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Effect of root pruning on shoot growth and flowering of mango cv. Alphonso grown under ultra high density planting system

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Abstract
An investigation was carried out in mango cv. Alphonso grown under UHDP system to study the effect of root pruning on shoot growth and the flowering. Two different group of trees were root pruned *viz.*, one during June and another during October at three different intensities *viz.*, 30 cm, 45 cm, and 60 cm from the trunk in circular fashion to a depth of 60 cm. The results revealed that the number of shoots emerged from the tress did not vary significantly among the treatments and the shoot length was reduced in T_2 (root pruning at 30 cm done during June) as compared to other treatments after three months of root pruning. Irrespective of the intensity of root pruning levels, panicle emergence was advanced by ten days as compared to control tress. Root pruned treed attained 50 per cent flowering much earlier than the unpruned trees.

Keywords: UHDP, mango, root pruning, panicle characteristics

Introduction
Mango is the choicest fruit of the tropics and is greatly valued in India as "The National Fruit" of India. Flowering in mango is still an enigma as it is influenced by many internal and external factors. Mango, a tropical terminal bearer of past season growth has a strong tendency of biennial bearing and malformation (Chako, 1989 and Whiley, 1992) [2, 18]. Mango has wide variations in the flowering period due to various agro climatic zones across India and its strong dependence on climatic conditions and age of flowering shoots (Ramirez and Davenport, 2010) [12]. Until mid of 20th century, mango is believed to be a poor respondent for flowering manipulations and more insight into the physiology of mango led to use of growth retardant chemicals supplemented with improved cultivation practices has made mango amenable for crop regulation (Narayanan *et al* 2017) [8]. Several studies have been carried out all over the globe in order to synchronize flowering in mango by pruning technologies and by using growth retardants like Paclobutrazol (Davenport, 2007 and Subbaiah *et al.*, 2017) [4,15]. Among the different strategies, root pruning is a proven viable horticultural practice that had effect on shoot growth, flower initiation and fruit development. Root pruning was found to induce flowering and alter flower characters, size and quality of fruits. Root pruning induces flowering in apple trees (Gardner *et al.*, 1952 and Turkey, 1964) [6, 17] and the flower number increases with root pruning with the expense of fruit set and fruit size in apple. Root pruning is used as a part of crop regulation process to induce flowering in the required *bahar* in crops *viz.*, guava, pomegranate, and mandarins in the northern and western parts of India (Narayan *et al.*, 2017) [9]. Root pruning, root exposure and pruning of minor roots of guava is done to rest the crop in rainy season and get a good winter crop (Cheema *et al.*, 1954) [3]. Root pruning is widely practiced in high density and ultra high density orchards of temperate fruit crops like apple, pear etc. There are no reports of the effect of root pruning in important tropical fruit crops like mango. In the light of foregoing, this field investigation is taken in mango cv. Alphonso grown under UHDP system to study the effect of root pruning on shoot growth and flowering behavior.

Materials and methods
The field study was carried out in a thirteen year old mango cv. Alphonso grown under Ultra High density Planting ystems at Jain Irrigations systems Pvt. Limited, Elayamuthur,

Udumalpet, Tamil Nadu, India during 2018-2019. It lies at 10° 34′ 48″ N latitude and 77° 14′ 24″ E longitute with an altitude of 1208 m above MSL and an average annual rainfall of 501.40 mm. The topography of the plot was uniform and the soil was sandy loam.Trees of uniform size was planted in the year 2005 at 3 × 2 m spacing is used for the study. The experiment consists of seven treatments replicated thrice laid out under Randomized Block Design (RBD) with one tree per replication. Root pruning was done during June, 2018 and October, 2018 in two different group of trees with three pruning levels *viz.*, 30, 45, 60 cm from the trunk. Root pruning was done by making a circular trench at respective distance from the trunk and cutting of all the visible roots up to a depth of 60 cm which is the active root zone area of superficial feeder roots in mango was done (Bojappa and Singh, 1974) [1]. The pruning treatments were temporally separated during June and October to investigate the effect of treatments on two different stages of bud development phase. The trench made was then filled with 20 kg of compost consisting of pressmud, coirpith and compost was filled and the trenches were again covered up. Paclobutazol (AuStar®) was applied during September, 2018 to the trees at 0.125 g a.i /tree. Shoots of trees were tip pruned to half of the past season growth uniformly after harvest during June, 2018. Irrigation is done through drip irrigation at 14.53 liters/plant/day. Fertilizers were applied through fertigation as urea, phosphoric acid, muriate of potash and magnesium sulphate.

The shoot growth from the root pruned trees was recorded after three months of shoot pruning. The length of the shoots emerged from the trees was measured from ten pruned shoots per tree of equal thickness and the mean was arrived. The number of shoots emerged from each pruned shoot of equal thickness and the mean was calculated. The duration for first flowering is taken as the number of days taken for first panicle emergence from shoot pruning was calculated and mean was arrived. The days taken for half bloom of the trees from shoot pruning was calculated and mean was computed.

Results and Discussion

Mango is a good respondent to pruning the auxillary buds beneath the pruned surface gets activated and produced current season growth. The number of shoots as current season growth from the pruned shoots ranged from two to six shoots and there was no significant difference among the treatments in the number of shoots that emerged as current season growth. The lowest number of shoots was recorded in T_2 (pruning at 30 cm during June) (2.43) (Table 1) and the highest number of shoots was recorded in T1- unpruned trees (4.88).

