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Pruning for crop regulation in high density guava (*Psidium guajava* L.) plantation

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Abstract

High density management and crop regulation are two important aspects in guava (*Psidium guajava* L.) production. Therefore, to find out the economic way of managing high density planting and crop regulation, the present work was carried out on 6-year-old guava trees of cv. Pant Prabhat under double-hedge row system of planting during 2009-10 and 2010-11. Seven different forms of pruning [FBT: flower bud thinning by hand, FBTT: flower bud thinning by hand followed by removal of terminal one leaf pair, RLFO: removal of leaves and flower buds by hand, retaining one leaf pair at the top, RLF: removal of all leaves and flowers by hand, OLPS: one leaf pair shoot pruning, FSP: full shoot pruning, OLPF: one leaf pair pruning of fruited shoots only] were studied along with control (C).Minimum annual increase in tree volume (6.764 m^3) was recorded with the treatment OLPF, which was 2.31 times less than the control (15.682 m^3). Highest yield during winter season (55.30 kg/tree) and total yield (59.87 kg/tree) was obtained from treatment OLPF. One leaf pair pruning of fruited shoots only (OLPF) was also found profitable among other treatments by recording cost:benefit ratio of 1:2.96. This treatment also recorded the highest return distributed in rainy as well as in winter season. On the basis of findings it can be concluded that one leaf pair pruning of fruited shoots only is suitable for profitable high density management as well as crop regulation of guava in farmer friendly manner.

Additional key words: guava crop regulation; guava pruning; profitable sustainable production.

Abbreviations used: C/B (cost: benefit ratio); FBT (flower bud thinning by hand); FBTT (flower bud thinning by hand followed by removal of terminal one leaf pair); FSP (full shoot pruning); OLPF (one leaf pair pruning of fruited shoots only); OLPS (one leaf pair shoot pruning); RLF (removal of all leaves and flowers by hand); RLFO (removal of leaves and flower buds by hand, retaining one leaf pair at the top).

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Introduction

Guava (*Psidium guajava* L.) is one of the most popular tropical and subtropical fruit crops grown in India owing to its several health promoting properties and value-addition avenues. It is well known fact that guava has two distinct botanical characteristics; one is the flowers are always borne on newly emerging vegetative shoots, irrespective of the time of year (Rathore & Singh, 1974; Singh, 1985). This feature makes guava unique, that it can be pruned as severely as temperate fruit tree (Lotter, 1990) for high density management. Several workers reported the beneficial effects of pruning on yield and fruit quality of guava (Jadhav *et al.,* 1998; Singh & Singh, 2001; Dhaliwal & Kaur, 2003; Dhaliwal & Singh, 2004). Second is that guava has more than one bearing season (Singh & Kumar, 1993). These two features provide an opportunity to regulate guava crop through pruning along with high density management.

In *tarai* region of India, three flowering seasons are very common, *viz.* April-May (for rainy season crop), July-August (for winter season crop) and October-November (spring season crop) (Singh & Kumar, 1993). During winter season, the flowering and vegetative growth is almost negligible due to low temperature (Chadha & Pandey, 1986). As a result plants accumulate sufficient food reserve, which results in maximum new vegetative growth in the following spring due to optimum temperature. This vegetative flush produces floral buds which produces flower during summer season (40 days after floral initiation)for rainy season crop (Sehgal & Singh, 1967). The production is being maximum during the rainy season (Dwivedi *et al.,* 1990). However, the fruits produced during rainy season are severely attacked by fruit fly (Stonehouse *et al.*, 2002) which leads significant loss in fruit production and it also have poor nutritive value and keeping quality. On the other hand, winter season crop is superior in quality, free from the pest and diseases, having long storage life and fetches more prices in the market as compared to the rainy season crop (Rathore & Singh, 1976). By keeping the above mentioned points in mind, it is beneficial to take winter season crop mainly. Crop regulation in guava is also used in other parts of world like in Hawaii and Kauai, where it is known as cycling (Bittenbender & Kobayashi, 1990). Pruning can be used for crop regulation (Lal, 1992). Pruning has its physiological effects basically due to changes in the partitioning of the reserves. It changes sink preference for allocation of photosynthates. Depending upon the time of the year, the extent and frequency of pruning, some sites of accumulation will disappear and others will be created. As a result, changes in seasonal fluctuations of reserves can appear as well (Clair *et al.,* 1999). In this way, pruning helps in both ways, firstly to regulate crop (Kindo, 2005) and secondly to manage high density (Kaur & Dhaliwal, 2001). Standard spacing for guava is 6 m × 6 m. Whereas, high density planting consists of planting at 3 m × 1.5 m, 3 m × 3 m and 6 m × 3 m. Meadow orcharding which is an ultra-high density planting accommodates 5000 plants/ha planted at 2 m × 1 m distance (Singh, 2008). These densities are for either square planting systems or rectangular planting system. But, guava can be planted in other planting systems also with higher densities as compare to square system like paired system, hedge row system, double hedge row system and cluster system. Out of these systems, double hedge row system is higher in density accommodating 20 trees in a plot of 24 m × 24 m (2.22 times more than square system of planting) (Lal *et al.*, 2007). Hence, this work has been carried out to assess profitability of crop regulation methods in high density management.

