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QUALITY IMPROVEMENT OF MANGOSTEEN FOR EXPORT THROUGH DRIP IRRIGATION SYSTEM AND YELLOW FLUORESCENT STICKY TRAP INSTALLATION

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ABSTRACT

Mangosteen (*Garcinia mangostana* Linn.) dubbed as "finest fruit of the world", has potential for both domestic market and export. However, this potential is threatened by low fruit quality caused by production of yellow latex and fruit scarring. The research objective was to obtain technology to reduce yellow latex and control *Scirtothrips dorsalis*, a pest that causes scarring on mangosteen. A randomized block design with four treatments and 14 replications was used in this research. Significant differences among the treatments were calculated using the Honestly Significant Difference (HSD) test. The results showed that treatment of drip irrigation system in combination with removing weeds under the canopy (A) or removing weeds followed by minimum tillage under the canopy (B) or removing weeds then covering with rice hay mulch under the canopy (C), where N, P, K, Ca, Mg fertilizer and yellow fluorescent sticky trap were applied could reduce scarring intensity and percentage of yellow latex on the fruit peel. However, the treatments did not significantly impact fruit diameter or percentage of yellow latex inside the fruit. Nevertheless, treatment C improved mangosteen quality by as much as 67.79% fulfilling export standard requirements.

Keywords: mangosteen, quality improvement, drip irrigation, yellow fluorescent sticky trap

INTRODUCTION

Mangosteen (*Garcinia mangostana* Linn.) dubbed as "the world's finest fruit", has potential for both domestic market and export and is consumed fresh and in a processed form. The fruit possesses dark violet or deep brownish-purple peel, white flesh and artistic symetrical shape making it one of the most beautiful tropical fruits in the world. It is considered a health food by many westerners and prized for its valuable nutritional and nutraceutical properties , as a result of its antioxidant.

Mangosteen juice is rich with antioxidants called xanthones. Xanthones possess anti-virus, anti-fungal, anti-bacterial, and reduces free radicals, strongly associated with cancer. Dench (2008) revealed that xanthones inhibit the oxidation of low density lipoprotein (LDL), one of the causes of arteriosclerosis (hardening of the arteries and heart attacks). Furthermore, mangosteen juice has shown promise in treating diabetes, premature aging and arthritis.

Its potential as a nutraceutical has increased both domestic and export markets, since 2010, the Indonesian Agency for Agricultural Research and Development (IAARD) had anticipated its popularity and designated mangosteen a top research priority, providing support for 8.275 hectares of mangosteen trees grown throughout the country.

However, since 2001 Indonesian mangosteen export has declined with only 4.9 - 13.1% of total Indonesian mangosteen production achieving International standard export quality (Indonesian Department of Agriculture, 2007). Problem resulting in failure to meet export standards include excessive yellow latex on the pericarp and endocarp of the fruit peel and visible fruit scarring caused by thrips (Thripidae: *Scirtothrips dorsalis* (Hood)) (Affandi and Emilda, 2009a).

Presence of yellow latex on the mangosteen peel creates a rough, unattractive

appearance. In addition, yellow latex contaminating the edible portion of the fruit makes the fruit inedible (Krishnamurthi and Rao, 1962; Verheij and Cornel, 1992;). To date, there is no consensus as to the cause of yellow latex in mangosteen fruit, which makes control impossible. Several experts have summarized that yellow latex is due to damage by insect or mechanical damage, during harvesting and packaging. Morton (1987) argued that the presence of yellow latex on the fruit was the result of a physiological abnormality due to inconsistencies in irrigation or weather patterns. Similarly, Varheij and Cornel (1992) believed that yellow latex was caused by over irrigation following a dry period. Since then, Jawal *et al*., (2008) has indicated yellow latex is a physiological response related to turgidity of cells that comprise the endodermis of the fruit peel. Turgidity pressure changes in the cell wall of the fruit peel due to the extreme environmental changes create the yellow latex inside the fruit.

