https://doi.org/ 10.33472/AFJBS.6.5.2024. 6477-6488

African Journal of Biological Sciences

Pruning and bacterial inoculation improves growth, Leaf nutrient status and productivity of Kinnow mandarin

Amandeep Singh Brar[1], Manish Bakshi[2], Anmol[3]*, Lakshya[1]

[1] Ph.D. Scholar, Department of Horticulture, Lovely Professional University, Phagwara-144411, Punjab.

[2] Associate Professor, Department of Horticulture, Lovely Professional University, Phagwara-144411, Punjab.

[3]Assistant Professor, Department of Horticulture, Lovely Professional University, Phagwara-144411, Punjab

Corresponding author: Anmol, **Email:** anmol.28381@lpu.co.in Contact number: 96530 08421

Article History
Volume 6, Issue 5, 2024
Received: 15 May 2024
Accepted: 22 May 2024
doi: ***10.33472/AFJBS.6.5.2024. 6477-6488***

Abstract

Pruning has shown to affect the growth and productivity of the fruiting plants but the intensity of pruning has a major role to play. Also, biofertilizer application induces nutrient availability thereby enhancing the output from the orchards. Study involving effect of pruning intensities and biofertilizer application on Kinnow plants was carried out. Treatments included two pruning intensities (25% and 50%) and two types of biofertilizer applications (Azotobacter and Mycorrhiza). Various vegetative, physical and chemical parameters were evaluated. It was observed that light pruning along with application of azotobacter resulted in enhanced plant growth as well as yield and quality characteristics in Kinnow mandarin which was at par with when heavy pruning was coupled with azotobacter application and light pruning along with mycorrhiza application. The study concluded that Kinnow mandarin plants do benefit from light pruning which induces growth leading to productivity increment. The beneficial effect of biofertilizers was also evident from the results obtained.

Keywords: Kinnow mandarin, pruning, azotobacter, mycorrhiza, growth, yield, quality

Introduction

Kinnow, a hybrid citrus species is common in the subtropical belt of north India. It belongs to family "Rutaceae" and sub-family "Aurantoideae" and can be cultivated in different climatic ranges of tropical and sub-tropical regions also. It performs well in semi-arid and humid conditions. For ideal growth, it requires good quality of irrigation water as it is sensitive to salinity besides ample amount of daylight along with a temperature which ranges between 15.5°C and 29°C. In India, it is cultivated over an area of 10 lakh hectares with 12.81 million tons of produce (Anonymous, 2021). Kinnow is an excellent appetizer, a source of ascorbic acid and its peel is used for making candies and extracting. It is also used for extraction of citric acid which is used in the form of acidifier as chelating agent and flavoring agent oils (Aschoff, 2015). Kinnow fruit has brought golden revolution in Punjab along with its adjoining regions, due to its best quality and because of its adaptability to climate and maximum production potential. Kinnow grows rapidly and is top ranked fruit in Punjab. 62% of total area under fruit crops in Punjab is under Kinnow with more than 12 million tons of production. In India, Punjab leads in production of Kinnow and has 29% share in total Kinnow production of the country. The plant owes its popularity to wide adaptability, pleasant flavor, juice content and prolific bearing potential.

Pruning is a major activity in fruit plants. In a pruned tree, apical meristem and upper buds are usually removed resulting in loss in cambial surface leading to a alteration in cambial proportions besides a loss of the substance of the pruning i.e. shoots and leaves. Pruning intensity has been related to the bud growth in plants leading to vegetative and floral abundance thereby enhancing the producibility of the trees. Normally it relates to the removal of dead, diseases and cris-cross branches in the plant structure but it has been positively linked with the fruit bearing potential of the plant. Level of pruning affects the plant physiology (Dhaliwal and Kaur; 2003;

