



Performance Studies of New Apple Cultivars on Different Rootstock under High-Density Plantation in Cold Dry Temperate Region of Kinnaur, Himachal Pradesh

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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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Abstract

Field experiments undertaken at the Vegetable Research Station, Kalpa farm, Dr YS Parmar University of Horticulture & Forestry, Nauni, Solan H.P., India during the year 2018-19 to study the performance of newly introduced apple cultivation on various rootstock under high-density plantations in the cold temperate region of Kinnaur. The high-density plantation of apples in Kinnaur district is indeed an important aspect in the upliftment of the socio-economic status of farmers in the farming community, keeping in mind that this trial was carried out to benefit the farming community in the coming years. The experiment evaluates four apple cultivars 'Red Cap Valtod/MM 106', 'Red Velox/M9', 'Jeromine/M9' and 'Super Chief/MM 106', planted at a spacing of 2.5×1.0 m². Maximum, shoot extension growth (17.61 cm), trunk Diameter (43.08 mm), plant height (313.13 cm), plant spread (E-W 183.13 cm; N-S (180.75 cm), fruit diameter (81.21 mm), number of fruits per tree (64.25), fruit weight (225.20 kg tree⁻¹), yield (3.58 kg tree) and productivity (14.32 mt ha⁻¹) were recorded with Red Velox on M9, whereas, maximum of flowers number (867.14 tree⁻¹) and fruits tree⁻¹ (20) was seen in Super Chief on MM 106. Higher percent fruit set (23.66%) was recorded with the cultivar Red Cap Valtod on MM 106 and Fruits length (76.20 mm) recorded maximum in cultivar Jeromine on M9. Studies have shown that grafted 'Red Velox' plants on M9 is superior in terms of growth, precedence, quality of fruit and productivity and thus it may be recommended to grow under high density plantations in cold temperate conditions of Kinnaur, Himachal Pradesh.

Keywords: Kinnaur, temperate fruits, high density plantation, red velox, m9

1. Introduction

Apple is a major fruit crop of Himachal Pradesh and in recent years, it has emerged as the leading cash crop among fruit crops. In temperate fruits, apple occupies prime position in Himachal Pradesh. The Himalayan mountain ecosystem is currently facing challenges arising due to increasing aridity, warm winters, variability in snowfall rainfall⁻¹, and unpredictable frosts (Renton, 2009; Dash and Hunt, 2007), which affect horticultural crops (Kala, 2013). Though, the Himalaya harbours rich biodiversity and is one of the most vulnerable mountain ecosystems to climate change (Xu et al., 2009; Bawa et al., 2010), there is paucity of systematic analysis of climate change and its impacts on the Himalayan ecosystems, biodiversity and local people's livelihoods (Shrestha et al., 2012). Mostly the apple plantation in the state is of Delicious group comprising mainly of Royal

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Delicious, Red Delicious and Rich-a-red (Bhatia and Kumar, 2009). Apple alone accounts for 49% of the total area of fruit crops and 74% of total fruit production. In Himachal Pradesh, the area under apple has increased from 400 ha in 1950–51 to 3,025 ha in 1960–61 and further 99,564 ha in 2009–10 (Anonymous, 2006; Anonymous, 2012). Furthermore, the area of apple has also increased from 97438 hectare in 2008–09 to 112634 hectare by 2017–18 (Anonymous, 2018). Fruit crops contribute more than 3313 crores towards GDP. The apple production level has gradually reached 368603 metric tons with a productivity of 3.27 mt in 2018–19 (Anonymous, 2018). The production of apples has increased gradually, but void of productivity and export quality fruit production, it is still a major concern for the farming community of this state to produce quality apples in the coming years. At present, these Delicious group cultivars mainly Red Delicious, Royal Delicious and Starking Delicious constitute nearly 80 % of apple trees. In order to improve the production, productivity and quality of fruits to meet the export standards, the horticulture sector is therefore constantly seeking for new practices to integrate in the management of the apple cultivation systems. Farmers in the Indian Himalayan region, such as Kinnaur, grow many fruit crops, including apples and pears, peaches, plum, apricots, almonds and walnuts (Ghosh, 1999); However apple has preference over all other horticultural crops (Kala, 2007). Worldwide, there are more than 7,500 known cultivars of apple (Thamaraikannan et al., 2010). Improved varieties are the backbone for successful crop production. Therefore, a large number of varieties has been developed as well as introduced from other countries like USA, New Zealand, and Italy etc. The introduced varieties were evaluated under different production areas to see their commercial potential. Based on their performance, these varieties were recommended for commercial cultivation in India (Mushtaq et al., 2018). Most of Kinnaur experiences temperate climate with long winters from October to May and low short summers from June to September. Since the early 2000s, average temperature in the Himalayan Mountains has increased by about 1 °C, which is around four times the global average (Anonymous, 2015). The lower parts of Kinnaur, adjacent to the Sutlej Valley and the Baspa Valley, receive monsoon rainfall. Nichar and Sangla Valley receive the highest rainfall in July. The upper areas of the Kinnaur valleys mainly fall in the rain shadow area. Farmers in Himachal Pradesh are currently in the fight to save their apples facing climate change. Overall decrease of about 2–3% in yield has been reported in Shimla, Kullu, Lahaul and Spiti districts in mid 2000s and the maximum decline of about 4% was witnessed in marginal farms (Bhagat et al., 2009). In addition to 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). They are adopting new technology of high-density apple orcharding introduced by the state government. One-third of the hill state's population depends on the ₹ 4,000-crore

