HERITABILITY AND CORRELATES OF MAIZE YIELD (*Zea mays* L.) UNDER VARYING DROUGHT CONDITIONS

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ABSTRACT
The study was undertaken to estimate broad-sense heritability and correlations between grain yields and other traits in maize under non-stress, intermediate stress and severe drought stress conditions. Fifty six genotypes were evaluated in a simple lattice design with two replications during the 2012/13 dry season at Institute for Agricultural Research farm Samaru (11°11'N; 07°38'E) in the Northern Guinea savannah of Nigeria. The results showed high (>60%) heritability estimates for all the traits studied except number of ears per plant under non-stress and intermediate stress that showed low (<30%) and moderate (30-60%) heritability of 33.33% and 50.00%, respectively, while leaf senescence under intermediate stress showed moderate heritability of 57.14%. The heritability of anthesis-silking interval (ASI), plant height, ear height, leaf senescence, and number of ears per plant increased with increasing drought stress, whereas, that of days to 50% tasseling, days to 50% silking and grain yield decreased with increasing drought stress. Correlation analysis revealed that days to 50% tasseling and silking under non-stress, ASI and leaf senescence under severe stress exhibited negative and significant correlations with grain yield. The correlations between grain yield and plant height, ear height under non-stress, intermediate and severe stress conditions, respectively and number of ears per plant under severe stress were positive and significant. Traits that had high heritability and positive correlation with grain yield may be considered as important traits in selection programmes aimed at maize yield improvement and the breeder may consider these traits as main selection criteria.

Keywords: Drought, Maize, Heritability, Correlation and Traits

INTRODUCTION
Maize (*Zea mays* L.) is the third most important cereal food crop of the world after wheat and rice. It is a multipurpose crop which provides food for humans, feed for poultry, fodder for livestock, edible oil for human use, to mention but a few. It has high potential for production and productivity in the savanna ecology of sub-Saharan Africa due to high solar radiation and low night temperatures (Undie *et al*., 2012). However, its production in the savanna regions of Nigeria is facing a lot of problems ranging from low soil nutrients status, drought and susceptibility to pests and diseases as well as poor adaptation to the agro-ecologies (Olaoye *et al*., 2004). Drought stress is believed to be one of the most important environmental factors that reduce growth, development and production of plants. It can be said that it is one of the most devastating environmental stresses (Khodarahmpour, 2012). Among various constraints responsible for average low maize yield per hectare, inadequate supply of water at critical development stages and high sensitivity of different maize cultivars to water stress are of immense importance. The occurrence of drought from a few days before anthesis to the beginning of grain filling, the most sensitive stages of the crop, can reduce grain yield by as much as 90% (NeSmith and Ritchie, 1992). Maize breeders have therefore devoted effort to developing superior genotypes for grain yield and adaptation to the different stress factors (Bello and Olaoye, 2009).

Grain yield of maize is considered as a complex inherited character, and therefore, direct selection for yield *per se* may not be the most efficient method for its improvement, rather indirect selection for other yield related characters, with high heritability estimates will be more effective. Correlation studies simply measure the associations between yield and other traits. It provides information that selection for one trait will result in progress for all positively correlated characters. Heritability on the other hand provides an idea to the extent of genetic control for expression of a particular trait and the reliability of phenotype in predicting its breeding value (Tazeen *et al*., 2009). High heritability indicates less environmental influence in the observed variation (Songsri *et al*., 2008). High heritability for a given trait also indicates that it is governed by additive gene action and, therefore, provides the most effective condition for selection (Tazeen *et al*., 2009). The present study was therefore, aimed at determining heritability estimates and correlations between grain yield and other traits in maize genotypes under varying drought conditions.

