

**Genetic variances, heritability and traits association of early maturing maize hybrids under drought imposed at seedling and flowering stages**

ABSTRACT

**Aims:** Information on traits association and inheritance are crucial to designing appropriate breeding strategies for improving maize production and productivity in drought-prone ecologies. The objectives of this study were to investigate inter-trait relationships among maize hybrids and estimate genetic variances and heritability of drought tolerance parameters under seedling and flowering drought conditions.

**Methodology:** Sixty-six single cross hybrids generated using diallel mating design plus nine hybrid checks were evaluated using a 5 x 15 alpha lattice and randomized complete block designs in three replicates on the field and in the screenhouse respectively, during 2015 cropping season. Data were collected on grain yield, ears per plant, anthesis-silking interval, seedling aspect, chlorophyll content and leaf area and these data were subjected to analysis of variance as well as correlation and path coefficient analyses.

**Results:** Significant mean squares ( $P = .05$ ) were observed for all measured traits except leaf area and shoot fresh weight. Narrow-sense heritability estimate for grain yield was moderate (33.4%) on the field and low (0 – 25%) for all the seedling traits. The low narrow-sense heritability estimates observed for most seedling traits implied that the scope for improvement of these traits in the genotypes is limited. Seedling traits under drought stress were not directly correlated with grain yield except number of dead leaves relative to the total number of leaves. Results of the path analysis revealed that number of leaves, number of dead leaves and chlorophyll content under the screenhouse conditions had significant direct effects on grain yield on the field

**Conclusion:** Number of leaves, chlorophyll content and number of dead leaves under drought at seedling stage could therefore be used as indicator traits for grain yield improvement in maize exposed to drought stress at flowering stage.

**Keywords:** Drought, heritability, genetic variance, path analysis, maize.

## 35 **Introduction**

36 Maize is an important staple food, animal feed and industrial crop in sub-Saharan Africa  
37 (SSA). The savannas of the sub region offer ideal environments for maize production because  
38 they are characterized by high solar radiation, low night temperatures, low incidence of pests,  
39 and diseases. Over 85% of the population of people in the rural areas in Africa grows maize  
40 due to its suitability in diverse farming systems and its ability for increased yield under  
41 improved management practices as compared to other cereal crops [1]. [2] recommended that  
42 the development and accelerated deployment of maize hybrids would increase maize yields in  
43 the major maize producing countries of West and Central Africa (WCA). Studies have  
44 demonstrated that hybrids can increase farmers' maize yields by more than 40% in  
45 favourable growing environments and by more than 30% even under stressful conditions [3].  
46 Drought is a major constraint in boosting maize production in Africa especially in the SSA,  
47 coupled with other abiotic stresses it has resulted in maize displacement by high value crops  
48 to marginal areas [4]. Drought exerts its effects on yield through its effects on physiological  
49 processes, and through losses in plant stand when such stress occurs during emergence and at  
50 the seedling stage. The extent of grain yield reduction in maize due to drought stress depends  
51 on the stage of crop development at the time of the stress and its severity. However, the  
52 flowering period in maize is the most sensitive to drought. The most economically feasible  
53 and sustainable way to boost maize production and productivity in SSA is to develop drought  
54 tolerant varieties for the farmers. Earlier studies conducted in the rainforest agro-climatic  
55 zone showed that maize planted early significantly out-yielded those planted later in the  
56 season primarily because grain filling coincided with the period of relatively high incident  
57 solar radiation [5]. Maize plants with excellent adaptive response to drought at seedling stage  
58 will help in combating the effect of early season drought in the rainforest agro-ecology of  
59 southwestern Nigeria. Therefore, the evaluation of maize crop at the seedling stage is an  
60 important aspect of crop breeding program with the objective to evolve drought tolerant  
61 varieties. Developing specific maize genotypes which can tolerate drought at seedling stage,  
62 especially in southwestern Nigeria where the rainfall pattern is bimodal, will offer the farmers  
63 in this region the opportunity of planting maize earlier in the year (that is, late February to  
64 early April), immediately after the first few rains and by extension West Africa. Therefore,  
65 development of high yielding cultivars that combine tolerance to drought at both seedling and  
66 flowering stages could be a coping strategy to combat detrimental effects of climate change  
67 on maize production and productivity in the sub-region.

