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Improvement of yield and quality of starfruit clone B10 cultivated under netted structure

(Peningkatan hasil dan kualiti belimbing besi, klon B10 yang ditanam di bawah struktur jaring kalis serangga)

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Key words: starfruit (*Averrhoa carambola* L.), netted structure, fruit quality, pesticide residue

Abstrak

Kajian untuk menilai hasil dan kualiti buah belimbing klon B10 di bawah struktur jaring kalis serangga telah dijalankan di ladang belimbing, MARDI, Serdang, Selangor. Hasil dan kualiti buah juga dibandingkan dengan pokok yang ditanam secara konvensional. Kehadiran lebah di bawah struktur jaring amat penting untuk memastikan pendebungaan dan seterusnya pembentukan buah berlaku dengan baik. Peratus kejadian buah (69% berbanding dengan 36% secara konvensional) dan bilangan buah yang elok dan dapat dibungkus bertambah di bawah struktur jaring (7.4 buah/tangkai berbanding dengan 1.4 buah/tangkai). Bilangan buah bengkok dan buah yang perlu dibuang pula berkurangan. Hasil di bawah struktur jaring tidak terjejas pada musim hujan dengan anggaran hasil sebanyak 23 tan/hektar/tuaian. Kualiti buah juga bertambah baik. Walaupun perbezaan nilai kerangupan buah adalah tidak ketara, tetapi nilai kerangupan buah di bawah struktur jaring adalah lebih tinggi (4 391 g) daripada buah ditanam secara konvensional (3 286 g). Buah tidak perlu dibungkus. Kualiti buah dari segi kosmetik dapat diperbaik dengan melindungi buah di bawah kanopi pokok. Buah juga mempunyai kandungan sisa racun yang rendah. Kaedah kawalan penyakit bintik buah antraknos di bawah struktur kalis serangga juga dibincangkan.

Abstract

A study to evaluate the yield and quality of starfruit, clone B10, cultivated under netted structure was conducted in the starfruit farm at MARDI, Serdang, Selangor. Comparison was also made with plants in the open. The presence of bee was very important to ensure good pollination and fruit set of plants under the netted structure. The percentage of fruit set (69% compared to 36% in the open) and the number of wrappable fruits increased under the netted structure (7.4 fruits/branch compared to 1.4 fruits/branch in the open), while the percentage of curved fruits and thinned fruits reduced. Yield under the netted structure remained high in the rainy season and was about 23 t/ha/harvest. Fruit quality was also improved. Although not significantly different, the crunchiness value of the fruit produced under netted structure was higher (4 391 g) compared to fruit in the open (3 828 g). Wrapping of individual fruit was no longer

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necessary. Fruit cosmetic appearance was improved by protecting the fruits under the canopy. Fruits were also safer to consume with very low pesticide residue. Control of fruit spot anthracnose disease for cultivation under the netted structure was also discussed.

Introduction

The Malaysian starfruit (*Averrhoa carambola* L.) is known to be the best quality and enjoys a niche market in Europe. The export value of fresh starfruit is rather stable about RM28 million per year (Anon. 2000). About 60% of the export is to Europe, 15.7% to Hong Kong, 15.2% to Singapore and 2.2% to Canada (Anon. 2000).

Starfruit is a fruit of great potential. However, the production area has decreased from 1 430 ha in 1997 to 955 ha in 1999 (Anon. 1999). The important factor that hindered production expansion is its high labour requirement especially in wrapping of individual fruits and thinning fruits against fruit fly. Because of the intensive nature of starfruit cultivation, starfruit farm has remained small about 5–6 ha only.

Besides the labour problem, several large European retailers have recently launched a harmonized third party certification scheme for their supplier of fresh produce, to establish a standard for Good Agricultural Practices (GAP). EUREPGAP is a standard for production practices up to farm gate, which includes integrated crop and pest management best practices as well as worker welfare standards (Anon. 2001; Whiteford 2001). By 2004 all fresh produce that are exported to Europe must meet the EUREPGAP requirement. Thus new techniques of production with less use of chemicals must be sought. One technique was to grow starfruit under netted structure. Another objective of the study was to improve yield and quality of starfruit under netted structure.

