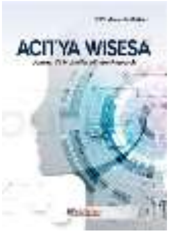

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Combining Ability of Maize Strains in Low Nitrogen Nutrition

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ABSTRACT

The nitrogen reduction in soil is a problem in maize cultivation that can cause production decrease. The efforts to prevent this problem is to assemble superior maize that is low nitrogren resistance and high production by crossing different corn former plants. This research was to analyze the combining power of five strains (G1, G2, G3, G4 and G5) under normal and low nitrogen conditions used a half diallel cross design by Griffing I method formula to analyze 10 genotypes. The research design used a divided plot design (RPT) with 3 replications, the research location was in the experimental garden of Balai Pengkajian dan Teknologi Pertanian in Kebondalem village, Mojosari district, Mojokerto district and the application of nitrogen fertilizer. The value of the general combining ability (DGU) of the G3 elders significantly affected the weight parameters of the cobs under low nitrogen conditions. The results of the special combining ability (DGK) on the G7 and G8 crosses had high DGK values on harvest character and weight of 100 seeds under normal and low nitrogen conditions. The genotype G6 has a high DGK value for cob weight characters.

Keywords: *Plant breeding; fertilization; Hybrid*

INTRODUCTION

Corn is the most productive cereal crop in the world, it is usually grown in high temperatures areas in Indonesia. Maize or corn (Zea mays L.) is a quite important commodity for the community as a staple food, processed cornstarch and animal feed industry. The demand for corn in the world and local markets has increased continuously every year as a result of the high rate of world population growth. National corn production in 2017 reached 27.95 million tons, an increase of 18.53 compared to 2016 which has 23.58 million tons. The corn harvested area in 2017 increased by 20.95% to 5.3 million hectares from 4.44 million hectares in 2016 (BPS, 2017).

The increasing crop production per unit area can be conducted in two ways, such as assembling varieties and improving cultivation techniques. The superior varieties that aim to produce hybrid varieties produce many desirable traits through plant breeding programs. The appearance of hybrid varieties is mainly determined by former farmer through the plant cross. The pure quality seeds from mixed maize varieties can guarantee high productivity (Fahmi T, 2015).

The production of hybrid corn through breeding activities is an effective and appropriate way to obtain superior hybrid maize varieties. The good hybrid varieties are usually characterized by high heterocyst and profitability values. By utilizing the results of the plant cross, it is possible to produce excellent hybrid varieties, especially in terms of plant productivity. (Yustiana, Syukur M, 2013).

The superior varieties of hybrid maize generally have perceptive trait to N fertilization since they are selected under favorable environmental conditions. The low content of N nutrients can affect the yield of corn crop production, and most of the soils in Indonesia are low in N nutrients. The reduced availability of N nutrients due to climate change has an impact on decreasing maize production in dry land, and According to (MM., 2015) the newest hybrid maize has properties that urgently require fertilization for nitrogen elements production for maximizing the harvest. In fertile soils, the N nutrients in soil are depleted by intensive cultivation and are not balanced by N nutrients return from plant biomass. With this condition, fertilization with inorganic and organic N nutrients is highly required by farmers for growing plants optimally (Syafruddin, Azrai M, 2013).

Low N tolerant maize varieties are one solution in reducing harvest failure in maize yields due to low N nutrition (Sayadi, MAR, Qiu JTJ, 2016). The diallel method between inbred plants is the process of forming hybrid varieties using crosses between plants. Diallel crossing is a method to determine the general binding capacity (DGU) and specific binding capacity (DGK) of several inbred strains. According to (Sutoro, 2015), it requires an inbred pair with high (FGK) and resistance in low nitrogen to form hybrid maize with high yields. The general affinity and special affinity are the main criteria in producing form maize hybrid varieties efficiently and effectively (Harriman JC, 2016)

Hybrid maize with high production supported by resistance in low N nutrition resulting from a good affinity method in plant breeding programs provides a very large opportunity.

