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Comparative N-response of maize cultivars developed for drought and *Striga* resistance during three breeding eras

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Three constraints, drought, low soil N and infestation by *Striga hermonthica* Del. (Benth) act and interact to reduce maize grain yield in the agro-ecologies of west and central Africa (WCA). The three constraints are being controlled by genetic enhancement of the maize germplasm and 50 early maturing cultivars, combining *Striga* resistance with drought tolerance were developed between 1988 and 2010 by the IITA Maize Program. Selection for *Striga* resistance is normally conducted under low-N conditions without deliberate selection for low-N tolerance. We tested the hypothesis that tolerance to low N had been significantly improved while selecting for drought tolerance and *Striga* resistance.

Methodology

Selection for drought tolerance and *Striga* resistance in early maize in WCA started independently in 1988 and 1994, respectively and has gone through three eras based on the germplasm subjected to improvement and methodologies used. A total of 50 drought tolerant and/or *Striga* resistant early cultivars were developed during three eras, including 15, 16 and 19 during the 1988-2000, 2001-2006 and 2007-2010 eras, respectively. The 50 varieties were evaluated in replicated field trials in 2010 and 2011 at Mokwa, a southern Guinea savanna location and Ile-Ife, a rainforest location in Nigeria under both low (30 kg N ha^{-1}) and high N (90 kg N ha^{-1}) levels. The data were subjected to ANOVA and regression analysis.

Results and Discussion

Under both low and high N, grain yield increased significantly from the first to the third breeding era (Table 1).

Table 1. Minimum, maximum and mean±se of grain yield of maize cultivars of three breeding eras under low- and high-N conditions at Mokwa and Ile-Ife, 2010 and 2011.

Era*	No. of varieties	Low N			High N		
		Min	Max	Mean±se	Min	Max	Mean±se
1	15	0.8	4.2	2.3±0.056	0.9	3.2	3.2±0.174
2	16	0.3	5.4	2.4±0.063	0.8	5.8	3.3±0.076
3	19	0.7	5.6	2.5±0.055	1.0	5.5	3.7±0.068

*Era 1 = 1988-2000, Era 2 = 2001-2006 and Era 3 = 2007-2010.

Similarly for both low and high N, plant and ear heights increased slightly, while ear aspect improved from Era 1 to Era 3 (data not shown). Breeding era did not alter number of days to flowering, stalk and root lodging. Rather, under low N, but not high N, plant aspect and the stay green characteristic improved in era 3 relative to era 1. In the ANOVA, cultivar-within-era source of variation was highly significant for both low- and high-N environments. The highest-yielding cultivars under both N environments, such as TZE-W DT C2 STR, EV DT-W 2008 STR, 2009 DTE-Y STR Syn, and TZE-W DT C1 STR were mainly from breeding era 3 (Fig. 1).

For the 50 cultivars, yield performance in the low-N environments predicted grain yield under high N fairly accurately with an R^2 value of about 0.54 (Fig. 2). Analysis on individual era basis, however, showed that grain yield in low-N environments for eras 2 and 3 cultivars predicted grain yield in high-N environments than era 1 cultivars (Fig. 3).

