MECHANISMS OF RESISTANCE IN SELECTED SORGHUM GENOTYPES TO THE SPOTTED STEM BORER *CHILO PARTELLUS* (SWINHOE) (LEPIDOPTERA:PYRALIDAE).

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A THESIS SUBMITTED TO THE FACULTY OF SCIENCE, RIVERS STATE UNIVERSITY OF SCIENCE AND TECHNOLOGY, PORT HARCOURT, NIGERIA, IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF DOCTOR OF PHILOSOPHY (Ph.D) IN APPLIED ENTOMOLOGY

APRIL, 1995

ACKNOWLEDGEMENTS

I am immensely grateful to my major supervisor,Professor K.N. Saxena, the Deputy Director General of the International Centre of Insect Physiology and Ecology (ICIPE), who from the outset and throughout the duration of this research showed keen interest and provided adequate guidance that have led to its successful completion. My thanks are also due to Dr A.M Nour, my second ICIPE supervisor, for the criticism of the manuscript and for providing the hybrids used for the various studies. I appreciate the assistance and encouragement provided by Dr W. Lwande, who was also a member of my supervisory committee.

I wish to express my sincere thanks to Dr B.A. Okwakpam, my University supervisor, for the invaluable advice and suggestions he gave on this thesis during his many trips to ICIPE and its Mbita Point Field Station (MPFS). I am also very grateful to him for the encouragement not to relent in my efforts at applying for a place in ARPPIS. I thank Dr Sagary Nokoe formerly of ICIPE for letting me know of and encouraging me to seek a position in ARPPIS.

My very sincere thanks go to the German Academic Exchange (DAAD) for generously providing the funds for this research.

I am also grateful for the research facilities provided by the ICIPE.

I am very grateful to Dr Adedapo Odulaja, Head of ICIPE's Biomathemathics Research Unit (BMRU), who despite his busy schedule always made himself available for statistical guidance and advice. My thanks are also due to Messrs. Christopher Olando and George Dome who also provided statistical assistance at MPFS.

My sincere thanks are also due to Dr K.V. Seshu Reddy, Scientist-in-Charge, MPFS, for the encouragement he gave as well as many facilities of the station. Dr S.O Ajala gave many suggestions and was morally supportive. I am grateful.

Mr Francis Onyango and Paul Odawa of the Insect and Animal Mass Rearing Unit were very supportive. Equally of tremendous assistance were Mr Peter Nyongesa and Mrs Helida Abade and Susan Kagondu. I am grateful.

I am full of appreciation for the field and laboratory assistance provided by Messrs. Pascal Agola, Romanus Odhiambo, James Marasa and Mrs Ruth Apiyo.

Finally, I would like to thank everyone who in one way or the other provided assistance. This work would not have been completed without the support of you all. I remain thankful.

DEDICATION

This thesis is dedicated to my wife Love and our two sons Alfred and Justice whose presence with me throughout the period of this research was inspiring.

DECLARATION

I, Timothy Tubokeyi Epidi, hereby declare that the research presented in this thesis for the award of the degree of Doctor of Philosophy (Applied Entomology) of the Rivers State University of Science and Technology, Port Harcourt, Nigeria, is my original work and has not been submitted for a degree in any other University.

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CERTIFICATION

We certify that this research work was carried out by Timothy Tubokeyi Epidi at the International Centre of Insect Physiology and Ecology (ICIPE) under our guidance and supervision.

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ABSTRACT

This work was undertaken to elucidate the mechanisms of resistance in some sorghum genotypes to the stem borer *Chilo partellus*. The information generated would be useful for developing and utilising resistance principles in the management of the stem borer on sorghum.

The sorghum genotypes studied were: five open pollinated (IS-1044, IS-18520 (Serena), IS-18363, Tx 623B, and 1441B) cultivars and three resistant hybrids (HYD-1, HYD-8, and HYD-9).

The aspects studied were :

1) Evaluation of the genotypes for different resistance characteristics
2) Evaluation for tolerance
3) Role of oviposition, larval orientation and development in behavioural non-preference and antibiosis mechanisms of resistance.

All selected resistant genotypes exhibited moderate to high level of resistance in the field trials except 1441B whose performance was as bad as the susceptible check IS 18363. HYD 1 and HYD 8 were comparable to the resistant (IS 1044) and tolerant (IS 18520) checks respectively. HYD 8 was found to be highly tolerant since despite sustaining high degree of damage, its yield reduction was low. Similarly, HYD 1 showed comparatively lower damage and exhibited low yield reduction suggesting antibiosis mechanism of resistance.

Tolerance of both HYD 8 and IS 18520 is probably related to increased root production as well as improved efficiency of both main and tiller roots at extracting nutrients from the soil. IS 18520 plants infested at the rate of 20 L1/plant had significantly higher root mass than control plants indicating an effort by the genotype to compensate for losses inflicted on it by *Chilo partellus*. HYD 9 and Tx 623B were moderately tolerant.

When reared on artificial diets incorporating the different genotypes, HYD 1 and IS 1044 slowed down larval development, and caused larval mortality. Although not as lethal as IS 1044, HYD 1 tremendously prolonged larval period and thus larvae raised on diet incorporating it had very low development indices. Further, significantly fewer eggs were laid by female moths reared on IS 1044 or HYD 1 incorporated diets. A similar result was obtained when larvae were reared on fresh leaves and stem pieces of these genotypes.

First instar *C. partellus* larvae demonstrated attraction toward test plants (single plants) of all genotypes as opposed to blank control. Attractancy of *C. partellus* to a group of IS 1044 plants was significantly lower than to a group of 1441B plants, indicating non-preference of larvae for IS 1044.

Larval arrest tests revealed that 4^{th} instar larvae dispersed from IS 1044, HYD 1, HYD 8 and HYD 9.

Ovipositional non-preference was not vividly demonstrated by female moths for any genotype when they were exposed to whole plant in ovipositional chamber. However, when plants were screened from the moths in an attempt to determine role of distance-perceivable stimuli in oviposition, significantly more eggs were laid in the environment of the susceptible check IS 18363. Female moths, therefore, appeared to respond more to volatiles from IS 18363 than volatiles from the other genotypes. The study on the role of contact-perceivable stimuli in oviposition showed that except IS 1044 on which comparatively fewer eggs were laid, all the other genotypes had adequate olfactory stimuli for female moths.

Non-preference for feeding as reflected in foliar damage was observed in IS 1044 and to some extent in HYD 1 presumably due to presence of some phytochemicals that acted as feeding inhibitors.

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CHAPTER ONE

1. INTRODUCTION

1.1 THE SORGHUM CROP AND ITS ECONOMIC IMPORTANCE

Sorghum (*Sorghum bicolor* (L.) Moench is the fifth most important cereal in the world and povides a major staple in the semi-arid tropics. It is the second most important cereal in Africa and is next in importance to rice and wheat in India (Anon., 1991). Sorghum is the most important cereal crop of millions of people in many parts of Africa especially the Eastern Africa region where it may be grown once or twice (long rainy season and/or short rainy season) a year. Of the total 47 million hectares of sorghum grown in the world, eastern Africa cultivates nearly 13% (Seshu Reddy and Omolo, 1985). Sorghum is a very hardy and dependable crop that grows well under adverse conditions. It has many uses. As a human food, it is ground into flour and made into porridges and bread. The grain is also used as feed for animals particularly in the Americas. The stalks provide fuel, shelter, sugar and syrup (Anon., 1991).

1.2 CONSTRAINTS TO PRODUCTION

Constraints to Sorghum production may be divided into: (i) Physical and (2) Biological Factors. Physical factors

such as soil and water present constraints to sorghum production, but their effects are minimal because sorghum very hardy, drought-tolerant and will grow well under a wi range of soil conditions (Purseglove, 1972).

On the other hand, the biological factors are many a include diseases and insect pests. Primarily, these facto exert tremendous pressure on the crop.

1.2.1 Sorghum Diseases

Important diseases which cause tremendous yield loss to Sorghum include anthracnose of the leaves, leaf blight, charcoal rot, milo disease, rust, sooty strip, downy mildev honeydew disease and smut caused by *Colletrichum graminicolum* (les.) G. W. Wils., *Helminthosporium turcicum* Pass., *Macrophomina phaseoli* (Manbl.) Ashby, *Periconia circinata* (Mangin) Sacc., *Puccinia purpurea* Cooke, *Ramulispora sorghi* (Ellis & Ev.) Olive & Lefebre, *Sclerospora sorghi* Weston & Uppal, *Sphacelia sorghi* McRae and *Sphacelotheca* spp. respectively (Purseglove, 1972).

1.2.2 Insect Pests

Sorghum also suffers heavy yield losses due to infestation by insect pests. The crop is attacked by nearly 150 insect species (Reddy & Davies 1979; Jotwani and Davies 1980). Amongst these are *Atherigona varia soccata* (Rond)

(Sorghum shoot fly), *Contarinia sorghicola* (Coq.) (Sorghum midge), *Heliothis armigera* (Hubn.) and *H. zea* (Boddie) (Bollworms), stored-products pests such as *Sitophilus oryzae* (L.) (rice weevil) and many stem borers (Purseglove, 1972). Seshu Reddy (1983) reported that 23 stem borer species infest sorghum (Table 1).

