



COMBINING ABILITY FOR PEARL MILLET (*Pennisetum glaucum* L.R.Br.) GRAIN YIELD AND OTHER AGRONOMIC TRAITS IN SUDAN SAVANNA OF BORNO STATE, NIGERIA

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ABSTRACT: Partial diallel was used to five millet parental lines to generate 10 crosses, 15 entries consisting of five parents and 10 crosses were evaluated in a randomized complete block design (RCBD) in Maiduguri for two years (2015 and 2016 combined). The objectives were to estimate the general and specific combining ability effects on yield and yield components. The combining analysis of variance showed that both the general combining ability (GCA) and specific combining ability (SCA) had significant effects on most of the agronomic traits indicated the presence of a large amount of genetic variability in the materials. The results of general combining ability effects revealed that parents SOSAT-C88 and LCIC9702 were the general combiners for earliness. Combining ability variance shows significant differences for days to 50% flowering, plant height (cm) and grain yield (kg ha⁻¹) on GCA x Years and SCA x Years interaction. Negative GCA effects display by these parents for days to 50% flowering and plant height (cm) implies that when crossed together would produce hybrids that will mature earlier. While EX-BORNO and EX-GASHU'A exhibited high plant height (cm) will be useful for making houses. Furthermore, the best general combiners were SOSAT-C88 and DMR43 for grain yield and other yield components. Three crosses of SOSAT-C88 x DMR43, SOSAT-C88 x LCIC9702 and SOSAT-C88 x EX-GASHU'A showed negative significant SCA effects for days to 50% flowering and plant height (cm) indicating that these crosses could be improved for earliness and resistance to lodging in the windy environment. EX-BORNO x SOSAT-C88, SOSAT-C88 x DMR43, SOSAT-C88 x LCIC9702 and DMR43 x LCIC9702 are the best crosses in term of grain yield ha⁻¹.

Key Words: Combining Ability Effects, Millet, Traits, Yield

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1. INTRODUCTION

Pearl millet (*Pennisetum glaucum* L.R.Br.) is the sixth important cereal crop annually cultivated as rain fed crop on about 26 million ha in arid and semi-arid areas of Africa and the Indian sub-continent (Atif *et al.* 2012). It is an important crop in Nigeria where moisture problem is the limiting factor for its optimal production. It has the potential of producing high total grain yield for the increasing population in this region under an ideal situation. It is also grown in over 40 countries predominantly in Africa and Asia as a staple food grain and source of feed, fodder and fuel and construction material in making thatch (Izge *et al.* 2007) The crop annual global production is around 30 million tonnes, of the million tonnes produced in the world about 90% is

utilized in the developing countries and the remaining is used in the developed countries (FAO 2007). To increase total grain yield in pearl millet in Nigeria it is necessary to develop high grain yielding pearl millet varieties that can be grown successfully in this area (Izge *et al.* 2007). Breeding for high yielding varieties remain the main feasible method for the poor farmer. This is the technology that is within the reach of the farmer and considered worthwhile by the farmer. However, information on the breeding materials with respect to their general and specific combining ability (GCA and SCA) needs to be exploited so as to design practical strategy for efficient choice of parental materials and methods to be used in developing productive base population for grain yield improvement. GCA implies the capacity of a parent to produce

superior progenies when crossed with another parent. GCA measures the average performance of a parent in a hybrid combination. SCA refers to those instances in which performance of a hybrid is relatively better or poorer than would be expected on the basis of average performance of the parent involved SCA is commonly associated with all effects which cannot be accounted for by schemes such as dominance, epistasis, genotype and environment interaction (Nwasike *et al.* 1992 and Kadams 2000).

2. MATERIALS AND METHODS

The parental materials used in this study were obtained from Lake Chad Research Institute. They are early to medium maturing varieties with 54 to 64 days to maturity. The five varieties were crossed in a partial diallel design and generated 10 F₁ hybrids during 2015 under irrigation. Evaluation were done during 2015 and 2016 rainy seasons at the Department of Crop Production Teaching and Research Farm University of Maiduguri (Latitude 11° 53' N Longitude 13° 16' E) with average annual rainfall of 400 to 500 mm. During evaluations five parents together with 10 hybrids were grown in randomized complete block design (RCBD) replicated three times. Each entry was made in two rows which were 5 m in length and planted at inter-row spacing of 75 x 50 cm to enhance plant population. Each plot was drilled and later thinned to two seedlings per hill at three weeks after sowing. Compound fertilizer (NPK 15:15:15) was applied at 60 kgN/ha⁻¹ in split doses. The first dose of 35 kgN/ha was applied as basal while the second dose of 25 kgN/ha⁻¹ was applied as top dressing three weeks after sowing. Weeding was done manually at three and seven weeks after sowing according to Onwueme and Sinha (1991). Parameters measured were: 50% days to flowering, tiller count, plant height (cm), panicle length (cm), panicle weight (g), 1000 grain weight (g), threshing% and grain yield (kg/ha⁻¹). Data collected were subjected to analysis of variance using diallel analysis. General and specific combining abilities (GCA and SCA) were computed using SAS (1991) for the five parental lines and their 10 F₁ hybrids for millet grain yield and other agronomic traits.

