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GENETIC VARIABILITY AND MODE OF GENE ACTION OF DIFFERENT MATURITY GROUPS OF MAIZE (*ZEA MAYS* L.) INBRED LINES FOR DROUGHT TOLERANCE

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Abstract: ***Drought tolerant maize (Zea mays L.) hybrids are crucial for the sustainability of maize production in the drought-prone areas of Sub-saharan Africa. Understanding the genetics of inheritance under drought is important in designing breeding strategies for improving grain yield and other agronomic traits under drought. Two studies were conducted to determine the the genetic variability and mode of gene action for grain yield and other traits of different maturity groups of maize inbreds for tolerance to drought and identify the promising drought-tolerant maize hybrid(s) for drought-prone regions. Eleven inbred lines of different maturity groups and endosperm-modification were crossed using diallel mating scheme to generate 55 F_1 hybrids. The 55 hybrids along with one check and 11 inbreds were separately evaluated under induced drought and optimum growing conditions at Samaru and Kadawa. The experiments were laid in a 7 x 8 alpha lattice design and replicated two times using single-row plot of 4-m long. Row and hill spacing were 0.75 m and 0.4 m respectively. General combining ability (GCA) and Specific combining ability (SCA) mean squares were significant ($p < 0.01$) for grain yield and most other traits under drought and optimum growing conditions. SCA accounted for 79.3% and 64.2% of the total genetic variation for grain yield under drought and optimum growing conditions, indicating that non-additive gene action largely controlled the inheritance of grain yield of the hybrids. Hybrid TZEE-W-Pop STR C_5 x TZEI 87 should be further tested in multiple environments for adoption by farmers in drought prone areas of Sub-saharan Africa***

• Introduction

• The risk of drought stress is severe particularly in the Sudan savanna zone due to unreliable and uneven distribution of rainfall (Eckebil, 1991). Even in those lowlands with adequate precipitation for maize production, periodic drought may occur at the most sensitive stages of the crop such as flowering and grain filling. While drought will impact the growth and ultimate performance of a crop at any stage, it is of most detriment at flowering and grain filling resulting in yield penalties of between 40 and 90% (Menkir and Akintunde, 2001; Badu-Apraku *et al*., 2011a; Badu-Apraku and Oyekunle, 2012). Therefore, improved tolerance to drought is an important breeding objective to stabilize maize production in the sub-region. Betran *et al.* (2003), Meseka *et al.* (2006), Badu-Apraku *et al.* (2011a) Makumbi *et al.* (2011) and Oyekunle and Badu-Apraku (2013) reported additive gene action to be more important than the non-additive gene action in early maturing maize inbreds evaluated under induced drought stress and optimal growing conditions. Similarly, Badu-Apraku and Oyekunle (2012) in a study involving 20 extra-early inbreds reported additive gene action to be more important than the non-additive gene action in modulating the inheritance of grain yield and other traits associated with *Striga* resistance and drought tolerance.

• However, information on the gene action conditioning grain yield and other traits of maize inbred lines of different maturity groups and different kernel modification for tolerance to drought is completely lacking. Such information is important for the development of acceptable hybrids for drought prone environments in Nigeria and other countries in Sub-saharan Africa.

• Material and method

Eleven maize inbred lines comprised five early maturing, four extra-early maturing and two early QPM inbred lines were selected based on their contrasting response to drought and availability of seed and were utilized in the genetic analysis study (Table 1). The 11 inbreds were crossed using the diallel mating design to generate 55 single-cross hybrids during the rainy season of 2015. The 55 F_1 hybrids plus one hybrid check were evaluated under induced drought and well-watered conditions at Samaru and Kadawa during the 2015/2016 dry season. The experiments were laid in a 7 x 8 alpha lattice design and replicated two times using single-row plot of 4-m long. Row and hill spacing were 0.75 m and 0.4 m respectively. Three seeds were planted per hill and seedlings were thinned to two per stand about two weeks after emergence, giving a population density of 66,666 plants per hectare. A compound fertilizer (NPK 15:15:15) was applied at the rate of 60 kg N ha^{-1}, 60 kg P ha^{-1} and 60 kg K ha^{-1} two weeks after planting. An additional 60 kg N ha^{-1} urea was top-dressed two weeks later in the drought experiment and 4 weeks later in the well-watered experiment. Irrigation was supplied twice every weak using furrow irrigation system. The managed drought stress was achieved by supplying irrigation water twice a week up to 35 days after planting. Thereafter, the irrigation water was withdrawn in the drought experiment, so that the maize plants relied on stored water in the soil for growth and development. On the other hand, the experiment under optimum growing conditions, continue to receive irrigation until physiological maturity. Except for the water treatment, all management practices were the same for both the optimum and drought experiments.

• Results and discussions

Mean squares from the combined ANOVA of combining ability of 11 maize inbred lines for grain yield and other agronomic traits evaluated under induced drought stress and optimum growing conditions at Samaru and Kadawa in 2016.