This study aims to select and determine the genotype of maize that has good general and special affinity values to make maize hybrids that are able to survive with low N nutrition.

RESEARCH METHODOLOGY

This research was conducted on the experimental land of Center for Agricultural Research and Technology, Kebondalem Village, Mojosari District, Mojokerto Regency, from March 24th 2021 to July 30th 2021.

The materials needed in this research were 15 genotypes of corn seeds consisting of 10 Single Cross (ST) F1 hybrids, S8 of 5 strains, urea fertilizer, TSP fertilizer, KCL fertilizer and manure.

This research used a factorial experiment (2 factors) which was designed using a split plot (RPT) with the first factor (maize genotype) consisting of G1 strains (Arjuna variety), G2 strains (Bhishma variety), G3 strains (popular hybrid population Bima 1, Bima 2 and Bima 3), strains G4 (Popular hybrid population variety, Bima 1, Bima 2 and Bima 3 crossed by Popular Hybrid Population). Strain G5 (Bhishma Variety crossed by Popular Hybrid Population), G6(G1xG2), G7(G1xG3), G8(G1xG4), G9(G1xG5), G10(G2xG3), G11(G2xG4), G12(G2x5), G13(G3xG4), G14(G3xG5), G15(G4xG5) and the second factor (fertilization dose of N nutrient) consisted of N2 : Normal Nitrogen (200kg/ha) and N1: Low Nitrogen (100kg/ha).

The research parameters included: plant height (cm), number of leaves (leaf blade), cob weight (g), seed weight per plant (g), seed yield (tons/ha), weight of 100 seeds (g). the data analysis using general combining power (DGU) and specific combining power (DGK) model Griffing method 2 (Mukherjee et al., 2016)

DGU = 1/(t+2)[∑(a.g+agg)-2agn/t+a..)
DGK = Yij ‐ 1/(t+2) (A.g + Agg + A.n + Agg) + 2A../
(t+1)(t+2)

Description:
t= Strain (former plant)
a.g= Sum and mean of crosses g
agg= mean from g x g crossed
A= Total numberl
Agn= mean cross of g x n

A.n= Total mean cross to n
Ann= mean cross of n x n

The results of the DGU values of the former plant and the results of the cross-sectional DGK values obtained from the study were further analyzed with the critical difference test (Mukherjee et al., 2016).
UBK = SK x (t5% dan t1%)

Description:
UBK= Critical Difference Test
SK= Standard Provisions = a (α is the variance of DGU/DGK test)

RESULT AND DISCUSSION

Affinity

Based on analysis results of the power combining variety, the DGU and DGK values for harvest parameters showed a significant effect on normal N conditions, while at low N conditions, DGU values showed a significant effect on harvest parameters (Table 2 and Table 4). Parameters of cob weight and 100 seeds weight of DGK values significantly affected in normal N conditions (Table 4).

The results of the affinity analysis on the DGU value which significantly affected the low N-resistant characters proved that there were characters controlled by the action of additive genes. The varying values of DGU or DGK indicate that the contribution of the resulting gene depends on certain conditions, it can be seen that the effect of non-additive genes has a better influence than additive genes (Santoso SB, Yasin MHG, 2014).

The seed weight parameter showed that the DGK value had a significant effect on low N conditions, while under normal N conditions; the DGK value had no significant effect on the seed weight parameter per plant (Table 3). The plant length parameter showed that the DGU value had a significant effect on normal N conditions (Table 1).

The results of middle square affinity value for the specific seed weight parameter per plant had a significant effect on low N. The results of the combined power analysis of the DGK value which had a significant effect showed that the character is resistance to low N which was influenced by non-additive genes, while in (Saputra EH, Syukur M, 2014) opinion, the results of combining power analysis on DGU values has a significant effect on positive and high values, indicating that these traits are influenced by additive genes.

