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PERFROMANCE AND STABILITY OF GRAIN MAIZE GENOTYPES IN PENINSULAR MALAYSIA

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BY

THAN DA MIN

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Doctor of Philosophy

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DEDICATION

TO MY BELOVED PARENT, SISTERS, SUPPORTIVE HUSBAND AND SON

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

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Chairman : Professor Ghizan Saleh, Ph. D.

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In plant breeding programmes, potential genotypes are usually evaluated in different environments (locations and years) before desirable ones are selected. Genotype x environment (G x E) interaction is associated with the differential performance of materials tested at different locations and in different years, and influences selection and recommendation of cultivars. Highly stable genotypes are desirable. Furthermore, spatial variability on soil properties and crop yield has been one of the major objectives in investigations related to agriculture production. Performance and stability of grain maize (*Zea mays* L.) genotypes were evaluated at four locations in Peninsular Malaysia *viz.* Padang Rengas (Perak), Rhu Tapai (Terengganu), Sungai Udang (Melaka) and UPM, Serdang (Selangor), in two years.

The objectives of this study were: (1) to determine the performance of 14 grain maize genotypes for grain yield and yield components at the four locations in two years, (2) to evaluate the G x E interaction effects, (3) to identify high yielding genotypes at each location and their stability by using different stability parameters, (4) to evaluate the

spatial variability of soil N, P and K, plant N, P and K, and their influence on grain yield, and (5) to investigate the relationship among grain yield and soil and plant nutrient variables.

The experiments at the locations were arranged in a randomized complete block design (RCBD) with four replications. Recommended agronomic practices were used at each location. Evaluations were conducted from June 2000 to March 2002. Genotype and G x E interaction effects were highly significant, indicating high variability among genotypes, and genotypes responded differently to the changing environments. Among the 14 genotypes evaluated, GxA, Selected GxA, SC-2, Putra J-58 and TWC-4 revealed high performance and have good potential to be used as source populations for future breeding programmes. Comparing performance of genotypes for grain yield and yield components, Selected GxA was found to have the highest grain yield (5726 kg ha^{-1}), shelling percentage (84.9 %), 100-grain weight (25.5 g) and ear weight per plant (149.5 g), earliest in flowering (50.6 days to tasseling, and 53.2 days to silking) and longest ears (15.5 cm). TWC-2 was found to be earliest to mature. SC-3 revealed the shortest plants, while Suwan 1 was the tallest and was late in maturity. The highest ear diameter was observed on SC-1. Terengganu in 2000 was found to be the most favourable environment, as shown by its highest environmental index.

Different methods of stability analyses were used, which include comparison of mean values, regression coefficient (b_i), deviation from regression (s^2_d), coefficient of determination (R^2), environmental variance (s^2), Wricke's ecovalence (W_i), Shukla's stability variance (σ^2_i) and genotype grouping involving coefficients of variation (CV).

Different methods were consistent with each other in revealing the stability of the genotypes. Selected GxA was identified as having the highest grain yield and most stable in performance, followed by DC-1, while SC-2 was the lowest yielding and most unstable genotype. Some genotypes revealed specific adaptability to specific locations, such as GxA in Perak, Putra J-58 in Terengganu and Selected GxA in Melaka and Selangor. This experiment led to the identification and possible release of a new, high yielding and stable grain maize synthetic variety, Selected GxA.

Broad-sense heritability estimates on the genotypes were moderate for grain yield in the year 2001 evaluation and years combined, and also for ear length, ear diameter and number of kernel rows per ear in each year and years combined. These indicate that genetic factors had moderate effects on the control of grain yield, ear length, ear diameter and number of kernel rows per ear in the population of genotypes.

In addition to the evaluation on genetic stability, spatial variability for grain yield and leaf and soil chemical properties were also evaluated at the four locations, where, different patterns of spatial variability for grain yield, and leaf and soil chemical properties were observed in the fields at all locations. The analysis also revealed that percent variability in grain yield variation was associated with soil N, P and K and leaf P contents. Grain yield was particularly positively correlated with soil P and K contents.