apple economy. Over the past few years, the changing climatic patterns due to the decline in chilling hours have shifted apple belts to higher areas in different districts like Apple production in Kullu valley has significantly declined during 1981–2000 (Negi et al., 2012), but the high-density plantation technique can fight that. This initiative, which deviates from traditional farming methods, is currently in Kinnaur, Himachal Pradesh. The high-density plantation of Apple in Kinnaur valley is still in inception stage. 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)]. High-density plantations are aimed at increasing both productivity and quality. It will also help the farmers to meet the challenge of labor shortage. The apple varieties are mainly spur type with high colouring stains. This technique can result in high yields ranging from 40 to 70 t. Farmers in Himachal Pradesh are seeing productivity up to 30 metric tonnes in their orchards under local conditions, despite the current 7–10 t ha⁻¹. High density planting refers to planting a greater number of saplings per unit area than normal planting. Traditionally, standard apple plants raised on seedling roots are planted with a planting density of 278 trees ha⁻¹ at a distance of 6×6 m² and spur varieties on seedling rootstocks with a planting density of 400 plants at a distance of 5×5 m². The average productivity of these orchards is about 6 to 8 mt t ha⁻¹, much lower than the productivity achieved in high-density orchards of 40 to 60 mt ha⁻¹, of growing 3500 to 8000 per ha⁻¹ apple plants on clonal rootstocks to increase productivity with improved quality. With increasing pressure on land and a decrease in the average size of land holdings, shifting is needed for higher density planting as it makes trees more precarious, heavier yielding and better quality fruit yielding. High-density plantations were thought to be adopted only in large flat lands, but in recent years, testing was done to adopt higher densities in hilly areas after creating smaller tracts. Furthermore, since high-density orchards can be developed on any fertile land, the technology is helpful in utilizing the land, provide ease in orchard inter-culture operations, plant protection, harvesting and obtaining export quality of the produce. Apple being highly sensitive to adversities of climate (Byrne and Bacon, 1992) and (Rana et al., 2008), this study of several apple varieties; Jeromine, Red Velox, Red Cap Valtod and Super Chief are carried out at this research station to screen out the superior cultivar for future recommendation to the farming community to uplift the farmers socio economic status.

2. Materials and Methods

The study was conducted in the Vegetable Research Station, Kalpa farm, Dr. Y.S. Parmar University of Horticulture & Forestry, Nauni, Solan H.P., India during the year 2018–19. The orchard was established at an altitude of 2740 meters above sea level, which delineates true arid cold temperate climate of North–West Himalayas. The climate is cold temperate. Rainfall is about 800 mm well distributed, mostly in the form of snow during winter with the main rainfall during June



July. Dr YSPUHF introduced four exotic cultivars of apple viz. 'Red Cap Valtod/MM 106', 'Red Velox/M9', 'Jeromine/M9' and 'Super Chief/MM 106', in the year 2016 from the Italian nursery GRIBA. The selected trees for this study were planted at a spacing of 2.5 m × 1 (4000 trees ha⁻¹) in a randomized block design with eight replications. The data on growth parameters viz., shoot extension growth, plant girth, height, spread, fruit characteristics like fruit weight, length and breadth and finally the yield were recorded at the harvesting stage of the apple crop. Plant spread was appraised with the help of measuring wooden scale by recording the maximum canopy spread in north-south and east-west directions. The contemplation on the fruit set were recorded at two weeks after petal fall and then were again corroborated at six weeks after full bloom so as to allow advisable time for the abscission of unfertilized fruits. The final fruit set was then computed by applying the formula as propounded by (Westwood, 1978). The total number of fruit set was enumerated from five randomly selected branches of each experimental tree. Productivity was numerated on kg plant⁻¹ and per unit areas basis. The fruits harvested from each selected plants were counted at every harvest and finally summed up to work out the average number of fruits per plant. Further for this study, it was recorded the following phenological characteristics: Half inch green tip, Tight cluster Stage, Pink bud, Full bloom, Petal fall and Fruit set recorded visually by observing peculiar stages of each parameter (Figure 1). Flowering stages including initial

and final bloom of each variety was recorded when 10 and 80% of the flowers had opened. The period from the date of flowering initiation to the date of petal fall was calculated as duration of flowering. The date for petal fall was recorded when 80% of petals were fallen.

