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Study of Apple Varieties in High-Density Plantation under Cold Dry Temperate Conditions of Kinnaur

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ABSTRACT

The study was carried out to evaluate four apple varieties on different rootstocks under high-density plantations in the cold temperate region of Kinnaur for growth, yield and quality attributes. The experiment evaluated four apple varieties 'Red Cap Valtod/MM 106', 'Red Velox/M9', 'Jeromine/M9' and 'Super Chief/MM 106' planted at a spacing of 2.5×1.0 m^2 in Randomized Block Design, with four replicates. From the evaluation of data on growth, floriculture and quality standards, it was clear that var. Jeromine/M9 followed by Red Velox/M9 has recorded better horticultural performance than other varieties studied. Among different varieties Red Velox/M9 recorded maximum shoot extension growth (22.65 cm), trunk girth (47.27 mm) and tree height (340.02 cm), tree spread (175.52 E-W and 181.68 cm N-S), number of fruit set $tree^{-1}$ (41.85), fruit Breadth (78.90 mm), fruit weight (207.39 g $fruit^{-1}$), TSS (10.11 °Brix), whereas, maximum fruit set (25.48%), fruit length (71.74 mm), yield (3.59 kg $tree^{-1}$) and productivity (14.35 MT Hac^{-1}) was recorded in cultivar Jeromine/M9. However, the maximum number of fruits $tree^{-1}$ was observed in the variety Red Cap Vatod/MM 106. Variety, Red Velox /M9 was found to be superior for growth, flowering, yield and quality characteristics with good market potential under Kinnaur conditions.

KEYWORDS: Jeromine, productivity, red velox, m9, red cap valtod

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Data Availability Statement: Legal restrictions are imposed on the public sharing of raw data. However, authors have full right to transfer or share the data in raw form upon request subject to either meeting the conditions of the original consents and the original research study. Further, access of data needs to meet whether the user complies with the ethical and legal obligations as data controllers to allow for secondary use of the data outside of the original study.

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1. INTRODUCTION

The dry temperate climate of Himachal Pradesh is suitable for growing the wide range of temperate fruits (Mehta et al., 2013). Temperate fruit plays an important role in boosting the economy of the farmers (Gangwar et al., 2008). Apple cultivation has completely transformed the socio-economic status of rural masses in the High Hills zone of the State (Sharma et al., 2018). The area under apple has increased from 97438-ha in 2008–09 to 114650-ha by 2021–22 (Anonymous, 2022). The production of apple has gradually reached 643000 MT with a productivity of 5.62 MT in 2022 (Anonymous, 2022). Though the production of apple in this state has steadily increased by bringing more areas into apple farming, the productivity has declined (Awasthi et al., 2001). The most widely grown varieties of apple belong to the delicious group grown in HP (Jindal et al., 1992). Kinnaur alone produces 57744 MT of temperate fruits in an area of 12712 hectares during 2019-20. Production of apples has increased gradually, but in the absence of productivity and export quality produce, the production of quality apples is still a major concern for the farming community of this district and state in the coming years. Apple is highly sensitive to adversities of climate (Rana et al., 2008) and the farmers are currently witnessing the impact of climate change in their orchards. In addition to the direct impact of climate change on apple productivity, it has also aggravated infestation of some diseases and pests resulting in more losses in yield (Sharma, 2012 and Gautam et al., 2013). Keeping the economic outlook in mind, technologies that facilitate the high productivity of quality fruits in orchards are recommended **(**Mushtaq et al., 2018). Studies have shown high-density orchards can provide large yields in the beginning and maintain a high potential for productivity over the entire crop during later periods (Robinson and Hoying, 2011). Over the past few years, changing climate patterns have shifted the apple belt to higher reaches of the Kinnaur district in view of low productivity of quality fruits. Initiative of high-density plantation with improved varieties, different from traditional farming methods, is currently underway in Kinnaur. Ultra-high density planting not only provides higher yields i.e. 40 to 60 MT ha^{-1} but also provides higher net economic returns per unit area in the initial years and also facilitates more efficient use of inputs (Reddy, 2004 and Singh et al., 2020). Some progressive orchardists have done high-density plantations of new varieties, currently seeing productivity up to 35 to 60 MT in their orchards under local conditions, despite 3-8 tonnes per hectare of 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 so that the highest total yield potential can be reached in the smallest possible area (Singh, 2005). Reduction in the average land holdings, shifting to high-density planting is the need of the hour, as it gives more precocious, higher yield and better quality fruits. Recently, the hilly region of Himachal Pradesh has adopted high density by constructing short paths and terraces with single rows.Studies on high-density planting in guava have increased reported by Lal et al. (1996) and Singh (2004). Since, the establishment of high-density orchards requires fertile land; this technology helps in exploiting the full resources of the land, facilitates intercultural operation of orchards and provides high productivity of export quality fruits. Therefore, in order to provide an excellent variety for growing in their high-density orchards, four advanced apple varieties are being proposed to be studied in this research station.

