Maize Ideotypes for sub-Saharan Africa

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Maize (*Zea mays* L.) is a major cereal crop for human food, livestock feed, and raw material for agro-based industries in Africa, but its production and productivity are seriously constrained by myriads of biotic, abiotic, and socio-economic factors. For optimum productivity of maize, breeders must develop maize ideotypes targeted to specific environmental conditions. In its broadest sense, an ideotype is a biological model which is expected to perform or behave in a predictable manner within a defined environment. More specifically, a crop ideotype is a plant model which is expected to yield a greater quantity or quality of grain, oil or other useful product when developed as a cultivar *(Donald, 1968 – Euphytica 17: 385-403)*. Maize production environments in sub-Saharan Africa (SSA) are generally characterized by low fertilizer application, especially N, unpredictable drought and in specific sub-regions, peculiar diseases, insect pests and obnoxious weeds. An ideotype for all environments in sub-Saharan Africa (SSA) must necessarily be tolerant of drought and low soil N

Studies conducted by CIMMYT in southern and eastern Africa, and IITA in central and west Africa consistently showed that genotypes selected under these stress conditions had value addition when evaluated under non-stress conditions much more than selections under non-stress evaluated under stress conditions. Examples are displayed in Figures 1 and 2.

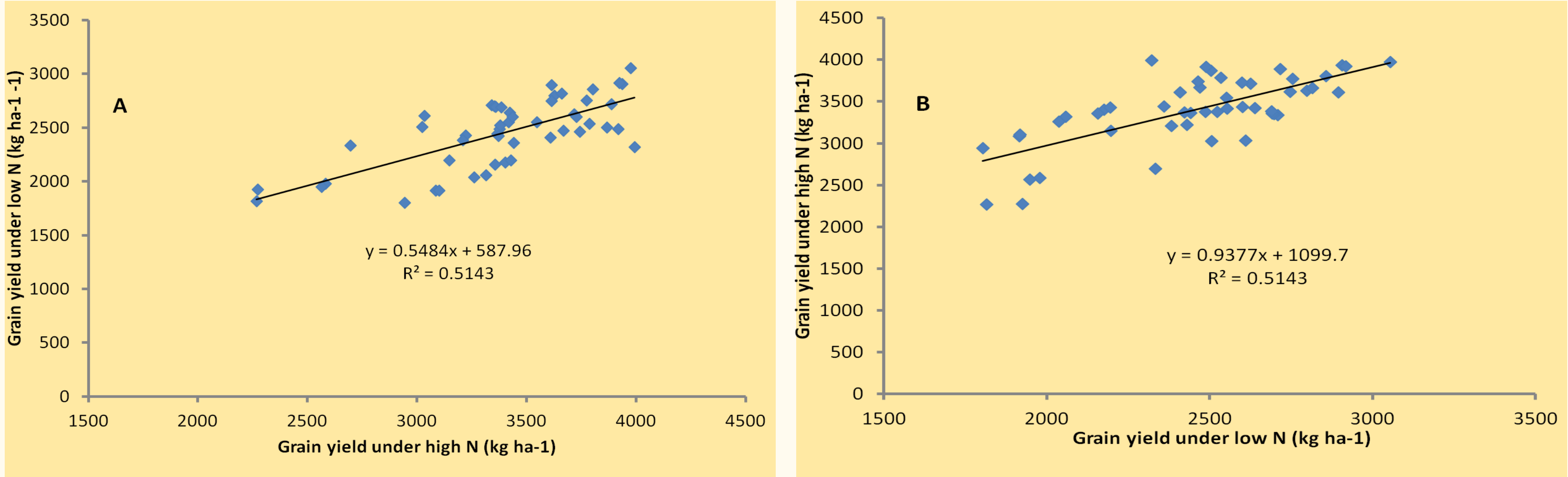

Fig. 1. Regression of (A) grain yield under low N environments on grain yield in high N environments and (B) grain yield in high N environments on grain yield under low N environments *(Badu-Apraku et al. 2015 –* Crop Science *55:527–539).*