	DF	Grain Yield (t/ha)	Days to anthesis	Days to silking	ASI	Plant Height (m)	Root Lodging (%)	Husk Cover	Plant Aspect	Ear Aspect	EPP	Cob Lengt (cm)
ught Stress												
	1	831890.29*	0.11	1.45	2.36	617.79*	50.16**	0.16	4.57**	1	0.08	3.3
)	2	245954.62	7.43*	6.61	0.17	266.15	0.15	1.3	0.68	0.97	0.04	2.16
e	55	1412485.12**	10.01**	11.28**	3.62	350.14**	0.62	1.16**	0.77	1.26*	0.09**	12.70
	10	1501674.81**	29.82**	25.72**	2.01	251.66	0.48	1.28**	0.61*	1.34**	0.09**	15.50
	44	1305128.44**	5.52**	8.25**	3.90*	380.45**	0.54	1.16**	0.79**	1.20**	0.08**	10.82
	55	407018.59**	4.00**	5.86	2.55	37.09	0.67	0.29	0.65**	0.68**	0.05	5.96
NV	10	412306.01*	10.61**	7.62*	3.17	30.87	0.44	0.31	0.67**	0.51	0.08*	5.64
NV	44	414908.72**	2.38	5.51	2.44	39.33	0.72	0.29	0.63**	0.73**	0.04	6.16
	110	171825.2	1.89	4.18	2.56	140.68	0.55	0.45	0.27	0.34	0.04	3.56
num Growing Conditions												
	1	6409902.92**	15.02**	6.44643	1.786	110.04	36.97**	3.02*	27.16**	4.72**	0.026	93.22
)	2	15257.65	1.36607	2.72321	0.232	124.629	0.3795	0.009	0.4375	0.372	0.006	1.082
	55	1386672.02**	11.23**	18.68**	2.39**	579.47**	0.69*	0.64**	0.20422	0.595	0.019	3.12*
	10	2617069.28**	36.04**	56.16**	3.77**	924.97**	0.5404	0.343	0.43*	1.12**	0.015	3.041
	44	1066598.64**	5.69**	9.50**	1.73**	488.44**	0.74*	0.72*	0.15833	0.475	0.02	3.204
	55	246198.7	2.64*	3.85*	0.74	15.8675	0.3869	0.336	0.22662	0.459	0.018	1.276
ENV	10	262984.13*	8.73**	10.97**	0.632	9.888	0.3212	0.237	0.20619	0.619	0.019*	1.57
NV	44	241639.46	1.3111	2.3051	0.771	16.986	0.4099	0.365	0.21073	0.421	0.019	1.236
	110	577248.1	1.82062	2.52321	0.723	104.102	0.4522	0.473	0.19659	0.378	0.015	2.471

GCA effects of maize inbreds for grain yield and other agronomic traits evaluated under induced drought stress and optimum water condition at Samaru and Kadawa in 2016.

Grain Yield (t/ha)		Days to anthesis		Days to silking		ASI		Husk Cover		Ear Aspect		EPP	
DS	WW	DS	WW	DS	WW	DS	WW	DS	WW	DS	WW	DS	W
-181.770*	-152.5	0.169	-0.311	0.391	-0.169	0.222	0.141	0.005	0.016	0.167	0.081	-0.041	-0.
-282.762**	272.9*	-1.136**	-1.449**	-0.831**	-2.114**	0.306	-0.664**	-0.245*	-0.053	0.347**	0.053	-0.096**	0.0
62.073	189.9	0.725**	-0.227	0.475	-0.114	-0.25	0.114	0.144	0.058	0.014	-0.044	0.026	0.
168.191*	-165.2	1.836**	2.217**	1.614**	2.803**	-0.222	0.586**	0.144	0.016	-0.236*	0.4**	0.066*	0.
199.021*	149.3	0.169	0.884**	0.003	0.997**	-0.167	0.114	0.061	0.016	-0.222*	-0.058	0.05	0.
-86.624	-233.7*	-1.164**	-1.172**	-1.109**	-1.086**	0.056	0.086	0.144	0.1	0.097	0.109	-0.005	-0.
-292.522**	-538.8**	0.447	0.106	0.780*	0.109	0.333	0.003	-0.356**	-0.122	0.208	-0.003	-0.054	-0.
-66.188	187.2	-0.497	-0.033	-0.247	0.22	0.25	0.253	0.088	0.128	0	-0.058	-0.037	-0.
292.055**	-93.04	0.225	0.662**	0.114	0.525	-0.111	-0.136	-0.245*	-0.192	-0.236*	0.011	0.029	5.0
-31.958	-9.673	0.28	-0.255	0.058	-0.447	-0.222	-0.192	0.144	0.086	-0.083	-0.239*	0.026	-0.
220.488**	393.5**	-1.053**	-0.422	-1.247**	-0.725*	-0.194	-0.303*	0.116	-0.053	-0.056	-0.253*	0.034	0.
0.16	0.42	0.89	1	0.54	0.94	0.03	0.35	0.16	0.03	0.16	0.46	0.17	0.

*, **, significant at 0.05 and 0.01 levels of probability
ASI: anthesis silking interval; EPP: ears per plant; LDS: leaf death score ; 1000 KG: 1000 kernels weight.

