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# Genetic variation in the grafted vegetatively propagated mango *(Mangifera indica)*

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**Key words: genetic variation; bud grafted mango.**

## RINGKASAN

*Tujuan projek ini adalah untuk mengkaji ketepatan sistem penamaan tentang mangga cantuman* (Mangifera indica). *Pada masa ini ada banyak jenis mangga biasanya ditanam. Jenis-jenis ini termasuk* Apple, Malgoa, Harummanis, Erwin *dan lain-lainnya. Mengenai sistem penamaan ini, ada dua kumpulan pendapat-pendapat dari ahli sains. Ada kumpulan yang menyarankan istilah 'klon' untuk jenis-jenis itu dan ada juga kumpulan yang menyarankan istilah 'varieti'.*

*Dari definisi, klon ialah sekumpulan tumbuhan atau individu yang dibiakkan dengan cara pembiakan tak mengawan secara 'tampang' dari sesuatu induk dan corak enzimnya mestilah serupa dan tetap. Jika variasi genetik yang tinggi didapati ditumbuhan-tumbuhan ini, maka tumbuhan-tumbuhan ini bukan dari satu 'klon' yang benar.*

*Enam 'klon' mangga telah dikaji dengan teknik eletroforesis. Corak jalur dari empat sistem enzim yang termasuk esteras, aspartat aminotransferas, asid dan alkaline phosphatas telah dianalisa. Daripada keputusan yang didapati, ini adalah lebih tepat jika istilah 'varieti' digunakan. Keputusan ini menunjukkan bahawa semua individu yang sama morfologi itu sebenarnya bukan dari induk yang sama. Sistem penamaan mangga yang masih dalam keadaan tidak teratur itu mesti ditetapkan dan diperbaiki supaya penamaan itu boleh digunakan sebagai asas untuk penyelidikan pembiakan tumbuhan.*

*Keputusan ini juga menonjolkan keperluan penyelidikan pada masa depan mengenai pokok cantuman untuk menyiasat kepentingan pengaruh genetik apabila menggunakan tampang akar yang jenisnya berlainan tetapi tunasnya dari induk yang sama.*

## SUMMARY

*The purpose of this project is to study the authenticity of the naming system of the bud grafted mango* (Mangifera indica). *Many types of mango are commonly cultivated, namely,* Apple, Malgoa, Harummanis, Erwin, *etc. Regarding the naming system, there are two schools of thought. One suggests that the different types are different 'clones'. The other view is that they are different 'varieties'.*

*Since a clone is defined as a group of plants or individuals propagated asexually from a single parent, their isozyme patterns should be uniform or identical. If the isozyme patterns of plants that reputedly belong to the same clone show a high degree of variation between individuals, this would indicate that they are not a true clone.*

*Six 'clones' of mango were studied using the electrophoretic technique. The banding patterns of four enzyme systems including esterases, aspartate aminotransferase and acid and alkaline phosphatases were analysed. From the results obtained, it is suggested that the term 'variety', rather than the term 'clone' is more appropriate. The results suggested that all the morphologically similar individuals of the same 'clone' in fact do not come from the same parent. The present chaotic naming system of mango should be standardised and improved so that it can be used as a basis for plant breeding research.*

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*This finding also suggests the need for further research on bud grafted trees to see the importance of genetic influences by using different root stocks. Planned studies on the genetic variation of the plants growing srom the grafted buds collected from a single parent but on different species of* Mangifera *as the root stocks fhould be carried out.*

## INTRODUCTION

Mango *(Mangifera indica)* belongs to the dicotyledonous family Anacardiaceae. It is one of the most popular fruits in the orient because of its attractive fragrance, beautiful shades of colours, delicious taste and good nutritional value.

The Mango is said to have originated in the Indo-Burma region and it has been undoubtedly under cultivation for more than 4000 years in Eastern India and Burma. It is believed that the mango was first introduced in the neighbouring South-East Asian countries in the eighteenth century.

*Mangifera indica,* as a result of cross pollination, exhibits a range of variation that provides a wide spectrum for the selection of the desirable types. Ultimately such selections were named, and the selected 'clones' were multiplied by vegetative propagation, i.e. grafting or budding. So far, the naming of a 'clone' appears to depend solely on the discretion of individual researchers. There are cases of identical clones being given different names by different workers and different clones being given the same name: the system of naming has thus become chaotic, with two schools of thought prevailing at present. One suggests that the different types of *Mangifera indica* are different 'clones'. The other view is that they are different 'varieties'.

