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DIFFERENTIAL SENSITIVITY OF PAPAYA VARIETIES IN EXPRESSION OF BORON DEFICIENCY SYMPTOMS

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RINGKASAN

Empat varieti betik telah diuji di kawasan tanah gambut di Stesen Penyelidikan MARDI Jalan Kebun, Kelang. Tanda-tanda kekurangan boron yang menunjukkan buah 'bumpy' telah diperhatikan pada semua varieti. Walau bagaimanapun tiap-tiap varieti menunjukkan daya sensitif yang berbeza-beza bagi menggambarkan tanda-tanda tersebut di berbagai peringkat boron pada petiol. Maradol adalah varieti yang paling sensitif sementara kacukan Solo adalah yang paling kurang. Maradol memerlukan sekurang-kurangnya 18 ppm boron di dalam tisu petiol sebelum buah-buah bebas dari tanda-tanda tersebut sementara bagi kacukan Solo pula, pembentukan buah yang tidak sempurna tidak berlaku walaupun paras boron pada petiol serendah 8 ppm.

Tiga dari varieti-varieti yang diuji, gambaran tanda-tanda kekurangan didapati amat berkait rapat dengan paras boron pada petiol (−0.5092** hingga −0.7759**). Walau bagaimanapun tiada didapati apa-apa hubungan antara petiol dan paras tanah bagi unsur pekit ini. Penemuan-penemuan yang nyata dari segi pengesyoran-pengesyoran varieti untuk kawasan-kawasan yang pembawaannya rendah dengan boron telah dibincangkan.

INTRODUCTION

The importance of boron in papaya nutrition has not been recognized until fairly recently. WANG and KO (1975) were the earliest workers to establish the importance of boron in papaya cultivation. They found that malformation of papaya fruits with rough or 'bumpy' surfaces frequently accompanied by latex exudation were typical symptoms caused by boron deficiency. The malformation of the fruit was the earliest symptom and most sensitive indicator of boron deficiency in papaya. In more severe cases, CHAPMAN, GLENNIE, AQUILIZAN and PAXTON (1978) reported that papaya leaves become brittle in texture and clawlike, followed usually by dieback of the terminal shoots. The plants are dwarfed and fruit set is severely affected. Such severe deficiency symptoms have rarely been observed in papaya orchards in Malaysia. However, milder symptoms expressed as 'bumpy' fruits are more widespread and have been commonly observed especially in plantings on coarse sandy soils.

Although boron does not appear to be a major problem in papaya cultivated on mineral soils in this country, the same may not be true when cropped on peat soils. Boron deficiencies have been recorded in oil palm and tomato grown on peat (JOSEPH, CHEW and TAY, 1974) and papaya has been observed to have similar problems when planted on this soil type. In line with the effort to diversify cropping on peat, there has been increasing interest on papaya cultivation on this soil type. However, with the relative sensitivity of. this crop to boron deficiency, breeding and selection efforts have been initiated at MARDI with the objective of identifying adaptable varieties of papaya for peat areas. This paper reports the differential sensitivity of some varieties in the expression of boron deficiency symptoms and discusses the significance of the findings in relation to selection and management of suitable varieties cultivated in boron deficient soils, particularly peat.

MATERIALS AND METHODS

Four varieties, namely Subang 6, Sitiawan, Maradol and the MARDI Backcross Solo were used in the experiment. Subang 6 and Sitiawan are popular local varieties while Backcross Solo is a variety developed at MARDI. Maradol is a Cuban variety introduced into this country via Brazil. The crop was planted on peat at the MARDI Research Station at Jalan Kebun,

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Klang on 25 April 1981. The chemical and physical properties of the peat in this station were fully described by JOSEPH *et al.* (1974).

The experimental design was a randomized complete block with four replicates, each consisting of four plots of 20 plants each. The planting distance was 1.8 m within row and 2.7 m between rows.

