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Diallel Cross of Six Inbred Waxy Corn (*Zea mays* L.)

Zainuddin Saleh[a*], Yunus Musa[b], Muhammad Farid BDR[c], Muhammad Riadi[d], Roy Efendi[e], Muhammad Azrai[f]

[a]*Doctoral Student, Agriculture Sciences, Hasanuddin University, Makassar South Sulawesi 90245, Indonesia*

[b,c,d]*Departement of Agronomy,Faculty of Agriculture,Hasanuddin University, Makassar South Sulawesi90245, Indonesia*

[e,f]*Indonesian Cereals Research Institute,Maros South Sulawesi 90514, Indonesia*

[a]*Email: ehainul@gmail.com*

Abstract

The waxy corn, *Zea mays* L. which has relatively low productivity can be improved by assembling hybrid and synthetic corn genotypes. The important thing to know is information about the combining ability of each inbred line that will be used to assemble the waxy hybrid corn. This information is needed to design future waxy corn development strategies. Research on the assembly of hybrid waxy corn has been done at Indonesian Cereals Research Institute (ICERI) experimental station, Maros South Sulawesi in June 2015 to April 2016. Analysis of GCA and SCA were based on the Griffing's fixed model of DiallelDesign Methods I with the aim of estimating the value of combining ability. Six inbred lines of waxy corn, namely: #huacai; #Jgm 926; #Jgm F1; #25 F1; #Ys-a; #Ys-b used as a parent in a full diallel cross to produce 15 single cross hybrids, 15 reciprocals and 6 parents. The evaluation of combining ability used a randomized block design with three replications. Combining ability analysis shows that genotype #Ys-b, #huachai, and #Ys-a have good general combining ability (GCA) and hybrid #Ys-b x #Jgm F1, #huachai x #Jgm F1, and #Jgm 926 x #huachai has specific combining ability (SCA) which is good for grain yield character.

Keywords: diallel cross; combining ability; hybrid; waxy corn.

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* Corresponding author.

1. Introduction

The corn *Zea mays* L. is a food source of carbohydrates that can replace rice food. The demand for corn from year to year is increasing in line with the increasing need of raw materials for food, feed, and biofuel industry. The current world food situation seems to be headed for crisis as food supply to the world market tends to decrease. This is one of the driving factors to spur corn production in the country.

One type of maize cultivated for human consumption is waxy corn. Waxy corn is a corn whose seed contains high amylopectin or low amylose so it is sticky when boiled. Today waxy corn is also used for industrial materials, feed, paper, textiles, and additional materials for industry. Farmers grow waxy corn for the purpose of young harvest, sold as boiled corn. The weakness of waxy corn is lowyield potential(2.0-2.5 t/ha) and is susceptible to downy mildewdisease [1,20].

Until now waxy corn breeding has not received much attention, especially in terms of increasing the yieldpotential. While demand for waxy corn continues to increase, especially for processed corn industry and boiled corn on the cob. For this purpose, waxy corn hybrids are of high yield and larger seeds [1]. Waxy corn breeding is done to improve grain yield and quality of amylopectin [13]. Given the need for corn for the industry is increasing and varied, it is necessary corn with special properties, such as waxy corn and early age corn. Corn with such special properties can be established through repetitive and programmed plant breeding programs [1]. One way that can be done to increase the productivity of waxy corn is to assembling high yield waxy corn hybrids.

The most important factor in hybrid formation is the selection germplasmof the basic population forming that will determine the availability of superior parent. Parents derived from superior genetic germplasmwith an ideal agronomic character will have high general combining ability (GCA) and high specific combining abilities (SCA) [18]. To assemble high-yielding varieties, we need combining ability parent information, both general combining ability (GCA) and specific combining ability (SCA) [9,5,6,7,8]. Diallel crosses is a widely used method for knowing the ability of combining each individual in a cross. This method is used to find out which parents have the potential to be used in crosses programs to produce new improved varieties [9,10]. Diallel analysis is the analysis of a set of crosses obtained from a combination of parent's (n) parent to produce the alleged genetic and gca and sca parameters [14,15].

