Research Application Summary

S_1 and S_2 selection of Longe 4 maize variety for tolerance to low soil nitrogen in Uganda

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Abstract

Low nitrogen is a major environmental stress leading to low yields in maize. Identification of varieties able to perform well under low soil N is of great significance to the resource poor farmers in the country especially when input costs are high and fertilizer use is very low (3%). For this purpose S_1, S_2 and S_2R (S_2 random) families derived from Longe 4; a popular early maturing OPV, were evaluated. Yield, yield components and other agronomic traits were assessed among families to compare mean performance of generations, to estimate heritability and the amount of genetic variance in the three samples, and to determine the magnitude of correlation between traits and between environments. Results obtained indicated that S_1s in both testing environments yielded higher than S_2s and gave larger predicted gains from selection. Genetic variances were higher for S1s in both environments; therefore, more rapid gains for yield in Longe 4 are expected from S_1 compared to S_2 selection. The overall yield reduction in the low-N test was 35% and 34% in 2009A and 2009B, respectively. Average broad sense heritability estimates under low N were 21% for grain yield, 17% for ASI (S_2); narrow-sense heritability was 0.24 and 0.52 for grain yield and ASI respectively. Genotype means under low N showed correlations between grain yield and: ASI, -0.23; plant height, 0.52; leaf senescence, 0.15 and leaf nitrogen concentration, 0.12. In conclusion, sufficient amount of genotypic variation was found for low N tolerance among Longe 4 S_1 and S_2 families which can be improved by selection. Selection should be done at S_1 to save time and avoid an extra season of selfing and the associated resources required. Predicted gains were higher for S_1 families and when ranks of grain yield were averaged across N-levels, therefore both environments should be used in selection of genotypes for low nitrogen performance if feasible.

Key words: Low nitrogen, S_1, selfed progeny 1, S_2, selfed progeny 2 and low N

Résumé

La faible teneur en azote est un stress environnemental majeur conduisant à de faibles rendements en maïs. L'identification des variétés capables de bien fonctionner dans le sol à faible N est d'une grande importance pour les agriculteurs pauvres en ressources dans le pays, en particulier lorsque les coûts d'entrée sont élevées et l'utilisation des engrais est très faible (3%). A cet effet, S1, S2 et S2R (aléatoire S2) familles issues de Longe 4, un VPO à maturité précoce, ont été évalués. Les rendements, les composantes du rendement, et d'autres caractères agronomiques ont été évalués entre les familles afin de comparer la performance moyenne des générations, pour estimer l'héritabilité et le montant de la variance génétique dans les trois échantillons, et de déterminer l'ampleur de la corrélation entre les traits et les environnements. Les résultats obtenus ont indiqué que S_1s dans les deux environnements de test a donné plus de S_2s et a prédit plus des gains provenant de la sélection. Les variances génétiques étaient plus élevées pour S1s dans les deux environnements, par conséquent, des gains plus rapides pour le rendement en Compartiment 4 sont attendus de S_1 par rapport à la sélection S_2. La diminution globale des rendements dans l'essai à faible N était de 35% et 34% en 2009a et 2009b, respectivement. La moyenne des estimations de sens d'héritabilité sous un faible N étaient de 21% pour le rendement grain, 17% pour les ASI (S_2); l'héritabilité au sens strict était de 0,24 et 0,52 pour le rendement grain et l'ASI, respectivement. Les moyens de génotype sous une faible N ont montré des corrélations entre le rendement grainier et: ASI, -0,23, la hauteur de la plante, 0,52, la sénescence des feuilles, de 0,15 et la concentration en azote des feuilles, 0,12. En conclusion, une quantité suffisante de la variation génotypique a été trouvé pour N en faible tolérance entre Longe 4 S_1 et S_2 familles qui peuvent être améliorées par la sélection. Le choix doit être fait au S_1 pour gagner du temps et éviter une saison supplémentaire d'autofécondation et les ressources connexes nécessaires. Les gains prévus avaient un teneur plus élevé de S_1 pour les familles et quand le rendement S_1 en grain a été en moyenne entre N-niveaux, donc à la fois les environnements devraient être utilisés dans la sélection de génotypes de la performance en faible teneur en azote, si possible.

Mots clés: Faible teneur en azote, S_1, autofécondation descendance 1, S_2, autofécondation descendance 2 et N faible

Background

In Uganda, maize yields are low (0.8-1.5 t/ha), partly because of the depletion of soil fertility on smallholder farms. Specifically, nitrogen (N) deficiency has become one of the most important abiotic factors limiting maize yields (Kikafunda *et al.*, 2001). Low N efficient varieties can be very useful to alleviate effects of low nitrogen due to declining soil fertility. Unfortunately, most high yielding commercial maize varieties were selected under optimum soil fertility and therefore are unstable when grown in low N soils such as those that most resource poor farmers use. For this reason, the Cereal Program of the National Crop Resources Research Institute (NaCRRI) began work towards improving maize varieties for nitrogen tolerance, targeting Longe 4, a popular farmer-preferred open-pollinated variety (OPV). Longe 4 is early maturing (105-110 d) and is grown mainly in drought prone areas. Improving this variety should increase production, and therefore availability, of maize. This study compared the performance of S1 and S2 selected progenies of Longe 4 for heritability, potential gains and the possibility of indirect selection based on key secondary traits related to yield. Selection and evaluation were carried out in two contrasting, carefully managed N levels (low and optimal).