The stem borers include *Busseola fusca* Fuller, *Eldana saccharina* Walker, *Sesamia calamistis* Hmps and *Chilo partellus* Swinhoe (Dogget, 1970). *C. partellus* (Plate 1) is the most widespread and destructive sorghum pest in the Indian sub-continent and in East, Central and Southern Africa (Ingram, 1958; Young and Teetes, 1977; Van Hamburg, 1980).

1.3 **CONTROL METHODS**

Control measures against *C. partellus* include use of insecticides, biological control, cultural control and use of resistant cultivars. The practice of identifying and cultivating plants with insect resistant qualities is an ancient one that has been increasingly accepted in many modern crop pests management systems. This is because the use of resistant cultivars has been recognized to have many advantages. Notably, the farmer is released from worrying about technical aspects such as timing of application, dosage of a chemical or biological agent, and there is no

TABLE 1.

LEPIDOPTEROUS STEM-BORERS OF SORGHUM RECORDED IN THE WORLD
(Seshu Reddy, 1983)

1. *Acigona ignefusalis* Hampson
2. *Busseola fusca* Fuller
3. *Busseola segeta* Bowden
4. *Chilo agamemnon* Bleszynski
5. *Chilo diffusilineus* J. de Joannis
6. *Chilo infuscatellus* Snellen
7. *Chilo orichalcociliellus* Strand
8. *Chilo partellus* Swinhoe
9. *Diatraea grandiosella* Dyar
10. *Diatraea lineolata* Walker
11. *Diatraea saccharalis* F.
12. *Elasmopalpus lignosellus* Zell.
13. *Eldana saccharina* Walker
14. *Ematheudes* spp.
15. *Maliarpha separatella* Rag.
16. *Ostrinia nubilalis* Hbn.
17. *Proceras venosatus*
18. *Sesamia botanephaga* Tams & Bowden
19. *Sesamia cretica* Lederer
20. *Sesamia calamistis* Hampson
21. *Sesamia inferens* Walker
22. *Sesamia penniseti* Tams & Bowden
23. *Sesamia poephaga* Tams & Bowden

Plate 1. Female moth, pupa, 6th and 4th instars respectively of *C. partellus*.(x 7)

direct cost to growers (Dabrowski, 1984). Thus, the grower has the advantage of genetically incorporated insect control for the cost of seed alone (Smith, 1989). Therefore, since sorghum is grown mainly by the resource-poor farmers, host plant resistance offers a cheap and safe method of insect control that readily fits into an integrated pest management (IPM) programme and is well suited to tropical environmental conditions (Taneja & Leuschner, 1985).

The development and use of resistant cultivars is not without disadvantages including:

(1) It is time-consuming and may be an expensive exercise.

(2) Insect-resistant cultivars that rely on the effects of a single, major gene often promote the development of resistance-breaking biotypes.

1.4 **THE PROBLEM**

Various cultivars of sorghum differ in their level of susceptibility or resistance to *C partellus* (Jotwani et al 1978; Jotwani & Davies, 1980; Lal and Pant, 1980; Jotwani, 1981; Dabrowski & Kidiavai, 1983; Singh et al, 1983; Saxena, 1990). In view of the observation that many susceptible varieties are potentially capable of producing good yield while on the other hand many resistant varieties are poor in grain yield, choice of varieties becomes very crucial. A farmer would prefer a variety that is a good yielder and resistant to insect pests. Such varieties are

scarce. Moreover, since many crops are grown over broad goegraphical ranges, encompassing widely diverse soil types and environmental conditions, different resistant cultivars may be required for different geographic regions (Smith, 1989). Therefore, more resistant and high yielding varieties would need to be developed to suit different ecological conditions. However, development of cultivars of this sort would only be facilitated if the mechanisms governing the differences in resistance between various cultivars are elucidated (Saxena, 1989).

Some behavioural responses (eg ovipositional response) of *C. partellus* to some sorghum cultivars have been studied. However,the studies have tended to concentrate on one response or the other. Saxena (1990) indicated that an interaction of these responses, rather than any one of them in isolation, determines the resistance or susceptibility of a cultivar. He thus emphasized the need to compare all these responses for different cultivars.

This study aims at comparing the above responses for the selected genotypes, and thus adding to the currently limited sources of host plant (sorghum) resistance to *C. partellus* in East Africa (Gebrekidan 1982; Seshu Reddy 1983). Further, resistance factors that would be identified would facilitate the development of cultivars combining high borer resistance with other desirable characters.

1.5 **OBJECTIVES**

The objectives of this research are:

(A) To determine the mechanisms of *C. partellus* resistance in selected sorghum genotypes.

(B) To develop profiles of components of resistance in these genotypes.

(C) To study physical and chemical factors responsible for resistance.

1.6 **AREAS OF STUDY**

The study involved the following areas:

1 (a) Evaluation of the level of tolerance/resistance of the selected genotypes vis-a-viz standard checks in the field.

(b) Assessment of rootmass of the genotypes in relation to tolerance.

2. Ovipositional response of *C. partellus* to the selected genotypes

For ovipositional response, the following were investigated

(a) Influence of the selected genotypes on oviposition

(b) Role of distance-perceivable stimuli in oviposition

(c) Role of contact-perceivable stimuli in oviposition

3 Orientation determining settling and dispersal of larvae

(1) Larval attraction to the genotypes

(a) Single plant tests

(b) Attraction to a group of plants

(11) Larval arrest

(a) Larval arrest of 1^{st} instars

(b) Larval arrest of 4^{th} instars

4 Development of the insect from first instar stage :

(1) On artificial diet incorporating fresh leaves of the selected genotypes

(11) On fresh leaves and stem tissues

(111) On whole plant in the screenhouse

(1V) Influence of the different genotypes on fecundity

CHAPTER TWO

2 LITERATURE REVIEW

2.1 SORGHUM YIELD AND FACTORS AFFECTING PRODUCTION LEVEL

In the tropics, sorghum is one of the principal food crops and is also used as fodder, fuel and building material. Generally, yields are very poor, ranging from 500 to 800 kg/ha compared with 4,500-6,500 kg/ha in the USA (Alghali and Saxena, 1988; Purseglove, 1977). As already noted, many factors, primarily diseases and insect pests are responsible for this low productivity.

2.2 DAMAGE SYMPTOMS OF *C. PARTELLUS*

The initial symptom of *C.partellus* infestation on young plants is rows of oval perforations in leaves of the unfolding whorl. This damage is caused by the feeding of the larvae. As development continues, the larvae tunnel into the leaf midribs, damage the growing point (causing a condition known as "deadheart") or bore into the stem (Alejandro, 1987). If the growing point has already moved upward, only stem tunnelling takes place (Srivastava, 1988).

2.3 THE INSECT AND ITS BIOLOGY

The straw-coloured or yellowish brown moths, which are about 15mm long, deposit oval yellowish-white, scale-like eggs in overlapping rows, usually on the underside of leaves (Alejandro, 1987). The eggs are deposited in batches of 50 to 100 and depending on environmental conditions they hatch in 3 to 8 days. The young stemborers are small, spotted and yellowish. When fully grown, they are 20 to 25mm long and spotted, with colored stripes along the dorsal side of the body. Before developing into pupae, the larvae prepare an exit hole for the adult by leaving intact at the end of their tunnels only the thin exterior wall of the stem. Entire life cycle is completed in 30-40 days (Srivastava, 1988).

2.4 HOST PLANT RESISTANCE

Host plant resistance has been defined as the heritable capacity of the plant that enables it to avoid, tolerate or recover from injury by insect populations (Dabrowksi, 1984). Borer resistance has been shown to be a quantitatively inherited trait which is governed by additive and non-additive genes (Agarwal and Taneja, 1989).

The use of resistant cultivars as a method of crop protection has gained acceptance in tropical countries.

Host plant resistance is now considered to be one of the primary lines of defence against target arthropods in all pest management programmes (Smith, 1989) .

2.5 **RESISTANCE MECHANISMS**

Cultivars differ in their level of susceptibility or resistance to *C. partellus* (Jotwani et al,1978; Jotwani & Davies, 1980; Lal & Pant, 1980; Jotwani, 1981; Singh et al 1983; Dabrowski & Kidiavai, 1983). Plant resistance has been shown to be governed by three mechanisms which are currently widely recognised and originally proposed by Painter (1951). All the three mechanisms have been reported in sorghum (Strivasta, 1985).

2.5.1 **Preference/non-preference**

This was subsequently referred to as non-preference by Painter (1958) and as `antixenosis' by Kogan and Ortman (1978), for different plants for oviposition, food, shelter, etc. Non-preference refers to the form of resistance that collectively protects the plant from insect attack by inhibiting the insect from selecting a particular plant for food, shelter or oviposition. Since the plant acts as a poor host, the insect is faced with the task of looking for an alternative host plant.

