

Evaluation of the Morpho-physiology characteristics of maize inbred lines introduced from CIMMYT to identify the best candidates for planting in acidic soil in Jasinga, Indonesia

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Abstract. Technological developments and climate change have affected crop planting strategies. For example, maize production has expanded to sub-optimal lands, including acidic soil common in areas like Indonesia. Breeding programs have created inbred lines of maize introduced from CIMMYT; they were tested locally in acidic soils to determine their adaptability and tolerance mechanisms. Breeds CLA 46 and NEI 9008 were found to be excellent candidates for acidic soil due to their ASI, high number of grains per year, and suitable dry seed weight.

Keywords: Maize, morpho-physiology, acid soil Indonesia

1. Introduction

High rainfall in some parts of Indonesia causes soil to become acidic. Sub-optimum land in Indonesia includes 91.9 million ha; of this, 62.6 million hectares (68.1%) is acidic dry land in Sumatra, Kalimantan, and parts of Java [10].

The main constraints of acid soil are Aluminium (Al) toxicity and Phosphor (P) deficiency, which decrease plant productivity [1]. Aluminum can affect plants morphologically and physiologically. In crop studies, morphological and physiological characteristics are used to identify crop tolerance to abiotic stress because these characteristics are easy to observe [5]; [13]; [14]. These selectors include plant height, ASI (Anthesis to Silking Interval), panicle length, and the weight of 100 seeds have been used to test maize tolerance to sub-optimum conditions [7]; [3].

To expand maize production, it is important to develop a crop variety tolerant to acidic soil. Introductions is one step in the breeding program used to increase the diversity of materials selection (citation). Crosses of maize inbred lines introduced from CIMMYT have been developed for acidic soils. Similarly, local inbred lines of maize have been developed for optimum soil, which increased the genetic diversity of materials from where selection for breeding plants tolerant aluminum can be done. Evaluating combining ability can be performed to evaluate and select prospective candidates of tolerant inbred line [11].

Evaluating and selecting characteristics associated with aluminium tolerance can be performed to identify prospective maize lines. This research evaluated the morpho-physiological characteristics of maize inbred lines from CIMMYT in acidic soil.



2. Materials and methods

The research was conducted on acid soil, with criteria Al-dd 1.87 me. 100 g⁻¹, pH 4.4 in Jasinga-Bogor from January 2013 - April 2013. The experiment used the Randomized Complete Block Design format [6], with three replications consisting of 20 treatments (genotype). Treatments were the result of crossbreeding maize inbred lines of CIMMYT (CLA 84, 46, 106) and local inbred lines obtained from Cereal Crops Research Institute in Maros, Indonesia (1042-71, NEI 9008), namely P1 - P20.

Table 1. F1 population.

F1 Code	Crosses Parent	F1 Code	Crosses Parent
P1	CLA 84 X CLA 46	P11	CLA 46 X 1042-71
P2	CLA 46 X CLA 84	P12	1042-71 X CLA 46
P3	CLA 84 X CLA106	P13	CLA 46 X NEI 9008
P4	CLA106 X CLA 84	P14	NEI 9008 X CLA 46
P5	CLA 84 X 1042-71	P15	CLA 106 X 1042-71
P6	1042-71 X CLA 84	P16	1042-71 X CLA 106
P7	CLA 84 X NEI 9008	P17	CLA 106 X NEI 9008
P8	NEI9008 X CLA 84	P18	NEI 9008 X CLA 106
P9	CLA46 X CLA 106	P19	1042-71 X NEI 9008
P10	CLA 106 X CLA46	P20	NEI 9008 X 104271

3. Data analysis

The observed variables are:

1. Analysis of variance

Analysis of variance was performed using SAS version 9.1 software. Analysis used a randomized block design with three replications using a statistical model:

$$Y_{ijkl} = m + T_{ij} + b_k + (bT)_{ijk} + e_{ijkl}$$

Table 2. Analysis variance.

Source	Df	MS	E(MS)
Replication	r - 1	M ₁	M1/M3
Genotype (G)	t - 1	M ₂	M2/M3
Error (e)	(r - 1) (t - 1)	M ₃	

4. Results and discussion

Morpho-physiologically characteristic appearances of maize genotypes in acidic soils.

A total of 20 F1 cross-breed maize inbred lines of CIMMYT and Maros research center cereal crops were planted in acidic soils in the experimental field in Jasinga, Bogor.

Table 3. Means Square Genotype of Morpho-physiology Character.

