Research Application Summary

Heterosis and combining abilities for multiple resistance to *Turcicum* leaf blight and maize streak virus

Opio, L.A.[1], Asea, G.[2], Baguma, Y.[2] & Okori, P.[1]
[1]Department of Crop Science, Makerere University, P.O. Box 7062, Kampala, Uganda
[2]National Crops Resources Research Institute (NaCRRI), P.O Box 7084, Kampala, Uganda
Corresponding author: atwok11@yahoo.com

Abstract

Fifty two single crosses were evaluated for resistance to Turcicum Leaf blight (TLB) and Maize Streak Virus (MSV) resistance across several locations in Uganda in 2009. The crosses were grown in 1-row plots with 2 replications. Subsequently108 triple crosses from the 54 F_1s were evaluated in 2-row plots for both diseases and agronomic performance in multi-environments during the second season of 2009. Genotypes were considered fixed and environment random. GCA and SCA effects were significantly different among parents and among crosses. Interactions of Environment with GCA and SCA were significant for both TLB and MSV. Plant height and yield were also significantly affected by Crosses x Environment interaction.

Key words: Crosses, environment, general combining ability, maize streak virus, specific combining ability, Turcicum leaf blight

Résumé

Cinquante-deux croisements simples ont été évalués pour la résistance à la brûlure des feuilles de Turcicum (TLB) et à la résistance du virus de strie du maïs (MSV) dans plusieurs endroits de l'Ouganda en 2009. Les croix ont été cultivées dans des parcelles à 1 ligne avec 2 répétitions. Par la suite, 108 croix triples de 54 F_1s ont été évaluées dans des parcelles à 2 lignes pour les deux maladies et les performances agronomiques dans des environnements multiples pendant la deuxième saison de 2009. Les génotypes ont été considérés comme fixes et d'environnement aléatoire. Les effets de GCA et SCA étaient significativement différentes entre les parents et les croix. Les interactions de l'environnement avec GCA et SCA ont été significatives pour TLB et MSV. La hauteur de la plante et le rendement ont également été considérablement affectées par les croix et l'interaction de l' Environnement.

Mots clés: Croix, environnement, aptitude générale à la combinaison, virus de strie du maïs, aptitude spécifique à la combinaison, brûlure de la feuille de Turcicum

Background

Maize occupies a strategic position in the food security of Uganda as in several countries in sub-Saharan Africa. In Uganda it is estimated that 2.5 million households are involved in the production of maize with annual cultivation coverage of 400,000 - 500,000 hactares (PSF, 2003). Although maize germplasm shows great variability, recurring biotic and abiotic constrains have devastating impacts on its productivity and quality (Fakorede *et al.*, 2003; Pratt *et al.*, 2003; Amusa *et al.*, 2005; Asea *et al.*, 2009). Significant yield loss in the lowland tropical and highland agroecologies of Uganda is attributed to Maize streak virus (MSV), *Turcicum* leaf blight (*Exserohilum turcicum*) (Kyetere *et al.*, 1998; Taiwo e*t al.*, 2005; Lagat *et al.*, 2008; Vivex *et al.*, 2009). Use of resistant maize cultivars reduce yield losses to the two diseases and slow down the spread of TLB and MSV diseases (Adipala, E., 1994; Mawere *et al.*, 2006).

Therefore, evaluation of maize lines with multiple resistance to foliar diseases, based on understanding of genetic mechanisms of leaf disease resistance, would be of benefit to seed companies and farmers in Uganda. Some of the maize inbred lines recently developed by National Crops Resources Research Institute (NaCRRI) in Uganda are known to have resistance against grain weevil. However, their reactions to TLB and MSV have not been characterised. The objectives of this study were to characterize 12 selected Ugandan maize inbred lines for reactions to TLB and MSV, and evaluate the triple test crosses for agronomic performace and resistance to both diseases in multi environments.

Literature Summary

In many economically important plant pathosystems, disease is controlled by breeding for genetic resistance in the host plant (Fakorede *et al.*, 2003; Pratt *et al.*, 2003). The genetics of northern leaf blight resistance have been extensively studied and are the subject of a recent review (Welz and Geiger, 2000). Efforts to control northern leaf blight (NLB) of maize *(Zea mays* L.), caused by the fungus *Exserohilum turcicum* (Pass.) Leonard & Suggs (syn. *Helminthosporium turcicum* Pass.; perfect state, *Setosphaeria turcica* (Luttrell) Leonard & Suggs, syn. *Trichometasphaeria turcica* Luttrell), have been directed toward resistance since previous works (Sigulas *et al*., 1988; Adipala, 1994; Slavica *et al.*, 2007). The most feasible method of controlling MSV disease has been through use of resistance materials, since cultural practices such as use of chemicals and rouging of diseased plants are economically and environmentally unsustainable (Lagat *et al.*, 2008; Magenya *et al.*, 2008).

