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Effect Branch Pruning on Shoot Growth and Flowering of Guava (*Psidium guajava* L.) Cultivar 'Crystal'

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ABSTRACT

Guava cv. Crystal is a prospective tropical fruit for commercial development due to a special sweet crunchy taste of its fruit. Although guava trees are able to bear crop at least twice yearly, incorporation of cultivation techniques, especially pruning, is important for controlling flowering to ensure high productivity. An experiment was conducted to evaluate the effect of pruning length on shoot growth and flowering of guava in during wet period located in Bengkulu. Treatments were the length of remaining branch following pruning at 10, 20, 30, and 40 cm from branch base, with control being un-pruned branch. The results of this experiment revealed that the number of produced flowers increased with longer cutting length, with the greatest number at cutting length of 30 cm, and then declining. Compared to those un-pruned branches, the branches pruned at 30 cm, produced higher flower number. However, following 30 cm cutting length, the branches experienced the greatest number of aborted flower.

INTRODUCTION

The increasing public awareness of the importance of consuming fresh fruit for health has promoted the market demand for fresh fruit, including guava. Guava (*Psidium guajava* L.) a member of family Myrtaceae is a highly prolific and remunerative fruit crop which grow well under wide range of soil and agro-climatic conditions. Fruits are good source nutirent, within 100 g of edible portion contain of energy 51calories, Vitamin A 12g, Vitamin C 200-300mg, sugars (9g and minerals like Sodium 2g, Potassium 417mg, Calcium 1g and Iron 1g (Mitra and Sanyal, 2004).

Guava varieties have diverse shape, size, taste and color of the fruits (Paull and Duarte 2012), and Crystal cultivar is gaining its popularity since the last decade. Guava fruits of most cultivars have a large number of seeds, the taste of fruit tends to tighten, and the fruit flesh is hard. These properties cause a lack of public interest in guava fruit. In contrast to guava those cultivars, Crystal cultivar, released by Minister of Agriculture in 2007 (Direktorat Perbenihan Hortikultura, 2007), has a very low number of seeds (less than 3% of the fruit), having sweeter taste of the flesh, and having crispy fruit texture. Cultivation of Crystal guava is very prospective to be developed commercially because it can bear fruit throughout the year, having the potential for import substitution of temperate fruits in Indonesia.

Good Agriculture Practices is of pivot role for ensuring highly productive crops with

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healthy fruits for the economic benefit of farmer and welfare of human being. In fruit culture, branch pruning has been a good common pratice which can be, based on its objectives, grouped into 3 types including canopy formation, maintenance and production (Dhaliwal *et al* . 2014, Zhang et al. 2018).

Pruning for canopy formation consists of trimming branches to shape, to regulate plant height and to form tree canopy. Plant canopy regulation can increase sunlight interception, so that photosynthesis takes place more optimally and shoots growth is better. Maintenance pruning is conducted to remove shoots that are not useful, including those attached by pests or diseases, dry or dead shoots. Production pruning directed to stimulate flowering and to control fruit growth, hence increasing fruit production and improving fruit quality. This pruning is done by cutting off unproductive branches or shading branches so that photosynthesis plants increases (Zhang *et al.* 2018).

Pruning by cutting branches at certain length from their bases to reduce the canopy size of tree may promotes the emergence of new shoots which may also bear flowers and fruit (Singh and Papnai, 2010). In new shoots, flowers commonly protrude close to its base, hence young leaves positioned above the flower may act as sinks, but when mature it may act as source of the photosynthates (Ryan et al. 2018). In The last case, pruning may improve fruit production and fruit quality. For this reasoning, production pruning is the focus of this study because it aims to improve the growing lateral branches so that it may accelerate and increase the quantity of flowering in guava plants.

Lateral shoot growth is affected by apical dominance. Apical dominance can be defined growth inhibition of lateral buds by the presence of apical buds. As long as there are apical shoots, the growth of lateral shoots will be inhibited to a certain distance from the shoots. The mechanism of apical dominance is that auxin hormone which is produced in apical buds diffused downward (polar) and buried in lateral buds. High concentration of auxin in the lateral buds will inhibit their growth. Accordingly, pruning of apical shoots removes apical dominance which triggers the growth of lateral shoots (Singh and Papnai, 2010, Ledesma et al. 2016). In the same reasoning, pruning apical branches at a certain distance from their bases will directly reduce the concentration of auxin in the buds below the cutting position. So that this condition triggers the growth of secondary shoots and followed by the emergence of flowers in the shoots.

