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# Standardization of pruning intensity for sweet oranges under ultra-high-density planting in North West Himalayan region

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## ABSTRACT

*A field experiment on the effect of pruning treatments was conducted in 2022-23 on six-year-old sweet orange plants (Blood Red and Mosambi) in the experimental farm of the Department of Fruit Science, College of Horticulture and Forestry, Neri, Hamirpur (HP). The study was aimed to find out the optimum pruning intensity for managing the canopy of sweet orange plants and strike a balance between vegetative growth and fruiting under high density planting system. The investigation comprised five treatments: T1 (2.5 cm Heading back), T2 (5 cm Heading back), T3 (10 cm Heading back), T4 (15 cm Heading back), and No heading back (control). The data obtained from the study revealed that higher intensity of pruning enhanced vegetative growth, as observed in the treatment with 15 cm Heading back. All flowering characteristics, including time of bud break, time of first flowering, fruit set, and full bloom, were recorded to be earlier in the treatment with 10 cm Heading back. Lower intensity of pruning, such as 5 cm and 2.5 cm Heading Back, resulted in lesser vegetative growth compared to 15 cm Heading Back, but there was also a reduction in fruit yield and quality. The maximum fruit yield (14.16 kg/plant) and fruit quality, including TSS (8.73 °B), reducing sugar (3.68%), and total sugar (6.23%), were recorded in the treatment with 15 cm Heading back.*

***Keywords:*** *Blood Red, Citrus, High Density, Mosambi, Pruning Intensity, Yield, Vegetative Growth*

## Introduction

Citrus is one of the most important fruit crops in India, belonging to the family Rutaceae and sub-family Aurantioideae. It is known for its high nutritive and refreshing value, distinct aroma, distinctive taste and also for its medicinal properties. Citrus fruits are notable for their fragrance, partly due to flavonoids and limonoids contained in the rind and most are juice-laden. The juice contains a high quantity of citric acid, which gives them their characteristic flavor [9]. Sweet orange (*Citrus sinensis* L.) is one of the most delicious fruits that belongs to the family Rutaceae. It was introduced to various parts of the world by Italian traders and Portuguese navigators. The most prominent citrus-producing countries in the world are the United States, Brazil, Spain, Italy, India, South Africa, and Egypt. Oranges are valued for their high vitamin C content and are a good source of vitamin A and B. They are also a source of other nutrients, including folacin, calcium, and potassium [1]. It is now widely known that vitamin C (ascorbic acid) and carotenoids are found in abundance in citrus fruits, which play an important role primarily in causing resistance against many diseases [3].

High-density plantings have been tested worldwide in advanced citrus production systems (ACPS) to increase the efficiency of water, fertilizer, and light, and to maximize productivity, although it is relatively a new concept in India. High-density planting in fruit plants requires continuous canopy management to keep the tree size in control and ensure sustainable production of high-quality fruits. Pruning has been used to control tree size for centuries because it has a much less stimulating effect on shoot regrowth. Pruning is an important tree management method used to control vegetative growth and flowering in a variety of fruit crops, particularly in high-density planting systems. Light becomes a limiting factor in overcrowded citrus groves, and pruning promotes sunshine penetration, which not only affects flowering and fruit set but also improves fruit quality and color development in fruit crops. Although, literature is available on canopy management through pruning in citrus, it is limited to a few countries and lacking in the Indian context, particularly in the Himalayan region. Therefore, the present study was undertaken to ascertain the effect of various pruning treatments on vegetative growth and fruiting of sweet oranges.

## Material and Methods

The present investigation was conducted during the year 2022-23 at the experimental farm of the Department of Fruit Science, College of Horticulture and Forestry, Neri, Hamirpur. The experimental site was situated at an elevation of 650 m above mean sea level with $31^0$41'47.6'' N latitude and $76^0$28'6.3'' E longitude. The region falls under the sub-tropical sub-montane low hills of Himachal Pradesh. This region experiences hot summers followed by a wet monsoon season from late June to early September. Winters are usually cold during December and January. The average annual rainfall in the region usually lies between 1000-1200mm, with the rainy season accounting for the majority of the rainfall. The experiment was conducted on six-year-old, uniformly growing plants of two varieties of sweet orange, Blood Red and Mosambi, planted at a spacing of 2x2m.

