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Performance studies of apple cultivars on rootstock under cold dry temperate region of Lahaul and Spiti Valley, Himachal Pradesh

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Abstract

A field experiment was carried out at Krishi Vigyan Kendra, Tabo, to study the performance of different apple cultivars grafted on EMLA-7 clonal rootstock under high-density plantations in the cold temperate region of Lahaul and Spiti valley, Himachal Pradesh, situated at an altitude of 3243 m. The experiment evaluates three apple cultivars ‘Oregon Spur-II/ EMLA-7’, ‘Super Chief/ EMLA-7’, ‘Scarlett Spur-II/ EMLA-7’ ‘Red Fuji/ EMLA-7 and ‘Coe Red Fuji/ EMLA-7’, planted at a spacing of 4.0×3.0 meters in Randomized Block Design (RBD). The present study evaluated different cultivars for growth, yield, and fruit quality parameters. Among the vegetative traits, Oregon Spur-II recorded the maximum annual shoot extension growth (21.26 cm), trunk diameter (43.36 mm), plant height (219.36 cm), and plant spread in the East–West direction (125.99 cm), while the minimum shoot growth (15.36 cm) and plant spread (80.36 cm) were observed in Scarlett Spur-II and Super Chief, respectively. The minimum trunk diameter (37.36 mm) and plant height (193.12 cm) were recorded in Red Fuji. In terms of fruit characteristics, Oregon Spur-II produced the maximum fruit length (75.36 mm), fruit width (79.36 mm), fruit weight (202.98 g), yield (6.92 kg/tree), and productivity (5.75 MT/ha), whereas the minimum fruit length (60.99 mm) and fruit width (66.12 mm) were recorded in Scarlett Spur-II, minimum fruit weight (138.14 g) in Super Chief, and minimum yield (3.34 kg/tree) and productivity (2.78 MT/ha) in Red Fuji. For quality parameters, Oregon Spur-II recorded the maximum TSS (15.36°Brix) and pedicel length (1.79 cm), while the minimum TSS (14.02°Brix) and pedicel length (1.30 cm) were observed in Scarlett Spur-II and Red Fuji, respectively. On the basis of present data cultivar Oregon Spur-II emerged as the best performing cultivar, exhibiting superior growth, yield, and fruit quality traits.

Keywords: High density plantation, Oregon Spur-II, productivity, quality, yield, EMLA-7

1. Introduction

Apple (*Malus × Domestica* Borkh) is an important temperate fruit crop in the world and belongs to family Rosaceae (Westwood, 1978) [16]. The dry temperate climate of Himachal Pradesh is highly favorable for the cultivation of a wide variety of temperate fruits (Mehta *et al.*, 2013) [6]. These fruits significantly contribute to enhancing farmers’ incomes and strengthening the rural economy (Gangwar *et al.*, 2008) [3]. Among them, apple cultivation has played a transformative role in improving the socio-economic conditions of rural communities, particularly in the High Hills zone of the state (Sharma *et al.*, 2018) [13]. The area under apple cultivation expanded from 97,438 hectares in 2008–09 to 114,650 hectares in 2021–22 (Anonymous, 2022) [1]. Correspondingly, apple production reached 643,000 metric tonnes with a productivity of 5.62 MT in 2022 (Anonymous, 2022) [1]. However, despite the increase in total production driven by expansion of cultivated area, productivity has shown a declining trend over time (Awasthi *et al.*, 2001) [2]. In Himachal Pradesh, the most widely cultivated apple varieties belong to the Delicious group (Jindal *et al.*, 1992). Although apple production has shown a gradual increase, the lack of improved productivity and export-quality produce remains a significant concern for farmers in the district as well as the state. Apple cultivation is highly sensitive to climatic adversities (Rana *et al.*, 2008) [8], and farmers are increasingly experiencing the effects of climate change in their orchards. Beyond its direct impact on productivity, climate change has

also intensified the incidence of pests and diseases, leading to further yield losses (Sharma, 2012; Gautam *et al.*, 2013) ^[12, 4]. Considering the economic importance of apple cultivation, the adoption of technologies that enhance both yield and fruit quality is essential (Mushtaq *et al.*, 2018) ^[7] another reasons for low productivity is attributed to the non-descript seedlings stocks that are predominantly being used as rootstocks in apple plantations (Sharma and Kumar, 2006) ^[11]. It is therefore, very necessary to identify suitable rootstocks for improvement in apple cultivation. With high-density orcharding systems have been found to deliver higher early yields while sustaining productivity over the long term (Robinson and Hoying, 2011) ^[10].