68 Grain yield is a complex trait and it is collectively influenced by various component traits,  
69 besides being polygenically inherited and highly influenced by environmental variation. The  
70 appropriate knowledge of interrelationships between grain yield and its contributing  
71 components can significantly improve the efficiency of breeding programs using appropriate  
72 selection indices [6]. In making selection for improved genotypes in maize, yield is the  
73 primary trait but selection under drought based on grain yield alone is inefficient due to low  
74 heritability of grain yield and the complexity of genotype-environment interactions [7].  
75 Genetic variance and heritability of maize grain yield are reduced under drought whereas  
76 secondary traits have relatively high genetic variance and heritability [8,9]. However, the  
77 relative usefulness of secondary traits as indirect selection criteria for grain yield is often  
78 inconclusive for all experiments because of the nature of the genetic materials and different  
79 conditions of experiments [10]. In the past years, the use of secondary traits with grain yield  
80 in making selection has increased selection breeding efficiency in maize grown under stress  
81 conditions by 20 to 50% [11,12]. [13] reported that the most reliable traits for selection for  
82 improved grain yield under drought stress in the early maturing germplasm were ear aspect,  
83 ears per plant, anthesis-silking interval, and plant aspect. There is dearth of information on  
84 reliable seedling drought traits for predicting improved grain yield under flowering drought  
85 conditions.

86 The determination of correlation coefficients helps to measure the level of relationships  
87 among traits and to establish the level at which these traits are mutually different [14]. Path  
88 coefficient analysis helps to know the nature, extent and direction of selection; it is the most  
89 valuable tool commonly used to establish the exact relationships in terms of cause and effect,  
90 identifying the direct, indirect and total (direct plus indirect) causal effects, as well as to  
91 remove any spurious effect that may be present [15]. Studies had reported that tolerance to  
92 drought stress at seedling stage and at flowering stage has no relationship, using correlation  
93 analysis [16]. However, correlation analysis, being a bivariate analysis only detect linear  
94 relationships between two variables while it assumes no significant influence of  
95 interrelationship of other variables. Therefore, the use of multivariate techniques such as path  
96 coefficient analysis, which considers the effect of several independent traits on a target  
97 (dependent) trait by partitioning the total correlation into direct and indirect effects (effects  
98 exerted through other independent variables) is necessary. In such analysis, traits with  
99 significant direct effect on a target trait are identified while those with indirect effect through  
100 other traits are also detected. Information obtained from such analysis is more important than

101 mere correlation and would not only help in identifying important secondary traits that could  
102 be used as indirect selection criteria for improving maize genotypes for a desired trait, but  
103 will provide adequate information useful to formulate base index which will in turn improve  
104 the efficiency of selection for the target trait.

105 The primary objectives of this present study were to (i) estimate genetic variance and  
106 heritability of drought tolerance traits at seedling and flowering stages of maize hybrids; and  
107 (ii) investigate the inter-trait relationships under seedling and flowering drought stress  
108 conditions, using simple correlations and path co-efficient analyses.

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## 110 **Materials and Methods**

### 111 **Generation of crosses**

112 Twelve inbred lines were planted in breeding nursery in a single-row plot, 5 m long at a  
113 spacing of 0.75m x 0.25m. Standard agronomic practices were employed to ensure good crop  
114 stand. At flowering, the twelve inbred parents were crossed in a diallel fashion to generate 66  
115 single-cross hybrids. The different crosses were harvested separately, processed and  
116 packaged into trials for evaluation.

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### 118 **Field performance evaluation**

119 Drought stress at flowering stage was achieved in the field. The experiment was conducted at  
120 the Crop Science Unit of the Teaching and Research Farm, Obafemi Awolowo University, Ile  
121 Ife ( $7^{\circ}28'N$   $4^{\circ}33'E$ , 244m, 1200 mm rainfall) during the 2015 cropping season. The planting  
122 was done on the 21<sup>st</sup> September, such that flowering could coincide with a period of no  
123 rainfall (drought). A trial composed of the sixty-six (66) single cross hybrids plus nine checks  
124 was laid out using a 5 x 15 alpha lattice design with three replications. Each entry was  
125 planted into a single-row plot, 5 m long with 0.75 m spacing between rows and 0.50 m  
126 spacing between plants within a row. Three seeds were sown per hole and later thinned to  
127 two plants per hill to attain a population density of 53,333 plants ha<sup>-1</sup>. A compound fertilizer  
128 of NPK 15:15:15 was applied at the rates of 60 kgN, 60 kgP and 60 kg K<sub>2</sub>O ha<sup>-1</sup> at two weeks  
129 after planting. An additional 60 kgN ha<sup>-1</sup> was also applied as side dressing at four weeks after  
130 planting (WAP) using urea (46% N). On each plot on the field, data were collected on days to  
131 anthesis, days to silking, number of ears per plant (EPP), plant and ear heights. Plant aspect  
132 was rated on a scale of 1 to 9, where 1 = excellent overall phenotypic appeal and 9 = poor