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The study comprised five treatments involving heading of previous season branches at 2.5 cm, 5 cm, 10 cm and 15 cm (Heading back) compared with control (No heading back) performed during the last week of January. Each treatment was replicated five times with four plants per replication in a Randomized Block Design. In addition, the standard pruning of dead and diseased branches, water shoots, and interfering branches was done in all the plants, including control. The observations pertaining to vegetative growth, flowering, and fruiting characteristics were recorded to find out the impact of treatments.

**Increase in plant height (cm)**

The height of selected plants was measured with a measuring tape from the ground level to the topmost shoot tip at the beginning and end of the growing season. The increase in plant height was calculated by substracting the initial measurement from the final measurement and is expressed in centimetres (cm).

**Tree spread (cm)**

The tree spread was measured in two different directions (North-South and East-West) using a measuring tape before and after applying the different treatments. The measurements were taken in two opposite directions (E-W, N-S)and expressed in centimeters (cm). The average tree spread was calculated using the following formula.

$$\textbf{Average canopy spread} = \frac{(N-S)+(E-W)}{2}$$

**Where, N-S is the tree spread in North-South direction, E-W is the tree spread in East-West direction**

**Yield (Kg/plant)**

To calculate the total fruit yield, the total yield of fruits per tree was calculated, and the value was expressed in kilograms (kg/tree).

**TSS (°Brix)**

The total soluble solids (TSS) were measured using a digital hand refractometer.

**Acidity and sugars (Non-reducing reducing, and total) (%)**

Acidity and sugars were estimated using the method given by Ranganna [11].

The data collected for various parameters were computed, tabulated, and analyzed using MS-Excel and a statistical package. The analysis of variance (ANOVA) procedure and Randomized Block Designs proposed by Gomez and Gomez [7] were used for analysis.

## Results and Discussion

Higher intensity of pruning was found to enhance vegetative growth in both varieties of sweet orange, as evident from the data (Table 1). The maximum increase in plant height was recorded at 65.98 cm in Mosambi and 63.62 cm in Blood Red under the treatment with 15 cm Heading back, which was significantly higher than all other treatments, including the control (52.99 cm in Mosambi and 48.44 cm in Blood Red). Similarly, tree spread, the number of new shoots and shoot extension growth were also highest in plants with heading back at 15 cm, indicating that higher rates of heading back are not effective in controlling the vegetative growth of high-density citrus plants.

Heading back also resulted in the formation of a bunch of new shoots at the apical end of the pruned shoot, with 5-8 new shoots arising at each tip. It was observed that heading back of the shoots above a lateral shoot was effective in reducing bunch formation, and the shoot extension growth was lesser. The results obtained in the present studies are in line with those of Ghosh et al. [5], who found in Assam lemon that the highest level of pruning gave the best results in terms of an increment in plant height. The increased vegetative growth in pruning treatments might be due to the better movement of air and light in the inner part of the plant, thereby resulting in greater photosynthesis activity of the plants that leads to the higher accumulation of the photosynthates, which were utilized by the developing shoots, leading to increased plant height. Patil et al. [10] reported that increasing the severity of pruning increases plant height in Acid Lime. It may be due to the lesser competition among the shoots that arise on the plant with heavy pruning than the tree under light pruning. Similar results were reported by Ingle et al. [8] in Acid Lime and Dhaliwal et al. [4] in kinnow.

The data on flowering parameters (Table 2) revealed that the highest number of flower buds per meter of shoot length (57.67) was observed in plants treated with T3 (10 cm Heading back). In contrast, the lowest number of flower buds was recorded in the control group. The highest fruit set was recorded in the Mosambi cultivar (64.50%) and the Blood Red cultivar (60.50%) of sweet orange under treatment T3 (10 cm Heading Back), while the control group exhibited the lowest fruit set (47.50% in Mosambi and 45.00% in Blood Red). These findings are consistent with those reported by Ghosh and Bera [6] in sweet orange.