A clone is defined as a group of plants or individuals propagated asexually from a single parent and it is a basic tenet of population biological research involving isozyme analysis that genetically identical individuals display consistent and reproducible electromorph phenotypes. A limited amount of within clone variation may be expected due to mutation (King, 1980, *per. comm.*)

The aim of this study was to determine the authenticity of the naming system of *M. indica* from their isozyme patterns using the electrophoretic technique. A high degree of isozyme variation within supposed clone may serve as an indication that indeed the individuals are not a true clone. Individuals of the same clone under the same environmental growing conditions are expected (barring mutation) to have no variation in isozyme patterns if the same extraction medium is used (Watson and Gail, 1981a; 1981b).

Attempts were also made to study the clonal/varietal differences in the isozymes. One can, in principle, distinguish the clonal/varietal differences through their protein or isozyme patterns (Boulter and Turner, 1966; Larsen, 1967; Johnson, 1969; Torres *et al.,* 1978a; 1978b; 1980; Ladizinsky and Hymowitz, 1979). The reports of this taxonomic study will be published elsewhere.

## MATERIALS AND METHODS

The leaves of six 'clones' of *Mangifera* were collected from three locations of the Universiti Pertanian Malaysia farm (Table 1). The leaves collected were kept separately in polythene bags, labelled and stored at −20°C.

TABLE 1
Numbers of individuals and clones of mango collected in the farm of Universiti Pertanian Malaysia.

| 'Clones' | Locations | N = sample size |
|---|---|---|
| | | Total N = 244 |
| *Apple* | LT, H | 30 |
| [1]Gemas | H | 10 |
| [1]Gemas<br>[1]Serdang Baru | TD | 54 |
| [2]*Harummanis* | LT | 21 |
| [2]Indonesia | H, TD | 28 |
| *Hj. Bakar* | H | 12 |
| | TD | 5 |
| *Irwin* | H | 10 |
| | TD | 5 |
| *Kent* | H | 11 |
| [3]*Malgoa* | LT, H, TD | 48 |
| [2]M. 200 | H | 10 |

(H = Horticulture Unit, LT = Farm Seven, TD = Farm Three D)

From the records of the Farm Office of the Universiti Pertanian, Malaysia,
[1]all the 'clones' the same as *Apple.*
[2]all the 'clones' the same as *Harummanis.*
[3]all the 'clones' the same as *Malgoa.*

Samples were collected from the mature elaves of the same age and at the same time of the day. The sampled trees were also checked for disease infection. These extra precautions were taken as it has been reported that isozyme patterns change during different stages of development in plants (Makinen, 1968; Bhatia and Nilson, 1969; Przybylska *et al.*, 1973; Gan *et al.*, 1977, 1981). Tan and Weinheimer (1976) have also observed that during fruit development of the papaya *(Carica papaya)*, some isozyme bands would show a very sudden increase or decrease in activity.

Upadhya and Yee (1968) and Bassiri and Adams (1978) have reported that isozyme patterns varied in different tissues of the same plant. Sako and Stahmann (1972) also reported that a diseased plant may have variable isozyme patterns compared to the normal plant.

Studies were also done on leaves collected from the same tree but exposed to different light intensities i.e. some leaves were collected from those directly under the sunlight and some were collected from the shade. No differences were found in the electromorph expression between sun and shade leaves.

Electrophoretic samples were prepared by grinding 300 mg of leaf in a chilled mortar containing 1 ml of extraction buffer (0.2 M pH 8.6 Tris-HCl containing 20% sucrose and 0.1% 2-mercaptoethanol). The leaf extracts obtained were directly used for starch gel electrophoresis. No centrifugation was used since the centrifuged samples showed identical enzyme patterns.

Two buffer systems were used. For the enzymes esterase, indophenol oxidase, leucine aminopeptidase, catalase, glutamate oxalo-transaminase and peroxidase, the gel buffer was 0.065M trizma and 0.01M citric acid pH 8.7. The box buffer was 0.2M boric acid and 0.25M lithium hydroxide pH 8.3. For the enzymes acid phosphatase and alkaline phosphatase, the gel buffer was 0.676M trizma and 0.005M citric acid pH 8.6. The box buffer was 0.3M boric acid and 1M NaOH pH 8.0. Electrophoresis was run at 300V and 60MA for four hours in the cold room at temperature 10°C. The staining methods for esterase, leucine amino-peptidase, catalase, peroxidase and glutamate-oxalo-transaminase were the same as reported by Brewbaker (1968). The staining methods for indophenol oxidase, alkaline and acid phosphatases were the same as reported by Smith (1969).

## RESULTS AND DISCUSSION

Morphologically, all the six 'clones' of mango studied are very distinct with respect to the size and shape of the tree crown, individual leaf and also the morphology and the taste of the fruits. In this study, the enzyme patterns of individuals belonging to these six 'clones' were examined. The banding patterns of the four enzyme systems including esterases (Table 2), aspartate amino transferase (Table 3), acid phosphatase (Table 4) and alkaline phosphatase (Table 5) were analysed. The isozyme bands of the zymograms were numbered 1 to 15 in order of anodal increasing mobilities. There are altogether 10 bands for the enzyme esterases, 11 bands for the enzyme aspartate-aminotransferase, 15 bands for acid phosphatase and 15 bands for alkaline phosphatase (Fig. 1). The banding patterns of the enzymes indophenol oxidase, leucine aminopeptidase, catalase and peroxidase were found to be unsatisfactory.