Pruning in guava have focus of some studies both in sub-tropical and in tropical regionsand has been recommended in Indonesia (Balai Penelitian Tanaman Buah (Balitbu), 2015). In subtropical India, Singh *et al.* (2001) reported that pruning can increase the number of guava plants from Indian cultivars by 70% (Sardar cultivars) and 73% (*Allahabad safeda* cultivars). An increase in the number of set fruits occurs because of an increase in the number of flowers formed in the plants that are pruned. In tropical Indonesia, Fitria (2016) demonstrated that pruning leaving four-leaf pairs above fruit resulted in better results on plant growth guava cv. Crystal, good vegetative growth (diameter of the plant canopy, leaf number, leaf area, and number of buds) and generative (total flowers, and *fruit set*). Similar results have been reported for cv. Merah Getas (Susanto, 2014).

The purpose of this study was to determine the effect of length of pruning on the growth and flowering of lateral shoots on guava plants cv. Crystal. The hypothesis we proposed was that there are the best distances of pruning from the base of the branch of the guava plant Crystal which improve the growth of lateral shoots and increase the number of flowers in the shoots.

MATERIALS AND METHODS

A field experiment was conducted in December 2016 - March 2017 in a guava garden with a block of cv Crystal trees located in Pematang Gubernor Village, Bengkulu Province. A nunber of 20 3-year old Crystal guava trees were selected for that their growth were a relatively homogeneous with stem diameter (9.6±1.1 cm).

Treatment was a single factor of branch pruning, involving cutting all tertiary and quarterly branch/shoots of the sample trees

with different cutting distances from the shoot base, i.e. 10, 20, 30, or 40 cm or control un-pruned tree. In a control tree, all tertiary and quarterly branches were left uncut. Treatments were arranged under a Completely Randomized Block Design with four trees as replications.

Treated branches or shoots are non-generative branches (branches that did not produce fruit) with a diameter of ± 2 cm. All non-productive branches selected in the experimental tree were cut at the same pruning length, dependig of the treatment. Of the total pruned branches, 10 samples were randomly assigned for shoot observation, in which each treatment sample was marked by a colored ribbon (blue, green, red, yellow or white), based on the level of pruning. Therefore, the number of material in this study was 20 guava trees with a total sample of 200 branches for observation .

Beside branch/shoot pruning, cultural practice of the guava trees followed local standard, especially for fertilizer and pest control. Fertilizer in the form of inorganic fertilizer and manure, and then at three months after first application. The doses of the fertilizer were ½ kg NPK 15-15-15 and cow manure at 5 kg per tree. Pest control was carried out when the damage reaches the economic threshold by spraying insecticides with active ingredients lambda cyhalothrin and thiametoxam, with a dose of 0.5 - 2 ml / L. Weed were controlled manually for those growing 60-cm within a circle surrounding guava tree trunks and by spraying glyphosate for those far from the tree trunk.

Samples of the treated and control branches/ shoots were observed every two weeks since the pruning treatment, consisting of vegetative variables (branch diameter, number of leaves, shoot length and shoot diameter) and of generative variables (percentage of productive shoots, total flowers, aborted flowers, and total set fruits.

Data from the observation and measurement results were analyzed their variation using the F test. Whenever a sigificant difference was found (F value < 5% F table), treatments were separated further using the Least Significant Difference test with a level of 5%.

RESULTS AND DISCUSSION

The effect of branch/shoot pruning with various length of the remaining branch from its base were assessed by observing vegetative growth and generative development of the treated branch and shoot. Variant analysis demonstrated that on vegetative development, branch pruning significantly affected formed leaf area, but not branch diameter, number of leaves, shoot length and diameter of the shoot. On generative growth of the cut-branchs, pruning treatment significantly affected the total amount of formed flower and very significantly effect on the amount of aborted flowers, but the treatment did not significantly affect the number of productive branches and the number of ovaries (Table. 1).

