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Original Research

Effect of Pruning to Improve Yield and Fruit Quality of 'Kinnow' Mandarin Plants under High Density Plantation

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ABSTRACT

Due to rapid increase in population and limited available resources, world trend is moving towards high density plantation for proper utilization of land and resources. The present experiment was planned to investigate the effects of pruning on plant yield and fruit quality of 'Kinnow' mandarin grown under high density plantation. Plants were pruned by three different ways i.e. i) pruning of one side's branches, (ii) pruning of both sides' branches and (iii) pruning of top branches. Overall results revealed that all the pruning treatments were effective but the plants pruned from both sides performed better in terms of improved yield (greater number of fruits and higher total fruit yield per plant) and fruit quality (increased fruit size, higher juice weight, lower peel weight, lower juice TA, greater TSS:TA ratio, and higher total phenolic content (TPC) and total antioxidants). Keeping in view the above results, it is concluded that 'Kinnow' plants grown under high density plantation should be pruned from both side of canopy to obtain better yield and fruit quality.

Keywords: *Citrus, drip irrigation, total phenolic content, total antioxidants.*

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INTRODUCTION

In Pakistan, 'Kinnow' mandarin is leading citrus cultivar ranked first in terms of production and export. It is in great demand due to its unique taste and other fruit characteristics, thus fetches a foreign exchange of almost 180-200 million US dollars every year (Ahmad, 2017; Ahmad, 2018). 'Kinnow' production in the year 2017 was recorded about 2.27 million tons however, it was decreased by 50,000 tons during 2018 due to limited availability of resources and improper management practices (Umar et al., 2017; Ahmad, 2018). Many biotic, a biotic factors and management practices (training, pruning, irrigation, fertilizer application and improper spacing etc.) directly affect the growth and productivity of 'Kinnow' mandarin. To meet the target of higher production and good quality fruits every year, there is need to optimize different growth parameters and to introduce latest scientific techniques and management practices in 'Kinnow' mandarin plants (Dhaliwal et al., 2014). Different modern systems (including tree spacing and high-density plantation) have been introduced to increase fruit production with long gestation period, early returns, better fruit quality and reduced cost. These techniques are used for efficient use of light, water and nutrients as well as to overcome limited available land resources (Singh et al., 2012; Mali et al., 2016). Due to rapid increase in world population, natural resources and agricultural land for cultivation are turning limited. To overcome these problems, many developed countries are moving towards high density plantation in citrus (Dhaliwal et al., 2014; Dogar et al., 2017).

Improper spacing may be one of the major reasons for lower production in different fruit crops. As the citrus trees have limited productive age, farmers can get maximum production per unit area by maintaining proper space between plants. To increase economic results, planting density is always arranged in such a way that different management or biological aspects correlate with each other and more trees can be planted at small area (Dhaliwal et al., 2014; Dhaliwal et al., 2016; Tiwari et al., 2018). Pruning is a common horticultural practice contributing a vital role in the canopy management and causes long-term effect on plant growth, vigour and yield. It manipulates a range of aspects of vegetative as well as fruiting behaviour. Previous studies suggest that without pruning, the citrus plants show sympodial growth habit resulting in bush form (5-6 m tall) growth. Proper canopy management results in good quality and 3-4 folds more fruit yield in different citrus cultivars. Fruit size can be increased by decreasing number of fruit buds that may result in lower yield but with better fruit quality and improved physico-chemical behaviour (Intrigliolo and Roccuzzo, 2011; Din et al., 2012; Jing et al., 2017).

Recommending a proper planting space is still a big issue for scientists in high density plantation and no standardized pruning method has been developed yet to control the canopy load of closely planted trees (Ahmad et al., 2006; Vijaya et al., 2017). It is very unfortunate that trend to adopt the adequate

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planting space and proper pruning method is not common in Pakistan and is being practiced at very small scale in fruit orchards resulting in poor yield and poor fruit quality. Keeping in view the above discussion, the present research work was planned to evaluate the effects of pruning on yield and fruit quality of 'Kinnow' mandarin plants grown under high density plantation.