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. 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 was 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 five varieties of apples viz., 'Super Chief/ EMLA-7, Scarlett Spur-II/EMLA-7, Oregon Spur-II/ EMLA-7, Red Fuji/ EMLA-7 and 'Coe Red Fuji/ EMLA-7 ' in 2020-2021. Four trees of each variety were randomly selected. The trees selected for this study were planted at a distance of 4 x3 m. (833 trees ha⁻¹) with four 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⁻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 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, bearing habit, fruit bearing

fruit texture and pedicle length were recorded. The data recorded in 2020 and 2021 were pooled and statistical analysis was carried out accordingly.

3. Results and Discussion

Growth characteristics viz. shoot extension growth, trunk girth, plant height and plant spread, showed non-significant differences during the study as depicted in Table 1. The observations presented in the table 1 indicate noticeable variation among the cultivars for different vegetative growth parameters. Among all the cultivars on EMLA-7 rootstock, cultivar Oregon Spur-II recorded the maximum annual shoot extension growth (21.26 cm), followed closely by Coe Red Fuji (20.36 cm) and Red Fuji (19.78 cm), which can be considered at par with each other due to their comparable performance. The minimum shoot extension growth was observed in Scarlett Spur-II (15.36 cm), indicating relatively lower vigor compared to the other cultivars. In terms of trunk diameter, the highest value was recorded in Oregon Spur-II (43.36 mm), which was at par with Coe Red Fuji (41.99 mm) and Super Chief (40.89 mm), while the minimum trunk diameter was noted in Red Fuji (37.36 mm). With respect to plant height, Oregon Spur-II again exhibited the maximum height (219.36 cm), followed by Coe Red Fuji (211.36 cm), both of which were at par and significantly superior to the remaining cultivars. Super Chief (198.99 cm), Scarlett Spur-II (195.36 cm), and Red Fuji (193.12 cm) showed comparatively lower plant height and can be grouped as at par with each other, with Red Fuji recording the minimum value among them. In the case of plant spread in the East-West direction, the maximum spread was recorded in Oregon Spur-II (125.99 cm), followed by Coe Red Fuji (123.69 cm) and Red Fuji (119.36 cm), which were at par. The minimum spread was observed in Super Chief (80.36 cm), indicating a relatively compact growth habit. For plant spread in the North-South direction, Scarlett Spur-II recorded the maximum spread (112.87 cm), which was at par with Oregon Spur-II (105.96 cm), Coe Red Fuji (101.89 cm), and Super Chief (100.36 cm). The minimum North-South spread was observed in Red Fuji (93.55 cm), though it remained relatively close to the other cultivars. Overall, the results suggest that Oregon Spur-II and Coe Red Fuji consistently performed better across most vegetative growth parameters and were frequently at par with each other, whereas Scarlett Spur-II and Red Fuji showed comparatively lower performance in certain traits. Growth characteristics viz. shoot extension growth, trunk girth, plant height, and plant spread, showed non-significant differences during the study, which might be due to the heredity character of the variety, which increases the growth by increasing the uptake of nutrients from root to aerial part of the tree.

Table 1: Growth parameters of different apple varieties in under cold dry temperate conditions of Lahaul and Spiti valley (Pooled data of 2020 and 2021)

Cultivar	Rootstock	Annual shoot extension growth	Trunk Diameter (mm)	Plant height (cm)	Plant Spread E-W (cm)	Plant spread N-S (cm)
Oregon Spur-II	EMLA-7	21.26	43.36	219.36	125.99	105.96
Super Chief	EMLA-7	18.79	40.89	198.99	80.36	100.36
Scarlett Spur-II	EMLA-7	15.36	38.92	195.36	83.98	112.87
Red Fuji	EMLA-7	19.78	37.36	193.12	119.36	93.55
Coe Red Fuji	EMLA-7	20.36	41.99	211.36	123.69	101.89
CD _{0.5}		0.48	0.80	6.08	2.18	3.71

The data presented in the table 2 reveal significant differences among the cultivars with respect to fruit physical characteristics, yield, and productivity. Among all the cultivars on EMLA-7

rootstock, Oregon Spur-II recorded the maximum fruit length (75.36 mm), which was distinctly higher than the other cultivars, while the minimum fruit length was observed in Scarlett Spur-II

