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Response of extended pruning period and intensity on yield and quality attributes of guava

K.K. Srivastava*, P. Barman, S.R. Singh and D. Kumar

ICAR-Central Institute for Subtropical Horticulture, Lucknow 226 101, Uttar Pradesh, India

ABSTRACT

An experiment was conducted to study the effect of extended period and intensity of pruning on yield and quality attributes of guava cv. CISH-Lalit. Results indicated significant tree growth, while pruned during last week of May. The fruits matured 64.05 days in advance, compared to those pruned during July last week, however, pruning severity delayed the fruit maturity. Fruit yield was significantly ameliorated in trees pruned during May and June last week, compared to those pruned during July last week (42.90 and 46.25%, respectively). Fruit weight recorded maximum (230.09/g) in 60% pruning intensity during last week of June pruning. Total soluble solids were improved with delay in pruning from May to June, however, declined afterwards, whereas the TSS was recorded significantly higher in trees pruned to 40% level. There were the positive correlations of yield with canopy spread, trunk cross-sectional area, fruit length, fruit breadth, average individual fruit weight and TSS, while negative correlation with days required for fruit maturity. Therefore, pruning of guava cv. CISH-Lalit can be delayed upto last week of June with 40% intensity to extend the availability of quality fruits can be extended during winter.

Key words: *Psidium guajava* L., pruning intensity, fruit maturity, yield efficiency, delayed pruning.

INTRODUCTION

Guava (*Psidium guajava* L.) has social and economic importance, but requires technological advancements to optimize tree growth and yield. In subtropics, guava bears varying amount of fruit throughout the year. In north India, major crop usually ripens from July to mid-October (rainy season) and a small distinct crop is produced from November to mid-February (winter season) (Singh *et al.*, 13). Though, the quantum of production is high in rainy season (Singh *et al.*, 14), it offers poor quality due to insipidness (Singh *et al.*, 10), and infestation of pest (Rawal and Ullasa, 9) in comparison to winter season. On the contrary, in winter season the quality fruits are produced and fetching premium prices (Singh *et al.*, 14). This necessitates for developing the effective crop regulating technique in guava for manipulating winter season crop as a major one thus, making guava cultivation highly profitable, sustainable and export oriented.

Guava tree bears flowers and fruits on the current season matured shoots either from the lateral buds on older wood or shoot terminals (Thakre *et al.*, 15). Therefore, increase in the number of current season's shoots significantly influences tree productivity. As the guava bears fruits on the current season shoots (Singh, 11), hence responds favorably to different pruning practices, which provides opportunity for planting guava under high density planting. Among different varieties of guava cultivated in India, CISH-Lalit, a high yielding pink fleshed variety, selected from the 'Apple Colour' has been released from ICAR- Central Institute for Subtropical Horticulture, Lucknow, India for commercial cultivation in guava growing regions of the country. CISH-Lalit is highly responsive to pruning, and suitable for high density orcharding of guava (Singh, 12).

Pruning strategy in guava aims at rational removal of rainy season crop so that the profitability can be maximized, by minimizing the growth rate of the plants. This can be achieved by regulating the time and intensity of pruning (Das *et al.*, 3). Although available studies have reported on enhanced yield by pruning, however, changing in climatic pattern have resulted change in physiological responses, and phenological parameters. Therefore, a field experiment was designed with an objective to determine the influence of different pruning times and levels on growth, flowering, fruiting pattern, and fruit quality attributes in guava cv. CISH-Lalit in sub-tropics.

MATERIALS AND METHODS

The experiment was laid out at the experimental research farm of ICAR-CISH, Lucknow, India, located at 80.45 °E longitude, 26.54 °N latitude and an altitude of 127 m above mean sea level. The soil of the experimental site belongs to the major group of Indo-Gangetic alluvium with well drained sandy

*Corresponding author: kanchanpom@gmail.com

loam texture. Soil is alkaline in nature with pH and electrical conductivity ranging from 6.64 to 8.18 and 0.04 to 0.13 dS/m, respectively. The region has typical subtropical climatic conditions characterized by hot and dry summer followed by cold winter. May is the hottest month with an average high-temperature of 40°C and an average low-temperature of 24.6°C, while January is the coldest month, with an average high-temperature of 22.5°C and an average low-temperature of 7.5°C.