Prior to planting, hydrated lime powder was worked into the soil of the experimental plot at a rate of 25 kg per 100 sq metres. At planting, 227 g of CIRP was added into each planting hole. Subsequently, a 14:14:14 compound fertilizer was added at a rate of 1.8 kg/tree/year and this was split into four equal applications. Pest and disease management included monthly sprays of Dithane M−45 at 0.2% a.i. for protection against anthracnose and Kelthane at 0.1% a.i. against spider mites.

Data records were taken when trees were one year old. A total sample of 80 plants, representing five random plants per plot, were taken. For estimation of occurrence of symptoms, the number of fruits showing symptoms of deficiency manifested as 'bumpy fruits' were recorded and expressed as per cent of the total fruits found on the tree. To show the severity of the deficiency, the number of bumps on each deficient fruit was counted and expressed as mean number of bumps per fruit for each sampled tree.

Petioles of the most recently matured leaf, corresponding to one whose axil bears the youngest flower (AWADA and LONG, 1971), were sampled for determination of boron levels in the one-year-old plants. The samples were immediately dried in a forced draught oven at 80°C for 24 hours, after which the temperature was lowered to 70°C and the petiole samples were kept at that temperature until completely dry. The dried samples were ground with a Micro-Hammer Mill using a 0.25-mm screen mesh. One gram of each ground sample was ashed in the furnace at 500°C−550°C and the ash was later mixed with 10 ml of 0.36N sulphuric acid. The boron in the filtrate was determined on the Auto-analyser using the Azomethine H method.

In determination of total and soluble boron in the soil, peat samples were taken at a depth of 45 cm in the vicinity of the 'drip-line' of each sampled plant. Total boron of the peat was determined in the same manner as described for petiole boron but for soluble boron, 5 g of the oven dried peat was refluxed with 50 ml of water. The water extract was evaporated and then ashed. The water-soluble boron was determined using the same method described earlier.

RESULTS AND DISCUSSION

The mean values obtained from the analysis of variance showed that variety was significant for per cent bumpy fruits, number of bumps/fruit and petiole boron levels *(Table 1)*. The differential sensitivity in symptom expression between the four varieties grown over the different replicates is indicated by the significant interaction component between replicate and variety for number of bumps/fruit *(Table 1)*. This implies that the severity in deficiency symptoms expressed by each variety was not consistent over the four replicates. The reason for this will be made clear later but for the time being, it is sufficient to say that the significant interaction component between replicate and variety was brought about by the relative insensitivity of some varieties in the expression of symptoms compared with others which may respond readily to the variation in factors influencing symptom expression between the four replicates.

In *Table 2*, the varietal differences in expression of symptoms as well as the petiole boron levels are shown. Maradol was the most sensitive towards both occurrence and severity of symptoms. About 68% of the fruits were malformed ('bumpy') and on the average each fruit had about 3.8 bumps. Fruits with such severe symptoms are quite unsightly and hardly marketable. In contrast, Backcross Solo was the least sensitive.

Table 1. Mean square values from analysis of variance of three variables

Sources	df	Mean squares		
		% Bumpy fruit	No. bumps/fruit	Petiole B
Rep	3	3 921.56**	14.57**	41.67**
Variety	3	17 959.85**	57.10*	19.56*
Rep*variety	9	1 324.36 ns	9.66**	2.93 ns
Error	64	661.94	2.75	3.83

**Significant at p = 0.01
*Significant at p = 0.05

Table 2. Occurrence and severity of boron deficiency symptoms and petiole boron levels of four papaya varieties

Varieties	Occurrence of symptoms (% bumpy fruits)*	Severity of symptoms (No. bumps/fruit)	Petiole boron (ppm)
Maradol	68.25 a	3.80 a	13.26 a
Subang 6	31.25 b	0.91 b	13.03 a
Sitiawan	9.46 c	0.55 b	12.58 ab
Backcross Solo	1.15 c	0.04 b	11.06 b

*Means within columns followed by similar alphabet are not significantly different at p = 0.05 according to the Duncan's Multiple Range Test.

