Relationships among Agronomic Traits of Tropical Early Maturing Maize Cultivars under Low-N and High-N Environments

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Introduction

Tolerance to low soil nitrogen (low-N) is crucial to reduce maize losses from low-N stress and increase productivity in West and Central Africa. Annual loss of maize yield due to low-N stress varies from 10 to 50% (Wolfe et al., 1988). Secondary traits can be used to improve the precision with which low-N tolerant genotypes are identified compared to measuring only grain yield under low-N stress. Therefore, breeders selecting genotypes for tolerance to low-N use a base index that combines high grain yield (YLD) with increased number of ears per plant (EPP), improved plant aspect (PASP), ear aspect (EASP), short anthesis-silking interval (ASI) and good stay green characteristics (LDTH). However, the value of these traits in an index for selecting early maturing genotypes under low soil nitrogen has not been assessed. The objective of this study was to analyze the interrelationship between grain yield and other traits with a view to identifying traits that are most appropriate for indirect selection for improved yield performance under low-N without compromising yield performance under high-N environments.

Materials and Methods

Twenty cultivars selected for tolerance to drought stress plus eight checks were evaluated under low (30 kg ha^{-1}) and high (90 kg ha^{-1}) N at Mokwa and Samaru, Nigeria in 2008 and 2009. A randomized incomplete block design with two replications was used for each test environment. A plot consisted of two rows, 5 m long, spaced 0.75 m apart with 0.40 m spacing between plants within the row in all trials. Three seeds were planted per hill. The plants were thinned to two per stand about 2 weeks after emergence to give a final population density of 66,000 plants ha^{-1}. The N-fertilizer was applied two weeks after planting. Also, single superphosphate (P_2O_5) and muriate of potash (K_2O) were applied to both low-N and high-N blocks at the rate of 60 kg ha^{-1}. The trials were kept weed free with the application of herbicides and by hand weeding. Combined analysis of variance (ANOVA) across locations and years was done for each research condition on plot means for YLD , days to 50% silk (DYS), ASI, EPP, plant height (PLHT), percentage stalk lodging (SLG), LDTH, PASP, EASP, and husk cover (HUSK). The analysis was done with PROC GLM of SAS, using the RANDOM statement with the TEST option. The genotype x trait biplots were generated based on model 2 of the GGE biplot software (Yan, 2001) to visualize trait-association and trait profile of the cultivars.

