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Incidence of insidious fruit rot as related to mineral nutrients in Harumanis mangoes

(Kejadian reput dalam buah dan kaitannya dengan nutrien galian dalam mangga Harumanis)

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Key words: mango cv. Harumanis, insidious fruit rot, fruit size, nitrogen and calcium content

Abstrak

Kajian telah dijalankan untuk menentukan kaitan antara reput dalam buah (IFR) dan kandungan nutrien di dalam buah mangga (*Mangifera indica* L.) kv. Harumanis. Kejadian IFR dipengaruhi oleh saiz buah. Buah yang besar lebih cenderung kepada kerosakan ini dengan ciri pemecahan tisu dalam buah. Nitrogen (N) dan kalsium (Ca) didapati mempunyai kaitan yang paling konsisten dengan kejadian IFR. Buah yang dijangkiti IFR mengandungi N yang tinggi dan Ca yang rendah. Sementara itu, N menunjukkan korelasi positif dan Ca menunjukkan korelasi negatif dengan kejadian IFR. Nisbah N/Ca dalam daun juga menunjukkan korelasi yang sama seperti yang ditunjukkan oleh N. Walau bagaimanapun, nisbah N/Ca dalam daun mempunyai kaitan yang lebih rapat dengan kejadian IFR dibandingkan dengan aras N dan Ca sahaja.

Abstract

A study was conducted to determine the relationships between insidious fruit rot (IFR) and mineral nutrients in mango (*Mangifera indica* L.) cv. Harumanis. The occurrence of IFR was influenced by fruit size. Bigger fruit was more affected by this disorder which was characterised by a tissue breakdown in the fruit. Nitrogen (N) and calcium (Ca) were found to be most consistently related to IFR. The affected fruit was found to be high in N and low in Ca. Nitrogen and Ca contents in leaves exhibited positive and negative correlation respectively with the incidence of IFR in fruit. The N/Ca ratio in leaves also showed similar correlation as N. However, the N/Ca ratio in leaves was more related to the IFR incidence compared with N or Ca level alone.

Introduction

Harumanis is the most popular mango cultivar in Malaysia for local fresh market as well as for export. It has been planted on about 1 000 ha of land in Perlis (Anon. 1985). However, the expansion of this cultivar is reportedly hindered due to the incidence of internal tissue breakdown or commonly known as 'insidious fruit rot' (IFR). Besides Perlis, IFR was also reported in several other states of Malaysia where losses amounting to 80% have been recorded by growers (Lim and Khoo 1985).

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Plate 1. Fruit severely affected by insidious fruit rot

This disorder resulted in poor fruit quality and thus reduced marketability.

The IFR in Harumanis occurs as the fruit approaches maturity. As described by Lim and Khoo (1985), the affected fruit does not show external damage at the time of harvest or at the ripe stage but occasionally a lack of firmness in the sinus region can be detected. When cut into halves, the fruit shows a characteristic watery, soft, yellowish-brown rot often accompanied by a yeasty odour *(Plate 1).* This breakdown often develops at the distal end of the fruit. A dark brown or black pulpy mass extends through most of the fruit when the breakdown is severe.

Several pathological analyses have been carried out but no pathogenic causes have been identified. Lim and Khoo (1985) reported that although various species of yeast and bacteria were found on diseased tissues of the affected fruit, no single microorganism was consistently isolated. Furthermore, the healthy flesh remained indifferent towards inoculation of isolated microorganisms (Lim, W. H., MARDI, Jalan Kebun, pers. comm. 1985), suggesting that the microorganisms present were secondary. This breakdown was apparently a physiological disorder caused by localised deficiencies of nutrients or growth substances during fruit development.

Physiological disorders in mango such as ‘soft nose’ and ‘spongy tissue’ were reported by Young and Miner (1961) in Florida and Subramanyam et al. (1971) in India. The IFR in Harumanis is probably similar to the ‘soft nose’ disorder in the mango variety Kent from Florida. The occurrence of the physiological disorder ‘soft nose’ in Kent mangoes (Young and Miner 1961) has been associated with low calcium and high nitrogen levels in the fruit and leaves. The objective of this study was to determine the relationships between fruit size and mineral nutrients and IFR in Harumanis mango.

Materials and methods

The fruit and leaves of Harumanis mango were collected from Kuala Kangsar area in Perak in October and November 1985.

Twenty-seven trees were selected randomly. About 35–40 fruit were harvested from each tree at the commercial harvest maturity stage (90–100 days after fruit set). After weighing, these fruit were packed in ventilated paper box cartons and ripened at ambient conditions (25–30 °C, r.h. 80%). Ripe fruit were cut into halves for examination of affected portions. Physical observations of tissue breakdown were made for colour, odour, location of tissue and extent of damage.