General Merging Power

Based on the general affinity value at low N conditions, the cob weight character has a positive value of 21.22 and significantly affects the critical difference test at 1% level, while in normal N conditions the general affinity value has a significant effect on plant height parameters of 15.53 and seed weight per plant of 8.79 with a critical difference test of 1% level (Table 1 and Table 2). This proves that the parameters of plant length and seed weight per plant are controlled by additive genes. There are two gene actions that determine affinity, called additive genes and non-additive genes. Additive genes are influenced by polygenes that produce a definite gene effect, while non-additive genes are obtained from dominant and epistatic actions. This agrees with the results of Gautam and Chauhan's research that former plant with high DGU can be used for varieties-forming plant that are capable of forming basic population plant through repeated selection methods. According to (El-ShamarkaSA, Ahmed MAS, 2015) and (Amegbor IK, 2017) High and positive affinity can be obtained from different former plant characters. The G3 strain has a positive DGU value on the cob weight parameters under normal and low N conditions, then the G3 line has good potential to be crossed (Table 2), according to (KanattiA.andRai KN, Radhika K, 2016) former plant or strain that produce DGU values positive has the chance of giving a good influence when crossed with other strain for producing high production potential hybrid varieties (Setyowidianto EP, Basuki N, 2017).. The harvest parameter of the general combining power value for G4 former plant is 0.67 and G5 is 0.09 still has a positive value, while in G1 strains, G2 and G3 had negative values at low N conditions (Table 2). Former plant G4 and G3 had positive affinity values for 4 parameters (plant length, number of leaves, cob weight and seed weight per plant) at normal and low N conditions (Table 1 and Table 2).

The G3 and G4 strains had the highest general affinity values under low N conditions among the observed strains for plant length parameters (Table 1). Then the G3 and G4 can be used as former plants in the assembly of synthetic varieties. High general combining power values under normal conditions can be used as former plant to produce resistant crosses resistant in low N nutrition (Efendi R, Takdir A, 2017) and also according to research by (BiabaniA, Rafli MY, Saleh G, Sahbanimofrad M, 2012) and (RuswandiD, Supriatna J, Makkulawu AT, Waluyo B, Marta H, Suryadi E, 2015) hybrid varieties obtained from former plant who have high DGU values.

Table 1. The value of general combining power (DGU) on plant length, number of leaves and seed weight per plant parameters under normal and low N conditions

Strains	plant length (cm)		Number of Leaves(leaf blade)		Seed Weight per plant(g)	
	N Fertilization Conditions					
	N1	N2	N1	N2	N1	N2
G1	-4,29	15,53**	-0,09	0,31	-3,96	-11,50**
G2	-4,12	-20,14**	-0,21	-0,83*	-7,09	-2,71
G3	5,68	6,66	0,17	0,36	1,11	8,79*
G4	5,25	9,16	0,15	0,46	11,85	2,61
G5	-2,53	-11,21*	-0,02	-0,30	-1,91	2,81

Description:
G1 (Arjuna Variety), G2 (Bisma Variety), G3 (Popular Hybrid Population Bima 1, Bima 2 and Bima 3), Strain G4 (Arjuna Variety crossed with Hybrid Popular Population),
Strain G5 (Bisma Variety crossed with Hybrid Popular Population).
N2 : Normal Nitrogen (200kg/ha), N1: Low Nitrogen (100kg/ha)
Significantly different from the 1% critical difference test = **
Significantly different from the 5% critical difference test = *

Table 2. The value of general combining power (DGU) on cob weight, the weight of 100 seeds, and yield parameters under normal and low N conditions.