133 overall phenotypic appeal. Ear aspect was scored on a scale of 1 to 9, where 1 = clean,  
134 uniform and large ears and 9 = rotten, variable and small ears. Stay-green characteristic (leaf  
135 death score) was scored per plot at 70 days after planting, on a scale of 1 to 9, where 1 =  
136 almost all leaves green and 9 = virtually all leaves dead. Harvested ears from each plot were  
137 shelled to determine the percentage grain moisture. Grain yield in  $\text{kg ha}^{-1}$  was adjusted to  
138 15% moisture content and computed from the shelled grain weight.

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#### 140 **Screenhouse evaluation**

141 Drought stress at seedling stage was imposed in the screenhouse. The sixty-six single-cross  
142 hybrids plus nine hybrid checks were planted under drought stress imposed at the seedling  
143 stage at the screen house, Department of Crop Production and Protection, Obafemi Awolowo  
144 University, Ile Ife in 2015. The trial was laid out in a randomized complete block design with  
145 three replications. Six seeds of each inbred were sown per pot. The methodology proposed by  
146 [17] for screening maize genotypes for tolerance to drought at seedling stage was adopted,  
147 water was applied to each pot at the rate of 0.6 litres daily for 7 days, after which watering  
148 stopped. Data were collected at two-day intervals from 3 days after watering had stopped  
149 (DAWS) till 9 DAWS on the following: plant height, number of leaves, number of dead  
150 leaves, leaf length and breadth, leaf area, and number of dead leaves relative to the total  
151 number of leaves (RDL) in percentage. In addition, seedling aspect was scored on a scale of 1  
152 to 9, where 1 = absence of visible symptoms of stress: vigorous plants, no wilting, no dead  
153 leaves, no chlorosis, no height reduction and unrolled turgid leaves and 9 = total collapse or  
154 100% death of seedlings, dried leaves and stem, as described by [17].

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#### 156 **Data analysis**

157 Data collected were subjected to analysis of variance using PROC general linear model  
158 (GLM) procedure of Statistical Analysis Software (SAS), version 9.2 [18]. In the analysis,  
159 genotype was considered as a random factor and to achieve that, random statement option in  
160 GLM was used. Genetic variances were estimated using Proc Varcomp procedure of SAS.  
161 Estimate of narrow-sense heritability was performed as the proportion of additive variance  
162 over phenotypic variance expressed in percentage and this was done on plot mean basis for  
163 all traits under the two study conditions. In addition, path coefficient analysis was carried out  
164 to partition total correlation among traits into direct and indirect effects considering grain  
165 yield as the dependent variable. Pearson correlation (phenotypic correlation) was first

166 calculated and then the correlation coefficients were partitioned into direct and indirect  
167 effects through path coefficient analysis using PATHSAS program developed by [19].

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## 169 **Results and Discussion**

170 Results of analysis of variance (ANOVA) showed significant ( $P = .05$ ) differences among the  
171 genotypes for all seedling traits evaluated in the screenhouse except leaf area and fresh shoot  
172 weight (Table 1). Similarly, significant ( $P = .05$ ) effects were observed for genotype for all  
173 measured traits under stress conditions on the field (Table 2). The significant mean squares  
174 observed among the genotypes under the different stress conditions indicated presence of  
175 wide genetic variability within the genetic materials, which implies that a good progress from  
176 selection for improvement for drought tolerance at both growth stages could be achieved.

177 The additive variance measures the variation due to the average effects of alleles (additive  
178 effects, same locus) and the variation in the effects that are transmitted from one generation  
179 to another while the dominance variance is the variance due to interaction of average effects  
180 of alleles (dominance effects, same locus) [20]. The dominance variance is a function of  
181 allele frequencies and the level of dominance. In our present study, the additive variance was  
182 greater than non-additive (dominance) variance for all traits except number of ears per plant  
183 under the flowering drought conditions (Table 3). In contrast, the dominance variance was  
184 greater than the additive variance for all traits under the seedling drought conditions, which  
185 implied that the dominance component is more important than the additive components for  
186 these traits. Estimates of additive genetic variance were significantly different from zero for  
187 all traits under field drought conditions and for all traits under the screenhouse conditions  
188 except seedling aspect, dry shoot weight and fresh shoot weight. Dominance variances were  
189 significantly different from zero for all measured traits except seedling fresh shoot weight.  
190 Due to negative estimates, additive variance of dry shoot weight and dominance variance of  
191 fresh shoot weight were equated to zero. Thus, their dominance to additive genetic variance  
192 ratio could not be estimated. The dominance to additive genetic variance ratios were greater  
193 than 0.5 for four out of the eight traits under drought at the flowering stage and for seven out  
194 of the nine traits under seedling drought conditions.