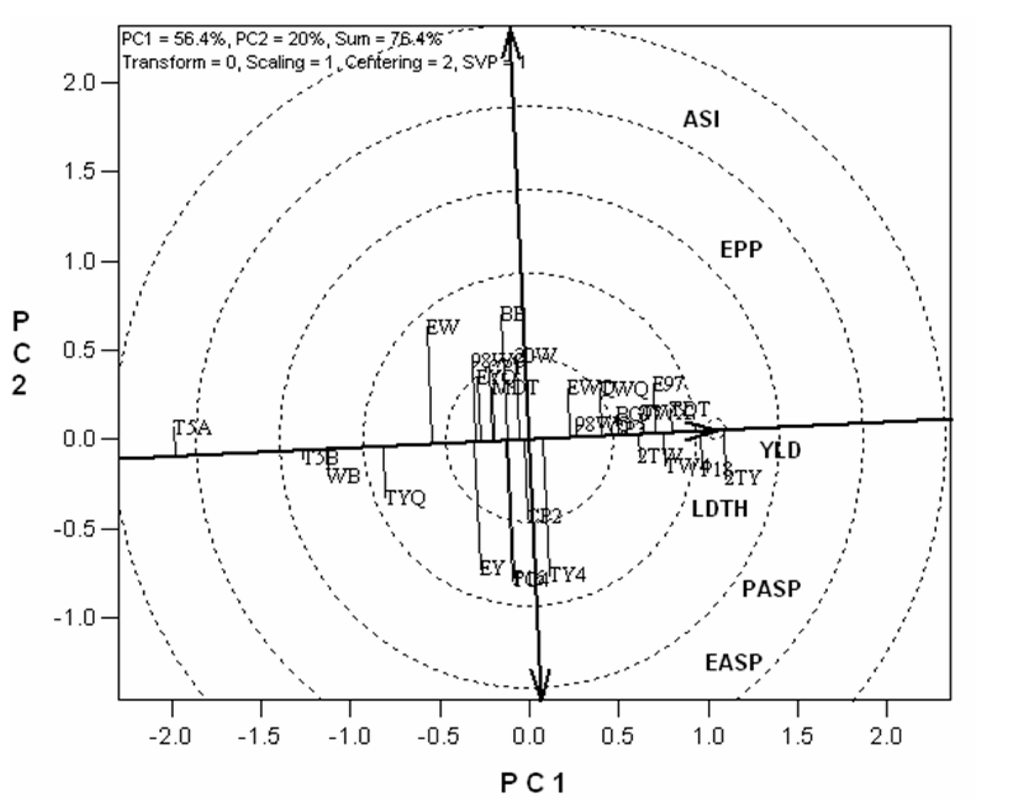
Results

Results showed that genotypes and environments were significant for grain yield and most measured traits of the cultivars under low-N and high-N conditions (Table 1). The genotype x environment interactions were significant for only EASP under both low and high N as well as for ASI and SLG under low-N conditions. Mean grain yield of the cultivars ranged from 720 to 2060 kg ha^{-1} under low-N and 1320 to 3710 kg ha^{-1} under high-N growing conditions. On average, YLD under low-N was 40% lower than under high-N conditions. Thirteen of the 28 cultivars had above average performance based on multiple traits under low-N conditions. Cultivar 2TY was the top-ranking genotype, while T5A was the lowest ranking genotype (Fig. 1). PLHT, EPP, and SLG had positive correlation coefficients with YLD, while ASI, DYS, DYA, LDTH, PASP, EASP and HUSK, were negatively correlated with it (Fig. 2). Figure 3 showed that PLHT, DYS, and PASP were the most reliable traits that can be used to select genotypes for improved grain yield in low-N environments. Under high-N conditions, YLD had positive correlation with EPP, SLG, and PLHT and negative correlation with DYS, DYA, PASP, and EASP (Figure not shown). The most reliable traits for selection for improved grain yield under high-N were EASP, PASP, EPP, and PLHT (Fig. 4).

Table 1. Mean ± S.E and ranges for grain yield and agronomic traits of early maturing maize varieties evaluated under low-N and high-N conditions at Samaru and Mokwa, Nigeria in 2008 and 2009.

	Grain yield, kg ha-1	Days to silking	Anthesis silking interval	Plant height, cm	Plant aspect	Ear aspect	Ears per plant	Stay green scores
Low-N condition								
Min	720	55	2	102	3.4	2.9	0.6	4
Max	2060	63	3	153	4.3	4.2	0.9	5
Mean±SE	1560±0.26	58±0.80	2±0.51	137±0.07	3.7±0.5	3.5±0.25	0.8±0.05	4.0±0.51
Genotype (G)	**	**	ns	**	ns	**	**	ns
Environment (E)	**	**	**	**	**	**	**	**
G x E	ns	ns	*	ns	ns	*	ns	ns
High-N condition								
Min	1320	54	1	112	2.8	1.9	0.7	-
Max	3710	63	3	156	4.1	3.7	0.9	-
Mean±SE	2590±320	57±0.92	2±0.51	138±6.0	3.3±0.24	2.8±0.31	0.8±0.05	-
Genotype (G)	**	**	ns	**	**	**	**	-
Environment (E)	**	**	**	**	**	**	**	-
G x E	ns	ns	ns	ns	ns	**	ns	-

*, **Significant at 0.05 and 0.01 levels of probability; ns = non-significant.



CULTIVARS	CODE
TZE-W DT STR C_4	TW4
TZE-Y DT STR C_4	TY4
TZE Comp 3 DT C_2F_2	CP2
TZE Comp 3 DT C_1F_2	CP1
TZE-W DT STR QPM C_0	TWQ
BG97 TZE Comp 3x4	BG97
2004 TZE-W Pop DT STR C_4	2TW
EV DT 97 STR C1	E97
EV DT-Y 2000 STR QPM C_0	EYQ
Tillering Early DT	TDT
EV DT-Y 2000 STR C_0	EY
BASE BARKA	BB
AC 90 Pool 16 DT STR	P16
TZE Comp 3 C_3	CP3
EV DT-W 99 STR C_0	EW
Pool 18-SR/AK94-DMRESR-Y*2	P18
Multicob Early DT	MDT
TZE-Y DT STR QPM C_0	TYQ
EV DT-W 99 STR QPM C_0	EWQ
WARI BASE	WB
TZE Comp 5-Y C_6 S_1 (SET A)	T5A
TZE Comp 5-Y C_6 S_1 (SET B)	T5B
98 Syn WEC STR C_0	98WC
98 Syn WEC STR QPM C_0	98WQ
TZE-W Pop X 1368 STR S_6 F_2 SET A2	TWX
TZE COMP 4 C_3	TC4
2000 Syn WEC	20W
2004 TZE Y Pop DT STR C_4	2TY

