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FLOWERING PHENOLOGY OF MANGOSTEEN (*Garcinia mangostana*L.) IN INDONESIA

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Abstrak: *The aim of the present study was to investigate the phenological characteristics of mangosteen and among-individual variation in flowering phenology at Bogor, Indonesia.Trees tend to flower after vegetative growth flushes and especially after dry weather. The dry period required to induce flowering in mangosteen. The fruiting season in the Bogor is from latest July to middle August. Bud stage to anthesis takes 19 days. Fruit development takes 115-140 days from anthesis. Fruits fast growth at 2-10 weeks after anthesis. After 13 weeks the growth of fruits is stop. Harvested period 44 days are from December 7 and latest in January 20. Fruits ripen over a 16-20 week period and picking is done by hand every 2-3 days. Generally, the fruits of mangosteen take 5 to 6 months to mature from fruit set. The pattern of fruit growth follows a sigmoid curve. In Bogor, mangosteen tree 25 years old, the fruit production is average of 50-100 fruits per tree. The fruit production is depending from canopy size. The yield varies from tree to tree and from season to season.*

Keywords: anthesis, flower, fruit, Mangosteen, phenology

INTRODUCTION

Mangosteen(*Garcinia mangostana* L.) plant is a tropical evergreen tree, believed to have originated in the Sunda Islands and the Moluccas (Misra *etal., 2009*). Mangosteen the family Guttiferae is a fruit tree of the humid tropics native to the South East Asia,ranging from the southern part of Thailand andpeninsular Malaysia to Indonesia and to some partsof the Philippines (Richards, 1990).Fruit orchards in Indonesia are generally found in villages and containseveral fruit species. The fruits possess a sweetpulp which is eaten fresh, but also used in processed form. It is grown inother parts of the tropics and is one of the most praised tropical fruits.

The producing countries show several climatic regimes, and so theproduction seasons for mangosteen in these countries show some distinctdifferences. Nakasone and Paull (1998) Malaysia, Indonesia, Philippines, Thailand andVietnam generally have similar production seasons with fruits available fromMay to January.In the South East Asia region inSeptember and October, mangosteen may not be available in the marketbecause this is the end of the seasons of Thailand, Malaysia and Indonesia.The Philippine crop occurs at a time when Thai, Malaysian and Indonesiaproduction is low since its production season is later. Thus, during thisperiod, there is a window of opportunity for the Philippine mangosteen fruitsto become available in August to November (Osman and Milan, 2006). The aim of the present study was to investigate the phenological characteristics of mangosteen and among-individual variation in flowering phenology.

METHODS

The experiment was conducted at a farmer's orchard in the Village Cangal District Leuwiliang Bogor Regency, West Java Province, Indonesia, with a height of 420 m above the sea level. Twenty-five year-old mangosteen trees (4.5 - 6.0 m height) grown at a spacing of 5×5 m were used. Eachtreatment was imposed across five single tree replicates, therefore 15 trees were used. The experiment was arranged as randomized complete block design. The survey was doneduring 2003, 2004, 2010 and 2013 year.Light intensity in mangosteen orchards was measured by light meter (LI-250A, LI-COR) on sunny and cloudy days in each sector in August of 2010. The monthly rainfall data from 2000 to 2013 was collected from Bogor Meteorological Station. Data on monthly temperature (maximum and minimum) and relative humidity (RH; %, observed in morning = 7.00 a.m., noon = 1.00 p.m., and evening = 6.00 p.m.) also was collected. Analysis of variance (ANOVA) was performed to test whether there were significant differences among

sectors (positions in the canopy). Means were compared using Duncan's Multiple Range Test. All statistical tests were carried out using SPSS version 16.0 (IBM SPSS Inc., Chicago) and differences with p-values less than 0.05 were considered significant.