Material and methods

The study was conducted at Horticulture Research Centre, Patharchatta, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Uttarakhand. Pantnagar is situated at the foothills of the Himalayas (29° N 79.3° E). The altitude of the place is 243.84 msl. Pantnagar has a humid sub-tropical climate with hot humid summers and cold winters. The maximum and minimum temperature range 33° − 42°C and 4° − 8°C during summer and winter respectively. The soil texture of experimental field is sandy loam with pH 7.6. The experiment was planted under double-hedge row system of planting, accommodating 20 trees in a plot of 24 m × 24 m. In double hedge row system of planting, there was pair of rows. Each pair of row situated 8 m apart and within pair of rows, the distant between row to row and plant to plant was 4 m (Fig. S1 [supplementary]).

Treatments and observations

The study was conducted on 6-yr old guava trees, cv. ‘Pant Prabhat’. The treatments consisted of seven different forms of pruning: FBT, FBTT, RLFO, RLF, OLPS, FSP, OLPF and control (Table 1). All the trees were maintained under uniform cultural practices during entire course of investigation.

Observations were recorded for new shoot emergence, tree growth (height, crown spread, trunk diameter and tree volume), physical fruit variables and yield per tree. New shoot emergence was counted on selected four branches before and after application of the treatments. The average data recorded from four branches is presented as new shoot emergence per branch for rainy as well as for winter season crop (fruiting season July-September and December-February, respectively). The observations on tree growth variables were recorded before application of treatments (*i.e.* during April) and in winter season (*i.e.* during January) and annual increase in the tree height, spread, volume and trunk diameter was calculated as per standard procedures. Physical fruit variables, *viz*. fruit weight, diameter, length and volume were measured as per the standard procedures. Fruit yield per tree was computed by multiplying the total number of fruits on each tree with the mean fruit weight for that tree for rainy and winter season crop separately. A representative sample of ten fruits per treatment per replication was taken randomly from all directions of the tree to take observations on physical variables of fruits for both seasons.

C/B ratio for all the treatments were calculated by considering all inputs and fruit yield during both the years (*i.e.* 2009-10 and 2010-11).

Statistical analysis

The experiment was laid out in Randomized Block Design (RBD) where treatment was replicated four

Table 1. Details of the treatments.