MATERIALS AND METHODS

The research was conducted during the 2012/13 dry season at the Institute for Agricultural Research (IAR) farms at Samaru (11°11'N; 07°38'E) in the Northern Guinea savannah ecological zone of Nigeria. Fifty six maize genotypes were used for this study comprising six drought tolerant male inbred lines; seven drought susceptible female inbred lines, forty two single cross hybrids and a commercial check. The single cross hybrids were generated in the year 2012 rainy season using North Carolina mating design II. The genotypes were grown in a simple lattice design replicated two times under varying drought conditions resulting in non-stress, intermediate stress and severe drought stress conditions. Apart from the targeted drought stress, the management of the trials was the same in all the three conditions. The non-stress conditions continued to receive irrigation water once every week until the end of physiological maturity. In the intermediate stress conditions, water stress was imposed by withdrawing irrigation water as from 6 weeks after planting until the end of the growing season, to enable drought stress at grain filling stage. The crop was allowed to mature only on stored soil water. In the severe stress condition, water stress was imposed by withdrawing irrigation water as from 5 weeks after planting to enable drought stress at flowering stage. Because the average anthesis-silking interval was between 3-5 days, an additional irrigation was applied at 14 days after the end of male flowering to enable the small amounts of grains formed filled adequately as per Banziger *et al*. (2000). Each entry was planted in a 3 m row plot spaced 0.75 m apart with 0.25 m spacing between plants within each row. Two seeds were planted in a hill and thinned to one plant after emergence to obtain a population density of approximately 53,333 plants per hectare. Data was taken on the following traits: days to 50% tasseling, days to 50% silking, anthesis-silking interval (ASI), plant height (cm), ear height (cm), leaf senescence, number of ears per plant and grain yield (kg/ha). Heritability and correlation estimates were worked out following the formulae and procedures as outlined by Singh and Chaudhary (1985).

RESULTS AND DISCUSSION

The results from the heritability estimates are presented in Table 1. Drought conditions played significant role in modifying the heritability estimates for different traits. Under non-stress conditions, high heritability (>60%) estimates were observed for days to 50% tasseling (90.24%) followed by days to 50% silking (86.63%), plant height (78.00%), ASI (70.80%), ear height (70.76%) and grain yield (69.34%). However, low heritability (<30%) estimate was observed for number of ears per plant (33.33%). Under intermediate stress condition, high heritability (>60%) estimates were observed for plant height (85.77%) followed by days to 50% silking (84.36%), days to 50% tasseling (83.65%), ear height (83.11%), ASI (75.30%) and grain yield (66.51%). However, moderate heritability ((30-60%) was obtained for leaf senescence (57.14%) and number of ears per plant (50.00%). Under severe stress condition, high heritability (>60%) estimates were observed for number of ears per plant (93.33%) followed by plant height (87.42%), ear height (85.89%), days to 50% silking (80.10%), days to 50% tasseling (78.54%), ASI (75.96%) leaf senescence (66.80%) and grain yield (64.48%). The high heritability obtained for most of the traits under the varying drought conditions suggests that the traits can easily be selected for in subsequent seasons for drought tolerance. Traits that had high heritability estimate indicate the preponderance of additive gene action. These results are in line with earlier results reported by Aminu *et al*. (2013), Olakojo and Olaoye (2011) and Wannows *et al.* (2010). The heritability of ASI, plant height, ear height, leaf senescence, and number of ears per plant increased with increasing drought stress, whereas, that of days to 50% tasseling, days to 50% silking and grain yield decreased with increasing drought stress. An increase in error variance under stress conditions has been reported to cause decrease in heritability estimates (Hulmel *et al*., 2005). Decreased heritability for these traits under stress conditions were reported earlier by Umar *et al*. (2014) and Bolanos and Edmeades (1996). The decreased heritability for traits under stress indicates the need for selection of genotypes under specific environmental conditions for rapid genetic improvement.

Table 1: Estimates for broad-sense heritability (%) for eight agronomic traits in maize under non-stress, intermediate stress and severe drought stress conditions

	Broad sense heritability (%)		
Traits	**Non-stress**	**Intermediate stress**	**Severe stress**
Days to 50% tasseling	90.24	83.65	78.54
Days to 50% silking	86.63	84.36	80.10
Anthesis-silking interval	70.80	75.30	75.96
Plant height	78.00	85.77	87.42
Ear height	70.76	83.11	85.89
Leaf senescence	-	57.14	66.80
Number of ears per plant	33.33	50.00	93.33
Grain yield	69.34	66.51	64.48
Range	33.33-90.24	50.00-85.77	64.48-93.33
Mean	71.30	73.23	79.07

Results of the correlation coefficients (Table 2) revealed significant and negative correlation between grain yield and days to 50 % tasseling (-0.38**) and days to 50 % silking (-0.37**) under non-stress, ASI (-0.21*) and leaf senescence (-0.22*) under severe stress.

