Research Application Summary

Resistance to the maize weevil (*Sitophilus zeamais* Motsch) among maize inbred lines

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Abstract

Maize is a very important crop for small-scale farmers in Africa and also as food and feed resource. Despite this, storage pests cause high quality and quantity losses to the crop. One of the most important storage pests of maize is the maize weevil (*Sitophilus zeamais* Motsch.). It is recognised that management of this pest can only be sustainably achieved through growing resistant genotypes. This study was therefore initiated to identify inbred lines resistant to the maize weevil for use in hybrid maize breeding. One hundred and twenty inbred lines were crossed in an alpha lattice design with two rows of 2 x 5 m and replicated thrice in the field at two locations; Kiboko and Embu in Kenya) for two seasons in 2010 and 2011. After harvest 100g grain samples infested with 50 unsexed newly reared insects were incubated for 3 months in jars. After 3 months, grain weight loss (%), number of adult progeny, and flour production (%) were assessed for each jar. Data for individual and combined locations were analysed. Differences in inbred lines were highly significant ($P < 0.05$) for maize weevil progeny emergence, grain weight loss and the flour weight. Based on grain weight loss, genotypes were categorised into resistant, moderately resistant, moderately susceptible, susceptible and highly susceptible. Genetic diversity for maize weevil resistance thus exists among tropical maize inbred lines. This offers an opportunity to exploit tropical germplasm to breed for weevil resistance and reduce post-harvest storage losses in maize.

Key words: Hybrids, inbred lines, maize, maize post-harvest losses, *Sitophilus zeamais*

Résumé

Le maïs est une culture très importante pour les petits agriculteurs en Afrique et aussi une nourriture et une ressource alimentaire. Malgré cela, les ravageurs des stocks causent de hautes pertes de qualité et de quantité à la culture. L’un de plus importants ravageurs de stock de maïs est le charançon du maïs (*Sitophiluszeamais*Motsch.). Il est reconnu que la gestion de ce ravageur peut seulement être durablement accomplie par l'accroissement des génotypes résistants. Cette étude a donc été lancée pour identifier les lignées pures résistantes au charançon du maïs pour les utiliser dans la reproduction du maïs hybride. Cent vingt lignées pures ont été croisées dans une conception en treillis alpha avec deux rangées de 2 x 5 m et reproduite trois fois dans le champ à deux endroits; Kiboko et Embu au Kenya pour deux saisons en 2010 et 2011. Les échantillons des grains de 100g après la récolte ont été infestés avec 50 insectes non sexués nouvellement élevés et incubés pendant 3 mois dans des pots. Après 3 mois, la perte de poids des grains (%), le nombre de descendants adultes, et la production de la farine (%) ont été évalués pour chaque pot. Les données pour les emplacements individuels et combinés ont été analysées. Les différences de lignées pures étaient hautement significatives (P <0,05) pour l'émergence de la lignée du charançon du maïs, la perte de poids du grain et le poids de la farine. Sur la base de la perte de poids du grain, les génotypes ont été classés en résistants, modérément résistants, modérément sensibles, sensibles et très sensibles. La diversité génétique pour la résistance du charançon du maïs existe donc au sein des lignées pures de maïs tropicaux. Ceci offre une opportunité d'exploiter le matériel génétique tropical à reproduire pour la résistance au charançon et de réduire les pertes dans le stock de maïs après la récolte.

Mots clés: Hybrides, lignées, maïs, pertes de maïs après récolte, *Sitophilus zeamais*

Background

Maize is an essential component of the global food security and forms a staple food for 100 million poor people, supplying 15-56% of total calories of people in the developing countries. In Africa maize is primarily grown by small-scale farmers for use as both food and feed. Its productivity is therefore critical to raising rural incomes and stimulating broad based economic growth (Byerlee and Eicher, 1997). Despite its importance, storage pests cause serious losses in both quality and quantity particularly in the tropics and sub-tropics. Maize inbred lines represent a fundamental resource for studies in genetics and plant breeding towards crop improvement. Though mainly used in hybrid development they are also critical for genetic diversity studies including the development of linkage maps and conducting phenotype-genotype association analysis in plant species in relation to traits of interest (Burr *et al*., 1988; Thornsberry *et al*., 2001). The objective of this study was, therefore, to identify inbred lines resistant to the maize weevil for use in hybrid maize breeding.

Literature Summary

Maize production for food by smallholder farmers often plays a vital role in alleviating poverty through income generation and contributes positively to the local and national economy (Jayne *et al*., 2001). Maize grains need to be stored from one harvest to the next in order to maintain its constant supply all year round and to preserve its quality until required for use. For smallscale farmers in Africa, the main purpose of storage is to ensure household food supplies (reserves) and seed for planting (Adetunji, 2007). The maize weevil (*Sitophilus zeamais* Motsch.) weevil aggravates shortage of food by causing annual postharvest losses of maize of 20%-30 % on average. Damage by the maize weevil is irreversible and leads to losses in quality and quantity. It is an important pest for stored maize in the tropics hence breeding for its resistance is crucial to the resource-poor farmers in developing countries and influences the adoption rate of improved varieties. Quantitative inheritance for storage pest resistance have been confirmed, but most breeding programmes focus more on improving yield and quality than resistance against storage insect pests. Genetic variability is important for progress in a breeding programme and new sources of resistance are needed for effective breeding for resistance to postharvest pests. It is an entry point for progress in understanding the biochemical, biophysical and genetic basis of host plant resistance which is essential in ensuring that traits being selected meet consumer demands.

