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VARIABILITY, DIVERGENCE, HETEROSIS, COMBINING ABILITY AND YIELD COMPONENT STUDIES IN SWEET POTATOES (IPOMOEA BATATAS (L) LAM.) FROM SABAH AND SARAWAK, MALAYSIA

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By

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TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

Abstract of dissertation submitted to the Senate of Universiti Pertanian Malaysia in fulfillment of the requirements for the degree of Doctor of Philosophy.

VARIABILITY, DIVERGENCE, HETEROSIS, COMBINING ABILITY AND YIELD COMPONENT STUDIES IN SWEET POTATOES (*Ipomoea batatas* (L) Lam) FROM SABAH AND SARAWAK, MALAYSIA

By

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Supervisor: Professor Yap Thoo Chai

Faculty: Agriculture

Studies were conducted to examine the breeding potential of the Malaysian indigenous sweet potato germplasm. A total of 99 sweet potato accessions was collected from five different regions in the states of Sabah and Sarawak, Malaysia. A total of 220 polycross progenies was obtained from sixteen randomly chosen accessions planted in a polycross block. The 99 accessions and their 220 progenies were evaluated in the field and 16 characters were measured. With the exception of plant type and vine thickness, other characters showed more than 20% CV values. The CV values for yield, tuber number and mean tuber weight were 76%, 57% and 48%, respectively. The means and CV's were similar for all characters between the regions indicating the presence of similar sweet potato type in all the regions. Cluster analysis showed the presence of three main groups of sweet potatoes in the states. Group 1 comprised cultivars with low yield.

Cultivars in Group 2 were high yielding with spreading plant type. The third group comprised only six cultivars with orange flesh colour, big leaves, semi-compact plant type and slightly lower yield. The mean, range and CV values for all characters studied were much larger for the polycross progenies as compared to the parents. Cluster analysis showed the presence of seven groups among the progenies indicating the formation of new genotypes as a result of outcrossing. Gene interactions in the new genotypes probably have led to the presence of larger means and ranges of many characters.

Analysis on diallel cross among six sweet potato accessions with different D^2-value showed the presence of more than 40% heterosis from many cross combinations for yield characters. With a few exceptions, most crosses showed less than 20% heterosis for morphological characters. The heterosis expressions for both yield and morphological characters showed no clear relation with D^2-values (divergence), differences between parental values, physical distance (km), longitude and latitude. The results indicated that heterosis expression did not depend on overall genetic divergence and different genes probably had different divergence levels depending on their response to eco-geographical variables.

The results of combining ability analyses showed significant GCA and SCA for yield, tuber number and mean tuber weight indicating the importance of both additive and non-additive gene actions for these characters. However, the GCA variances for yield and mean tuber weight were much larger than their respective SCA variances, whereas the SCA variance for tuber number was six times larger than it's GCA variance. Plant type, growth rate, internode length, vine thickness, leaf lobbing and petiole thickness showed significant difference only for SCA but not GCA. Significant difference for GCA was found for leaf size only but not for both GCA and SCA for petiole length. The results revealed that GCA was more prevalent in yield, mean tuber weight and leaf size. SCA was more important for tuber number, plant type, growth rate, internode length and leaf lobbing.

Correlation studies failed to relate yield with other agronomic characters. Regression analysis showed that leaf lobbing was the third important yield contributing character besides tuber number and mean tuber weight. Number of tubers per plant and mean tuber weight were the two main components of yield. Yield in sweet potatoes was determined by the following formula, Yield = -0.387 + 2.684 mean tuber weight + 0.159 tuber number - 0.032 leaf lobing.

The findings showed that a substantial amount of genetic variability and genetic divergence occurred in the local sweet potatoes. Exploitation of heterosis through biparental crossing between selected parents is a good approach for breeding this crop. Selection of parents, however, should not base solely on the divergence of the two parents but their combining ability should also be considered.