2.5.1.1 Ovipositional non-preference

Ovipositional non-preference has been reported to occur in sorghum by several workers (Rana and Murty, 1971; Lal and Pant, 1980; Singh and Rana, 1984). Saxena (1987) attributed ovipositional non-preference by *C. partellus* for sorghum cultivars IS 1044 and IS 23175 to lack of adequate olfactory stimuli and presence of hairs respectively.

In maize, Ampofo (1985) reported that smooth areas of the plant (i.e the lower leaf surface and the midrib concavity were preferred for oviposition. Also, lower leaves of 3-4 weeks old plants were significantly preferred over the upper leaves for oviposition.

2.5.1.2 Non-preference for feeding

There have been a number of reports indicating that feeding responses of various insect species to resistant varieties of certain plant species are lower than those to susceptible ones. For example, Eigenbrode and Trumble (1994) attributed the resistance to fall army worm (Spodoptera exigua (Hubner)) in tomato cultivar LA 1320 to larval non-preference for fruits. Wiseman et al. (1981) found that the corn earworm (*Heliothis zea*) larvae fed significantly less on the resistant Zapolote Chico variety than on the susceptible Stowell's Evergreen variety. Similarly, larvae

of the corn borer *Ostrinia nubilalis* have been observed to feed less on resistant than susceptible cultivars.

Some plants have been reported to be rejected by insects because of the presence of repellents, feeding or oviposition deterrents. For example, a cyanohydrin glucoside, dhurin, in young sorghum plants inhibits feeding and, hence, causes its rejection by *Locusta migratoria* (Woodhead and Bernays, 1978). Plants could also be rejected by insects due to their reaction to initial damage by such insects (Robinson et al., 1978).

2.5.1.3 Orientational non-preference

Orientation of insects may determine the establishment of the insect in two ways (Saxena 1985):

a) An insect which is away from plants may avoid some because of their repellency or lack of attractancy, and arrive on other plants because of their attractancy or lack of repellency.
b) An insect like a larva emerging from an egg may already be on a plant and its orientation may involve: (1) continued stay on it because of its attractancy or lack of repellency, or (11) departure from the plant because of its repellency or lack of attractancy.

Considering the case of insects which are away from plants and select the latter, say, for egg-laying, differences in their attraction to susceptible and resistant

host plants have been observed on the basis of numbers or percentages of eggs laid on them. Everly et. al. (1979) observed that some susceptible genotypes of maize, viz WF9 and L319 elicit increased egg-laying and concluded that they attracted the females of the European corn borer *O. nubilalis* more than various resistant cultivars such as inbred A and W23.

In the case of insects which may already be on the plant (eg larvae emerging from eggs), there have been reports of greater departures of larvae from resistant varieties than from susceptible varieties of host plant species. For example, Robinson et al.(1978) reported greater departures of corn borer larvae (*O. nubilalis*) from resistant maize genotypes CI31A and OH43 than from susceptible WF9 and R101. Factors which may cause greater departures of insects from resistant cultivars than from susceptible ones include production of olfactory repellents or possession of some morphological features by the plant (Smith, 1989).

2.5.2 **Antibiosis**

Antibiosis refers to the plants ability to disrupt the normal functions of insect life. This disruption is usually manifested in the form of reduced fecundity, reduced sizes of both adult and/or immature stages, or death. Antibiosis has been confirmed in many plant species, and has been

attributed to the presence of chemicals which occur in higher concentrations in resistant than in susceptible varieties of different crops. Examples of such chemicals include DIMBOA in maize plants resistant to the European corn borer *O. nubilalis* larvae (Klun et al.,1967); gossypol in the glanded cotton varieties resistant to the corn earworm *H zea* and the tobacco budworm *Heliothis virescens* (Lukefahr and Martin, 1966); maysin in the silks of certain maize varieties, eg Zapalote Chico resistant to the larvae of corn earworm *H. zea* (Waiss et al.,1979); and saponins in alfafa varieties resistant to a number of insect pests (Horber et al.,1974).

Antibiosis has been reported against *C. partellus* on maize (Sekhon and Sajjan, 1987), and on Sorghum (Saxena, 1992). Sorghum cultivar IS 1044 was found highly resistant since it manifested:

(a) lowest levels of all three behavioural responses (i.e oviposition, orientation and/or feeding) reflecting high non-preference, and
(b) poorest larval development, reflecting antibiosis.

On the other hand, cultivar IS 18363 was most susceptible due to high levels of the behavioural responses and faster development of larvae to the adult stage.

2.5.3 **Tolerance**

The tolerance component of resistance involves the plant more than the the insect in the insect-plant

interaction. Painter (1968) considered it to be present when the plant is able to produce well despite an insect population equal to that which damages a susceptible host. Tolerance, therefore, describes the inherent genetic qualities of a plant which afford it the ability to withstand or recover from insect damage (Smith, 1989). The recovery involves repair or regeneration of damaged tissues.

Amongst the sorghum cultivars screened at Mbita Point Field Station of the International Centre of Insect Physiology and Ecology (ICIPE), Dabrowski and Kidiavai (1983) found IS 18520 and IS 2205 tolerant under Western Kenya conditions.

Tolerance has been observed in maize to the western corn rootworm *Diabrotica virgifera virgifera* LeConte and was attributed to the greatly increased root volume of tolerant cultivars compared to susceptible ones (Zuber et al. 1971).

2.6 **FACTORS DETERMINING THE VARIOUS MECHANISMS**

A knowledge of the factors responsible for the differences between resistant and susceptible cultivars i.e. the modes of operation of the above mechanisms would facilitate the development of borer resistant and high yielding cultivars (Saxena, 1990).

Saxena (1969, 1985) arranged these factors into two broad categories:

(A) the insects colonising responses, leading to the establishment of its population on the plant, and

(B) the plant characters which determine these responses.

The colonising responses were distinguished by Saxena (1985) into the following main categories:

1. orientation of the insect determining its arrival/arrest on, or avoidance of a plant,
2. feeding
3. utilisation of ingested food determining the insects nutrition
4. development of the larvae
5. egg-production (fecundity) in the adult, and,
6. oviposition.

He concluded that the lower the insect's response in each of these categories to a cultivar, the greater the plants resistance.

The plant characters identified by Saxena (1985) that determine these responses include:

1. Sensory stimuli perceivable either at a distance, or by contact (including physical features)
2. chemical constituents of the ingested plant material which promote or hamper normal metabolic processes in the insect.

Saxena (1990) argued that an interaction of different factors rather than individual factors in isolation determines a cultivar's resistance or susceptibility to a pest. In their study of ovipositional response of

C. partellus to some sorghum cultivars, Lal& Pant (1980), Dabrowski and Kidiavai (1983) and Singh and Rana (1984) did not look at the effect of other behavioural responses. Similarly, Roome (1980), Bernays et al (1983) and Chapman et al (1983) provided some information on orientation of early larval instars of *C. partellus* without providing information on oviposition or feeding responses.

Stressing the importance of insect behaviour in plant resistance studies, Chapman and Woodhead (1985) said that this area had been almost totally neglected by entomologists and plant breeders alike in developing resistant crop varieties.

Saxena (1985) observed that many of the responses of insects to plants are behavioural. The first step is orientation of the insect, involving avoidance of or arrival on a plant. In case of avoidance, the process of the insect's establishment on the plant is interrupted and subsequent responses would not follow. If the insect arrives on a plant whether by chance or as a result of orientation, it either feeds or oviposits. The feeding response would follow if the arriving insect is in a stage which needs food from the plants. But, if the arriving insect visits a plant for laying eggs and not for feeding, viz. adult female lepidopterans or dipterans, the oviposition response would follow. The larvae emerging from the eggs would also show orientation response resulting in their departure from the

plant or their arrival and stay at an appropriate site where their feeding response may follow. The intensity of their feeding response would determine their food intake. The ingested food would then undergo metabolism and determine the insect's nutrition. The food intake and its nutritive value would both determine the insect's development, if in larval stage, or survival and egg production, if in adult stage. Thereafter, the sequences of responses would be repeated, beginning with orientation. Orientation, feeding and oviposition responses by the insect would be involved in the 'non-preference' type of mechanism of resistance in a plant having characters which fail to elicit these responses or inhibit them. The metabolic responses of insects would be involved in the 'antibiosis' type of mechanism of resistance in a plant providing inadequate nutrients or metabolic inhibitors and thus causing poor larval development, reduced survival and egg production in the adult stage.

In his review of insect behaviour and host plant resistance, Baliddawa (1985) highlighted different factors that affect insect behaviour through olfactory, physical and visual stimuli. These factors are insect repellents, plant surface texture, shape and colour.