Genotype	Cob Weight (g)		The weight of 100 seeds		Yield (Tons)	
	N Fertilization Conditions					
	N1	N2	N1	N2	N1	N2
G1	-8.22	-5.72	4,31	0,99	-0,21	0,68**
G2	-13.68*	-15.20	-2,38	-2,33	-0,53*	-0,33
G3	21.22**	6.99	-0,48	-0,43	-0,03	0,11
G4	4.31	11.97	-1,70	-0,01	0,67**	-0,38
G5	-3.63	1.95	0,26	1,79	0,09	-0,08

Description: G1 (Arjuna Variety), G2 (Bisma Variety), G3 (Popular Hybrid Population Bima 1, Bima 2 and Bima 3), Strain G4 (Arjuna Variety crossed with Hybrid Popular Population), Strain G5 (Bisma Variety crossed with Hybrid Popular Population).
N2 : Normal Nitrogen (200kg/ha), N1: Low Nitrogen (100kg/ha) Significantly different from the 1% critical difference test = **
Significantly different from the 5% critical difference test = *

Special Combining Power

Based on the special affinity analysis under low N conditions, the G9 and G11 crosses had a DGK value which had a significant effect on seed weight per plant parameter, while under normal N conditions had no significant effect (Table 3). The G6 cross had a significant effect on cob weight parameters and the weight of 100 seeds under normal N conditions (Table 4), the G6, G7 and G8 crosses had a significant effect on weight parameter of 100 seeds under normal N conditions (Table 4). According to (GM., 2020) the parameters that have different GD values are influenced by more dominant non additive gen. the parameter of seed weight of crosses G9 and G11 at low N conditions had the best DGK values of 48.50 and 35.99 (Table 3) and significantly different in 1% critical difference test. On the parameter weight of cob crosses G6 under normal N conditions had the best GK value of 69.70 and significantly different in the 1% critical difference test (Table 4). The G7 cross under normal conditions had the best DGK value of 16.09 and significantly different in the 1% critical difference test for 100 seeds weight parameter (Table 4). The G7 cross under normal N conditions had a significant DGK value of 3.29 and at low N conditions a positive GD value was 0.51 in the yield parameter (Table 4). This is in accordance with research result (Haydar FMA, 2014) and (Niyonzima JP, Nagaraja TE, Lohithaswa HC, Uma MS, Pavan R, Niyitanga F, 2015) stated that hybrids that had a high DGK rate were usually caused by the two former plant which have the highest DGU, or from one of former plant that having the highest DGU. Meanwhile, the hybrids with the highest DGK values came from a pair of strain with highest DGK numbers or from a pair of strains with the lowest DGK numbers. (ErtiroBT, Beyene Y, Das B, Mugo S, Olsen M, Oikeh S, Juma C, Labuschagne M, Prasanna BM, 2017) and (Noëlle MAH, Richard K, Vernon G, Martin YA, Laouali MN, Liliane TN, 2017) also mentions that it is very possible to get high harvesting hybrid maize under normal and low N conditions. The yield parameters of the special combining power values for the G7 and G8 crosses still have positive values under low and normal N conditions, while other crosses do not have positive values for both low N and normal N conditions. The parameter weight of 100 seeds in the G7 cross had positive DGK values in normal and low N conditions (Table 4).

Table 3. Special combining values for plant length, number of leaves and weight seeds per plant parameters under normal and low N conditions

Genotype	Plant Length(cm)		Number of Leaves (leaf blade)		Seed weight per plant (g)	
	N Fertilization Conditions					
	N1	N2	N1	N2	N1	N2
G6	20,59	13,93	1,14	1,16	16,55	1,66
G7	11,63	24,97	0,43	-0,81	7,83	10,94
G8	-13,07	6,42	-0,22	0,98	2,43	-17,91
G9	-9,48	-4,24	-0,71	-0,70	48,50**	19,64
G10	-6,88	-16,02	-0,11	-0,78	-12,50	-5,83
G11	3,77	-18,40	0,02	-1,65	35,99**	18,57
G12	-20,56	-1,26	-0,70	-0,89	-10,93	-1,53
G13	-0,08	-32,28	-0,37	-0,62	-29,57**	-6,16
G14	2,52	2,46	0,63	0,27	-17,25*	12,43
G15	8,17	6,70	0,60	0,49	-1,78	0,53

The positive DGK value indicates the combined cross has a higher value than the two former plant, while a negative special combining power value indicates the opposite. The G7 and G8 crosses have positive values on harvest parameters under normal and low N conditions, the G6 and G7 crosses have good DGK yields at low N conditions (Table 4). According to (Efendi R, Takdir A, 2017) and (Fasahat P, Rajabi A, Rad JM, 2016) stated that genotypes that are resistant to low N stress have good DGK values since many dominant alleles can bind and interact actively, or genes that can anticipate genes that harm their former plants, then it can resulted in high production at low N nutrition. High DGK values in low N conditions were obtained from the ability of the former plant to inherit low N nutrition resistance.