Sarkar et al., 2005; Shaban and Haseeb, 2009). Annual pruning after harvesting of fruits encourages emergence of new shoots (Jadhav *et al.*, 2002). Different percentage of pruning (25% and 50%) and pruning intervals have shown to affect the fruit yield and overall performance of the fruit plant. Citrus trees respond to pruning in terms of increased vigour which leads to a balanced portioning of assimilates (Apelblat, 2014). Bio-fertilizer, the living microbes are useful to plants as well as soil. These colonize the interior of the plant and improve plant health with the nutrient availability to host. Bio-fertilizers like *Azotobacter*, Mycorrhiza are bacterial inoculations which can activate nutritive elements into soluble form from non-soluble through biological procedure. Biofertilizers catalyze the ion conversion reactions in the soil and thus enhance the availability of nutrients to the fruit tree which translates into incremental increase of the plant growth and yield characters. The use of biofertilizers significantly influence the growth, yield and value of fruit crops as they are more economically and socially beneficial than chemical fertilizers. It is safer and beneficial in the production and maintains the quality of food by using the bio-fertilizer instead of using chemical fertilizers (Martin-Gorriz *et al.*, 2021).

Materials and Methods

This experiment was undertaken in the horticultural farms of Department of Horticulture during the growing cycle of the Kinnow mandarin crop. Kinnow mandarin trees of nearly 7 years age which were uniform in growth, healthy and showing no symptoms of decline or any other disease were selected for the purpose of study. The trees were tagged in the field. All the plants under study received uniform cultural practices and recommended dose of fertilizers as per the recommendations of Punjab Agricultural University (Anonymous, 2021a). Organic manure was incorporated in the basins of the fruit trees in rings followed by application of inorganic fertilizers. Biofertilizers were incorporated as per treatments 20 days after the application of inorganic fertilizers. For application of biofertilizers, a slurry of 10 % jaggery solution was made with Azotobacter and Mycorrhiza @100 g per plant was applied to the Kinnow mandarin trees as per the treatment combinations. Pruning of the Kinnow mandarin trees was carried out after application of biofertilizers in the month of January and February. For pruning, healthy branches were marked on all the sides and pruning was done as per the treatment combinations. Plant height was recorded using graduated stick from bottom of the plant to the highest leaf. Plant spread was observed from north-south and east-west directions using graduated stick. Yield, quality and leaf nutrient parameters were recorded as per the standard procedures. Data generated during the course of the experiment was subjected to statistical analysis using SPSS Version 16 (Anonymous, 2016) to arrive at homogenous subsets.

Results and Discussion

Percent increase in plant height and plant spread (Table 1) was maximum with light pruning and Azotobacter application which recorded values of 34.2 per cent increase in plant height and 11.70 per cent EW and 9.26 percent NS increase in plant spread. The highest % increase in canopy volume was 16.33% where heavy pruning along with Mycorrhizal application was done. It was observed that light pruning along with azotobacter application boosted the regenerative growth in Kinnow mandarin plants as compared to heavy pruning. *Azotobacter* plays the major role in increasing plant height. There is increase of carbohydrates formation which leads to increase in the growth of the treated plants which ultimately led to an increase in plant spread and in diameter of canopy which leads to boost growth of plants (Martin-Gorriz *et al.*, 2021, Cynthia, 2000). Sunlight is pivotal for color development and quality by affecting the flowering and fruit set. Pruning of the trees builds a strong framework and ensures the regular bearing each year Shaban and Mohsen, 2009).

Yield characters also showed variability in results under different pruning intensities and biofertilizer application (Table 2). Fruit number per plant (360), yield (119.80 kg/plant) and peel percentage (41 %) were highest with light pruning (25%) along with Azotobacter application. Same observations were reported by Trivedi et al. (2012) wherein alteration of flowering phenology by vesicular arbuscular mycorrhiza (VAM) colonization in the roots of Kinnow mandarin trees was reported. The plants which are colonized with growth promoting bacteria produce more flowers that leads to increase in the total number of fruits. Light pruning of shoots in citrus resulted in development of healthy roots and shoots. When the number of fruit buds are decreased on the fruit plant, they trend to give the more superior quality fruit which also increases the total desired fruit (Ahmad et al. 2006). When the number of fruit buds are decreased on the fruit plant, they trend to give the more superior quality fruit which also increases the total desired fruit.