Materials and methods

The study was initiated at the starfruit farm at MARDI, Serdang in 1998 using 6-year-old B10 trees on Serdang series. It consisted of three experiments.

Experiment 1

Plant performance under the netted structure and in the open was compared. The experiments consisted of three treatments:

- Plants under netted structure with bee introduced at full bloom
- Plants under netted structure without bee
- Plants in the open

The treatments were arranged in a randomized complete block design replicated four times with four plants per treatment.

Fruit set At full bloom, 10 branches per plant were selected at random and tagged. The number of flower inflorescence for a distance of 60 cm from the base of each branch was counted. About 3 weeks after fruit set, when the size of the fruitlets was about 30–40 cm, the number of fruits that set along the tagged branches was counted. The percentage of fruit set was then determined.

Number of curved fruits Curved fruits are fruits that have undergone incomplete pollination. The number of curved fruits was counted along the 60 cm length branch which was tagged for fruit set.

Number of wrappable fruits and total number of fruits thinned per tree Wrappable fruits are those fruits that can be wrapped meaning that they are straight, in normal shape and with no insect attack.

Before wrapping, fruits were thinned at approximately the same time to remove

curved fruits, damaged fruits and those infected by pests and diseases.

Experiment 2

Yield performance and fruit quality of starfruit under the netted structure and in the open were compared. The trial was initiated in October 2000. For fruit quality assessment there were three treatments as follows:

- Fruits under netted structure protected by the tree canopy
- Fruits under netted structure exposed and not protected by the tree canopy
- Individually wrapped fruits in the open

The plants were arranged in a completely randomized design and replicated four times. The data taken were as follows:

- Yield was measured in terms of total fruit number and fruit weight per plant. Total number of exportable fruits and their weights were also recorded.
- Fruit quality was measured in terms of total soluble solids. Fruit crunchiness was measured in terms of hardness (cutting force in g) using a penetrometer. The fruit cosmetic appearance was also described.

Experiment 3

The effectiveness of several fungicides to control fruit anthracnose under the netted structure was studied.

Four types of fungicide were sprayed twice, that was at full bloom and when fruitlets were about 4 cm in length. The treatments were arranged in a randomized complete block design and replicated four times. Scoring for severity of anthracnose spots on the fruit was done at harvest. The four chemicals tested were prochloraz, benomyl, propiconazole and azoxystrobin.

Pesticide residue analysis A batch of fruits was sent in March 2001 for chemical residue analysis. A multi-residue method was used for the analysis of organophosphorous, organochlorine and pyrethroid insecticides.

Analysis of variance was performed using the procedure SAS (SAS Institute Inc. 1985). The Duncan Multiple Range Test and the t-Test were used to compare between treatments, whenever appropriate.

Results and discussion

Comparison of plant performance

Fruit set The highest percentage of fruit set was observed in plants under netted structure with bee, 69%, followed by plants in the open, 36% *(Table 1)*. Plants under the netted structure without bee had a very low percentage of fruit set, 1.9% only. The result clearly showed that bee was very necessary for pollination and fruit set under the netted structure.

Curved fruits Curved fruit is an indication of incomplete pollination and fertilization. The number of curved fruits of the various treatments were significantly different at $p < 0.01$ *(Table 1)*. Most of the fruits that set under the netted structure without bee were curved fruits (35%). This was followed by fruits in the open (19%

Table 1. Plant performance of starfruit under netted structure and in the open

Treatment	Fruit set		Curved fruit		Wrappable fruit		Thinning (fruit no./tree)	
	Fruit no./ branch	%	Fruit no./ branch	%	Fruit no./ branch	%	Insect injury	Curved fruit
Under net (+ bee)	10.1a	69.0	1.4a	13.8	7.4a	74.1a	40b	20b
Under net (– bee)	0.2c	1.9	0.07b	35.0	0.1c	6.2c	–	–
In the open (+ bee)	4.7b	36.0	0.9b	19.1	1.6b	36.7b	210a	195a

Values followed by different letters in a column are significantly different at $p < 0.01$

curved fruits) and fruits under the netted structure with bee (13.8% curved fruits). Considering higher percentage of fruit set thus the number of completely fertilized, well formed and straight fruit was higher under the netted structure with bee introduced.