All the six 'clones' of mango studied showed within 'clone' variation in the four types of enzymes analysed. The following observations were made: i. There were bands which were fixed in a 'clone' (band frequency = 1), for example, bands 5 and 6 (esterase) were found in all the individuals of the 'clone' *Harummanis* from all the locations sampled. ii. There were bands which were absent in all the individuals of one population but present in other populations of the same 'clone' planted in different locations; for example, band 2 of the enzyme esterases was absent in all the individuals of *Harummanis* collected from Farm Three D but was present in the samples collected from the Horticulture Unit (band frequency = 0.30) i.e. this band was found in 3 of the 10 samples examined. In Farm Seven, this band was found in 17 of the 21 samples examined (band frequency = 0.80) iii. Variable band frequencies were found between populations collected in different locations of the same 'clone'. For example, the band 2 of the enzyme esterases of the 'clone' *Apple* had a band frequency of 0.25 from the samples collected from the Horticulture Unit, 1.0 from the samples collected from Farm Seven and 0.43 from the samples collected from Farm Three D.

If these individuals were indeed propagated from the graft of the same parent, the isozyme patterns should be uniform or identical. However, from the results obtained, it was obvious that the individuals of the same 'clone' showed a high degree of variation.

TABLE 2

Relative band frequency of esterases of the six different 'clones' of Mango collected from different locations in the farm of Universiti Pertanian Malaysia.

| 'CLONES' | LOCATION | N | Rf×100 Band No. | 10–15 1 | 17–22 2 | 25 3 | 29–38 4 | 39–44 5 | 46–51 6 | 58 7 | 61–73 8 | 77–87 9 | 90–95 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Apple | H | 20 | | 0.00 | 0.25 | 1.50 | 0.20 | 0.95 | 0.80 | 0.15 | 0.20 | 0.65 | 0.25 |
| | LT(7) | 20 | | 0.00 | 1.0 | 0.00 | 0.00 | 1.00 | 0.50 | 0.00 | 0.00 | 0.50 | 0.00 |
| | TD(3D) | 54 | | 0.00 | 0.43 | 0.26 | 0.28 | 0.96 | 0.80 | 0.28 | 0.17 | 0.19 | 0.28 |
| | TOTAL | 94 | | 0.00 | 0.50 | 0.18 | 0.20 | 0.97 | 0.73 | 0.19 | 0.14 | 0.35 | 0.21 |
| Harummanis | H | 10 | | 0.40 | 0.30 | 0.00 | 0.00 | 1.00 | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | LT(7) | 21 | | 0.00 | 0.80 | 0.00 | 0.00 | 1.00 | 1.00 | 0.00 | 0.00 | 0.52 | 0.00 |
| | TD(3D) | 18 | | 0.00 | 0.00 | 0.22 | 0.00 | 1.00 | 1.00 | 0.27 | 0.00 | 0.11 | 0.16 |
| | TOTAL | 49 | | 0.08 | 0.41 | 0.08 | 0.00 | 1.00 | 1.00 | 0.10 | 0.00 | 0.27 | 0.06 |
| Hj. Bakar | H | 12 | | 0.42 | 0.00 | 0.00 | 0.58 | 0.41 | 0.58 | 0.00 | 0.00 | 0.08 | 0.00 |
| | TD(3D) | 5 | | 0.60 | 0.20 | 0.00 | 0.20 | 0.80 | 1.00 | 0.00 | 0.00 | 0.40 | 0.20 |
| | TOTAL | 17 | | 0.58 | 0.05 | 0.00 | 0.47 | 0.58 | 0.70 | 0.00 | 0.00 | 0.17 | 0.05 |
| Irwin | H | 10 | | 0.00 | 0.00 | 0.00 | 1.00 | 1.00 | 1.00 | 0.00 | 0.00 | 1.00 | 0.00 |
| | TD(3D) | 5 | | 0.00 | 0.00 | 0.00 | 0.20 | 1.00 | 0.60 | 0.00 | 0.00 | 0.60 | 0.00 |
| | TOTAL | 15 | | 0.00 | 0.00 | 0.00 | 0.73 | 1.00 | 0.86 | 0.00 | 0.00 | 0.86 | 0.00 |
| Kent | H | 11 | | 0.27 | 0.00 | 0.00 | 0.81 | 1.00 | 1.00 | 0.27 | 0.18 | 0.18 | 1.00 |
| | TOTAL | 11 | | 0.27 | 0.00 | 0.00 | 0.81 | 1.00 | 1.00 | 0.27 | 0.18 | 0.18 | 1.00 |
| Malgoa | H | 21 | | 0.53 | 0.09 | 0.00 | 0.53 | 1.00 | 1.00 | 0.00 | 0.00 | 0.52 | 0.57 |
| | LT(7) | 20 | | 0.00 | 0.00 | 0.30 | 0.00 | 1.00 | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | TD(3D) | 17 | | 0.00 | 0.00 | 0.59 | 0.00 | 0.88 | 0.76 | 0.71 | 0.00 | 0.29 | 0.12 |
| | TOTAL | 58 | | 0.19 | 0.03 | 0.28 | 0.19 | 0.97 | 0.93 | 0.21 | 0.00 | 0.28 | 0.24 |