MATERIALS AND METHODS

The current research work was carried out at the Experimental Fruit Orchard, Post Graduate Agricultural Research Station (PARS), University of Agriculture, Faisalabad (UAF) Pakistan (31° 25' 0" North, 73° 5' 0" East, 184 m elevation). Seven years old plants of 'Kinnow' mandarin (planted at 3 × 3 m) with uniform vigour and healthy growth were selected for pruning during last week of January 2017. All the plants were provided with normal cultural practices and drip irrigation method was used for all the treatments to enhance the water use efficiency. Following pruning treatments were applied to the plants; a) control (no pruning), b) pruning one side's branches at a distance of 0.5 m away from main stem, c) pruning both sides' branches at distance of 0.5 m away from main stem, and d) pruning of top branches at a height of 1.8 m. The experiment was laid out according to randomized complete block design (RCBD) and each treatment was replicated four times. A single plant from each replication was used as an experimental unit and five fruits from each experimental unit were selected to analyse physical and biochemical quality parameters of fruits.

Determination of physical attributes and physiological parameters

Fruit yield was estimated in terms of number of fruits and by total fruit weight (kg) per plant from each treatment. Fruit length (cm) and fruit diameter (cm) were measured by using a digital Vernier calliper. Peel weight, juice weight and rag weight were calculated in percentages by using the following formulas.

$$Peel\ weight\ (\%) = \frac{Average\ peel\ weight}{Average\ fruit\ weight} \times 100$$

$$Juice\ weight\ (\%) = \frac{Average\ juice\ weight}{Average\ fruit\ weight} \times 100$$

$$Rag\ weight\ (\%) = \frac{Average\ rag\ weight}{Average\ fruit\ weight} \times 100$$

Total soluble solids (TSS), titratable acidity (TA) and ripening index (TSS:TA ratio)

The manual extractor was used to extract 'Kinnow' juice without seeds and Whatman® filter paper No.1 was used to filter the juice. TSS was determined by digital refractometer (RX 5000, Atago, Japan) at room temperature and after every reading prism was washed with distilled water to avoid error. To determine fruit TA, 10 mL juice was taken and titrated against 0.1 N NaOH and phenolphthalein was used as indicator to achieve the end-point of pink colour (Hortwitz, 1960). TA was determined according to the following formula.

$$TA\ (\%) = \frac{0.1N\ NaoH \times 0.0064 \times 100}{mL\ of\ juice\ used}$$

Ripening index as TSS:TA ratio was calculated in each sample by dividing the values of TSS with the TA.

Determination of sugars

Sugars in juice samples were estimated following the method as described by Hortwitz (1960). Ten mL juice was taken in 250 mL volumetric flask in which 100 mL distilled water, 25 mL lead acetate solution (25%) and 10 mL potassium oxalate (20%) solution were added. The volume was made with distilled water and filtered through Whatman® filter paper No.2. The filtrate was used for the estimation of the different forms of sugars.

The above-mentioned filtrate was taken in a 50 mL burette and titrated against 10 mL Fehling's solution with continuous boiling on soft flame until brick red colour appeared. Then 2-3 drops of 1% methylene blue were added and titration was continued adding the aliquot drop wise on boiling solution until brick red colour was developed again. The quantity of aliquot used was recorded and reducing sugars were calculated. For total sugars determination, 25 mL of already prepared aliquot was taken in a 100 mL volumetric flask adding 20 mL of distilled water and 5 mL concentrated HCl. The solution was kept overnight for complete hydrolysis in order to convert the non-reducing sugars into reducing sugars. Next day, it was neutralized by 0.1 N NaOH using phenolphthalein as an indicator and volume was made with distilled water. This solution was taken into the burette and titrated against 10 ml Fehling solution for the estimation of total sugars. Calculations were made according to the following formulas.

Reducing sugars (%) = 6.25 × (X/Y)

Total sugars (%) = 25 × (X/Y)

Non reducing sugars (%) = 0.95× (total sugars % - reducing sugars %)

Where 'X' is the volume (mL) of standard sugar solution titrated against 10 mL Fehling's solution and 'Y' is the volume (mL) of sample aliquot used against 10 mL Fehling's solution.

