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EFFECTS OF TREE MANAGEMENT PRACTICES ON GROWTH INDICES, SPUR FORMATION AND FRUIT SET IN APPLE (*MALUS* × *DOMESTICA* BORKH.)

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ABSTRACT

Jammu and Kashmir being endowed with natural advantages of topography coupled with tremendous diversity of agro-climatic conditions possesses immense scope for horticultural development. Apple is the principal fruit crop of Jammu and Kashmir but the yield of apple although appears to be highest among the apple producing states in the country yet it is far below the level achieved by advanced countries. The yield is governed by a number of factors including canopy development that forms an important tree management practice. Among different management practices applied in orchard, shoot bending, girdling, summer pruning was used as growth control strategies and to induce flower bud formation. The trees of uniform size, vigour and bearing capacity were selected, marked and maintained under uniform cultural operations during the year under study as per package of practices for apple. The most effective strategy in reducing trunk girth increment was girdling followed by shoot bending. Minimum leaf area to the extent of 36.47 cm^2 was observed in shoot bending + girdling + heading back treated plants. Among the different treatments T_{11} (shoot bending + girdling + heading back) was found to be the best strategy in reducing plant vigour and increasing bloom density and number of spurs. The present study revealed that the combined application of shoot bending + girdling + heading back registered highest fruit set in the following year.

Keywords **:** Apple; shoot bending; girdling; heading back; thinning out.

Introduction

Apple (*Malus* × *domestica* Borkh.) is one of the most exquisite and patronized fruit widely cultivated in the temperate regions of the world. Cherished as 'King of Temperate Fruits', apple is undoubtedly the most ubiquitous of all temperate fruits. The genus *Malus* consists of six sections with twenty-seven primary species, including two from Europe, four from North America and the rest from Asia many of which are cultivated as ornamental trees for their profuse blossom and the attractive fruits (Forsline *et al*., 2003). Jammu and Kashmir being endowed with natural advantages of topography coupled with tremendous diversity of agro-climatic conditions possesses immense scope for horticultural development. The region offers good scope for cultivation of horticultural crops, covering a variety of temperate fruits like apple, pear, cherry, peach, plum, almond, kiwi, etc. Apple is the principal fruit crop of Jammu and Kashmir, accounting for 48.14 per cent of area and 77.26 per cent of total fruit production. It occupies an area of 1.65 lakh hectares with a total production of 20.26 lakh metric tonnes and yield of 12.16 t/ha (Anonymous, 2020). The yield of apple although appears to be highest among the apple producing states in the country yet it is far below the level achieved by advanced countries where productivity is 50-60 MT/ha. In fruit trees, the fruiting potential is largely governed by its architecture, canopy density and photosynthetic efficiency. Among traditional methods of orchard

management and cultural practices applied in orchard, shoot bending, trunk scoring/girdling, summer pruning, root pruning or regulated deficit irrigation have been most commonly used as growth control strategies to maintain a balance between growth and fruiting and to induce flower bud formation in fruit plants . The present study was, therefore, undertaken at Experimental Farm, Division of Horticulture, Faculty of Agriculture, Wadura to determine the effect of girdling, summer pruning and branch bending on vegetative characters, flowering behaviour and fruit set.

Materials and Methods

The present investigation entitled "Effects of tree management practices on growth indices and spur formation in apple Cv. Red Velox" was conducted at Experimental Farm, Division of Horticulture, FOA, Wadura, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir. The intended experiment was conducted on 8-year-old apple cultivar Red Velox grafted on MM-106 rootstock at 4 m × 2.5 m spacing and trained as modified leader system. The trees of uniform size, vigour and bearing capacity were selected, marked and maintained under uniform cultural operations during the year under study as per package of practices for apple issued by SKUAST-K, Shalimar. The treatments were given during early June (shoot bending and trunk girdling) and summer pruning performed in mid-July (heading back and thinning out). On each selected tree four branches, one along each direction (N, S, E and W) were marked for various observations. The experiment was laid in Randomized Complete Block Design (RCBD) with a total of sixteen treatments comprising of three replications in each treatment.