(60.99 mm). The cultivars Super Chief (61.36 mm) and Red Fuji (62.78 mm) showed comparable values and may be considered at par with Scarlett Spur-II, whereas Coe Red Fuji (65.78 mm) exhibited intermediate performance. In terms of fruit width, Oregon Spur-II again recorded the maximum value (79.36 mm), followed by Coe Red Fuji (73.28 mm) and Red Fuji (71.36 mm), which can be considered at par. The minimum fruit width was recorded in Scarlett Spur-II (66.12 mm), closely followed by Super Chief (69.78 mm), both of which were relatively similar. With respect to fruit weight, Oregon Spur-II produced the heaviest fruits (202.98 g), significantly outperforming all other cultivars. The remaining cultivars, namely Coe Red Fuji (147.12 g), Red Fuji (146.34 g), Scarlett Spur-II (141.69 g), and Super Chief (138.14 g), exhibited comparatively lower fruit weights and can be considered at par with each other. The minimum fruit weight was observed in Super Chief (138.14 g). Regarding yield per tree, Oregon Spur-II recorded the highest yield (6.92 kg/tree), followed by Super Chief (5.63 kg/tree) and Scarlett Spur-II (5.49 kg/tree), which were at par. The lowest yield was

recorded in Red Fuji (3.34 kg/tree), while Coe Red Fuji (4.82 kg/tree) showed intermediate performance. Similarly, in terms of productivity, Oregon Spur-II achieved the maximum productivity (5.75 MT/ha), followed by Super Chief (4.68 MT/ha) and Scarlett Spur-II (4.57 MT/ha), which were statistically at par. Coe Red Fuji (4.01 MT/ha) showed moderate productivity, whereas the minimum productivity was recorded in Red Fuji (2.78 MT/ha). The variation in size of the fruits have been reported by several workers (Rathore, 1986; Kumar and Verma, 2001; Sumrah *et al.*, 2000; Sharma and Chauhan, 2008 and Singh, 2013) [9, 5, 15, 11, 14] and is attributed to several factors like variety, soil, age and vigour of plant and orchard management practices being followed. Overall, the results clearly indicate that Oregon Spur-II performed superiorly across all fruit and yield parameters, while Super Chief and Scarlett Spur-II showed moderate but comparable performance. In contrast, Red Fuji consistently recorded the minimum yield and productivity, indicating comparatively lower performance under the given conditions.

Table 2: Fruiting parameters of different apple varieties under cold dry temperate conditions of Lahaul and Spiti valley (Pooled data of 2020 and 2021)

Cultivar	Rootstock	Fruit Length (mm)	Fruit width (mm)	Fruit weight (g)	Yield (kg/tree)	Productivity (MT/Ha)
Oregon Spur-II	EMLA-7	75.36	79.36	202.98	6.92	5.75
Super Chief	EMLA-7	61.36	69.78	138.14	5.63	4.68
Scarlett Spur-II	EMLA-7	60.99	66.12	141.69	5.49	4.57
Red Fuji	EMLA-7	62.78	71.36	146.34	3.34	2.78
Coe Red Fuji	EMLA-7	65.78	73.28	147.12	4.82	4.01
CD _{0.5}		2.30	1.95	5.76	1.66	0.15

The data presented in the table 3 indicate variation among the cultivars with respect to quality and morphological characteristics. Among all the cultivars, Oregon Spur-II recorded the maximum total soluble solids (TSS) content (15.36°Brix), followed closely by Red Fuji (15.01° Brix), and these two cultivars can be considered at par due to their comparable values. The minimum TSS was recorded in Scarlett Spur-II (14.02° Brix), while Super Chief (14.23°Brix) and Coe Red Fuji (14.36° Brix) showed intermediate values and may also be grouped as at par. Regarding bearing habit, Oregon Spur-II and Super Chief exhibited a spur-type bearing habit, whereas Scarlett Spur-II, Red Fuji, and Coe Red Fuji showed a mixed bearing habit (shoot and spur), indicating variability in fruiting behavior among the cultivars. In terms of fruit shape, Oregon Spur-II, Super Chief, and Scarlett Spur-II produced globose conical fruits, while Red Fuji and Coe Red Fuji exhibited

obloid-shaped fruits, highlighting distinct varietal differences. With respect to fruit texture, Oregon Spur-II had coarse texture, whereas all other cultivars showed intermediate texture, indicating relatively finer flesh consistency in the latter group. For pedicel length, Oregon Spur-II recorded the maximum value (1.79 cm), which was significantly higher than the rest of the cultivars. It was followed by Super Chief (1.46 cm), while Coe Red Fuji (1.36 cm), Scarlett Spur-II (1.32 cm), and Red Fuji (1.30 cm) exhibited shorter pedicel lengths and may be considered at par. The minimum pedicel length was observed in Red Fuji (1.30 cm). These characters are also influenced by climatic and moisture availability during the growing season. According to Hudina *et al.*, (2001), the applied agro-technical and pomological measures such as fertilization, irrigation and the training systems can influence these parameters. The

Table 3: Chemical and physical parameters of different apple under cold dry temperate conditions of Lahaul and Spiti valley (Pooled data of 2020 and 2021)