The experiment was carried out in randomized block design for two years on guava cultivar CISH-Lalit, planted at a spacing of 3 m × 3 m during 2014, with the treatments having two factors, *viz*., time of pruning and severity of pruning. The current year's growth from shoot tips were pruned at different levels such as 20% (P_1), 40% (P_2) and 60% (P_3) during different time intervals as last week of May (May 25-27) (D_1), last week of June (June 25-27) (D_2), 2nd week of July (July 12-15) (D_3) and last week of July (July 25-27) (D_4), resulting in 12 treatment combinations. Each treatment was replicated thrice with two trees per replication. The vegetative traits like canopy spread and trunk cross-sectional area (TCSA) were recorded during September-October. Fruits were harvested at color break stage and various yield attributes were recorded. Four fruits from each replication of each treatment were selected for estimation of quality attributes. Growing degree days (GDD) was calculated as per the formula of Grigorieva *et al*. (6) where the base temperature for fruit growth stage was kept 12°C.

Two years data were pooled and analyzed using SPSS software version 16.0, and treatment differences were expressed for least significant differences (LSD) at 5% level of significance.

RESULTS AND DISCUSSION

There existed a significant effect of different pruning time and severity for growth attributes on guava cv. CISH-Lalit. Canopy spread between rows was maximum (2.71 m) in trees pruned during May last week, while minimum in trees pruned during July last week (2.19 m), regardless of pruning severity (Table 1). Irrespective of time of pruning, trees pruned to 60% had significantly highest tree spread (2.60 m). Among the interaction effects, trees pruned to 60% during May last week had highest tree spread (2.76 m), which were at par with those pruned to 40 and 20% during May last week (2.71 and 2.67 m, respectively), and those pruned to 60 and 40% during last week of June (2.70 and 2.68 m, respectively).

Canopy spread within row was maximum in trees pruned during May last week (2.68 m), regardless of pruning intensity (Table 1). It had higher values (2.61 and 2.58 m, respectively) in trees pruned to 60 and 40%, regardless of pruning interval. Interaction effect revealed highest values in trees of 60% pruning done in May last week (2.73 m), which were statistically at par with those pruned to 40 and 20% during May last week (2.66 and 2.65 m, respectively) and those pruned to 40 and 60% during June last week (2.65 m).

It was clear from the data that TCSA was significantly highest in trees pruned during May and June last week (6.75 and 6.45 cm^2, respectively) (Table 1). Trees imposed to 60 and 40% pruning had highest TCSA (6.40 and 6.05 cm^2, respectively). Among the interaction study, trees pruned to different levels during May last week and those pruned to 40 and 60% during June last week exhibited the highest TCSA in guava trees.

The late pruned trees were unable to make up the loss of growth caused by pruning in short period

Table 1. Response of guava cv. CISH-Lalit to different time and severity of pruning for growth attributes (2 years pooled data).

Pruning date	Canopy spread between rows (m)				Canopy spread within row (m)				Trunk cross-sectional area (cm^2)			
	P_1	P_2	P_3	Mean	P_1	P_2	P_3	Mean	P_1	P_2	P_3	Mean
D_1	2.67*	2.71*	2.76*	2.71*	2.65*	2.66*	2.73*	2.68*	6.12*	7.03*	7.11*	6.75*
D_2	2.61	2.68*	2.70*	2.66	2.61	2.65*	2.65*	2.64	5.59	6.76*	7.01*	6.45*
D_3	2.04	2.40	2.57	2.34	2.44	2.53	2.60	2.52	4.95	5.43	6.13	5.50
D_4	1.91	2.29	2.38	2.19	2.34	2.47	2.49	2.43	4.88	4.99	5.36	5.08
Mean	2.31	2.52	2.60*		2.51	2.58*	2.61*		5.39	6.05*	6.40*	
For comparing means of		S.E.±	$LSD_{0.05}$			S.E.±	$LSD_{0.05}$			S.E.±	$LSD_{0.05}$	
Pruning date (D)		0.13	0.06			0.06	0.06			0.39	0.65	
Pruning intensity (I)		0.09	0.05			0.03	0.05			0.30	0.56	
Interaction (T × I)		0.08	0.11			0.03	0.11			0.25	1.12	