Results and Discussion

Horticultural practices such as shoot bending, pruning, scoring, girding, fruit thinning are valuable interventions in orchard management and have long been used to regulate growth and tree size besides increasing flowering, flower bud formation and quality of fruit. In the present investigation, perusal of data Table-1 reveals that all the tree management practices showed reduction in increment in trunk girth as compared to control. Plants treated with shoot bending + girdling + heading back showed minimum trunk girth increment (0.56 cm) among all the treatments followed by shoot bending + girdling + heading back + thinning out which exhibited trunk girth increment of 0.58 cm. Maximum trunk girth increment (0.85 cm) was recorded in untreated plants which was statistically at par with thinning out (0.84 cm), heading back (0.82 cm) and heading back + thinning out (0.81 cm). Shoot bending in combination with girdling and heading back recorded minimum shoot length to the extent of 50.70 cm followed by summer pruning (heading back and thinning out) combined with shoot bending and girdling (50.86 cm). Summer pruning in combination with shoot bending and another treatment of shoot bending + girdling both recorded shoot length of 51.60 cm. Reduction in shoot length to the tune of 52.36 cm was recorded in shoot bending + girdling + thinning out followed by shoot bending combined with heading back (52.71 cm). The results of present study regarding tree morphological characteristics are in conformity with the finding of Raja *et al.* (2018) who observed that trunk incision in combination with summer pruning decreased trunk girth increment and trunk cross sectional area whereas, summer pruning alone did not significantly affect the tree morphological characteristics of Chinese Sand pear. The diminution in trunk girth and trunk cross sectional area might be due to the fact that different treatments particularly trunk girdling and shoot bending limits the carbohydrate accumulation in the tree trunk and roots. Reduction in radial growth of trunk was also recorded in Royal Delicious apple with the orientation of trees at 30^0, 45^0 and 60^0 angles from the soil line (Sharma and Jindal, 1992). Bending of shoots during early spring has been found to increase the number of lateral shoots in apple cv. Fuji due to loss of apical dominance and may produce vigorous water sprouts, increasing the total number of shoots and reducing average shoot length (Han., 2003).

The data pertaining to the manipulation of tree canopy in apple by various techniques revealed that number of nodes per shoot were enhanced by various treatments (Table -1). Maximum numbers of nodes (28.59) were recorded in plants treated with shoot bending combined with girdling and summer pruning (heading back and thinning out) whereas, minimum number of nodes (21.73) were observed in reference plants. Formation of more nodes in treated plants and subsequent reduction in inter nodal length might be due to decrease in gibberellic acid synthesis in treated plants particularly in shoot bending and girdling. The gibberellic acid might unduly extend plastichron (i.e., the time interval between successive nodes) resulting in reduction of node formation thereby indirectly inhibiting flowering as in case of apple it is only after a critical node number is reached, does flower initiation begin (Westwood, 1993).

The data in the present study depicts the effect of various tree management practices on leaf area in apple cv. Red Velox. The leaf area ranged between 36.47 to

39.89 cm^2. Minimum leaf area to the extent of 36.47 cm^2 was observed in shoot bending + girdling + heading back treated plants which was statistically at par with shoot bending in combination with girdling and summer pruning (36.54 cm^2) whereas, the maximum leaf expansion of 39.89 cm^2 was observed in untreated plants that was significantly superior to all other treatments. Strategies like shoot bending combined with girdling, shoot bending combined with girdling and thinning out, girdling combined with summer pruning and girdling combined with heading back also recorded significantly lower leaf expansion of 36.98 cm^2, 37.14 cm^2, 37.29 cm^2 and 37.46 cm^2 respectively. Schechter *et al.* (1994) reported that girdling by removing 1-2 cm strip of bark increased the specific leaf area, stomatal resistance, dry matter of fruits and internal CO_2 concentration in apple cv. Sturpeespur. However, Peng and Rabe (1996) observed significant reduction in chlorophyll content and leaf area in Mikowase Satsuma mandarin due to summer trunk girdling. Significant reduction in leaf area was recorded in Chinese Sand pear due to summer pruning in combination with trunk incision (Raja *et al*, 2018). Similarly, Ashraf *et al*. (2017) observed lowest leaf area (19.12 cm^2) in summer pruning + PP333 (750ppm) treated plants as compared to reference plants (23.96 cm^2) in Red Delicious apple. Reduction in leaf area by trunk incision may be due to lowering of leaf expansion (Smart *et al*., 2006) possibly by creating water stress and by reducing root functions such as absorption and accumulation of nutrients (Fumuro, 1998).