Wrappable fruit and fruit thinning Wrappable fruits are fruits that can be wrapped. The highest number of wrappable fruits (7.4 fruits/branch) was from those plants under the net pollinated by bees followed by those in the open (1.6 fruits/branch). The number of wrappable fruits under the net without bee is rather negligible. The difference was significant at 0.01% *(Table 1)*. Similar trend was observed for percentage of wrappable fruits. The number of wrappable fruits is lower for those plants in the open because many fruits have to be thinned due to insect pests in the farm (Ithnin et al. 1992). The average number of fruits removed during wrapping due to insect attack was 210 fruits/tree for plants in the open compared to 40 fruits/tree for plants under the net *(Table 1)*. The main insect pest under the net was the *Spodoptera* species. Besides fruit damaged by insect, some well shaped and good fruits still have to be removed during wrapping to allow only 1–2 fruits to be wrapped per point. Such thinning was very minimal for plants under the netted structure as the fruits need not be wrapped.

Comparison of yield and fruit quality under the netted structure and in the open

Yield The yield obtained under the netted structure is high (Zabedah et al. 1999). Out in the open the fruits are prone to fruit fly attack and this is the main cause of yield loss. It is worth while to notice that the rainy season in the months of October–December hinders fruit set for harvest in January and February (*Table 2*). This is demonstrated in *Table 3* which compares the yield obtained under the netted structure and in the open during the January–February harvest. The t-test done showed that for all yield parameters taken, plants under the netted structure performed significantly better than in the open (p <0.01). The total fruit weight per tree in the netted structure was 75 kg. Due to the rainy weather and poor fruit-set only about 6 kg of fruits per tree, yielding 2.2 t/ha was obtained in the open. The average yield was estimated at 23.8 t/ha under the netted structure compared to 2.2 t/ha in the open *(Table 3)*.

Fruit set was good under the netted structure despite the rainy weather in October–December. Thus the production of starfruit under the netted structure is able to overcome the low production trend obtained in the months of January–February. This is very important as it is winter season in Europe, thus the demand for starfruit is good and the price is high. Traditionally exporters have been having problems to get supply of

Table 2. Mean monthly rainfall in Serdang in the year 2000

Month	Mean rainfall (mm)
January	248
February	257
March	359
April	159
May	137
June	151
July	115
August	179
September	205
October	151
November	356
December	209

Table 3. Yield of starfruit (January–February)

	Under netted structure	In the open
Fruit wt. (kg/tree)	75.0a	6.0b
Fruit no./tree	568.0a	25.0b
Exportable fruit (no./tree)	334.0a	24.0b
Yield (t/ha)	23.8a	2.2b

Values followed by different letters are significant at p <0.01

starfruit at this time of year. Thus with proper management, fruit can be made available through production under the netted structure.

Fruit quality It was initially observed that fruit quality under the netted structure improved when the fruits were protected under the tree canopy. These fruits had the luster and were firm. Exposed fruits under the netted structure on the other hand lacked luster, were bleached and seemed to be less firm.

The fruits under the netted structure were also observed to be crunchier. To quantify the crunchiness, comparison in terms of hardness was made among fruits in the netted structure protected under the tree canopy, exposed fruits under netted structure and wrapped fruits in the open. Although the result of the analysis of variance of fruit hardness showed that they were not significantly different, it is worth while to note that fruits under the netted structure protected under the tree canopy had the highest hardness value (4 391 g) compared to wrapped fruits in the open (3 828 g) and exposed fruits under the netted structure (3 763 g) (*Table 4)*. Fruit hardness is usually associated with fruit calcium content. In this study the mineral composition of the fruit was not analysed. But literature reveals that about 20% of calcium moves out of fruits during hot weather (Kupfermar 1988). Since the temperature of the exposed fruits is always higher than the protected fruits they may lose more calcium. The exposed fruits also tend to lose more water than the protected fruits and look rather flaccid. These factors may attribute to the result that exposed, unprotected fruits under the netted structure are less crunchy (hardness value 3 763 g).