TOTAL N = 244
(H = Horticulture unit, LT = Farm Seven, TD = Farm Three D)

TABLE 3

The relative band frequency of aspartate aminotransferase of the six different 'clones' of mango collected from different locations in the Farm of Universiti Pertanian Malaysia.

| 'CLONES' | LOCATION | N | Rf×100 Band No. | 11–15 1 | 17–19 2 | 21–26 3 | 35–40 4 | 42–44 5 | 45–47 6 | 49–60 7 | 67 8 | 72–73 9 | 82–85 10 | 87–90 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Apple | H | 20 | | 0.3 | 0.45 | 0.2 | 0.65 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | LT(7) | 20 | | 0.00 | 0.00 | 1.0 | 0.50 | 0.55 | 0.00 | 0.45 | 0.00 | 0.00 | 0.00 | 0.00 |
| | TD(3D) | 54 | | 0.22 | 0.29 | 0.7 | 0.39 | 0.24 | 0.28 | 0.24 | 0.11 | 0.07 | 0.00 | 0.00 |
| | TOTAL | 94 | | 0.19 | 0.27 | 0.66 | 0.49 | 0.26 | 0.16 | 0.23 | 0.06 | 0.04 | 0.00 | 0.00 |
| Harummanis | H | 10 | | 0.2 | 0.8 | 0.00 | 1.0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | LT(7) | 21 | | 0.00 | 0.00 | 0.95 | 0.05 | 0.00 | 0.00 | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 |
| | TD(3D) | 18 | | 0.28 | 0.22 | 0.17 | 0.00 | 1.0 | 0.00 | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 |
| | TOTAL | 49 | | 0.35 | 0.24 | 0.37 | 0.22 | 0.37 | 0.00 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 |
| Hj. Bakar | H | 12 | | 0.58 | 0.00 | 0.00 | 0.75 | 0.00 | 0.33 | 0.25 | 0.00 | 0.00 | 0.00 | 0.00 |
| | TD(3D) | 5 | | 0.80 | 0.00 | 0.4 | 0.40 | 0.4 | 0.20 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | TOTAL | 17 | | 0.65 | 0.00 | 0.12 | 0.65 | 0.12 | 0.29 | 0.18 | 0.00 | 0.00 | 0.00 | 0.00 |
| Irwin | H | 10 | | 0.3 | 0.00 | 0.5 | 0.00 | 1.0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | TD(3D) | 5 | | 0.8 | 0.00 | 0.00 | 0.6 | 0.00 | 0.6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | TOTAL | 15 | | 0.47 | 0.00 | 0.33 | 0.2 | 0.67 | 0.2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Kent | H | 11 | | 0.00 | 0.45 | 0.00 | 0.45 | 0.00 | 0.09 | 0.18 | 0.00 | 0.09 | 0.09 | 0.00 |
| | TOTAL | 11 | | 0.00 | 0.45 | 0.00 | 0.45 | 0.00 | 0.09 | 0.18 | 0.00 | 0.09 | 0.09 | 0.00 |
| Malgoa | H | 21 | | 0.05 | 0.45 | 0.38 | 0.00 | 0.48 | 0.00 | 0.00 | 0.00 | 0.00 | 0.48 | 0.4 |
| | LT(7) | 20 | | 0.00 | 0.00 | 0.65 | 0.5 | 0.50 | 0.5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | TD(3D) | 17 | | 0.53 | 0.00 | 0.76 | 0.65 | 0.47 | 0.41 | 0.06 | 0.00 | 0.06 | 0.00 | 0.00 |
| | TOTAL | 58 | | 0.17 | 0.17 | 0.59 | 0.36 | 0.48 | 0.29 | 0.02 | 0.00 | 0.02 | 0.16 | 0.16 |

TOTAL N = 244
(H = Horticulture unit, LT = Farm Seven, TD = Farm Three D).