The occurrence of deficiency symptoms in this variety was negligible (1.15%) and even in deficient fruits, the malformation was noted to be very slight. In general, other varieties expressed varying degrees of deficiency but none was as dramatic as that of Maradol.

A point of interest is that Maradol showed severe symptoms even though its petiole boron level was the highest among the four varieties tested *(Table 2)*. Conversely, Backcross Solo had the least symptoms although its petiole boron level was the lowest. This indicates that there is a differential threshold for boron requirements among the four varieties. There are no clear reasons for this but it suggests differences in uptake and utilization of this microelement between the varieties tested. This is not uncommon as varietal differences in uptake have been reported for other fruit crops such as citrus (SMITH, 1966).

Within each variety, expression of deficiency symptoms was strongly related to petiole boron levels. This is indicated by the significant negative correlation between the two variables for the majority of varieties tested *(Table 3)*. With the exception of the least sensitive variety Backcross Solo, the correlation between symptoms and petiole boron levels range from −0.5092** to −0.7759**. To illustrate this point further, *Figure 1* shows quite clearly the differential expression of boron deficiency of the four varieties at various levels of petiole boron. The higher requirements of Maradol for boron sufficiency is evident. Petiole boron levels of at least 18 ppm is required for Maradol before this variety can produce normal fruits. On the other hand, fruits of Backcross Solo do not show deficiency symptoms even with petiole boron levels as low as 8 ppm. At this level, fruits of the other three varieties can be expected to be extremely malformed because of boron

Table 3. Correlation coefficients of symptoms with petiole boron levels of four papaya varieties

Varieties	% Bumpy fruits	No. bumps/fruit
Maradol	−0.6327**	−0.7759**
Subang 6	−0.5845**	−0.6025**
Sitiawan	−0.5170**	−0.5092**
Backcross Solo	−0.3625	−0.3669