Determination of bioactive juice components

Total Phenolic Contents (TPC)

1 mL juice (stored at -80 °C) was homogenized by adding 5 mL of methanol: acetone: HCl solution to determine TPC. Samples were centrifuged at 13000 × *g* for 3 min at room temperature and the supernatant was used for assessing its absorbance at 765 nm and 517 nm using a spectrophotometer and TPC (mg GAE/g) were recorded (Ainsworth and Gillespie, 2007).

Total Antioxidants

Total antioxidants of 'Kinnow' juice were determined by using 2, 2-diphenyl-1-picrylhydrazyl radical (DPPH) assay (Brand-Williams et al., 1995) with some modifications. Supernatant (50

Table 1: Effects of different pruning treatments on yield and physical fruit quality parameters of 'Kinnow' mandarin.

Treatments	Fruit yield per plant		Fruit length (cm)	Fruit width (cm)	Peel weight (%)	Juice weight (%)	Rag weight (%)
	Number of fruits	Weight (kg)					
No pruning	56.06^{c}	9.27^{c}	6.04^{b}	7.04^{b}	26.66^{a}	48.99^{b}	24.11^{b}
One side pruning	73.00^{b}	13.25^{b}	6.22^{ab}	7.40^{ab}	25.80^{b}	49.60^{a}	24.35^{b}
Both side pruning	81.19^{a}	15.38^{a}	6.51^{a}	7.75^{a}	25.18^{c}	49.79^{a}	24.78^{ab}
Top pruning	41.69^{d}	7.65^{c}	6.37^{ab}	7.67^{a}	25.65^{bc}	48.85^{b}	25.26^{a}

Means sharing same letters in a group show non-significant differences (p ≤ 0.05)

μL) was added to 5 mL methanol solution. Then 50, 100, 150 μL amounts of sample were tested (30 minutes interval) and test tubes were incubated in dark. The decrease in absorbance was determined at 517 nm at an interval of 30 minutes and the final reading was calculated by the formula given below.

$$Inhibition\ of\ DPPH\ (\%) = \frac{A1 - A2}{A1 \times 100}$$

Where 'A1' is the *absorbance of the blank sample containing DPPH without sample* and 'A2' is the *absorbance of DPPH after adding the sample*.

Statistical analysis

The data recorded were analysed by using analysis of variance (ANOVA) technique with the help of software Statistix ver. 8.1 and treatment means were compared using least significant difference (LSD) test at a significance level of 0.05 (Steel et al., 1997).

RESULTS

Plant yield

Fruit number per tree was significantly affected ($p \leq 0.05$) by the pruning treatments. Results revealed that maximum (81.19) number of fruits was observed in the plants that were pruned from both sides, followed by those pruned from one side (73.0), un-pruned plants (56.06) and those which were top pruned (41.69), respectively. Each pruning treatment was significantly different from other treatments (Table 1). Significant effect ($p \leq 0.05$) of pruning was also found on total fruit yield (weight basis) as the plants pruned from both sides gave the maximum yield (15.38 kg), followed by one side pruned plants (13.25 kg), However, these two pruning treatments were statistically different. The minimum total fruit yield was achieved in top pruned plants (7.65 kg), which was statistically similar with un-pruned ones (9.27 kg) (Table 1).

Fruit size

A significant impact of different pruning treatments was observed on fruit size i.e., fruit length and fruit width. Pruning treatments significantly improved size of the fruits as compared to control (no pruning) treatment. The maximum value for fruit length (6.51 cm) was recorded in the plants with both side pruning followed by those with top pruning (6.37 cm) and one side pruning (6.22 cm). Un-pruned plant resulted in the minimum fruit length (6.04 cm) (Table 1). Almost same trend was observed for fruit width. The plants pruned from both sides had the maximum fruit width (7.75 cm), followed by top pruned (7.67 cm) and one side pruned ones (7.40 cm). The minimum fruit width (7.04 cm) was recorded in un-pruned plants (Table 1).