Table 2: Correlation coefficients between grain and other traits under non-stress, intermediate stress and severe drought stress conditions

Traits		DYTS	DYSK	ASI	PLHT	EHT	SEN	EPP	GY
DYTS	NS	1.00	0.74**	-0.02	-0.16	-0.08	-	0.22*	-0.38**
	IS	1.00	0.83**	-0.01	-0.12	-0.17	-0.24*	0.31**	-0.14
	SS	1.00	0.80**	0.10	-0.22*	-0.17	-0.15	0.14	-0.01
DYSK	NS		1.00	0.35**	-0.17	-0.11	-	0.06	-0.37**
	IS		1.00	0.43**	-0.17	-0.15	-0.11	0.26*	-0.17
	SS		1.00	0.67**	-0.39**	-0.24*	-0.13	0.09	-0.12
ASI	NS			1.00	-0.15	0.01	-	-0.14	-0.16
	IS			1.00	-0.11	-0.01	0.14	-0.01	-0.17
	SS			1.00	-0.36**	-0.19*	-0.01	-0.02	-0.21*
PLHT	NS				1.00	0.54**	-	-0.03	0.33**
	IS				1.00	0.60**	-0.08	-0.30**	0.42**
	SS				1.00	0.81**	-0.20*	-0.25*	0.27*
EHT	NS					1.00	-	0.01	0.23*
	IS					1.00	-0.14	-0.28*	0.48**
	SS					1.00	-0.03	-0.31**	0.19*
SEN	IS						1.00	-0.03	-0.18
	SS						1.00	-0.10	-0.22*
EPP	NS							1.00	0.13
	IS							1.00	0.09
	SS							1.00	0.27*
GY	NS								1.00
	IS								1.00
	SS								1.00

*P<0.05; **P<0.01; NS = non-stress; IS=intermediate stress; SS=severe stress; DYTS=days to 50% tasseling; DYSK=days to 50% silking; GY=grain yield; ASI=anthesis-silking interval; PLHT=plant height; EHT=ear height; SEN = leaf senescence; EPP = number of ears per plant

These findings are consistent with findings of Zaidi *et al*. (2004) and Betran *et al*. (2003). This indicates that an increase in any of these traits could result in a corresponding decrease in grain yield and this suggests that grain yield can be improved by selecting for early tasseling and silk emergence and shorter ASI. The correlation between grain yield and plant height (0.33**, 0.42** and 0.27*), ear height (0.23*, 0.48**, and 0.19*) under non-stress, intermediate and severe stress conditions, respectively and number of ears per plant (0.27*) under severe stress were positive and significant. Similar results were reported by Bello *et al*. (2010) and Wannows *et al*. (2010). This shows that selection for any of these traits could result in corresponding increase in grain yield. However, this contradicts the reports of Mohan *et al.* (2002) and Olakojo and Olaoye (2011) who reported negative correlation between grain yield and plant height and ear height.

CONCLUSION

The results showed that days to 50% tasseling, days to 50% silking, ASI, plant height, ear height and grain yield had high broad-sense heritability under both contrasting drought conditions. High to moderate heritability indicated considerable potential for development of drought tolerance and high yielding varieties through selection of desirable plants in succeeding generation. The decreased broad sense heritability of days to 50% tasseling, days to 50% silking and grain yield remind breeders for selection of genotypes under specific environments for rapid genetic improvement. Some traits such as plant height, ear height and number of ears per plant were positively correlated with grain yield under drought stress. Traits that had high heritability and positive correlation with grain yield may be considered as important traits in selection programme aiming to maize yield improvement and the breeder may consider these traits as main selection criteria.

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