FRUIT THINNING IMPROVES FRUIT QUALITY AND LESSEN ALTERNATE BEARING IN STRAWBERRY GUAVA (*PSIDIUM CATTLEIANUM*)

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Abstract

Strawberry guava naturally bears a heavy crop at the end of the hot and rainy season, with poor fruit quality as a consequence. Nitrogen triggers a floriferous flush in that species, leading to a better off-season production. Because phenological constraints, nitrogen is usually applied just after the heavy natural crop, and the triggered flush is weak and not very floriferous. As carbohydrate availability seems to play a role in the triggered flush, fruit thinning on the natural production thus appeared to be a means to overcome the low response to nitrogen. Two treatments were compared, thinned and unthinned trees, for their effect on the fruit quality of the natural production, and on the characteristics of the triggered flush. Results showed that fruit thinning had a positive effect on the fruit quality of the natural cycle: the mean fruit weight was improved (7.1 g for thinned trees versus 5.4 g for unthinned trees), but total soluble solids were not affected. Fruit thinning also had a positive effect on the intensity and the floriferous quality of the triggered flush, leading to a heavier off-season crop. The overall annual production was not affected by the treatments and was more evenly distributed between the natural and the triggered production cycles on thinned trees, whereas alternate bearing occurred on unthinned trees. The positive effect of thinning on yield steadiness continued during five consecutive production cycles.

INTRODUCTION

Strawberry guava (*Psidium cattleianum* Sabine) is a shrub of the Myrtaceae family, native to South America but now naturalized throughout the tropics and subtropics. Introduced to Reunion Island in the beginning of the 19th century, it rapidly colonized forests and uncultivated lands up to 1,300 m (Cadet, 1980). Although it adapts well to many ecological conditions, this species grows better in humid areas. It produces a sweet-smelling and dark red round berry appreciated by the local population. In the past few years, the food-processing industry has offered many red berry-based products. Much of the production comes from natural areas where gatherers collect the fruit, but supply is limited.

To diversify the highland farming system and improve the smallholders' incomes, a domestication program on strawberry guava have been conducted since 1993 on the windward East coast of the island (Normand, 2002a). The aim of this work is to improve productivity and fruit quality by the means of improved agronomic practices.

Strawberry guava natural production occurs during the rainy and hot season. But warm weather lessens fruit pigmentation and increases the fruit fly population. Furthermore natural fructification is usually high, which makes berries small.

Nitrogen fertilisation triggers a floriferous flush (Normand and Habib, 2001). This technical innovation leads to an off-season production that improves farmer incomes and reduces the production seasonality. The triggered production occurs during a more favourable cropping season in terms of fruit quality and market opportunities. Low temperature reduce fruit fly damage and improve berries coloration. Moreover, the lack of fruit on the local market during this period enhances the crop value.

The intensity and homogeneity of the plant response to nitrogen correlates with the plant phenological stage at fertilisation (Normand and Habib, 2001). When fertilisation is applied after a three-month resting period following natural harvest, the induced flush is intense and floriferous and the variability in plant reaction is low. When fertilisation is applied just after harvest, the response varies widely among plants and the induced flush is weak and produces few flowers. Because phenological constraints, nitrogen is usually applied just after natural harvest and alternate-bearing is often observed between natural and triggered fructification. This phenomenon is all greater as natural fructification is intense. A delay in fertilisation would limit alternate-bearing, but harvest would not occur at an appropriate period with respect to fruit quality and economic opportunities.

Previous results suggest that carbohydrate availability is involved in the plant response to nitrogen, in particular floriferous characteristics of the flush (Normand and Habib, 2001). Then, the improvement of carbon balance of strawberry guava tree at harvest, when nitrogen is applied, may result in a more intense and floriferous plant response. Fruit thinning is a classic way to reach this goal, by limiting the number of sinks on the plant. This technique can moreover improve fruit quality on the thinned trees.

