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Breeding for Insect Pests Resistance in Cereals: With Emphasis on Sorghum

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ABSTRACT

Insect pests of cereals especially sorghum in the savanna regions of Nigeria arc gaining more importance in recent times due to their damaging effects and yield reduction ability. Eight economically important sorghum insect pests (shoottly, stem borer, greenbug, spittle bug, sorghum midge and head bug) with high yield reduction potentials were reviewed out of the numerous insects that attack cereals such as soil insect, foliage feeder, stem feeder, panicle feeder and stored grain insects. Information on their genetics of resistance were presented and breeding method based on genetics of resistance were highlighted. An integrated pest management program that includes biological control, cultural control and host-plant resistance are encouraged.

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INTRODUCTION

There are well over one hundred thousand different kinds of insects found in Africa, south of Sahara. These insects affect our lives in many ways, sometimes to advantage and most often to our disadvantages.

Invited paper presented at the West and Central Africa Sorghum Research Network/ICRISAT, Held in Niamey, Niger. 1 l[th] - 14[lh] July, 2005.

Global losses due to insect pests activities especially on cereals is about 30% of potential world food (NRI, 1992) with very high proportion in the developing countries in Africa. Insect pests are chronic problems of agriculture and have attained high magnitude in the developing world as a result of agricultural intensification, thus creating new or greater pests problems.

Host-plant resistance alone or with biological control are methods of insect pest control that are less expensive, environmentally friendly, safe, self renewing, good for low-in-put farming, affordable and compatible with other control measures. (Ooi and Lim, 1989; Herren and Neuenschwander, 1991; Sharma *et al.*, 1996; Showemimo, 2003).

This paper highlights the major insect pests of cereals with emphasis on sorghum, its mechanism of resistance and breeding approaches for sorghum resiatnce to major insect pests.

Major Insect Pests of Cereal Crops

Cereal crops are affected by different insect pests and they are treated herein based on where they attack most or the plant part.

Soil Insect

i. Wireworms: The two popular ones are chick beetles (Coleoptera :Elateridae) and dark beetles (Coleoptera:Tenebrionidae). They attack the planted seeds and roots of cereal crops.

White grubs, *Phyllophaga crinita* (Burmeister) (Coleoptera:Scarabaeidae) attack all cereals roots and cause stak rot, stunted seedlings and promote seedling lodging.

Foliage feeders

i. **Shoot fly**; *Atherigona soccata* (Rodani) (Diptera:Muscidae). It is widespread with severe damaging effect on sorghum and millet. It's activities leads to leaf wilt and later dries up. Maggot feeds on decaying tissue and the crop may produce side tillers that may also be affected.

ii. **Maize Stalk borer:** *Busseola fusca* (Fuller) (Lepidoptera:Noctuidae). It affects all cereals especially maize, sorghum and millet. Young larvae feed on leaves and lead to chlorosis, while mature larvae bore into the stem and produce dead hearts. Severe infestation reduces or retards growth, while flowering and grain production are reduced significantly.

Panicle feeders

Insect pests that belong to this category are sorghum midge, head bug, hairy caterpillar, earhead worm, etc. However, sorghum midge and headbug are the most devastating.

i. **Midge**; *Contarinia sorghicola* (Coquillett) (Diptera:Cecidomyidap). It is the most widely distributed sorghum insect pests. Most injurious effect is caused by larvae feeding on ovary of the plant preventing normal grain development and result into blasted panicle.

ii. **Headbugs**; There are four well known genera (*Calocoris, Campylomma, Creontiades* and *Eurystylus*). *Eurystylus oldi* Poppius (Hemiptera: Miridae) is the most populous with astonishing damaging effect on sorghum. It is found all over Africa and Asia. Both the feeding and ovipositional activities lead to redistribution resulting in colour changes with shades of tanned in cases of severe feeding, poor grain filling, poor grain colour which affects quality and quantity.

Stored grain insect

Stored grain insect pests include: maize weevil, rice weevil, rice moth, flat grain beetle, red flour beetle, etc. The most important insect pests of cereal in this group are maize and rice weevil, and flat grain beetle.

i. **Maize weevil:** *Sitophilus zeamais* (Motschulky) and rice weevil; *Sitophilus oryzae* (L.) (Coleoptera:Curculionidae). They are cosmopolitan and the most destructive insect pests of stored grain in the world. The adult, larvae and nymph feed on stored grains and winnow they damaged beyond use.

ii. **Flat grain beetle**: *Cryptolestes pusillus* (Schonherr) (Coleoptera:Cucujidae). It is also cosmopolitan in distribution. It is a scavenger and often infests grains and meals that is not in good condition, so it is a follow up pests often in association with rice weevil.

