Hans H. Ruthenberg-Graduierten-Förderpreis 2011/

Hans H. Ruthenberg Award for Graduates 2011

Willmar Leiser "Variation for Adaptation of Sorghum (Sorghum bicolor L. Moench) to Low Phosphorous Soils in Mali (West Africa)"

University of Hohenheim, 2010

Supervisor: Prof. Dr. Albrecht E. Melchinger

Summary

A growing world population juxtaposed with diminishing phosphorus (P) resources presents new challenges for current and future plant breeding. Soils in Sub-Saharan Africa are mostly poor of plant available phosphorus. Fertilizers are often not available or too expensive. Sorghum is the second most grown crop in West-Africa and is especially important for low-fertility soils. Plants have developed different adaptation strategies to accommodate low phosphorus conditions, mostly better rooting properties. Those parameters are difficult to investigate in field trials for large breeding populations. High spatial variability of soil properties is common in low-input fields. A four year multi-location experiment was conducted in Mali, West Africa. Seventy sorghum genotypes were evaluated under low and high P conditions for vigor, plant height, date of heading and grain yield. The objectives of this study were: (I) analyze spatial field variability of available phosphorus, (II) investigate statistical solutions for spatial adjustments, (III) investigate the general effect of low phosphorus on plant development, (TV) characterize genetic variation for adaptation to low phosphorus conditions (V) identify well adapted and stable genotypes for West Africa and (VI) set breeding strategies based on GEI patterns. A high small scale spatial variation (CV 39.4%) for plant available P was detected in a low P field. Spatial models (AR1, AR2) could significantly improve broad sense heritability and relative efficiency of grain yield compared to randomized complete block (RCB) and lattice designs. No specific model was best for all environments. Spatial models increased genetic variance and reduced environmental error, leading to different genotype ranking for grain yield compared to RCB. Thus use of spatial models is recommendable for low-input trials. Generally, low phosphorus decreased grain yield, vigor and plant height significantly, whereas date of heading was significantly delayed. Vigor and plant height were positively correlated to grain yield under low P conditions, whereas date of heading showed ambiguous relationships due to location differences in rainfall. Delay of heading in low P compared to high P was negatively correlated to grain yield in low P, whereas photosensitive Guinea-landraces showed less delay than photo-insensitive inter-racial breeding-lines. Landraces showed higher grain yield in low P whereas breeding-lines were superior in high P. A Cross-over genotype-environment interaction was detected across low and high P environments. Grain yield in high and low P showed a high correlation (r=0.77), nevertheless direct selection in low P was superior to indirect selection in high P due to high heritability values in low P. GGE-biplots and AMMI2 biplots were created for mega-environment delineation and detection of special adaptation patterns. No clear mega-environments were detected, whereas AMMI2 was superior for mega-environment and genotype evaluation. Dynamic and static stability was evaluated within high and low P environments. Index selection with AMMI stability value (ASV), response coefficient b and best linear unbiased prediction (BLUP) for grain yield seemed to be an appropriate approach for selection for low P conditions.