Other considerations involved in studying plant resistance include physical and chemical plant factors. Chemical plant factors have been associated with stem borer resistance. These include low sugar content (Swarup &

Changale, 1962) amino acids, total sugars, tannins, total phenols, neutral detergent fiber (NDF), acid detergent fiber (ADF), lignins (Khurana & Verma, 1982, 1983), and high silica content (Narwal, 1973). Other chemicals are produced only when the tissues are damaged and by oxidation of precursors exposed to the air. In sorghum, hydocyanic acid (HCN) is produced by hydrolysis of glucoside, dhurrin, and phenolic acids are derived from phenolic esters (Chapman & Woodhead 1985).

Regarding physical factors, the antennae, tarsi and ovipositor of *C. partellus* are well endowed with mechano-receptor hairs (Chadha & Roome, 1980) and the insect is able to make decisions based on these. Bernays et al (1983) found that bloom of wax on the culm of sorghum can interfere with larval movement up the culm. Also, small anatomical features such as hairs in the leaf axil, which collect debris also hinder larvae returning to the culm from an excursion on to a leaf blade, and therefore reduce the success of the larvae in reaching the whorl. Similarly, Woodhead & Taneja (1987) showed that erect leaves and curled leaf bases were involved in larval establishment. Edge spines were also implicated by Bernays et al (1985).

CHAPTER 3

MATERIALS AND METHODS

3.0 GENERAL MATERIALS

The studies were conducted at the Mbita Point Field Station of the International Centre of Insect Physiology and Ecology (ICIPE) located on the shores of Lake Victoria in Western Kenya (1,170 m above sea level (0° 25-30'S, 34° 10 - 15'E). The insects used in the studies were obtained from the station's culture of *C. partellus* maintained on artificial diet incorporating dry maize leaf powder (Ochieng et al, 1985). Instars were determined using head capsule size (Ampofo, 1988). The sorghum genotypes tested included three resistant hybrids (HYD-1, HYD-8, & HYD-9) and five open-pollinated varieties (IS-1044, IS-18520 (Serena), IS-18363, Tx 623B and 1441B). HYD-1, HYD-8 and HYD-9 were developed at ICIPE and identified as having high yield potential and an improved level of stemborer resistance (Nour and Saxena,1991; Nour and Saxena,1993). IS-1044 is resistant while IS-18363 is susceptible (Saxena,1992). Both cultivars as well as 1441B (resistant) were obtained from the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). Tx 623B was obtained from Texas A & M

University, and is also resistant. IS-18520 is tolerant (Dabrowski and Kidiavai, 1983) and is the recommended variety in East Africa. Three of the above genotypes viz IS-1044, IS-18363, and IS-18520 served as standard checks in the various studies (Table 2).

The studies were conducted in the field, screenhouse or laboratory as specified.

3.1 **TOLERANCE/RESISTANCE**

3.1.1 EVALUATION OF THE GENOTYPES FOR TOLERANCE/RESISTANCE

For many field crops, data on yield and damage parameters from genotypes under test compared with those from standard checks subjected to the same treatment under the same environmental conditions would give an indication of tolerance/resistance or susceptibilty .

Evaluation of the level of tolerance/resistance of the selected genotypes vis-a-viz standard checks IS-18363, IS-18520 and IS-1044 was carried out in the field. All eight genotypes were planted (Plate 2) in the field during the long and short rainy seasons of 1993 at a spacing of 60cm x 30cm (60 cm between rows and 30 cm within rows). Plot size was 5m x 3m, giving a population of 72 plants per plot. Nitrogen Fertilizer was applied at the rate of 60 kg N/ha at 2 weeks after emergence (WAE). Plots were handweeded and irrigated using an overhead sprinkler, when necessary. At 3

TABLE 2

GENOTYPES EMPLOYED IN THE STUDY

GENOTYPE	RESISTANCE RATING
IS 18363	Susceptible (Check)
IS 18520	Tolerant (Check)
IS 1044	Resistant Check)
HYD 1	Under test
HYD 8	Under test
HYD 9	Under test
Tx 623B	Under test
1441B	Under test

Plate 2. A field of sorghum for evaluation of the genotypes for tolerance/resistance (long rains, 1993).

WAE each genotype was subjected to three C. partellus infestation levels viz 0, 15 and 30 1st–instars per plant (L1/plant), the larvae being introduced into the central whorl of the plants with the help of a camel hair brush. The experiment was replicated 3 times and arranged in a randomized complete block design (RCBD). The following data were collected: plant height, percent height reduction, foliar damage (scale 1-9 ;Guthrie et al., 1960), stem tunnelling, percent stem tunnelling, yield, percent yield reduction, and the length and girth diameter of the third internode from plant base(for possible use as a measure of tolerance). Data were subjected to ANOVA and correlation analyses.

3.1.2 ASSESSMENT OF ROOTMASS OF FIVE OF THE GENOTYPES FOR INDICATION OF TOLERANCE.

Plants tolerant to insect attack withstand damage or repair it by compensating for the loss (Pathak, 1990). A possible way of compensating for damage could be increased intake of nutrients from the soil through increased rootmass (Zuber et al., 1971).

Genotypes IS-18520, IS-1044, HYD 1, HYD 8 and HYD 9 were planted in pots (25 cm diameter and 24 cm deep) in the screen house and arranged in a completely randomized design (CRD) (Plate 3). For each genotype, two sets of plants were subjected to two 1st-instar *C. partellus* infestation levels

Plate 3. A portion of the screen house showing plants to be assessed for indication of tolerance using rootmass.

(0 and 20 L1/plant) at 3 WAE. Four weeks later, pots were upturned and all the roots in the rhizosphere were collected, washed and the dry weights determined. For the two treatments, there were 3 replicates of ten plants each. Data were subjected to ANOVA.

3.2 **OVIPOSITIONAL RESPONSE**

Successfully laying eggs on the host plant is the first step toward eventual colonisation of the host. Different genotypes may have different attributes that promote or retard oviposition.

3.2.1 INFLUENCE OF THE SELECTED GENOTYPES ON OVIPOSITION

Tests were conducted in the field with a constant number of females in a standardized physiological state in a 3-compartment chamber (Saxena, 1987) (Figure 1) to avoid differences in numbers of eggs laid on different genotypes due to non - plant factors such as female population, fecundity, physiological state, etc. in the test arena. The test chamber (210 x 80 x 80cm) was marked off into 3 equal compartments. Excepting its floor which formed the test arena, the entire chamber was covered by nylon-mesh (6 meshes/cm) of approximately the same size. The chamber was aligned with its long axis at right angles to the wind direction. Three test plants, 3 weeks old, were arranged

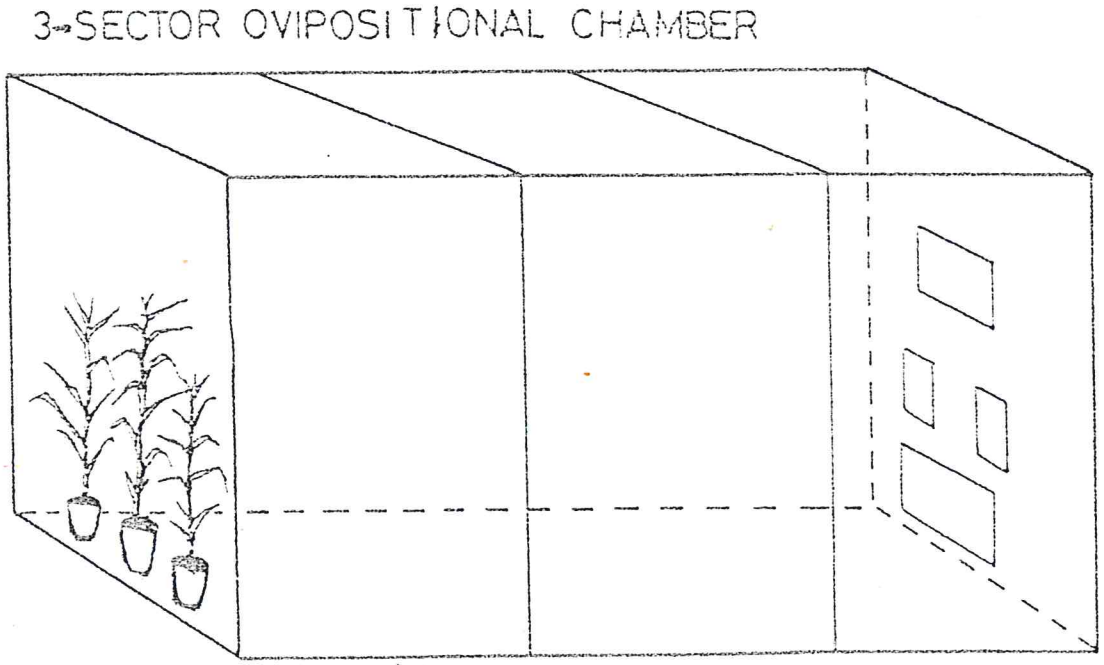


Fig 1. 3-Sector Ovipositional Chamber used to study ovipositional response of *C. partellus* to the genotypes in the field.

inside one end-compartment in a row along the end wall. The opposite end compartment had in place of plants wax paper sheets (15 x 15cm each) stuck to its end wall to serve as the "blank" non-plant, ovipositional substrate (Kumar & Saxena, 1985). Six females, mated on the night of emergence, were released in the central compartment during the following night. The next morning, the eggs laid on the plants and on the wax paper sheets were counted. The difference between the number of eggs laid on the plants and on wax paper would reflect the suitability of the cultivars for oviposition by the insect. The experiment was replicated 5 times and data were subjected to ANOVA and T - test.