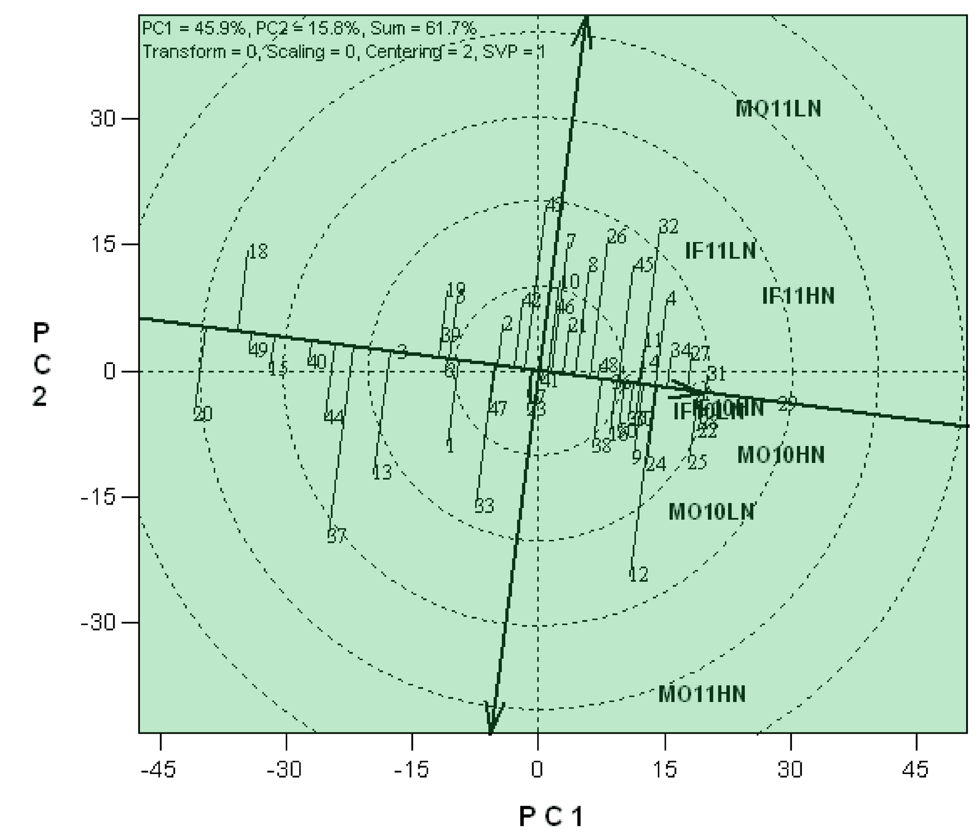

Figure 1. The 'mean vs. stability' view of the GGE biplot based on a genotype × environment yield data of 50 early-maturing maize cultivars evaluated under low- and high-N environments in 2010 and 2011. MO10 and MO11 = Mokwa under low-N (LN) and high-N (HN) conditions in 2010 and 2011 and IF10 and IF11 = Ile-Ife under low-N (LN) and high-N (HN) conditions in 2010 and 2011. Principal component (PC)1 and PC 2 explained 61.7% of yield variation.

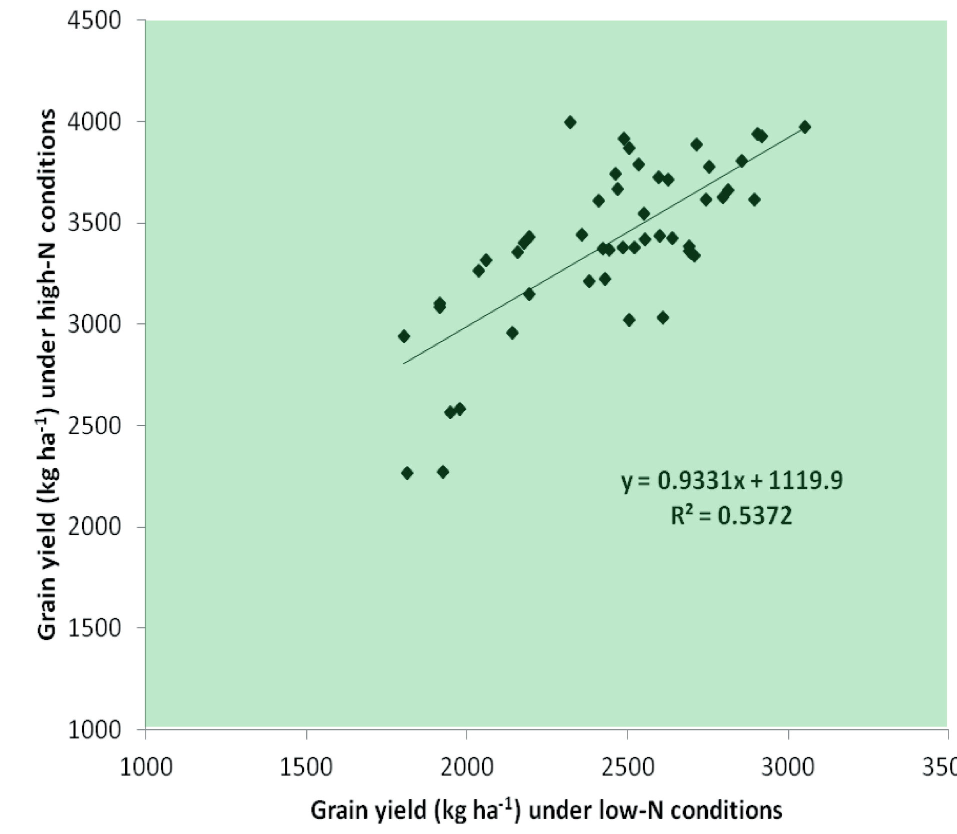

Figure 2. Prediction of grain-yield performance under high-N environment from performance under low-N environments for 50 early maize cultivars developed in three breeding eras.