Treatments	Treatment description	
FBT: Flower bud thinning by hand	The flower buds of the entire guava tree were removed twice by hand at 15 days interval.	
FBTT: Flower bud thinning by hand followed by removal of terminal one leaf pair	The flower buds of the entire tree were removed once by hand and the terminal one leaf pair was also pinched by hand.	
RLFO: Removal of leaves and flower buds by hand, retaining one leaf pair at the top of shoot	All leaves and flower buds of current season shoots were removed once by hand by retaining one leaf pair at the top of shoot for entire tree.	
RLF: Removal of all leaves and flower buds by hand	All leaves and flower buds of the entire tree were removed once by hand without keeping any leaves or flowers on current season shoot.	
OLPS: One leaf pair shoot pruning (retaining one leaf pair at the base of the shoots)	The upper portions of all current season shoots were pruned with the help of secateur once by keeping one leaf pair at the base of the shoot.	
FSP: Full shoot pruning	All current season shoots of the entire tree were removed once from the base of the shoot with the help of secateur.	
OLPF: One leaf pair pruning of fruited shoots only	The upper portions of all fruited shoots of the entire tree were pruned with the help of secateurs by keeping one leaf pair at the base of the fruited shoot.	
C: Control	Untreated.	

times by taking two trees in each treatment per each replication. The experiment was conducted twice, *i.e.* 2009-10 and 2010-11. The pooled data of two years were statistically analyzed for analysis of variance in Randomized Block Design (Snedecor & Cochran, 1968). The mean separation analysis was done by using Duncan´s Multiple Range Test. The whole analysis was done using SAS software version 9.3. The effect of treatments on physical variables of fruit for rainy season crop was compared using 't' test (Snedecor & Cochran, 1968).

Results

Growth variables

Maximum new shoot emergence per branch for winter season crop (98.31) was found with the treatment RLF followed by treatments FSP, OLPF and OLPS (Table 2). They had non-significant differences among themselves but differed significantly with the treatment RLF. The minimum new shoot emergence per branch (33.72) was recorded in control (C).

The annual increase in tree height and tree volume, which is a major concern with respect to high density planting, was minimum with the treatments OLPS and OLPF. The maximum annual increase in tree height (0.475 m) was recorded with the severe form of pruning, *i.e.* with FSP. The minimum annual increase in crown spread (1.022 m) was recorded with FBTT treatment. It did not differ significantly with OLPF. The maximum annual increase in the crown spread (1.363 m) was recorded with RLF. Remaining treatments recorded more than double annual increase in tree volume in comparison to OLPS and OLPF. As far as annual increase in trunk diameter is concerned, the maximum annual increase in trunk diameter (1.324 cm) was observed in case of FBT, which had non-significant difference with treatments FBTT, RLFO, RLF and FSP. However, the minimum annual increase in trunk diameter (1.018 cm) was observed in case of OLPF, which was non-significantly different with C treatment. This could be due to heavy crop load.

Yield

Being aimed to regulate the crop, the pruning treatments affected the fruit yield in both the crops, *i.e.* rainy and winter season (Table 2). The treatments significantly reduced the yield per tree for rainy season

Table 2. Effect of various methods of crop regulation on growth variables and yield of guava cv. Pant Prabhat.

Treatment	New shoot emergence per branch		Annual increase in:				Yield/tree (kg)		
	Rainy	Winter	Tree height (m)	Trunk diameter (cm)	Crown spread (m)	Tree volume (m^3)	Rainy	Winter	Total
FBT	49.25a	44.12c	0.338b	1.324a	1.215ab	16.281b	0.00c (0.71)	52.01ab	52.01c
FBTT	44.91a	44.63c	0.228d	1.239ab	1.022d	15.082b	0.00c (0.71)	53.99ab	53.99bc
RLFO	46.47a	44.47c	0.228d	1.205ab	1.070bcd	15.000b	0.00c (0.71)	50.27b	50.27c
RLF	41.27a	98.31a	0.241d	1.203ab	1.363a	16.240b	0.00c (0.71)	33.29c	33.29d
OLPS	48.39a	72.82b	0.145e	1.126bc	1.197abc	7.370c	4.60b (2.25)	52.27ab	56.87ab
FSP	45.11a	78.39b	0.475a	1.235ab	1.139bcd	18.290a	0.00c (0.71)	33.50c	33.50d
OLPF	48.91a	75.88b	0.173e	1.018c	1.039cd	6.764c	4.57b (2.25)	55.30a	59.87a
C	42.89a	33.72d	0.303c	1.019[c]	1.085bcd	15.682b	51.52a (13.46)	6.28d	57.79ab