TABLE 4

Relative band frequency of acid phosphatase of the six different 'clones' of mango collected from different locations in the farm of the Universiti Perianian, Malaysia.

| 'CLONES' | LOCATION | N | Rf × 100 Band No. | 2–4 1 | 6–9 2 | 10–14 3 | 15–18 4 | 19–21 5 | 35–39 6 | 40–43 7 | 44–48 8 | 50–52 9 | 54–58 10 | 61–68 11 | 72–78 12 | 80–84 13 | 86–87 14 | 91–92 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Apple | H | 20 | | 0.45 | 0.00 | 0.40 | 0.55 | 0.15 | 0.20 | 0.45 | 0.45 | 0.45 | 0.50 | 0.50 | 045 | 0.00 | 0.65 | 0·00 |
| | LT(7) | 20 | | 0.35 | 0.00 | 0.00 | 0.35 | 0.60 | 0.00 | 0.00 | 1.00 | 0.00 | 0.50 | 0.50 | 0.00 | 0.45 | 0.70 | 0.00 |
| | TD(3D) | 54 | | 0.20 | 0.17 | 0.03 | 0.30 | 0.44 | 0.63 | 0.31 | 0.44 | 0.11 | 0.24 | 0.26 | 0.26 | 0.33 | 0.52 | 0.00 |
| | TOTAL | 94 | | 0.29 | 0.09 | 0.11 | 0.36 | 0.41 | 0.40 | 0.28 | 0.56 | 0.16 | 0.35 | 0.36 | 0.24 | 0.29 | 0.59 | 0.00 |
| Harummanis | H | 10 | | 0.30 | 0.20 | 0.50 | 0.00 | 0.00 | 0.80 | 0.20 | 0.00 | 0.10 | 0.00 | 0.00 | 0.90 | 0.00 | 0.90 | 0.00 |
| | LT(7) | 21 | | 0.00 | 0.33 | 0.29 | 0.95 | 0.00 | 0.24 | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.24 | 0.00 | 0.38 | 0.19 |
| | TD(3D) | 18 | | 0.39 | 0.44 | 0.56 | 0.50 | 0.33 | 0.78 | 0.74 | 0.33 | 0.00 | 0.00 | 0.00 | 0.56 | 0.72 | 0.22 | 0.00 |
| | TOTAL | 49 | | 0.20 | 0.35 | 0.43 | 0.59 | 0.12 | 0.55 | 0.47 | 0.22 | 0.02 | 0.00 | 0.00 | 0.49 | 0.27 | 0.43 | 0.08 |
| Hj. Bakar | H | 12 | | 0.00 | 0.00 | 0.25 | 0.33 | 0.58 | 0.00 | 0.67 | 0.83 | 0.00 | 0.33 | 0.25 | 0.17 | 0.17 | 0.50 | 0.00 |
| | TD(3D) | 5 | | 0.00 | 0.00 | 1.00 | 0.60 | 0.20 | 0.00 | 0.80 | 0.80 | 0.00 | 0.60 | 0.40 | 0.40 | 0.60 | 0.20 | 0.00 |
| | TOTAL | 17 | | 0.00 | 0.00 | 0.47 | 0.41 | 0.47 | 0.00 | 0.71 | 0.82 | 0.00 | 0.59 | 0.29 | 0.24 | 0.29 | 0.41 | 0.00 |
| Irwin | H | 10 | | 0.00 | 0.00 | 0.20 | 0.10 | 0.00 | 1.00 | 0.70 | 0.00 | 0.00 | 0.00 | 0.80 | 1.00 | 0.20 | 0.00 | 0.00 |
| | TD(3D) | 5 | | 0.00 | 0.00 | 0.40 | 0.60 | 0.00 | 1.00 | 0.80 | 0.00 | 0.00 | 0.00 | 0.20 | 1.00 | 0.60 | 0.00 | 0.00 |
| | TOTAL | 15 | | 0.00 | 0.00 | 0.27 | 0.27 | 0.00 | 1.00 | 0.73 | 0.00 | 0.00 | 0.00 | 0.60 | 1.00 | 0.33 | 0.00 | 0.00 |
| Kent | H | 11 | | 0.00 | 0.00 | 0.18 | 0.55 | 0.00 | 0.91 | 0.00 | 0.55 | 0.00 | 0.00 | 0.36 | 0.73 | 0.73 | 0.00 | 0.00 |
| | TOTAL | 11 | | 0.00 | 0.00 | 0.18 | 0.55 | 0.00 | 0.91 | 0.00 | 0.55 | 0.00 | 0.00 | 0.36 | 0.73 | 0.73 | 0.00 | 0.00 |
| Malgoa | H | 21 | | 0.48 | 0.00 | 0.43 | 0.38 | 0.14 | 0.48 | 0.48 | 0.43 | 0.00 | 0.38 | 0.34 | 0.34 | 0.57 | 0.00 | 0.71 |
| | LT(7) | 20 | | 0.00 | 0.00 | 0.20 | 0.30 | 0.70 | 0.00 | 0.35 | 0.00 | 0.80 | 0.10 | 0.00 | 0.10 | 0.00 | 0.50 | 0.50 |
| | TD(3D) | 17 | | 0.18 | 0.00 | 0.35 | 0.53 | 0.35 | 0.00 | 0.94 | 0.53 | 0.23 | 0.12 | 0.24 | 0.29 | 0.53 | 0.53 | 0.06 |
| | TOTAL | 58 | | 0.22 | 0.00 | 0.33 | 0.40 | 0.40 | 0.17 | 0.57 | 0.31 | 0.34 | 0.21 | 0.20 | 0.29 | 0.36 | 0.33 | 0.45 |