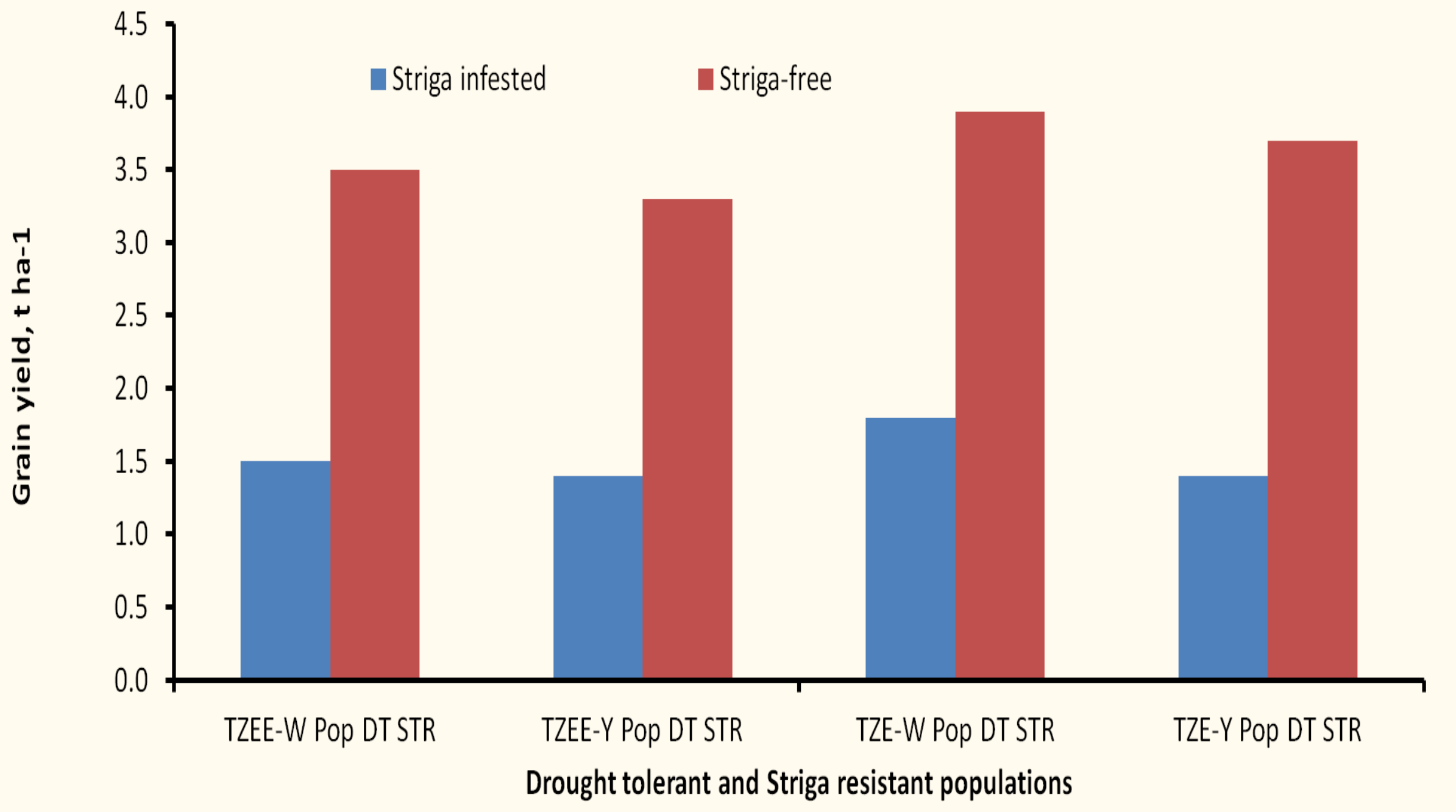

Fig. 2. Grain yield (t ha^{-1}) of four maize populations evaluated in *Striga*-infested and *Striga*-free environments in Nigeria after four cycles of S$_1$ recurrent selection for *Striga* resistance *(Adapted from Badu-Apraku et al. 2015 – Crop Science 55: 527–539).*

Maize production environments may be grouped on the basis of prevalent stress factors (Fig. 3 and Table 1) so that additional traits may be bred into ideotypes for specific niches such as maize streak resistance for all WCA countries, maize lethal necrosis (MLN) resistance for all eastern Africa countries (Plate 1), and resistance to *Striga hermonthica* (Del.) Benth (Plate 2) for some specific areas of mass infestation in WCA.

Maize breeders in national programs may exploit the available germplasm at IITA-Ibadan Nigeria and CIMMYT-Nairobi Kenya to develop ideotypes for the niches of their jurisdiction. An example of a good source of germplasm for MLN resistance is the facility established in eastern Africa with support from the Bill & Melinda Gates Foundation and the Syngenta Foundation for Sustainable Agriculture to combat MLN. Since its inception in 2013, researchers have evaluated over 60,000 accessions from more than 15 multinational and national seed companies and research programs. Also, all of the several thousands of maize germplasm at IITA are routinely screened for resistance to the streak virus and several other diseases.