Similar letters indicate there is no significant difference between the treatments at 5% level of significance. Figures in parenthesis indicate transformed values.

crop. The maximum yield (51.52 kg/tree) during rainy season was recorded in the unpruned control followed by OLPS and OLPF treatments. The control varied significantly with the treatments OLPS and OLPF, however, these two treatments showed non-significant difference with each other. The remaining pruning treatments did not result in any yield due to complete removal of the fruiting shoots. The maximum yield (55.30 kg/tree) during winter season was recorded in case of treatment OLPF. The treatments FBT, FBTT, RLFO, OLPS and OLPF were non-significantly different with each other. The minimum yield (6.28 kg/tree) during winter season was recorded in case of control (C). The treatments RLF and FSP recorded intermediate yield and did not differ significantly. The maximum total yield per tree (59.87 kg/tree) was recorded with the treatment OLPF followed by C and OLPS treatments.

Physical variables of fruits

The maximum fruit weight, diameter and volume in rainy season crop (Table 3) were recorded with OLPS treatment which differed non-significantly with OLPF treatment and minimum value for above mentioned variables were recorded with control. The variation among treatments for fruit length was found significant.

In winter season crop, the maximum fruit weight and diameter (Fig. 1) were recorded with FBT treatment and the minimum with FSP treatment. There was non-significant difference among treatments for fruit length (Fig. 1). There was non-significant difference between treatments FBT, FBTT, RFLO, OLPF and C with respect to fruit volume (Fig. 1). The maximum fruit volume (116.392 mL) was recorded in FBTT treatment and minimum fruit volume (98.322 mL) in FSP treatment. The treatments RLF and OLPS differed non-significantly with each other.

Table 3. Effect of various methods of crop regulation on physical variables of fruit for rainy season crop.

Treatment	Fruit weight (g)		Fruit diameter (cm)		Fruit length (cm)		Fruit volume (mL)	
OLPS	146.69		6.59		5.98		144.72	
OLPF	143.14		6.35		5.56		142.99	
C	112.82		6.14		5.36		109.32	
Comparison	*t* value	*p*=0.05	*t* value	*p*=0.05	*t* value	*p*=0.05	*t* value	*p*=0.05
OLPS *vs* C	3.372	S	2.245	NS	1.787	NS	2.671	S
OLPF *vs* C	5.432	S	2.670	S	1.202	NS	5.755	S
OLPS *vs* OLPF	0.358	NS	1.196	NS	1.333	NS	0.144	NS

S, significant at 5% level, NS, non-significant at 5% level.