Peel weight, rag weight and juice weight

Results revealed significant differences ($p \leq 0.05$) among the pruning treatments regarding peel weight, juice weight and rag weight (Table 1). Significantly higher peel weight (26.66%) was observed in the un-pruned plants, while significantly lower (25.18%) was recorded in the plants pruned from both sides, followed by those which were top pruned (25.65%). Both side and one side pruning treatments had positive effects on juice content of fruits as the maximum juice weight (49.79%) was recorded in the plants pruned from both sides, followed by those pruned from one side (49.60%). Fruits from top pruned (48.85%) and un-pruned plants (48.99%) had lower juice weight. On the other hand, rag weight (25.26%) was higher in the fruits of top pruned plants, followed by the fruits of plants pruned from both sides (24.78%). The fruits harvested from un-pruned plants (24.11%) and those from one side pruned plants (24.35%) resulted in the minimum rag weight (Table 1).

TSS, TA and TSS:TA ratio

The pruning treatments caused a significant effect on TSS and TA. Single side pruning resulted in the maximum TSS (11.26 °Brix) of fruit juice, followed by no pruning (10.91 °Brix). These two pruning treatments were statistically similar. The minimum TSS (10.46 °Brix) was observed in the fruits harvested from both sides pruned plants, followed by top pruned (10.55 °Brix) and un-pruned plants (10.91 °Brix). These three treatments were statistically at par with each other (Fig. 1). Un-pruned plants gave acidic fruits with the maximum TA value (1.30%) being statistically similar with TA of juice of the fruits harvested from one side pruned plants (1.24%). Pruning from both sides resulted in the minimum TA (0.84%) of fruit juice (Fig. 1).

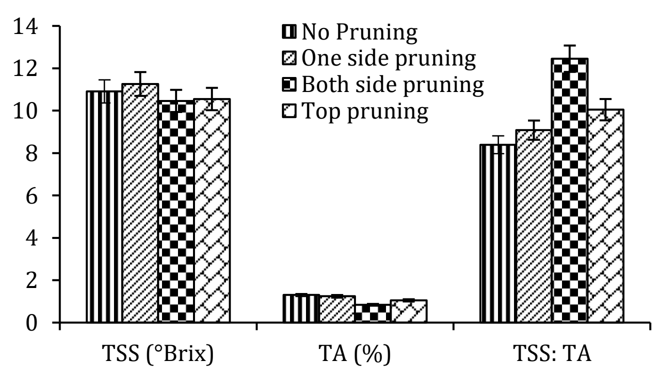

Figure 1: Effect of different pruning treatments on fruit TSS (°Brix), TA (%) and TSS: TA (ratio) of 'Kinnow' mandarin.

Ripening index (TS:TA ratio) was also significantly affected by different pruning treatments as it was calculated from TSS and TA values. The plants pruned from both sides exhibited the maximum TSS:TA ratio (12.45) that was significantly higher from other treatments. Un-pruned plants resulted in significantly lower TS:TA ratio (8.39) as compared with rest of the pruning treatments (Fig. 1).

Total, reducing and non-reducing sugars

It was interesting to observe that 'Kinnow' mandarin plants pruned from one side exhibited the maximum reducing sugars (3.40%), non-reducing sugars (13.88%), and total sugars (17.27%) in their fruit juice. The minimum value of reducing sugars (2.85%) was observed in the fruits of un-pruned plants; however, non-reducing sugars (10.84%) and total sugars (13.94%) were found to be the minimum in top pruned plants (Fig. 2).

TPC and total antioxidants

Both TPC and total antioxidants were significantly influenced by the pruning treatments. Significantly greater TPC (261.64 mg GAE/g) and antioxidants (61.22%) were observed in 'Kinnow' mandarin fruits which were collected from the plants pruned from both sides. All other pruning treatments resulted in significantly lower antioxidants. However, fruits from unpruned plants (54.99%), followed by from top pruned plants (55.67%) resulted in significantly lower TPC (Fig. 3).