*indicates significance at LSD (*P* = 0.05) (SPSS 16.0), respectively (*n* = 2), D_1 = May last week, D_2 = June last week, D_3 = July first week, D_4 = July last week, P_1 = 20% pruning, P_2 = 40% pruning, P_3 = 60% pruning.

compared to early pruning. Irrespective of pruning time, pruning severity increased the vigorous shoot growth because of modification of apical dominance by pruning and increased nutrient availability to the left-over shoots (Adhikari and Kandel, 1).

Significantly earliest fruit maturity (166.54 days after pruning) recorded in 20% (P1) pruning intensity and late maturity (172.23 days after pruning) in 60% (P3) pruning intensity irrespective of pruning time. It was found significantly advanced maturity by 5.69 and 2.21 days in trees pruned at 20 and 40% pruning intensity respectively, as compared to 60% pruning, regardless of pruning intervals. Irrespective of pruning severity, fruits matured 64.05 and 56.20 days earlier in trees pruned during May and June last week, respectively, compared to those pruned during July last week (Table 2). Interaction effect significantly exhibited the advancement in fruit maturity, when trees were pruned at different levels during May last week, and those pruned to 20 and 40% during last week of June.

Early fruit maturity in earlier pruning may be attributed to the early start of new vegetative growth, which eventually induced flowering earlier (Adhikari and Kandel, 1) and quick completion of growing degree days (GDD) during the fruit growth (Fig. 1). Pruned trees started vegetative growth immediately after pruning and almost, entire amount of carbohydrates, which otherwise would form flower buds, might have been utilized in tree growth, resulting in a late start of flowering in severely pruned trees (Dhaliwal and Singh, 4).

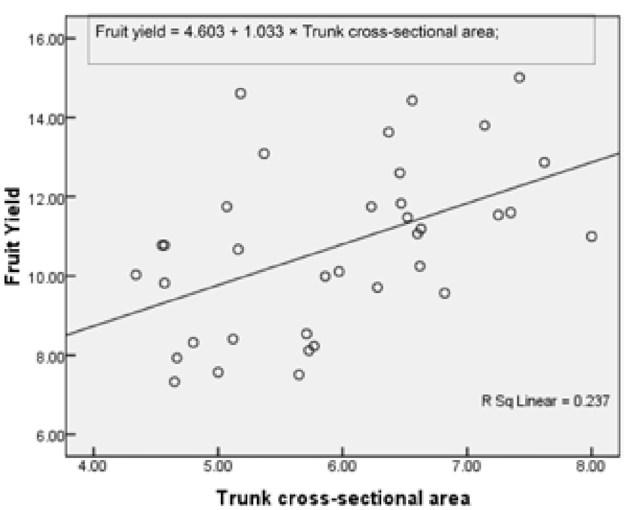

Fig. 1. Relationship between fruit weight and growing degree days from fruit set to maturity in guava cv. Lalit as influenced by different time and level of pruning during 2018 (A) and 2019 (B). Data are the means of different levels of pruning at specific date. D_1 = last week of May, D_2 = last week of June, D_3 = first week of July, D_4 = last week of July.

Irrespective of pruning time, trees imposed to 40% pruning intensity significantly had highest fruit length (70.32 mm) and weight (183.38 g). Fruit breadth was non-significant among different time and severity of pruning. Interaction effect revealed that trees imposed to 40 and 60% pruning during June last week had significantly highest fruit length (74.75 and 74.14 mm, respectively). Sixty percent pruning on June last week resulted maximum fruit weight (230.09 g fruit^{-1}). Maximum yield (12.56 kg tree^{-1}) recorded in last week of June pruning (D2), interaction effect for the yield was found significant. Maximum yield (12.65 kg tree^{-1}) recorded in 60% pruning intensity at the last week of June pruning. The fruit yield was significantly improved by 46.25 and 42.90% in trees pruned during last week of June as well as last week of May compared to those pruned during July last week, regardless of pruning intensity (Table 2). Trees pruned to different intensity showed non-significant difference among themselves, regardless of pruning frequency.