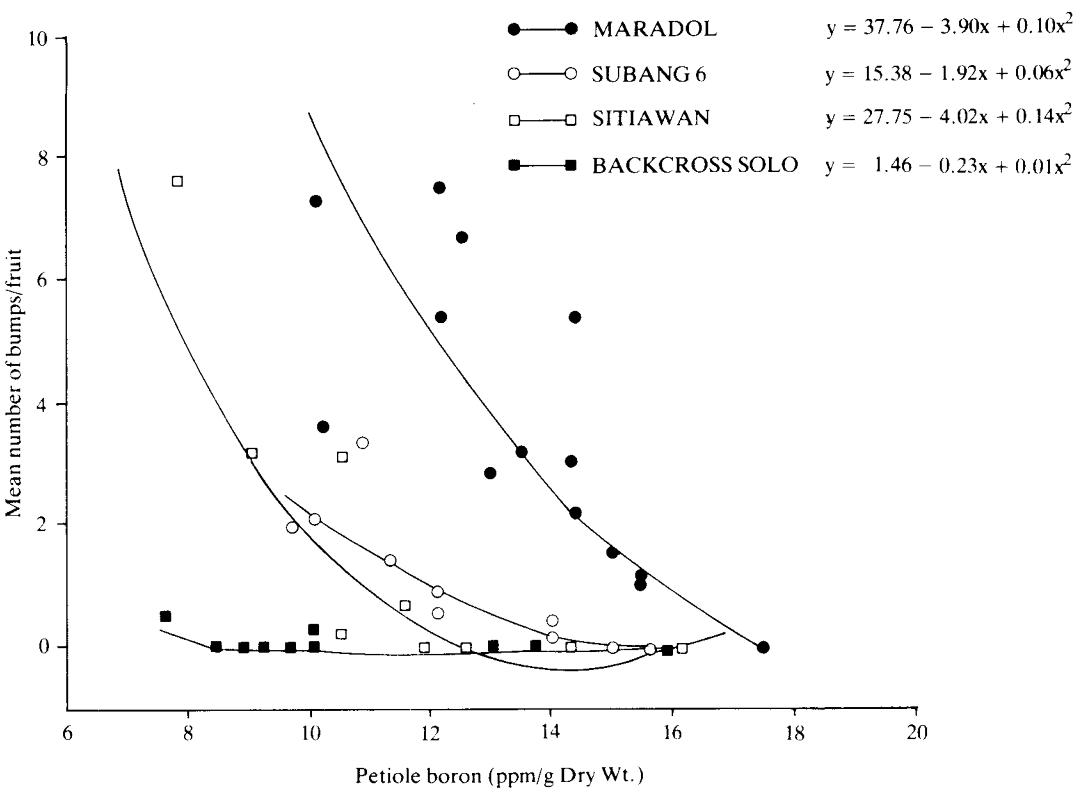

Figure 1. Relationship of boron deficiency symptoms with petiole boron levels of four papaya varieties.

deficiency. For Subang 6 and Sitiawan, 14–16 ppm of boron in petiole tissues may be required for development of healthy fruits.

To investigate further, the boron contents of the peat around each sampled tree were examined. In general, it was noted that total boron found in the experimental area was low, in the range of 7–10 ppm while the soluble part was estimated to be about 15% of the total boron. Petiole boron levels which was earlier shown to be an important criterion in governing expression of symptoms, was found to have no relationship with either total or soluble boron in the soil. This may be explained by the fact that boron content in peat is extremely low and furthermore, with limited variation obtained, concomitant variation may not show up in petiole levels. Against soil boron content higher than the range that was observed in the present studies, achieved through appropriate application of the microelement in the soil, petiole levels may be significantly raised. This has been demonstrated by the successful treatment of boron deficiency by application of borax to deficient soils (WANG and KO, 1975; CHAPMAN *et al.*, 1978).

In the recommendation of varieties for cultivation on peat areas, consideration must of course be given to performance in yield and other economic characters. From the present findings however, the extreme sensitivity of Maradol towards expression of boron deficiency symptoms may be sufficient reason to preclude recommendation of this variety on peat areas. On the other hand, Backcross Solo and Sitiawan which are relatively tolerant to low soil boron levels, may be suitable varieties for such areas.

It is not implied that boron deficiency problems are insurmountable and that the choice of tolerant varieties is mandatory for areas low in this microelement. Prophylactic treatments such as soil dressing and foliar sprays of borax and boric acid have been widely reported to be successful in overcoming this malady. However, regular vigilance for symptoms and additional costs in treatment may be obviated through use of less sensitive varieties in problem areas.

It may be added that the hypersensitivity of Maradol towards low soil boron levels may be exploited to advantage by papaya growers. Several trees of this variety, well located in the orchard, may be useful indicator plants for predicting petiole boron levels without having to resort to cumbersome methods of foliar sampling and analysis. Fruit malformation in Maradol may serve as early warning before onset of symptoms in other less sensitive varieties such as Backcross Solo and Sitiawan. It was noted in the present studies that other plant parts as well as yield were not appreciably affected in less sensitive varieties at the stage when Maradol showed the first signs of fruit malformation. Foliar application of boron to redress the impending deficiency in other less sensitive varieties may be made well in advance before their productivity is affected.

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SUMMARY

Four varieties of papaya were tested in a peat area at the MARDI Research Station at Jalan Kebun, Klang. Boron deficiency symptoms manifested as 'bumpy' fruits were observed in all the varieties. Each variety, however, exhibited a differential sensitivity to the expression of symptoms at various levels of petiole boron. Maradol was the most sensitive variety while Backcross Solo was the least. The former requires at least 18 ppm of boron in petiole tissues before fruits were free of symptoms while in the latter, fruit deformation did not occur even at petiole boron level as low as 8 ppm.

For three of the tested varieties, expression of deficiency symptoms were found to be strongly correlated with petiole boron levels (−0.5092** to −0.7759**). No relationship, however, was found between petiole and soil levels of this microelement. The significance of the findings in terms of recommendations of varieties for areas with inherent low boron was discussed.

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