The fruit length, width, weight, and total yield per plant all increased with the severity of pruning (Table 3). The highest fruit length (6.95 cm) and width (5.63 cm) were observed in Mosambi under the 15 cm Heading back treatment, which was significantly greater than the control. All pruning treatments resulted in a significantly higher yield per plant compared to the control. The highest yield was recorded in the Mosambi cultivar (14.87 kg), followed by Blood Red (13.48 kg) under the 15 cm Heading Back treatment. The maximum fruit weight was observed in Mosambi (153.29 g) and Blood Red (137.03 g) under the same treatment. The lowest fruit weight was recorded in the control for both cultivars. These findings are consistent with the explanation provided by Ahamed et al. [2], who suggested that heavily pruned plants receive more photosynthates, leading to larger fruit sizes. Conversely, the smaller fruit size in unpruned plants may be attributed to increased photosynthetic competition among the developing fruits. TSS concentration of the fruit was significantly affected by the various pruning treatments. In terms of total soluble solids, all treatments were significantly higher than the control. The treatment T4 (15 cm Heading back) had the highest (8.73 °B) TSS, which was significantly higher than all other treatments, and the minimum TSS (7.45 °B) was recorded in the control. Among the cultivars, Mosambi was observed to have a maximum (8.35 °B) TSS than Blood Red (7.97 °B). A similar trend was observed for total sugar content. The highest number of fruits per plant was also observed in plants with shoots headed back by 15 cm and these results are similar to those reported by Ingle et al. [8], who studied the effect of the severity of pruning on growth, yield, and quality of acid lime and found the highest number of fruits per plant in medium pruning (25-45 cm).

## Conclusion

The data from the present study suggest that a higher intensity of pruning (15 cm heading back) promoted greater vegetative growth in the plants. Additionally, both yield and fruit quality were improved compared to the control. In contrast, lower pruning intensities (5 cm and 2.5 cm heading back) resulted in reduced vegetative growth relative to the 15 cm heading back treatment, accompanied by a significant decline in fruit yield and quality. The highest fruit yield (14.16 kg) and best fruit quality—measured in terms of TSS (8.73 °B), reducing sugars (3.68%), and total sugars (6.23%) were observed in treatment T4. Therefore, 15 cm heading back can be considered the most effective treatment for maximizing fruit yield and quality, though it did not control plant size. Pruning along lateral branches was more effective than blunt cuts while heading back, as it prevented the formation of bunches of new shoots.

**Future scope:** The scope of the study included manual pruning at different intensities for canopy management in citrus. The future studies should be focussed on mechanical pruning in order to reduce the labour components. In addition, the use of growth retardants should also be evaluated to reduce vegetative growth and stimulate flowering, particularly in high density orchards.

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**Conflict of interest:** The authors declare that there is no conflict of interest pertaining to this study.

*Table 1. Effect of pruning treatments on vegetative growth of sweet orange cultivars.*