3. Results and Discussion

Most of the growth characteristics viz. shoot extension growth, trunk girth, plant height and plant spread, showed significant differences during the study (Table 1). The study revealed (Table 1) that the maximum shoot extension growth (17.61 cm), trunk diameter (43.08 mm), plant height (313.50 cm) and plant spread (183.13 cm EW, 180.75 cm NS) was recorded in Red Velox grafted on clonal rootstock M9. However, minimum shoot extension growth (13.99 cm), trunk diameter (27.01 mm), plant spread (East- West, 90.25 cm; North-South, 92.25 cm) recorded in Jeromine on clonal rootstock M9, and minimum plant height (191.63 cm) was noted in Red Cap Valtod/M9. Results in Table 1 revealed that trees of cultivar Red Velox/ M9 significantly more vigorous in terms of shoot growth (17.61 cm) then cultivar Jeromine/ M9, whereas non-significant differences was observed with the other cultivars on rootstock combination studied. Trunk Diameter was also noted significantly more (43.08 mm) in cultivar Red Velox/ M9 in comparison to all the other cultivars during the study, followed by the cultivars Red Cap Valtod/ MM 106 and Super Chief/MM 106. However, significantly lower in cultivar (27.01 mm) in cultivar Jeromine/M9. This might be due to heredity character of the variety, which increases the growth by increasing the uptake of nutrients from root to aerial part of the tree. Similar, finding on apricot was reported by (Kumar et al., 2013). Results further revealed that the plant height (313.13 cm) was significantly higher in cultivar Red Velox/ M9 and lower (191.63 cm) in cultivars Red Cap Valtod/MM 106 and Jeromine/M9. Plant spread (183.13 cm EW, 180.75 cm NS) was recorded significantly higher in Red Velox grafted on clonal rootstock M9, which was followed by Super Chief/ MM-106 and Red Cap Valtod/ MM 106. Lower plant spread (90.25 cm EW, 92.75 cm NS) in the cultivar Jeromine, which was statistically at par with the cultivars Red Cap Valtod /MM106 and Super Chief.

Phenological stages of apple cultivars under high density planation

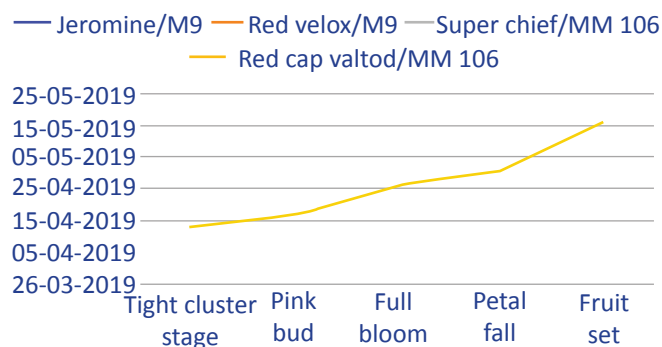


Table 1: Growth characteristics of various improved apple cultivars planted at Vegetable Research Station, Kalpa

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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	13.99	27.01	198.75	90.25	92.75
Red velox	M9	17.61	43.08	313.13	183.13	180.75
Super chief	MM-106	17.33	30.08	236.43	125.71	156.43
Red cap valtod	MM 106	15.34	35.65	191.63	110.00	102.50
CD ($p=0.05$)		2.86	4.49	36.59	37.30	40.95

In this study, (Table 2) significant variation in the flowering and fruiting characteristics amongst the cultivars had recorded. The cultivar Super Chief/MM 106 had significantly higher total flowers/tree (867.14), as compared with all other cultivars except, Red Velox/M9 (603.13), which was statistically at par

and least (71.67) in cultivar Red Cap Valtod/MM 106, which was however, statistically at par with the cultivar Jeromine/M9. The number of fruit set per tree was significantly vary amongst the cultivars as maximum (64.25) was recorded in cultivar Red Velox/M9, which was significantly higher than

Table 2: Fruiting characteristics of various improved apple cultivars planted at Vegetable Research Station, Kalpa