2. MATERIALS AND METHODS

This study was conducted at the Vegetable Research Station, the experimental orchard at Kalpa Farm of Dr. YS Parmar University of Horticulture and Forestry, Nauni, Solan, H.P. for three years from December 2018 to December 2020. The site is located at a latitude of 31.5377° N and longitude of 78.2754° E with an altitude of 2740 m above mean sea level. The orchard was established at an altitude of 2740 meters above sea level, which portrays the true dry temperate climate of the northwest Himalayas. Rainfall is distributed about 800 mm well in the form of snow during the winter, with the main precipitation during June – July. The study was conducted in four exotic varieties of apples viz., 'Red Cap Valtod/MM 106', 'Red Velox/M9', 'Jeromine/M9', and 'Super Chief/MM 106' in 2016, imported from the Italian nursery GRIBA. Three trees of each variety were randomly selected. The trees selected for this study were planted at a distance of 2.5×1 m^2 (4000 trees ha^{-1}) 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 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. Observations about various phenotypic stages of fruit development viz. silver tip, green tip, tight cluster stage, pink bud, full blossom, petal fall and harvesting were recorded by observing the peculiar phases of each parameter (Figure 1). The fruit set was recorded three weeks after petal fall and the fruit drop was calculated by subtracting the total number of fruits retained from the total number of fruit sets using the formula given by Westwood (1993). 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^{-1} (kg plant^{-1}). Fruits harvested from each selected plant were counted on each harvest and finally totaled to extract the average number of fruits plant^{-1}. Productivity was calculated on the basis of kg plant^{-1} and per unit area. The data recorded in 2019 and 2020 were pooled and statistical analysis was carried out accordingly.

3. RESULTS AND DISCUSSION

The pooled data collected about growth characteristics are projected in Table 1. The Red Velox/M9 in various varieties recorded higher shoot extension growth (22.65 cm), which was statistically equivalent to the Super Chief/MM 106 (21.11 cm), whereas, significantly trunk diameter (47.27 mm), tree height (340.02 cm), tree spread (175.52 cm E-W, 181.68 cm N-S) than all other varieties studied. However, significant reductions in shoot extension growth, plant height (210.38 cm) and plant spread N-S (95.51 cm) were reported in Red Cap Valtod/MM106. In addition, the Jeromine/M9 also showed a significant decrease in trunk diameter (28.81 mm) and plant spread EW (95.13 cm), compared to the rest of the varieties under study. Variation in growth parameters may be due to the heredity character of the variety, which enhances growth by increasing the nutrient uptake from the root to the aerial part of the tree. The performance of varieties is a function of genetic makeup and environment. The results are consistent with the findings of Kumar et al. (2013) and Kumar (2020). The variation could also be the result of phenotypic characteristics of the varieties, management practices and the site of the plantation (Bhat et al., 2006 and Hampson et al. (2009). This variation could be due to the phenotypic characteristics of the cultivars, management practices. Singh et al. (1977) reported variation in growth traits such as plant height, girth, among different clones of banana.

