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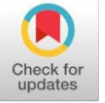
# Performance of New Apple Varieties under Cold Dessert Conditions of Lahaul and Spiti Valley

Meena Kumari\*<sup>1</sup>, Savita Kumari<sup>2</sup>, Sudhir Verma<sup>3</sup>, Rajesh Kumar Dogra<sup>1</sup> and Munmun Joshi<sup>1</sup>

<sup>1</sup>Department of Fruit Science, College of Horticulture and Forestry, YSPUH&F, Nauni, Solan, Himachal Pradesh (173 230), India

<sup>2</sup>Department of Social Science, College of Horticulture and Forestry, Neri, Hamirpur, Himachal Pradesh (177 001), India

<sup>3</sup>Department of Soil Science, College of Forestry, YSPUH&F Nauni Solan Himachal Pradesh, India



## ABSTRACT

High density orcharding and the quest for high quality produce is gaining day by day and extending its spread into the dry temperate regions. Lahaul and Spiti region of Himachal Pradesh, India is known for its quality apple production but is a quite fragile ecotype with high degree of vulnerability to the climatic changes. Agro-ecologically the region is quite variable from wet temperate conditions to highly dry temperate dessert conditions. Intensive apple cultivation therefore in the region needs critical prior assessment for its sustained success. The studies presented in this research article discuss the expected performance score of different clonal and seedling rootstocks, spur and high coloring cultivars in high densities of planting. Six apple varieties on different rootstocks under high-density plantations were evaluated for growth, yield and quality parameters. The experiment evaluated six apple varieties 'Super Chief/MM 106', 'Red Velox/M9', 'Jeromine/M9', 'Gale Gala/M9', 'Redlum Gala/M9' and 'Auvial Early Fuji/M9' planted at a spacing of 2.5×1.0 m<sup>2</sup> in Randomized Block Design, with three replications. From the evaluation of data on growth, yield and quality traits, it was found that var. 'Super Chief/MM 106', followed by cultivars 'Red Velox/M9' and 'Jeromine/M9', has recorded better horticultural performance than other varieties studied. Among different varieties 'Super Chief/MM 106' recorded maximum annual shoot extension growth (25.72 cm), trunk girth (45.16 mm) and tree height (290.20 cm), tree spread (322.31 E-W and 291.15 cm N-S), fruit Breadth (80.17 mm), fruit weight (213.08 g fruit<sup>-1</sup>), TSS (12.60 °Brix), fruit length (72.82 mm), fruit yield (4.61 kg tree<sup>-1</sup>) and productivity (18.44 MT Hac<sup>-1</sup>). Cultivar 'Super Chief/MM 106' was found to be superior for growth, flowering, yield and quality characteristics.

**Keywords:** Cultivar, High Density Planting, Jeromine, Productivity, MM106, Red Velox, Rootstock, Super Chief, Variety.

## 1. INTRODUCTION

In temperate fruits, Apple is a major fruit crop occupies prime position in Himachal Pradesh and in the recent years; it has emerged as the leading cash crop among all the fruit crops. In the last ten years have been sufficient to explain the climatic changes, less precipitation and increased average temperatures have melted glaciers and changed the distribution of vegetation. In Himachal Pradesh, one of the miracles of climate change is the apple farming in the Cold dry temperate region of the Spiti valley (2400–6517 m) because the bulk of people in the tribal area had no idea that apples could be grown for profit five to ten years ago. The area's quick climatic change caused an adjustment in the apple farming zone. The average land use per farm in Lahaul and Spiti valley showed more than two percent shift towards apple cultivation with increased income more than 10 percent, but similarly, it also showed reverse trend in other apple growing regions of Himachal Pradesh. It is thought that for this crop to benefit from the chilling treatment that prevents epidemic diseases there must be a moderate amount of snowfall between December and February. Additionally, apples cultivated in harsh, cold climates have a lengthy shelf life, making them valuable for international standard exports.

