Research Application Summary

Usefulness of F_3 testcrosses to identify bi-parental maize populations with the best potential for producing superior inbreds

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Abstract

Maize is an important crop in the East African region, but continues to be plagued by biotic and abiotic constraints. Genotypes carrying genetic resistance to these constraints in addition to having good agronomic traits are the most desirable. A cross between CIMMYT lines and NaCRRI weevil lines generated 112 populations. These need to be reduced to facilitate intensive testing to obtain inbreds with highest potential for developing hybrids with the desired traits. To achieve this, 10 F_2 were selfed and advanced to F_3, testcrossed and evaluated in 3 environments. Preliminary results on inheritance and heritability of 3 traits in this study revealed additive genes action or lesser dominance effect for turcicum leaf blight (TLB) and maize streak virus (MSV). Anthesis-silking interval (ASI) was quantitatively inherited with minor genes effects. Both ASI and TLB showed moderate values of heritability ranging from -0.20 to 0.58. Low correlation values between F_2 and F_3 also emphasized low heritability of traits apart from E111 for TLB ($r = 0.90$). Index selection showed a huge disparity with visual selection. Managed and imposed environments will be used in evaluation of 250 F3 testcrosses to determine the level of tolerance to drought and TLB and MSV diseases and usefulness criterion will be used to choose promising populations.

Key words: Bi-parental population, heritability, inheritance, testcross, usefulness criterion

Résumé

Le maïs est une culture importante dans la région de l'Afrique de l'Est, mais continue d'être en proie à des contraintes biotiques et abiotiques. Les génotypes porteurs d'une résistance génétique à ces contraintes en plus d'avoir de bonnes caractéristiques agronomiques sont les plus souhaitables. Un croisement entre les lignes du CIMMYT et NACRRI a généré 112 populations. Celles-ci doivent être réduites pour faciliter les tests intensifs pour obtenir les lignées avec la plus grande potentialité de

développement des hybrides ayant les caractéristiques souhaitées. Pour atteindre cet objectif, 10 F2 ont été autofécondée et mis ensemble avec F3, dans un test croisé et évalué dans 3 environnements. Les résultats préliminaires sur l'héritage et l'héritabilité de 3 traits de cette étude a révélé une action additive des gènes ou un effet moindre de dominance pour la « brûlure des feuilles turcicum »(TLB) et le virus de la striure du maïs (MSV). L'Antithèse-sortie de l'intervalle (ASI) a été quantitativement hérité des gènes avec des effets secondaires. Les deux ASI et TLB ont montré des valeurs modérées de l'héritabilité allant de -0,20 à 0,58. Les valeurs de corrélation faible entre F2 et F3 ont également souligné la faible héritabilité des caractères en dehors de E111 pour TLB (r = 0,90). L'indice de sélection a montré une grande disparité avec la sélection visuelle. Un environnement géré et imposé sera utilisé dans l'évaluation de 250 tests de croisementF3 pour déterminer le niveau de tolérance à la sécheresse et aux maladies TLB MSV et les critères d'utilité seront utilisés pour choisir les populations prometteuses.

Mots clés: La population biparentale, l'héritabilité, l'héritage, test de croisement, critère d'utilité

Background

Advancing and selecting best maize families in segregating populations for disease resistance, agronomic characteristics and environmental stresses is difficult and sometimes impractical due to number of progenies that results from individual crosses. Therefore, testing and selection in early generations is more beneficial; but this requires that only populations with high breeding value are advanced to late generations. Usefulness Criterion ($U_á$) has been suggested in this study as a potential aid to select the most promising populations, in which the most intense selection would be applied since it combines mean and genetic variance information. This study aimed at i) developing a selection index for selecting among populations, based on the Usefulness Criterion for yield of testcrosses, resistance to TLB and ASI values of inbreds and their testcrosses, and ii) to determine whether selection among segregating maize populations using the Usefulness Criterion of testcrosses can predict higher yields than selection of populations based only on the mean of the testcrosses.