RESULT AND DISCUSSION

Intensity Solar Radiation

Plant productivity associated with the process of plant photosynthesis. The active part photosynthesis will have more high-carbohydrate compared with the less active as in the leaves in the shadow. To find out the measurements performed on photosynthesis solar radiation intensity. The intensity of solar radiation measured at the time of fruit diameter of approximately 25 mm or the age of 8 weeks after the shoot that is broken in the first week of November 2003. Measurements made at the time of the solar radiation intensity, field conditions in the orchard area bright and not shadow by clouds. Results showed that observation on the position outer top canopy the intensity of radiation solar most high, especially in the afternoon about 125.20 Wm^{-2}. Table 1 indicate that the radiation intensity occurs the lowest at position inner bottom canopy; center bottom canopy; outer bottom canopy; and inner middle canopy each with a value between 10.06 - 26.83 Wm^{-2}. The solar had high radiation intensity in the noon and the lowest in the afternoon.

Table 1: The Average Intensity Of Solar Radiation Across Positions In The Canopy Position

Canopy position	Intensity of solar radiation (Wm^{-2})		
	Morning	Noon	Afternoon
Inner bottom canopy	13.41 f	15.65 d	10.06 e
Center bottom canopy	26.83 e	21.24 d	15.65 e
Outer bottom canopy	20.12 ef	24.59 d	14.53 e
Inner middle canopy	17.89 ef	15.65 d	13.41 e
Center middle canopy	45.83 d	50.30 c	42.48 d
Outer middle canopy	52.54 cd	70.42 b	54.77 c
Inner top canopy	60.36 c	68.19 b	55.89 c
Center top canopy	73.78 b	79.37 b	68.19 b
Outer top canopy	**112.90 a**	**125.20 a**	**92.78 a**

Means with the same letter within the same column are not significantly different at 5% level ($p<0.05$).

Rainfall

Indonesia has a tropical monsoon climate. The climate shows a distinct seasonal pattern of rainfall. Bogor area has the high rainfall average above 300 mm per month. The pattern of rainfall in Bogor area is almost same every year with the heavy rainfall period was occurred between October and December, then rainfall gradually decrease at the end of December until June (Fig. 1). Drying period occurred from July to August (case 2003 and 2009), followed by the flowering period from September to October. In 2010, however, the phenological pattern of mangosteen trees (Table 2) was changed markedly owing to irregular rainfall (Fig. 1). Climate in 2010 was anomalous, and a drought occurred in April inducing flowering of mangosteen in May. The pattern of monthly rainfall and dry season in 2010 was change and made effect on mangosteen flowering. There was an increasing trend in yearly rainfall during 2006 to 2010 (Fig. 1). The annual rainfall was 2808, 3240, 4014, and 4944 mm during from 2007 to 2010, respectively.

Temperature And Relative Humidity

Average daily maximum and minimum temperatures were ranged from 29.6 to 32.8 °C and from 21.2 to 22.7 °C, respectively (Fig. 3). Maximum temperature was high in June to September. Bogor district is a tropical temperature type remains relatively constant throughout the year and seasonal variations are dominated by precipitation.

Relative humidity (RH) in Bogor was highest in morning then gradually decreased at noon and increased at evening. The average of RH at mangosteen orchards in Bogor was ± 90 %, ± 65 %, and ± 80 % in morning, noon, and evening, respectively (Fig. 3). Both in morning and evening the average of RH was almost stable

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every month, except in January was highest and during August to September was lowest. Whereas RH in noon was highest in January then decreased from February to December. Regardless of time, RH in August and September was lowest compared another month.