Cultivar	Rootstock	TSS°B	Bearing habit	Fruit shape	Fruit texture	Pedicel length (cm)
Oregon Spur-II	EMLA-7	15.36	Spur	Globose conical	Coarse	1.79
Super Chief	EMLA-7	14.23	Spur	Globose conical	Intermediate	1.46
Scarlett Spur-II	EMLA-7	14.02	Shoot and Spur	Globose conical	Intermediate	1.32
Red Fuji	EMLA-7	15.01	Shoot and Spur	Obloid	Intermediate	1.30
Coe Red Fuji	EMLA-7	14.36	Shoot and Spur	Obloid	Intermediate	1.36
CD _{0.5}		0.46				

4. Conclusion

Studies have shown that cultivar Oregon Spur-II/EMLA-7 proved to be the superior cultivar under high-density planting in the cold temperate region of Lahaul and Spiti. It consistently exhibited the highest vegetative growth, fruit size, yield, productivity, and quality parameters. Therefore, Oregon Spur-II/EMLA-7 is recommended for achieving maximum growth

and productivity in similar high-density apple orchards.

References

- Anonymous. Horticultural at a glance. Department of Horticulture, Himachal Pradesh, India; 2022.
- Awasthi RP, Verma HS, Sharma RD, Bhardwaj SP, Bhardwaj SV. Causes of low productivity in apple orchards

- and suggested remedial measures. In: Jindal KK, Gautam DR, editors. Productivity of temperate fruits. Solan: Dr. Y.S. Parmar University of Horticulture and Forestry; 2001. p. 1-8.
3. Gangwar MP, Rai R, Karnwal MK, Singh YP, Kumar C. Evaluation of apple cultivars introduced from New Zealand at nursery stage. *Progressive Horticulture*. 2008;42:235-236.
 4. Gautam HR, Bhardwaj ML, Kumar R. *Current Science*. 2013;105(12):1685-1691.
 5. Kumar J, Verma HS. Performance of apple cultivars under low altitude conditions of Kullu Valley. *Haryana Journal of Horticultural Sciences*. 2001;30:139-142.
 6. Mehta P, Thakur RK, Chauhan S. Production and marketing of apple fruit crop: a study premise to Shimla District of Himachal Pradesh. *International Journal of Bio-resource and Stress Management*. 2013;4(4):610-613.
 7. Mushtaq R, Ashaq P, Mohammad, Tauseef ARHS, Raja MK, Sharma N, Nazir AK. Phenological features of four exotic apple cultivars on M9T₃37 rootstock under high density plantation in North Himalayan region of India. *Current Journal of Applied Science and Technology*. 2018;29(6):1-5.
 8. Rana RS, Bhagat RM, Kalia V, Lal H. Impact of climate change on shift of apple belt in Himachal Pradesh. In: ISPRS Archives XXXVIII-8/W3 Workshop Proceedings; Impact of Climate Change on Agriculture; 2008. p. 131-137.
 9. Rathore DS. Preliminary evaluation of genetic resources of apple. In: Chadha TR, Bhutani VP, Kaul JL, editors. *Advances in research on temperate fruits. Proceedings of National Symposium on Temperate Fruits*; 1984 Mar 15-18; Solan: Dr. Y.S. Parmar University of Horticulture and Forestry; 1986. p. 3-6.
 10. Robinson T. Advances in apple culture worldwide. *Revista Brasileira de Fruticultura*. 2011;33(spl.):37-47.
 11. Sharma DP, Chauhan JS. Performance of apple cultivars under cold desert conditions of North-Western Himalayas. *Acta Horticulturae*. 2008;772:199-201.
 12. Sharma IM. In: *Proceedings of the National Symposium on Blending Conventional and Modern Plant Pathology for Sustainable Agriculture*. Indian Institute of Horticultural Research, Bengaluru; 2012.
 13. Sharma R. Mapping of leaf nutrient status of apple (*Malus domestica* Borkh.) plantations, Northwestern Himalayas. *International Journal of Chemical Studies*. 2018;6(2):866-871.
 14. Singh J. Studies on the performance of some newly introduced cultivars of apple (*Malus × domestica* Borkh.) under high hill conditions of Kinnaur (H.P.) [thesis]. Department of Fruit Science, Dr. Y.S. Parmar University of Horticulture and Forestry, Solan; 2013. p. 1-56.
 15. Sumrah MA, Nasir MM, Allah B, Nawaz MZ. Performance of some apple cultivars under sub-mountain climatic conditions. *Sarhad Journal of Agriculture*. 2000;16:393-395.
 16. Westwood MN. *Temperate zone pomology*. San Francisco: W.H. Freeman and Co.; 1978. p. 300-303.