| Treatments | Increase in plan theight (cm) | | | Increase in tree-spread (cm) | | | Number of newshoots | | | Shoot extension growth (cm ) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (V1) Mosambi | (V2) BloodRed | Mean | (V1) Mosambi (EW-NS) | (V2) BloodRed (EW-NS) | Mean | (V1) Mosambi | (V2) BloodRed | Mean | (V1) Mosambi | (V2) BloodRed | Mean |
| **T1 (2.5 cm Heading Back)** | 56.52 | 52.97 | **54.74** | 35.13 | 34.66 | **34.88** | 4.00 | 3.50 | **3.75** | 10.25 | 9.75 | **9.99** |
| **T2 (5 cm Heading Back)** | 58.24 | 55.20 | **56.72** | 36.87 | 36.13 | **36.50** | 4.50 | 3.50 | **4.00** | 11.78 | 10.28 | **11.02** |
| **T3 (10 cm Heading Back)** | 63.71 | 61.00 | **62.36** | 38.45 | 37.84 | **38.15** | 4.75 | 4.25 | **4.50** | 14.88 | 13.48 | **14.17** |
| **T4 (15 cm Heading Back)** | 65.98 | 63.62 | **64.79** | 41.98 | 40.70 | **41.33** | 5.75 | 5.25 | **5.50** | 12.58 | 11.78 | **12.17** |
| **T5 (control)** | 52.99 | 48.44 | **50.72** | 27.42 | 26.08 | **26.75** | 3.50 | 3.25 | **3.37** | 9.81 | 9.23 | **9.51** |
| **Mean** | **59.48** | **56.25** | | **35.95** | **35.08** | | **4.50** | **3.95** | | **11.86** | **10.89** | |
| **Factor** | **T** | **V** | **T×V** | **T** | **V** | **T×V** | **T** | **V** | **T×V** | **T** | **V** | **T×V** |
| **C.D0.05** | 1.48 | 0.94 | N/S | 1.41 | N/S | N/S | 0.55 | 0.35 | N/S | 0.84 | 0.52 | N/S |
| **SE(m)** | 0.51 | 0.32 | 0.72 | 0.48 | 0.30 | 0.68 | 0.19 | 0.12 | 0.27 | 0.28 | 0.19 | 0.40 |
| **SE(d)** | 0.72 | 0.45 | 1.02 | 0.68 | 0.43 | 0.97 | 0.27 | 0.37 | 0.27 | 0.40 | 0.25 | 0.56 |

*Table 2. Effect of pruning treatments on flowering and fruit set of sweet orange cultivars.*

| Treatments | No. of flower buds/meter shoot length | | | Fruit set (% | | |
|---|---|---|---|---|---|---|
| | (V1) Mosambi | (V2) BloodRed | Mean | (V1) Mosambi | (V2) BloodRed | Mean |
| **T1 (2.5 cm Heading Back)** | 49.45 | 41.56 | **45.51** | 53.50 | 49.50 | **51.50** |
| **T2 (5 cm Heading Back)** | 51.14 | 44.62 | **47.88** | 56.50 | 51.50 | **54.00** |
| **T3 (10 cm Heading Back)** | 57.67 | 50.80 | **54.25** | 64.50 | 60.50 | **62.50** |
| **T4 (15 cm Heading Back)** | 54.10 | 47.70 | **50.90** | 61.50 | 55.50 | **58.50** |
| **T5 (control)** | 38.37 | 35.09 | **36.75** | 47.50 | 45.00 | **46.25** |
| **Mean** | **50.15** | **43.96** | | **56.70** | **52.40** | |
| **Factor** | **T** | **V** | **T×V** | **T** | **V** | **T×V** |
| **C.D0.05** | 1.79 | 1.14 | N/S | 1.43 | 0.90 | N/S |
| **SE(m)** | 0.62 | 0.39 | 0.87 | 0.49 | 0.31 | 0.69 |
| **SE(d)** | 0.87 | 0.55 | 1.23 | 0.69 | 0.44 | 0.98 |

*Table 3. Effect of pruning treatments on yield and physical quality parameters of sweet orange cultivars.*