Table 1. Analysis of variance results of the effect of pruning length on vegetative and generative growth of guava cv. Crystal

Growth Variable	Fishcer value	Significancy	Coeffient of Variation (%)
Growth of branch diameter (mm per 2 weeks)	0.110	ns	1.38 %
Number of formed leaves (strands per 2 weeks)	1,229	ns	12.43 %
New shoot length (cm)	0.663	ns	15.56 %
New shoot diameter (mm)	0.781	ns	4.43 %
New leaf area (cm^2)	8.414	**	17.33%
Percentage of productive branches (%)	3.037	ns	17.25 %
Number of formed flowers (per branch)	4.787	*	26.04 %
Number of aborted flowers (per branch)	6.207	**	23.22 %
Number of set fruit (per branch)	2.000	ns	30.44 %

Notes : ns = no significant effect; * = significant effect when F value > F table 5% (3.055); **= very significant effect when F value > F table 1% (4.89); Sig=Significancy; CV= Coeffient of Variation

Table 2. Vegetative growth of guava cv. Crystal branch as affected by branch pruning length, observed until 92 weeks after pruning.

Growth Variable	Fishcer value	Sig.	CV (%)
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Notes: BD = Branch diameter growth rate per 2 weeks; GRL=Growte rate of leaf (number per 2 weeks); NSL= New shoot length; NSD=New shoot diameter

Effect of branch pruning length on vegetative growth of guava cv. Crystal

Branch pruning treatment was evaluated on vegetative growth of Crystal guava plants by observing five growth variables, namely, growth rate of branch diameter, new leave number, new of shoot length, new shoots diameter and leaf area. The observation was made until 92 days following pruning. Branch pruning significantly affected formed leaf area, but not branch diameter, number of leaves, shoot length and diameter of the shoot (Table 1). Guava branch diameter grew at an average rate of 0.39 mm per 2 weeks, ranged between 0.36 mm and 0.41 mm (Table 2) . The average number of formed leaves also was 4.1 with a range of 3 and 4. The average length of new shoot growth was 27.3 cm ranget from 23.7 to 32.7 cm. Whereas, new shoot diameter grew at an average of 4.82 mm with a range of 4.33 mm to 5.15 mm.

Branch pruning significantly affected leaf area growth of guava cv. Crystal (Table 1). The longer the remaining branch consistently the greater was the leaf area at 98 days following pruning. Those 10 cm-left pruned branch produced the narrowest leaves with 1,337 cm^2 area, but those branch left at 40 cm had 2,037 cm^2; whereas those unpruned produced the largest leaf area of 2,571 cm^2.

Effect of branch pruning length on generative growth of guava cv. Crystal

During the December 2016 - March 2017 trials, the flowers begin to bloom in the 8th week after branch pruning. Generative growth of Crystal guava was assessed by observing percentage of productive shoots, total flowers, number of aborted flowers, number of set fruits. Flowers emerged on day 48 after pruning. Branch pruning treatment significantly affected the total amount of formed flowers and very significantly effected on the amount of aborted flowers, but pruning did not significantly affect the percentage of productive branches and the number of set fruits (Table. 1).

The percentage of productive shoots ranged from 37.5% to 82.5%, with an average of 63.5%; whereas, the number of set fruits per branch ranged from 3 to 8.7, with an average of 5.6 (Table 3). The number of flower per branch increased with increasing length of the left branch, from the least number of 10 formed flowers at 10 cm-left branch to the greatest average of 45.5 flowers reached at 30 cm-pruned branchs. Subsequently, the number of formed flowers tended to decreased with longer left-branch of 40 cm (36 flowers); even those in uncut branch, guava branch only produced in average of 28 flowers. Similar results were observed in the case of aborted fruits. Aborted

Table 3. Reproductive growth of guava plants cv. Crystal as affected by pruning branch at various lengths from its base.

Pruned branch length from its base	BD (mm)	GRL	NSL (cm)	NSD (mm)	Leaf area (cm^2)
10 cm	0.43	4	29.6	5.07	1337 c
20 cm	0.36	4	25.9	5.10	1575 bc
30 cm	0.41	3	24.4	4.48	1865 b
40 cm	0.39	5	32.7	5.14	2037 b
Unpruned control	0.40	4.5	23.7	4.33	2571 a

Notes: PPB = Percentage of productive branches; NF = Number of flowers; NAF = Number of aborted flowers; NSF = Number of set fruits

fruits increased with the increasing length of left-branch, from 7 dehinced-flower at 30 cm-left branch to the maximum of 38 dehisced-flowers at 30 cm left-branch. Subsequently, the trend of aborted-flower drecreased, becoming only 31 flowers at 40 cm-left branch; even a signicifant reduction with 20 aborted flowers was found in control un-cut branches.

