet with acidic blend	1.3	Cling Stone
Santa Rosa	38	172	130	Reddish Yellow with bloom	Yellowish	Medium	Globose to ovate	Sweet with acidic blend	0.7	Cling Stone
SEm±										
CD (p=0.05)	6.2	1.0	1.5	-	-	-	-	-	0.1	-

fruit length (5.4 cm), breadth (6.4 cm) and fruit weight (130 g) was observed by cv. Black Amber followed by cv. Frontier and Mariposa having fruit length of (5.2 cm and 5.1 cm), breadth (6.0 cm and 5.5 cm) and fruit weight of (110 g and 90 g). Minimum fruit length (2.5 cm), breadth (2.9 cm) and fruit weight (16 g) was observed by cv. Kala Amritsari. Red Beaut is one of earliest variety, the fruits ripens in late May provided good quality fruit and mild flavour. Red Beaut has globose to ovate medium size fruits weighing 29–65 g having smooth, bright red colour skin that turns reddish-purple when fully ripe. The yellowish cling stone flesh is fairly firm to slightly soft and very juicy with a pleasantly sweet flavour and slightly tart skin. Seeds are broad ovate and small in size weighing 0.6 g. Au Rosa is resistant to Bacterial canker, bacterial fruit spot and leaf spot. The fruit of Au Rosa are round, medium in size weighing 49–73 g having dark red

Table 3: Physico-chemical characteristics of different plum cultivars

Cultivars	Fruit weight (g)		Fruit length (cm)	Fruit breadth (cm)	TSS °Brix	Acidity (%)	Reducing sugars (%)	Non-Reducing Sugars (%)	Total sugars (%)
	Max.	Min.							
Red Beaut	65	29	4.0	3.7	9.3	1.3	5.2	0.2	5.8
Au Rose	73	49	5.2	5.4	11.0	1.3	6.9	0.7	7.6
Au Amber	72	45	4.8	4.8	11.1	1.3	5.4	0.6	6.5
Kala Amritsari	16	13	2.5	2.9	11.0	2.3	4.8	1.2	6.0
Satluj Purple	40	25	4.5	4.4	13.2	1.5	4.9	2.5	7.4
Shiro	45	35	3.8	4.3	10.5	1.6	5.0	1.0	6.0
Frontier	110	90	5.2	6.0	14.1	1.0	7.9	0.4	8.3
Mariposa	90	75	5.1	5.5	14.0	1.0	7.8	0.4	8.2
Black Amber	130	100	5.4	6.4	11.4	1.4	5.9	0.8	6.7
Queen Rosa	107	80	5.1	5.9	11.6	1.0	5.9	0.9	6.8
Santa Rosa	66	50	4.3	4.2	12.5	1.2	5.4	1.3	6.7
SEm±									
CD (p=0.05)	4.5	5.6	1.2	1.0	1.6	0.4	0.9	0.6	1.5

skin with sweet saffron yellow coloured cling stone flesh. Fruits have adequate firmness for handling, packing and shipping. Seeds are narrow kidney shaped and small in size weighing 0.9 g Au Amber is a heavy producer of 72–45 g dark red skinned roundish, medium sized sweet with acid blend amber coloured semi clingstone flesh. Good for fresh eating and canning. Seeds are ovate and weighing 1.4 g. Satluj Purple is a self-unfruitful cultivar and requires Kala Amritsari as pollinizer. Kala Amritsari should be planted as alternate plant in alternate row for achieving good fruit set. The tree is medium in vigour with upright growth habit. The fruits are elongated heart shaped, purplish red with bloom, medium size weighing 25–45 g. The skin develop crimson colour on ripening. The skin is thick and flesh is yellowish in colour, firm fleshed and clingstone. Seeds are ovate and small in size weighing 1.2 g. Kala Amritsari is self-fruitfull high yielding variety. The trees are vigorous with profuse branching. Fruits are medium size, round oblate depressed at both ends weighing 16–13 g. The skin on ripening becomes dark brown. The flesh is yellowish in colour, cling stone and juicy. Fruit is preferred for making jam and squash.Seeds are broad elliptic in shape weighing 0.7 g. Shiro is best in yellow plum. Shiro grows clusters of plum all throughout the tree. Fruits are small to medium in size globose to heart shaped with yellowish skin weighing 35–45 g. The flesh is yellowish in colour, cling stone and juicy. Seeds are elliptic in shape weighing 1.0 g. Frontier is a blood plum that is sweet to eat. The skin colour is red and there is no tartness in the skin. The plum is large in size, heart shaped weighing 90–110 g with a lighter red coloured free stone flesh. Seeds are small weighing 1.0 g. It is a self-unfruitful cultivar and requires other compatible variety for pollination. Mariposa is another Japanese blood plum that is sweet to eat. The fruits are large heart shaped weighing 90 g. Fleshed is blood red, sweet, juicy, firm, delicious and free stone. The seed is small weighing 1.7 g. Epicarp is mottled maroon over green skin. It is a self-unfruitful cultivar. Black Amber is a heavy bearing plum which produces plenty of large round black coloured fruits weighing 100–130 g. The flesh is semi cling stone, deliciously juicy and yellowish in colour. Seeds are small weighing 0.8 g. It is partially self-fertile variety. It is good variety for export because of its good keeping quality.

Queen Rosa is red coloured slightly tart skinned, mildly sweet, cling stone, yellow fleshed plum. The fruits are heart shaped large size weighing 80–107 g. Seeds are small weighing 1.3 g. It is partially self-fertile variety. Santa Rosa tree produce abundant sweetly flavored, dark purple fruits. The fruits are globose to ovate in shape and medium size weighing 29–38 g. The yellowish cling stone flesh is fairly firm to slightly soft and very juicy with a pleasantly sweet flavour and slightly tart skin. Seeds are broad ovate and small in size weighing 0.7 g.

This variation may result from variations in cultivar genetic makeup and crop load, which appear to be the causes of variations in fruit weight and size. The findings of Sharma et al. (2018) and Ozakman et al. (1995) who reported that the cause of variance in fruit weight may be related to various fruit size (length and breadth) and different crop loads, are in agreement with the results. Additionally, the

current findings are consistent with past research by Bal and Chohan (1981) and Mishra and Srivastava (1973).

3.5. Chemical character

Maximum TSS was observed with cv. Frontier (14.1°B) followed by cv. Mariposa (14.0°B) and minimum TSS was observed with cv. Kala Amritsari. Fruit acidity of different cultivars ranged from 1.0% to 2.3%. The plum varieties Kala Amritsari showed maximum fruit acidity i.e. 2.3% and minimum fruit acidity was recorded with cultivars Frontier, Mariposa and Queen Rosa. Reducing sugars and non-reducing sugars in different cultivars varied from 4.8% to 7.9% and 0.2% to 2.5%, respectively. This Variation in TSS, acidity, reducing sugars and non-reducing sugars may be due to the genetic makeup of the plum cultivars and also may due to agro climatic conditions, management practices, location and storage conditions (Sharma et al., 2018, Son, 2010, Erturk et al., 2009). The chemical composition of various cultivars varies because of varied rates at which complex organic acids are converted into simple sugars at maturity, as well as due to agro-climatic condition and nutritional factors (Fotiric et al., 2023)

4. CONCLUSION

The plum cultivars Red Beaut, Frointer, Mariposa and Black Amber were ideal for commercial cultivation in Himachal Pradesh as these cultivars extends repining period from May to July and the fruits have good taste, flavour, keeping and Shipping quality.

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