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KAJIAN KEPELBAGAIAN, PERCAPAHAN, HETEROSIS, KEUPAYAAN BERGABUNG DAN KOMPONEN HASIL TANAMAN KELEDEK (*Ipomoea batatas* (L) Lam) DARI SABAH DAN SARAWAK, MALAYSIA

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Kajian telah dilakukan untuk menentukan potensi germplasma tanaman keledek tempatan Malaysia. Sebanyak 99 aksesi telah diperolehi dari lima wilayah di negeri Sabah dan Sarawak, Malaysia. Seterusnya, 220 progeni polikacukan didapati dari 16 aksesi yang diperolehi secarak rawak dari himpunan germplasma tersebut yang ditanam dalam blok polikacukan. Semua 99 aksesi dan 220 progeni polikacukan tersebut telah diuji di ladang dan data diperolehi dari 16 sifat. Semua sifat yang dikaji, kecuali bentuk pokok dan tebal batang, menunjukkan nilai CV yang melebihi 20%. Sifat hasil mempunyai nilai CV yang tinggi iaitu 76% untuk hasil, 57% untuk bilangan ubi dan 48% untuk purata berat ubi. Nilai purata dan CV untuk semua sifat yang dikaji adalah hampir sama bagi kelima-lima wilayah tersebut. Ini menunjukkan bahawa tiap wilayah mempunyai jenis keledek yang serupa. Analisis kelompok membahagikan germplasma keledek tersebut kepada tiga kumpulan. Kumpulan 1 terdiri dari varieti yang berhasil

rendah. Varieti dari Kumpulan 2 berhasil tinggi dan mempunyai bentuk pokok yang merayap. Kumpulan 3 terdiri dari hanya enam varieti yang semuanya mempunyai ubi bewarna oren, saiz daun yang lebar, bentuk pokok merumpun dan mempunyai hasil yang rendah. Nilai purata, julat dan CV sifat-sifat yang dikaji adalah lebih tinggi di kalangan progeni polikacukan berbanding induknya. Analisis kelompok membahagikan progeni tersebut kepada tujuh kumpulan. Ini menunjukkan genotip baru terbentuk hasil dari kacukan. Saling tindakan gen dalam genotip baru tersebut mungkin menyebabkan wujudnya nilai purata dan julat yang lebih besar untuk kebanyakan sifat dikalangan progeni tersebut.

Keputusan analisis kacukan dwialel menggunakan enam aksesi keledek dengan nilai D^2 yang berlainan, menunjukkan heterosis sifat hasil yang melebihi 40%. Untuk sifat morfologi, kecuali beberapa kombinasi kacukan, kebanyakan kacukan memberikan nilai heterosis yang kurang dari 20%. Heterosis untuk sifat hasil dan morfologi tersebut tidak mempunyai hubungan nyata dengan nilai D^2 (percapahan), perbezaan nilai induk, perbezaan jarak fizikal (km), longitud dan latitud. Ini menunjukkan heterosis tidak bergantung sepenuhnya kepada percapahan menyeluruh genetik induk dan gen mengalami kadar percapahan yang berbeza bergantung kepada tindak-balasnya terhadap pembolehubah eko-geografi.

Analisis keupayaan bergabung memberikan nilai GCA dan SCA yang bermakna untuk sifat hasil, bilang ubi dan purata berat ubi. Ini menunjukkan kedua-dua tindakan gen menambah dan gen tak-menambah memainkan peranan dalam menentukan hasil keledek. Walau bagaimanapun, nilai varians GCA hasil dan purata berat ubi adalah lebih besar berbanding nilai varians SCA nya, sebaliknya nilai varians SCA untuk bilangan ubi pula adalah lebih besar dari varians SCA. Untuk bentuk pokok, kadar pertumbuhan, panjang ruas, tebal batang, bentuk cuping daun dan tebal tangkai daun hanya SCA yang bermakna. Nilai GCA yang bermakna hanya dari luas daun. Kedua-dua GCA dan SCA untuk panjang tangkai daun tidak bermakna. Keputusan ini menunjukkan bahawa GCA penting untuk sifat hasil, purata berat ubi dan luas daun, manakala SCA lebih penting untuk bilangan ubi, bentuk pokok, kadar pertumbuhan, panjang ruas and bentuk cuping daun.

Kajian korelasi gagal menunjukkan perhubungan antara sifat hasil dengan sifat agronomi yang lain. Analisis regrasi mendapati bahawa bentuk cuping daun adalah sifat penyumbang hasil yang ketiga penting disamping bilangan dan purata berat ubi yang merupakan dua sifat penyumbang hasil yang utama. Hasil keledek ditentukan oleh formula berikut, hasil = - 0.387 + 2.684 berat ubi + 0.159 bilangan ubi - 0.032 bentuk cuping daun.