3. RESULTS AND DISCUSSION

3.1 Combining Analysis of Variance for Grain Yield and other Agronomic Traits in Millet across Years

Combined ANOVA for millet grain yield and eight agronomic traits across the years (2015 and 2016) are presented in Table1. All the traits showed significant differences between years at $\leq 5\%$. This indicated

differential response of varieties to factors of environment across the years. GCA effects were significant for almost all traits except tillers count and 1000 seed weight (g). Similarly, Years and SCA effects were significant in plant height (cm), panicle length (cm), head weight (g), threshing%, 1000 seed weight (g) and grain yield (kg/ha⁻¹). GCA x year effects was significant in only days to 50% flowering and 1000 seed weight (g), but SCA x year effects were significant for almost all the traits except tillers count and panicle length (cm). These results indicated high genetic variability to different climatic changes in both years. This work is in agreement with that of Bello and Olaoye (2009); Aminu and Izge (2013). The authors suggested that climatic variation could be an important factor in breeding for desirable characters in the study area. The ratio of SCA to GCA effects indicated a preponderance of GCA component in the expression of all the traits. The results therefore, suggested that additive type of gene action is primarily involved in determining grain yield and other agronomic traits.

3.2 General Combining Ability x Year Effects for Grain Yield and other Agronomic Traits in Millet

Estimate of GCA x year interaction effects for eight agronomic traits in millet combined across years are presented in Table2. The GCA effects implies capacity of a parents to produce superior progeny or otherwise when crossed with another parent (Izge *et al.* 2007). It is essential for selection of suitable parent for hybridization and identification of promising hybrids for the development of improved varieties for a diverse agro-ecology. The results from this study revealed that SOSAT-C88 and LCIC9702 were higher general combiners for earliness. The GCA variance component in this study was found to be significant and larger than the SCA variance component for days to 50% flowering signifying the importance of additive genetic effects in the control of days to flowering similar results were reported by Kimbeng and Nwasike (1994). Because maturity period is an important factor affecting grain yield, this study suggested the possibility of developing genotypes that combines shorter growth duration and higher grain (Izge *et al.* 2007). Parent SOSAT-C88 showed superior GCA effects for most of the characters except tiller count and threshing%. Negative GCA effects display by SOSAT-C88 and LCIC9702 for days to 50% flowering implies that parents when crossed together would produce hybrids that will mature earlier (Martinez *et al.* 1993). Parent EX-BORNO showed superior and significant GCA effects except tiller count, panicle length (cm), head weight (g) and threshing %. Similarly, DMR43 revealed significant GCA effects for panicle length (cm), head weight (g), 1000 seed weight

(g) and grain yield (kg ha^{-1}), indicating these parents have potentials for the development of heterotic segregates for these traits. The best general combiner was SOSAT-C88 followed by DMR43 while the least was EX-GASHU'A. However, poor general combiners gave better cross combinations. Kadams (2004) reported on wheat population and Aminu *et al.* (2014) on maize grain yield population showed that crossing of superior and poor parents could generate a large gene pool which can break, linked or blockage of gene through mass selection as in the case of EX-GASHU'A x SOSAT-C88.

3.3 Specific Combining Ability x Year Effects for Grain Yield and other Agronomic Traits in Millet

Specific combining ability effects for eight agronomic traits in millet across years are presented in Table 3. Three crosses of SOSAT-C88 x DMR43, SOSAT-C88 x LCIC9702 and SOSAT-C88 x EX-GASHU'A showed negative significant SCA effects for days to 50% flowering indicated that these hybrids could be improved for earliness. The negative SCA recorded for plant height (cm) is desirable in breeding for earliness and the short stature hybrids could resist lodging particularly in windy environment like the studied area. This result however, revealed the following hybrids: SOSAT-C88 x DMR43, SOSAT-C88 x EX-GASHU'A and EX-GASHU'A x LCIC9702 could be a good cross combination when breeding for early maturing. The SCA effect was not significant for tiller count and threshing%, similar result was reported by Bain *et al.* (1967). This study identified EX-BORNO x DMR43, SOSAT-C88 x DMR43, SOSAT-C88 x EX-GASHU'A and DMR43 x LCIC9702 hybrids for positive and significant panicle length (cm). The SCA effects were also significant for almost all the traits in head weight (g) except EX-BORNO x DMR43, EX-BORNO x EX-GASHU'A and SOSAT-C88 x EX-GASHU'A. Similarly, the 1000 seed weight (g) showed positive and

significant effect EX-BORNO x SOSAT-C88, EX-BORNO x DMR43, SOSAT-C88 x DMR43 and DMR43 x LCIC9702. These hybrids should be encouraged for improvement in pearl millet production. In particular, the cross combinations of the following: EX-BORNO x SOSAT-C88, SOSAT-C88 x DMR43, SOSAT-C88 x LCIC9702 and DMR43 x LCIC9702 have been identified as the best in terms of total grain yield (kg ha^{-1}). Crossed seeds with excellent SCA estimates were equally those parents with brilliant mean performances in most cases, for one character or the other. A close look at the results indicated that SCA variance component was greater than the GCA variance component for grain yield, implying the importance of non-additive genetic effect for the control of total grain yield per hectare (Kadams 1999). This study has identified good number of desirable cross combination for each of the trait studied in pearl millet combined across years (EX-BORNO x SOSAT-C88, SOSAT-C88 x DMR43, SOSAT-C88 x LCIC9702 and DMR43 x LCIC9702).

