UNIVERSITI PUTRA MALAYSIA

EFFECTS OF LIMING AND PHOSPHORUS FERTILIZATION ON GROWTH, YIELD AND NUTRIENT CONCENTRATION OF PAPAYA (CARICA PAPAYA L.)

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EFFECTS OF LIMING AND PHOSPHORUS FERTILIZATION ON GROWTH, YIELD AND NUTRIENT CONCENTRATION OF PAPAYA (*CARICA PAPAYA* L.)

By

RAVEENDRANATHAN PRABHAKARAN

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To my parents

for their love, guidance and sacrifices

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May 1994

Chairman: Assoc. Prof. Dr. Surjit Singh, Ph.D.

Faculty: Agriculture

Two experiments, one in the field and the other in polybags, were conducted at the MARDI Research Station Serdang, to study the effects of four levels of lime and four levels of phosphorus, in factorial combination, on growth, yield and nutrient concentration of papaya cv. Eksotika on a Munchong soil (Tropeptic Hapludox). A randomized complete block design, with two replications in the field and five in polybags, were used for both the experiments. Uniform seedlings were selected and planted in both trials.

For the field experiment, plant height, stem girth and canopy diameter were taken at two month intervals,

soil pH at four month intervals while yield data were recorded from first fruiting until the plants were 1.5 years old. Nutrient concentration was determined on the leaf petiole. The same growth parameters and soil pH were taken at two weekly intervals up to a period of five months from plants in the polybag experiment.

In both experiments, no lime x phosphorus interactions were significant for any of the parameters measured.

Lime applications produced variable pH responses in the field and polybag trials. While response in the field trial was somewhat erratic, the polybag trial recorded significant increases in soil pH with each increment of lime applied, up to 4.5 mt ha^{-1} of ground magnesium limestone (GML).

Both lime and P fertilization did not significantly improve plant growth or yield under the field conditions. Nevertheless, lime significantly enhanced petiole Ca concentration but decreased those of N, Mn and Fe. Even though papaya plants did not respond to P fertilization, it improved petiole concentrations of P and Mg. A petiole P content of 1.7-2.4 g P kg^{-1}

was found to be adequate for papaya growth and yield on this Munchong soil.

On the other hand, lime significantly improved the growth of plants in the polybag beginning one month after application. Plants receiving 4.5 mt ha^{-1} of lime were taller and had bigger stem girth, while canopy diameter was unaffected. Plants receiving P fertilization were not significantly different from those not receiving P.

Measurements at 2.5 and 5 months showed that lime treated plants recorded significantly higher stem, petiole, leaf blade and root dry matter production only at 5 months, inspite of improved growth performance recorded earlier. Phosphate fertilization however did not affect either the total plant dry matter production or any of its individual components at both sampling dates. Lime application significantly increased petiole number and total leaf area only at 5 months. Liming also significantly increased the concentration of Ca and Mg in the petiole but depressed those of Mn and Fe. Phosphorus fertilization did not influence the nutrient status in the petioles, unlike in the field experiment.

Abstrak tesis yang dikemukakan kepada Senat Universiti Pertanian Malaysia bagi memenuhi syarat keperluan untuk mendapatkan Ijazah Master Sains Pertanian.

KESAN PENGAPURAN DAN PEMBAJAAN FOSFORUS TERHADAP PERTUMBUHAN, HASIL DAN KEPEKATAN NUTRIEN PADA BETIK (*CARICA PAPAYA* L.)

Oleh

RAVEENDRANATHAN PRABHAKARAN

Mei 1994

Pengerusi: **Prof. Madya Dr. Surjit Singh, Ph.D**

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Dua percubaan, satu di ladang dan satu lagi menggunakan polibeg telah dijalankan di Stesen Penyelidikan MARDI Serdang untuk mengkaji kesan empat kadar kapur dan empat kadar fosforus dalam bentuk kombinasi faktorial terhadap pertumbuhan, hasil dan kepekatan nutrien pada betik cv. Eksotika yang ditanam di tanah jenis Munchong (Tropeptic Hapludox). Kedua-dua percubaan dijalankan dengan menggunakan rekabentuk blok terawak lengkap dengan dua replikasi bagi percubaan di ladang dan lima replikasi bagi percubaan polibeg. Anak benih yang seragam telah dipilih dan ditanam bagi kedua-dua percubaan.