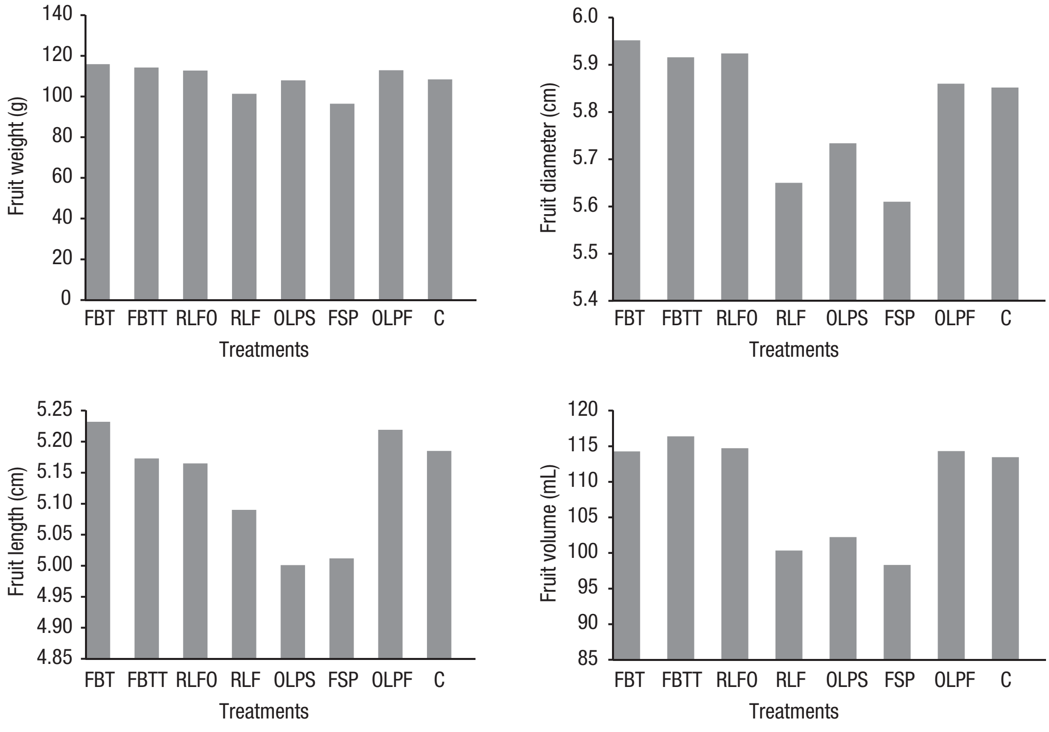

Figure 1. Effect of various methods of crop regulation on physical variables of fruit for winter season crop.

Economics of the production

Cost of chemicals, fertilizer and machinery per year (A) was (in rupees) ₹11,750. Labour and machinery cost per year (B) was ₹28,250. So, initial cost of inputs per year (excluding treatment application cost) (C= A+B) was ₹40,000/ha/year. Treatment application cost/tree/year (D) was ₹15/hour. Treatment application cost/ha/year (347 trees/ha) is presented by E (Table 4). The cost of application of various methods of crop regulation differed due to different time required for application. The maximum treatment application cost was ₹31,230.00/ha/yr in FBT treatment, while it was minimum in OLPF treatment. The maximum total cost/ha/yr (₹71,230.00) was estimated in treatment FBT, the minimum (₹40,000.00) was in C. The maximum total returns/ha/yr (₹199,830.00) was obtained with the treatment OLPF followed by OLPS and FBTT treatments (Table 4). The maximum C:B ratio (1:2.96) was estimated for pruning in OLPF treatment followed by OLPS treatment. The C:B ratio (1:1.78) of unpruned control trees was greater than the C:B ratio of the treatments FBT, RLF and FSP. The minimum C:B ratio (1:0.90) was noted in the treatment RLF.

Discussion

The minimum new shoot emergence per branch for winter season crop recorded in control (C) might be due to non-disturbance in the apical dominance of the growing shoots. In guava, flowers are always borne on newly emerging vegetative shoots irrespective of the time of year (Rathore & Singh, 1974), due to which it is suitable for pruning for various purposes. Decapitation usually results in the growth of one or more of the lateral buds due to removal of apical dominance. The various extent of new shoot emergence depends on the fact that how many lateral buds were present after pruning, which depends upon the severity of pruning (Tiwari, 1985; Lal, 1992). Apical dominance is associated with more vertical growth. When apical dominance disturbed by any means, then plant corrects the change (Acquaah, 2002) and results in change in tree canopy size due to new shoot emergence. The treatments OLPS and OLPF produced new shoots from leaf axils (if fruits were not there) which resulted in more lateral growth. This is the reason behind minimum annual increase in tree height and volume in treatments OLPS and OLPF. The treatment FSP recorded maximum annual increase in tree height because full shoot pruning forced the axillary buds, present on old shoots, to sprout and grow, as it was reported previously by Chandra & Govind (1995), Jadhav *et al.* (1998) and Kaur & Dhaliwal (2001). The annual increase in tree volume was half in case of treatments OLPS and OLPF as compared to other treatments.

Application of treatments reduced rainy season yield. It is due to fact that the treatments were applied in the last week of April and first fortnight of May, coinciding with the flowering season for rainy season crop in *tarai* regions (Singh & Kumar, 1993). When the harvest of rainy and winter seasons is compared, it was clear that the control (untreated) produced heavy fruiting during rainy season, with meagre crop in winter season. While, the remaining treatments comprising severe pruning (except RLF and FSP), produced higher yield in winter season. This confirms the fact that it is the way and extent of pruning which decides the yield in the forthcoming season by creation and destruction (reduction of crown volume, foliage removal and new sinks) of food reserves (Clair *et al.*, 1999). The treatments RLF and FSP recorded intermediate yield. Lal (1992) and Kindo (2005) also reported similar results.