Provision of information among diverse inbred lines in response to maize weevil attack would form a basis for a stable breeding programme towards addressing post harvest losses due to storage pests. The exploitation of maize inbred lines for generation of hybrids which are resistant to the storage pests requires a detailed knowledge of the genetics among lines and understanding of their genetic diversity.

Study Description

One hundred and twenty inbred lines including resistant and susceptible checks were used in an alpha lattice design (20 x 6) with two rows of 2 x 5 m with three replications at two locations (Kenya Agricultural Research Institue-Kiboko and Embu) for two seasons in 2010 and 2011. After harvest and drying, the cobs were shelled and grain samples of 100g were taken and disinfested by fumigation with phostoxin for 7 days to eliminate infestation from the field. The kernels were placed in 250 ml jars, infested with 50 unsexed newly reared insects and incubated for 3 months. The experimental design in the laboratory was completely randomised design. The contents in each jar were sieved to separate grains, insects and flour after 3 months. The grain weight loss (%), number of adult progeny, and flour production (%) were measured/ counted. Data on flour produced (%) and weight loss (%) was arcsine transformed while progeny data was log transformed before statistical analyses. The data for individual and combined locations was subjected to analysis of variance using the GLM procedure of SAS and means separated using the least significant difference method.

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The analysis of variance showed highly significant ($P < 0.05$) differences among the inbred lines for maize weevil progeny emergence, grain weight loss and the flour weight. The mean weight loss for the most resistant susceptible genotype was 3.45 and 32.90 % respectively (Table 1). The genotypes were categorised into resistant (1-5%), moderately resistant (5.1-8%), moderately susceptible (8.1-10%), susceptible (10.1-13) and highly susceptible (>13.1%) based on the percentage weight loss which had been found as a key trait of discriminating genotypes in relation to resistance (Mwololo *et al.*, 2012; Tadele *et al.*, 2011). Most of the inbred lines were categorised as moderately resistant (47 %), 10% were resistant and 43 % were moderately susceptible to highly susceptible (Fig. 1). The number of emerged insects was highest among the susceptible inbred lines (Table 1). Consequently the rate of multiplication of the insects is due to genetic characteristics of the grains of the inbred line in question. Most of the resistant lines have their origin from “CubaGuard” a Caribbean germplasm accession at CIMMYT which showed significant levels of resistance to storage pests though with poor agronomic traits (Kumar, 2002). Inbred lines, which had been developed for stem borer resistance (MBR series) were either moderately resistant or moderately susceptible hence they might have some genes of resistance to the maize weevil. Based on the results, genetic diversity for maize weevil exists among tropical maize inbred lines thus offering opportunity to exploit the variability towards reducing post-harvest storage losses through genetic improvement.

Table 1. Resistance parameters of the most resistant and the most susceptible among the inbred lines evaluated.

Entry	Name	Remarks	No. insects	Flour weight (%)	Weight loss (%)	Grain damage (%)
69	(CUBA/GUAD C1 F27-4-3-3-B-1-Bx[KILIMA ST94A]-30/MSV-03-2-10-B-2-B-B)-160-1-B-1-B-B-B-B	Bred for SPR	20.58	0.2	3.45	5.57
99	(CUBA/GUAD C1 F27-4-3-3-B-1-Bx[KILIMA ST94A]-30/MSV-03-2-10-B-2-B-B)-463-1-B-5-B-B-B-B	Bred for SPR	58.33	0.22	3.51	7.6
71	(CUBA/GUAD C1 F27-4-3-3-B-1-Bx[KILIMA ST94A]-30/MSV-03-2-10-B-2-B-B)-160-1-B-4-B-B-B-B	Bred for SPR	30.42	0.21	3.57	9.89
27	CML204	Bred for SPR	24.33	0.19	3.63	6.41
73	(CUBA/GUAD C1 F27-4-3-3-B-1-Bx[KILIMA ST94A]-30/MSV-03-2-10-B-2-B-B)-160-1-B-6-B-B-B-B	Bred for SPR	26.77	0.19	3.64	8.17
82	(CUBA/GUAD C1 F27-4-3-3-B-1-Bx[KILIMA ST94A]-30/MSV-03-2-10-B-2-B-B)-277-1-B-1-B-B-B-B	Bred for SPR	34	0.3	4.13	14.82
86	(CUBA/GUAD C1 F27-4-3-3-B-1-Bx[KILIMA ST94A]-30/MSV-03-2-10-B-2-B-B)-306-1-B-2-B-B-B-B	Bred for SPR	28.46	0.24	4.5	9.34
70	(CUBA/GUAD C1 F27-4-3-3-B-1-Bx[KILIMA ST94A]-30/MSV-03-2-10-B-2-B-B)-160-1-B-2-B-B-B-B	Bred for SPR	27.92	0.11	4.54	5.42
98	(CUBA/GUAD C1 F27-4-3-3-B-1-Bx[KILIMA ST94A]-30/MSV-03-2-10-B-2-B-B)-463-1-B-4-B-B-B-B	Bred for SPR	38	0.27	4.72	11.17
19	MBR C5 Bc F14-3-2-8-B-4-2-B-B-B	Bred for SBR	104.25	0.84	7.73	24.57
44	CML78	Bred for DT/Yield	90.33	1.01	7.77	26.8
1	MBR C6 Bc F299-2-B-#-1-1-B-B-B-B-B-B –B	Bred for SBR	94.84	0.73	7.92	21.84
9	MBR C5 Bc F13-3-2-1-B-4-2-B -B-B	Bred for SBR	98.67	0.53	8.26	25.13
.	MBR/MDR C3 Bc F1-1-1-1-B-3-2-B -B-B	Bred for SBR	72.75	0.54	8.26	20.49