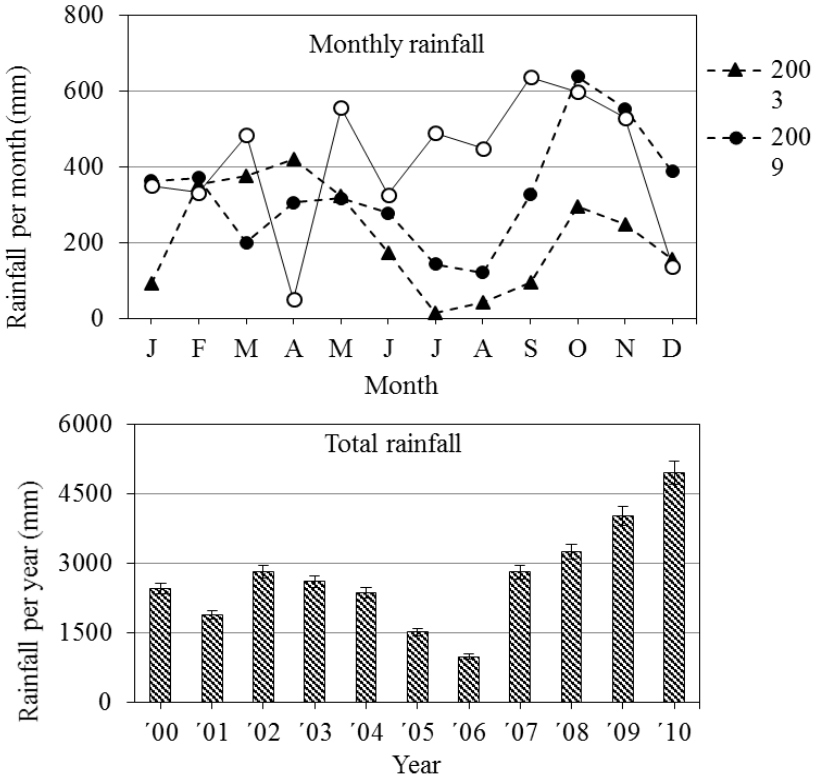

Figure 2. Seasonal Changes Of Rainfall Per Month In 2003, 2009, And 2010, And Total Rainfall Per Year In Mangosteen Orchards

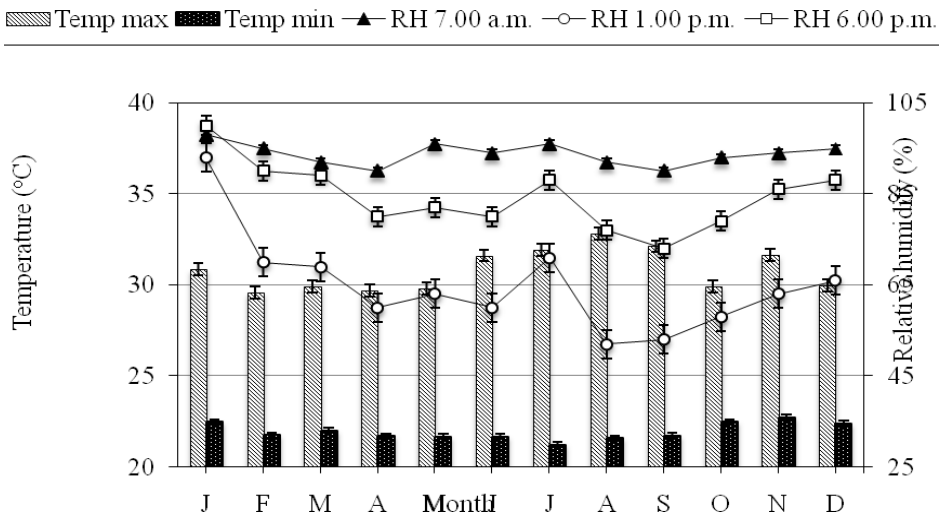

Figure 3. The Seasonal Changes Of Maximum And Minimum Air Temperature And Relative Humidity. RH (%) Was Recorded At 7.00 A.M., 1.00 P.M., And 6.00 P.M. In The Mangosteen Orchard

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Mangosteen Phenology

Mangosteen tree produced new vegetative shoots in February, and then fell into dormancy from March 18th to April 19th. Flowering occurred in August after the drought condition (Table 7). Fruit was growth around 13 weeks and harvested during December 2003 to January 2004. Mangosteen trees are slow to come into bearing. Trees tend to flower after vegetative growth flushes and especially after dry weather. June - July is dry seasons. The dry period required to induce flowering in mangosteen. The fruiting season in the Bogor, Indonesia is from latest July to middle August. Bud stage to anthesis takes 19 days. Fruit development takes 115-140 days from anthesis. Fruits fast growth at 2-10 weeks after anthesis. After 13 weeks the growth of fruits is stop (data not shown). Fruit should be harvested after the pericarp is light greenish yellow, with distinct irregular pink red spot over the entire fruit. Harvested period 44 days are from December 7 and latest in January 20 (Table 2). Fruits ripen over a 16-20 week period and picking is done by hand every 2-3 days. Generally, the fruits of mangosteen take 5 to 6 months to mature from fruit set. The pattern of fruit growth follows a sigmoid curve. Only the fruits that have turned purplish violet are picked. In Indonesia, mangosteen tree 25 years old, the average fruit production are 50-100 fruits per tree. The fruit production is depending from canopy size. The yield varies from tree to tree and from season to season. From observations in the field found that the fruit produced at the tip of older mature shoots can produce 3-5 flowers in a stalk. It is known that during the mangosteen fruit is produced on a tip shoots.

