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THE UTILIZATION OF LAMPUNG PODZOLIC 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 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 famers and the types of hybrid seed available in the markets were limited. The objectives of the study were to utilize Lampung podzolic 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 has done in a randomized complete block design with three replicates. The results indicated the Lampung podzolic 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 podzolic soil, local genetic source, maize breeding, synthetics hybrid*

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 it is

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still be planted by farmers due to its perfect adaptation to specific ecological hindrances such as infertile soils, low soil 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 the fields where quite a few hybrids, obsolete and new, the hybrids were planted together the inbreeding depression deterred and generated open-pollination hybrid progenies which performed comparable with that of new hybrids in both vegetative growth and yield perspectives.

The study generated by Hikam and Sudrajat (2010) 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) were a synthetic 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 and Sudrajat, 2010). In a rich environment**,** an inferior hybrid could perform about equal with a more superior one. However, the superior hybrid could perform poor in a stressful environment with well adapted.

The Lampung podzolic soils would not too desirable to be used as a screen field in a plant breeding program. The soil is low fertility, low pH due to high Fe, and required an irrigation during dry season (Prihastuti and Sudaryono, 2013). These all characteristics increased the cost of screening. However, Hikam and Sudrajat (2010) and Hikam et al. (2017) had been using Lampung podzolic 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.

METHODS

The study was done at The Lampung State Polytechnics Field in Bandar Lampung in March – July 2019. The soil has been classed a Red-Yellow Podzolic. There were one synthetic 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 the 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 irrigated by sprinkle irrigation due to the low of rainfalls.

Five from 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 was 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).

The data was analyzed using *analysis of variance* to find the different traits differences from their grand mean at P> 0.05 or P> 0.01. The analyses were followed by analysis of means following Tukey's $HSD_{0.05}$ 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 following 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	DF_3	MS_3	
Hybrid	DF_2	MS_2	$\sigma^2 + r\,\sigma^2g$
Error	DF_1	MS_1	σ^2
Total			

Hence,

Genetic variation (σ^2g) ± standard error (se σ^2g) = $(MS_2 - MS_1)/r \pm \sqrt{[2/r2 \times \{MS_2^2/(DF_2 + 2) + MS_1^2/(DF_1 + 2)\}]}$

Broad-sense heritability (h^2_{BS} %) ± standard error (se h^2_{BS} %) = $(\sigma^2g/ MS_2) \times 100 \pm (se\ \sigma^2g/ MS_2) \times 100$

Genetic coefficient variation (CVg %) = $(\sqrt{MS_1}/\bar{X}) \times 100$

RESULTS AND DISCUSSION

Mean Square Analysis

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 were 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 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}.

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 (dap)	172.05 (cm)	15.09	16.19	54.04 (% 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 (cm)	91.59 (g)	785.03 (g)

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

Rank of Lines Evaluated Using Tukey's $HSD_{0.05}$

The data for rank appropriated for each hybrid were presented in Table 3. 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 were 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.

The Lampung podzolic soil was suitable to screen the newly developed hybrids without excessive amelioration except being given standard fertilization and additional irrigation. The finding was important as the red-yellow podzolic soils were the majority class of soil in Lampung. The poor characteristics of the podzolic 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.

Table 3. The rank of hybrids appropriated based on Tukey's $HSD_{0.05}$

	Superior Female Hybrid							
Trait	SFH1	SFH2	SFH3	SFH4	SFH5	Synthetics	P36	HSD
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.

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

The genetic variance ($\sigma^2 g$) predicted for whether there was large enough genetic differences among the screened hybrids for a certain trait to select for the better hybrids, while the broad-sense heritability (h^2_{BS}) 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) was 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 $\sigma^2 g$ for traits: anthesis, plant height, leaf number, ear seed weight, and yield m^{-2}; and the concomitant h^2_{BS} 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.

Table 4. The predicted values of σ^2g, h^2_{BS}, and CVg for all traits

Trait	σ^2g	±	se σ^2g	h^2_{BS} %	±	se h^2_{BS} %	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 σ^2g and h^2_{BS} were greater than zero at 1X their standard errors.

CONCLUSION

The study concluded that podzolic 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 σ^2g for the traits: anthesis, plant height, leaf number, ear seed weight, and yield m-2; and their concomitant h^2_{BS} 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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