This study aims to estimate general combining ability (GCA) of 6 inbred lines and specific combining ability (sca) hybrids generated through full diallel cross, 6 x 6. It is assumed that one or more inbred lines used have good general combining ability (GCA) or as a good joiner and one or more hybrids are suspected to have a good combining ability (SCA) for a particular character. Hybrids with good sca for grain characteristics can be directed to the formation of high yield pulp hybrid yields.

General combining ability (GCA) is the average appearance of an inbred line that is crossed with several other inbred lines [13]. General combining ability (GCA) of an inbred line is the average contribution that the inbred makes to hybrid performance in a series of hybrid combinations in comparison to the contribution of the inbred lines to hybrid performance in the same series of hybrid combinations [12].

Specific combining ability (SCA) is the contribution of an inbred line to hybrid performance in a cross with a specified inbred line, in relation to its contributions in crosses with an array of specified inbred lines [12]. Specific combining ability (SCA) is the distortion of the crossover appearance of the inbred line with another inbred line to gca. The ability of certain combinations (SCA) is essential for producing hybrid varieties [11,17,20].

2. Material and Methods

2.1. Formation of F1 Hybrid Population

Formation of population of hybrid F1 was done by using full method diallel crosses method I model 1 Griffin's in June to October 2015 at Indonesian Cereals Research Institute, Maros South Sulawesi. Six genotypes of waxy corn inbreds were used as parents to produce a hybrid F1 population. Each inbred waxy corn genotype was planted in 2 plots in each plot and repeated three times. The hybrid F1 genotype combinations resulting from full diallel crosses were 36 genotypes consisting of 6 genotypes parent, 15 F1, and 15 reciprocals.

2.2. Evaluation of Hybrid F1

The hybrid F1 evaluation was conducted from January to April 2016 at the Indonesian Cereals Research Institute (ICERI), Maros South Sulawesi. A total of 36 genotypes of full-tuber crosses were planted for evaluation using a randomized, complete randomized trial design with three replications.

2.3 Observation

The observed plant characteristics were length of ear, ear diameter, number of kernel row per ear, number of kernels per row, weight 100 seeds, and grain yield.

2.4. Data Analysis

The estimation of general combining ability (GCA) and specific combining ability (SCA) uses method 1 (parent, F1, and F1 reciprocals) model 1 of Griffing (1956) [6,9,20]. Combining ability analysis using the AGDR (Genetic Design in R.) version 3.0 software.

3. Result and Discussion

The analysis of variance presented in Table 1 shows that the genotype has a significant effect on all characters. Similarly, with combining abilities, the effect is real on all characters. This means that there is at least one genotype parent that has better general combining ability (GCA) in each character. Similarly, the specific combining ability (SCA), has a significant effect on all characters meaning that there is at least one hybrid with better specific combining ability (SCA) in each character. Characters that have gca with a very real or apparent influence are controlled by the action of the additive gene, whereas characters that have a very real or real effect are controlled by the action of the dominant gene [9,7]. The reciprocal effect has no significant effect on ear length, ear diameter, kernel per row number, 100 seeds weight, and grain yield, meaning that there is no extra chromosomal gene influence on the characters, while the kernel row per ear and 100 seeds weight have a significant effect which means there is a maternal effect on that character [13]. The same thing is reported Effendi (2015) that the variety of reciprocating effect on the character of maize results in drought stress conditions.

Table 1: Analysis of divergent varieties of dialel six inbred of waxy corn

Source of Variations	df	Mean Square Value					
		EL	ED	NRE	NKR	100SW	GY
Treatments	35	8.46**	31.38**	3.94**	51.94**	52.79**	9.28**
GCA	5	18.80**	25.48*	7.53**	51.48**	101.19**	4.36**
SCA	15	11.70**	55.90**	5.00**	93.60**	63.88**	18.82**
Reciprocal	15	1.80tn	8.84tn	1.69**	10.43tn	25.56*	1.378tn
Error	70	2.69	8.95	0.61	11.78	12.34	1.01

Description: EL = ear length, ED = ear diameter, NRE = number of kernel row per ear, NKR = number of kernels per row, 100SW = 100 seeds weight, GY = grain yield ** = significant effect on stage 1%, * = a real effect on the level of 5%, and tn = no real effect