Literature Summary

The best way to choose the right segregating population for the successful development of maize inbred lines with highest breeding value is to test and examine its progeny for heritability

and predict genetic gain of targeted traits (Bernado, 2003). Unfortunately, this process is held back and becomes impractical due to large numbers of progenies per cross and limited resources. Although visual selection and the mean performance have much been used in early selection of populations, yet genetic variability controls how much gain can be made within a population (Dismic *et al*., 2003; Singh, 2005). The $U_{á}$ is a function that combines the information about mean performance and genetic variance (Hallauer *et al.,* 2010). It is has not been much used by breeders in identification of potential population or parents yet it provides the way of comparing populations based on their mean and genetic variance. For all breeders, the ultimate objective is the selection of genotypes with maximum desired traits. Therefore, index selection suggested by Smith (1936) has the advantage of improving simultaneously several traits and is most suitable where the relative value of each trait is directly determined through its economic value based on genotypic and phenotypic variances of each trait and the respective covariances (Dessaune *et al.,* 2007; Hallauer e*t al.,* 2010).

Study Description

Ten F_2 populations were advanced to F_3 during 2011A season (March - June) at NaCRRI-Namulonge in Central Uganda and 694 F_3 progeny rows were selfed at Namulonge, and testcrossed to the tester CML312/CML404 in isolation plots at Kasese in Western Uganda during 2011B (September - December). In the same season, F_3 were subjected to artificial screening against TLB and MSV. Anthesis date (AD) and silking date (SD) were taken to 50% of pollen shedding and 50% silk emergence, ASI was calculated by subtracting SD from AD. TLB reaction was assessed using a rating scale of 1 to 5 and MSV incidence was done by counting diseased plants and converting the counts into percentages. In the framework of achieving our main objective, 250 F_3 Testcrosses were selected from 10 populations using index selection, and are being evaluated in 3 environments predetermined based on relative contribution to the study.

Research Application

There were no distinct phenotypical classes in all populations for all three traits studied. The histograms of TLB and MSV were right skewed in all populations which indicated involvement of additive genes in inheritance. The tendency towards a normal distribution for ASI revealed that it was quantitatively inherited with minor genes effect (Fig. 1). Reduced mean from F_2 to F_3 for ASI indicated the segregation of

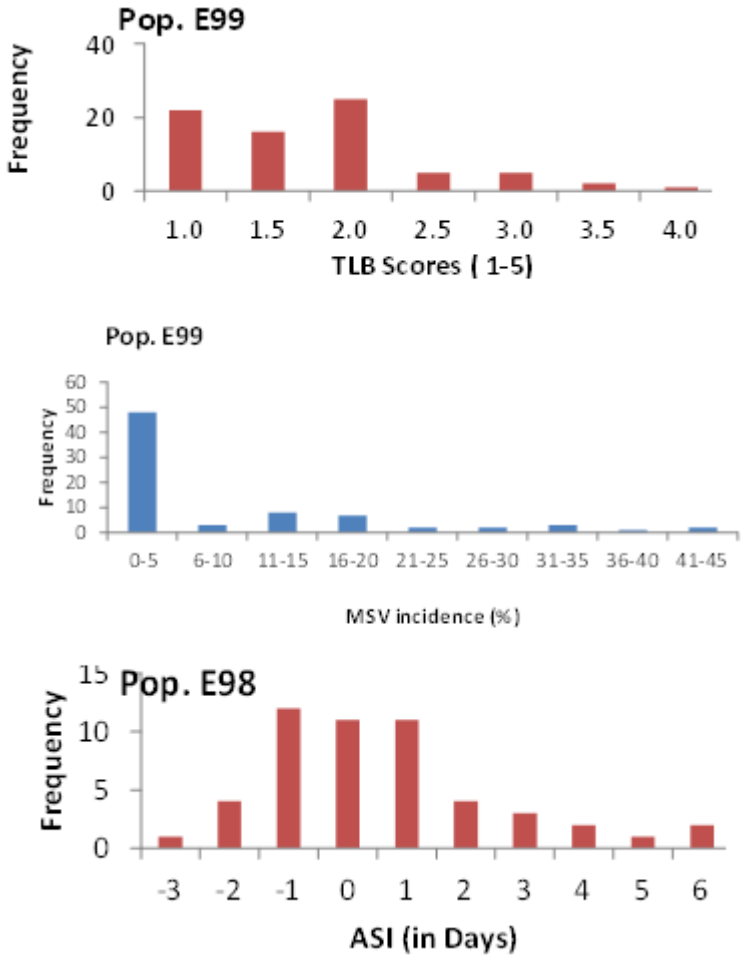

Figure 1. Sample of frequency distribution of MSV, TLB and ASI.