Symptoms of mangosteen fruit scarring include: silvering of the fruit peel, pale, yellow/brown discoloration, elongated and patchy hardened scars, and an alligator-skin appearance that may cover the entire fruit surface. Heavy scarring can sometimes affect fruit growth. Controlling these most serious constraints in mangosteen cultivation are a vital requirement for the export market. Use of drip irrigation may stabilizes physiological activity related to turgidity of cells and installing yellow fluorescent sticky traps can reduces the population of thrips responsible for scarring the fruit peel.

This study is specifically aimed at developing management techniques that reduce production of yellow latex and damage caused by *S. dorsalis*.

MATERIAL AND METHODS

The research was conducted in mangosteen orchard in Leuwiliang, Bogor, West Java, from September 2009 to January 2010. The mangosteen trees were planted in monoculture planting system. The 17 years old mangosteen trees reached a height of 4 – 5 meters and were planted 9 m apart.

The randomized block design consisted of 4 treatments and 14 replications. The treatments included:

(1) Drip irrigation system (DIS) + removing weeds under the canopy + application of Nitrogen (N), Phosphate (P), Kalium (K), Calcium (Ca) and Magnesium (Mg) fertilizer + installation of yellow fluorescent sticky traps (A).

(2) DIS + removing weeds followed by minimum tillage under the canopy + application of N, P, K, Ca and Mg fertilizer + installation of yellow fluorescent sticky traps (B).

(3) DIS + removing weeds followed by an application of rice hay mulch under the canopy + application of N, P, K, Ca and Mg fertilizer + installation of yellow fluorescent sticky traps (C).

(4) Control consisting of the current mangosteen grower practices i.e. without DIS + no weed remove nor rice hay mulch under the canopy + no application of N, P, K,, Ca and Mg fertilizer or use of yellow fluorescent sticky traps.

Each treatment consisted of a single tree replicated 14 times for a total of 56 trees. Sources of N, P, K fertilizers included Urea, SP-36 and KCl. Meanwhile, sources of Ca and Mg were $CaCO_3$ and Kiserit (MgO). The dosage for Urea, SP-36, KCl, $CaCO_3$, and Kiserit were 2 kg, 1 kg, 2 kg, 3 kg and 1 kg, respectively. Two applications were made, with ½ dosage applied two months prior to flowering stage and the remaining applied 2 months after flowering stage.

The drip irrigation system consisted of a 2 x 2 m square of PVC pipe laid beneath the canopy of the mangosteen tree. Water was applied at the rate of 50 litters/ 24 hours.

Removal of weeds beneath the canopy was accomplished by a grass cutting machine with minimum tillage using a hoe, on a monthly basis. Inversion of soil beneath the canopy exposed the pupae to natural enemies, in order to decrease the thrip population.

Flower weeds beneath the canopy were removed using a grass cutting machine, followed by the covering with 30 cm rice hay mulch beneath the mangosteen. Later on, this rice hay mulch would decay after 4-5 months increasing the organic matter in the soil.

A yellow fluorescent sticky trap (YST) consisted of a 10 cm diameter and 21.5 cm height of aluminium tube. Each tube was nailed onto a 3 m wooden stick. Transparent “Ultra Super” glue commonly used for trapping rats and mice was applied to one side of the surface of a 21 x 33 cm transparent plastic overhead

projection sheet (OHP) ("Yashica" Inc.). The plastic, with the sticky side facing out was then put on the YST tube (Fig. 1). Four traps were placed on 4 opposite sides, approximately 30 cm from the outside of the canopy. Insects were captured in the sticky surface and *S. dorsalis* were counted using a dissecting microscope. Sticky trap were rechanged every two weeks.

Weed removal using minimum tillage was repeated monthly until the harvest time. The combination treatment of removing weeds or removing weeds and minimum tillage together with installing yellow fluorescent sticky traps was performed by combining the two procedures as mentioned above.