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196 Table 1: Mean squares of seedling aspects and other seedling traits of 66 hybrids plus 9 checks evaluated under induced drought at seedling stage at the  
 197 screen house, 2015.

SV	Df	Seedling aspect score	Chlorophyll content	Plant height, cm	Leaf area, cm <sup>2</sup>	Number of dead leaves	Number of leaves	RDL	Fresh shoot weight, g	Dry shoot weight, g
Rep	2	12.20**	25.39	102.09**	90.15	5.32	39.66	854.30	9.07**	0.16*
Entry	74	1.83*	55.62**	29.04*	94.20	10.00**	55.56**	717.58**	0.26	0.05**
Error	148	1.27	16.39	19.34	79.73	3.17	35.91	416.36	0.26	0.03
R <sup>2</sup>		0.46	0.63	0.45	0.37	0.62	0.44	0.47	0.49	0.53
C.V		20.65	11.95	18.61	40.84	37.11	30.95	41.90	50.95	41.68

198 \*, \*\* Significant at 0.05, 0.01 probability levels respectively.

199 RDL = number of dead leaves relative to the total number of leaves.

200 Table 2: Mean squares for grain yield and other agronomic traits of 66 hybrids plus 9 hybrid checks evaluated under drought at flowering stage, at the  
 201 Teaching and Research Farm Obafemi Awolowo University, Ile Ife, 2015.

Source of variation	Df	Grain yield	Ears per plant	Plant aspect	Ear Aspect	Anthesis - silking interval	Plant height	Ear height	Stay green characteristics
Block (Rep)	12	652613.3**	0.16**	6.91**	5.64**	9.55**	1223.52**	388.68**	3.99**
Rep	2	977096.1**	0.47**	9.76**	21.63**	9.75**	2628.29**	882.79**	13.26**
Genotype	74	318140.3**	0.112**	2.24**	2.73**	4.69**	455.57**	162.38**	2.17**

Error	136	120633.0	0.06	0.77	1.59	1.65	124.48	50.26	0.93	202
R <sup>2</sup>		0.68	0.62	0.75	0.63	0.71	0.79	0.75	0.68	
CV		27.26	33.22	15.35	16.7	31.69	11.35	16.35	16.3	203

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208 \*, \*\* Significant at 0.05, 0.01 probability levels respectively; NS= not significant

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UNDER PEER REVIEW

213 Table 3: Additive ( $\hat{\sigma}_A^2$ ) and non-additive  $\hat{\sigma}_{NA}^2$  variances, narrow-sense heritability estimates ( $h^2$ ),  
 214 for grain yield and other agronomic traits of hybrids generated from diallel crosses evaluated under  
 215 terminal drought in the field and under imposed drought in the screen house.

Traits	$\hat{\sigma}_A^2 \pm SE$	$\hat{\sigma}_{NA}^2 \pm SE$	$\hat{\sigma}_{NA}^2 / \hat{\sigma}_A^2$	$h^2, \%$
Flowering drought environment				
Grain yield	40465.76±3512.730	36639.40±2026.930	0.91	33.4
Ears per plant	0.02±0.001	0.02±0.001	1.00	7.3
Plant aspect	0.35±0.030	0.22±0.020	0.63	35.7
Ear aspect	0.53±0.040	0.06±0.020	0.11	46.0
Anthesis-silking interval	0.90±0.070	0.37±0.030	0.41	45.0
Plant height	99.55±7.380	30.60±2.590	0.31	49.9
Ear height	17.70±1.590	13.58±1.010	0.77	31.1
Stay green characteristic	0.436±0.030	0.20±0.020	0.45	44.0
Seedling drought environment				
Seedling aspect	0.002±0.010	0.140±0.015	61.670	0.390
Chlorophyll content	3.154±0.390	15.270±0.360	4.840	17.000
Plant height	2.000±0.240	2.080±0.230	1.040	18.700
Leaf area	1.520±0.540	4.970±0.910	3.270	4.300
Number of dead leaves	0.412±0.070	2.080±0.060	5.060	11.600
Number of leaves	6.870±0.690	12.200±0.500	1.770	25.000
RDL	5.320±1.190	30.060±1.630	5.650	7.600
Fresh weight	0.001±0.001	0±0.003	0	0.380
Dry weight	0±0.0002	0.011±0.001	0	0