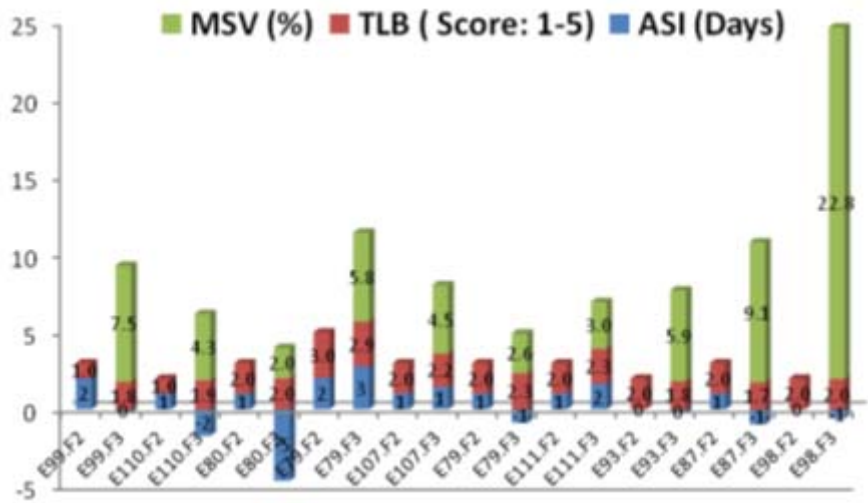

Figure 2. Mean comparison of F2 and F3 populations.

Table 1. F2 on F3 regression, correlation and heritability for ASI and TLB.

Pop.	Trait	dfRegr.	df Res.	MS Regr.	MS Res.	b(h^2)	R^2	R
E99	ASI	1	73	0.27	5.57	0.03	0.0007	0.03
	TLB	1	73	3.30**	0.45	0.41	0.0898	0.30
E110	ASI	1	85	5.33	12.61	0.10	0.0049	0.07
	TLB	1	85	1.65	0.49	0.27	0.0379	0.19
E80	ASI	1	83	74.23*	15.11	0.58	0.0559	0.24
	TLB	1	85	3.63**	0.53	0.27	0.0748	0.27
E79	ASI	1	54	11.11	15.87	0.25	0.0128	0.11
	TLB	1	54	1.72	0.50	0.21	0.0600	0.25
E107	ASI	1	69	49.85**	7.94	0.45	0.0834	0.29
	TLB	1	69	5.14	5.05	0.14	0.0145	0.12
E74	ASI	1	75	2.70	6.70	0.12	0.0053	0.07
	TLB	1	75	7.05***	0.41	0.39	0.1860	0.43
E111	ASI	1	41	0.23	7.92	0.04	0.0007	0.03
	TLB	1	41	209.76***	1.14	0.43	0.8178	0.90
E93	ASI	1	73	7.60	5.69	-0.20	0.0180	-0.13
	TLB	1	73	0.26	0.45	0.09	0.0078	0.09
E87	ASI	1	58	3.25	3.29	0.15	0.0168	0.13
	TLB	1	58	0.68	0.43	0.17	0.0263	0.16
E98	ASI	1	51	8.15	3.81	0.31	0.0402	0.20
	TLB	1	51	0.56	0.42	0.27	0.0379	0.19

ASI: Anthesis-Silking interval, TLB : Turcicum Leaf Blight, dfRes.: Degree of freedom of residual, dfRegr.: Degree of freedom of regression, M.S Res. Mean square of residual and M.S Regr.: Mean square of regression, pop: Population, R^2: Coefficient of determination and r: Coefficient of regression.

populations towards the drought tolerant parents. Over 50% of the families had ASI ranging from -3 to 1 day(s) except population E80 which had only 18% of the families within this range. Narrow sense heritability estimated from F_2-F_3 regression coefficients on single family basis were moderately low implying that early selection in F_3 is not easy except in E99 (0.41), E74 (0.39) and E111 (0.43) for TLB, and E80 (0.58), E107 (0.45) and E98 (0.31) for ASI where heritability was moderately high (Table 2). Low correlation values between F_2 and F_3 also emphasized low heritability of traits apart from E111 for TLB (r = 0.90) (Table 1). Index selection developed using key traits showed huge difference from visual selection, thus study recommended index selection when many traits are considered with different economic importance.

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