The percentage of IFR incidence for each tree was calculated based on the number of affected and healthy fruit. The number of IFR-affected fruit was also recorded based on weight groups, i.e. <350, 350–400, 401–450, 451–500 and >500 g.

For mineral analysis, healthy and affected fruit were divided into four groups. Each group represented a replicate consisting of five fruit randomly picked from all fruit sampled. The flesh of the fruit was divided into three portions: distal end, middle and stem end. Representative samples from the combined tissue portions of five fruit were homogenized in a Waring blender. The samples were oven dried at 60–65 °C for about 72 h and then ground in a Waring blender.

Leaves were sampled from each tree at harvest by employing the sampling method proposed by Koo and Young (1972). To avoid chance sampling of younger or older flushes, leaves of each sampled tree were taken from the fourth and fifth leaf from the base of the current flushes. The leaf samples were washed with running tap water and then rinsed with distilled water. The samples were then oven dried at 60–65 °C and ground in a Wiley mill.

The ground samples of fruit flesh and leaf were ashed at 450 °C for 3–5 h. After cooling, 5 mL of 6M HCl was added to each sample and the solution was evaporated to dryness on a hot plate. The residue was redissolved with 10 mL of 20% HNO_3, heated and digested to about 3 mL, immediately filtered through filter paper into a 100 mL volumetric flask and made up to volume. Total N was determined colourimetrically by the method of AOAC (1975), and P, K, Ca, Mg, Fe, Mn, Zn and B were determined by ICP (inductively coupled plasma) as reported by Fassel and Kniseley (1974a, b).

The data were analysed by using Statistical Analysis System (SAS) software package. The relationship between IFR incidence and fruit size was determined using the Chi-Square method. Analysis of variance was employed to relate the fruit condition and fruit portions with mineral contents. Correlation coefficient between percentage incidence of IFR and mineral contents of leaves from 27 trees sampled were also determined.

Results

Most of the fruit studied were at their commercial harvest maturity stage and their weight ranged from 300 g to 600 g. As shown in *Table 1*, fruit weight influenced the incidence of IFR. Generally, the incidence of IFR increased with fruit weight. Bigger fruit were more favourably affected, especially those above 450 g in weight. The damage of such fruit was more than 25%.

From overall observations on mineral nutrients in the fruit and leaves of Harumanis mango, only N, Ca and N/Ca ratio were found to be consistently related to IFR disorder. Thus, the discussion would be restricted mainly to these elements.

The affected fruit had significantly higher N content but significantly lower Ca level than the healthy fruit *(Table 2)*. The N/Ca ratio of affected fruit was significantly higher than that of healthy fruit.

Table 1. Insidious fruit rot of Harumanis mangoes in relation to fruit weight

Fruit weight (g)	Insidious fruit rot (%)	No. of fruit examined
<350	7.43	175
350–400	11.19	143
401–450	19.60	199
451–500	35.09	114
>500	24.93	337
Overall	19.83	968

The percentages of incidence are significantly different by weight at 0.1% level by Chi-Square Method (χ^2 = 45.84)

Table 2. Mean values of N and Ca content of healthy and affected mango fruit, and in three portions of the fruit

	N (%)	Ca (%)	N/Ca
Fruit condition			
Healthy	0.466 **	0.048 **	10.14 **
Affected	0.537	0.040	14.10
Fruit portion			
Stem end	0.452c	0.051a	9.08c
Middle	0.502b	0.042b	12.32b
Distal end	0.552a	0.039c	14.95a

**Mean values in each column are significantly different at 1% level.
Mean values with the same letter in each column are not significantly different at 5% level by LSD

The N content was high while Ca content was low at the distal end as compared with those of the middle and stem end of the fruit *(Table 2)*. Consequently, N/Ca ratio was higher at the distal end of the fruit. This phenomenon seemed to correspond well with the pattern of IFR occurrence in the fruit. The IFR developed initially at the distal end which contained the highest N but the lowest Ca, and later extended towards the stem end of the fruit as the incidence became more severe.

Correlation studies between percentage incidence of IFR and N and Ca levels in leaves showed that there were significant correlations between N, Ca and N/Ca ratio in leaves with IFR incidence where their values of correlation coefficient (*r*) were 0.59, –0.64 and 0.65 respectively. Nitrogen and N/Ca ratio correlated positively while Ca correlated negatively with IFR incidence *(Figure 1)*.