Fruit physical characters also showed variations (Table 3) with fruit width (7.0 cm) and fruit length (4.9 cm) being maximum under treatment T_5 (light pruning + Azotobacter). The least values for fruit width and fruit length recorded were in treatment T_1 (control) with 4.7 cm and 3.7 cm, respectively. Maximum fruit weight (443.33 g) and fruit volume (445.0 ml) were recorded under treatment T_5 (light pruning + Azotobacter). Treatment T_6 (heavy pruning (50%) + Mycorrhiza) recorded the highest specific gravity (1.02%) and least was recorded in T_7 (heavy pruning +Azotobacter) and T_8 (Mycorrhiza) where it was 0.96%. The juice content in T_5 (light pruning + Azotobacter) and rag content (62%) was recorded highest with 64 % and least (35 %) was recorded in the T_1 (control). The extreme fruit length, breadth, fruit weight, TSS and total sugar were recorded with Azotobacter inoculation while the minimum values were associated with un-inoculated plants (Ahmad *et al.,* 2006). Increment in juice content might be due to increase in size of juice vesicles and ultimately juice sap, this can also be due to increase in size and weight of the fruit. Thus, light pruning proved incremental in increasing juice content and fruits from un-pruned plants had thick peel. The juice content in T_5 – light pruning + *Azotobacter* was 29% more from unpruned plants which may be due to enhanced light entrapment and enhanced nutrient availability (Salama, 2018).

Chemical parameters

For most of the fruit quality parameters, light pruning with azotobacter application recorded highest values (Table 4). Highest T.S.S, least % of acidity (0.7 %), highest T.S.S to acid ratio (15.81) and highest ascorbic acid content (35.1 mg/100 ml juice) was observed in the fruits of the plants treated with low intensity of pruning and azotobacter application. Similarly, total sugar content (6.04%), reducing sugar (2.98 %) was highest under T_5 (light pruning + Azotobacter) and lowest values (2.54%) were recorded under the T_1 (Control). In non-reducing sugars, the highest reading (3.28 %) was recorded in the T8 (Mycorrhiza) and least reading was recorded in T_6 (heavy pruning + Mycorrhiza) that is 2.92 per cent.

It was observed that Kinnow trees treated with light pruning intensity had higher TSS. It may be due to ample synthesis and supply of photosynthates (Rana and Chandel, 2003; Umar *et al.*, 2017). Superior fruit quality parameters were recorded with Azotobacter inoculation while the minimum values were associated with un-inoculated plants. Application of bio-fertilizer in Guava cv. L-49 resulted in increased fruit length, diameter, and total soluble solids through inoculation of guava plants with *Azotobacter* than over the uninoculated control (Nasir *et al.*, 2016).

Leaf N, P and K content was non-significant among the treatments, however it was significant when compared to control (Table 5). Highest leaf N (2.55 %) and P content (0.15 %) were recorded under treatment T_5. However maximum leaf K (0.67 %) content was recorded under control (T_1). Effect of pruning on plant nutrient status was more pronounced when compared with control (T1) but the results were non-significant when pruning severity was analyzed. Both light pruning and heavy pruning resulted in non-significant variations in the levels of leaf N content. Light pruning coupled with microbial inoculation resulted in enhanced levels of leaf N and P. The results find support with the works of Gosh and Bera (2014). Maximum benefit cost ratio of (3.91) was obtained under treatment comprising light pruning and *Azotobacter* (T_5) (Figure 1) followed by benefit cost ratio of 3.84 and 3.23 obtained under treatment T_9 (*Azotobacter*) and T_8 (*Mycorrhiza*). Lowest benefit cost ratio of 1.34 was obtained under treatment T_2 (light pruning).

Conclusion

Bio-fertilizers have an established role in improving the nutrient availability in plants by modifying the rhizosphere environment and converting the nutrients available in to a more readily absorbable form. This coupled with pruning holds great promise in improving the productivity and quality of Kinnow mandarin as pruning has been reported to induce new vigour in the plants and tends to increase the fruiting wood thereby increasing the crop load. The findings of this study clearly indicated a positive effect of microbial intervention and pruning on the growth, yield, quality and plant nutrient status in Kinnow mandarin.