TOTAL N = 244
(H = Horticulture unit, LT = Farm Seven, TD = Farm Three D)

TABLE 5

Relative band frequency of alkaline phosphatase o; the six different 'clones' of mango collected from different locations in the farm of Universiti Pertanian Malaysia.

| 'CLONES' | LOCATION | N | Rf×100 Band No. | 2–4 1 | 11–12 2 | 13–14 3 | 16–19 4 | 23 5 | 32–36 6 | 37–42 7 | 43–44 8 | 46–68 9 | 51–56 10 | 71–76 11 | 78–79 12 | 81–86 13 | 87–89 14 | 92–95 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Apple | H | 20 | | 0.00 | 0.05 | 0.20 | 0.20 | 0.00 | 0.00 | 0.20 | 0.50 | 0.50 | 0.00 | 0.70 | 0.00 | 0.15 | 0.60 | 0.00 |
| | LT(7) | 20 | | 0.00 | 0.00 | 0.20 | 0.40 | 0.00 | 0.50 | 0.00 | 0.50 | 0.00 | 0.00 | 0.50 | 0.00 | 0.75 | 0.00 | 0.50 |
| | TD(3D) | 54 | | 0.00 | 0.28 | 0.41 | 0.63 | 0.00 | 0.46 | 0.20 | 0.61 | 0.09 | 0.00 | 0.38 | 0.00 | 0.33 | 0.28 | 0.26 |
| | TOTAL | 92 | | 0.00 | 0.17 | 0.32 | 0.49 | 0.00 | 0.37 | 0.16 | 0.56 | 0.16 | 0.00 | 0.49 | 0.00 | 0.38 | 0.29 | 0.26 |
| Harummanis | H | 10 | | 0.00 | 0.60 | 0.00 | 0.00 | 0.00 | 0.90 | 0.00 | 1.00 | 0.00 | 0.00 | 0.50 | 0.90 | 0.00 | 0.00 | 0.00 |
| | LT(7) | 21 | | 0.00 | 0.86 | 0.00 | 0.29 | 0.00 | 0.33 | 0.00 | 1.00 | 0.24 | 0.00 | 0.19 | 0.29 | 0.14 | 0.00 | 0.00 |
| | TD(3D) | 18 | | 0.00 | 0.78 | 0.00 | 0.44 | 0.00 | 0.00 | 0.00 | 1.00 | 0.00 | 0.00 | 0.67 | 0.00 | 0.67 | 0.00 | 0.00 |
| | TOTAL | 49 | | 0.00 | 0.78 | 0.00 | 0.29 | 0.00 | 0.33 | 0.00 | 1.00 | 0.10 | 0.00 | 0.43 | 0.31 | 0.31 | 0.00 | 0.00 |
| Hj. Bakar | H | 12 | | 0.00 | 0.00 | 0.42 | 0.42 | 0.67 | 0.00 | 0.62 | 0.00 | 1.00 | 0.75 | 0.25 | 0.00 | 0.58 | 0.00 | 0.25 |
| | TD(3D) | 5 | | 0.00 | 0.00 | 0.80 | 0.40 | 0.20 | 0.00 | 0.80 | 0.00 | 1.00 | 0.80 | 0.20 | 0.00 | 0.60 | 0.00 | 0.60 |
| | TOTAL | 17 | | 0.00 | 0.00 | 0.52 | 0.41 | 0.35 | 0.00 | 0.71 | 0.00 | 1.00 | 0.76 | 0.23 | 0.00 | 0.59 | 0.00 | 0.35 |
| Irwin | H | 10 | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.70 | 0.80 | 0.80 | 0.00 | 0.00 | 1.00 | 0.00 | 0.30 | 0.00 | 0.00 |
| | TD(3D) | 5 | | 0.60 | 0.00 | 0.00 | 0.20 | 0.00 | 0.80 | 0.80 | 1.00 | 0.00 | 0.60 | 0.60 | 0.00 | 0.40 | 0.00 | 0.60 |
| | TOTAL | 15 | | 0.20 | 0.00 | 0.00 | 0.06 | 0.00 | 0.73 | 0.80 | 0.87 | 0.00 | 0.20 | 0.87 | 0.00 | 0.33 | 0.00 | 0.20 |
| Kent | H | 11 | | 0.00 | 0.27 | 0.00 | 0.55 | 0.00 | 0.00 | 1.00 | 1.00 | 0.82 | 0.00 | 0.00 | 0.00 | 0.82 | 0.00 | 0.00 |
| | TOTAL | 11 | | 0.00 | 0.27 | 0.00 | 0.55 | 0.00 | 0.00 | 1.00 | 1.00 | 0.82 | 0.00 | 0.00 | 0.00 | 0.82 | 0.00 | 0.00 |
| Malgoa | H | 21 | | 0.48 | 0.52 | 0.00 | 0.29 | 0.00 | 0.52 | 0.43 | 0.00 | 0.48 | 0.48 | 0.43 | 0.00 | 0.76 | 0.43 | 0.24 |
| | LT(7) | 20 | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.25 | 0.60 | 0.40 | 0.25 | 0.80 | 0.00 | 0.50 | 0.00 | 0.30 |
| | TD(3D) | 17 | | 0.41 | 0.59 | 0.00 | 0.71 | 0.00 | 0.00 | 0.82 | 0.70 | 0.47 | 0.47 | 0.24 | 0.00 | 0.71 | 0.00 | 0.41 |
| | TOTAL | 58 | | 0.29 | 0.36 | 0.00 | 0.39 | 0.00 | 0.18 | 0.48 | 0.24 | 0.45 | 0.39 | 0.50 | 0.00 | 0.66 | 0.16 | 0.31 |