Discussion

Studies carried out on the incidence of IFR, a physiological tissue disorder in Harumanis, revealed that the fruit weight influenced this disorder. Bigger fruit showed greater tendency to be affected by the breakdown compared with the smaller ones. This phenomenon is similar to that of internal breakdown in Alphonso mangoes reported by Subramanyam et al. (1971). The occurrence of certain physiological disorder related to tissue breakdown in fruit has always been associated with low level of fruit Ca. Bangerth (1983) reported that increased fruit size reduced Ca content in fruit as Ca got diluted, resulting in increased postharvest physiological disorders. A negative correlation between fruit size and Ca concentration in apple is well established (Faust and Shear 1968).

This study indicated that the affected flesh of Harumanis mango contained high N and low Ca. Similar results of high N and low Ca reducing fruit quality and increasing tissue breakdown were also reported in Kent mangoes (Young and Miner 1961) and in apples (Shear and Faust 1975). Nevertheless, N has been applied regularly and often in excess in many of the orchards in many countries.

The association of N and Ca with metabolic disorders is further emphasized by the relation between the pattern of N and Ca distribution in the fruit and the site of disorders. In Harumanis mango, the distribution of nutrients within the fruit showed that internal rot disorder is most likely to develop in the distal end portion which contains higher N and lower Ca concentrations. This similar trend in N and Ca concentrations in apple has also been reported by Redmond (1975), Wightman et al. (1970), and Shear and Faust (1975). They explained that the Ca concentration was considerably lower in the calyx end than in the stem end portion of the fruit. Disorders such as internal breakdown, water core, cork spot and bitter pit develop in the flesh where Ca is lowest. Furthermore, bitter pit and cork spot develop most often in the calyx half of the apple fruit (Shear and Faust 1975).

The higher N/Ca ratio in affected fruit and in the distal end of the fruit indicates that tissue breakdown is most likely to occur when N/Ca ratio in the flesh exceeds 10. Shear (1974) demonstrated that if N/Ca ratio in the apple is around 10, the fruit quality is high and if it is around 30, breakdown of fruit is almost certain.

Although leaf analysis is a diagnostic tool for identifying nutrient deficiencies and imbalances in fruit trees, it also correlates well with physiological breakdowns in fruit as well as fruit quality (Young and Miner 1961; Young and Koo 1969; Martin et al. 1975; Lewis et al. 1977). Internal disorder in fruit of Harumanis mango was closely correlated with N and Ca in leaves. The disorder correlated positively with N and negatively with Ca. Similar relationship between N and Ca levels in leaves with ‘soft nose’ disorder in Kent mango has also been reported by Young and Miner (1961), Young et al. (1962), and Young and Koo