| Treatments | Fruit weight (g) | | | Fruit length (cm) | | | Fruit breadth (cm) | | | Fruit yield/plant (kg) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (V1) Mosambi | (V2) BloodRed | Mean | (V1) Mosambi | (V2) BloodRed | Mean | (V1) Mosambi | (V2) BloodRed | Mean | (V1) Mosambi | (V2) BloodRed | Mean |
| **T1 (2.5 cm Heading Back)** | 117.06 | 106.87 | **111.97** | 6.35 | 5.95 | **6.15** | 5.21 | 5.12 | **5.16** | 10.09 | 9.25 | **9.67** |
| **T2 (5 cm Heading Back)** | 132.69 | 124.87 | **128.78** | 6.55 | 6.25 | **6.38** | 5.38 | 5.32 | **5.35** | 11.31 | 10.56 | **10.98** |
| **T3 (10 cm Heading Back)** | 142.38 | 132.25 | **137.32** | 6.75 | 6.37 | **6.56** | 5.45 | 5.36 | **5.41** | 13.15 | 11.75 | **12.48** |
| **T4 (15 cm Heading Back)** | 153.29 | 137.03 | **145.15** | 6.95 | 6.60 | **6.77** | 5.63 | 5.45 | **5.56** | 14.87 | 13.48 | **14.16** |
| **T5 (control)** | 106.43 | 101.56 | **103.99** | 5.95 | 5.60 | **5.76** | 5.06 | 4.88 | **4.97** | 7.68 | 6.87 | **7.28** |
| **Mean** | **130.37** | **120.52** | | **6.50** | **6.15** | | **5.35** | **5.23** | | **11.48** | **10.37** | |
| **Factor** | **T** | **V** | **T×V** | **T** | **V** | **T×V** | **T** | **V** | **T×V** | **T** | **V** | **T×V** |
| **C.D0.05** | 3.36 | 2.13 | 4.75 | 0.22 | 0.14 | N/S | 0.04 | 0.02 | 0.05 | 0.75 | 0.47 | N/S |
| **SE(m)** | 1.15 | 0.73 | 1.63 | 0.07 | 0.05 | 0.11 | 0.01 | 0.01 | 0.02 | 0.25 | 0.16 | 0.36 |
| **SE(d)** | 1.63 | 1.03 | 2.31 | 0.11 | 0.06 | 0.15 | 0.02 | 0.01 | 0.03 | 0.36 | 0.23 | 0.56 |

*Table 4. Effect of pruning treatments on biochemical parameters of sweet orange cultivars.*

| Treatments | Number of fruits/plant | | | TSS (°B) | | | Titratable acidity(%) | | | Non-reducing sugar(%) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (V1) Mosambi | (V2) BloodRed | Mean | (V1) Mosambi | (V2) BloodRed | Mean | (V1) Mosambi | (V2) BloodRed | Mean | (V1) Mosambi | (V2) BloodRed | Mean |
| **T1 (2.5 cm Heading Back)** | 73.50 | 64.75 | **69.12** | 8.05 | 7.75 | **7.90** | 0.52 | 0.57 | **0.54** | 1.77 | 1.80 | **1.78** |
| **T2 (5 cm Heading Back)** | 78.75 | 69.75 | **74.25** | 8.35 | 8.05 | **8.20** | 0.49 | 0.59 | **0.54** | 1.85 | 1.85 | **1.85** |
| **T3 (10 cm Heading Back)** | 83.50 | 77.50 | **80.50** | 8.65 | 8.35 | **8.50** | 0.46 | 0.53 | **0.49** | 1.82 | 1.85 | **1.84** |
| **T4 (15 cm Heading Back)** | 88.50 | 80.25 | **84.37** | 8.97 | 8.45 | **8.73** | 0.31 | 0.35 | **0.33** | 1.75 | 1.60 | **1.67** |
| **T5 (control)** | 66.50 | 61.25 | **63.87** | 7.65 | 7.25 | **7.45** | 0.59 | 0.62 | **0.61** | 1.57 | 1.55 | **1.56** |
| **Mean** | **78.15** | **70.70** | | **8.35** | **7.97** | | **0.47** | **0.53** | | **1.75** | **1.73** | |
| **Factor** | **T** | **V** | **T×V** | **T** | **V** | **T×V** | **T** | **V** | **T×V** | **T** | **V** | **T×V** |
| **C.D0.05** | 3.38 | 2.14 | N/S | 0.15 | 0.09 | N/S | 0.05 | 0.03 | N/S | 0.13 | N/S | N/S |
| **SE(m)** | 1.16 | 0.74 | 1.64 | 0.05 | 0.03 | 0.07 | 0.02 | 0.01 | 0.02 | 0.06 | 0.04 | 0.08 |
| **SE(d)** | 1.64 | 1.04 | 2.32 | 0.07 | 0.04 | 0.12 | 0.02 | 0.01 | 0.01 | 0.04 | 0.03 | 0.06 |

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