The objective of this study is to experiment fruit thinning on natural fructification of strawberry guava as a way to improve fruit quality of the natural production, and to prevent alternate-bearing by increasing yield of the triggered production.

MATERIALS AND METHODS

The trial was conducted on a six-year old orchard located at 480 m of elevation. Plants were grown from seed and were thus all genetically different. Two treatments were compared for their consequences on fruit quality and on the intensity of the following triggered flush :

- Fruit thinning on a natural production cycle
- Control without fruit thinning on a natural production cycle.

The objective was to raise the leaf-to-fruit ratio at the tree level, considered as an indicator of the carbohydrate balance. The heavy crop of natural cycle leads generally to low leaf-to-fruit ratio. As strawberry guava is a small berry, thinning fruit by fruit would be tedious work. The technique we used consisted in removing all the terminal shoots that bore more fruit than leaves in order to reduce the number of fruit without removing too many leaves.

We used a complete randomised block design with four replicates. Each plot consisted in 15 trees, two of which were randomly chosen for data collection. Overall, 16 trees were monitored.

Natural blossoming occurred in November 1998 and harvest spread from mid-February to mid-Mai 1999 with harvest peak from early March to mid-April. Fruit thinning was done only once during this three-year experiment and was carried out on the natural cycle in December 1998, few days after fruit set.

Nitrogen was applied during the last decade of March 1999, in the middle of the natural harvest peak (36 g N per plant). Triggered shoots and flower buds emerged in May and flowered in June 1999. Triggered harvest period spread from early October to the end of November 1999.

In order to study the long term effect of fruit thinning, we collected data on the same trees during the 2000 and 2001 natural production cycles, and during a cycle triggered in March 2000, i.e. during five production cycles after fruit thinning.

Data Collection

We recorded the total number of fruit and the total yield per tree on each production cycle. During harvest peak, 50 individual fruit per treatment were weighted and their seeds were counted.

During the 1999 natural and triggered production cycles, the total soluble solids content (TSS) was estimated on a sample of 50 fruit per treatment with a hand refractometer.

The intensity of the response to nitrogen was recorded during the 1999 triggered cycle. Twenty terminal branches on each tree were chosen and tagged when nitrogen was applied. The number of shoots and flowers triggered by nitrogen on these branches were recorded just before flowering.

Statistical Analysis

One-way analysis of variance were performed with S-Plus 2001 software (Insightful, 2001) to test the effect of treatments on the variables. Differences between means were assessed using Fisher LSD method.

RESULTS

Fruit Thinning Enhanced Fruit Quality

The average number of fruit on unthinned trees was 60 % higher than on thinned trees (Table 1). This result confirmed the effectiveness of the fruit thinning method. However, yield differences between the two treatments were not significant. This was a consequence of a significant 27 % increase of individual fruit weight on thinned trees (Table 1). The number of seeds per fruit and the TSS content were not affected by fruit thinning (Table 1).

Fruit Thinning Enhanced the Triggered Production Cycle

The number of shoots produced by 20 terminal branches did not differ significantly on thinned and unthinned trees, but the number of flowers borne by these shoots was affected by the treatment (Table 2). Shoots triggered on thinned trees were almost 3.5 times more floriferous than those on unthinned trees. As a consequence, the number of fruit per tree and the yield of the triggered cycle were significantly higher on thinned trees, whereas the individual fruit weight was lower (Table 2). The number of seeds per fruit and the TSS content were not affected by treatment.

Fruit Thinning Affected Alternate Bearing on the Long Term

Yield was monitored on five consecutive production cycles after fruit thinning. Unthinned trees had a typical behaviour of alternate bearer, with heavy natural crop and light triggered crop (

Fig. 1 and already shown in Table 1 and 2). Thinned trees showed a drastic reduction in these yield changes, with a more stable yield between natural and triggered crops (

Fig. 1). Yield differences between thinned and unthinned trees are significant on the second and third production cycle after fruit thinning.