4. CONCLUSION

1. The combined analysis of variance showed that parents and crosses had significance effects on most of the traits.
2. This was an indication of the presence of large genetic variability in the materials which could be used to enhance selection for further improvement in other locations.
3. A close look at the results indicated that SCA variance component was greater than the GCA variance component for grain yield (kg ha^{-1}) implying the importance of non-additive genetic effect for the control of total grain yield ha^{-1} .
4. This study has identified good number of desirable cross combination for each of the trait studied in pearl millet combined across years.

Table 1. Combining Analysis of Variance for Eight Agronomic Traits in Millet across Years (2015 and 2016)

Source of variation	Df	Days to 50% flowering	Tiller count	Plant height (cm)	Panicle Length (cm)	Head weight (g)	Threshing %	1000 seed weight (g)	Grain yield (kg ha^{-1})
Year	1	7.810	3.187	7.38.166	57.110*	4386.61*	281.876*	0.667	2638911.05**
GCA	4	10.683**	1.982	734.430*	116.069**	5456.31**	101.034	0.873	768131.23*
SCA	9	7.932	1.667	693.895*	47.635*	4897.66*	98.643	2.013*	674421.09*
GCA x Year	4	11.503*	1.931	496.313	40.911	553.36	79.781	2.163*	496932.12
SCA x Year	9	10.346*	1.794	560.464*	32.146	4881.17*	121.667*	1.934*	688364.53**
Poole Error	26	4.856	1.230	411.017	13.221	236.11	41.563	0.586	5460.09
SCA:GCA		0.231	0.141	0.326	0.675	0.226	0.502	0.172	0.337

*= significant, **= highly significant

Table 2. Estimate of General Combining Ability Effects for Eight Agronomic Traits in Millet across Years (2015 and 2016)

Parents	Days to 50% flowering	Tiller count	Plant height (cm)	Panicle Length (cm)	Head weight (g)	Threshing %	1000 seed weight (g)	Grain yield (kg ha ⁻¹)
EX-BORNO	1.873*	0.183	25.763**	1.321	-58.361	-1.632	-10.161*	-94.621**
SOSAT-C88	-0.167*	0.037	-20.342*	11.936*	46.431*	0.681	12.166**	59.983*
DMR 43	1.018	0.674	14.381	9.321*	38.364*	1.487	12.679**	55.566*
LCIC9702	-0.161*	1.022	-0.621	1.615	43.611*	0.862	6.337*	65.761*
EX-GASHU'A	0.142	1.138	22.433*	13.657*	20.476	-0.764	-4.363	-39.637
LSD (0.05)	0.761	0.831	8.263	4.624	12.168	0.476	2.813	21.671

*= significant, **= highly significant

Table 3. Specific Combining Ability for Eight Agronomic Traits in Millet across Years (2015 and 2016)

Hybrids	Days to 50% flowering	Tiller count	Plant height (cm)	Panicle Length (cm)	Head weight (g)	Threshing %	1000 seed weight (g)	Grain yield (kg ha ⁻¹)
EX-BORNO x SOSAT-C88	4.837	5.209	-0.264	2.318	1.698*	2.011	1.307*	10.474*
EX-BORNO x DMR 43	10.252*	-0.536	20.371*	5.861*	-0.932	-5.920	0.238	-2.930
EX-BORNO x LCIC9702	6.120	0.399	17.613*	-2.317	1.759*	4.037	1.643*	0.418
EX-BORNO x EX-GASHU'A	10.612*	-0.426	-3.118	-3.010	-0.847	-3.010	0.329	-3.137
SOSAT-C88 x DMR 43	-14.821*	5.493	7.463	1.310*	1.704*	-1.309	2.671**	12.613*
SOSAT-C88 x LCIC9702	-12.417*	5.381	-25.177**	3.935	1.426*	-4.002	0.181	10.639*
SOSAT-C88 x EX-GASHU'A	-13.023*	-0.311	-35.413**	7.199**	0.697	2.118	0.210	-6.317
DMR 43 x LCIC9702	-1.863	0.451	2.611	2.377	1.556*	0.709	1.536*	11.079*
DMR 43 x EX-GASHU'A	2.015	0.436	10.692	6.620**	1.632*	3.689	0.662	6.963
EX-GASHU'A x LCIC9702	-10.513*	0.121	-30.016**	1.076	1.411*	-3.134	0.401	7.434
LSD (0.05)	4.936	3.863	7.163	2.961	0.613	3.137	0.763	4.163

*= significant, **= highly significant

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