Table 1: Growth characteristics of apple varieties in high-density plantation under cold dry temperate conditions of Kinnaur, Himachal Pradesh

Name of cultivar/Rootstock	Shoot extension growth (cm)	Trunk Dia. (mm)	Plant Height (cm)	Plant Spread E-W (cm)	Plant spread N-S (cm)
Jeromine/M9	18.66	28.81	212.01	95.13	108.85
Red Velox/M9	22.65	47.27	340.02	175.52	181.68
Super Chief/MM 106	21.11	32.28	242.11	125.17	142.17
Red Cap Valtod/MM 106	15.45	36.96	201.007	96.12	95.51
CD (p=0.05)	1.541	2.53	5.97	1.80	0.276

The collected pooled data on flowering and fruiting characteristics are presented in Table 2 and Table 3,

Table 2: Flowering characteristics of apple varieties in high-density plantation under cold dry temperate conditions of Kinnaur, Himachal Pradesh.

Name of cultivar/Rootstock	Total number of flowers tree^{-1}	Number of fruit set tree^{-1}	% fruit set	Number of fruits tree^{-1}	% fruit drop
Jeromine/M9	195.85	37.38	25.48	24.28	17.77
Red Velox/M9	376.24	41.85	14.93	19.43	37.22
Super Chief/MM 106	446.12	25.23	15.51	16.09	76.54
Red Cap Valtod/MM 106	153.11	34.35	24.48	26.52	14.88
CD (p=0.05)	1.117	0.087	3.74	0.26	0.33

Table 3: Fruiting characteristics of apple varieties in high-density plantation under cold dry temperate conditions of Kinnaur, Himachal Pradesh (Pooled data of 2019 and 2020)

Name of cultivar/Rootstock	Fruit Size (mm)		fruit weight (g fruit^{-1})	Yield (kg tree^{-1})	Productivity (MT Hac^{-1})
	Length	Breadth			
Jeromine/M9	71.74	75.95	189.46	3.59	14.35
Red Velox/M9	71.45	78.90	207.39	3.35	13.42
Super Chief/MM 106	68.43	74.87	191.60	2.57	10.28
Red Cap Valtod/MM 106	70.74	75.88	184.78	3.28	13.02
CD (p=0.05)	0.312	0.163	0.728	NS	1.724

indicating that these parameters were strongly influenced by different varieties. Significantly, the maximum number of flowers (446.12) tree^{-1} has been recorded in Super Chief/MM 106, followed by variety Red Velox/M9 (376.24) and lowest (153.11) in Red Cap Valtod/MM 106. Singh (2013) reported that variation in flowering and fruiting characteristics can be attributed to the genetic makeup of the four varieties understudy, the number of fruit sets per tree was significantly higher (41.85) in Red Velox/M9, while the minimum was observed in variety, Super Chief/MM 106. The percent fruit set was maximum in variety Jeromine/M9 (25.48%), which was on par with var. Red Cap Valtod/MM106 (24.48%), while it was minimal in the Red Velox/M9 (14.93%). Variation in the fruit set is mainly attributed to several factors such as the genetic makeup of a variety i.e. self-consistent or self-incompatible, the placement of pollinators in an orchard and the prevailing climatic conditions at the time of flowering (Sharma, 2011 and Singh, 2013). Similar, observations have been recorded by many workers with different categories of fruit drop (Singh, 2013). The maximum number of fruits tree^{-1} (26.52) was recorded by the variety Red Cap Valtod / MM106. The second best variety for this character was Jeromine/M9 (24.26). Significantly, the variety Super Chief/MM 106 (16.09) saw a low value as compared to other varieties under study. The dropping of fruits in Super Chief/MM 106 (76.54%) was considerably high and lowest in Red Cap Valtod/MM 106 (14.88%).