Table 2: The Phenological Development Of Mangosteen Trees In 2012-2013

Phenology	Start	Finish	Duration (days)
Shoot growth	Feb 14th	Feb 28th	15
Dormancy	Mar 18th	Apr 19th	32
Dry condition	July 1st	July 31st	31
Flowering	July 30th	Aug 15th	16
Fruit harvest	Dec 7th	Jan 20th	44

Discussion

Mangosteen thrives in the temperature range of 25-32°C but growth becomes affected when the temperature falls below 25°C (Osman and Milan, 2006). Temperatures below 5°C and above 38-40°C are lethal and since growth is slowed at temperatures 15-20°C, this is not recommended for cultivation. Mangosteen has symmetrical branches witch form dense canopy that protect sun radiation intensity to penetrate, and keeps the radiation intensity remain below normal of its need (Setiawan*et al.*, 2005). Issarakraisila and Settapakdee (2008) reported that an increase of light intensity from 25% of full sun to higher light intensity levels increased the thickness of lamina and stomata frequency. Maximum growth was found when exposed to 40% light intensity condition.In Indonesia, shade is offered by other trees in the traditional mixed orchards and home gardens. Dense canopy structure of upper branches has inner and bottom canopy protect from light availability (Setiawan and Poerwanto, 2008). There are no reports of photoperiod response. The photosynthetic rate is steady over a 27-35°C temperature range, under 20-50% shade (Weibel *et al.*, 1993).

Annual rainfall of 1270 mm is necessary and the ideal temperature range is 25-35°C with RH over 80% (Krishnamurthi and Rao, 1962). Mangosteen appears to require an uninterrupted water supply with a short dry season of 15-30 days, the latter initiating flowering. Ideally, the rainfall should be well distributed throughout the year. In the Philippines, fruiting trees may also be found where rainfall is not evenly distributed (Osman and Milan, 2006). Malip and Masri (2006) reported during flushing nitrogen was low but reversed during flowering implying that nitrogen was heavily used for vegetative or shoot development.

A major problem in the cultivation of mangosteen is its extremely slow rate of development (Downton*et al.*, 1990). The root system of young seedlings, extremely slow growth of the plants and long period required 8-10 years to begin producing fruit (Te-chato and Lim, 2004).The mangosteen fruit grown in Thailand is harvested in the season of optimum ripeness for maximum efficacy (Misra*et al.*, 2009). In Thailand mangosteen produce flowers in March-April and July-September (Te-chato, 2007).However, depending on

zone, weather conditions and farm management practices, fruiting season can begin four to six weeks earlier. In mangosteen, the flowers develop at the terminal buds of young branches, solitary or paired (Te-chato, 2007; Nakasone and Paull, 1998).From Fig. 4 showed the tip can produce 3 fruits and 5 flowers in a stalk. The Fig. 5 fruit develop at both terminal and axillary buds from the node without flush new shoots.

The first crop may yield 100-300 fruits per tree, and about 500 in a fully grown tree (Osman and Milan, 2006). The yield steadily increases up to 1,000-2,000 fruits per tree in the 10-20th years of cropping. In Thailand, the average yield in 1987 was 4.5t/ha. For an estimated mean weight of 75 g per fruit and 150 trees/ha, this equals 400 fruits per tree (Verheij, 1992). Trees in two small orchards in the Nilgirihills in southern India produced on average of 360 fruits per year over a period of 18 years, the best trees yielding consistently up to 500 fruits per year (Verheij, 1992). Application paclobutrazol to promote fruiting twigs in the tree canopy, an average of only 20% of the total available shoots in the whole canopy flowered every year (Omran and Semiah, 2006).

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