Table 2: General combining ability (GCA) values for character of yield and yield components 6 parents inbred line waxy corn

Parents	ER	ED	NRE	NKR	100SW	GY
#huacai	1.17	-0.05	-0.33	2.04	0.96	0.38
#Jgm 926	-0.81	-1.46	-0.32	-0.43	-0.2	-0.4
#Jgm F1	-0.68	0.23	-0.32	-1.46	0.45	-0.46
#25 F1	0.01	0.29	-0.12	-0.5	0.83	0.13
#Ys-a	-0.03	1.12	0.3	-0.26	1.24	0.26
#Ys-b	0.34	-0.12	0.79	0.61	-3.27	0.09

Description: EL = ear length, ED = ear diameter, NRE = number of kernel row per ear, NKR = number of kernel per row, 100SW = 100 seeds weight, GY = grain yield

The general combining ability (GCA) value is presented in table 2. The general combining ability (GCA) value for character ofthe yield component andyield presented in table 2 shows that positive values are in all characters. For positive value ear length characters is found ingenotype:#huacai and # Ys-b. For ear diameter characters the positive value diameter is found in genotype: # Ys-a, # 25 F1, and #Jgm F1. For character number of kernel row per ear positive value is found in genotype # Ys-b and # Ys-a. For the character number of kernel per row positive values is found in the #huacai genotype and # Ys-b. For the 100 seeds weight character a positive value is found in genotype # Ys-a, #huacai, # 25 F1, and #Jgm F1. For the positive value grain yield characters is found in #huacai genotype, # 25 F1, # Ys-a, and # Ys-b. This indicates that the #huacai genotype, # 25 F1, # Ys-a, and # Ys-b are good combiners of grain yield characters. For ear length, #huacai genotype, # 25 F1 and # Ys-b are good combiners. Genotype #Jgm F1, # 25 F1, and # Ys-a, are good combiners of ear diameter characters. For the number of kernel row per ear, character which is a good combiner is genotype # Ys-a and # Ys-b. The #huacai and # Ys-b genotypes are good combinersofnumber of kernel per row. For 100 seeds weight characters a good combiner is the genotype: #huacai, #Jgm F1, # 25 F1, and # Ys-a.

Table 3: Specific combining ability (SCA) for character of yield and yield componentsof genotype combination of diallel cross 6 parents inbred line waxy corn

Crosses		EL	ED	NRE	NKR	100SW	GY
Parent 1	Parent 2						
#Jgm 926	#huacai	1.15	1.61	0.74	2.14	2.63	1.73
#Jgm F1	#huacai	2.27	2.47	-0.18	5.21	1.74	1.71
#Jgm F1	#Jgm 926	-0.87	-0.76	-0.57	-2.21	-2.59	-0.66
#25 F1	#huacai	0.82	2.65	-0.09	2.08	1.77	0.48
#25 F1	#Jgm 926	-0.01	-1.77	-0.69	-1.16	-2.19	-0.84
#25 F1	#Jgm F1	-0.93	-1.69	0.02	-2.13	-1.56	-1.36
#Ys-a	#huacai	0.67	3.16	-0.05	2.09	3.65	1.05
#Ys-a	#Jgm 926	0.87	1.65	0.98	3.72	0.59	0.73
#Ys-a	#Jgm F1	0.61	2.09	0.48	-0.44	3.77	0.83
#Ys-a	#25 F1	0.09	1.93	0.32	0.27	0.8	0.61
#Ys-b	#huacai	0.2	-0.18	0.83	1.26	-1.92	-0.19
#Ys-b	#Jgm 926	-0.36	-0.2	-0.34	0.32	0.83	1.23
#Ys-b	#Jgm F1	0.57	1.69	0.94	3.76	4.04	1.49
#Ys-b	#25 F1	0.29	0.58	0.62	0.42	0.88	1.23
#Ys-b	#Ys-a	0.23	-0.35	0.62	1.72	-0.85	0.23

Description: EL = ear length, ED = ear diameter, NRE = number of kernel row per ear, NKR = number of kernel per row, 100SW = 100 seeds weight, GY = grain yield