Study Description

Experiments were carried out in Alpha lattice design at Namulonge, Masaka and Serere in Uganda during first and second rains of 2009. The three sites represent diverse agro-ecologies of Uganda - Namulonge in central Uganda represent the humid, forest-wet central region; Masaka is also wet, while Serere represented the savana grassland (cereal-farming system) of eastern and northern Uganda. Fifty two (52) single crosses and two local checks, obtained from NaCRRI, were evaluated for TLB and MSV. The experiments consisted of 1-row plots each with 2 replications, planted at Namulonge and Masaka on 15th and 17th April 2009, respectively. A screen house trial involving the same 54 entries was also performed. Leafhoppers reared at NACRRI and maize leaves infected with TLB from field at NaCRRI were used as sources of artificial inoculation. Subsequently 108 triple crosses developed from the 54 F_1s were evaluated in 2-row plot experiments for both diseases and agronomic performance during the second rains 2009 (September - December 2009). The same 108 materials were evaluated for resistance to TLB and MSV under screen house conditions following the procedures outlined above. Data were analysed for combining abilities (Griffing, 1956) and heterosis was estimated following the methods used by Lim and White (1978). Hybrid x Tester analysis was performed based on data combined across environments. Estimates of general (GCA) and specific (SCA) combining ability were based on approach given by Dabholker (1992). Hybrids and Testers were considered fixed and environment random.

Results

Diallel analysis across environments showed significant GCA and SCA effects among the genotypes for the traits under study. This indicates that the 12 inbred lines should have good combination performance. Mean squares for GCA were more than those of SCA for most traits indicating the availability of non-additive gene effects for controlling those traits. Resistance to TLB, MSV and yield parameters is controlled by GCA effects with presence of dominant genes (Ojulong *et al.*, 1996; Welz *et al.*, 2000; Okello *et al.*, 2006; Lagat *et al.*, 2008; Balint-Kurti *et al.*, 2009; Vivek *et al.*, 2009). Environment, Crosses, GCA and SCA, and their various interactions with Environment were significant suggesting that the hybrids did not have the same relative performances among environments (Table 1). Variations due to SCA x Environment were not

Table 1. Analysis of variance of diallel crosses of 12 inbred parents for TLB, MSV and Yield components across environments 2009[1].

Source of variation	D.f.	Mean squares				F-test
		TLB 1-5	MSV%	Silk.Date day	PlantHt cm	YieldT/ha
Env	1	1.45**	14.35***	243.80***	353.33**	39.59***
Crosses	40	1.67***	2.31***	18.55**	209.68**	2.84**
GCA	11	1.95*	3.39*	25.46*	354.22*	2.94*
SCA	29	1.56***	1.91***	22.14**	154.86*	2.81**
Env*Crosses	40	0.38**	0.63*	8.13***	86.63*	1.10***
Env*GCA	11	0.68**	1.07**	7.06**	87.42**	0.9*
Env*SCA	29	0.26^{NS}	0.47^{NS}	8.54***	86.33*	1.156**
Pooled error	62	0.20	0.34	2.57	46.00	0.46

***significantly different at P<0.001, ** significantly different at P<0.01, NS = not significantly different (P>0.05), 1=First season rains.

significantly different from zero for TLB and MSV. The results agree with those of Nass *et al.* (2000), Gama *et al.* (2005), Vivek *et al*. (2009) and Vieira *et al.* (2009). The higher GCA effects suggest that contribution to synthetic variety development could be effective and the significant SCA effects could be useful when high yielding specific combinations are desired; especially in hybrid maize development where selection of parental material is required (Paterniani *et al.*, 2000; Malik *et al.*, 2004; Silva and Moro, 2004).

Acknowledgement

- Makerere University
- National Crops Resources Research Institute (NaCRRI)
- Regional Universities Forum (RUFORUM)
- Strengthening Capacity for Agricultural Research and Development in Africa (SCARDA)

References

Fakorede, M.A.B., Fajemisinb, J.M., Ladipoa, J.L., Ajalac, S. O. and Kimd, S. K., 2003. Development and regional deployment of streak virus resistant maize germplasm: an overview. Plant virology in sub-Saharan Africa: Proceedings organized by IITA, Ibadan, Nigeria.

Kyetere, D.T., Ming, M.D. M., Pratt, R.C., Brewbaker, J. and Musket, T. 1999. Genetic analysis of tolerance to maize streak virus in maize. *Genome* 42:20–26

Ojulong, H.F., Adipala, E. and Rubaihayo, P.R. 1996. Diallel analysis for reaction to Exserohilum turcicum of maize cultivars and crosses. *African Crop Science Journal* 4 (1):19-27.

Lagat, M., Danson, J., Kimani, M. and Kuria, A. 2008. Quantitative trait loci for resistance to maize streak virus disease in maize genotypes used in hybrid development. *African Journal of Biotechnology* 7(14):2573-2577.

Paterniani, M.E. A.G. Z., Sawazaki, E., Dudienas, C., Duarte, A.P. and Boller, P. 2000. Diallel crosses among maize lines with emphasis on resistance to foliar diseases. *Genetics and Molecular Biology* 23(2):381-385.

Vivek, B.S., Odongo, O., Njuguna, J., Imanywoha, J., Bigirwa, G., Diallo, A. and Pixley, K. 2009. Diallel analysis of grain yield and resistance to seven diseases of 12 African maize (*Zea mays* L.) inbred lines. *Euphytica* DOI 10.1007/s10681-009-9993-5.