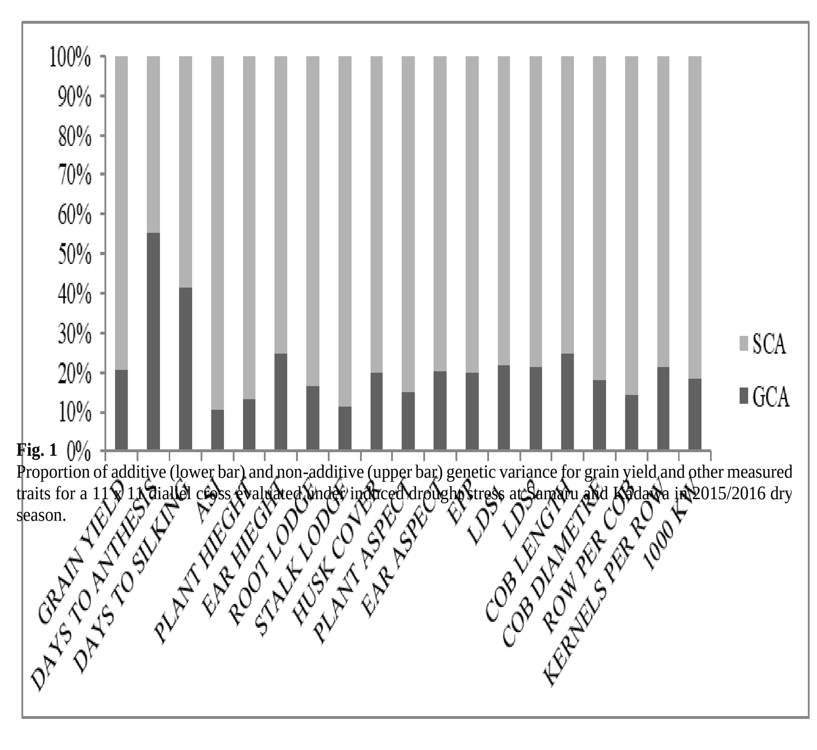

Fig. 1
Proportion of additive (lower bar) and non-additive (upper bar) genetic variance for grain yield and other measured traits for a 11 x 11 diallel cross evaluated under induced drought stress at Samaru and Kadawa in 2015/2016 dry season.

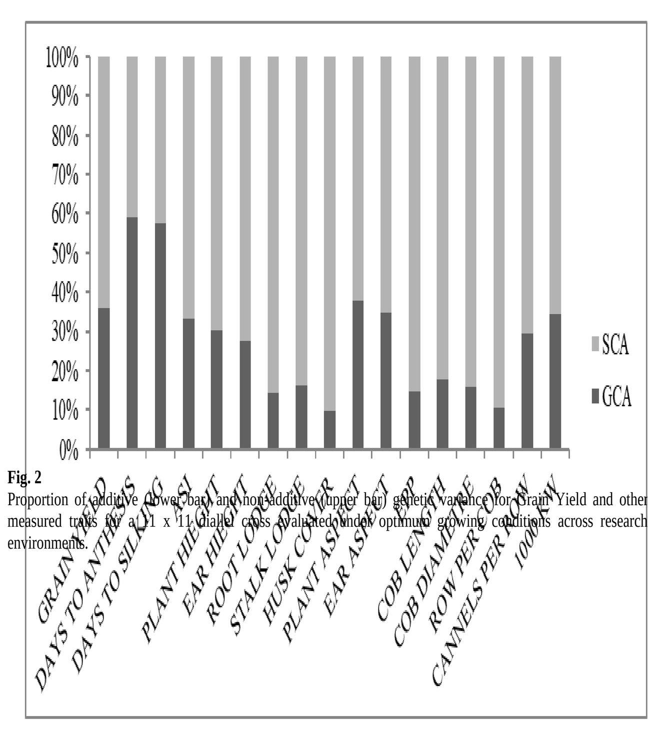

Fig. 2
Proportion of additive (lower bar) and non-additive (upper bar) genetic variance for Grain Yield and other measured traits for a 11 x 11 diallel cross evaluated under optimum growing conditions across research environments.

• Conclusions

Maize is the third most important cereal in the world after wheat and rice, its productivity has greatly been constrained by several biotic and abiotic factors, among which is drought which remain the single most important factor threatening the food security of people in the developing world. Therefore, improved tolerance to drought is an important breeding objective to stabilize its production so as to address the problems of food insecurity. Information on the gene action conditioning grain yield and other traits of maize inbred lines of different maturity groups and different kernel modification for tolerance to drought is completely lacking. Based on this, 11 inbreds of different maturity groups and different kernel modification were crossed using the diallel mating design to generate 55 single-crossed hybrids which were evaluated along with one check (SAMMAZ 42) in Samaru and Kadawa during the 2015 dry season. Irrigation was withdrawn 35 days after planting so that plants rely on available soil water for growth under the induced drought stress. Data collected were subjected to diallel analysis and combined analysis of variance (ANOVA) for inbreds and hybrids, using appropriate software.