TOTAL N = 244
(H = Horticulture unit, LT = Farm Seven, TD = Farm Three D)

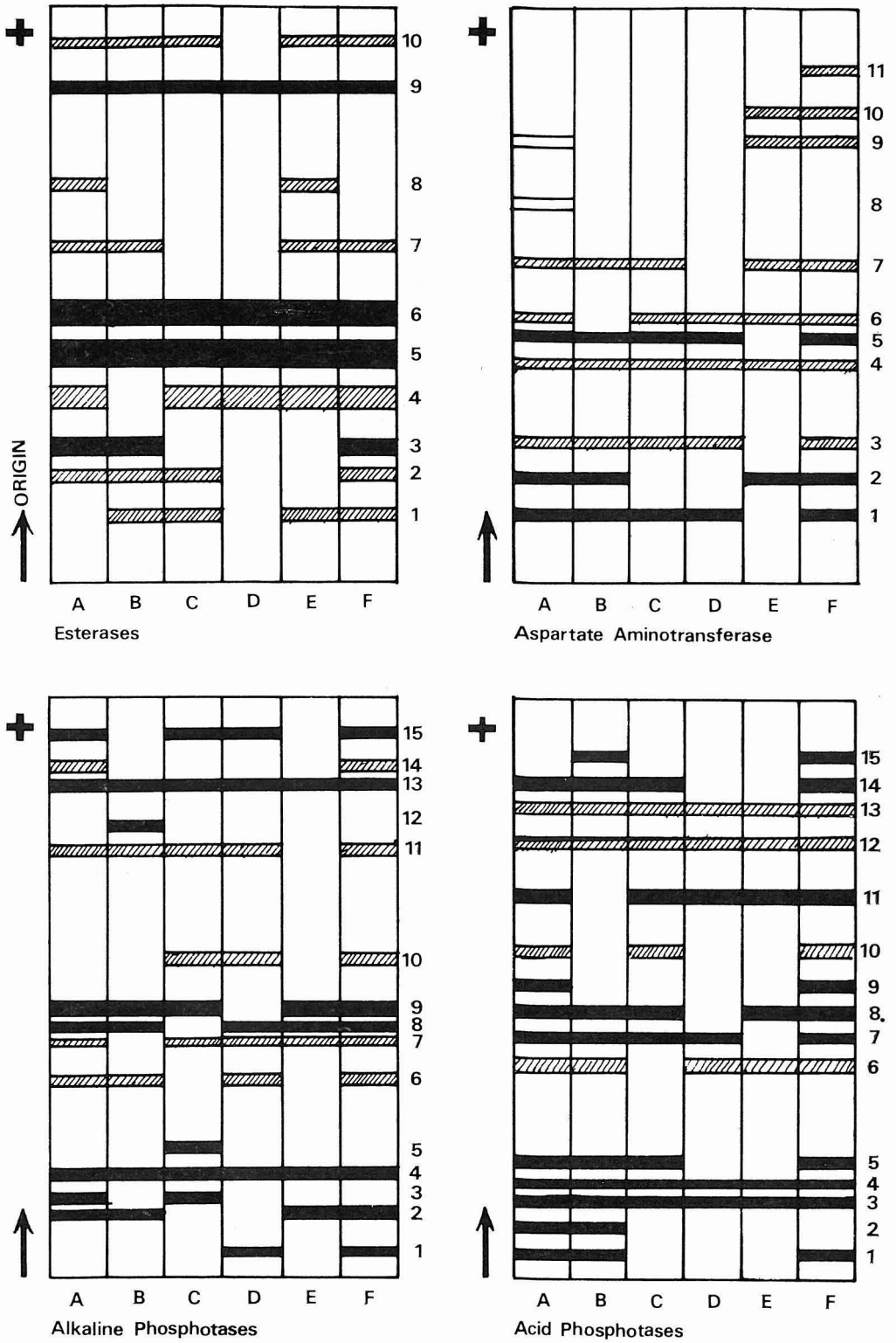


*Figure 1. The zymograms of esterases, aspartate aminotransferases, acid and alkaline phosphatases of the six clones of mango. A – Apple, B – Harummanis, C – Hj. Bakar, D – Irwin, E – Kent, F – Malgoa.*

From the records of the Farm Office of the University, the sources of the origin of the different 'clones' of mango were obtained from different locations throughout Malaysia. This may probably give rise to the chaotic classification of 'clones'.

Our results here strongly suggest that the samples studied do not belong to the same clone. We propose that the term 'varieties' should be used instead of 'clones'.

This wide degree of variation is unlikely to be due to environmental factors, since precautions have been taken in the collection of the samples, although soil texture, irrigation, extremes of climate and fertiliser treatments could bring about significant alteration of the protein patterns (Coulson and Sim, 1964; Watson and Gail, 1981a). Furthermore the three sampling sites are very close to each other, all within a distance of less than 1 km. This is further substantiated by the fact that even individuals of the same 'clone' collected from the same sampling site also exhibit a wide range of variation. We thus conclude that this variation was due to intravarietal differences. Intravarietal or intraspecies differences are common in population genetic studies where the variation in allelic frequencies in different loci are usually calculated.

In comparison with the present studies, Brown *et al.* (1978) have evaluated the potential genetic resources of the wild relatives of crop plants. They have surveyed the intravarietal isozyme variation at 28 loci of 28 populations of wild barley *(Hordeum spontaneum)*. They reported that the enzyme loci exhibited a great range of polymorphism. The allozyme diversity was apportioned into 17% between regions, 32% between populations within regions, and 51% within populations.

In this study, unfortunately, we were unable to calculate the allozyme allelic frequency since we did not have the breeding experiment data. However, it is obvious that from the variation in band frequencies of all the enzymes studied, the results indicate that *Mangifera indica* too represents very rich reserves of genetic variability which in turn will provide a wide spectrum for the selection of desirable types from the germplasm.