Untuk percubaan di ladang, ketinggian pokok, lilitan batang dan diameter sudur telah diukur setiap dua bulan, pH tanah diambil setiap empat bulan manakala data hasil telah dicatatkan daripada pengeluaran buah pertama sehingga pokok berumur 1.5 tahun. Kepekatan nutrien telah ditentukan pada petiol daun. Bagi pokok-pokok di dalam polibeg, parameter-parameter pertumbuhan yang sama dan pH tanah telah diambil setiap dua minggu selama lima bulan.

Dalam kedua-dua percubaan, interaksi kapur x fosforus didapati tidak bererti bagi kesemua parameter yang telah diukur.

Pengapuran telah menghasilkan gerakbalas pH yang berubah-ubah bagi kedua-dua percubaan. Sementara gerakbalas dalam percubaan di ladang didapati tidak tetap. Percubaan polibeg telah mencatatkan pertambahan pH tanah yang bererti bagi setiap pertambahan kadar pengapuran sehingga 4.5 mt ha^{-1} batu kapur magnesium (GML).

Pengapuran dan pembajaan P tidak meningkatkan pertumbuhan pokok atau hasilnya dengan bererti dalam percubaan di ladang. Namun demikian, kapur telah menambahkan kepekatan Ca petiol dengan bererti tetapi menurunkan kepekatan N, Mn dan Fe. Walaupun pokok-pokok betik tidak menghasilkan gerakbalas terhadap pembajaan P, kepekatan P dan Mg petiol didapati bertambah. Kandungan P petiol sebanyak 1.7-2.4 g P kg^{-1} didapati mencukupi untuk pertumbuhan pokok betik dan penghasilan buah di tanah Munchong.

Kapur sebaliknya telah menambahkan pertumbuhan pokok dalam polibeg dengan bererti mulai sebulan selepas pengapuran. Pokok-pokok yang menerima 4.5 mt ha^{-1} kapur didapati lebih tinggi dengan lilitan batang yang lebih besar sementara diameter sudur tidak berubah. Pokok-pokok yang menerima pembajaan P dan yang tidak menerima P tidak berbeza dengan bererti.

Pengukuran pada bulan 2.5 dan 5 telah menunjukkan bahawa pokok-pokok yang menerima kapur menghasilkan bahan kering yang lebih tinggi dengan bererti bagi batang, petiol, lai daun dan akar hanya pada bulan ke 5 walaupun merakamkan pertumbuhan yang memuaskan sebelumnya. Pembajaan fosfat bagaimanapun tidak mempengaruhi jumlah pengeluaran bahan kering pokok atau komponen individu pada kedua-dua tarikh persampelan. Pengapuran telah menambahkan bilangan petiol dan jumlah keluasan daun dengan bererti hanya pada bulan ke 5. Pangapuran juga telah menambahkan kepekatan Ca dan Mg dengan bererti pada petiol tetapi menurunkan kepekatan Mn dan Fe. Berbeza dengan percubaan di ladang, pembajaan fosforus tidak mempengaruhi status nutrien petiol.

CHAPTER I

INTRODUCTION

Papaya is a popular fruit in Malaysia because it is non-seasonal, inexpensive and has a high nutritive value in terms of vitamins A and C (Chan, 1975). However despite its popularity, the total hectarage under papaya cultivation in Peninsular Malaysia has remained fairly constant at about 700 ha till the early eighties (Ngah, 1985).

One of the main limiting factors to the expansion of the papaya industry has been unavailability of good quality local varieties. Attempts at introducing the Hawaiian Sunrise Solo, a variety well received in the international market, were unsuccessful as the fruits produced were too small, weighing about 250 - 400 g each and were not readily acceptable to Malaysians (Chan and Tee, 1975).

Recognising this constraint, the Malaysian Agricultural Research and Development Institute (MARDI) intensified its papaya breeding research and successfully developed a new variety, the Eksotika

Malaysia, which has excellent fruit qualities and is rated highly for its export potential (Chan, 1989).