The results also indicate the effectiveness of site-specific soil management such as reduced fertilizer applications to increase grain yield through minimizing yield variation in grain maize fields. In addition, soil and plant N, P and K analyses provided some information on genotype x environment interaction effect.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia bagi memenuhi keperluan untuk ijazah Doctor Falsafah.

PRESTASI DAN KESTABILAN GENOTIP JAGUNG BIJIAN DI SEMENANJUNG MALAYSIA

Oleh

THAN DA MIN

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Dalam program pembiakbakaan tumbuhan, genotip-genotip yang berpotensi biasanya dinilai di pelbagai persekitaran (lokasi dan tahun) sebelum genotip yang diingini dipilih. Interaksi genotip x persekitaran (G x E) berkait rapat dengan perbezaan prestasi bahan yang dikaji di pelbagai lokasi dan tahun, dan ianya mempengaruhi pemilihan dan pengesyoran kultivar. Genotip yang mempunyai kestabilan yang tinggi adalah diingini. Tambahan pula, perbezaan kawasan atas sifat-sifat tanah dan hasil tanaman merupakan salah satu objektif utama dalan penelitian berkaitan dengan pengeluaran tanaman. Prestasi dan kestabilan genotip jagung bijian (*Zea mays* L.) telah dinilaikan di empat lokasi di Semenanjung Malaysia, iaitu Padang Rengas (Perak), Rhu Tapai (Terengganu), Sungai Udang (Melaka) dan UPM, Serdang (Selangor), selama dua tahun.

Objektif kajian ini adalah (1) untuk menentukan prestasi 14 genotip jagung bijian bagi hasil bijian dan komponen hasil di empat lokasi selama dua tahun, (2) untuk menilai kesan interaksi genotip dan persekitaran (G x E), (3) untuk menentukan genotip berhasil tinggi di setiap lokasi serta kestabilannya dengan menggunakan beberapa parameter kestabilan, (4) untuk menilai perbezaan kawasan dalam kandungan N, P dan K tanah serta pokok, dan pengaruhnya terhadap

hasil bijian, dan (5) untuk mengkaji perhubungan di antara hasil bijian dan pembolehubah nutrien dalam tanah dan pokok.

Eksperimen di lokasi-lokasi tersebut disusun mengikut rekabentuk blok berawak penuh (RCBD) dengan empat replikasi. Amalan agronomi yang disyorkan telah digunakan di setiap lokasi. Penilaian dijalankan mulai Jun 2000 hingga Mac 2002. Kesan genotip dan interaksi G x E adalah sangat bererti, menunjukkan variasi yang tinggi di kalangan genotip, dan genotip memberikan respon yang berbeza di persekitaran yang berlainan. Di kalangan 14 genotip yang dinilai, GxA, Selected GxA, SC-2, Putra J-58 dan TWC-4 menunjukkan prestasi yang tinggi dan mempunyai potensi yang baik untuk digunakan sebagai populasi sumber bagi program pembiakan di masa depan. Melalui perbandingan prestasi genotip bagi hasil bijian dan komponen-komponen hasil, Selected GxA didapati memperolehi hasil bijian (5726 kg ha^{-1}), peratus peleraian (84.9 %), berat 100-biji (25.5 g) dan berat tongkol sepokok (149.5 g) yang tertinggi, berbunga lebih awal (50.6 hari pentaselan dan 53.2 hari perambutan) dan memperolehi tongkol terpanjang (15.5 cm). TWC-2 didapati matang paling awal. SC-3 menunjukkan pokok-pokok yang terendah, manakala pokok-pokok dari Suwan 1 adalah yang tertinggi dan matang lewat. Garispusat tongkol paling besar dilihat pada SC-1. Terengganu dalam tahun 2000 merupakan persekitaran terbaik, sebagaimana ditunjukkan oleh indeks persekitarannya yang tertinggi.