Table 1. Contd.

Entry	Name	Remarks	No. insects	Flour weight (%)	Weight loss (%)	Grain damage (%)
116	MBR C5 Bc F8-1-1-1-B-2-2-B -B-B	Bred for SBR	88.46	1.2	9.03	23.58
57	CML488	Bred for DT/Yield	96.75	0.8	9.34	25.01
47	CML511	Bred for DT/Yield	78.88	0.57	9.58	18.52
16	CML-264	Bred for DT/Yield	121.83	0.9	9.91	41.94
21	CML311/MBR C3 Bc F95-2-2-1-B-B-B-B -B-B	Bred for SBR/Yield	83.25	0.88	10.1	27.68
37	CML444	Bred for DT/Yield	76.58	0.63	10.54	30.4
118	Pool B –36-B-4-3-B -B-B	Bred for DT/Yield	145	1.26	12.29	27.8
25	CML202	Bred for DT/Yield	58.22	0.97	12.38	19.34
60	CML441	Bred for DT/Yield	157.42	1.34	12.41	40.78
59	CZL03007	Bred for DT/Yield	145.58	1.18	13.35	39.94
24	CML334	Bred for DT/Yield	167.83	1.72	14.57	49.19
58	CZL00003	Bred for DT/Yield	191.83	1.78	15.35	55.24
56	CML443	Bred for DT/Yield	168.08	2.09	17.24	48.69
10	CML312	Bred for DT/Yield	153.17	1.4	17.38	48.36
62	CZL01005	Bred for DT/Yield	183.08	1.7	17.64	45.21
46	CZL03014	Bred for DT/Yield	229.08	1.86	18.71	50.66
3	CML395	Bred for DT/Yield	247.33	2.71	20.59	62.9
42	CML197	Bred for DT/Yield	263.17	4.33	24.05	74.2
CV			23.65	34.51	32.9	17.52
P Value			P<0.001	P<0.001	P<0.001	P<0.001

Key: SPR-storage pest resistance; SBR-stem borer resistance; DT-drought tolerance

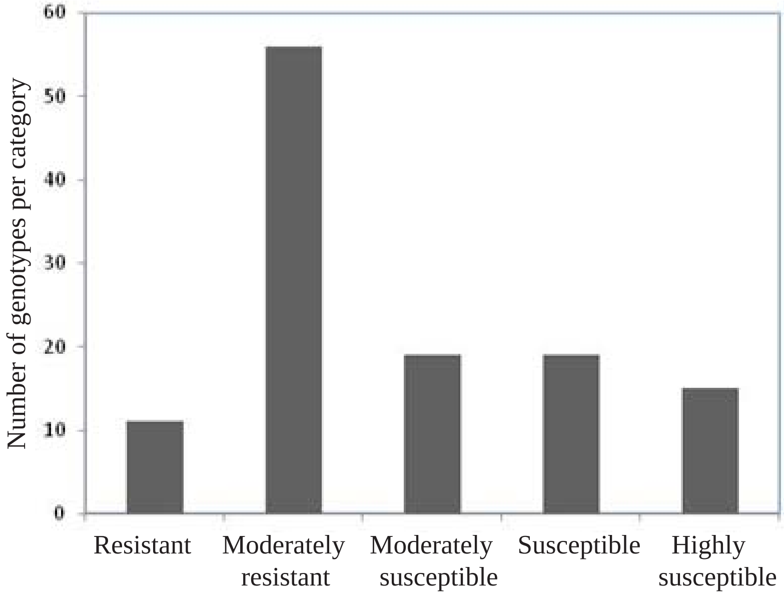

Figure 1. Distribution of genotypes among the different categories of resistance based on the kernel weight loss.

Conclusion and Recommendations

Genetic variation for weevil resistance exists among tropical maize inbred lines. This therefore can form the foundation for a successful breeding programme to address storage pests. The most resistant and susceptible inbred lines identified can be deployed in quantitative trait loci and association mapping for identification of molecular markers for use in marker assisted breeding for resistance to *Sitophilus zeamais*.

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