DISCUSSION

Fruit thinning on a heavy natural crop of strawberry guava affects positively its fruit quality and the vegetative and reproductive intensity of a consecutive triggered cycle. Yield of this triggered cycle is higher on thinned trees. The alternate bearer behaviour of unthinned strawberry guava trees is broken on thinned trees.

The fruit thinning method we used reduced the number of fruit per tree by almost one half. But harvest weight per tree was not affected by this fruit loss because of a significant increase in mean fruit weight (Table 1). Fruit thinning therefore improved fruit quality on the thinned crop. Although the thinning method removed some leaves, it globally increased the leaf-to-fruit ratio at the tree level by reducing fruit load. Our results on the natural and triggered production cycles show a negative relationship between mean fruit weight and fruit load (Tables 1 and 2). They are in accordance with data from an other experiment where fruit load explained 64% of the variability in mean fruit weight (Normand, 2002a). Relationship between fruit load, or leaf-to-fruit ratio, and fruit size are reported for several fruit species such as peach (Weinberger and Cullinan, 1932) or kiwifruit (Lai et al., 1990). Individual strawberry guava fruit weight is also affected by the number of seeds (Normand, 2002b). But our data showed that the mean number of seeds per fruit was not affected by treatment, which was normally expected. Therefore differences in mean fruit weight are actually related to fruit load, on the natural as well as on the triggered cycle. Fruit thinning did not affect TSS content, suggesting that inter-fruit competition in our experiment was not strong enough to reduce TSS content, even on heavy loaded unthinned trees. Génard (1992) showed that TSS content was little affected by leaf-to-fruit ratio in peach. Soluble sugars generally appear as a less sensitive indicator of the carbohydrate status than starch (Monselise and Goldschmidt, 1982).

The vegetative and reproductive intensity of the triggered production cycle was higher on thinned than on unthinned trees. Nitrogen was applied during natural harvest peak, which is an unfavourable time as the plant response is then weak and little floriferous (Normand and Habib, 2001). Unthinned trees behaved in this way, whereas thinned trees produced very floriferous flushes. Normand and Habib (2001) hypothesised that the floriferous characteristics of the triggered flush are related to the plant carbohydrate availability when nitrogen is applied. Carbohydrates play a role on growth and flowering in various tree species such as citrus (Goldschmidt and Golomb, 1982) or kiwifruit (Buwalda and Smith, 1990). Overload and carbohydrate depletion are important factors involved in alternate bearing (Monselise and Goldschmidt, 1982). The higher floriferous intensity of the triggered flush on thinned trees may thus be related to a better carbohydrate status than on unthinned trees, probably due to the lower fruit load during the natural cycle.

This more intense flowering of the triggered cycle on thinned trees leads to yield as high as on the natural cycle, whereas yield is reduced by more than half on unthinned trees. The following natural cycle flushed during harvest of this triggered cycle, and, according to the previous results, its reproductive characteristics were affected by fruit load of the triggered cycle. Consequently, the following natural cycle was less floriferous on thinned trees because of the higher yield on triggered flush. Result was a lower yield as shown on figure 1. This naturally induced reduction in fruit load mimicked a new fruit thinning. Therefore, only one fruit thinning on heavy loaded trees can break the alternate bearer behaviour of strawberry guava. Annual yield is more evenly distributed between natural and triggered cycles. In the same way, mean fruit weight remains almost constant on thinned trees, whereas unthinned trees alternate between natural and triggered cycle in producing many small fruit with poor quality on the former and then few large fruit on the latter.

Yield increase of triggered cycle consecutive to fruit thinning has important economical consequences because of better fruit quality and off-season market opportunities. This actually improves farmers incomes. But to thin fruit by hand may appear as an expensive operation. A cost-benefit analysis on this experiment showed that fruit thinning is effectively a labour investment: 275 to 333 $h.ha^{-1}$. Benefits are expected at two levels: first, time required to harvest the natural cycle is lower because of the lower number of fruit, and second, returns are higher because of better fruit quality and larger off-season production. The economic evaluation is positive as early as the first year, and positive economical consequences are expected during at least two and a half years after thinning (Fig. 1). Practically, heavy natural crop should be thinned every two or three years. The intensity of flowering and fruit set are efficient indicators to decide fruit thinning.