References

1. Ahmad, S., Chatha, Z.A., Nasir, M., Aziz, A., Virk, N.A. and Khan, A. (2006). Effect of pruning on the yield and quality of Kinnow fruit. *J Agric Soc Sci* 2: 51-53.
2. Anonymous (2021a). Package of Practices for cultivation of Fruit Crops. Punjab Agricultural University, Ludhiana.
3. Anonymous (2016). IBM Corp. Released 2016. IBM SPSS Statistics for Windows, Version 24.0. Armonk, NY: IBM Corp.
4. Anonymous (2021). Horticultural statistics at a glance. National Horticulture Board, India.

5. Apelblat A. (2014). Properties of citric acid and its solutions. *Citric acid*, Publisher: Springer Nature 13-141.
6. Aschoff JK, Kaufmann S, Kalkan O, Neidhart S, Carle R, Schweiggert RM. (2015). In vitro bioaccessibility of carotenoids, flavonoids, and vitamin C from differently processed oranges and orange juices [Citrus sinensis (L.) Osbeck]. *J Agric Food Chem* 63(2): 578-587.
7. Chandra, R., and S. Govind. 1995. Influence of time and intensity of pruning on growth, yield and fruit quality of guava under high-density planting. Trop. Agr. (Trinidad) 72(2):110–113.
8. Cynthia B, Kumar N. and Soorianathasundaram K. (2000). Genetic variability and association of economic characters in red fleshed dioecious lines in papaya (*Carica papaya* L.). *South Indian Hort*. 48(1/6): 11-17.
9. Dey, P., Rai, M., Nath, V., Das, B. and Reddy, N. N. (2005). Effect of biofertilizers on physico-chemical characteristics of guava fruit. *Indian J Agric Sci* 75(2): 95-96.
10. Dhaliwal, G.S., and R. Kaur. 2003. Effect of time and pruning intensity on age of bearing shoot and fruit quality of 'Sardar' guava. Haryana J. Hort. Sci. 32:21–24.
11. Evans, J. and Poorter, H. (2001). Photosynthetic acclimation of plants to growth irradiance: The relative importance of specific leaf area and nitrogen partitioning in maximizing carbon gain. *Plant Cell Environ* 24(8): 755-767.
12. Gosh, S.N. and Bera, B. (2014). Effect of pruning on productivity in sweet orange. *J Hort. Sci* 9(2): 206-208.
13. Jadhav, B.J., V.K. Mahurkar, and V.S. Kale. 2002. Effect of time and severity of pruning on growth and yield of guava (Psidium guajava L.) cv. Sardar. Orissa J. Hort. 30(2):83–86.

14. Khehra, S and Bal, J.S. (2014). Influence of organic and inorganic nutrient sources on growth of lemon [*Citrus limon* (L.) Burm.] cv. Baramasi. *J Exp Biol Agric Sci* 2: 126-129.
15. Martin-Gorriz B, Martinez-Barba C and Torregrosa A. (2021). Lemon trees response to different long-term mechanical and manual pruning practices. *Sci Hortic* 275:109700.
16. Nasir, M., Khan, A.S., Basra, S.A., Malik, A.U. (2016). Foliar application of moringa leaf extract, potassium and zinc influence yield and fruit quality of 'Kinnow' mandarin. *Sci Hortic* 210: 227-235.
17. Rana, R.K. and Chandel, J.S. (2003). Effect of biofertilizers and nitrogen on growth, yield and furit quality of strawberry. *Progress Hortic* 35 (1): 25-30.
18. Salama, T.S. (2018). Effect of some pruning treatments on Olinda orange. CU Theses.
19. Sansavini, S. and Musacchi, S. 1994. [Plant models-architecture and pruning in modern pear orchards].[Italian]. *Rivista di Frutticoltura e di Ortofloricoltura*.
20. Sarkar, A., B. Ghos, S. Kundu, and P. Sukul. 2005. Effect of shoot pruning and bending on yield and fruit quality in guava cv. L-49. Environ. Ecol. 23S(3):621–623.
21. Shaban A.E.A., and G.M.M. Haseeb. 2009. Effect of pruning severity and spraying some chemical substances on growth and fruiting of guava trees. Amer.-Eurasian J. Agr. Environ. Sci. 5(6):825–831.
22. Shaban, A.E.A. and Mohsen A.T. (2009). Response of citrus rootstocks and transplants to biofertilizers. *J Hortic Sci Orname Plants* 1(2): 39-48.
23. Trivedi, Y.V., Patel, N.L., Ahlawat, T.R., Gaikwad ,S.S. and Bhalerao, P.P. (2012). Impact of organic manures and inorganic fertilizers on growth, yield, nutrient uptake and soil nutrient status in guava. *Indian J Hortic* 69(4): 501-506.

