Selection and evaluation the corn lines from multiple-cross progeny based on targeted selection environment on acid soil

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Abstract : Development of tolerant variety can be conducted in the targeted area. It will increase efficiency in producing the acid-tolerant lines. However, the availability of diversity is key in selection. Multiple crosses or crosses between F1 hybrids can be one approach in creating high population diversity. Therefore, the development and selection of offspring of the selfing 1 generation from a cross of two hybrids can be a solution in producing tolerant lines. This study aimed to select multiple-cross maize lines in the generation S1 in an acidic environment. The research was carried out from August to November 2019 at the Maros Cereal Research Center, South Sulawesi. This study was designed with an Augmented Design as an experimental design and a randomized block design as an environmental design. The lines used consisted of 100 S1 lines from crosses of NK7328/HJ28 that did not repeat and six comparison varieties, namely NK7328, HJ28, Sukmaraga, Srikandi Kuning, Bima-9, and Piooner 36 repeated in each block. Based on the results of this study, the evaluation of maize S1 lines under acid soil showed a good variability, especially on generative traits. The ear weight is the best secondary character supported the Grain weight per Ear as the main character. The result of selection showed that 20 S1 lines recommended to selfing cross for continued on the next generation.

1. Introduction

Maize (*Zea mays* L.) is one of the important food crops in Indonesia besides rice. The increasing population and current industrial development will directly have an impact on the increasing demand or consumption of maize [1]. Apart from being a source of food needs, maize is also used as a source of animal feed and industrial raw materials. Efforts to increase maize production are still facing various problems so that domestic maize production has not been able to meet national needs [2]. Therefore, increasing maize production is a priority that must be done.

Maize production continues to increase every year. However, the increase in production was dominated by an increase in the planting area. Based on BPS data [3], maize productivity in 2018 increased by 0.02 tons ha-1 from 2017 or around 5.24 tons ha-1. This shows that intensification of development must be accelerated considering that the expansion of land for agricultural areas is dwindling. However, it is also necessary to increase production by extensification for marginal areas,

such as acid soil areas. Both concepts are believed to be able to increase maize production to meet the demand.

Maize extensification in acid areas has challenges in the process of increasing its production. In general, acid soil is a planting area that has a low pH level, the pH scale of the soil is said to be acidic if it is below 5.5. Low pH levels are caused by several factors. Acidic soils cover about 30% of the total arable land worldwide [4]. Problems that arise from the acidity of an area can occur due to the weathering process of minerals and rocks and very fast leaching [5]. Sources of soil acidity can come from Al and Fe [6]. Currently, the sub-optimal land use has not been able be maximized. Indonesia with a total acid land area of 108. 8 million ha has the potential to increase maize production [7]. This can be done by utilizing varieties that have high production and are resistant to acidity stress.

The development of these varieties can be done by assembling hybrid maize varieties that are tolerant to acid stress. The assembly process requires high diversity. This diversity can be done with the concept of double cross or multiple crosses [8]. This cross is believed to be able to produce high diversity in the breeding process. Based on Farhan's research [9]. There were several double-crosses of the S1 selfing line. These strains need to be evaluated both for their tolerance properties and for their adaptability in aluminum-critical environments. Therefore, it is necessary to evaluate the double-cross lines in the S1 generation in a critical environment. One of them is carried out in a targeted manner in an acidic soil environment.

The evaluation of the maize S1 gakur also involves other growth characters or with the word others do not depend on productivity. This is in line with Orlimao et al., [10] which states that there is a good money relationship between productivity and the growth characteristics of other maize plants. In addition, according to [11],[12] the character of productivity is highly polygenic and has low genetic diversity in a critical environment. Therefore, the purpose of this study was to determine good secondary characters in the evaluation of maize on acid soils and to select S1 maize lines that were adaptive to acid soil stress.

2. Materials and Methods

The research was carried out at the Maros Cereal Crop Research Institute, South Sulawesi at an altitude of 60 m asl, with coordinates 040 59'51.9" LS-1190 34'19.9" E which lasted from August to November 2019. The soil pH conditions at the location ranged from 4.56, so that location is declared sour. This study uses an Augmented design with a Randomized Block design (RAK) as the environmental design. The treatments consisted of 83 genotypes with details of 77 S1 lines from S1 NK7328 / HJ28 crosses and 6 comparison varieties (NK7328, HJ28, Piooner-36, Bima-9, Sukmaraga (sour tolerant), and Srikandi kuning (sour sensitive)). The treatments were divided into two blocks, where the lines were not repeated, while the comparison varieties were repeated in each block. This causes the number of experimental units to be 89 experimental units. Each experimental unit consisted of 6 plants planted in a row system with a length of 1.2 m. The spacing used is 50 cm x 20 cm. Meanwhile, each planting hole is planted with 2 seeds.