Table 4. The value of special combining power on cob weight, weight of 100 seeds, and yields parameters under normal and low N conditions.

Genotype	Cob Weight(g)		Weight of 100 seeds		Harvest result (Ton)	
	N Fertilization Conditions					
	N1	N2	N1	N2	N1	N2
G6	-4.96	69.70**	9,43	8,26*	1,11	-0,26
G7	-0.43	2.21	9,35	16,09**	0,51	3,29**
G8	-11.93	15.37	1,76	8,91*	0,79	2,02**
G9	10.94	-53.48*	-1,35	2,15	-0,61	2,84**
G10	-11.27	24.25	-2,59	0,07	-1,53	3,91**
G11	13.81	-45.81*	0,67	0,28	-0,23	1,18**
G12	-6.20	-50.53*	-0,55	-2,87	-0,06	-0,76
G13	-21.34	-20.25	5,21	-3,22	0,00	-1,19**
G14	28.30	23.12	1,73	-1,29	0,22	-0,73
G15	19.50	36.67*	-0,98	-1,87	-0,17	0,25

Description: G6(G1xG2), G7(G1xG3), G8(G1xG4), G9(G1xG5), G10 (G2xG3), G11(G2xG4), G12(G2x5), G13(G3xG4), G14(G3xG5), G15(G4xG5
N2 : Normal Nitrogen (200kg/ha), N1: Low Nitrogen (100kg/ha)
Significantly different from the 1% critical difference test = **,
Significantly different from the 5% critical difference test = *

CONCLUSION

The G3 strain had the highest general affinity value for the weight parameter of corn cobs under low nitrogen conditions. The G4 strain had the highest general affinity for plant length parameters under nitrogen conditions. G7 and G8 crosses showed high DGU values for harvest parameters and weight of 100 seeds under normal and low nitrogen conditions. The G6 cross had a special combining power value that matched the weight cobs characteristics.

REFERENCES

Amegbor IK, B.-A. B. andAnnor B. (2017). Combining ability and heterotic patterns of extra-early maturing white maize inbreds with genes from Zea diploperennis under multiple environments. *Euphytica*, 24–39.

BiabaniA, Rafli MY, Saleh G, Sahbanimofrad M, andLatif M. (2012). Combining ability analysis and evaluation of heterosis in Jatropha urcas L. F1-hybrids. *AJCS*, 1030–1036.

BPS. (2017). *Grafik Produksi dan Luas Lahan Tanaman Jagung Di Indonesia.*

Efendi R, Takdir A, A. M. (2017). Daya Gabung Inbrida Jagung Toleran Cekaman Kekeringan dan Nitrogen Rendah pada Pembentukan Varietas Hibrida. *Penelitian Pertanian Tanaman Pangan*, *1*.

El-ShamarkaSA, Ahmed MAS, E.-N. M. (2015). Heterosis and combining ability for yield and its components through diallel cross analysis in maize (Zea mays L.). *Alex. J. Agric*, 87–94.

ErtiroBT, Beyene Y, Das B, Mugo S, Olsen M, Oikeh S, Juma C, Labuschagne M, Prasanna BM, and L. T. (2017). Combining ability and testcross performance ofdrought-tolerant maize inbred lines under stress and nonstress environments in Kenya. *Plant Breeding*, 1–9.