Sampling Technique

Observations of fruit quality were done at harvest time by evaluating 100 mangosteens chosen at random. Each mangosteen was evaluated using the following criteria:

1. Fruit diameter (cm).
2. Percentage of yellow latex inside the fruit.
3. Percentage of yellow latex on the peel of the fruit.
4. Percentage and intensity of the fruit scars. Percentage of scars was calculated by dividing the number of scarred fruit by total number of observed fruit. The modified method of Mahfud *et al*. (1994) was used to evaluate scarring intensity. Scarring intensity of 1-100 was assigned by evaluating a 1/8 section of the fruit, determined by positioning the fruit upright, then observing a quarter of the upper or lower half of the fruit, resulting in approximately 12.5% of the total fruit surface.
5. International standard for exported fruit quality. This standard follows the Codex standard for mangosteen export. Mangosteen criteria include: (1). no abnormal fruit shape, (2). No yellow latex inside the fruit, (3). No yellow latex on the peel, and (4). A scar intensity of less than 10 %.
6. Population fluctuations of thrips trapped by yellow fluorescent sticky traps were recorded from flowering to harvest time.

RESULTS AND DISCUSSION

Controlling Yellow Latex and Thrips Scarring of Mangosteen Fruit

Results (Table 1) indicate all treatments show significant differences compared to control, except in diameter and percentage of yellow latex inside the fruit. Overall large fruit diameter was either due to choice of cultivar or inherent soil fertility and not influenced by additional fertilizer or drip irrigation.

Table 1. Effect of combination treatment including drip irrigation, fertilizer application and use of yellow fluorescent sticky traps on fruit diameter, percentage and intensity of thrips induced scarring and percentage of yellow latex inside and outside of mangosteen fruit.

Treatments	Diameter (cm)	Scar intensity	Scarring percentage	Percentage of yellow latex on peel	Percentage of yellow latex inside the fruit
Drip irrigation system (DIS) + removing weeds under the canopy + application of N, P, K, Ca and Mg fertilizer + installing yellow fluorescent sticky traps (A)	5.187 ^{ns}	5.825 b	64.147 ab	16.569 b	11.997 ^{ns}
DIS + removing weeds followed by minimum tillage under the canopy + application of N, P, K, Ca and Mg fertilizer + installing yellow fluorescent sticky traps (B)	5.074	8.496 b	70.113 ab	22.286 ab	14.211
DIS + removing weeds then covering with rice hay mulch under the canopy + application of N, P, K, Ca and Mg fertilizer + installing yellow fluorescent sticky traps (C).	5.089	8.771 b	56.613 b	20.985 b	11.451
Control	5.149	17.647 a	80.134 a	34.510 a	12.790

Remarks = Means value in each column with the same letter is not significantly different (p = 0.05) based on Honest Significantly Different (HSD) test

Jawal *et al*. (2008) revealed that yellow latex was a physiological activity related to turgidity of cells that arrange the endodermis of fruit peel. Turgidity pressure changes at fruit peel cells walls due to the extreme environmental changes especially the availability of water resulting in yellow latex inside the fruit. Verheij and Cornel (1992) pointed out that yellow latex was caused by excessive irrigation following a dry period. In this current study, a supplemental drip irrigation system was added to minimize moisture-stress conditions, which result in fluctuations in cell turgidity, in effort to control production of yellow latex. However, in the treatment A, B and C (with drip irrigation) there was no significant difference compared to the control which lacked drip irrigation. Rainfall during the research averaged between 19.8 and 47 mm/day (Appendix 1). These data suggest that stable cell turgidity, either the result of continuous drip or continuous drought conditions, decreases the production of yellow latex in the fruit.

Observations of scar intensity on the mangosteen fruit peel due to feeding by *S. dorsalis* showed that all treatments applied including removal of weeds, minimum tillage, addition of rice hay mulch beneath the canopy with addition of a yellow fluorescent sticky trap, all resulted in significant differences when compared to the control.

Intensive orchard care by removing weeds effectively reduced thrips infestation. Various weeds are used as alternative hosts for breeding, food and as a refugia by the thrips (Rethwisch *et al*., 1998; Hadisutrisno, 2002; Kuepper, 2004). Recent work by Affandi and Emilda (2009a) revealed that application of yellow fluorescent sticky traps in a mangosteen orchard decreased scarring intensity by 26.28% (year 1) and 10.82% (year 2) compared with the control. In addition, the combined treatment of intensive orchard care (removing weeds using minimum tillage) and use of yellow fluorescent sticky traps (IOC+YST) can reduce scarring intensity (32.14% in year 1 and 15.81% in year 2) compared with the control. Therefore, it is clear that sanitation and use of yellow fluorescent sticky traps reduces thrips population