Beberapa kaedah analisis kestabilan yang berbeza telah digunakan, yang meliputi perbandingan nilai min, pekali regresi (b_i), sisihan dari regresi (s^2_d), pekali penentuan (R^2), varians persekitaran (s^2), ekovalen Wricke (W_i), varians kestabilan Shukla (σ^2_i) dan penghimpunan genotip melibatkan pekali variasi (CV). Kaedah-kaedah tersebut memperlihatkan kestabilan genotip secara konsisten. Selected GxA telah dikenalpasti memberikan hasil bijian tertinggi dan paling stabil dalam prestasi, diikuti oleh DC-1, manakala SC-2 adalah genotip yang paling rendah hasilnya, dan paling tidak stabil. Terdapat genotip yang boleh mengubahsuai kepada lokasi tertentu, seperti GxA di Perak, Putra J-58 di Terengganu, dan Selected GxA di Melaka dan Selangor. Kajian ini dapat mengenalpasti dan memberi kemungkinan menghasilkan varieti jagung bijian sintetik yang baru, berhasil tinggi dan stabil, iaitu Selected GxA.

Anggaran kebolehwarisan luas pada genotip adalah sederhana untuk hasil bijian pada tahun penilaian 2001 dan gabungan tahun, dan juga untuk panjang tongkol, garispusat tongkol dan bilangan baris biji setongkol pada setiap tahun dan gabungan tahun. Ini menunjukkan bahawa faktor genetik mempunyai kesan sederhana terhadap pengawalan hasil bijian, panjang tongkol, garispusat tongkol dan bilangan baris bijian setongkol dalam populasi genotip tersebut.

Tambahan kepada penilaian terhadap kestabilan genetik, perbezaan kawasan terhadap hasil bijian dan sifat-sifat kimia dalam daun dan tanah juga dikaji pada keempat-empat lokasi tersebut, di mana corak perbezaan kawasan yang berbeza bagi hasil bijian dan sifat-sifat kimia daun dan tanah dilihat di ladang di semua lokasi. Analisis ini juga menunjukkan bahawa peratus perbezaan dalam hasil bijian adalah berhubungkait dengan kandungan N, P dan K dalam tanah, serta kandungan P dalam daun.

Keputusan juga memperlihatkan keberkesanan pengurusan tanah secara khusus tempat seperti mengurangkan pemberian baja untuk meningkatkan hasil bijian dengan merendahkan variasi hasil dalam ladang jagung bijian. Tambahan pula, analisis N, P dan K dalam tanah dan pokok memberikan maklumat terhadap kesan interaksi genotip x persekitaran.

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LIST OF ABBREVIATIONS

FAO	Food and Agriculture Organization
CIMMYT	International Maize and Wheat Improvement Center
UPM	Universiti Putra Malaysia
MARDI	Malaysia Agricultural Research and Development Institute
b_i	Regression coefficient
s^2_d	Deviation from regression
s^2	Environmental variance
h^2_B	Broad-sense heritability
R^2	Coefficient of determination
W_i	Ecovalence
σ^2_i	Stability variance
E_i	Environmental index
CV	Coefficient of variation
Σ	Summation
χ^2	Chi-square
GIS	Geographic Information System

CHAPTER 1

INTRODUCTION

Maize (*Zea mays* L.) is a well-known cereal throughout the world. It is an annual, monoecious grass, grown mainly for food, feed and industrial raw materials. It is also an important source of raw materials for extraction of oil, sugar, syrups, starch and other products (Dowswell *et al.*, 1996).

Maize, with its large number of cultivars of different maturity periods can be grown over a wide range of environmental conditions. It is known for its versatile nature and tremendous genetic variability, enabling it to grow successfully throughout the world. In Asia, maize is grown in various environmental conditions, from tropical lowlands at sea level to high elevations in the Himalaya region, and from latitudes of 45° N to 20° S (De Leon and Paroda, 1993).

According to the Food and Agriculture Organization (FAO, 2001), the world's maize productions were 600 million tons, where 39% were from the United States, amounting to 235 million metric tons, 18% from the Peoples Republic of China, with 110 million metric tons, 13% from Brazil, Argentina and Mexico, with 76 million metric tons, while other key areas of production include the Europian Union, India, Indonesia, Canada and South Africa (John, 2001).

In Malaysia, grain maize is grown as a minor crop produced for livestock feed. Grain maize and sweet corn are grown on 21,000 hectares of land, with a total