The release of this new variety transformed the existing papaya industry, which was being ventured mainly by smallholders on a semi-commercial scale on marginal soils. However with the new found commercial prospects, large commercial farms, averaging 10 to 20 ha each, emerged and its cultivation was shifted to the richer and less problematic mineral soils.

The sudden shift to commercial cultivation on mineral soils was accompanied by requests for an interim fertilizer programme that would address both the limitations of tropical soils and specific nutritional requirements of the papaya crops.

The two most common characteristics of Malaysia mineral soils are their high acidity (pH < 5.0), inherent low P content and high P fixing capacities (Owen, 1947, 1953; Zaharah, 1979). However documented evidences from overseas indicate that papaya prefers less acidic soils (Awada et al., 1975 and Younge and Plucknett, 1964) and also requires large amounts of P for good growth and productivity (Leigh, 1969 and Purohit and Singh, 1978).

Although there has been a large increase in the hectarage under papaya in Peninsular Malaysia, including acidic and P deficient soils (Ultisols and Oxisols), there is little information locally on these aspects. It is imperative that research efforts should be directed towards overcoming these major soil limitations to papaya growth for their utilization in further expanding the areas suited for payaya cultivation. With this in mind, field and polybag studies were conducted with the following objectives:

(i) to study the effects of different levels of lime and phosphorus, and their interactions, on the growth and yield performance of papaya.

(ii) to determine the rate of lime and P fertilization for optimum growth and productivity of papaya on a Munchong series soil (Tropeptic Hapludox), and

(iii) to determine the petiole P concentration for estimating the adequacy of phosphorus for optimum growth and productivity of papaya.

CHAPTER II

LITERATURE REVIEW

Taxonomy of papaya

The papaya (Carica papaya L.), is an important fruit of tropical and subtropical regions of the world. It belongs to the family Caricaceae which consists of the following genera: Carica, Cylicomorpha, Jacaratia and Jarilla. The genus Carica contains about 21 species, all indigenous to tropical America. Cylicomorpha contains two species native to tropical America, while Jarilla consists of a single species native to central Mexico (Storey, 1969). Carica is the only genus having species that are cultivated for their fruit. The other three genera have a number of species which are cultivated as ornamentals.

Origin and distribution of papaya

The consensus of opinion among botanists is that papaya originated in the lowlands of Central America in the region between Southern Mexico and Nicaragua/Costa Rica (Purseglove, 1969; Storey, 1969). Following the discovery of the New World, the papaya was distributed along the tropical trade routes by travellers of various maritime nations. It reached Panama as early as 1953, Puerto Rico by 1540, and Cuba soon thereafter (Storey, 1969). It was taken by the Spanish to the Philippines and later to Malacca and India in the mid 16th century.

Today papaya is grown extensively throughout the tropical and subtropical regions both as a plantation crop and as a favourite fruit tree for the home garden. In the past 60 years the fruit has continually increased in popularity and the tree has gained importance as a plantation crop in Hawaii, South Africa, Australia, India, Ceylon, the Philippines, in tropical America and Southeastern Asia.

General characteristics of tropical soils

Soils of the humid tropics have developed under conditions where rainfall exceeds evapotranspiration during most of the year (Kamprath and Foy, 1971). Under the abundant rainfall and high temperatures of the tropics, weathering processes are intense. Hydrolysis and oxidation are rapid and the leaching action of CO_2 - charged water percolating through the profile of a base saturated soil removes the soluble bases such as Ca, K, Mg and Na away quickly. Due to the mobility of these cations, soils in the well-drained humid region become quite acidic (McLean, 1971). As a result, the solubility of the silica is encouraged and that of Fe, Mn and Al is retarded (Chan et al., 1977).

As weathering proceeds Al and Fe are released from the clay minerals and Al^{3+} remains as the dominant exchangeable cation. Ultimately most of the crystalline clay minerals give way to amorphous hydrous oxides of Al and Fe.

Thus acid soil infertility is a major limitation to crop production on the highly weathered and leached soils in the humid tropics. Two fundamental factors limit the fertility of such acid soils: impoverished nutrient status (e.g. deficiencies of P, Mo, S, K, Ca, Cu or Zn) and the presence of phytotoxic substances (e.g. soluble Al and Mn). In particular, phosphate presents special difficulties because it is subject to strong fixation by soil components (Haynes, 1984).