Fahmi T, S. E. (2015). Keragaan Produktivitas Varietas Jagung pada Musim Hujan di Lahan KeringDataran Tinggi Kabupaten Bandung. Jawa Barat. *Prosiding Sem Nas Masy Biodiv Indonesia*.

Fasahat P, Rajabi A, Rad JM, and D. J. (2016). Principles and utilization of combining ability in plant breeding. *Biom Biostat Int J*, 1–24.

GM., B. T. and L. (2020). Heterosis, combining ability and their inter-relationship for morphological and quality traits in yellow maize single crosses across enviroment. *Agrivita Journal of Agricultural Science*, 174-190.

Harriman JC, and N. C. (2016). Utilization of diallel analyses for heritability, GCA and SCA studies in crop improvement. American Advances. *Journal of Biological Science*, 159–167.

Haydar FMA, P. N. (2014). Combining Ability Analysis for Different Yield Components In Maize (Zea Mays L.). *Plant Breed. Genet.*, 17–23.

KanattiA.andRai KN, Radhika K, and G. M. (2016). Tester effect on combining ability and its relationship with line performance per se for grain iron and zinc densities in pearl millet. *Crop Science*, 689–896.

MM., K. (2015). Diallel analysis of some yellow maize inbred line under low and normal nitrogen levels. *Internasional Journal of Plant Breeding and Genetics*, 32–43.

Mukherjee, D., Roquib, M. A., Das, N. D., & Mukherjee, S. (2016). A Study on Genetic Variability, Character Association and Path Co-Efficient Analysis on Morphological and Yield Attributing Characters of Taro [Colocasia esculenta (L.) Schott]. *American Journal of Plant Sciences*, *07*(03), 479–488. https://doi.org/10.4236/ajps.2016.73042

Niyonzima JP, Nagaraja TE, Lohithaswa HC, Uma MS, Pavan R, Niyitanga F, K. A. (2015). Combining Ability Study for Grain Yield and Its Contributing Characters in Maize (Zea Mays L.). *Int. J. Agron. Agric. Res*, 61–69.

Noëlle MAH, Richard K, Vernon G, Martin YA, Laouali MN, Liliane TN, and G. N. (2017). Combining ability and gene Action of tropical Maize (Zea mays L.) inbred lines under low and high nitrogen conditions. *Journal of Agricultural Science*.

RuswandiD, Supriatna J, Makkulawu AT, Waluyo B, Marta H, Suryadi E, and R. S. (2015). Determination of combining ability and heterosis of grain yield components for maize mutants based on line x tester analysis. *Asian Journal of Crop Science*, 19–33.

Santoso SB, Yasin MHG, F. (2014). Daya Gabung Inbred Jagung Pulut untuk Pembentukan Varietas Hibrida. *Penelitian Pertanian Tanaman Pangan*, *33*.

Saputra EH, Syukur M, A. S. (2014). Pendugaan Daya Gabung dan Heritabilitas Komponen Hasil Tomat pada Persilangan Dialel Penuh. *J. Agron. Indonesia*, 203–209.

Sayadi, MAR, Qiu JTJ, L. Z. (2016). for Drought Tolerance in Maize (Zea Mays L.). *American Journal of Plant Sciences*, 1858–1870.

Setyowidianto EP, Basuki N, D. (2017). Daya Gabung dan Heterosis Galur Jagung (Zea mays L.) pada Karakter Hasil dan Komponen Hasil. *J. Agron.*

Indonesia, *45*, 124–129.

Sutoro, S. M. (2015). Daya gabung umum, daya gabung khusus, dan keragaan hasil hibrida jagung pada dua tingkat pumupukan N. *Penelitian Pertanian Tanaman Pangan*, 55–59.

Syafruddin, Azrai M, S. (2013). Seleksi genotipe jagung hibrida toleran N rendah. *Buletin Plasma Nutfah*, 73–80.

Yustiana, Syukur M, S. S. (2013). Analisis Daya Gabung Galur-Galur Jagung Tropis di Dua Lokasi. *J. Agron. Indonesia*, 105–111.