Yield efficiency was increased with delay in pruning from May to June, and thereafter declined, though found non-significant. Irrespective of pruning frequency, yield efficiency was significantly highest in trees pruned to 20% (2.01 kg cm^{-2}) and 40% (1.81 kg cm^{-2}). The interaction effect was non-significant except those pruned to 60% during July 2nd week and last week (Table 2).

Low crop load resulted in a larger growth rate than a high crop load, due to there being less competition for available photo-assimilates. Thus, withdrawal of photo-assimilates by developing fruits and reduced light intensity during winter might have resulted in reduced fruit retention in those trees, where fruits matured during November, as compared to October. However, during severe winter, when daily mean temperature reached below base temperature, fruit growth rate might have been reduced (Fig. 1) due to less enzyme activity and less mobilization of photo-assimilates, might have reduced fruit drop, thereby again increasing number of fruits per tree, when fruits were matured beyond November. Thus fruits size showed increasing trend with delay in pruning from May to June as fruits maturity also delayed from October to November last week and December first week, however, fruits matured during severe winter, when pruning was further delayed to July, were smaller in size, which could be attributed to the reduced photosynthesis activity by the leaves due to low chlorophyll content in cold periods (Julius *et al.*, 8), thereby lesser translocation of metabolites for the developing fruits. Under subtropical climate, accumulation of growing degree days from fruit set to maturity were optimum for enhanced size of fruits matured during November last week to December first week, while fruits matured from December last week and

Table 2. Response of guava cv. CISH-Lalit to different time and severity of pruning for fruit maturity and yield attributes (2 years pooled data)

Pruning date	Fruit maturity (Days after pruning)				No. of fruits per tree				Yield (kg tree^{-1})				Yield efficiency (kg cm^{-2})			
	P_1	P_2	P_3	Mean	P_1	P_2	P_3	Mean	P_1	P_2	P_3	Mean	P_1	P_2	P_3	Mean
D_1	141.67*	143.98*	145.67*	143.77*	60.79*	56.50	58.98	58.76	12.32*	12.15*	12.34*	12.27*	2.05*	1.73*	1.74*	1.84
D_2	148.96*	151.58*	154.30	151.61	55.54	53.08	53.71	54.11	12.61*	12.65*	12.42*	12.56*	2.31*	1.86*	1.80*	1.99
D_3	169.75	176.51	179.28	175.18	70.06*	64.83*	65.66*	66.85*	9.63	9.71	9.37	9.57	1.95*	1.84*	1.53	1.77
D_4	205.77	208.01	209.67	207.82	67.71*	67.26*	67.70*	67.55*	8.29	8.94	8.53	8.59	1.74*	1.82*	1.60	1.72
Mean	166.54*	170.02*	172.23		63.52	60.41	61.51		10.71	10.86	10.66		2.01*	1.81*	1.67	
For comparing means of		SE ±	$LSD_{0.05}$			SE ±	$LSD_{0.05}$			SE ±	$LSD_{0.05}$			SE ±	$LSD_{0.05}$	
Pruning date (D)		14.38	5.93			3.25	5.93			0.99	1.43			0.06	NS	
Pruning intensity (I)		1.66	5.13			0.91	NS			0.06	NS			0.10	0.31	
Interaction (T × I)		7.55	10.26			1.76	10.26			0.52	2.48			0.06	0.62	

* and NS indicate significance and non-significance at LSD (P = 0.05) (SPSS 16.0), respectively (n = 2), D_1 = May last week, D_2 = June last week, D_3 = July first week, D_4 = July last week, P_1 = 20% pruning, P_2 = 40% pruning, P_3 = 60% pruning.