Keputusan kajian ini menunjukkan masih wujud kepelbagaian yang besar dikalangan keledek tempatan. Memperolehi heterosis melalui kacukan antara dua induk terpilih merupakan kaedah yang sesuai untuk membiakbaka tanaman ini. Walau bagaimanapun, memilih pokok induk harus berdasarkan tidak hanya pada kadar percapahan genetik tetapi juga kepada keupayaan bergabung antaranya.

CHAPTER 1

INTRODUCTION

The sweet potato, *Ipomoea batatas* (L.) Lam., is the second important tuberous food crop in the world after the Irish white potato, *Solanum tuberosum* (Horton, 1987). The crop is grown in more than 100 countries (Horton, 1989) with different climatic conditions located between 15°S and 45°N (MacKay, 1989). The sweet potato tuber is a staple food in Papua New Guinea, Irian Jaya (Indonesia), Vietnam and some parts of China (MacKay, 1989). In Taiwan, it is used as animal feed (Yeh, 1982). In Japan, 40% of sweet potato tubers are for table food and about 30% as the material for starch production (Kobayashi and Sakamota, 1988). In many developing countries the tips of the sweet potato vines are also consumed as vegetable (Villareal, 1982).

In Malaysia, sweet potato is normally grown in small scale, with the average farm size of less than 0.1 hectare (Saad and Yap, 1986). However, farms with more than 10 hectares in size are found in the states of Kedah, Johore, Kelantan and Pahang. In Kelantan, sweet potato is planted alternate to tobacco and rice and in Kedah sweet potato is planted under young rubber trees as an intercrop. There are more than 7,000 hectares of sweet potato in Malaysia (Khelikuzzaman and Saad, 1987).

Research on sweet potato improvement is very limited in Malaysia. There is no established variety in the country. Most farmers grow their own cultivars (Saad and Yap, 1986). These cultivars are normally selected from several cultivars obtained from other farmers or their friends. Nevertheless, some advanced farmers have brought in superior varieties from other countries such as China and Indonesia. Sweet potato breeding in the past was only confined to screening of cultivars from the collections. From 1948 to 1969, a total of 44 varieties was evaluated by the Department of Agriculture. Four of them namely Large white, Serdang-1, Hoey Tong and Empat Bulan were recommended for planting. However, these varieties were not popular among the farmers. In the early 1980's, Malaysian Agricultural Research and Development Institute (MARDI) had collected more than 500 sweet potato accessions from Peninsular Malaysia (Khelikuzzaman, 1986). Evaluation on part of the germplasm resulted in one variety named Bukit Naga. However, later trials showed that this variety yielded 25% lower than the AVRDC variety, CN 941-32 (Khelikuzzaman and Saad, 1987).

Evidently, the full potential of the local sweet potato germplasm has to be fully exploited. Selecting the best local varieties is undoubtedly the most important step in a breeding programme. However, the potential of the germplasm cannot be fully exploited until hybridization is done. Hybridization allows formation of new segregating genotypes. Furthermore, if the right parents are used one might be able to exploit the heterosis and more vigorous hybrids can be produced through vegetative propagation. In Malaysia, some prominent varieties of other crops are derived from crosses between parents from locally adapted, indigenous cultivars or from overseas. However, in sweet potato, breeding by hybridization has yet to be started in Malaysia.

The objectives of the study were to determine the variability and divergence in relation to heterosis, inter-relationship among agronomic characters and at the same time also try to get information on combining ability of some genotypes of the characters studied in order to set up the sweet potato breeding programme in Malaysia.

CHAPTER 2

LITERATURE REVIEW

Status of Sweet Potatoes

Area, Production and Distribution

The sweet potato originated in the New World. However, the main growing areas are in Asia and Oceania. In 1987, there were 8.6 million hectares planted with sweet potatoes in the world producing about 116 million tons of tubers (Mackay, 1989). According to Horton (1988), about 80% of the sweet potato areas are in Asia, 15% in Africa and about 6% in the rest of the world. China, the main sweet potato producing country, produced 94 million tons of sweet potato tubers per year from 6.9 million hectares (MacKay, 1989), followed by Vietnam (500,000 hectares) (Mai, 1989), Indonesia (325,000 hectares), India (212,000 hectares), the Philippines (191,000 hectares) and Papua New Guinea (102,000 hectares) (Mackay, 1989). Japan has about 65,000 hectares of sweet potato with the annual production of 14 million tones. This is the only developed country which produces a substantial amount of sweet potato.