24. Umar, M., Ahmad, S., Haider, S. T. A. and Naz, S. (2017). Effect of pruning to improve yield and fruit quality of 'Kinnow'mandarin plants under high density plantation. *J Hortic Sci Technol 2*(3), 85-98.

Table 1: Effect of pruning and microbial inoculation on growth of Kinnow mandarin.

Treatments	Plant height (%)	Plant spread (%) EW	Plant spread (%) NS	Canopy volume (%)
T_1 - Control	17.7^{a}	6.07^{a}	5.32^{a}	6.66^{a}
T_2 – light pruning	20.9^{a}	7.47^{ab}	5.47^{a}	11.37^{a}
T_3 – heavy pruning	22.3^{a}	6.34^{a}	6.18^{ab}	7.10^{a}
T_4 – light pruning + *Mycorrhiza*	17.4^{a}	8.38^{b}	8.20^{cd}	7.78^{a}
T_5 – light pruning + *Azotobacter*	34.2^{b}	11.70^{c}	9.26^{d}	10.06^{a}
T_6 – heavy pruning + *Mycorrhiza*	15.8^{a}	6.86^{ab}	8.07^{cd}	16.33^{a}
T_7 – heavy pruning +*Azotobacter*	17.2^{a}	8.40^{b}	6.62^{ab}	13.95^{a}
T_8 – *Mycorrhiza*	17.6^{a}	8.37^{b}	7.36^{bc}	10.54^{a}
T_9 – *Azotobacter*	11.9^{a}	6.46^{a}	8.09^{cd}	5.61^{a}

*Values with similar letters in superscript as non-significant among themselves.

Table 2: Effect of pruning and microbial incoculation on yield characters of kinnow mandarian.

Treatments	Numbers of fruit per plant	Yield per plant (kg)	Peel percentage (%)
T_1 - Control	193.33^{a}	65.27^{a}	27.33^{a}
T_2 – light pruning	250.00^{b}	65.93^{a}	21.33^{ab}
T_3 – heavy pruning	263.33^{b}	76.47^{ab}	31.00^{bcd}
T_4 – light pruning + *Mycorrhiza*	278.33^{b}	95.30^{b}	36.00^{bc}
T_5 – light pruning + *Azotobacter*	360.00^{c}	119.80^{c}	41.00^{e}
T_6 – heavy pruning + *Mycorrhiza*	265.00^{b}	87.10^{ab}	26.00^{cd}
T_7 – heavy pruning +*Azotobacter*	241.67^{b}	86.02^{ab}	28.00^{cd}
T_8 – *Mycorrhiza*	236.00^{b}	75.57^{ab}	25.33^{d}
T_9 – *Azotobacter*	266.67^{b}	86.32^{ab}	24.67^{cd}

Table 3: Effect of pruning and microbial inoculation on physical characters of Kinnow mandarin fruit.