DISCUSSION

Pruning citrus trees is thought to be helpful in maintaining plant vigour and health, and reducing stress, which ultimately results in balanced vegetative and reproductive behaviour of crop. Moreover, different pruning intensities also affect physico-chemical properties of fruits (Sharma and Chauhan, 1996; Intrigliolo and Roccuzzo, 2011). In the present study, it was observed that plants pruned from both sides resulted in the maximum number of fruits per plant which may be due to increase in the growth of new shoots resulting in new fruiting wood and more number of fruits per plant. Previous studies also confirmed that severely pruned trees had more yield (greater number of fruits) in comparison with lightly pruned 'Kinnow' mandarin plants (Ahmad et al., 2006; Nasir et al., 2006).

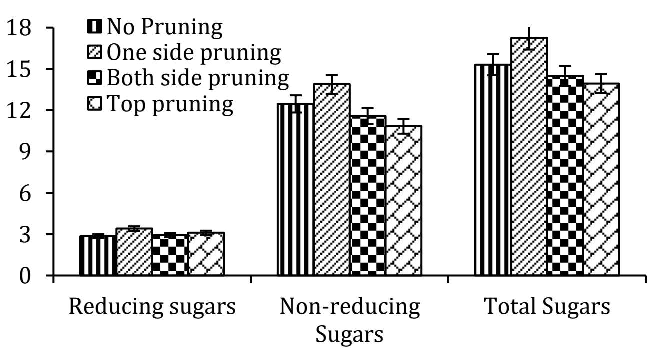

Figure 2: Effects of different pruning treatments on reducing, non-reducing and total sugars (%) of 'Kinnow' mandarin.

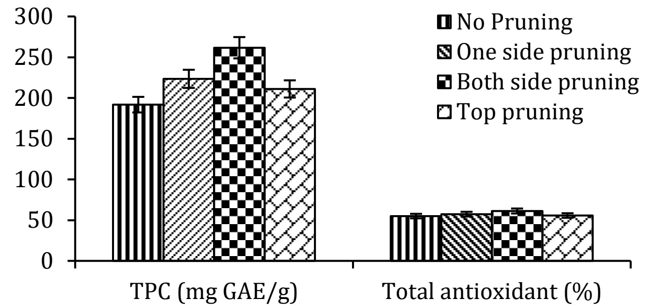

Figure 3: Effect of different pruning treatments on TPC (mg GAE/g) and total antioxidants (%) of 'Kinnow' mandarin fruit.

Fruit size is considered an important criterion to determine the fruit quality of 'Kinnow' mandarin. Data presented in Table 1 suggested that the pruning treatments improved fruit size (fruit length and width) in comparison of un-pruned plants. Fruit size mainly depends upon the supply of carbohydrates from canopy and fruit growth rate. Therefore, increased size may be result of increased accumulation of photosynthates in leaves and their supply to the fruits. As fruit number was increased and fruit size was improved due to side pruning, it ultimately affected fruit yield per plant. Thus, the plants pruned from both sides gave higher fruit yield, followed by one side pruned plants. These results are also in accordance with previous research findings, which suggested that implementation of pruning resulted in better fruit length, width and weight (Yadav and Singh, 1996; Stover et al., 2003; Singh et al., 2012).

The fruits harvested from the plants with both side pruning and one side pruning were juicier with thin skin. However, rag content was higher in top pruned plants followed by those pruned from both sides. Thus, side pruning improved juice content, top pruning increased rag content and fruits from un-pruned plants had thick peel. The increased juice weight in the fruits harvested from plants with pruning from both sides may be due to enhanced sunlight penetration and more nutrients availability to the plants (Nasir et al., 2016).

In the present study, the pruning treatments significantly affected TSS, TA and ripening index. This in interesting that the fruit harvested from the plants pruned from one side had higher TSS, which may be due to higher sugar content (reducing, non-reducing and total sugars) in these fruits. However, the fruits harvested from both sides' pruned plants had low TA and high ripening index. Higher TSS in fruits may be due to more accumulation and adequate supply of carbohydrates (Sansavini and Musacchi, 1994; Nasir et al., 2006). Previous studies also recorded increased TSS and total sugars in different fruit crops after pruning. More light penetration increases the rate of photosynthesis ultimately resulting in more TSS and sugars in the fruits harvested from pruned trees (Hasani and Rezaei, 2007; Mercier et al., 2008; Ashraf and Ashraf, 2014), which also reduces TA and consequently results in high ripening index.