The treatment of DIS + removing weeds and adedition of rice hay mulch under the canopy + application of N, P, K, Ca and Mg fertilizer + installing yellow fluorescent sticky traps (C) although better at reducing the percentage of fruit scarring, it was not significantly different compared to treatments of A and B. Application of rice hay mulch slowed growth of weeds, the alternative hosts for thrips. Composted rice hay mulch also functions as a refuge and breeding habitat for predators of third instars larvae, pre-pupae and pupa of mangosteen thrips found in the soil. The composted hay provides a refuge for predatory mites, including *Euseius hibisci* (Chant) a known as predator of thrips *S. perseae* on avocado (Hoddle and Morse, 2003).

Predatory mites belonging to Phytoseiidae and Ascidae can survive on thrips as an alternative food source until their primary phytophagous arboreal prey reaches pest status. At that time, the predatory mite populations are primed to quickly manage pest populations (Settle *et al*., 1996; Chuleui and Croft, 2000; Gerson, 2003). Similar research showed that an application of composted organic yard waste under the canopy of avocado trees demonstrated a 50% reduction in larval *Scirtothrips perseae* Nakahara emergence (Hoddle and Morse, 2003). Larentzaki *et al*. (2008) stated that application of rice hay mulch to union could decrease the population of *Thrips tabaci* Lindeman as much as 54 % compared to the control. Furthermore, rice hay mulch is more efficient at controlling weeds than removing weeds and a combination of removing weeds and minimum tillage treatment which must be repeated monthly. In contrast, it is only necessary to apply rice hay mulch once at flowering.

Observation of percentage of yellow latex on the mangosteen peel showed that treatments A and C were significantly different compared with the control. Meanwhile, treatment B was not significantly different. Jawal *et al*. (2008) stated that yellow latex on the peel was caused by mechanical injury, either from insects feeding or from brushing during harvesting and packaging.

Percentage of Mangosteen Meeting International Export Standard

Treatment A resulted in a slightly higher proportion of export quality fruit (Table 2). Continuous drip irrigation in combination with removing weeds under the canopy, application of N, P, K, Ca Mg fertilizer and installation of

yellow fluorescent sticky traps resulted in a higher quality of fruit (67.79%). However, this treatment was not significantly different from treatment B and C, indicating that the fruit produced in treatment B and C fulfill the export quality standard (Table 2).

Scar Intensity

Mangosteens were evaluated for scar intensity found on the peel when they were in marble size until two weeks before harvesting. All treatments resulted in low scar intensity (< 6%) compared with the control which reached 11%. Continuous drip irrigation combined with the fertilizer application of N, P, K, Ca and Mg fertilizer, rice hay mulch under the canopy and the use of yellow fluorescent sticky traps resulted in the lowest scar intensity, 2% (Figure 1).

Thrips Population Patched on Yellow Fluorescent Sticky Trap

During mangosteen flowering, thrip population was the highest (> 1000 thrips per trap). However, one month following installation of yellow fluorescent sticky traps, the average population of thrips dropped below 10 thrips per trap. After one month, trap count ranged from 1 – 3 thrips per trap (Figure 2).

Table 2. Average percentage of mangosteen that fulfils standards for export approved by Codex

Treatments	Percentage of mangosteen that fulfils international standard for export
Drip irrigation system (DIS) + removing weeds under the canopy + application of N, P, K, Ca and Mg fertilizer + installing yellow fluorescent sticky traps (A)	67.79 a
DIS + removing weeds and then followed by minimum tillage under the canopy + application of N, P, K, Ca and Mg fertilizer + installing yellow fluorescent sticky traps (B)	57.89 ab
DIS + removing weeds then an application of rice hay mulch under the canopy + application of N, P, K, Ca and Mg fertilizer + installing yellow fluorescent sticky traps (C)	59.80 ab
Control	42.96 b

Remarks = Means value in each column with the same letter is not significantly different (p = 0.05) based on Honest Significantly Different (HSD) test.