3.2.2 ROLE OF DISTANCE-PERCEIVABLE STIMULI IN OVIPOSITION

This study was done as outlined in 3.2.1 except that 4 test plants were arranged outside the nylon-mesh end compartment to prevent any physical contact of the insects with the plants.

3.2.3 ROLE OF CONTACT-PERCEIVABLE STIMULI IN OVIPOSITION

For this study, a circular chamber (Plate 4) consisting of a wire-net base `b'(11.5cm diameter ; 3.5cm height) supporting a removable wire-net cover `c' (11.5cm diameter

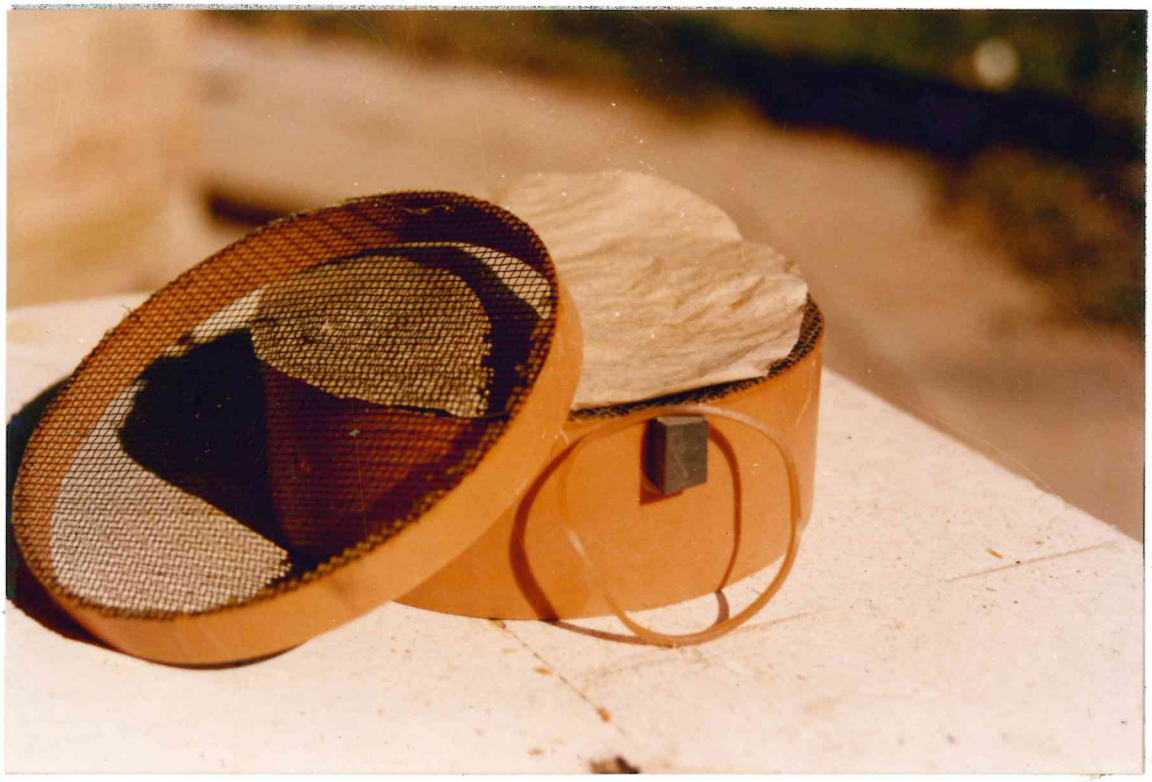


Plate 4. Circular-contact chamber used for the study of role of contact-perceivable stimuli in oviposition.

; 1.5cm height) was used (Saxena,1987). A leaf of the test plant was stretched across the chamber (Plate 5) between the base and the cover occupying one half of the circular arena while the other half of the arena was occupied by wax paper, a non plant ovipositional substrate. An ovipositing female was released at dusk within the chamber and given a wet cotton swab to meet its water requirement. The insect could move around but remained in contact with the test material or wax paper. The number of eggs laid on the test material and wax paper during the night was counted and recorded. The experiment was replicated 8 times and data subjected to Anova and T-test.

3.3 **LARVAL ORIENTATIONAL RESPONSE**

Larvae emerging from eggs laid on non-host plants and those emerging from host plants that are unsuitable for their development as well as older instars that crawl out of aging plants are faced with the task of looking for an alternative host plant. Their success or failure would depend on the attractancy of available host plants and their ability to arrest arriving larvae. Therefore, the response of ***C. partellus*** larvae to different genotypes was compared in terms of`attraction' and `arrest'.

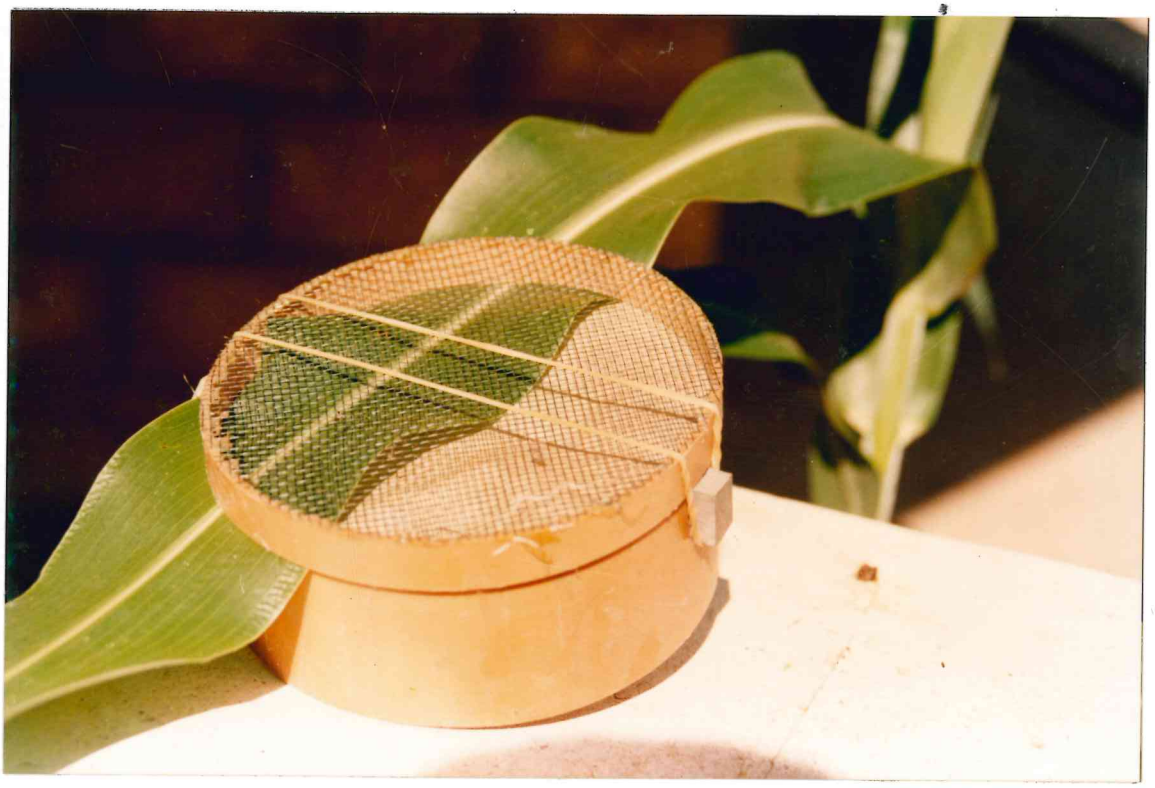


Plate 5. Circular-contact chamber showing a portion of a leaf of a plant stretched across its floor for studying role of contact perceivable stimuli in oviposition.

3.3.1 ATTRACTION OF 1st-INSTAR LARVAE

3.3.1.1 Attraction to single plants of the target genotypes.

This study involved the use of a two-piece rectangular board marked into 4 circles of 10, 20, 30, and 40 cm diameter (Figure 2; Plate 6). A potted plant was partially buried in the soil such that only the leaves and the stem were exposed. The two pieces of the rectangular board were brought together such that the test plant occupied the centre of the board. Ten 1st-instars of *C. partellus* were released from 10, 20, 30, and 40cm distance from the plant in four directions (North, South, East and West. All the genotypes including a blank (no plant) were tested. The number of larvae reaching the centre of the board in 15 minutes was recorded. The experiment was replicated 4 times and subjected to ANOVA and T-test.