Phenolics are important secondary plant metabolites playing active role in plant defence mechanisms against stress, which mostly increase during stress conditions (Lavola et al., 2000). It was observed that fruits from pruned trees had higher phenolic content at the time of harvesting. It can be assumed that phenolics synthesis was triggered due to shock or stress to the plants induced by pruning (Asrey et al., 2013). Total antioxidant activity of fruits mainly depends on the amount of bioactive compounds including total carotenoids, phenolic compounds and ascorbic acid. In the present study, the maximum antioxidants content was observed in the trees pruned from both sides, which may be associated with higher phenolic content (Gardner et al., 2000; Asrey et al., 2013).

CONCLUSION

Pruning treatments performed well under high density planation to improve physical and physicochemical properties in 'Kinnow' mandarin fruits. Pruning from both sides of plant significantly increased fruit yield with a greater number of fruits per plant and better fruit quality. One side pruning was still better than top pruning and no pruning treatments. Therefore, it is concluded that both side pruning in 'Kinnow' mandarin is more helpful to improve fruit yield and quality parameters under high density plantation.

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REFERENCES

Ahmad, S., Chatha, Z.A., Nasir, M.A., Aziz, A., Virk, N.A. and Khan, A.R. 2006. Effect of pruning on the yield and quality of Kinnow fruit. *Journal of Agriculture and Social Sciences*, 2(1): 151-53.

Ahmad, W. 2017. Exporting citrus fruit to developed markets. *Dawn News*, November 27, 2017.

Ahmad, W. 2018. PFVA to cut Kinnow export target by 13%. *All Pakistan Fruit & Vegetable Exporters, Importers & Merchants Association (PFVA). Business Recorder, E. Paper. November 30, 2018.*

Ainsworth, E.A. and Gillespie, K.M. 2007. Estimation of total phenolic content and other oxidation substances in plant tissue using Folin-Ciocalteu reagent. *Nature Protocols*, 2: 875-877.

Ashraf, N. and Ashraf, M. 2014. Summer pruning in fruit trees. *African Journal of Agricultural Research*, 9(2): 206-210.

Asrey, R., Patel, V.B., Barman, K. and Pal, R.K. 2013. Pruning affects fruit yield and postharvest quality in mango (*Mangifera indica* L.) cv. Amrapali. *Fruits*, 68(5): 367-380.

Brand-Williams, W., Cuvelier, M.E. and Berset, C. 1995. Use of free radical method to evaluate antioxidant activity. *LWT-Food Science and Technology*, 28(1): 25-30.

Dhaliwal, H.S., Banke, A.K., Kumar, L. and Brar, J.S. 2016. Standardization of pruning severity for healthy bud production in 'Kinnow' (*C. nobilis × C. deliciosa*) mother plants. *Acta Horticulturae*, 1130: 311-315.

Dhaliwal, H.S., Banke, A.K., Sharma, L.K. and Bali, S.K. 2014. Impact of pruning practices on shoot growth and bud production in Kinnow (*Citrus reticulata* Blanco) plants. *Journal of Experimental Biology and Agricultural Sciences*, 1: 507-513.

Din, A., Asghar, M., Parveen, S. and Ali, M.A. 2012. Evaluation of Kinnow mandarin as influenced by pre-harvest management practices. *Journal of Agricultural Research*, 50(3): 381-392.

Dogar, W.A., Khan, A.A., Ahmed, S., Tariq, S., Ahmad, M., Imran, M., Noman, M. and Khan, N. 2017. Study to determine the effects of high density plantation on growth and yield of citrus. *Sarhad Journal of Agriculture,* 33(2): 315-319.

Gardner, P.T., White, T.A.C., McPhail, D.B. and Duthie, G.G. 2000. The relative contributions of vitamin C, carotenoids and phenolics to the antioxidant potential of fruit juices. *Food Chemistry*, 68: 471-474.

Hasani, G.H. and Rezaei, R. 2007. Effect of training system and rate of pruning on yield and quality of peach fruit. *Journal of Agricultural Science*, 17(1): 31- 37.