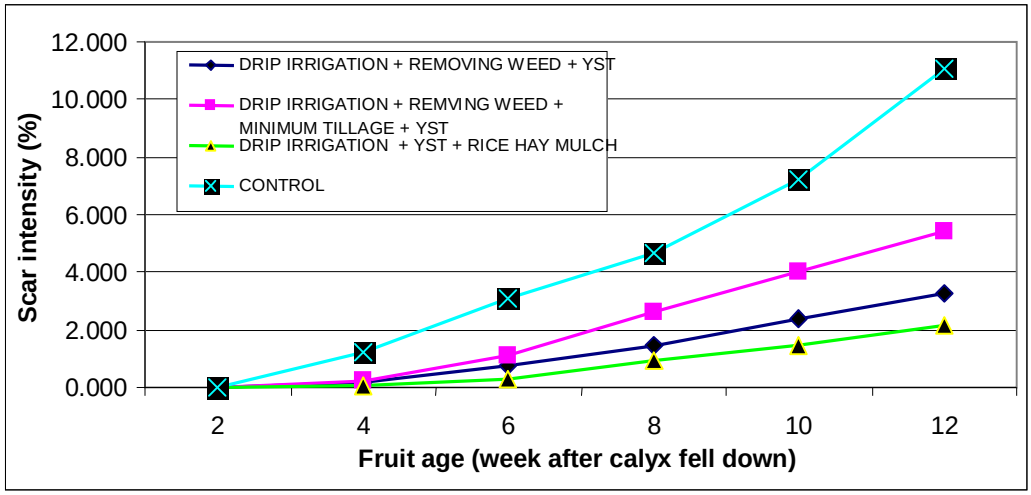

Figure 1. Development of scar intensity from marble sized fruit until 2 weeks prior to harvest.

It appears that the critical period for thrip attack spans from beginning of flowering until ten weeks later. Therefore, control measures should be timed during this stage in order to achieve the best results. Affandi and Emilda (2009b) stated that 1-1.5 months after flowering was the most critical period of thrip attack on the fruit. Any measure applied after that period would be ineffective.

CONCLUSIONS

All treatments reduced the scarring intensity and percentage of yellow latex on the fruit peel. Fruit diameter and percentage of yellow latex inside the fruit was not affected.

Drip irrigation system (DIS) in combination with removing weeds under the canopy, application of N, P, K, Ca and Mg fertilizer including installing yellow fluorescent sticky traps could improve the proportion of mangosteen meeting export standards by 67.79%.

The first month after flowering stage was the most critical period for mangosteen thrips attack. Therefore, for the best results, thrips control should be carried out during this time.

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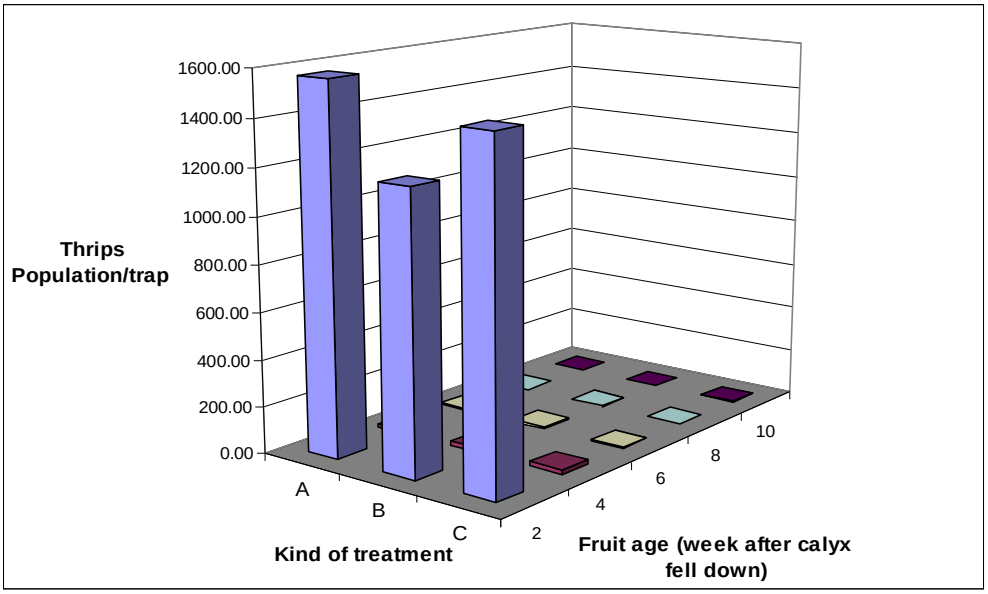

Figure 2. Average population of thrips trapped on yellow fluorescent sticky traps

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Appendix 1. Average rainfall during conducted the research (mm/day).