HOST PLANT RESISTANCE IN SORGHUM TO INSECT PESTS

Recent research findings that are published are highlighted especially in the area of breeding methods using genetic information. The sorghum insect pests covered are; Shoot fly, spotted stem borer, green bug, spittle bug, sorghum midge and head bug.

A. Shoot fly

Shoot fly is an important pest of sorghum in Asia, Europe, Africa, etc. It attack sorghum from the seedling stage causing reduced plant stand and under severe infestation, total crop failure occurs. Shootfly completes it's life cycle between 17 – 21 days.

Various screening techniques have been discussed and used (Jotwani, 1978; Taneja and Leuschner, 1985). Interlard-Fishmeal Technique was used to build shootfly population and uniformity. Taneja, *et al.* (1986); Nimbalkar and Bapat (1992) used field and cage screening to select resistant/tolerant sorghum lines based on number of deadhearts at 28 days after crop emergence (Damage evaluation).

Table 2 shows screened sorghum genotypes and percent dead hearts. ICSV 714 and ICSV 713 showed low incidence, while those with <35% deadhearts are moderate or tolerant. Indra *et al* (1972), Nimbalkar and Bapat (1992) reported the importance of both additive and non-additive gene effects for inheritance of resistance to shootfly but predominantly by additive gene effects. However, Agrawal and Abraham (1985) reported the importance of non-additive genes. Resistance in sorghum to shootfly is antixenosis using the mechanism of simple trichomes. Vertical resistance breeding that centred around qualitative trait improvement via pedigree selection methods have been advocated for shootfly (Dent, 1991; Simmond, 1991).

B. Spotted Stemborer

This insect attacks sorghum at the second week after emergence until harvest, it attack all plant parts except the roots. Infested plants show leave scarification, ragged appearance, stem tunneling, peduncle tunneling or partially chaffy panicles.

Natural and artificial screening methods had been used to obtain sources of resistance to spotted stem borer (Taneja and Leuchner, 1985; Taneja, 1987). Resistance is reportedly quantitatively inherited. Both additive and non additive gene effects are important but additive gene effects are predominantly for deadheart and leaf injury. Leaf feeding, deadheart and stem tunneling are polygenic traits (Singh and Verma, 1988; Pathak, 1990). Pedigree selection or hybridization could be used for developing sorghum's resistant to spotted stem borer.

C. Green bug

It is an aphid that feed on the sorghum leaves causing reddish spots on the leaves, then leaves turn brown and eventual death. It also cause sorghum charcoal rot. A single dominant gene control resistance. Both additive and non-additive gene effects are significant but additive gene effects are more important.

GCA (general combining ability), SCA (specific combining ability), maternal and specific reciprocal effects are significant for antibiosis and tolerance. However, no definite genetic information is available for the inheritance pattern for the resistance factors (Tan *et al.*, 1985; Dixon *et al.*, 1990). A combination of cultural, chemical (insecticide) and greenbug – resistant sorghums are most suited for greenbug control, in an integrated fashion (IPM).

D. Spittlebug

The two important species are *Locris ruben* and *Poophilus costalis* but the most populous and destructive in the Nigerian savanna is *L. rubens*. Infestation was by birds spread throughout northern Nigeria ranging from 22% to 100% plants in farmers field (Ajayi and Oboite, 1999). Sorghum grain yield reduction of 35% in 1994 was recorded and other yield traits were also affected when 15 pairs of *L. rubens* infest sorghum for 5 weeks (Table 1 and 3).

Chemical control had been suggested, there were scanty genetic information as regards host plant resistance method. Work is on-going in the aspect of breeding for resistance, however, sorghum had been found to differ in their susceptibilities to spittle bug.

E. Sorghum midge

It is the most widely spread and damaging insect attacking sorghum. It is cosmopolitan and the most widely researched insect pests of sorghum. Damage is caused by nymph, larvae and adult feeding and prepositional activities leading to blasted panicle thus entire crop failure under severe infestation (Table 1).