\*Corresponding Author: **Meena Kumari**

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It is currently seen as a significant source of revenue for the local farmer community. Apple cultivation has completely transformed the socio-economic status of rural masses in the High Hills zone of the State [10]. The apple cultivation area has been increased from 97438 ha<sup>-1</sup> in 2008–09 to 114650-ha<sup>-1</sup> by 2021–22 with the production of apple has gradually reached 643000 MT with a productivity of 5.62 MT in 2022 [1]. The production of apple has gradually increased by bringing more area, into apple farming but in the same time overall export quality and productivity has declined and in state, it is still a major concern for the apple farming community [2]. Using technologies for the enhancement of productivity and quality of fruits in orchards, considering the economic outlook [8]. Studies have shown that by way of planting of new cultivars in the high density planting systems provide possibilities to the growers and farmers for getting large yields with higher returns in the beginning years and maintain a high potential for getting significant productivity over the entire crop during later. High density plantation (HDP) with improved cultivars and new production techniques different from traditional farming methods which is not only provides higher yields but also provides higher net economic returns per unit area in the initial years and also facilitates more efficient use of inputs. In Spiti valley, some of the progressive farmers/orchardists inspired by the demonstration block under HDP established by Krishi Vigyan Kendra, Tabo, with some new varieties, currently seeing higher productivity (30 to 60 MT) in their orchards under local environment conditions as compared to 3-8 tons/hectare with low density traditional orchards.

The basic function of HDP is to confine the exploitation zone of the plant with regard to light, water and nutrients etc. Added to it, the farmers of Spiti valley also have a great option to remove high density orchard after 15-20 years or so to replant to newer, higher value cultivars which further enhance the probability of profit. There is not much of data available to support the suitability of high density plantations from an Indian perspective when it comes to utilizing the advantages of apple High Density Planting particularly in light of Himachal Pradesh hilly terrain. Now, it is a hope of the most inhabitants that dry and cold desert area is on the way of becoming green valley in future. The introduced new apple varieties of apple from America have a potential to produce fruits earlier than the local varieties. There is an urgent need to plant the varieties which gives early production, so the people could adopt cultivation of apples for their subsistence. Dwarf varieties possessing vertical branches (more or less) with high productivity of fruits should be planted in the area, because harvesting practices is performed in the month of late October to November end. Therefore, to provide an excellent variety for growing in their high-density orchards with suitable rootstocks and planting systems for the varied agro-ecological situations of Spiti valley of Himachal Pradesh performance of six advanced apple varieties Jeromine, Red Velox, Super Chief, Redlum Gala, Auvial Early Fuji and Gale Gala are being proposed to be studied in the Krishi Vigyan Kendra, Tabo for future recommendation to the farming community to uplift their overall socio economic status.

## 2. MATERIALS AND METHODS

This study was conducted at Krishi Vigyan Kendra, Tabo, Lahaul and Spiti-II of Dr. YS Parmar University of Horticulture and Forestry, Nauni, Solan, H.P. for two years from December 2018 to December 2020. The site is located at latitude of 32° 5.15' North latitude and 78° 23.054' East longitude on the globe with an altitude of 3243 m above mean sea level. The orchard portrays the true dry temperate climate of the northwest Himalayas. There is virtually no rainfall during monsoon in the region because of rain shadow effect but in recent past few years there was unprecedented rainfall and snowfall has also been observed. The summer is very dry and short, while winter is long cold and freezing. The study was conducted in six exotic varieties of apples viz., 'Red Velox/M9', 'Jeromine/M9', 'Super Chief/MM 106', 'Gale Gala/M9', 'Redlum Gala' and 'Auvial Early Fuji/M9' in 2016, imported from GRIBA (Italian nursery).

**Table 1: Growth parameters of apple varieties in high-density plantation under cold dry temperate conditions of Lahaul and Spiti valley, Himachal Pradesh (Pooled data of 2019 and 2020)**

Name of cultivar	Rootstock	Annual shoot extension growth			Trunk Diameter (mm)			Plant height (cm)			Plant Spread E-W (cm)			Plant spread N-S (cm)		
		2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
Jeromine	M9	19.88	25.22	22.55	32.25	43.55	37.90	181.00	192.86	186.93	122.24	140.42	131.33	95.50	108.35	101.92
Super Chief	MM106	22.12	29.32	25.72	39.49	50.83	45.16	265.00	315.41	290.20	315.33	329.3	322.31	281.16	301.14	291.15
Red Velox	M9	21.05	26.25	23.65	37.82	49.19	43.50	251.33	308.62	279.97	143.60	156.78	150.19	270.17	291.31	280.74
Gale Gala	M9	15.88	19.25	17.57	28.42	38.73	33.58	149.66	162.35	156.01	51.60	72.28	61.94	40.97	67.26	54.11
Redlum Gala	M9	18.69	24.55	21.62	32.55	42.5	37.52	154.66	169.07	161.87	104.21	114.01	109.11	92.89	104.47	98.68
Auvial Early Fuji	M9	16.53	21.96	19.25	31.15	37.62	34.38	141.33	148.78	145.06	56.52	71.28	63.90	47.93	59.31	53.62
CD <sub>00.5</sub>		0.79	1.10	1.00	1.47	1.36	2.04	7.62	8.44	11.95	6.07	10.35	7.11	8.33	10.22	7.16

Table 2 Pooled data revealed that the higher fruit length (72.82 mm), fruit breadth (80.17 mm) and fruit weight (213.06 g fruit<sup>-1</sup>) was noted in Super Chief/MM 106, whereas minimum fruit length (58.71 mm), fruit breadth (66.42 mm) were recorded in varieties Auvial Early Fuji/M9 and fruit weight (136.42 g fruit<sup>-1</sup>) was recorded in cultivar Redlum Gala/M9.