Table 3 revealed the higher fruit length (71.74 mm) in var. Jeromine/M9, which was on par with the variety Red Velox/M9 (71.45 mm) and both were significantly higher than the rest of varieties under study, whereas minimum (68.43 mm) was found in the Super Chief/MM 106. The highest was fruit breadth (78.90 mm) and fruit weight (207.39 g fruit^{-1}) was noted in Red Velox/M9, whereas minimum fruit breadth (74.87 mm) and fruit weight (184.78 g fruit^{-1}) was recorded in varieties Super Chief/MM 106 and Red Cap Valtod/MM 106, respectively. Non-significant differences in yield per tree were recorded among the four varieties under study; however, higher yields were recorded by cultivars. Jeromine / M9 (3.59 kg tree^{-1}). The var. Red Velox/M9 (3.35 kg tree^{-1}) was found to be second best followed by var. Red Cap Valtod/MM106 (3.28 kg tree^{-1}) for this character, while the minimum (92.57 kg tree^{-1}) was recorded in Super Chief/MM 106. The variation in fruit yield has been attributed to many factors such as variety and rootstock (Kumar and Verma, 2001, Sharma, 2011 and Kumar, 2020). The apple variety Jeromine recorded the highest productivity (14.35 mt ha^{-1}), which was, statistically on par with the var. Red Velox/M9 (13.42 mt ha^{-1}) and Red Cap Valtod/MM106 (13.02 mt hac^{-1}) and significantly lower productivity (10.28 mt ha^{-1}) was recorded in the variety Super Chief/MM 106. The better performance of Red Velox/M9 and Jeromine/M9 might be due to inherent vigour 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.

The study further revealed (Table 4) non-significant differences in quality attributes among the varieties under study, except fruit firmness during the study. The maximum fruit firmness (11.24 kg cm^{-2}) was recorded in the variety Red Cap Valtod/MM 106, followed by Red Velox/M9 (10.96 kg cm^{-2}), while the minimum was found in Super Chief/MM 106 (9.85 kg cm^{-2}). However, maximum titratable acidity (0.310%), reducing sugars (7.68%), total sugars (28.48%) and anthocyanin (0.60%) were recorded in Red Cap Valtod/MM 106, whereas, variety super chief/MM 106 reported a minimum titratable acidity (0.283%) and total sugars (27.96%), while minimum reducing sugars (7.45%) and anthocyanin (0.58%) content was recorded in the variety Jeromine/M9. TSS (10.11°Brix) and Non-reducing sugars (2.63%) were highest in the variety Super Chief/MM106, while the lowest TSS (10.11°Brix) in Red Cap Valtod/MM 106 and Non-reducing sugars (2.63%) in Jeromine/M9. Further in this table ascorbic acid was recorded maximum in variety Jeromine/M9 (0.39%) while, variety Red Velox/

Table 4: Quality attributes of apple varieties in high-density plantation under cold dry temperate conditions of Kinnaur, Himachal Pradesh (Pooled data of 2019 and 2020)

Name of cultivar/ Rootstock	TSS (°Brix)	Firmness (kg cm^{-2})	Titratable acidity (%)	Reducing sugars (%)	Total sugars (%)	Non-Reducing sugars (%)	Ascorbic acid (%)	Anthocyanin (%)
Jeromine/M9	9.85	10.783	0.287	7.453	28.477	2.423	0.39	0.58
Red Velox/M9	10.05	10.96	0.303	7.537	28.367	2.487	0.36	0.603
Super Chief/MM 106	10.11	9.85	0.283	7.55	27.96	2.63	0.36	0.59
Red Cap Valtod/ MM 106	9.623	11.243	0.31	7.667	28.483	2.607	0.38	0.6
CD (p=0.05)	NS	0.432	NS	NS	NS	NS	NS	NS

M9 and Super Chief/MM 106 recorded minimum (0.36%). These findings are in line with the findings of Singh et al., 2020, as non-significant results on TSS, reducing sugar, non-reducing sugar and acidity (%) were obtained under high density plantation of guava. Further, during the study phenological characteristics i.e. Silvertip, half-inch green tip, a tight cluster stage, pink bud, full bloom, petal fall, fruit set and harvesting stages enumerated in Figure 1 was observed invariably different among the varieties, which might be due to the occurrence of similar temperatures during an early stage of vegetative development (Kumar, 2020).

