Combining ability and heterotic patterns of early-maturing provitamin A inbreds under contrasting environments

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Introduction

Vitamin A deficiency is a major health problem in sub-Saharan Africa (SSA). The maize plant can accumulate significant quantity of Pro-vitamin A (PVA) in the endosperm and has significant genetic variation for the PVA trait. Therefore, increasing PVA level in maize through breeding is a feasible approach for alleviating PVA deficiency in the sub region. Apart from PVA problem, maize production in SSA is constrained by *Striga hermonthica* parasitism, drought and low soil nitrogen (low-N). Therefore, there is need to develop and commercialize multiple-stress tolerant PVA maize in the effort to fight malnutrition in SSA.

The objectives of the present study were to: (i) determine the combining ability of 20 early pro-vitamin maize inbreds under *Striga*-infested, drought, low-N and rain-fed environments (ii) classify the inbreds into heterotic groups using the heterotic grouping based on general combining ability (GCA) of multiple traits (HGCAMT) and the heterotic groups' specific combining ability (SCA) and GCA of grain yield (HSGCA) methods (iii) identify inbred tester(s) and (iv) examine the performance of the inbreds in hybrids combinations.

Materials and Methods

Twenty early maturing PVA maize inbred lines were used in the present study (Table 1). Prior to the study, the inbreds were analysed for PVA content at the IITA-Ibadan Chemical Analysis Laboratory in 2016. The 20 PVA inbreds were crossed in all possible combinations to obtain 190 F_1 hybrids using the diallel mating design. The 190 F_1 hybrids plus six yellow hybrid checks were evaluated using 14 x 14 lattice design with two replications under *Striga* infestation at Mokwa, terminal drought at Bagauda, low-N at Mokwa and rainfed environments at Ikenne and Mokwa, all in Nigeria during the 2016 growing season. Data were recorded on grain yield and other traits and subjected to analysis of variance from which other parameters were estimated. The GCA and SCA effects of grain yield and other measured traits were estimated across environments following Griffing's method 4, involving F_1 hybrids only (Griffing, 1956). The inbred lines were classified into heterotic groups based on HSGCA method proposed by Fan et al. (2008) and HGCAMT method by Badu-Apraku et al. (2013). Inbred tester(s) were identified according to the method proposed by Pswarayi and Vivek (2008). The GGE biplot was used to identify outstanding single cross hybrids in terms of yield and stability across environments (Yan et al. 2000).

Results and Discussion

Results of the chemical analysis revealed that the PVA content of the inbred lines ranged from 2.65 to 8.18 µg/g (Table 1). Analysis of variance across environments revealed significant GCA and SCA effects for grain yield and most measured traits (Table not shown). There was preponderance of GCA over SCA effects for most measured traits (Fig. 1), suggesting that additive gene action was more important in the inheritance of most traits in the set of inbred lines. The lines were classified into three heterotic groups each by the HSGCA and HGCAMT methods (Table 2). The inbred TZEI 129 was identified as tester across environments by the two methods. The tester should facilitate the development of superior pro-vitamin A hybrids for commercialization in SSA. The GGE biplot identified the pro-vitamin A hybrids TZEIOR 2 x TZEIOR 157 and TZEIOR 4 x TZEIOR 65 as the highest yielding and most stable across environments (Fig. 2). The hybrids should be further tested in on-farm trials and commercialized to improve food and nutrition security as well as alleviate poverty in the sub-region.

Table 1. Reaction to stresses and pro-vitamin A content of inbreds used for the diallel study.

S/N	Pedigree	Reaction to stresses: Drought	Reaction to stresses: *Striga*	Provitamin A content (µg/g)
1	TZEIOR 2	T	S	4.91
2	TZEIOR 4	T	T	3.23
3	TZEIOR 6	T	T	4.92
4	TZEIOR 30	T	S	6.30
5	TZEIOR 52	T	T	7.96
6	TZEIOR 62	T	T	5.32
7	TZEIOR 68	T	T	8.18
8	TZEIOR 73	T	T	7.62
9	TZEIOR 79	T	S	5.48
10	TZEIOR 117	T	S	4.12
11	TZEIOR 119	T	S	3.61
12	TZEIOR 124	T	S	3.28
13	TZEIOR 125	T	T	3.75
14	TZEIOR 157	S	T	4.42
15	TZEIOR 158	T	S	2.65
16	TZEIOR 163	T	T	2.95
17	TZEIOR 164	T	S	7.40
18	TZEIOR 165	S	T	4.43
19	TZEI 25	T	T	5.30
20	TZEI 129	T	T	8.16

Table 2. Summary of the heterotic groups of 20 early-maturing pro-vitamin A maize inbred lines based on the HGCAMT and HSGCA grouping methods across five environments in Nigeria, 2016.