Hortwitz, W. 1960. Official and Tentative Methods of Analysis (9th Ed.). Association of Official Agricultural Chemists, Washington DC, pp. 314-320.

Intrigliolo, F. and Roccuzzo, G. 2011. Modern trends of *Citrus* pruning in Italy. *Advances in Horticultural Sciences*, 25(3): 187-192.

Jing, D.W., Liu, F.C., Wang, M.Y., Ma, H.L., Du, Z.Y., Ma, B.Y. and Dong, Y.F. 2017. Effects of root pruning on the physicochemical properties and microbial activities of poplar rhizosphere soil. *Public Library of Science (PLoS) One*, 12(11): e0187685.

Lavola, A., Tiitto, R.J., Rosa, T.M., Lehto, T. and Aphalo, P.J. 2000. Allocation of carbon to growth and secondary metabolites in birch seedlings under UV-B radiation and CO_2 exposure. *Physiologia Plantarum*, 109: 260-267.

Mali, D.S., Ranpise, S.A., Kulkarni, S.S. and Nikumbhe, P.H. 2016. Influence of pruning techniques on yield and fruit quality attributes in high density planting of guava cv. Sardar. *Ecology, Environment and Conservation*, 22: 411-414.

Mercier, V., Bussi C., Plenet, D. and Lescourret, F. 2008. Effect of limiting irrigation and of manual pruning on brown rot incidence in peach. *Crop Protection*, 27(5): 678-688.

Nasir, M., Khan, A.S., Basra, S.A., and Malik, A.U. 2016. Foliar application of moringa leaf extract, potassium and zinc influence yield and fruit quality of 'Kinnow' mandarin. *Scientia Horticulturae*, 210: 227-235.

Nasir, M.A., Aziz, A., Mohar, T.A., Ahmad, S. and Rehman, M.A. 2006. Effect of plant spacing on the growth and quality of Kinnow under Sargodha climatic condition. *Sarhad Journal of Agriculture*, 22(1): 37-40.

Sansavini, S. and Musacchi, S. 1994. Canopy architecture, training and pruning in the modern European pear orchards: an overview. *Acta Horticulturae*, 367: 152-172.

Sharma, D.P. and Chauhan, S.J. 1996. Effect of pruning intensities under different levels of nitrogen and potassium on fruit set, yield and quality of peach cv. 'July Elberta'. *Indian Journal of Horticulture*, 53: 339-345.

Singh, S., Gill, P.S., Dhillon, W.S. and Singh, N. 2012. Effect of heading back on photosynthesis, yield and fruit quality in pear. *Notulae Science Biology*, 4(4): 90-94.

Steel, R.G.D., Torrie, J.H. and Dicky, D.A. 1997. Principles and Procedures of Statistics: A Biological Approach, 3rd Ed. McGraw Hill Book Co. Inc., New York, USA.

Stover, E., Ciliento, S. and Murphy, T. 2003. Late summer topping increase fruit size in Indian river 'Murcott' with little reduction in yield. *Proceedings of the Florida State of Horticultural Society*, 116: 275-278.

Tiwari, B., Silas, V.J., Mishra, K.K. and Ojha, J. 2018. Effects of pruning techniques on yield in high density planting of guava (*Psidium guajava* L.) cv. Lucknow-49. *International Journal of Current Microbiology and Applied Sciences,*7(12): 2423-2425.

Umar, M., Zia-ul-Hassan, S.M. and Dogar, W.A. 2017. Citrus and its Post-harvest losses. *Weekly Technology Times,* September 9, 2017. Accessed on 01 August 2019. Available at: https://www.technologytimes.pk/citrus-and-its-post-harvest-losses-2/.

Vijaya, H.M., Godara, R.K., Singh, S. and Sharma, N. 2017. Influence of different level of water and fertilizer application through drip system on growth and yield of Kinnow mandarin (*Citrus reticulata* Blanco). *Journal of Experimental Biology and Agricultural Sciences*, 5(6): 840-845.

Yadav, M.P. and Singh, H.K. 1996. Influence of corm size and their spacing on growth and flowering of gladiolus cultivar Sylvia. *Progressive Horticulture*, 28: 96-100.