CONCLUSION

Fruit thinning on heavy loaded natural crop is an efficient method to improve fruit size without reduction of yield and to enhance plant response to nitrogen fertilisation leading to a higher yield on triggered cycle. This method breaks the alternate bearer behaviour usually observed on strawberry guava between natural and triggered cycles. The effect of fruit thinning remains at least on five production cycles. Such a practice could enhance profitability of strawberry guava production for farmers in Reunion Island.

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Tables

Table 1. Yield, number of fruit (No. fruit), mean fruit weight, mean number of seeds per fruit (No. seeds per fruit) and mean total soluble solid content (TSS) on unthinned and thinned strawberry guava trees.

Treatments	Yield per tree (g.)	No. fruit per tree	Fruit weight (g)	No. seeds per fruit	TSS (°brix)
Unthinned	15 740	2 890 a	5.5 b	16.0	10.9
Thinned	12 652	1 776 b	7.0 a	15.7	11.4
	n.s.	*	**	n.s.	n.s.

n.s. : non-significant; * : $P \leq 0.05$; **: $P \leq 0.01$. Means followed by different letters are significantly different (Fisher LSD method)

Table 2. Vegetative and reproductive characteristics of the production cycle triggered with nitrogen just after the natural harvest on unthinned and thinned strawberry guava trees. Number of shoots and flowers were recorded on 20 terminal branches per tree. The other variables are sum or mean at the tree or at a treatment level.

Treatments	No. shoots	No. flowers	Yield per tree (g.)	No. fruit per tree	Fruit weight (g)	No. seeds per fruit	TSS (°brix)
Unthinned	30.6	47.3 b	6 922 b	763 b	11.2 a	16.6	11.7
Thinned	36.5	162.4 a	13 896 a	2 172 a	6.6 b	18.8	11.9
	n.s.	**	**	**	**	n.s.	n.s.

n.s. : non-significant; * : $P \leq 0.05$; **: $P \leq 0.01$. Means followed by different letters are significantly different (Fisher LSD method)

Figures

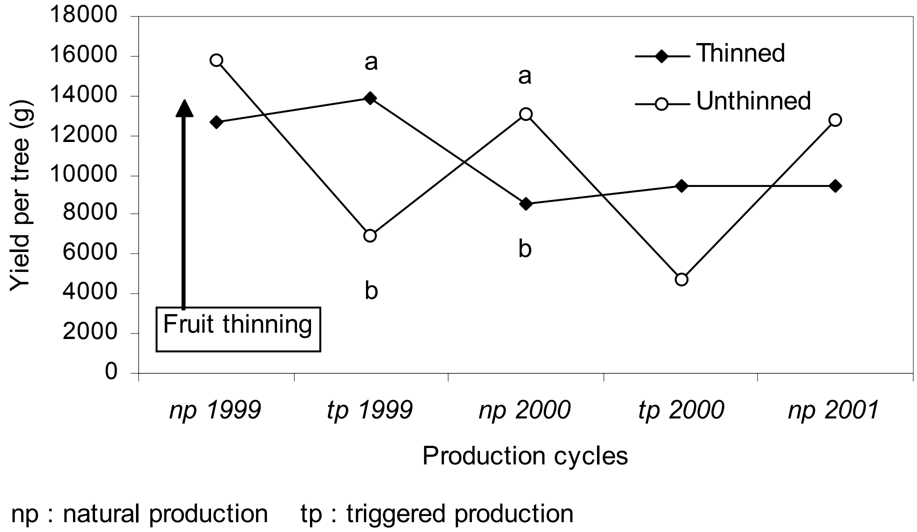

Fig. 1. Changes in the yield during five natural and triggered production cycles on unthinned and thinned strawberry guava trees. Data are mean of 8 trees per treatment. For each cycle, different letters indicate significant differences (P<0.05).