Method	Group 1	Group 2	Group 3
HGCAMT	TZEIOR 2, TZEIOR 4, TZEIOR 6, TZEIOR 30, TZEIOR 52, TZEIOR 62, TZEIOR 119, TZEIOR 125, TZEIOR 164, TZEI 25 and TZEI 129	TZEIOR 68, TZEIOR 73, TZEIOR 79, TZEIOR 117 and TZEIOR 124	TZEIOR 157, TZEIOR 158, TZEIOR 163 and TZEIOR 165
HSGCA	TZEIOR 2, TZEIOR 4, TZEIOR 6, TZEIOR 30, TZEIOR 52, TZEIOR 62, TZEIOR 68, TZEIOR 73, TZEIOR 79, TZEI 25 and TZEI 129	TZEIOR 117, TZEIOR 119, TZEIOR 124 and TZEIOR 125	TZEIOR 157, TZEIOR 158, TZEIOR 164 and TZEIOR 165

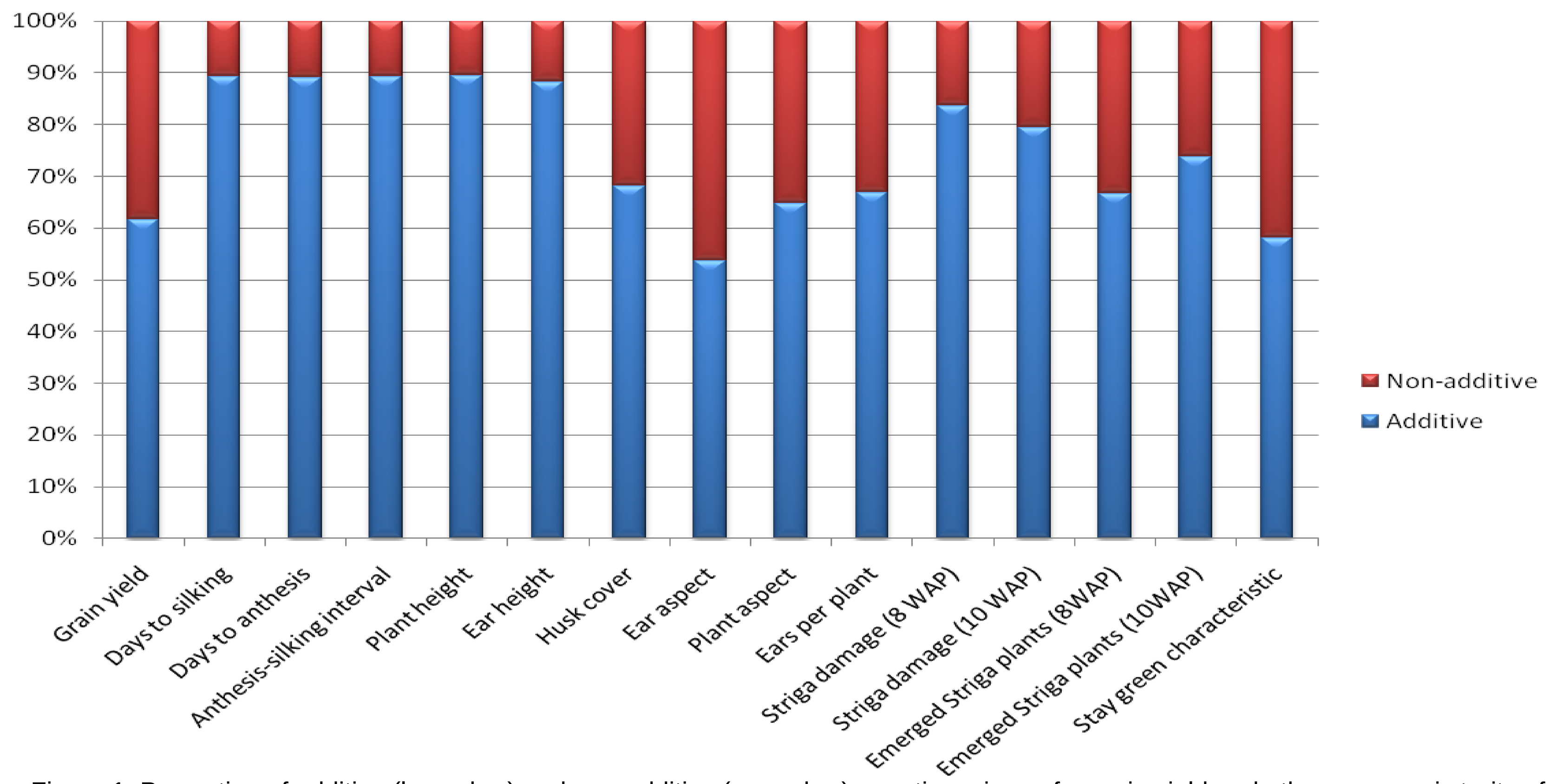
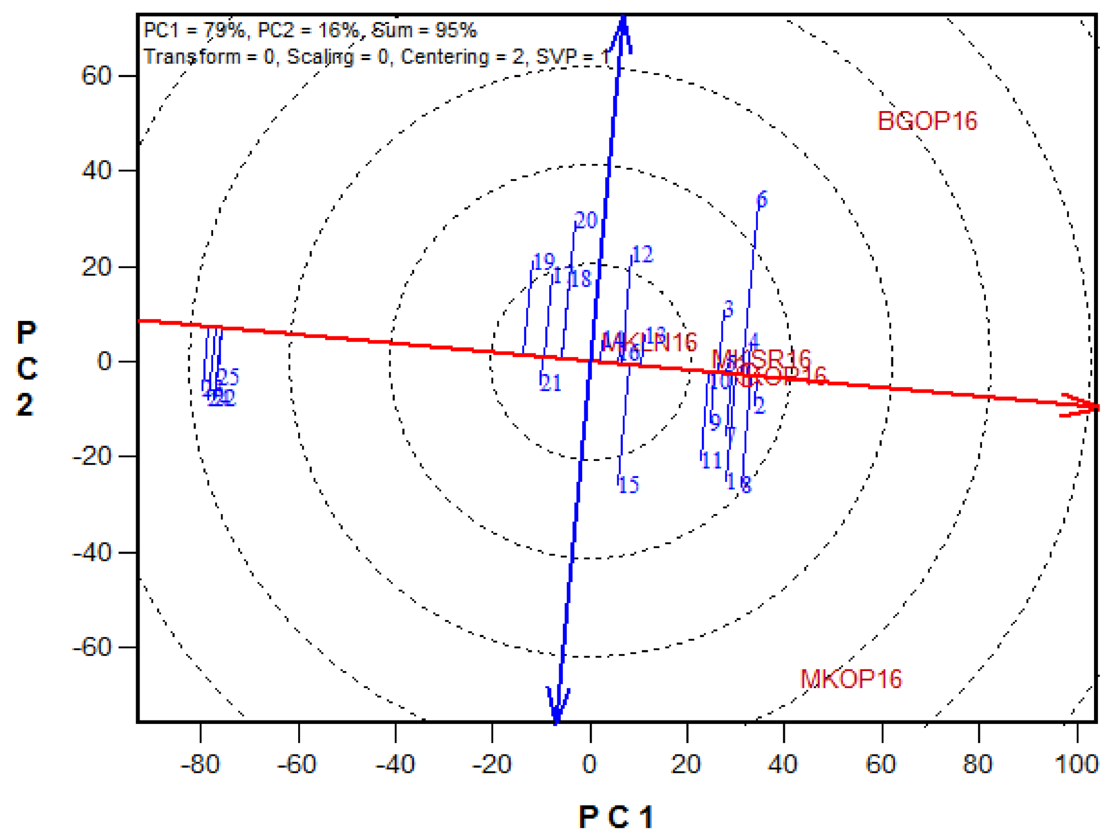