Morpho-physiology Character	MS
<i>Anthesis Silk Interval (ASI)</i>	34.22**
The number of grains per ear	7542.87**
The number of row per ear	6.89**
The seed dry weight	2399.19**
The cob dry weight	3518.32**

* = significantly different $P > \alpha = 0.05$, ** = significantly different $P > \alpha = 0.01$

The results showed that F1 maize inbred lines of CIMMYT and Maros showed significant differences in ASI, the number of grains per ear, the number of rows per ear, seed dry weight, and cob dry weight (Table 3). The analysis of variance results showed that all characteristics showed genetic diversity.

ASI is the best indicator to determine plants tolerance to abiotic stress during flowering. A small ASI value shows that flowering is synchronized, which means the chances of pollination are high. A

high ASI value indicates asynchronous flowering, which inhibits pollination [12]. A value of 1 to 3 days represents the best value for improved varieties maximum production [15].

Higher stress results in longer flowering periods. Collet et al. [4], conveyed that Al stress conditions resulted in larger ASI values. Efforts to accelerate the flowering and obtain the lower ASI suspected to be the way overcoming stress conditions Al. There are similarities between the Aluminum stress and drought stress. Root damage caused by Aluminum toxicity leads to reduced water supply, which results in drought at flowering. Hassan et al. [7], conveyed that maize will reduce ASI by accelerating flowering to improve drought stress tolerance.

A large ASI value in stress condition affects the number of grains per ear, and inhibits pollination and seed formation. Collet et al. [4], showed that ASI negatively correlated with corn seed production. Increasing ASI will reduce the seed corn production. Borrás et al. [2], stated that the indirect effect resulting in stresses Al is assimilates decreased. The revenue sharing of assimilates will be hampered to the plants that need. Low assimilates will reduce fotosintat flow to the cob (sink).

The crosses obtained differences in male and female flowering dates ranging from 3.97- 15.63 days; cross combination CLA 46 X CLA 84 had the highest ASI, while cross combination NEI 9008 X CLA 106 had the lowest ASI (Table 4). Cross combination CLA 46 X NEI 9008 is a prospective hybrid combination due to its favorable ASI, number of rows per ear, number of grains per ear, seed dry weight, and dry cob weight; it showed high productivity and a low ASI value in acidic soil (Table 4).

NEI 9008 was the best combiner because it had a high GCA value. CLA 46 was not the best combiner for yield, but a combination of CLA 46 X NEI 9008 had a higher GCS value for yield (GCA and GCS data are not shown). Crosses between strains have high GCA and low GCA; they generally give high GCS [8]. Appearance best combination of tolerance characters and good yield can be developed as a potential candidate for a hybrid [9]. It is suspected that the distant relationship between lines CLA 46 (origin CIMMYT) and NEI 9008 (original Maros) caused the F1 offspring to have a better appearance.

Table 4. Means square of ASI, Seed Dry Weight (SDW), Number of Rows per Ear (NRE) , Number of Grains per Ear (NGE) and Cob Dry Weight (CDW).

Genotype	ASI Mean	SDW Mean	NRE Mean	NGE Mean	CDW Mean
CLA 84 X CLA 106	7.77	30.80	10.00	112.00	42.33
CLA 106 X CLA 84	5.20	19.50	11.87	141.87	23.67
CLA 84 X CLA 46	13.67	20.73	12.40	214.27	33.00
CLA 46 X CLA 84	15.63	20.27	9.00	155.27	20.63
CLA 84 X 1042-71	6.87	51.87	12.13	256.80	75.67
1042-71 X CLA 84	5.90	45.07	11.07	177.47	68.67
CLA 84 X NEI 9008	4.67	75.80	11.87	196.40	90.33
NEI 9008 X CLA 84	6.77	69.37	12.67	195.87	71.67
CLA 106 X CLA 46	11.00	14.87	8.00	63.00	16.50
CLA 46 X CLA 106	8.53	36.20	10.67	161.73	56.67
CLA 106 X 1042-71	11.90	14.10	11.87	148.93	23.33
1042-71 X CLA 106	9.10	25.63	12.67	162.67	35.33

CLA 106 X NEI 008			12.67	176.67	38.67
	8.53	32.80			
NEI 9008 X CLA 106		41.03	11.87	159.33	94.00
	3.97				
CLA 46 X 1042-71	11.	26.30	11.30	125.20	23.33
	90				
1042-71 X CLA 46		74.33	13.33	220.40	83.33
	9.10				
CLA 46 X NEI 9008		108.47	12.40	228.67	
	5.70				123.33
NEI 9008 X CLA 46			13.60	225.07	97.33
	4.57	87.13			
1042-71 X NEI 9008		56.67	11.73	160.27	70.00
	8.20				
NEI 9008 X 1042-71		76.87	12.40	193.20	96.67
	7.90				

5. Conclusion

This study evaluated ASI, number of grains per ear, and seed dry weight to determine that the cross-breed CLA 46 and NEI 9008 are good candidates for planting in acidic soil.

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