**THE UTILIZATION OF LAMPUNG PODSOLIC SOIL TO SCREEN SYNTHETICS AND FEMALE SUPERIOR MAIZE HYBRIDS DEVELOPED FROM LOCAL GENETIC SOURCES**

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 **ABSTRACT**

Choosing the field suitable for screening new developed maize hybrids was not an easy assignment. The soil as part of environment in a whole should be as such to not negate gene effects within the hybrids. The soil could be so rich that the inferior hybrids would perform as good as the superior ones, or the soil could be so poor that the superior hybrids would perform less than the inferior but well adapted ones. The development of maize hybrids following single-cross and or double-cross methods was making the seeds expensive for the maize growers and the kinds of hybrid seed available in the markets were limited. After being introducing numerous maize hybrids since 1975 to overcome *Peronoscerospora* disease on maize there were many of obsolete hybrids grown in maize-producing provinces by subsistence growers by reasons of their adaptability to local hindrances such as drought, low soil fertility and pH and plant diseases and insects while maintaining acceptable productivity. The objectives of the study were to utilize Lampung podsolic soils to screen synthetics and female superior maize hybrids developed from local genetic sources from five provinces. The six hybrids were tested for their performances as compared to those of the Pioneer-36 hybrid. The study was done in April – July 2019 at The Lampung State Polytechnics Field in a Randomized Complete Block Design with three replicates. The results indicated the Lampung podsolic soil was suitable to screen the newly developed hybrids and ranked the hybrids to four classes. The performance of the synthetics and the female superior hybrids were in par with those of the Pioneer-36 hybrids measured as time to anthesis 52.67 – 58.33 dap, plant height 139.67 - 180.83 cm, leaf number plant-1 12.33 – 17.00, tassel number plant-1 14.33 – 19.00, ear number plant-1 1.67 – 2.33, ear diameter 3.41 – 4.60 cm, ear seed weight 46.32 – 122.57 g, and seed yield 397.0 – 1050.6 g m-2, respectively. The genetic variation of the traits: anthesis, plant height, leaf number, ear seed weight, and yield m-2; and the concomitant broad-sense heritability were greater than zero which indicated that the traits could be selected for a better progeny performance.

**Keywords**: female-superior hybrid, Lampung podsolic soil, local genetic source, maize breeding, synthetics hybrid.

**I. INTRODUCTION**

The development of maize hybrids in Indonesia was spurred in 1975 to overcome *Peronosclerospora* downy mildew disease. The introduction of the hybrids was extraordinarily fast every year inasmuch draining the source of capable parents. On the other hand there were obsolete hybrids which once were superior hybrids distributed to all over the country could be found everywhere. The obsolete hybrids not managed by breeders any longer but still be planted by farmers due to their perfect adaptation to specific ecological hindrances such as infertile soils, low pH, low water availability, and high resistance to pests and diseases while maintained high yield in par with new hybrids (Hikam *et al*., 2017). After so many years without recombination, obsolete hybrids, or local genetic source (LGS), experienced selfing or sib mating resulted in inbreeding depression. However, in a fields where quite a few hybrids, obsolete and new, were planted together the inbreeding depression was deterred and the hybrids generated open-pollination hybrid progenies which performed comparable with that of new hybrids both in vegetative and yield perspectives.

In this study Hikam *et al*. developed maize hybrids using local genetic sources collected from five provinces. The hybrids were developed following synthetics and female superior recombination (Hikam and Sudrajat, 2010) those were one synthetics and five female superior hybrids. The purpose of the study was to rank the hybrids according to their performance in the field. The field should neither be too rich or too poor which could negate its power in the selection due to environment factors (Hallauer *et al*., 2010). In a rich environment an inferior hybrid could perform about equal with a more superior one, and in a stressful environment a superior hybrid could perform even less than an inferior-but-well adapted one.

The Lampung podsolic soils would not too desirable to be used as a screen field in a plant breeding program. The soil was of low fertility, low pH due to high Fe, and required irrigation during dry season (Prihastuti and Sudaryono, 2013). These all increased the cost of screening. However Hikam and Sudrajat (2010) and Hikam *et al*. (2017) had been using Lampung podsolic soils for some times to screen maize and rice lines they developed. With addition fertilizers, lime or dolomite, and irrigation, the soil was satisfied in screening for promising new lines.