Trait	CODE
Grain yield	YLD
Days to 50 % silk	DYS
Days to 50 % anthesis	DYA
Anthesis-silking interval	ASI
Plant height	PLHT
Ears per plant	EPP
Ear aspect	EASP
Plant aspect	PASP
Stalk lodging	SLG
Husk cover	HUSK
Leaf death score	LDTH

Fig. 1. An entry/tester view of genotype x trait biplot of six selected traits of 28 early maturing maize cultivars evaluated under low-N conditions at Mokwa and Abuja, Nigeria in 2008 and 2009.

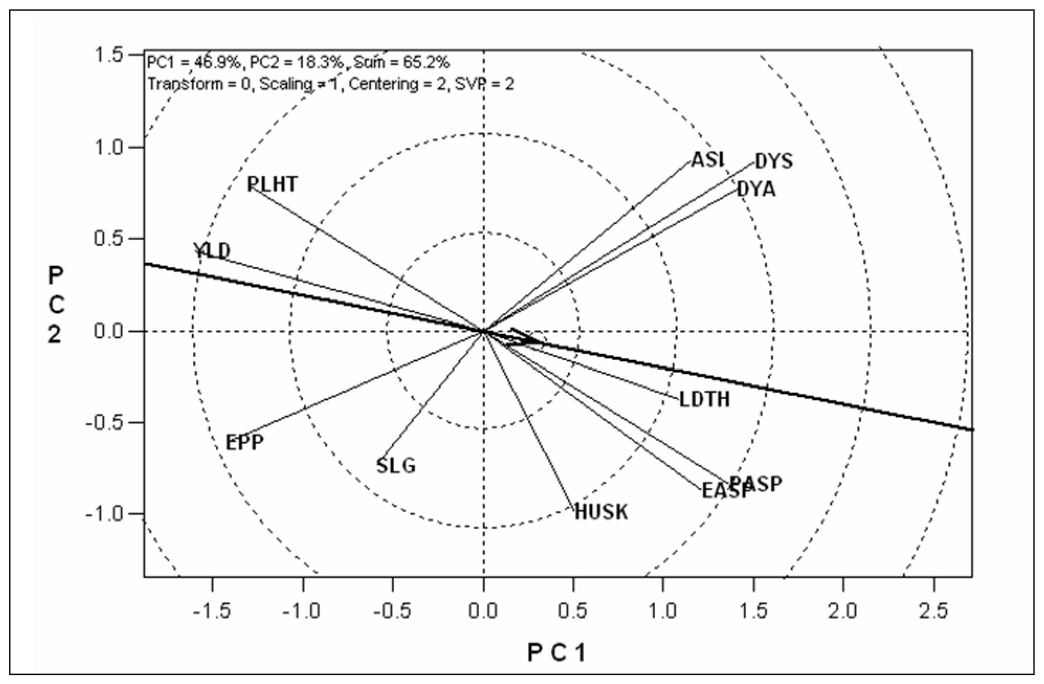


Fig. 2. A vector view of the genotype-by-trait biplot showing interrelationships among all traits of 28 early maturing maize cultivar evaluated under low-N at Mokwa and Samaru, Nigeria in 2008 and 2009. See Fig. 1 for legend.