The total soluble solid content was significantly different between the treatments (p <0.01). Wrapped fruits in the open had the highest value (8.6%) compared to fruits protected under the canopy in the netted structure (7.6%) and exposed fruits under the netted structure (6.5%) *(Table 4)*.

Control of black spot anthracnose disease The main disease problem of starfruit is anthracnose caused by *Colletotrichum gloeosporoides*. The disease can be serious especially under humid condition. As the relative humidity in the netted structure remained quite high in the morning, this provided a condusive environment for disease development. The disease first appears as tiny brown-blackish spots on the fruit surface. Fruits damaged by fruit spots are not exportable.

Thus a screening test on five chemicals was conducted to determine their efficacy in controlling anthracnose of starfruit under the netted structure. The disease severity was highest in the control where no chemicals was sprayed (disease index 54.6). The chemicals which were effective were propiconazole and prochloraz with a disease index of 17.5 and 15.9 respectively *(Table 5)*. Fruits sprayed with these chemicals were rather clean with minimal disease development on the fruit. Thus anthracnose spot on starfruit can be successfully controlled under the netted structure.

Table 4. Fruit quality under netted structure and in the open

Treatments	Hardness (g)	TSS	Fruit cosmetic appearance
Under net, protected by canopy	4 391	7.6b	Lustre present, clean, of right colour, look 'firm'
Under net, exposed fruits	3 763	6.5c	Lack luster, bleached and look flaccid
Wrapped fruits in the open	3 828	8.6a	Lustre present, clean, of right colour

Values followed by different letters are significant at p <0.01

Pesticide residue analysis

The samples had low levels of endosulphan (0.053 mg/kg), cypermethrin (0.01 mg/kg) and low residue of deltamethrin (0.002 mg/kg) *(Table 6)*. Currently there are no Codex MRLs of these pesticides for starfruit. However, these levels are very low if compared to MRLs for citrus (EEC), whereby the MRLs for endosulphan is 0.5 mg/kg, cypermethrin 2 mg/kg and deltametrin 0.05 mg/kg. (Anon. 2003).

Table 5. Effect of various chemicals on severity of anthracnose of starfruit under the netted structure

Chemical	Disease index
Control	54.6a
Azoxystrobin	37.5b
Benomyl	34.5b
Propiconazole	17.5c
Prochloraz	15.9

Values followed by different letters are significant at p <0.01

Conclusion

Starfruit can be successfully produced under the netted structure. Bee must be introduced under the netted structure during flowering to ensure good pollination and fruit set. The yield under the netted structure is high. It is interesting to note that cultivation under the netted structure ensures fruits to be successfully set during the rainy months for good harvest in January–February to coincide with the winter season in Europe where demand is very good. The pesticide residue in the fruits is very low so fruits are safe to consume. Thus there is potential in cultivation of starfruit under the netted structure, as labour is rather scarce especially in the near future.

Table 6. Result of pesticide residue analysis on starfruit under netted structure

	Pesticide	Concentration* (mg/kg)
Organophosphates	Chlorpyrifos	
	Dimethoate	Not detected
	Monocrotophos	Not detected
	Acephate	Not detected
	Parathion-ethyl	Not detected
	Parathion-methyl	Not detected
	Diazinon, prothiophos	Not detected
	Methamidophos, sulfotep, fenthion, malathion,	Not detected
	profenofos, phethoate, dichlorvos, quinalphos	Not detected
Organochlorines	Lindane	Not detected
and Cyclodiene	Total DDT	Not detected
	Total endosulphan	0.053
	Dieldrin	Not detected
	Aldrin	Not detected
	Chlorothalonil	Not detected
Synthetic pyrethroids	Cypermethrin	0.01
	Permethrin	Not detected
	Deltamethrin	0.002
Dithiocarbamates	Mancozeb, maneb, zineb, propineb (Expressed in terms of CS_2)	Not detected

*Average of 3 replicates
Condition of sample: Good
Date sample received: 23 March 2001
Date sample preparation/analysis commenced: 25 March 2001

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