Literature Summary

A very serious constraint emerging is the general decline in soil fertility including nitrogen deficiency that reduces grain yield by 37 to 78% ((Bänziger *et al.*, 1997). The importance of adequate soil N to crop yield has been well documented. Many studies have demonstrated that low N not only resulted in reduced grain yield, but also affected nutrient levels in kernels, particularly of protein content (Bertin and Gallais, 2001). Heritability and genetic variance for grain yield usually decreases under abiotic stress as yield levels fall. The use of secondary traits might improve selection efficiency as indirect selection for a single secondary trait sometimes results in greater progress for grain yield than direct selection for grain yield and may prove more useful in stress environments where heritabilities for grain yield are low.

Study Description

This study was carried out at National Crops Resources Research Institute (NaCCRI), in Namulonge, Uganda for two seasons (2009A & 2009B) under both optimal and low N conditions, in fields adjacent to each other Soils are ferralitic (red sandy clay loams), with a native pH of 4.9-5.0, with tall grassland vegetation. Each trial was established as a 10x15 alpha lattice design with two replications in each environment. Initial soil fertility at the site was established before planting by the National Agriculture Research Laboratories (NARL).

Data collected include; days to anthesis and silking (and the resulting anthesis-silking interval (ASI)), leaf senescence, yellowing, leaf nitrogen concentration, and plant height. *Turcicum* leaf bright (TLB) and maize streak virus disease (MSV) were also evaluated as key diseases prevailing in the region. Data were subjected to ReML and ordinary analysis of variance using Genstat 12th edition. Generation and family means were computed and separated by Fisher's protected LSD (P<0.05). Broad sense heritability estimates were calculated and the parent-offspring regression coefficient "b" was used as an estimate of narrow sense heritability (Vogel *et al.*, 1980). Predicted gains based on parent-offspring regression were calculated. Correlations of entry means were determined between grain yield and secondary traits, and between N-levels and generations.

Research Application

Soil N-levels influenced all traits across seasons. In each season and across seasons, mean grain yields were higher for opt-N than for low-N. The means for some important traits were; 2.3 t/ha for grain yield, 2.5 d for ASI and 0.96 ears per plant. S_1 lines in each season and across seasons significantly out-yielded S_2 lines while means for selected (S_2) and random (S_2R) lines did not differ significantly. For all variables, significant differences were observed between seasons and between N-levels. Broad sense heritability (H^2) for grain yield was 0.42 for S_1 lines and 0.16 for S_2 lines under low N conditions, and was higher than that of ASI, ears per plant and leaf senescence. Narrow-sense heritability was 0.24 and 0.52 for grain yield and ASI respectively (Table 1). There was a weak, but statistically significant, negative correlation of yield with ASI, and weak, positive correlations with plant height and LNC. Correlations of S_1 family means in different N-levels in 2009B were 0.74 and 0.53 for grain yield and ASI, respectively, and were 0.47 and 0.42, respectively, for S_2s. Predicted gains from selection were higher for S_1s under both N-levels and higher under for opt-N than for low-N in 2009A, and similar for N-levels in 2009B.

Recommendation

Selection should be done at S_1 since the lower predicted gain for S_2 indicates that the extra season and extra resources required to obtain S_2 seed would not be justified. Both testing environments should be used for selection if feasible.

References

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Table1. Parent-offspring regression for grain yield and ASI of S_2 on S_1 families during 2009A and 2009B.

Source	d.f	Mean squares							
		GY				ASI			
		2009A		2009B		2009A		2009B	
		Low N	Opt N	Low N	Opt N	Low N	Opt N	Low N	Opt N
Regression	1	0.002	1.27	0.56*	2.33***	3.72	3.73	41.99***	22.26**
Residual	48	0.179	0.40	0.08	0.15	5.32	3.71	3.02	1.82
Total	49	0.176	0.42	0.09	0.19	5.27	3.71	3.81	2.24
"b"		0.01	0.21	0.24*	0.29***	0.13	0.17	0.52***	0.51**
S.E (b)		0.120	0.12	0.009	0.073	0.16	0.17	0.14	0.15

Opt N, Optimal nitrogen, LN, Low nitrogen, S_1 and S_2 generations. *, **, ***, ns Significant at P≤0.05, P≤0.01, P≤0.001, and non significant respectively.

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