The perusal of data depicted in Table-2 revealed that bloom density was significantly affected by all the treatments compared to control. Maximum number of flowers (126.33) were recorded in shoot bending + girdling + heading back which was significantly superior to all other treatments whereas, minimum number of flowers (79.83) were noticed in reference plant. The next best treatment that recorded maximum bloom density (113.67) was found to be shoot bending + girdling followed by shoot bending in combination with summer pruning (110.75), shoot bending + heading back (110.08), shoot bending + girdling + thinning out (108.17), shoot bending + girdling + heading back + thinning out (103.92) and shoot bending (103.17) which also registered significantly higher intensity of flowers.

It is evident from the data that all the treatments significantly increased the number of spurs per metre over the control. The highest number of spurs per metre (24.83) was noted in plants treated with shoot bending + girdling + heading back followed by plants subjected to shoot bending + girdling (22.33), shoot bending combined with summer pruning (21.83), shoot bending + heading back (21.67), shoot bending + girdling + thinning out (21.50), shoot bending (20.50) and shoot bending combined with girdling and summer pruning (20.00).The plants that received no treatment registered lowest number of spurs per metre (16.42) which was however, statistically at par with thinning out (16.67), girdling (17.17) and girdling + thinning out (17.50). These observations are in conformity with the results obtained by Nasr *et al.* (2015) who noticed that shoot bending alone or in combination with removal of one third length of shoot or girdling increased floral precocity and spur percentage in Le Conte pear. Similarly, Aly *et al.* (2012) also showed that shoot bending and girdling increased spur number per metre compared to control. Khattab *et al.* (2003) while investigating the effect of shoot bending on Le Conte pear trees observed that winter shoot bending increased lateral growth, spur number and flowering spurs. The increase in bloom density and spur formation might be due to mechanically induced stress created by bending vertical branches to horizontal that resulted in increasing internal ethylene concentration and exhibiting lower auxin transport and cytokinin levels as compared to vertical shoots (Sanyal and Bengerth, 1998).

The perusal of data presented in Table-2 recorded in following year reveals that the highest fruit set (55.20%) was recorded in plants treated with shoot bending + girdling + heading back followed by shoot bending + girdling (53.90%). Increased fruit set (52.90%) was also recorded in plants subjected to all the canopy management practices i.e., shoot bending, girdling and summer pruning. The treatments in chronological order of superiority in influencing fruit set following combined application of treatments were shoot bending + girdling + thinning out (52.80%), shoot bending + heading back (52.70%), girdling + heading back (52.60%), shoot bending (52.20%), shoot bending combined with summer pruning (51.90%). Lowest fruit set of 45.90% was noticed in untreated plants. These results are in consonance with the findings of Nasr *et al.* (2015) in pear who observed that shoot bending in combination with removal of one-third of shoot length and girdling recorded highest fruit set (48.04%) followed by shoot bending + girdling (46.31%). Similar finding were reported by Aly *et al.* (2012) in Le Conte pear and Lauri *et al.* (1998) in cherry.