3.3.1.2 Attraction to groups of plants of the target genotypes.

For this experiment, plants of each genotype were grown in a plot (3.0 x 2.5m) in 5 rows parallel to the wind direction. The spacings between the plants were 60cm between rows and 30cm within rows. The plots of the genotypes were arranged side by side in a row at right angles to the direction of the wind. A rectangular tray

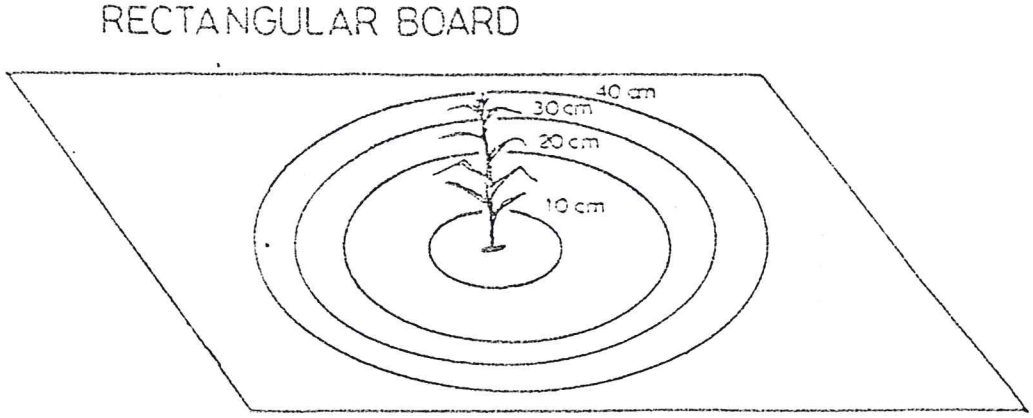


Fig 2 2-piece rectangular board used to study larval attraction (single plant test).

Plate 6. A rectangular board with a plant ready for the test on larval attraction (simgle plant test).

(Plate 7) (40cm long x 25cm wide) aligned with filter paper with the two longer sides continuing upward as 10 cm high vertical wall was placed 20cm from the downwind end of each plot with its long axis parallel to and in line with the central row of plants (Plate 8). Distance perceivable stimuli from the plants, e.g. visual, hygro and olfactory, would thus reach the tray. Twenty 1st-instar larvae were released in the middle of the tray in the morning (08.00 am - 10.00 am). The number of larvae that moved to the two ends of the tray in 30 minutes was recorded. The percentage which would reach the end nearest the plants would thus reflect larval attraction to the plants. Tests with each genotype were repeated 4 times. Each replicate of all the genotypes was run on the same day and the order of testing was randomized.

3.3.2 LARVAL ARREST

3.3.2.1 Arrest of 1st instar larvae.

For this study, each test plant was infested with 20 neonate 1st-instar larvae on the outermost leaf (Plate 9) of the whorl at 3 weeks after emergence (WAE). The experiment was replicated 5 times with 10 plants per replicate of each genotype. The infested plants were dissected after 72 hours.

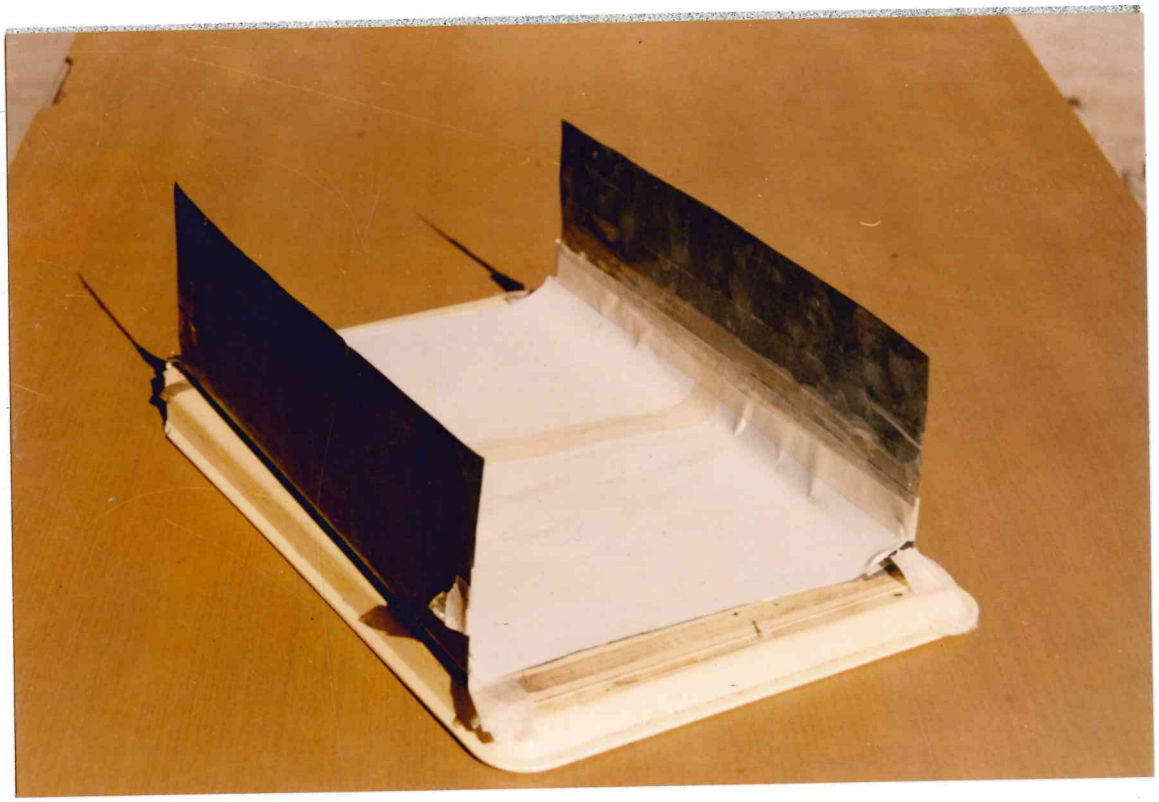


Plate 7. A rectangular tray used for the study on larval attraction to a group of plants.

Plate 8. A rectangular tray set for larval attraction to a group of plants.

Plate 9. Introduction of 1st or 4th instar *C. partellus* on extra whorl leaf for the studies on larval arrest.

The percentages of the larvae recovered from the plants were determined and taken to reflect arrest.

3.3.2.2 Arrest of 4th instar larvae.

This study was done as above except that 4th instar larvae were used and plants were infested at 6 WAE. Plants were dissected after 24 hours and tests were repeated 5 times and the percentages of the larvae recovered were taken to reflect arrest.

3.4 **LARVAL DEVELOPMENT**

3.4.1 LARVAL DEVELOPMENT ON FRESH LEAVES AND STEM PIECES.

Ten neonate 1st-instar larvae were given a 7 -cm leaf whorl segment in 8 x 2 cm glass vial (Plate 10). The larvae were examined and the whorl segment was replenished on alternate days. When the larvae reached the late 3rd-instar, they were given a 7-cm stem segment. The percentage of the larvae that developed on each genotype to the pupal and adult stages and the period of development as well as the number of instars found was recorded. The percentages of larvae in various instars and the growth index (percentage of larvae developing divided by mean development period) when compared with the tolerant check , Serena , would

Plate 10. A set of vials each containing a portion of a fresh stem and a larva for studying larval development.

reflect the suitability of the genotypes tested for larval development. Data collected were subjected to ANOVA.

3.4.2 LARVAL DEVELOPMENT ON LIVE PLANTS IN THE SCREEN HOUSE

Genotypes IS-18520, IS-1044, HYD 1, HYD 8, and HYD 9 were planted in pots (25 cm dia. and 24 cm deep) at a spacing of approximately 1 m x 1 m and arranged in a completely randomized design (CRD). Plants were each infested with 20 1^{st}-instar *C. partellus* at 3 WAE. Twenty four days later, the plants were dissected and the number of various instars found was recorded. The percentages of larvae in various instars and the growth index when compared with the tolerant check, serena, would reflect the suitability of the genotypes tested for larval development. Data collected were subjected to ANOVA.

3.4.3 LARVAL DEVELOPMENT ON ARTIFICIAL DIET.

Ten different diets were prepared using the method of Ochieng et al.(1985) excluding maize leaf powder. Each diet had a total weight of 750 g in which the ratio of constituents was maintained as in Ochieng et al (1985)(Table 3). There were two control diets, one having cellulose (27.8 g) and the other IS-18520 (Serena) dry leaf powder (27.8 g) in place of maize leaf powder. The Serena dry leaf powder

TABLE 3.