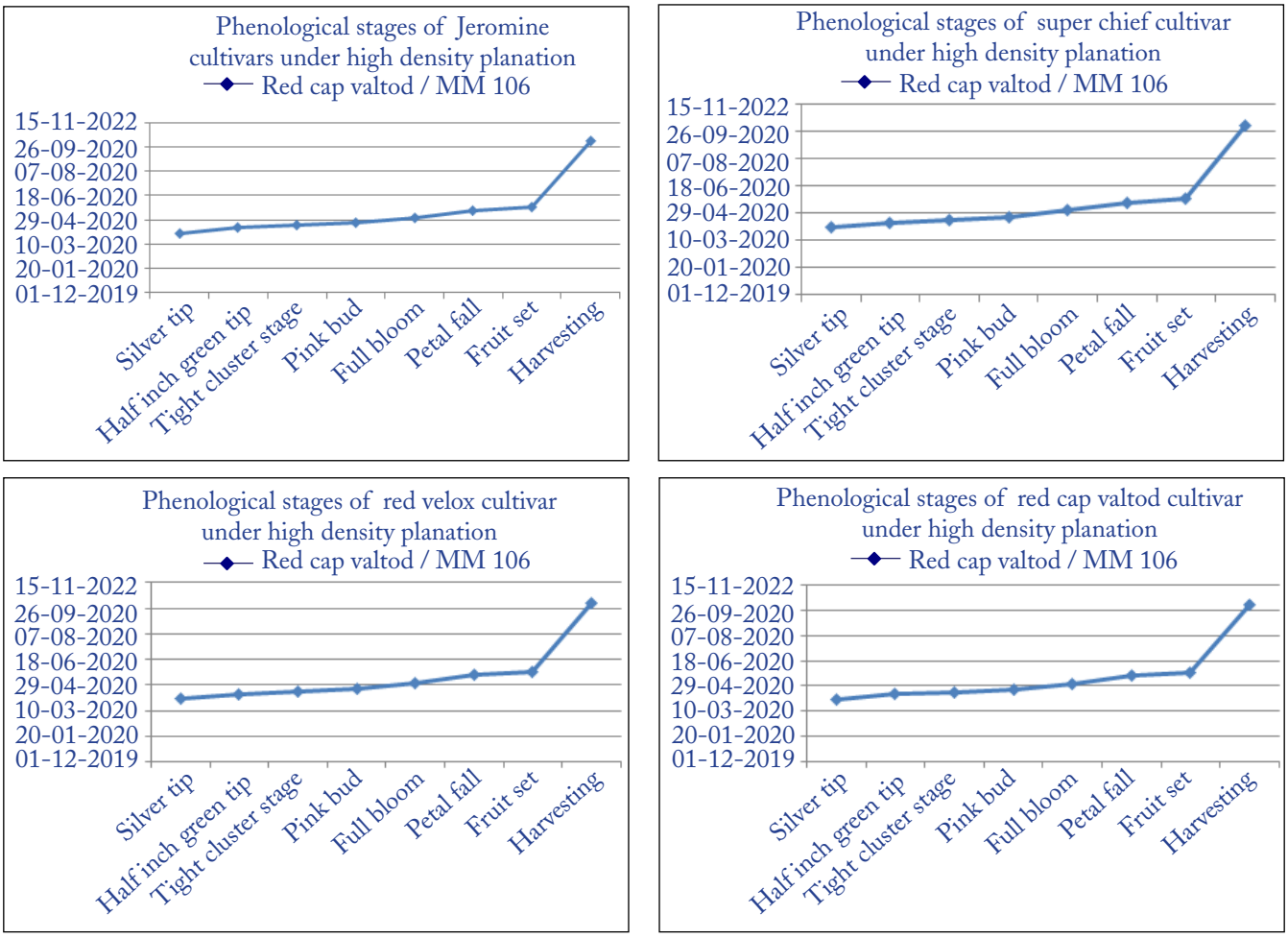

Figure 1: Phenological stages of apple varieties under high-density plantation during the 2020 season at the experimental orchard of VRS Kalpa farm

4. CONCLUSION

Red Velox grafted on M9 clonal rootstockwas 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 Kinnaur.

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