beyond that did not receive sufficient heat units above threshold temperature resulting in reduced fruit size (Fig. 1). Ferreira *et al.* (5) also observed direct influence of air temperature on vegetative and reproductive development of guava which represents the daily energy accumulation available for the development of the plant. Therefore, time of pruning exerted significant effect on ultimate yield of the canopy. Larger fruits by moderate level pruning (40%) were obtained because of retention of lesser total number of fruits on these trees compared to those of low-level pruning (20%) resulting in increased availability of metabolites per fruit, besides optimizing light interception and distribution within the canopy. Although light availability was increased with severity of pruning, however, as compared to medium pruned trees, fruit size of severely pruned trees were restricted by source limitation during fruit growth phases (Jorquera-Fontena *et al.*, 7).

Irrespective of different pruning severity, the time of pruning exerted significant effect on alteration of fruit TSS content and it was 27.76 and 17.35 % more in trees pruned during June and May last week compared to those pruned during end of July end. Trees pruned to 40%,significantly registered highest TSS (10.48°Brix), regardless of pruning frequency (Table 3). The interaction effect exhibited significantly highest TSS in trees pruned to 40% during June end (11.73°Brix) and May end (11.59°Brix). Improvement in TSS in fruits of early pruned trees than those of late pruned trees might be attributed to the fact that early pruned plants got adequate time for optimum vegetative growth before winter compared to late pruned trees, thereby increased uptake of nutrients by the trees and consequently more synthesis of carbohydrates and other metabolites and their translocation to the fruits took place in early pruned trees compared to late pruned trees (Choudhary *et al.*, 2).

Correlation analysis (Table 4) revealed significantly positive correlation of TCSA with canopy spread (between rows and within row) (+0.818 and +0.914) at $p \leq 0.01$ (SPSS). Increase in fruit yield was significantly associated with increase in canopy spread (between rows and within row), TCSA, fruit length, fruit breadth, average individual fruit weight and TSS (+0.644, +0.606, +0.487, +0.680, +0.802, +0.864 and +0.594, respectively), while decrease in days required for fruit maturity after pruning (-0.645) at $p \leq 0.01$ (SPSS 16.0). Regression model exhibited 23.70 % influence of TCSA on variation in fruit yield and with increase in yield was 1.033 times more than TCSA (Fig. 2). Thus there existed significant effect of time and intensity of pruning on TCSA in guava which could aid in improved transport of nutrients from root to different aerial parts of the plant and enhanced tree growth and the distribution of photo-assimilates from site of

Table 3. Response of guava cv. Lalit to different time and severity of pruning for fruit quality attributes (2 years pooled data).

Pruning date	Fruit length (mm)				Fruit breadth (mm)				Fruit weight (g)				Total soluble solids (°Brix)			
	P_1	P_2	P_3	Mean	P_1	P_2	P_3	Mean	P_1	P_2	P_3	Mean	P_1	P_2	P_3	Mean
D_1	67.60	70.67	69.70	69.32	75.05*	77.70*	76.00*	75.05*	202.09	214.34	208.83	208.42	9.50	11.59*	8.97	10.02*
D_2	72.47	74.75*	74.14*	73.78*	74.69*	78.43*	76.50*	74.69*	226.17	237.67*	230.09*	231.31*	10.50	11.73*	10.50	10.91*
D_3	64.44	69.37	65.38	66.40	71.24*	74.50*	75.23*	71.24*	137.00	149.25	142.50	142.92	8.97	9.97	9.10	9.35
D_4	63.05	66.49	64.13	64.56	67.35	73.89*	72.25*	67.35	121.75	132.25	125.67	126.56	8.42	8.62	8.59	8.54
Mean	66.89	70.32*	68.34		72.08	76.13	74.99	72.08	171.75	183.38*	176.77		9.35	10.48*	9.29	
For comparing means of		SE ±	$LSD_{0.05}$			SE ±	$LSD_{0.05}$			SE ±	$LSD_{0.05}$			SE ±	$LSD_{0.05}$	
Pruning date (D)		2.01	0.65			1.26	NS			25.24	5.93			0.50	0.09	
Pruning intensity (I)		0.99	0.56			1.21	NS			3.37	5.13			0.39	0.08	
Interaction (T × I)		1.15	1.12			0.87	10.26			13.26	10.26			0.33	0.15	

* and NS indicate significance and non-significance at LSD (P = 0.05) (SPSS 16.0), respectively (n = 4), D1 = May last week, D2 = June last week, D3 = July first week, D4 = July last week, P1 = 20% pruning, P2 = 40% pruning, P3 = 60% pruning.