Name of cultivar	Clonal rootstock	Total no. of flowers tree ⁻¹	No. of fruit set tree ⁻¹	% fruit set	No. of fruits tree ⁻¹	Fruit Size (mm)		fruit weight (g fruit ⁻¹)	Yield (kg tree ⁻¹)	Productivity (MT Hac ⁻¹)
						Length	Breadth			
Jeromine	M9	258.75	41.25	16.44	14.63	76.20	79.91	220.11	3.02	12.09
Red velox	M9	603.13	64.25	11.01	18.75	73.51	81.21	225.20	3.58	14.34
Super chief	MM-106	867.14	38.63	4.47	20.00	68.08	75.44	193.20	3.14	12.55
Red cap valtod	MM 106	71.67	24.40	23.66	8.50	73.99	78.58	214.00	0.95	3.79
CD ($p=0.05$)		327.56	27.82	9.17	8.86	3.17	3.46	23.03	1.13	4.50

rest of the cultivars under study. Minimum number of fruit set per tree was observed in cultivar Red Cap Valtod/Mm 106, closely followed by Super Chief /MM106 and Jeromie/M9. Furthermore, in this study. The percent fruit set was significantly variable (4.47 to 23.66%) among the different cultivars, which was higher in Red Cap Valtod (23.66%) and Jeromine(16.44%), whereas, fruit set was found to be significantly lower in cultivar Super Chief/MM106 (4.47%) and Red Velox/M9 (11.01) in comparison to all other cultivars. Similarly, significantly higher number of fruits per tree were found in cultivars Super Chief/MM 106 (20.00), Red Velox/M9 (18.75) and Jeromine/M9 (14.63)), while these were lower (8.50) in cultivar Red Cap Valtod/MM106. In this study, (Table 2) cultivars Jeromine/M9 had significantly higher length of fruits (76.20mm), which was statistically at par with the cultivar Red Cap Valtod/MM106. However, maximum fruit diameter (81.21 mm) was observed in cultivar Red Velox/M9. Whereas, significantly lower fruit length (68.08 mm) and diameter (75.44 mm) were seen in cultivar Super Chief/MM 106. The variations in flowering fruit⁻¹ set might be due to varietal characters (Kumar et al., 2016). The significantly higher fruit weight was observed in the cultivars of Red Velox/M9 (225.20 g fruit⁻¹), Jeromine/M9 (220.11 g fruit⁻¹) and Red Cap Valtod/MM 106 (214.00 g fruit⁻¹), which were at par with each other too. However, the fruit weight was significantly lesser in cultivar Super chief/MM106 in comparison to all other cultivars. The better performance of Red Velox/M9, Jeromine/M9 and Red Cap Valtod/MM 106 might be due to inherent vigour and bearing habit of the apricot variety. Similar, (Kumar et al., 2013) reported findings; as evident from the table 2, the fruit yield significantly differ among different cultivars. The fruit yield per tree was significantly higher in the cultivars Red Velox/M9 (3.58 kg tree⁻¹), Super Chief/MM 106 (3.14 kg tree⁻¹) and Jeromine/M9 (3.02 kg tree⁻¹), which were statistically at par with each other, whereas yield per tree was found to be significantly lower (0.95 kg tree⁻¹) side in cultivar Red Cap Valtod/MM 106. The higher yield in spur

type cultivars in comparison to standard cultivars is primarily because of their genetic makeup towards more spur formation and precocity. Denby (1982) has reported yield variations among various apple cultivars. The productivity of fruits per hectare was more in cultivars Red Velox (14.34 mt ha⁻¹), Super Chief/MM 106 (12.55 mt ha⁻¹) and Red Velox/M9 (12.09 mt ha⁻¹), which in this respect was however, statistically at par with each other, while minimum productivity (3.79 mt ha⁻¹) was recorded in cultivar Red Cap Valtod. Maximum productivity efficiency in cultivar Red Velox/M9 might be due to the positive relationship between growth, flowering and yield. Similar, positive relationship was also reported by (Kumar et al., 2008).

Further, during the study Phenological characteristics i.e. Half inch green tip, Tight cluster Stage, Pink bud, Full bloom, Petal fall and Fruit set enumerated in Figure 1 were observed invariably different amongst the cultivars, which might be due to the occurrence of similar temperatures during an early stage of vegetative development. Flowering date and period of blooming varies according to cultivar aptitude as well as ecological and cultural conditions (Facteau et al., 1986).

4. Conclusion

Cultivar like Red Velox' plants on M9 is superior in terms of growth, precedence, quality of fruit and productivity and thus it may be recommended to grow under high density plantations in cold temperate conditions of Kinnaur, Himachal Pradesh.

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