Three trees of each variety were randomly selected. The trees selected for this study were planted at a distance of 2.5×1.0 m<sup>2</sup> (4000 trees ha<sup>-1</sup>) with three replicates in a randomized block design. Growth parameters were recorded after the plants entered dormancy and before pruning. Average trunk diameter (mm), tree height (cm), tree spread (cm) and annual shoot extension growth (cm) were measured, following standard procedures. The spread of the tree was evaluated with the help of measuring the wood scale by recording the maximum canopy spanning the North-South and East- West directions. The fruit set was recorded three weeks after petal fall. The yield of fruits under different treatments was recorded at the time of harvest by weighing the total fruits on a top pan balance. The yield was expressed in kilograms tree<sup>-1</sup> (kg plant<sup>-1</sup>). Fruits harvested from each selected plant were counted on each harvest and finally totaled to extract the average number of fruits plant<sup>-1</sup>. Productivity was calculated on the basis of kg plant<sup>-1</sup> and per unit area. The fruit's physical properties in terms of weight (g) and size (cm) were recorded by calculating the mean of ten fruits at final harvesting stage. The chemical characteristics of the fruits viz. TSS, titratable acidity, reducing sugars, total sugars and non-reducing sugars were recorded by using the methods described by [9]. The data recorded in 2019 and 2020 were pooled and statistical analysis was carried out accordingly.

## 3. RESULTS AND DISCUSSION

The data presented during study (Table 1) revealed that the most of the characteristics (growth) viz. annual shoot extension growth, trunk diameter, plant height and plant spread (E-W and N-S) recorded significant differences during the study. The pooled data revealed that the maximum annual shoot extension growth (25.72 cm), trunk diameter (45.16 mm), plant height (290.20 cm) and plant spread (322.31 cm EW, 291.15 cm NS) was recorded in Super Chief grafted on clonal rootstock MM106. However, minimum annual shoot extension growth (17.57 cm), trunk diameter (33.58 mm), plant height (145.06 cm), plant spread (East- West, 61.94 cm and North- South 53.62 cm) observed in Gale Gala on clonal rootstock M9. The variation could also be the result of phenotypic characteristics of the varieties, management practices and the site of the plantation, variation in growth traits such as plant height, girth, among different clones of banana [3] [4] [6] and [12].

Non-significant differences in yield per tree were recorded among the four varieties under study; however, higher yield (4.61 kg tree<sup>-1</sup>) and productivity (18.44 MT/hac) were recorded by cultivar Super Chief/MM 106, while the minimum yield (3.22 kg tree<sup>-1</sup>) and productivity (12.88 MT/hac) were recorded in cultivar Auvial Early Fuji/M9. Variation in fruit yield has been attributed to many factors such as variety and rootstock [7] [11] [5]. The better performance of Super Chief /MM106 and Jeromine/ M9 might be due to inherent vigor and bearing habit. The higher yield in spur type varieties compared to standard varieties is mainly due to their spur formation and their genetic make-up.

**Table 2: Fruiting parameters of apple varieties in high-density plantation under cold dry temperate conditions of Lahaul and Spiti valley, Himachal Pradesh (Pooled data of 2019 and 2020)**

Name of cultivar	Rootstock	Fruit Length (mm)			Fruit width (mm)			fruit weight (g)			Yield (kg/tree)			Productivity (MT/Ha)		
		2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
Jeromine	M9	70.07	65.70	67.88	74.37	75.24	74.81	211.07	168.33	191.25	4.16	3.85	4.00	16.64	15.40	16.02
Super Chief	MM106	73.99	71.66	72.82	80.67	79.67	80.17	231.37	199.66	213.08	4.06	5.16	4.61	16.24	20.64	18.44
Red Velox	M9	73.27	60.71	66.99	78.12	72.15	75.13	168.88	152.73	163.74	3.66	3.59	3.62	14.64	14.36	14.50
Gale Gala	M9	59.67	60.43	60.05	69.14	66.35	67.74	137.94	143.66	141.21	3.56	3.25	3.40	14.24	13.00	13.62
Redlum Gala	M9	73.00	58.80	65.90	79.00	62.42	70.71	161.98	117.33	136.42	3.92	3.13	3.52	14.00	12.52	13.26
Auvial Early Fuji	M9	58.33	59.09	58.71	65.33	67.52	66.42	183.9	150.33	167.68	3.03	3.41	3.22	12.12	13.64	12.88
CD <sub>0.05</sub>		3.92	4.00	2.98	2.63	3.61	4.79	8.92	6.14	8.79	0.17	0.12	0.29	0.74	0.71	0.79