**II. MATERIALS AND METHODS**

**2.1 Site and Time of Study**

The study was done at The Lampung State Polytechnics Field in Bandar Lampung in March – July 2019. The soil was classed a Red-Yellow Podsolic.

**2.2 Method of Planting**

There were one Synthetics and five Superior Female Hybrids: SFH1, SFH2, SFH3, SFH4, and SFH5 recombined from female parent from Padang, Palembang, Lampung, Jogjakarta, and West Kalimantan local genetic sources, respectively. The six hybrids were compared for their performances to Pioneer 36 (P36) a national certified hybrid as control.

The hybrids and the control were planted in a Randomized Complete-Block Design with three replicates. The hybrids were planted in a two-row plot of 2 m long at 20 cm X 70 cm (71400 plants ha-1). The plants were fertilized with urea, TSP, and KCl at dose of 400, 100, and 100 kg ha-1, respectively. The field was sprinkle irrigated in addition to low rainfalls.

**2.3 Sampling and Data Collection**

Five out of 22 plants from each plot were sampled. Sampled plants were taken from both rows in each plot, two or three plants row-1 following randomization. Data were taken at anthesis as time to anthesis (days after planting; dap), plant height (cm), leaf number plant-1, and tassel number plant-1; and after harvest as ear position (% plant height), ear number plant-1, ear diameter (cm), ear seed weight (g), and yield m-2 (g).

**2.4 Data Analyses**

Data was analyzed using analysis of variance to find traits different from their grand mean at P> 0.05 or P> 0.01. The analyses continued on to analysis of means following Tukey’s HSD0.05 to construct the rank of each hybrid as compared to the control P36 hybrid.

The mean squares of the analysis of variance were used to predict the values of genetic variation, broad-sense heritability, and genetic coefficient of variation followed Hikam *et al*. (2017) as presented in Table 1.

Table 1. Calculating genetic variation, broad-sense heritability, and genetic coefficient of variation based on the mean squares of the analysis of variance.

|  |  |  |  |
| --- | --- | --- | --- |
| Source of Variation | DF | MS | Expected MS |
| Replicate | DF3 | MS3 |  |
| Hybrid | DF2 | MS2 | σ2 + r σ2g |
| Error | DF1 | MS1 | σ2 |
| Total |  |  |  |

Hence,

Genetic variation (σ2g) ± standard error (se σ2g) =

(MS2 – MS1)/r ± √ [2/r2 X {MS22/(DF2 + 2) + MS12/(DF1 + 2)}]

Broad-sense heritability (h2BS %) ± standard error (se h2BS %) =

(σ2g/ MS2) X 100 ± (se σ2g/ MS2) X 100

Genetic coefficient variation (CVg %) = (√MS1/X̅) X 100

**III. RESULTS AND DISCUSSION**

**3.1 Mean Square Analyses**

Table 2 indicated that hybrids were different (P> 0.05 and P> 0.01) except for tassel number, ear number and ear diameter which informed that the traits were not different with those of the control P36 (Table 2). Tassel number was a typical QTL controlled by multiple genes (Chen *et al*., 2017) so was ear number (Wills *et al*., 2013) and ear diameter (Zhang *et al*., 2010). Apparently the effects of environment on the traits could be disregarded. The data in Table 2 showed that the mean of tassel number, ear number, and ear diameter was 16.19, 2, and 4.01 cm, respectively.

The traits differed for anthesis, plant height, leaf number, ear position, ear seed weight, and yield m-2. However the mean for the traits: 53.48 dap, 172.05 cm, 15.09, 54.04 %, 91.59 g, and 785.03 g, respectively, was as expected as the national standard for maize hybrids (Aqil and Arvan, 2016).