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227 Narrow-sense heritability estimate for grain yield was moderate (33.4%). The values of  
228 narrow-sense heritability for the traits ranged from 7.3% for ears per plant to 50% for plant  
229 height under drought at flowering and 0.38% for fresh weight to 25% for number of leaves  
230 under seedling drought conditions. Heritability estimates provide information on how  
231 efficient a trait could be transmitted from parents to their offspring [20]. Low narrow-sense  
232 heritability estimate observed for most measured traits, especially under drought at seedling  
233 stage is an indication that the scope for improvement of these traits in the parents is limited.  
234 However, introgression of genes for tolerance to seedling drought stress into the genotypes  
235 under study could guarantee continued progress from selection for improved grain yield and  
236 seedling traits under drought stress conditions. In addition, it might be desirable to increase  
237 the number of replications and locations to increase the accuracy of estimated entry means,  
238 and thus the heritability.

239 Adequate knowledge on the inter-relationship among traits is important in designing effective  
240 selection programs for crop improvement. Results showed that seedling traits were not  
241 directly correlated with grain yield except number of dead leaves relative to the total number  
242 of leaves which displayed significant negative relationship (Table 4). Ears per plant showed  
243 significant negative relationship with number of dead leaves and number of dead leaves  
244 relative to the total number of leaves. This implied that a hybrid with high number of dead  
245 leaves under drought at seedling stage will possibly give lower number of ears harvested per  
246 plot under drought conditions at flowering. Plant aspect had significant negative relationship  
247 with leaf area, number of leaves, shoot fresh weight and shoot dry weight. This suggests that  
248 maize hybrids under drought stress at seedling stage with high number of leaves, leaf area,  
249 shoot fresh weight and shoot dry weight would give rise to plants with excellent physical  
250 appearance under the same condition at flowering stage. In addition, stay green characteristic  
251 showed significant positive relationship with number of dead leaves and number of dead  
252 leaves relative to the total number of leaves. Though some of the seedling drought traits were  
253 found to be significantly correlated with traits taken on the field under flowering drought  
254 conditions, the strength of the relationships was generally low. The highest value of  $r$  (0.30)  
255 was obtained between number of dead leaves at seedling and stay-green characteristics at  
256 flowering. Therefore, the results of this study showed that seedling drought tolerance traits  
257 cannot be used as the main criteria for predicting grain yield in the hybrids under flowering  
258 drought conditions. This corroborates the findings from the study of [16] who reported that  
259 the seedling drought conditions were independent of drought responses at flowering on the  
260 field, possibly due to the type of screening environments used and the high genetic diversity

261 that segregated for traits conditioning drought tolerance. Even though low values of  
262 correlation coefficients ( $r$ ) were obtained,  $r$  measures only linear relationship, which path  
263 analysis helps to decompose among the studied characters, thereby enhancing better  
264 interpretation of relationships as well as pattern of the effects of one trait on the other.

265 An important objective of this study was to identify seedling drought traits with greatest  
266 influence on grain yield for use in future breeding programs. Thus, the correlation  
267 coefficients of the seedling drought traits with grain yield were further partitioned into direct  
268 and indirect effects through path analysis (Table 5). The low residual effect (0.25) indicates  
269 that the seedling traits altogether contributed substantially to grain yield. Among the seedling  
270 traits, path analysis identified number of leaves (0.290), and number of dead leaves (-0.242),  
271 chlorophyll content (0.051) as traits with significant direct contributions to grain yield,  
272 whereas number of leaves had the highest direct effect. This result was not surprising since  
273 leaf synthesizes the photosynthates which are stored in plant tissues and culminate in yield  
274 for the crop. Number of leaves was related to the number of photosynthetic components such  
275 as chloroplasts and therefore an increase in the number of leaves improves photosynthetic  
276 capacity. Path coefficient analysis showed that number of seedling leaves was the most  
277 important trait for grain yield improvement through its direct and indirect effects on grain  
278 yield. Number of leaves, relative number of dead leaves to the total number of leaves are  
279 contributing indirectly to the number of dead leaves. For number of leaves, number of dead  
280 leaves recorded the highest indirect effect. Under seedling drought conditions, in our study,  
281 number of leaves, chlorophyll content and leaf area were identified as the most important  
282 traits contributing to the variation in grain yield, suggesting that they are reliable secondary  
283 traits under drought stress conditions. In addition, these traits can be used as criteria for  
284 selecting for drought-tolerant genotypes under seedling stress conditions in early maturing  
285 maize hybrids. Under the field conditions, the path analysis identified ear aspect (-0.48), ears  
286 per plant (0.331), ear height (0.283), plant height (-0.255) and plant aspect (-0.219) as traits  
287 with the highest direct effect on grain yield on grain yield (Table not shown). These results  
288 are similar with those of [9], who identified plant and ear aspects and plant and ear heights as  
289 the most reliable traits for the simultaneous selection in the extra-early inbreds for improved  
290 yield under low-N and drought stress environments.