COMPOSITION OF ARTIFICIAL DIET USED FOR REARING *C. PARTELLUS*

(750 g diet)

	1	2	3	4	5	6	7	8	9	10
FRACTION A										
Distilled water (for blending) (ml)	347.22	347.22	224.84	209.97	223.47	204.57	164.55	182.09	223.47	186.66
Benlate (g)	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69
Celluse (g)	-	27.78	-	-	-	-	-	-	-	-
Formaldehyde (40%) (ml)	1.395	1.395	1.395	1.395	1.395	1.395	1.395	1.395	1.395	1.395
Vitamin E (g)	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72
FRACTION B										
Bean powder (g)	76.125	76.125	76.125	76.125	76.125	76.125	76.125	76.125	76.125	76.125
Brewer's yeast (g)	5.55	5.55	5.55	5.55	5.55	5.55	5.55	5.55	5.55	5.55
Sorbic acid (g)	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69
Ascorbic acid (g)	1.83	1.83	1.83	1.83	1.83	1.83	1.83	1.83	1.83	1.83
Methl-p-hydroxy benzoate (g)	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11
FRACTION C										
Distilled water (ml) (for agar)	277.80	277.80	277.80	277.80	277.80	277.80	277.80	277.80	277.8	277.8
Agar	8.475	8.475	8.475	8.475	8.475	8.475	8.475	8.475	8.475	8.475
FRACTION D										
Fresh leaf blend (g) (of genotypes)	-	-	150.165	165.03	151.53	170.43	210.45	192.915	151.53	188.34
IS 18520 (g) (dry leaf powder)	27.78	-	-	-	-	-	-	-	-	-

1 = artificial diet (Ochieng et al., 1985) except that maize leaf powder was replaced by IS 18520 dry leaf powder and Ingredients were formulated for 750g diet.

2 = diet devoid of sorghum

3 - 10 = diets with fresh leaf blend of IS 18520, IS 18363, IS 1044, HYD 1, HYD 9, HYD 8, Tx 623B and 1441B respectively.

was prepared by drying freshly excised whorl leaves of 3 weeks old plants in an oven at 60^{o} C for 5 days , and then pulverising them in a grinding meal. The other eight diets contained well-ground fresh leaf paste of the whorl leaves of 3 weeks old plants of the different genotypes including IS-18520. The water content and dry weight per unit fresh weight of the genotypes was determined and adjusted for in the amount of distilled water for blending to ensure that all diets contained the same quantity of water (625 ml) and actual plant material (27.8 g). Other constituents of the diets were made up of mixture A: benlate (0.69 g), 40 % formaldehyde (1.395 ml), vitamin E (0.72 g), rosccoco bean (*Phaseolus vulgaris*) powder (76.13 g), brewer's yeast (5.55 g), sorbic acid (0.69 g),ascorbic acid (1.83 g) and methyl-p-hydroxy benzoate (1.11 ml). Mixture B contained agar (8.475 g) boiled in 277.8 ml distilled water but cooled to 60 o C, and the plant material or cellulose was progressively added to mixture A as the blending process continued. About 18 g of each diet was dispensed into 8 X 2 cm diameter sterilized glass vials (Plate 11) and the whole lot was covered with a sterilized piece of cloth and left to cool till the following morning. A 1st-instar *C. partellus* was then introduced into each vial following which the vial was covered with a piece of sterile cotton wool to prevent contamination of diet and escape of larvae. Each vial was examined daily until the larva died or became adult. Data were collected on percent larval mortality, percent

Plate 11. A set of vials each containing artificial diet and a larva for the study on larval development.

pupation, days to pupation, days to adult emergence and number of eggs laid (fecundity) by mated emerging females. Each diet consisted of 3 or 4 replications of ten vials each arranged in a completely randomized design (CRD). Data were subjected to Anova using the GLM procedure of SAS package.

CHAPTER FOUR

4.0 RESULTS

4.1 EVALUATION OF TOLERANCE AND/OR RESISTANCE OF THE GENOTYPES TO THE STEM BORER IN THE FIELD AT THREE INFESTATION LEVELS (LR & SR, 1993)

4.1.1 STEM TUNNELLING

Long Rains

Results are presented in Table 4 and Appendices 1 and 2

Cummulative Tunneling

The uninfested control plants of the various genotypes did not differ in mean cumulative tunnelling. However, at infestation rate of 15 L1/plant, cummulative tunneling was highest in HYD 9 but was not significantly different from the values obtained for IS 18363, HYD 1, HYD 8 and IS 18520. The least cumulative tunneling was obtained on Tx 623B and 1441B but the values were not different from those recorded for IS 1044, IS 18520 and IS 18363.

At 30 L1/plant, cummulative tunneling remained highest in HYD 9 (53.9 cm) but this amount of tunneling was not statistically different from that in IS 18363, IS 1044, HYD 8, and Tx 623B. IS 18520 and 1441B had significantly lower cummulative tunneling than HYD 9.

TABLE 4

EFFECT OF LARVAL DENSITY ON DAMAGE PARAMETERS LEVELS, TILLERING AND YIELD (LONG RAINS, 1993)

TREATMENT	GENOTYPE	CUMULATIVE TUNNELING[1]	% TUNNELING[2]	% FOLIAR DAMAGE[3]
	IS 18363	23.6 ± 3.3 A	11.6 ± 1.0 A	0.0 ± 0.0 A
	IS 18520	21.1 ± 5.6 A	13.1 ± 3.6 A	1.0 ± 1.0 A
	IS 1044	15.2 ± 3.7 A	6.6 ± 1.6 A	0.0 ± 0.0 A
0L1	HYD 1	21.5 ± 2.8 A	7.9 ± 1.0 A	1.0 ± 1.0 A
	HYD 8	15.0 ± 2.1 A	5.8 ± 0.8 A	0.5 ± 0.5 A
	HYD 9	25.8 ± 5.3 A	9.8 ± 1.8 A	0.0 ± 0.0 A
	Tx 623B	13.0 ± 3.2 A	9.9 ± 2.6 A	0.0 ± 0.0 A
	1441B	15.9 ± 4.7 A	11.5 ± 3.1 A	0.0 ± 0.0 A
	IS 18363	36.8 ± 10.3 ABC	27.7 ± 8.3 A	40.9 ± 9.5 A
	IS 18520	26.7 ± 5.4 BC	19.7 ± 3.4 A	20.5 ± 2.9 A
	IS 1044	29.7 ± 2.5 BC	15.1 ± 0.7 A	13.3 ± 5.4 A
15L1	HYD 1	42.2 ± 1.2 AB	17.4 ± 0.9 A	21.4 ± 3.3 A
	HYD 8	46.3 ± 0.9 AB	23.1 ± 0.6 A	32.4 ± 3.4 A
	HYD 9	51.1 ± 6.6 A	25.0 ± 6.6 A	28.6 ± 10.0 A
	Tx 623B	18.1 ± 4.1 C	17.7 ± 4.1 A	30.0 ± 4.6 A
	1441B	16.7 ± 1.8 C	20.2 ± 3.1 A	24.8 ± 5.9 A
	IS 18363	40.2 ± 10.8 AB	30.4 ± 10.2 A	44.3 ± 4.1 A
	IS 18520	20.6 ± 2.7 B	15.5 ± 2.6 A	17.6 ± 4.2 A
	IS 1044	35.7 ± 10.0 AB	19.3 ± 6.4 A	27.1 ± 8.4 A
30L1	HYD 1	34.1 ± 4.2 AB	14.1 ± 1.1 A	18.6 ± 7.1 A
	HYD 8	50.2 ± 8.0 AB	23.1 ± 3.4 A	31.9 ± 2.9 A
	HYD 9	53.9 ± 1.3 A	25.9 ± 2.4 A	25.7 ± 3.8 A
	Tx 623B	28.6 ± 1.4 AB	26.5 ± 0.7 A	32.8 ± 11.7 A
	1441B	18.7 ± 2.1 B	21.9 ± 3.7 A	34.3 ± 0.8 A