The research procedure follows the general procedure for growing maize at ICERI Maros. The general procedure starts with land preparation and seed. Land preparation is done by plowing the soil evenly along with manure. As for the preparation of seeds, the seeds planted are seeds that have a good shape such as free from pests and diseases (healthy seeds), minimum germination of 80%, pithy, shiny, and pure both physically and genetically (purity guaranteed). Before planting, the seeds were treated with fungicide (metalaxyl) first. Planting is done by making a single planting hole with a spacing of 50 cm x 20 cm. Each planting hole is given Furadan to prevent soil pests from attacking. After 7 days, replanting and thinning are done to fill the gaps for seeds that do not grow or have failed growth and to optimize the population. After the embroidery process, the maintenance process is carried out.

The maintenance process consists of weeding, fertilizing, hoarding, irrigation, and spraying pesticides. Weeding is done by cleaning weeds around the maize plants using a hoe, done 2 times when the plants are 12 days after planting (DAP) and 35 DAP. This weeding is followed by a hoarding process. Fertilization is done twice in a single way. The first fertilization was carried out on maize plants aged 7

DAP), the plants were fertilized with the first dose of fertilization, namely 150 kg ha-1, 200 kg ha-1 SP36, and 100 kg ha-1 KCl in a single way between maize plants. The second fertilization was carried out after the plants were 30 DAP with a dose of 150 kg ha-1 Urea. Irrigation is carried out using a water pump and a water hose. Irrigation is done by inundating the irrigated plots to the height of the embankment, then the water is allowed to seep by itself. Irrigation is carried out at intervals of 10 days from planting until ready to harvest by paying attention to weather conditions. Spraying of pesticides is carried out periodically according to the intensity of the attack by plant-disturbing organisms. Harvest is the final stage of research. This process is carried out when it reaches physiological maturity which is characterized by the presence of a black layer on the seeds. Harvest is the final stage of research. This process is carried out when it reaches physiological maturity which is characterized by the presence of a black layer on the seeds. Harvest is the final stage of research. This process is carried out when it reaches physiological maturity which is characterized by the presence of a black layer on the seeds.

Parameters observed in this study consisted of plant height, stem diameter, spad, ear height, days to male flower, days to the female flower, breast milk, ear weight, ear length, ear diameter, ear rows, grain weight per ear, the weight of 100 grains. The analysis carried out includes analysis of variance, heritability analysis, correlation analysis, path analysis, and the real test of the character of productivity and product support. All analyzes used the STAR 2.01 software, except for the path analysis which were analyzed with Excel 2016.

3. Results and Discussion

The results of the analysis of variance (Table 1) showed that the control varieties had differences in the characters of Plant Height, Ear Weight, Grain weight per Ear, and Weight of 100 grains. The source of the diversity of lines shows certain characters, namely ear weight, grain weight per ear, and Weight of 100 grains. Meanwhile, the comparison between control and line showed significant differences in many characters, namely plant height, ear height, ear weight, ear length, ear diameter, ear rows, grain weight per ear, and Weight of 100 grains.

The results of the ANOVA indicated that this study has a fairly good diversity, especially the comparison between control and strains. Although in some vegetative characters, the diversity of the three characters has relatively no significant effect. The greatest diversity is found in the production and productivity characters, especially Grain weight per Ear and Weight of 100 grains which are significantly affected by the three sources of diversity. In general, the productivity character is very polygenic [11], so the diversity in S1 is considered to be quite high compared to other characters. These results also indicated that the evaluation of the diversity of the S1 lines from the F1 cross was considered efficient in the presence of high diversity in an acidic environment. According to [12], low diversity in a selection or evaluation can reduce progress and effectiveness. Therefore, based on the results of the evaluation and selection variance of the S1 strain, it can be analyzed further.