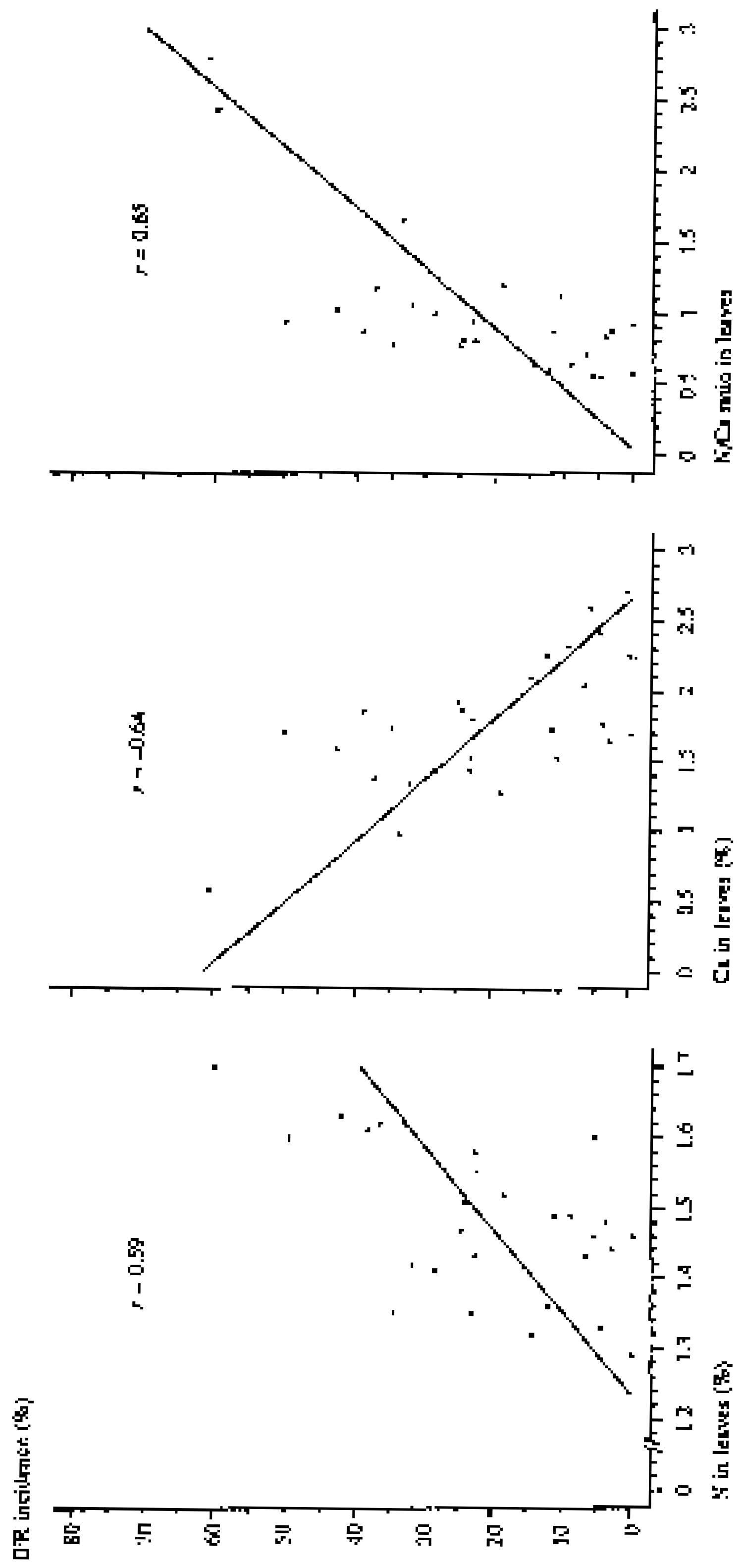

Figure 1. Relationship between incidence of insidious fruit rot and contents of N and Ca, and N/Ca ratio in leaves

(1969). They found that the incidence of 'soft nose' in fruit increased with increasing N and decreasing Ca in leaves. According to Young and Koo (1969), leaf Ca levels of 2.5% or above were suggested because the incidence of 'soft nose' decreased with high Ca levels particularly when N levels were relatively high. In the case of Harumanis mango, leaf Ca level at 2.0–3.0% showed very low incidence of IFR. In apple, Martin et al. (1975) also found that N and Ca exhibited positive and negative correlations respectively with 'bitter pit'.

Shear (1975b) reported that N nutrition, regardless of source, plays an important role in the Ca nutrition of the tree, especially the fruit. Nitrogen fertilization during the early period of fruit development acts to reduce fruit Ca concentration. Fertilizer trials with Kent mango (Young et al. 1965) and apple (Martin et al. 1975; Lewis et al. 1977) indicated that the incidence of 'soft nose' in mangoes and 'bitter pit' in apple were reduced with increased Ca and decreased N fertilization. The antagonistic effect of N and Ca accumulation in leaves and fruit has been very well established especially when ammonium source is used (Young et al. 1962, 1965; Shear 1975b; Lewis et al. 1977; Ludders 1979). In relation to this antagonistic effect, N/Ca ratio is probably more closely related to incidence of IFR than N and Ca alone as it indicates the balance between these two nutrients. This study showed that N/Ca ratio in the leaves of Harumanis mango was positively correlated with incidence of IFR, indicating the strong influence of N nutrition on incidence of IFR. An increase in N concentration in the leaves would result in an increase in IFR incidence even if Ca concentration remained unchanged. It was observed that N/Ca ratio in the leaves was more closely related to incidence of IFR than N and Ca levels alone. Similarly, Shear (1975a) observed that the N/Ca ratio in the leaves and fruit of York Imperial apples was more closely related to the incidence of 'bitter pit' and 'cork spot' than Ca level alone. He found a high positive correlation between the incidence of both 'bitter pit' and 'cork spot' and N/Ca ratio in both leaves and fruit. This was true even when the fruit Ca was at levels previously considered high enough to prevent these disorders (Shear 1972). For Harumanis, the use of N/Ca ratio as a measure of IFR incidence needs further investigation. This is important particularly in cases when N or Ca level alone at levels considered low or high to prevent IFR does not show significant correlation with the IFR incidence. However, N and Ca levels could be used as indicators to predict the occurrence of IFR in Harumanis mango.

From the limited evidence presented in this paper, it appears that there is an inter-relationship between N and Ca with IFR in Harumanis mango. Calcium at relatively high level in fruit and leaves tends to reduce the incidence of IFR while N tends to increase it. Further studies on remedial measures need to be conducted to overcome the problem of IFR in Harumanis mangoes.

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