Especially for anthesis of 53.48 dap with period of seed filling averaged at about 28 – 32 days to physiological maturity, explained that the maize plants could harvest at 90 – 100 dap. This

Table 2. The mean square analysis for traits

|  |  |  |
| --- | --- | --- |
| Source of Variation | DF | Mean Squares of |
| Anthesis | Plant Height | Leaf Number | Tassel Number | Ear Position  |
| Replicate | 2 | 7.05 | 433.8 | 3.62\* | 6.33 | 49.1 |
| Hybrid | 6 | 51.87\*\* | 661.74\* | 5.97\*\* | 15.54 | 208.83\*\* |
| Error | 12 | 8.66 | 212.24 | 0.73 | 26.11 | 27 |
| CV % |  | 5.5 | 8.47 | 5.66 | 31.56  | 9.61 |
| Mean  |  | 53.48 | 172.05 | 15.09 | 16.19 | 54.04 |
|  |  | (dap) | (cm) |  |  | (% height) |

|  |  |  |
| --- | --- | --- |
| Source of Variation | DF | Mean Squares of |
| Ear Number | Ear Diameter | Ear Seed Weight | Yield m-2 |
| Replicate | 2 | 0 | 0.01 | 6029 | 443.01 |
| Hybrid | 6 | 0.22 | 0.44 | 1747540\*\* | 128390.73\*\* |
| Error | 12 | 0.22 | 0.22 | 218026 | 16018.25 |
| CV % |  | 23.57 | 11.79 | 16.12 | 16.12 |
| Mean  |  | 2 | 4.01 | 91.59 | 785.03 |
|  |  |  | (cm) | (g) | (g) |

\* and \*\* = differed at P> 0.05 and P> 0.01, respectively.

allowed two planting year-1. For ear position mean of 54.04 % of plant height, or at about mid-stalk, would make it practical to machined harvest. And yield m-2 mean of 785.03 g was equivalent to 7.85 t ha-1.

**3.2 Rank of Lines Evaluated Using Tukey’s HSD0.05**

The data for rank appropriated for each hybrid were presented in Table 3. Although in general the value of hybrid in association with a certain trait was in par with the value expected for national maize hybrids (Aqil and Arvan, 2016). The screened hybrids and its control showed significant differences.

The rank made over all of nine traits on the screened hybrids and its control was classed into four, the first rank being the superior female hybrids SFH2 and SFH3, and the Synthetics which were better than the control P36. The importance of the result as showed by Table 2 and Table 3

Table 3. The rank of hybrids appropriated based on Tukey’s HSD0.05

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Trait | Superior Female Hybrid | Synthetics | P36 | HSD |
| SFH1 | SFH2 | SFH3 | SFH4 | SFH5 |
| Anthesis (dap) |  58.33a |  57.67a |  52.67ab |  52.67ab |  45.67b |  53.33ab | 54.00ab | 8.41 |
| Plant Height (cm) | 172.50ab | 172.67ab | 176.33ab | 180.83ab | 139.67b | 178.67ab | 183.67a | 41.63 |
| Leaf Number |  15.67a |  15.00a |  17.00a |  15.00a |  12.33a |  15.67a | 15.00a | 2.44 |
| Tassel Number |  14.33a |  14.33a |  17.67a |  19.00a |  19.00a |  15.00a | 14.00a | 14.6 |
| Ear Position (% height) |  47.31bc | 52.26abc |  65.76a |  60.57ab | 55.72ab |  56.12ab | 40.54c | 34.12 |
| Ear Number |  1.67a |  2.00a |  2.33a |  1.67a |  2.00a |  2.33a |  2.00a | 1.35 |
| Ear Diameter (cm) |  4.04a |  3.82a |  3.80a |  3.41a |  4.60a |  4.06a |  4.32a | 1.35 |
| Ear Seed Weight (g) |  92.74ab | 122.57a |  98.70ab |  77.11bc |  46.32c | 104.58ab | 99.08ab | 42.19 |
| Yield m-2 (g) |  795.0ab | 1050.6a |  846.0ab |  661.0bc |  397.0c |  896.4ab | 849.3ab | 361.67 |
| Number of “a” | 8 | 9 | 9 | 7 | 5 | 9 | 8 |  |
| Rank | 2 | 1 | 1 | 3 | 4 | 1 | 2 |  |

Values by hybrid were not different when followed by the same letter.

Letter “a” indicated hybrid the best for concomitance trait.

SFH1, SFH2, SFH3, SFH4, and SFH5 were superior female hybrids recombined of female parent from Padang Palembang, Lampung, Jogjakarta, and West Kalimantan local genetic sources, respectively.

was that the Lampung podsolic soil was suitable to screen the newly developed hybrids without excessive amelioration except being given standard fertilization and additional irrigation.