The pooled data pertaining to total soluble solids, titratable acidity, total sugars, reducing sugars and non reducing sugars have been recorded (Table 3). The analysis of variance revealed significant differences for total soluble solids characteristics. The data relating to total soluble solids indicated that the maximum TSS (17.16 °Brix) was recorded for in Gale Gala/M9 closely followed by Redlum Gala/M9 (17.08 °Brix). The lowest TSS (12.60 °Brix) was observed for Red Velox/M9. Maximum titratable acidity was recorded in (0.30 %) in Super Chief/MM106 and minimum was found in (0.15 %) in Jeromine/M9. Total sugar was recorded highest in Super Chief /MM106 (29.06 %) which was found to be statistically at par with Red Velox/M9 (28.64 %) Jeromine/M9 (28.14 %) and Auvial Early Fuji/ M9 (27.64 %).

Reducing sugars was found maximum in Super Chief/MM106 (8.02 %) and minimum in cultivar Redlum Gala (7.01 %) where as non-reducing sugars was found maximum in Super Chief/MM106 (3.93 %) and minimum in cultivar Redlum Gala (2.53 %)

**Table 3: Fruit quality parameters of apple varieties in high-density plantation under cold dry temperate conditions of Lahaul and Spiti valley, Himachal Pradesh (Pooled data of 2019 and 2020)**

Name of cultivar	Rootstock	TSS(°Brix)			Titratable acidity (%)			Total sugar (%)			Reducing Sugars (%)			Non reducing-sugars		
		2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
Jeromine	M9	15.18	13.25	14.21	0.16	0.14	0.15	28.71	27.56	28.14	8.23	7.52	7.88	3.76	3.56	3.66
Super Chief	MM106	15.28	13.89	14.58	0.31	0.29	0.30	29.76	28.36	29.06	7.81	8.23	8.02	2.26	2.96	2.61
Red Velox	M9	14.10	11.10	12.60	0.26	0.24	0.25	29.06	28.21	28.64	7.46	8.54	8.00	2.25	3.01	2.63
Gale Gala	M9	18.10	16.23	17.16	0.23	0.22	0.22	25.61	25.36	25.49	7.39	7.02	7.21	3.86	3.99	3.93
Redlum Gala	M9	18.14	16.02	17.08	0.24	0.23	0.23	25.23	24.55	24.89	6.92	7.09	7.01	3.05	3.58	3.32
Auvial Early Fuji	M9	16.08	14.18	15.13	0.25	0.24	0.24	27.38	27.89	27.64	7.98	7.23	7.61	2.18	2.88	2.53
CD <sub>0.05</sub>		1.22	0.65	0.83	NS	0.04	0.01	1.67	1.10	1.48	0.25	0.23	0.39	0.12	0.10	0.15

#### 4. CONCLUSION

Super Chief grafted on MM106 clonal rootstock was excellent variety in terms of growth, precedence, quality of fruit, productivity followed by Jeromine grafted on M9 in terms of highest productivity with optimum growth characteristics shows its better feasibility in ultra/ high-density plantation and thus found suitable for commercial cultivation under high-density plantation under cold arid temperate conditions of Lahaul and Spiti Valley

#### SCOPE OF THE STUDY

High density plantation system is profitable over the traditional system if properly maintained. Further, the high density planting systems extend the possibilities to the growers for realizing greater returns by way of planting of new cultivars and getting significant production.

Added to it, the growers have an option to remove high density orchard after 15 years or so to replant to newer, higher value cultivars which further enhance the probability of profit. Most of the data which exists worldwide is based on HDP studies are from the regions which are technologically sound in nutrition and moisture management, rootstock and cultivar choices, plant canopy management and having strong marketing network. And, therefore there is greater opportunity for adoption apple HDP under the Indian conditions especially in Himachal Pradesh and more orchards and suggested remedial measures. Specifically in Lahaul and Spiti valley where the agro-ecological situations are quite variable and extreme. Adoption of alien recommendations without rational exegesis may prove perilous leading to escalation in proportion of debit laden growers in the region.

**Conflict of interest**

The authors declare no potential conflicts of interest concerning the research, authorship, and/or publication of this research article.

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