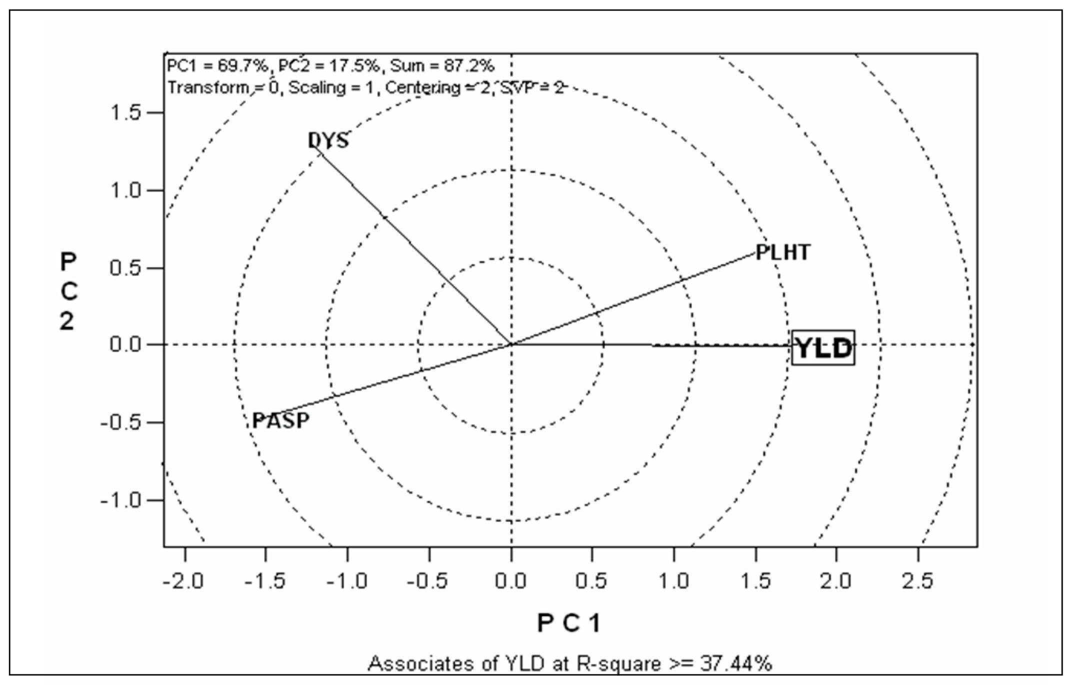


Fig. 3. A vector view of the genotype-by-trait biplot displaying most reliable traits for indirect selection for yield (inside box) under low-N at P < 0.01 and R^2 value ≥ 37.44 %. See Fig. 1 for legend.

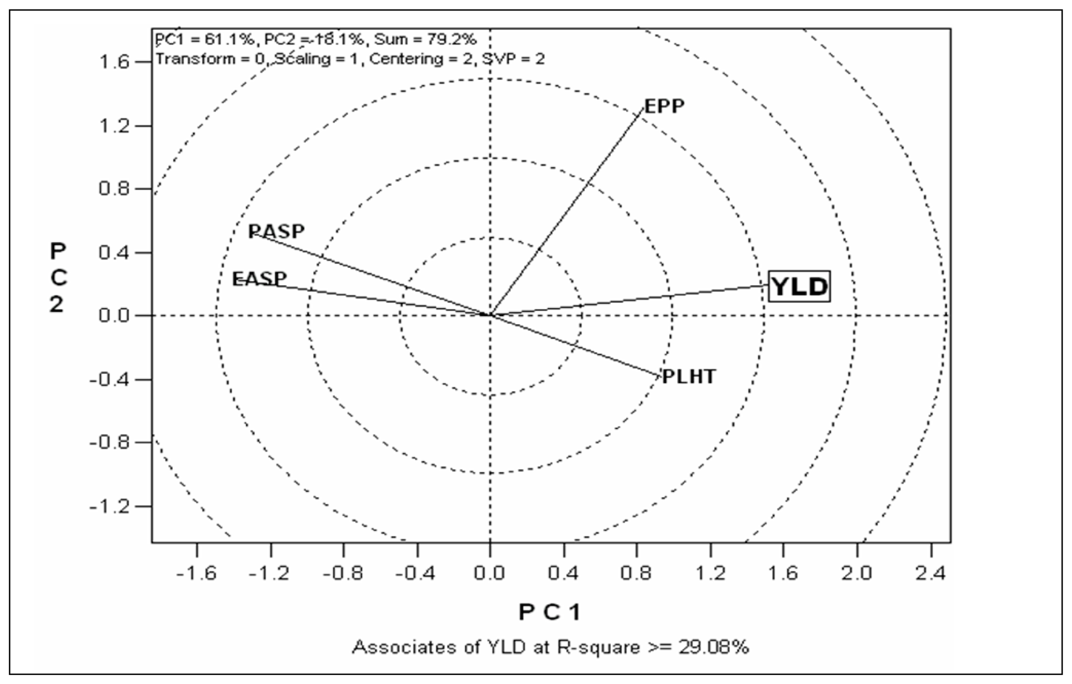


Fig. 4. A vector view of the genotype-by-trait biplot displaying most reliable traits for indirect selection for yield (inside box) under high-N conditions at P < 0.01 and R^2 value ≥ 29.08 %. See Fig. 1 for legend.

Conclusions

In this study, 2TY was identified as the best genotype in terms of the multiple traits used under low-N conditions. Since PLHT and PASP were identified among the most reliable traits for indirect selection for improved yield performance under both growing conditions, then, selecting for these under low-N will improve grain yield under stress and non-stress environments.

Acknowledgement

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