The finding was important since the Red-Yellow Podsolic soils were the majority class of Lampung soil. The low properties of the podsolic soil impeded it to be used in screening newly developed varieties, whether they were maize and any other plant varieties without excessively being given amelioration substances such as organic and/or chemical fertilizers and liming. The difficulties in finding suitable land to screen new varieties would deter the progress in a plant breeding program.

**3.3 Prediction of Genetic Variances, Broad-Sense Heritabilities, and Genetic Coefficient of Variation**

The genetic variance (σ2g) predicted for whether there was large enough genetic differences among the screened hybrids for a certain trait to select for the better hybrids, while

Table 4. The predicted values of σ2g, h2BS, and CVg for all traits

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Trait | σ2g | ± | se σ2g  | h2BS % | ± | se h2BS % | CVg % |
| Anthesis |  14.40\* | ± | 8.71 | 26.30\* | ± | 15.91 | 5.50 |
| Plant Height | 149.83\* | ± | 113.49 | 20.46\* | ± | 15.49 | 8.47 |
| Leaf Number | 1.75\* | ± | 1.00 | 28.11\* | ± | 16.08 | 5.66 |
| Ear Number | 0.00 | ± | 0.05 | 0.00 | ± | 15.67 | 23.45 |
| Ear Position  | 60.61\* | ± | 34.97 | 27.82\* | ± | 16.05 | 9.62 |
| Tassel Number | -3.52 | ± | 4.19 | -14.53 | ± | 17.27 | 31.56 |
| Ear Diameter | 0.07 | ± | 0.08 | 14.29 | ± | 15.27 | 11.70 |
| Ear Seed Weight | 509.84\* | ± | 292.55 | 28.01\* | ± | 16.07 | 0.51 |
| Yield m-2 | 37.46\* | ± | 21.49 | 28.01\* | ± | 16.07 | 16.12 |

\*= the values of σ2g and h2BS were greater than zero at 1X their standard errors.

the broad-sense heritability (h2BS) informed whether or not the trait would perform on the progenies of the selected hybrids when the hybrids were recombined (Hallauer *et al*., 2010). The genetic coefficient of variation (CVg) were used by Hikam *et al*. (2017) to predict the magnitude of gene effect over environmental effect on the performance of a trait. When a CVg value of a trait was ≤ 10 %, it indicated that the gene effect was greater than the environmental effect and the environmental effect could be ignored, whereas when the CVg value was ≥ 10 %, the environmental effect was greater than the gene effect and the environmental effect could not be ignored. Without predicting CVp (phenotypic coefficient of variation) as it was done by Bin Mustafa *et al*. (2014), Hikam *et al*. (2017) would decide to duplicate the study in a different site when the CVg value was ≥ 10 %.

The data in Table 4 showed that the σ2g for traits: anthesis, plant height, leaf number, ear seed weight, and yield m-2; and the concomitant h2BS were greater than zero which indicated that the traits could be used to select for a better progeny performance following the breeder preference. However the CVg for yield m-2 was > 10 % (16.12 %) which indicated that the trait was effected greater by environment than by gene. It was understandable since the yield m-2 quantitatively effected by many genes each gave small effect to the trait.

**IV. CONCLUSIONS**

The study concluded that podsolic soil could be utilized to screen the Synthetics and the Female Superior Hybrid maize recombined from local genetic sources. On the soil, seven out of nine hybrids tested revealed differences although all traits were in range of expectable means as those of the national hybrids. The rank made based on the traits indicated that the Synthetics and two out of five Superior Female Hybrids performed better than the national hybrid used as control. Mean time to anthesis reached at 53.48 dap indicated that the hybrids achieved physiological maturity at 85 – 90 dap, or early mature hybrids. The σ2g for the traits: anthesis, plant height, leaf number, ear seed weight, and yield m-2; and their concomitant h2BS were greater than zero which indicated that the traits could be used to select for a better progeny performance. The best yielders of the screened hybrids were the SFH2 of Palembang female parent, the Synthetics, and the SFH3 of Lampung female parent which yielded 1050.6, 896.4, and 846.0 g m-2 or equal to 10.51, 8.96, and 8.46 t ha-1, respectively.

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