Heritability analysis was the first further analysis in the process of evaluating the S1 strain under acid stress. Based on the results of this analysis in Table 1, the characters of plant height, SPAD, days to male flower, ASI, Ear Weight, Ear Diameter, and Weight of 100 grains are classified as characters with high heritability. Meanwhile, the Grain weight per Ear character as the main character has moderate heritability. In general, heritability values are the initial basis for assessing the effectiveness of selection [8]. Good selection if the selection is made on characters with high heritability values [14]. However, based on this analysis, Grain weight per Ear only has a heritability value of 38.87 which is categorized as moderate. This indicates that the selection should not only focus on Grain weight per Ear so that the determination of secondary characters becomes important in evaluating and selecting the S1 maize line under acid soil stress. One of the basic analyzes in this determination is correlation analysis.

Table 1. Path and heritability analysis of the agronomic character of the S1 line under acid soil stress

Characters	F hit			h^2bs	
	Control (C)	Lines (L)	CxL	value	te
Plant Height	**14.68****	8.3	**58.46****	80.66	High
Stem Diameter	0.36	0.39	0.99	28.33	Moderate
SPAD	0.69	0.65	0.09	64.68	High
Ear Height	2.76	2.37	**9.6***	42.30	Moderate
days to male flower	1.63	4.23	3.27	61.69	High
days to female flower	0.55	1.91	0.42	29.09	Moderate
breast milk	0.76	0.81	1.3	95.26	High
Ear Weight	**9:40pm****	**13.16****	**195.09****	88.32	High
Ear Length	6.68*	1.54	**22.83****	37,20	Moderate
Ear Diameter	2.56	1.05	**23.62****	73.60	High
Ear Rows	2.32	1.48	**12.37***	18.98	Low
Grain weight per ear	**16.42****	**10.42****	**142.06****	38.87	Moderate
Weight of 100 grains	**5.36***	**6.30***	**29.57****	73.25	High

The results of the correlation analysis showed that Grain weight per Ear was significantly correlated in almost all characters, except for days to male flower, days to the female flower, ASI (Table 2). This indicates that in general all growth characters are related to the potential productivity of lines under acid soil stress. This also indicates that it is necessary to determine the character that has a significant effect on productivity. This determination will facilitate the evaluation process because the evaluation will be more focused. One of the analyzes that can be carried out is path analysis.

Table 2. Correlation analysis on the agronomic character of the S1 line under acid soil stress

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	**1.00**	0.52**	0.54**	0.90**	-0.36tn	-0.35tn	-0.12tn	0.77**	0.73**	0.74**	0.60**	0.59**	0.68**	0.74**
2		**1.00**	0.42**	0.56**	-0.35tn	-0.34	-0.19tn	0.51**	0.46**	0.50**	0.54**	0.26*	0.44**	0.54**
3			**1.00**	0.51**	-0.34tn	-0.38	-0.03tn	0.50**	0.54**	0.60**	0.33**	0.45**	0.50**	0.51**
4				**1.00**	-0.37tn	-0.34tn	-0.15tn	0.77**	0.68**	0.69**	0.62**	0.55**	0.65**	0.76**
5					**1.00**	0.98**	0.44**	-0.36tn	-0.16tn	-0.24tn	-0.19tn	-0.17tn	-0.23tn	-0.39tn
6						**1.00**	0.30**	-0.34tn	-0.15tn	-0.23tn	-0.13tn	-0.15tn	-0.22tn	-0.38tn
7							**1.00**	-0.08tn	-0.03tn	-0.09tn	0.01tn	-0.03tn	-0.08tn	-0.07tn
8								**1.00**	0.83**	0.87**	0.67**	0.76	0.88**	0.98**
9									**1.00**	0.93**	0.68**	0.81**	0.79**	0.79**
10										**1.00**	0.61**	0.80**	0.85**	0.83**
11											**1.00**	0.65**	0.55**	0.68**
12												**1.00**	0.74**	0.73**
13													**1.00**	0.83**
14														**1.00**

Notes : 1 = Plant height, 2 = Stem diameter, 3 = SPAD, 4 = Ear height, 5 = Days to male flower, 6 = Days to female flower, 7 = ASI, 8 = Ear weight, 9 = Ear length, 10 = Grain ear length, 11 = Ear diameter, 12 = Ear rows, 13 = Grain weight per Ear, 14 = Weight of 100 grains

Path analysis is one of the analysis of the development of correlation analysis combined with regression analysis. This analysis is able to divide the correlation of a character to the main character into direct and indirect effects. This direct effect is one of the important parameters in assessing the effectiveness of a character on the diversity of the main characters [12] based on the results of path analysis, Ear Weight is a character that directly affects the diversity of Grain weight per Ear (Table 3). The potential for Ear Weight as the character with the highest direct influence was also reported by [15] on the evaluation of maize hybrid lines against drought stress. In addition, this character also has high heritability (88.32). According to [13], Characters that have a high correlation to the main character and high heritability can be used as secondary characters. Therefore, the character of Ear Weight and Grain

weight per Ear can be used as a basis in the evaluation and selection process of the S1 line under acid soil stress.