Conclusion

The present investigation revealed that tree morphological characteristics were markedly affected by different tree management practices. The most

effective strategy in reducing trunk girth increment was girdling followed by shoot bending. Among treatments minimum trunk girth increment and shoot length was recorded in shoot bending + girdling + heading back treated plants followed by shoot bending in combination with girdling plus summer pruning (heading back+ thinning out) whereas, the maximum increment in trunk girth and shoot length was observed in untreated plants. Application of various tree management practices have shown significant effect on next year's bloom density and number of spurs. Among the different treatments T_{11} (shoot bending + girdling + heading back) and T_{15} (shoot bending + girdling + heading back + thinning out) was found to be the best strategy in reducing plant vigour and increasing bloom density, number of spurs and fruit set. The best strategy among individual treatments in increasing bloom density and spur number was shoot bending. Summer pruning and girdling forms the second and third best strategy to influence the bloom density and spur number. Among different treatment combinations shoot bending + girdling + heading back treated plants recorded maximum number of flowers and spurs per metre followed by shoot bending + girdling whereas, minimum was registered by control plants. The present study revealed that the combined application of shoot bending + girdling + heading back registered highest fruit set in the following year whereas, lowest fruit set was observed in reference plants.

Table 1 : Effect of tree management practices on trunk growth, shoot length, number of nodes and leaf area of apple cv. Red Velox

Treatments	Increment in trunk girth (cm)	Shoot Length (cm)	No. of nodes/shoot	Leaf Area (cm^2)
T_0 : Control	0.85	68.75	21.73	39.89
T_1 : Shoot Bending	0.77	53.49	26.60	38.74
T_2 : Girdling	0.63	56.21	23.73	37.64
T_3 : Heading Back	0.82	66.76	24.80	39.07
T_4 : Thinning Out	0.84	67.73	22.63	39.33
T_5 : Shoot Bending + Girdling	0.59	51.60	26.63	36.98
T_6 : Shoot Bending + Heading Back	0.76	52.71	26.40	37.68
T_7 : Shoot Bending + Thinning Out	0.78	53.26	26.13	38.22
T_8 : Girdling + Heading Back	0.64	57.88	25.48	37.46
T_9 : Girdling + Thinning Out	0.64	58.22	24.21	38.07
T_{10} : Heading Back + Thinning Out	0.81	65.83	21.97	38.99
T_{11} : Shoot Bending + Girdling+ Heading Back	0.56	50.70	27.20	36.47
T_{12} : Shoot Bending + Girdling+ Thinning Out	0.59	52.36	27.70	37.14
T_{13} : Shoot Bending + Heading Back + Thinning Out	0.70	51.60	26.62	38.44
T_{14} : Girdling + Heading Back + Thinning Out	0.62	56.97	25.91	37.29
T_{15} : Shoot Bending + Girdling + Heading Back + Thinning Out	0.58	50.86	28.59	36.54
CD ($p \leq 0.05$)	0.04	2.01	1.65	**0.26**

Table 2 : Effect of tree management practices on bloom density, number of spurs and fruit set of apple cv. Red Velox

Treatments	Bloom Density (No. of flowers/m)	No. of spurs/m	Fruit set (%)
T_0 : Control	79.83	16.42	45.90
T_1 : Shoot Bending	103.17	20.50	52.20
T_2 : Girdling	84.25	17.17	49.40
T_3 : Heading Back	92.67	18.17	47.50
T_4 : Thinning Out	82.42	16.67	46.60
T_5 : Shoot Bending + Girdling	113.67	22.33	53.90
T_6 : Shoot Bending + Heading Back	110.08	21.67	52.70
T_7 : Shoot Bending + Thinning Out	98.83	19.67	51.00

T_8 : Girdling + Heading Back	95.50	19.00	52.60
T_9 : Girdling + Thinning Out	90.75	17.50	51.60
T_{10} : Heading Back + Thinning Out	94.42	18.50	48.90
T_{11} : Shoot Bending + Girdling+ Heading Back	126.33	24.83	55.20
T_{12} : Shoot Bending + Girdling+ Thinning Out	108.17	21.50	52.80
T_{13} : Shoot Bending + Heading Back + Thinning Out	110.75	21.83	51.90
T_{14} : Girdling + Heading Back + Thinning Out	93.67	18.17	51.70
T_{15} : Shoot Bending + Girdling + Heading Back + Thinning Out	103.92	20.00	52.90
CD ($p \leq 0.05$)	1.49	1.17	1.90

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