Treatments	Fruit length (cm)	Fruit width (cm)	Fruit weight (gm)	Fruit volume (ml)	Specific gravity	Juice content (%)	Rag content (%)
T_1 - Control	3.7[a]	4.7[a]	260[a]	265.0[a]	0.98[a]	35.0[a]	31[e]
T_2 – light pruning	4.4[bcd]	5.4[bc]	340.00[b]	339.3[bc]	1.00[a]	44.3[a]	31[e]
T_3 – heavy pruning	4.0[ab]	5.2[b]	293.33[ab]	294.0[ab]	0.99[a]	40.7[a]	42.5[d]
T_4 – light pruning + *Mycorrhiza*	4.5[bcd]	5.5[bc]	343.33[b]	346.7[bc]	0.99[a]	35.3[a]	49[bc]
T_5 – light pruning + *Azotobacter*	4.9[d]	7.0[e]	443.33[c]	445.0[d]	0.99[a]	64.0[b]	62[a]
T_6 – heavy pruning + *Mycorrhiza*	4.6[bcd]	5.9[d]	330.00[ab]	321.7[abc]	1.02[a]	62.3[b]	46.5[c]
T_7 – heavy pruning +*Azotobacter*	4.2[abc]	5.5[bcd]	356.67[b]	368.3[c]	0.96[a]	57.7[b]	51[b]
T_8 – *Mycorrhiza*	4.8[cd]	6.0[d]	320.00[ab]	330.0[abc]	0.96[a]	62.7[b]	31[e]
T_9 – *Azotobacter*	4.6[bcd]	5.9[cd]	323.33[ab]	328.3[abc]	0.98[a]	55.3[b]	41.5[d]

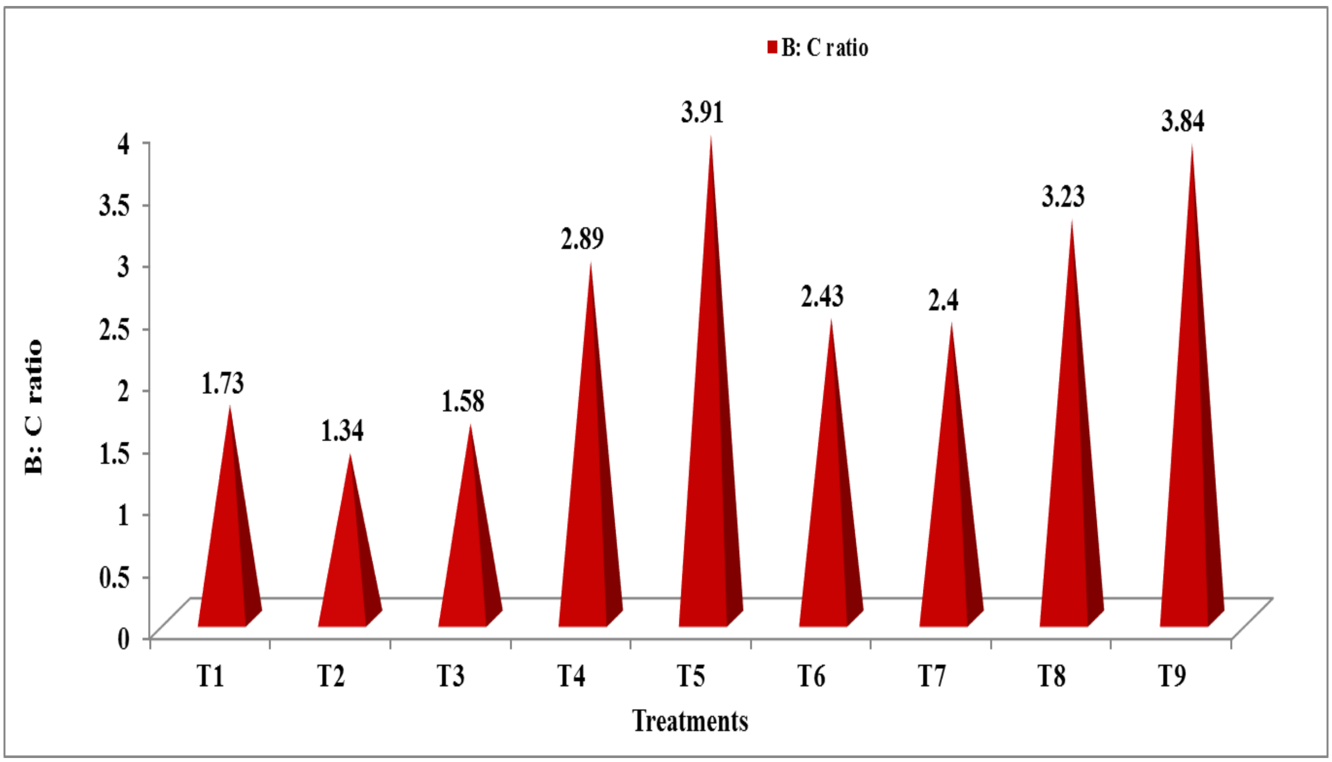
Table 4: Effect of pruning and microbial inoculation on TSS, titratable acidity, TSS: acid ratio, Ascorbic acid, Total sugar, reducing sugar and non-reducing sugar content of Kinnow mandarin fruit.