Inbred lines that have positive GCA values are expected to have good general combining ability to produce genotypes with better yield potential [16]. General combining abilities (GCA) are great and positive indicating that the parent have good combining ability [13]. Inbred lines that have good combining ability, have a great opportunity to have a combination of good combining ability (SCA) good. The best crossing couples that have a high SCA value, are generally obtained from a combination of inbred line GCA high x GCA low or from a combination of GCA high x GCA high. Parents that have good combining ability are indicated to have dominant alleles that can combine and interact positively or have profitable genes that can mask disadvantageous genes in their partner's parents, thus influence their hybrid performance (F1) for the better with high productivity [3].

The sca value for the character of yieldcomponent and yield shown in table 3, shows that there are several cross combinations that have positive values for all characters: #Jgm 926 x #huacai, # Ys-ax #Jgm 926, # Ys-a x # 25 F1, # Ys-b x #Jgm F1, and # Ys-b x # 25 F1. For earlenght characters there are several combinations of crosses that have a positive value. The highest positive value is obtained from crossing between #Jgm F1 x #huacai (2.27). For the character of the ear diameter, there are also some positive crossing combinations. The highest positive value is obtained from the cross between #25 F1 x #huacai (2.65). For the character of the number of kernel row per ear there are several combinations of crosses that are positive. The highest positive value is at the cross between # Ys-b x #Jgm F1 (0.94). For the character of the number of kernel per row there are several combinations of crosses that are positive. The highest positive value is in the cross between #Jgm F1 x #huacai (5.21). For 100 seeds weight character there are several combinations of crosses that are positive. The highest positive value is at the cross between #Ysb x #Jgm F1 (4.04).

The highest crossover combination with the highest positive value for grain yield character is obtained from the cross between #Jgm 926x #huacai with a value of 1.73, #Jgm F1 x #huacai with a value of 1.71 and # Ys-b x #Jgm F1 with a value of 1.49. Hybrids #Jgm 926 x #huacai and #Jgm F1 x huacai are formed from one of the parent with a positive DGU, that is #huacai. Hybrid # Ys-b x #Jgm F1 is also formed from one of the parent with a positive DGU, that is #Ys-b. According to Irianyet. al. (2011), crossings between inbred lines that have positive GCA with inbred lines that have negative GCA generally provide high SCA effect. The same is said by Sujiprihati and his colleagues (2012), that hybrids that have a high SCA value, are usually generated from cross-recommendation with at least one parent having a high GCA value. This phenomenon is thought to be due to the profitable genes in an inbred line that can maskdisadvantageous genes in their partners and be able to combine well [9].

Specific combining ability (SCA) positively indicates that the parent has a high hybrid combination with one of the parent used. Conversely, if the value is negative it means that the parent does not have a high hybrid combination with any of the parents used [9]. Genotypes have a high enough SCA value is a indicate that the genotype is able to combining the other genotype and give the best performance opportunities [16]. If the crossover value is better than the overall average of the crosses involved, then the intersection pair has a good specific combining ability (SCA) [12]. Specific combining ability (SCA) value is an indicator of the action of dominant genes and epistasis, while the value of GCA indicates the action of an additive gene that controls a character. High specific combining abilities (SCA) supported by a positive dominant variety will give a positive result [11,16].

4. Conclusion

Based on combining ability analysis, it can be concluded that inbred #huacai, #25 F1, #Ys-a, and #Ys-b are good combiners for grain yield character, so it is potential to be developed as superior waxy corn synthetic varieties. Hybrid F1 #Jgm 926 x #huacai, #Jgm F1 x #huacai, and #Ys-b x #Jgm F1 has the highest positive specific combining ability for grain yield character, respectively with values 1.73, 1.71, and 1.49, potential to be developed as a single high yield waxy corn hybrid. The high specificity combining ability (SCA) in the F1 hybrid #Jgm 926 x #huacai and #Jgm F1 x #huacai is supported by one of the parent with positive GCA value, that is: #huacai. Whereas # Ys-b x #Jgm F1 is supported by one of its parent with positive DGU value, that is: #Ys-b.

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