High density planting, by using a closer spacing for obtaining higher yield per unit area, is gaining its popularity in fruit crop production, including guava. Although at high density planting yield of individual tree will be reduced, yield in in per area base will be increased. In such planting system, canopy management by pruning and fruit thinning have to be conducted (Mitra et al. 2018). Pruning becomes an important agricultural practice as plant leaf response to light inteception for photosynthesis process to fix free carbon from the atmosphere and subsequently effiency of assimilate translocation to generative formation and fruit growth are determinant factors for fruit yield and quality, without compromising vegetative development to sustain growth during the current season, or in the future.

In India, pruning study by Pratibha et al. (2013) demonstrated that one leaf-pair pruning of cultivar Sardar significantly decreased the annual increment in tree height, tree spread, trunk diameter and tree volume as compared unpruned tree during the winter. Such pruning also increase the number of flower buds and yield. The results of our study in cultivar Crystal explains further that the length of pruning plays an important regulator of flower formation. Short pruning (10 cm, leaving one pair leaf) is not recommended in cultivar Crystal as it reduced about 50% leaf area, reducing 64% formed flowers as compared to those of unpruned branches. In the contrary, pruning by leaving 30 cm of branch base was beneficial as it increase flower formation by 60% as compared to those in unpruned control branches, but longer remaining shoot base during pruning (40 cm length) decreased the flower promotion effect. However, the beneficial effect in flowering at 30-cm pruning was not brought further for increasing set fruit as the pruning also caused the highest number of aborted flowers, an 96% increase from those un-pruned branches. These phenomenone might be because in our experiment was conducted in rainy season, shoots were pruned in 6 December 2018 and flowering occured in January 2019 as high rain during the month of January 2019 (416 mm in 21 days) detering bees to foraging and reducing sun ligh duration; and hence polination and photosynthetic capacity of the tree abolished the beneficial promotion of flowering. In our results,that pruning did not followed by the success in fuit set in guava cv. Crystal was also reported by Widiyastuti et al (2018).

Table 4. Reproductive growth of guava plants cv. Crystal as affected by pruning branch at various lengths from its base.

Pruned branch length from its base	PPB (%)	NF (Per branch)	NAF (Per branch)	NSF
10 cm	37.5	10.3 c	6.8 c	3.5
20 cm	57.5	21.0 bc	17.0 bc	4
30 cm	82.5	45.5 a	38.3 a	7.25
40 cm	75.0	35.8 ab	31.0 ab	4.75
Unpruned control	65.0	28.3 ab	19.5 bc	8.75

The importance of pruning of guava is related to its flowering characteristics that in natural condition, i.e. flowers are formed on newly emerging lateral shoots in the current season growth, irrespective of time of year, being erratic depending on the environmental condition (Singh et al., 2003). As profuse vegetative growth delayed cropping, regular pruning following fruit harvest reduces, promoting formation of lateral shoots from which flowering occurs. In Brazil, Serrano et al. (2008) studied the effect of pruning time and intensity on ‘Paluma’ guava. They found that the period between pruning time and the beginning of fruit ripening varied from 189 days (pruning in November and December) to 203 days (pruning in February). Regarding pruning intensity, light pruning caused more flowering, fruit set and yield, while heavy pruning produced less number of fruits with higher fruit weight. Pruning in the month of February was suggested to get the maximum yield. Similarly in Indonesia, Widyastuti et al (2018) from their pruning experiment on

cultivar Crystal at different time including April, May and June. They reported that different pruning did not affect the number of fruit set, but at any time pruning promoted the production of more flowers dan greater fruit yields than those unpruned tree.

CONCLUSIONS

Pruning branches of guava cv. Crystal at 30 cm from their base increased the total amount of flowers in the branches by 60% more than those of un-pruned branches; however, this did not cause increase in set fruit as the number of aborted fruits was also 96% higher.

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