Treatments	TSS (^{o}Brix)	Acidity (%)	TSS: acid ratio	Ascorbic acid (mg per 100g juice)	Total sugar (%)	Reducing sugar (%)	Non-reducing sugar (%)
T_1 - Control	9.1[a]	0.9[b]	10.61	28.1[a]	5.47[a]	2.54[a]	2.93[d]
T_2 – light pruning	10.4[abc]	0.8[ab]	13.62	28.3[a]	5.78[cd]	2.57[ab]	3.21[ab]
T_3 – heavy pruning	10.3[abc]	0.8[ab]	12.93	31.5[ab]	5.71[bc]	2.64[bc]	3.07[bc]
T_4 – light pruning + *Mycorrhiza*	9.5[ab]	0.9[b]	10.63	30.0[ab]	5.65[b]	2.58[ab]	3.07[bc]
T_5 – light pruning + *Azotobacter*	11.3[c]	0.7[a]	15.81	35.1[b]	6.04[f]	2.98[d]	3.05[bc]
T_6 – heavy pruning + *Mycorrhiza*	10.0[abc]	0.8[ab]	11.86	30.3[ab]	5.53[a]	2.61[ab]	2.92[d]
T_7 – heavy pruning +*Azotobacter*	10.0[abc]	0.8[ab]	12.84	30.5[ab]	5.91[e]	2.70[c]	3.22[ab]
T_8 – *Mycorrhiza*	10.5[bc]	0.8[ab]	12.71	32.2[ab]	5.86[de]	2.57[ab]	3.28[a]
T_9 – *Azotobacter*	10.7[bc]	0.8[ab]	13.06	31.5[ab]	5.82[cde]	2.58[ab]	3.23[ab]

Table 5: Effect of pruning and microbial inoculation on leaf nutrient status of Kinnow mandarin.

Treatments	Nitrogen content (%)	Phosphorus content (%)	Potassium content (%)
T_1 - Control	2.01^{e}	0.05^{d}	0.67^{a}
T_2 – light pruning	2.43^{bc}	0.13^{abc}	0.65^{ab}
T_3 – heavy pruning	2.45^{bc}	0.14^{ab}	0.63^{bc}
T_4 – light pruning + *Mycorrhiza*	2.53^{a}	0.13^{abc}	0.64^{abc}
T_5 – light pruning + *Azotobacter*	2.55^{a}	0.15^{a}	0.63^{bc}
T_6 – heavy pruning + *Mycorrhiza*	2.51^{ab}	0.12^{bc}	0.64^{abc}
T_7 – heavy pruning +*Azotobacter*	2.43^{bc}	0.1^{c}	0.65^{ab}
T_8 – *Mycorrhiza*	2.41^{cd}	0.12^{bc}	0.61^{d}
T_9 – *Azotobacter*	2.53^{a}	0.15^{a}	0.64^{abc}

*Values with similar letters in superscript as non-significant among themselves.



T_1 – Control, T_2 – light pruning, T_3 – heavy pruning, T_4 – light pruning + *Mycorrhiza*, T_5 – light pruning + *Azotobacter*, T_6 – heavy pruning + *Mycorrhiza*, T_7 – heavy pruning +*Azotobacter*, T_8 – *Mycorrhiza*, T_9 – *Azotobacter*

Figure 1: Benefit cost ratio of different pruning and microbial inoculation treatments in Kinnow mandarin.