Shoot growth of the trees got arrested by Paclobutrazol application during 15th of September. The length of the shoots varied from 13 cm to 21 cm. Trees pruned in June varied significantly as compared to other treatments as lowest length was recorded in T_2 pruning at 30 cm during June) with 13.02 cm (Table 1) compared to unpruned trees. There was no difference among treatments T_1, T_5, T_6 and T_7. Shoot growth of T_5, T_6 and T_7were in line with the control trees as they did not receive any root pruning during September when the measurements were made during the last week of September. This results are in line with the fact that root pruning reduced shoot growth in tree crops as reported by Young and Werner (1989) [20] ; Schppp and Ferree (1990) [15] in temperate crops.

Table 1: Effect of root pruning on number of new shoots emerged and shoot growth in mango cv. Alphonso grown under UHDP

Treatments	Number of new shoots emerged	Length of the shoots (cm)
T_1	4.95	18.01
T_2	2.43	13.02
T_3	2.88	14.25
T_4	4.07	21.57
T_5	3.50	17.13
T_6	3.87	17.10
T_7	3.42	17.97
S Ed	0.74	3.60
CD(0.05)	1.42	6.21

T1-Control (No pruning);T2-(30 cm from trunk during June);T3-(45 cm from trunk during June);T4-(60 cm from trunk during June);T5-(30 cm from trunk during October);T6-(45 cm from trunk during October);T7-(60 cm from trunk during October)

The flowering period was continued from the last week of December, 2018 to third week of February, 2019 for a period of 50 days irrespective of root pruning levels. Emergence of panicles were quiet earlier in the root pruned trees as compared to control trees. Panicles started emerging from the trees from 29th of December, 2018 and continue to emerge till 16thFebruary, 2019. On an average root pruned trees took 197.05 days for first flower emergence while control trees took 207.33 days i.e. almost 10 days later than the pruned trees (Table 3). Root pruning at 45 cm during June T_4recorded the earliest (195 days) of the treatments followed by T_3 (195 days) and T_2 (197.33 days) for panicle emergence. The advancement of flowering in pruned trees is explained by the stress imposed to the trees as a result of pruning. Root pruning generally causes water deficit which promotes earlier and profuse flowering in mango. The results obtained were in occordance with Lu *et al.* (1997) [8] and Núñez-Elisea and Davenport (1994) [10] where water deficit condition favoured earlier and intense flowering in mango cultivars.

Table 2: Number of panicles in the trees found every 7 days during the flowering period

Treatment \ Date	29-Dec-2018	05-Jan-2019	13-Jan-2019	19-Jan-2019	26-Jan-2019	02-Feb-2019	09-Feb-2019	16-Feb-2019
T_1	0.0	3.0	6.3	20.3	35.3	54.7	76.0	88.7
T_2	3.5	7.0	12.3	28.7	41.7	56.7	74.7	86.0
T_3	4.7	10.7	17.3	33.0	59.0	73.0	90.0	100.3
T_4	1.5	7.0	11.3	28.3	46.7	67.7	85.0	95.3
T_5	3.0	4.7	8.7	21.3	37.3	55.0	67.0	77.3

T_6	5.0	8.0	18.0	22.7	36.0	51.7	68.7	76.3
T_7	7.0	7.7	21.3	32.7	47.3	57.0	68.0	75.3
S Ed	1.89	1.87	4.03	3.95	5.11	5.82	6.34	7.24
CD (0.05)	2.61	4.13	8.88	5.79	11.30	12.81	14.03	15.96

T1-Control (No pruning);T2-(30 cm from trunk during June);T3-(45 cm from trunk during June);T4-(60 cm from trunk during June);T5-(30 cm from trunk during October);T6-(45 cm from trunk during October);T7-(60 cm from trunk during October)

The number of panicles per tree at the end of the flowering season was found significantly higher in the June root pruned trees than the October root pruned trees. The highest number of panicles per tree was observed in T_3 (100.3 panicles) followed by T_4 (95.33 panicles) whereas unpruned trees had 88.67 panicles (Table 3). The number of panicles produced is the direct reflection of fruit bud differentiation with the amount of carbohydrate reserves (Whiley, 1989; Shivu Prasad *et al.,* 2014) [18, 14]. The reduced number of panicles in the October pruned trees explains the effect of stress on the trees during the period of flower bud differentiation and loss of available carbohydrate reserves in roots as a result of pruning of roots imposes an anti-incumbency on the total carbohydrate reserve of the tree (Palanichamy *et al.,* 2011*;* Khan *et al.,* 1998) [11, 7]. Trees pruned in June has managed to produce a fair amount of panicles as compared to control because of the stress at the earlier stage of flower bud differentiation lead to diversion of available carbohydrate reserves to the putative sinks. In addition, growth of new roots from the June pruned trees has rendered support for the trees to cope up the stress and produce more panicles which was not available for October root pruned trees.

Table 3: Days taken for first flower emergence and half bloom of the root pruned mango trees

Treatments	Days taken for 50% flowering (days)	Days taken panicle emergence bloom (days)
T_1	223.41	207.33
T_2	217.32	197.33
T_3	215.44	195.00
T_4	218.21	194.00
T_5	217.24	198.33
T_6	209.73	198.67
T_7	211.65	199.00
S Ed	2.12	2.08
CD(0.05)	4.68	4.59

T1-Control (No pruning);T2-(30 cm from trunk during June);T3-(45 cm from trunk during June);T4-(60 cm from trunk during June);T5-(30 cm from trunk during October);T6-(45 cm from trunk during October);T7-(60 cm from trunk during October)

Conclusion

Therefore, the results indicated that root pruning has an effect on mango and could be used in crop regulation practices to manipulate flowering event of mango.

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