Figure 1. Proportion of additive (lower bar) and non-additive (upper bar) genetic variance for grain yield and other agronomic traits of 20 early pro-vitamin A inbred lines involved in diallel crosses evaluated across drought, *Striga*-infested, low-N and rainfed environments in Nigeria, 2016.



Code	Hybrid
1	TZEIOR 4 x TZEIOR 165
2	TZEIOR 2 x TZEIOR 157
3	TZEIOR 4 x TZEIOR 68
4	TZEIOR 4 x TZEIOR 65
5	TZEIOR 6 x TZEIOR 157
6	TZEIOR 6 x TZEIOR 73
7	TZEIOR 68 x TZEIOR 157
8	TZEIOR 4 x TZEIOR 158
9	TZEIOR 119 x TZEIOR 158
10	TZEIOR 79 x TZEIOR 157
11	Check 1 - TZEI 124 x TZEI 25
12	TZEIOR 68 x TZEIOR 117
13	TZEIOR 52 x TZEIOR 165
14	TZEIOR 158 x TZEI 129
15	TZEIOR 4 x TZEIOR 163
16	TZEIOR 6 x TZEIOR 62
17	TZEIOR 2 x TZEIOR 62
18	TZEIOR 79 x TZEIOR 165
19	TZEIOR 68 x TZEIOR 124
20	TZEIOR 62 x TZEI 25
21	TZEIOR 52 x TZEIOR 125
22	TZEIOR 4 x TZEIOR 6
23	TZEIOR 124 x TZEIOR 125
24	TZEIOR 117 x TZEIOR 124
25	TZEIOR 164 x TZEIOR 165

Figure 2. The entry/tester genotype plus genotype x environment biplot based on grain yield of selected early pro-vitamin A maize hybrids plus one early yellow hybrid check evaluated under *Striga* infestation at Mokwa (MKSR16), low-N at Mokwa (MKLN16), terminal drought at Bagauda (BGDT16) and rainfed conditions at Ikenne (IKOP16) and Mokwa (MKOP16) during the 2016 growing season.

Conclusions

The classification of the set of PVA inbreds into heterotic groups will facilitate the development of productive hybrids through planned crosses among inbreds of opposing heterotic groups. The identified inbred tester would be invaluable in the development of productive hybrids and classification of other PVA lines into heterotic groups. However, there is a need for more genetic studies involving the PVA early inbreds not included in the present study. Food and nutrition security could be significantly improved through the commercialization of the high-yielding and stable PVA hybrids in the sub-region.

References

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