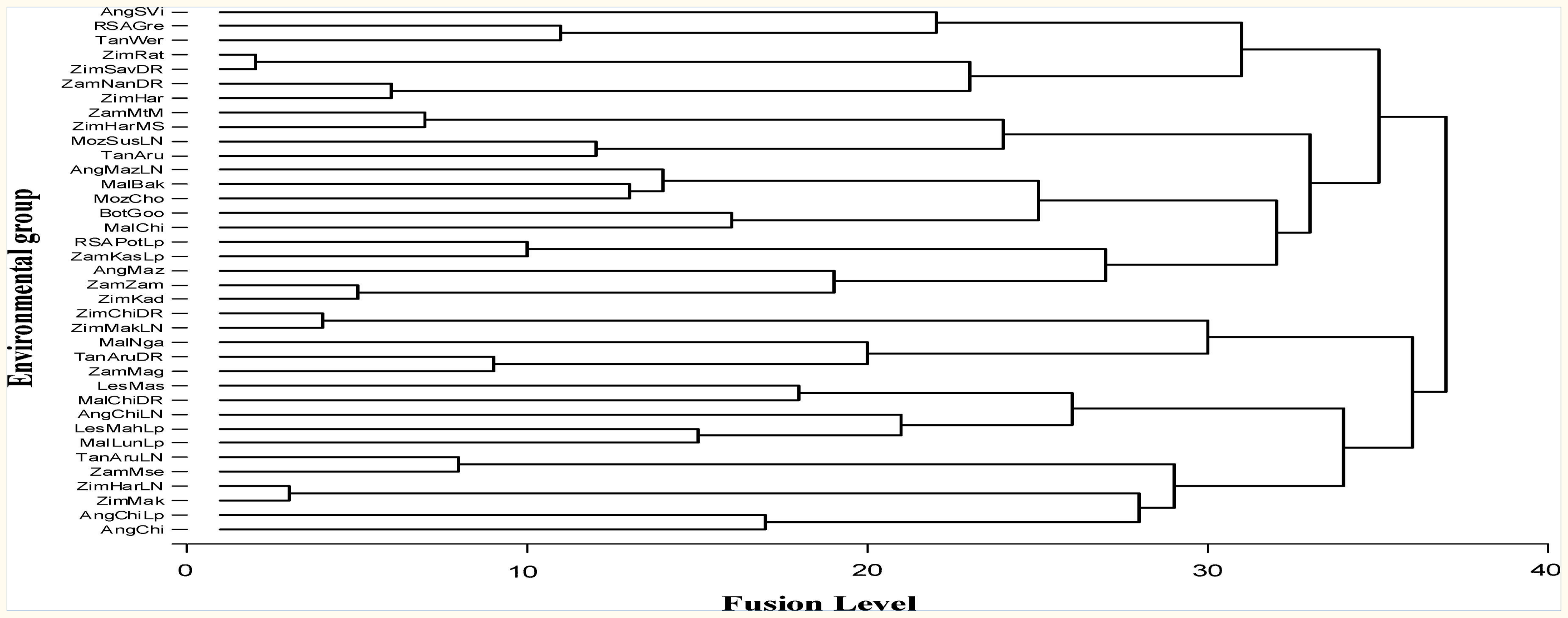

Fig. 3. Dendrogram from classification of 38 locations used to develop maize mega-enironments in the Southern African Development Community (SADC) 1999–2001 *(Setimela et al. 2005 – Euphytica 145:123-132).*

Table 1. Factor loadings of repeatability estimates of grain yield and several agronomic traits from 18 early maturing OPVs evaluated in 17 sites representing different agro-climatic zones of West Africa and a mid-altitude elevation in Ethiopia in 2006 and 2008 *(Fakorede and Badu-Apraku, 2016 – Unpublished).*

Location	Country	Agro-climatic zone	Factor loading	
FACTOR 1				
Zaria	Nigeria	N. Guinea Savanna	0.956	
Kita	Mali	Sudan Savanna	0.944	
Ejura	Ghana	Forest-Savanna Transition	0.878	
Babile	Ethiopia	Mid-Altitude	0.678	
		Mean Yield = 3.8 t ha^{-1}	R^2, %	21.5
		Mean CV = 21.3%	Cummulative R^2, %	21.5
FACTOR 2				
Ikenne	Nigeria	Rain Forest	0.850	
Ilorin	Nigeria	S. Guinea Savanna	-0.843	
Minjibir	Nigeria	N. Guinea Savanna	0.815	
Nyankpala	Ghana	N. Guinea Savanna	-0.754	
Manga	Ghana	Sudan Savanna	0.687	
		Mean Yield = 2.8 t ha^{-1}	R^2, %	18.9
		Mean CV = 20.0%	Cummulative R^2, %	40.4
FACTOR 3				
Fumesua	Ghana	N. Guinea Savanna	-0.901	
Bagou	Benin	S. Guinea Savanna	0.749	
Mokwa	Nigeria	S. Guinea Savanna	0.626	
		Mean Yield = 2.7 t ha^{-1}	R^2, %	16.5
		Mean CV = 24.0%	Cummulative R^2, %	56.9
FACTOR 4				
Ina	Benin	S. Guinea Savanna	0.928	
Samaru	Nigeria	N. Guinea Savanna	-0.752	
Bagauda	Nigeria	N. Guinea savanna	0.730	
		Mean Yield = 3.4 t ha^{-1}	R^2, %	15.2
		Mean CV = 19.3%	Cummulative R^2, %	72.1
FACTOR 5				
Katibougou	Mali	Sudan Savanna	0.981	
Angaradebou	Benin	Sudan Savanna	0.658	
		Mean Yield = 2.9 t ha^{-1}	R^2, %	14.9
		Mean CV = 21.0%	Cummulative R^2, %	87.0

Plate 1. Typical symptom of maize lethal necrosis (MLN) on susceptible variety (left) relative to a symptomless resistant variety on the right side (Nelson et al. 2011 – Plant Disease 79:1-6).

Plate 2. Full grown plant of *Striga hermonthica* (Del.) Benth parasitizing a maize plant in the field *(Adapted from IITA, 2015).*