The results of the LSD further test on the character of Ear Weight and Grain weight per Ear are shown in Table 4. Based on the character of Ear Weight, the best comparison variety was NK 7328 with a value of 145.15 g, while the lowest comparison was HJ 28 (46.85 g). The Sukramamaraga variety as an acid tolerant control had an Ear Weight of 114.2 g. In addition, there were 20 lines that had a better ear weight value than the HJ 28 comparison and only G22 (156 g) had a significantly better ear weight value than the Sukramamaraga variety. Based on the character of Grain weight per Ear, the comparison varieties with the best and the lowest were also owned by NK 7328 (105.3 g) and HJ 28 (46.85 g), respectively. The Sukramamaraga variety has a Grain weight per Ear of 75.8 g. Other than that, There were 14 lines which had significantly better Grain weight per Ear compared to HJ 28. The G22 (132.22 g) and G39 (118.08 g) lines were significantly better than the Sukramamaraga variety. Based on the results of the evaluation, the 20 lines were recommended to be self-seeded to be continued in the next generation.

Table 3. Path analysis on characters that have a significant correlation with grain weight per ear

Characters	direct effects	Indirect Effect							the total of Indirect effect
		PH	EH	EW	EL	ED	ER	W100G	
Plant Height (PH)	-0.075		0.049	0.852	-0.051	0.031	-0.003	-0.078	0.740
Ear Height (EH)	**0.054**	-0.067		0.852	-0.048	0.032	-0.002	-0.075	0.760
Ear Weight (EW)	**1.106**	-0.057	0.042		-0.059	0.034	-0.003	-0.101	0.980
Ear Length (EL)	-0.070	-0.054	0.037	0.918		0.035	-0.004	-0.091	0.790
Ear Diameter (ED)	**0.051**	-0.045	0.034	0.741	-0.048		-0.003	-0.063	0.680
Ear Rows (ER)	-0.004	-0.044	0.030	0.841	-0.057	0.033		-0.085	0.730
Weight of 100 grains (W100G)	-0.115	-0.051	0.035	0.973	-0.056	0.028	-0.003		0.830
Residual	0.032								

Table 4. Best lines based on cob peeled weight and seed weight per cob

Label	Lines Name	Ear Weight (g)	Grain Weight per Ear (g)
G5	♀NK7328 / ♂HJ28	121.3	93.0
G6	♀NK7328 / ♂HJ28	110.3	78.3
G7	♀NK7328 / ♂HJ28	101.3	65.7
G8	♂NK7328 / ♀ HJ28	97.7	61.0
G16	♀NK7328 / ♂HJ28	91.0	43.3
G19	♂NK7328 / ♀ HJ28	104.0	57.0
G20	♂NK7328 / ♀ HJ28	97.3	55.7
G21	♀NK7328 / ♂HJ28	122.0	102.0
G22	♀NK7328 / ♂HJ28	156.0	130.0
G24	♂NK7328 / ♀ HJ28	100.7	79.3
G26	♀NK7328 / ♂HJ28	96.0	73.0
G34	♀NK7328 / ♂HJ28	97.7	77.7
G35	♂NK7328 / ♀ HJ28	99.0	71.0
G38	♀NK7328 / ♂HJ28	152.0	111.0
G39	♀NK7328 / ♂HJ28	147.0	120.3
G43	♂NK7328 / ♀ HJ28	107.0	82.0
G53	♀NK7328 / ♂HJ28	127.0	95.3
G58	♂NK7328 / ♀ HJ28	95.3	71.7
G59	♀NK7328 / ♂HJ28	95.0	74.7
G65	♂NK7328 / ♀ HJ28	125.7	87.3

4. Conclusion

Evaluation of the S1 maize line on acid soils showed good diversity, especially on generative characters. Ear Weight character is the best secondary character that supports Grain weight per Ear as the main character in the selection. The selection results show that there are 20 lines that are recommended for self-cultivation to be continued in the next generation.

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