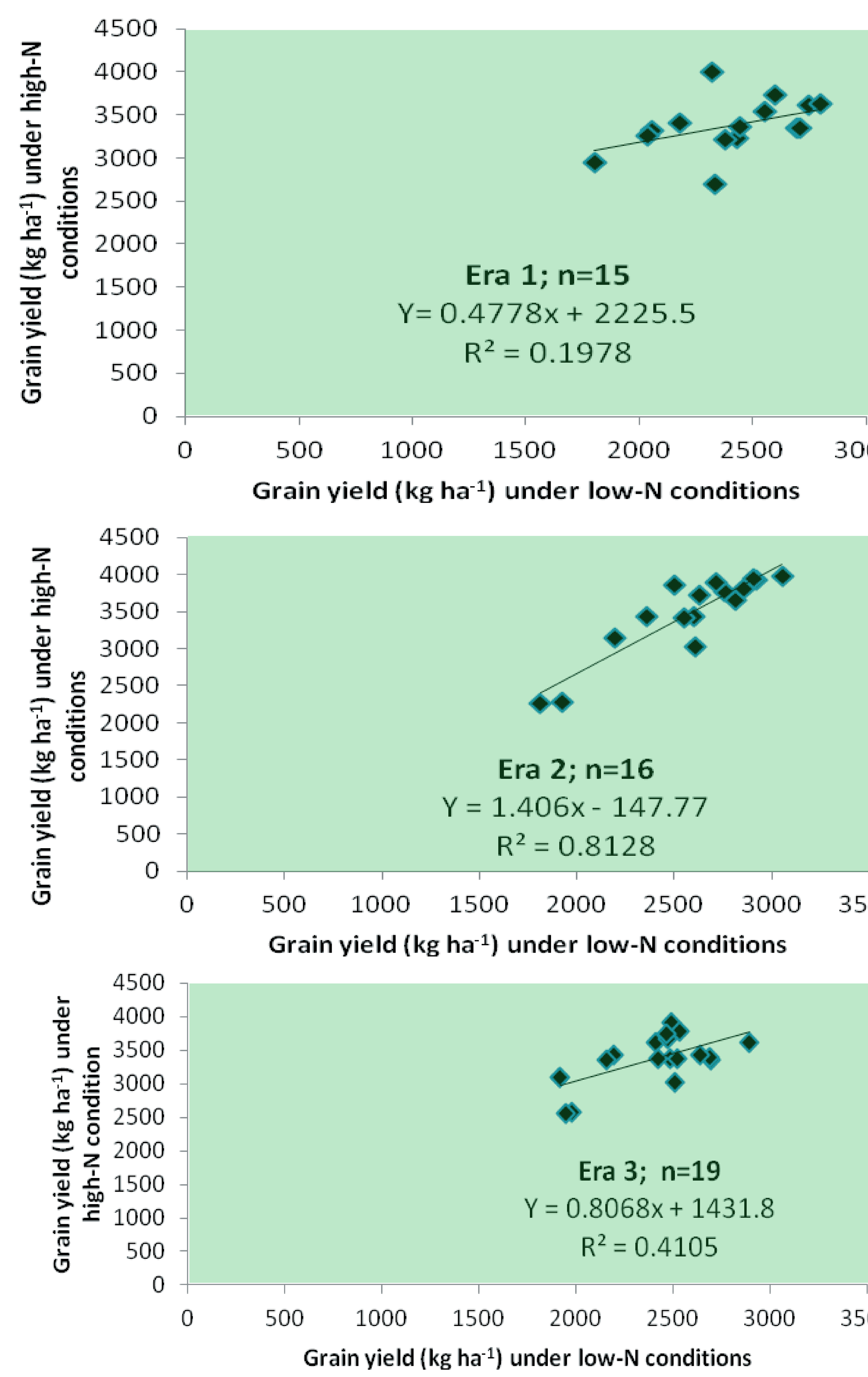

Figure 3. Prediction of grain-yield performance under high-N environments from performance under low-N environments for early maize cultivars developed in three different breeding eras.

Conclusions

Selection for *Striga* resistance and drought tolerance in early maturing maize populations enhanced low-N tolerance in the maize cultivars derived from the populations. The improvement was higher in later than earlier breeding eras in west and central Africa.