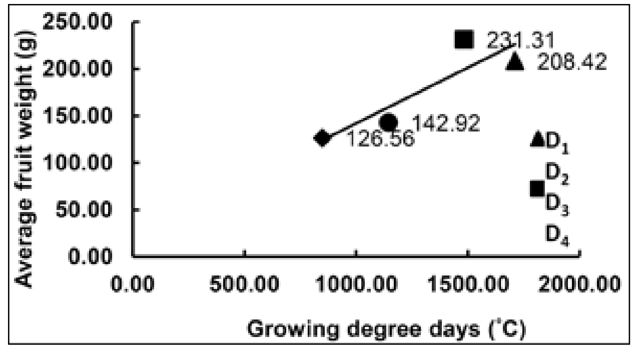

Fig. 2. Regression analysis model between fruit yield and trunk cross-sectional area in guava cv. Lalit as influenced by different time and level of pruning

production to site of utilization which resulted in Our study also indicated that as days required for fruit maturity increased, fruit size and yield decreased, which might be attributed to the fact that periods of delayed fruit maturity coincided with severe winter when there was rapid fall in air temperature and also low solar radiation which resulted in lesser production of photo-assimilates caused by the decreased leaf area thereby also affected source-to-sink transport of photo-assimilates through the phloem.

Therefore, it can be concluded that pruning alone at the right time and to the adequate extent improves yield and quality of fruits in guava. Guava plants can be imposed to moderate pruning (40%) and time of pruning can be extended up to last week of June so as to extend the fruit availability up to first week of December. However, fruit maturity from December end onwards due to delay in pruning up to mid/end July, was not found economical as the fruit growth significantly declined along with delay in fruit maturity.

AUTHORS' CONTRIBUTIONS

Designing and implementation of experiment, recording data and drawing interpretation (KKS, DK, SRS), preparing of manuscript (KKS, PNB, DK).

DECLARATION

The authors declare that they have no potential conflict of interest.

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Table 4. Pearson's correlation analysis between different parameters in guava cv. Lalit.

Trait	CSBR	CSWR	TCSA	FM	FL	FB	FW	NF	TY	YE	TSS
CSBR	1.000										
CSWR	0.949**	1.000									
TCSA	0.818**	0.914**	1.000								
FM	-0.717**	-0.753**	-0.629**	1.000							
FL	0.750**	0.714**	0.662**	-0.697**	1.000						
FB	0.430**	0.351*	0.265	-0.175	0.379*	1.000					
FW	0.792**	0.746**	0.657**	-0.837**	0.896**	0.483**	1.000				
NF	-0.619**	-0.590**	-0.574**	0.705**	-0.725**	0.265	-0.664**	1.000			
TY	0.644**	0.606**	0.487**	-0.645**	0.680**	0.802**	0.864**	-0.207	1.000		
YE	-0.058	-0.181	-0.387*	-0.112	0.120	0.608**	0.313	0.308	0.606**	1.000	
TSS	0.611**	0.552**	0.552**	-0.675**	0.849**	0.363*	0.793**	-0.647**	0.594**	0.119	1.000

**Correlation is significant at the 0.01 level (2-tailed); *Correlation is significant at the 0.05 level (2-tailed); n = 3 (SPSS 16.0); CSBR = Canopy spread between rows, CSWR = Canopy spread within row, TCSA = Trunk cross-sectional area, FM = Fruit maturity, FL = Fruit length, FB = Fruit breadth, FW = Fruit weight, NF = Number of fruits, TY = Total yield, YE = Yield efficiency, TSS = Total soluble solids.

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