The effect of treatments on physical fruit variables is due to the fact that apart from affecting the apical

Table 4. Effect of various methods of crop regulation on economics of guava production cv. Pant Prabhat.

Treatments	[D]	[E]	[F]	Yield/tree (kg)		Yield/ha (tonnes)		[G]			[H]	C/B ratio
				Rainy	Winter	Rainy	Winter	Rainy at ₹5/kg	Winter at ₹10/kg	Total		
FBT	90	31,230	71,230	0.00	52.01	0.00	18.046	0.00	180,460	180,460	109,230	1:1.53
FBTT	75	26,025	66,025	0.00	53.99	0.00	18.735	0.00	187,350	187,350	121,325	1:1.84
RLFO	60	20,820	60,820	0.00	50.27	0.00	17.445	0.00	174,450	174,450	113,630	1:1.87
RLF	60	20,820	60,820	0.00	33.29	0.00	11.550	0.00	115,500	115,500	54,680	1:0.90
OLPS	60	20,820	60,820	4.60	52.27	1.596	18.138	7,980.00	181,380	189,360	128,540	1:2.11
FSP	45	15,615	55,615	0.00	33.50	0.00	11.624	0.00	116,240	116,240	60,625	1:1.09
OLPF	30	10,410	50,410	4.57	55.30	1.586	19.190	7,930.00	191,900	199,830	149,420	1:2.96
C	0	0	40,000	51.52	6.28	17.877	2.179	89,385.00	21,790	111,175	71,175	1:1.78

[D]: Treatment application cost (₹)/tree·yr at ₹15/hour. [E]: Treatment application cost (₹)/ha·yr (347 trees/ha). [F]: Total cost (₹)/ha·yr = Total cost of inputs/yr [(excluding treatment application cost) *i.e.* ₹40,000]+[E]. [G]: Total returns **(₹)** /ha·yr [It is calculated by multiplying the yield (in kg) to prevailing price of season]. [H]: Net profit/ha/yr = [G]–[F]. C/B ratio=[H]/[F].

dominance, pruning is known to produce changes in the partitioning of the photo-assimilates through modification in source-sink relationship. Pruning time, extent and frequency decides whether new sites are going to be created or existing one will disappear (Clair *et al.*, 1999). Sink strength is the ability to attract metabolite from different sources and decides the direction of flow of photo-assimilates. Sink strength determined by the growth rate (sink activity) and the size of the sinks. Actively growing plant parts are strong sinks (Wolstenholme, 1990). Fruit, as the final growth stage of a reproductive organ, is commonly a strong sink for assimilates, at the expense of vegetative growth (Bollard, 1970). Once fruits start to develop, both the direction and pathway of assimilate transport change in favour of fruit growth (Ho & Hewett, 1986). In control trees, where more number of strong sinks (fruit) was present for rainy season crop, they produced less vegetative growth (new shoots) for winter season bearing. When the treatments were applied, the potential sinks (fruits) were removed, and shifted the flow of photosynthates towards new growing shoots, as potential sinks. In treatments where fruits were present, by adopting partial removal of fruits, the existing leaf area was supporting less number of developing fruits, making more photosynthates available for each fruit unit, leading to increased fruit size (Fischer *et al.*, 2012). Economic analysis indicates that OLPF recorded maximum cost:benefit ratio followed by the treatment OLPS. Tiwari & Lal (2007) also reported that maximum return can be obtained by one leaf pair shoot pruning.

It can be concluded that the high density planting in guava can be maintained profitably by adopting one-leaf pair pruning of fruited shoots only, which results in reduction in the annual increase in tree volume by half as compared to un-pruned trees and recorded the highest cost: benefit ratio (1:2.96) due to higher production of quality fruits during winter season.

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