BADAN METEOROLOGI KLIMATOLOGI DAN GEOFISIKA
STASIUN KLIMATOLOGI DARMAGA BOGOR

Alamat : Jl. Alternatif IPB - Situgede, Telp. (0251) 621976
Kotak Pos 174 Bogor 16001 Fax. (0251) 628468

BMKG Email. klimat_bgr@yahoo.com

Location : PLTA Karacak – Leuwiliang - Bogor
Transversal : 6º 37' 1'' LS
Longitudinal : 106º 38' 39'' BT
Elevation : 308 m

Year of 2009 **Month**

Date	JUN	JUL	AGS	SEPT	OKT	NOP	DES
1	34	-	-	-	-	-	16
2	35	22	-	-	-	-	3
3	34	-	-	-	110	-	4
4	21	-	-	-	10	7	-
5	24	2	-	-	95	-	11
6	-	-	-	38	30.5	-	21
7	-	-	-	-	-	64	23
8	-	-	-	-	10	51	17
9	-	5	-	-	-	35	23
10	-	-	-	-	-	20	-
11	-	-	-	35	-	-	-
12	16	-	-	55	-	15	25
13	19	-	-	-	42	13	68
14	9	-	15	-	-	27	-
15	-	-	16	-	38	18	-
16	13	-	56	47	14	11	23
17	-	-	16	-	2	60	-
18	21	-	5	57	13	18	-
19	-	-	-	47	5	-	-
20	-	-	-	-	-	37	-
21	-	21	-	-	-	3	-
22	-	30	-	-	-	10	-
23	-	-	-	-	93	-	-
24	30	-	-	-	70	-	5
25	-	25	-	50	68	80	16
26	13	24	-	-	-	30	57
27	-	15	14	-	5	5	60
28	-	-	-	-	5	13	14
29	78	-	-	-	5	21	-
30	-	-	-	-	-	16	3
31		-	-		6		2
Total	347	144	122	329	621.5	554	391
AVERAGE	**26.7**	**18.0**	**20.3**	**47.0**	**34.5**	**26.4**	**21.7**

Note : (-) No rain

Appendix 1. Average rainfall during conducted the research (mm/day) (continued).

Year of 2010 **Month**

Date	**JAN**	**PEB**	**MAR**	**APR**	**MEI**	**JUN**
1	13	-	-	-	25	4
2	-	-	26	11	18	-
3	-	35	45	-	18	20
4	-	-	55.5	-	15	11
5	-	58	2	-	-	71
6	-	-	4	-	-	-
7	8	-	25	-	-	6
8	1	-	5	-	25	24.5
9	15	-	1.5	-	55	-
10	52	10	14	-	35	-
11	-	30	19	-	48	9
12	20	3	-	-	14	-
13	5	23	-	-	-	-
14	98	-	48	3.5	-	-
15	23	20	25	-	-	48
16	3	13.5	24	3	18	5
17	7	28	23.5	-	-	-
18	12	13.5	48	-	-	29
19	3	23	-	-	35	-
20	-	34	-	-	64	-
21	20	30	1	-	-	6
22	25	-	12	-	-	-
23	12	3	-	-	67	-
24	5	5.5	5	-	14	46.5
25	6.5	-	-	-	10	66.5
26	-	-	9	10	351	3
27	55	5	32	-	10	2
28	30	-	32	-	-	6
29	-		7	-	-	7
30	-		20	-	65	-
31	2		25		65	
Total	415.5	334.5	508.5	27.5	952	364.5
AVERAGE	**19.8**	**20.9**	**21.2**	**6.9**	**50.1**	**21.4**

Note : (-) No rain