Table 6 summarises the number of polymorphic and monomorphic bands found in *Mangifera indica*. When a particular band was present in all individuals, this band was considered to be monomorphic. However, when a band was present in some individuals and absent in others, this particular band was considered as polymorphic. It was found to have 190 polymorphic bands and only 11 monomorphic bands in this species surveyed. This high degree of variation may be due to its wide range of origin from different parts of Asia.

TABLE 6
Numbers of polymorphic and monomorphic bands found in *Mangifera indica*

| Varieties | N | Monomorphic bands | Polymorphic bands |
|---|---|---|---|
| Apple | 94 | – | 42 |
| Malgoa | 58 | – | 42 |
| Harummanis | 49 | 3 | 30 |
| Hj. Bakar | 17 | 1 | 31 |
| Irwin | 15 | 3 | 21 |
| Kent | 11 | 4 | 24 |
| Total | 244 | 11 | 190 |

So far, studies in the genetic variation within species have been done extensively in animal species. In plants, very few surveys have been reported. Pioneer studies were reported by Marshall and Allard (1970a; 1970b) and Clegg and Allard (1973). They have found clear polymorphism in the two species of wild oats, *Avena barbata* and *Avena fatua,* despite the fact that these are strongly inbreeding species. However, Solbrig (1972) found less allozymic variation in self compatible, and presumably to some extent, self-pollinated species of *Leavenworthia* (Eruciferae) than in obligatory outbreeding species.

For the study of genetic variation of tropical plants, Gan *et al.* (1977) showed that the estimate for the proportion of polymorphic loci in *Shorea leprosula* was in the range of 0.5-0.6, and it was 0.3 for *Xerospermum intermedium.* Gan (unpublished) also found a high level of polymorphism in the tropical plants *Elaeis guineensis* (oil palm) and *Nephelium lappaceum* (rambutan). It will be very interesting to compare the level of polymorphism between tropical plants and temperate plants when more data are available.

In this study one cannot be absolutely certain that the different root stocks of the different *Mangifera* species had no effect on the genetic constituents of the resulting adult plants; the possibility that the high degree of polymorphism may have been caused by the use of different root stocks cannot be ruled out completely. Further

research on the genetic variation of the plants growing from grafted buds collected from a single parent as well as on the different species of *Mangifera* as the root stocks is called for.

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