Resistance to sorghum midge is quantitatively inherited, controlled by additive genes with some cytoplasmic effect (Agrawal *et al.*, 1988). However, GCA ad SCA effects are significant, thus both additive and non-additive gene effects are important. Morphological traits such as glume length, glume hardiness and hairiness are important factors of resistance (Sharma *et al.*, 1990; 1996). Pedigree, pure line selection (recurrent selection) and resistance x resistance (hybridization) are good breeding methods that had been used in midge resistance breeding. However, integrated pest management as a wholistic approach is encouraged.

F. Headbug

The most populous and damaging of the four genera is *Eurystylus oldi*. It has been established to be an economic important insect pest of sorghum in the Nigerian savannas. It accounted for yield losses of up to 86% in Nigeria and $550 million loss in the Semi-Arid Tropics (Ajayi and Tabo, 1995; Ratnadas and Ajayi, 1995; Showemimo, 1998).

In recent times information on sorghum resistant to *E. oldi* are readily available sorghum screened for *E. oldi* resistance differed significantly and various genetic studies revealed the importance of loose and semi-compact panicle types with high percent glume coverage. Non-additive gene effects with moderate narrow sense heritability are important for resistance. In a similar study dominance gene effect was confirmed to be controlling resistance, inheritance is conditioned by one or two dominant gene(s). Recurrent pedigree breeding method is useful for a successful *E. oldi* resistance breeding in sorghum (Showemino *et al.*, 2001, Showemimo, 2003; 2004a and b).

CONCLUSION

This work was mainly based on the published scientific study, thus suggestions here in should be treated with caution. However, this paper had been able to identify serious insect pest of cereals especially sorghum, their damage potentials, genetic information, host-plant response and breeding method suitable for host plant resistance. Integrated Pests Management (IPM) that involves all control measures especially biological control and host-plant resistances are encouraged.

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Table 1: Important insect pest of major cereal crops in the Nigerian savanna.

Insect	Host crop	Plant part attack	Symptom	Yield reduction potential	Control measure	Genetic mode of host resistance
Shootfly	Sorghum, millet	Leaves, stem	Deadheart, decaying tissue, tissue, witting	15-16% yield reduction	Cultural practice/Resistance variety	Additive and non-additive gene effect but more of additive controlling antixeno sp traits
Spotted stem borer	Sorghum	All parts except roots	Ragged appearance, shot-holes deadheart, panicle breakage	10% to total crop failure	Chemical control. Cultural practice	Additive and non-additive gene effect but more of additive control factor of resistance.
Greenbug	Maize, Sorghum	Leaves	Reddish spots, browning, leaf death	NA	Cultural practice	GCA & SCA are significant for antibiosis traits
Spittle bug	Sorghum, millet	Leaves	Chlorotic spot, blotches, stunting small panicles	Upto 35% yield reduction	Chemical, cultural practice	NA
Sorghum midge	Sorghum	Panicle	Shrivelled seeds blasted panicle	40% total crop failure	Resistant cultivars	Quantitatively, additive gene effect with cytoplasmic effect
Head bug	Sorghum	Panicle	Unfilled grain, shrievelled grain chaffy panicle	30-86% yield reduction	Host-plant resistance, biological control	Non-additive gene effect with moderate narrow sense heritability

Table 2: Sorghum genotypes screened for shootfly resistant/tolerant.

Genotyope	Plant height	50% flowering	Deadhearts (%)
ICSV 707	180	72	25
ICSV 708	180	70	27
ICSV 711	170	77	29
ICSV 712	185	79	26
ICSV 713	170	80	19
ICSV 714	135	82	11
ICSV 717	240	78	40
PS 35805	150	87	22
PS 35832-1	200	76	31
Resistant control			
IS 18551	330	71	28
Susceptible control			
CSH1	155	58	72

Adapted from ICRISAT Information Bulletin No. 38.

Table 2: Sorghum genotypes screened for **shootfly resistant/tolerant**.

No. of bug adult caged/plant (pairs	Plant height (cm)	Panicle weight (g)	Grain yield/panicle (g)
0	169.8(0)[a]	23.4(0)	17.5(0)
1	155.4(9)	20.4(13)	16.5(6)
2	151.0(11)	19.2(18)	14.6(17)
3	140.2(18)	16.2(31)	12.8(27)
5	142.1(16)	15.2(35	11.2(36)
Mean	151.6	18.9	14.5
SE	±3.96	±4.2	±3.59
df	35	12	12

Adapted from Ajayi and Oboite, 1999.

[a] Numbers in parenthesis are % reduction for the given parameters.