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293 Table 4: Pearson correlation of traits evaluated under drought induced at the seedling at the greenhouse, Faculty of Agriculture and under drought at  
 294 flowering stage at the Teaching and Research Farm, Obafemi Awolowo University, Ile Ife, 2015.

		Traits under drought at flowering stage							
		Anthesis- silking interval	Ears per plant	Plant height, cm	Ear height, cm	Plant aspect	Stay green characteristics	Ear aspect	Grain yield, kg/ha
Traits under drought at seedling	Number of dead leaves	0.15*	-0.15*	0.07	0.03	0.01	0.30**	0.17**	-0.07
	Leaf area, cm <sup>2</sup>	0.02	0.08	0.06	0.02	-0.14*	-0.08	-0.02	-0.02
	RDL	0.14*	-0.18**	-0.03	-0.06	0.11	0.28**	0.24**	-0.14*
	Number of leaves	0.06	-0.11	0.11	0.10	-0.18**	0.09	0.05	0.12
	Seedling aspect	0.02	-0.13	-0.03	-0.05	0.12	0.13	0.07	-0.02
	Chlorophyll content	0.06	0.07	-0.09	-0.03	0.08	0.05	-0.03	0.09
	Shoot fresh weight, cm	-0.03	0.03	0.10	0.08	-0.20**	-0.12	-0.09	0.04
	Shoot dry weight, cm	-0.09	0.09	0.17**	0.16**	-0.22**	-0.10	-0.11	0.06

295 \*, \*\* Significant at 0.05, 0.01 probability levels respectively

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301 Table 5: Estimates of direct (diagonal values in bold) and indirect (off-diagonal values) effects of yield attributing characters on grain yield, evaluated under  
 302 drought induced at the seedling stage in the screenhouse, and under drought that coincided with flowering stage.

	Seedling height	Number of dead leaves	Leaf area	RDL	Number of leaves	Seedling aspect	Chlorophyll content	Shoot fresh weight	Shoot dry weight
Seedling height	<b>-0.051</b>	-0.055	0.003	0.001	0.108	-0.002	-0.005	-0.006	-0.018
Number of dead leaves	-0.011	<b>-0.242</b>	0.001	0.149	0.169	0.003	0.001	0.006	-0.002
Leaf area	-0.021	-0.023	<b>0.008</b>	-0.007	0.069	-0.001	-0.009	-0.005	-0.020
RDL	0.000	-0.183	-0.003	<b>0.196</b>	0.035	0.003	-0.001	0.005	0.005
Number of leaves	-0.019	-0.139	0.002	0.023	<b>0.294</b>	0.001	-0.001	-0.001	-0.013
Seedling aspect	0.012	-0.109	-0.001	0.086	0.055	<b>0.007</b>	0.006	0.013	0.019
Chlorophyll content	0.005	-0.003	-0.001	0.001	-0.007	0.001	<b>0.052</b>	0.002	0.008
Shoot fresh weight	-0.013	0.068	0.002	-0.047	0.008	-0.004	-0.004	<b>-0.022</b>	-0.034
Shoot dry weight	-0.013	-0.007	0.002	-0.014	0.052	-0.002	-0.006	-0.011	<b>0.073</b>

303 Residual effect = 0.2517

304 **Conclusion**

305 There was narrow genetic base for seedling drought tolerance traits in the early-maturing  
306 maize germplasm studied and this might limit the scope of improvement of the traits under  
307 drought stress. In addition, low additive variances and heritability estimates were obtained  
308 for most traits. Number of leaves and number of dead leaves under seedling drought stress  
309 had the highest direct effects on grain yield under field conditions indicating that these  
310 seedling traits are reliable predictor of grain yield of early maize hybrids.

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