TREATMENT	GENOTYPE	MEAN NO. OF HOLES[4]	NO. OF PRODUCTIVE TILLERS[5]	% HEIGHT REDUCTION[6]	YIELD (ton/ha.)[7]	% YIELD REDUCTION[8]
	IS 18363	6.4 ± 1.4 A	1.0 ± 1.0 B		1.7 ± 0.1 C	
	IS 18520	4.7 ± 1.5 A	11.3 ± 2.0 A		3.8 ± 0.1 A	
	IS 1044	3.6 ± 0.7 A	5.0 ± 1.5 AB		3.7 ± 0.2 A	
0L1	HYD 1	5.0 ± 0.8 A	5.7 ± 1.9 AB		3.8 ± 0.3 A	
	HYD 8	2.8 ± 0.4 A	10.7 ± 2.8 A		3.1 ± 0.1 B	
	HYD 9	6.4 ± 2.4 A	10.3 ± 2.0 A		3.8 ± 0.4 A	
	Tx 623B	3.7 ± 1.6 A	0.3 ± 0.3 B		4.1 ± 0.1 A	
	1441B	3.0 ± 1.0 A	3.7 ± 2.0 AB		1.8 ± 0.1 C	
	IS 18363	9.9 ± 2.4 B	0.0 ± 0.0 C	51.0 ± 8.9 AB	0.6 ± 0.0 C	61.2 ± 1.7 A
	IS 18520	8.0 ± 0.9 B	9.0 ± 0.6 A	20.4 ± 8.5 BC	2.8 ± 0.2 AB	25.5 ± 5.7 BC
	IS 1044	7.3 ± 0.6 B	2.7 ± 1.8 ABC	17.2 ± 3.8 BC	3.3 ± 0.2 A	12.4 ± 5.4 C
15L1	HYD 1	11.9 ± 1.3 B	2.7 ± 0.3 ABC	12.7 ± 2.7 C	3.5 ± 0.1 A	6.5 ± 1.7 C
	HYD 8	13.9 ± 1.3 B	6.7 ± 2.6 AB	30.0 ± 4.2 ABC	2.4 ± 0.2 B	20.8 ± 6.1 BC
	HYD 9	20.2 ± 2.5 A	8.3 ± 2.0 A	23.4 ± 16.0 BC	2.9 ± 0.3 AB	23.3 ± 6.8 BC
	Tx 623B	9.3 ± 1.7 B	0.7 ± 0.7 C	29.0 ± 4.8 ABC	2.5 ± 0.2 B	40.3 ± 5.6 AB
	1441B	6.8 ± 1.2 B	1.3 ± 0.9 BC	62.5 ± 9.4 A	1.1 ± 0.1 C	41.4 ± 6.6 AB
	IS 18363	10.7 ± 2.8 B	0.0 ± 0.0 C	44.5 ± 15.4 A	0.1 ± 0.0 C	93.1 ± 1.9 A
	IS 18520	6.5 ± 0.7 B	11.0 ± 1.1 A	19.9 ± 6.1 A	2.5 ± 0.3 A	35.3 ± 7.2 CD
	IS 1044	10.3 ± 2.8 B	4.7 ± 1.9 B	20.1 ± 7.3 A	2.7 ± 0.1 A	26.6 ± 1.6 CD
30L1	HYD 1	11.1 ± 1.1 B	8.3 ± 1.8 A	14.2 ± 4.7 A	2.9 ± 0.3 A	23.7 ± 8.6 CD
	HYD 8	15.8 ± 3.4 AB	9.3 ± 0.9 A	19.9 ± 2.9 A	2.5 ± 0.3 A	19.8 ± 8.5 D
	HYD 9	23.3 ± 3.0 A	9.0 ± 0.6 A	24.7 ± 8.9 A	2.7 ± 0.2 A	29.1 ± 5.1 CD
	Tx 623B	10.3 ± 0.9 B	0.0 ± 0.0 C	25.0 ± 7.7 A	1.4 ± 0.1 B	65.3 ± 1.7 B
	1441B	7.6 ± 1.3 B	0.7 ± 0.3 C	57.6 ± 9.2 A	0.9 ± 0.0 B	49.1 ± 1.4 BC

1, 7- untransformed data;
4- square root (x)

2, 3, 6, 8- Arcsine-square root transformed data;
5- square root (x + 0.5)

Figures are composed of means ± standard error. Means followed by the same letter within a column for each treatment are not significantly different ($P \leq 0.05$; SNK) on original or transformed data as indicated.

Percent Tunneling

At all three infestation levels, mean percent tunneling was not significantly different for all genotypes.

Short Rains

Results are presented in Table 5, Figures 3 and 4 and Appendices 3 and 4.

Cummulative Tunneling

With respect to the uninfested control, cumulative tunnelling was of the same degree in almost all the genotypes. However, IS 18520 showed significantly more cumulative tunnelling than IS 1044, HYD 1, HYD 8, and Tx 623B. All the other genotypes were not different from IS 18520.

When plants were infested at the rate of 15 l1/plant, IS 18363, the susceptible check showed significantly more cumulative tunnelling than the other genotypes. IS 18520 was next to IS 18363 in terms of cumulative tunnelling but did not differ from the three hybrids. Tx 632B did not differ from the hybrids but had significantly less cumulative tunnelling than IS 18520.

At 30 L1/plant, IS 18363 still had the highest degree of cumulative tunnelling and it was again followed by IS 18520 which did not differ from HYD 1. HYD 8, HYD 9, Tx 623B, and 1441B had lower cumulative tunnelling than IS 18520 but they were not different from HYD 1. IS 1044 had the least amount of tunnelling.

TABLE 5

EFFECT OF LARVAL DENSITY ON DAMAGE PARAMETERS, TILLERING AND YIELD (SHORT RAINS, 1993)

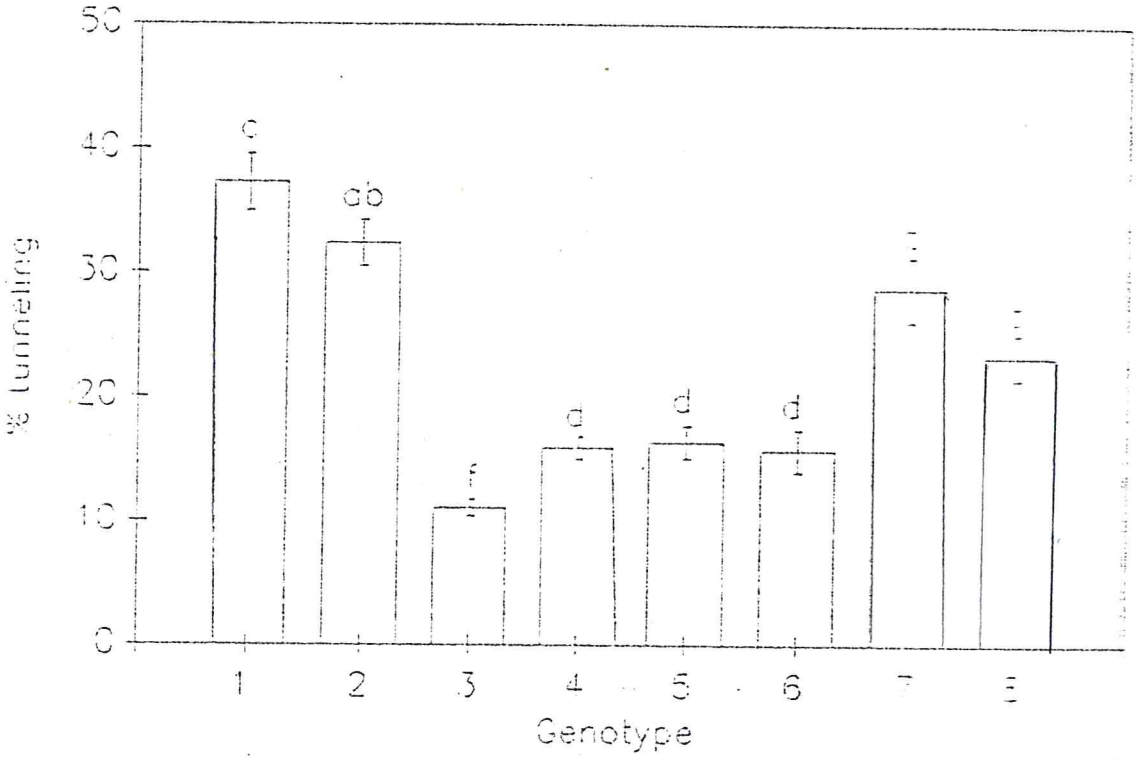
TREATMENT	GENOTYPE	CUMULATIVE TUNNELING[1]	% TUNNELING[2]	% FOLIAR DAMAGE[3]
	IS 18363	18.3 ± 1.5 AB	10.7 ± 1.1 AB	8.1 ± 8.1 A
	IS 18520	23.0 ± 3.4 A	14.8 ± 1.9 A	0.0 ± 0.0 A
	IS 1044	6.2 ± 1.2 C	3.0 ± 0.6 C	0.0 ± 0.0 A
0 L1	HYD 1	9.9 ± 2.0 BC	4.4 ± 1.0 C	3.3 ± 3.3 A
	HYD 8	9.2 ± 1.6 BC	4.1 ± 0.7 C	0.0 ± 0.0 A
	HYD 9	16.3 ± 1.2 AB	6.4 ± 0.6 BC	0.0 ± 0.0 A
	Tx 623B	12.1 ± 3.3 BC	10.1 ± 2.5 AB	0.5 ± 0.5 A
	1441B	14.4 ± 0.5 ABC	11.9 ± 0.5 AB	3.8 ± 3.8 A
	IS 18363	47.2 ± 2.8 A	37.3 ± 2.3 A	18.1 ± 6.2 A
	IS 18520	39.0 ± 2.0 B	32.4 ± 1.9 AB	17.1 ± 6.2 A
	IS 1044	20.9 ± 1.3 D	11.1 ± 0.7 F	9.1 ± 7.0 A
15 L1	HYD 1	31.9 ± 1.8 BC	15.9 ± 0.9 D	14.3 ± 4.4 A
	HYD 8	31.9 ± 1.9 BC	16.4 ± 1.3 D	12.9 ± 6.2 A
	HYD 9	33.1 ± 4.2 BC	15.7 ± 1.7 D	19.0 ± 2.7 A
	Tx 623B	28.9 ± 1.2 C	28.7 ± 2.6 B	24.3 ± 13.6 A
	1441B	24.1 ± 0.0 CD	23.3 ± 1.8 C	18.6 ± 3.8 A
	IS 18363	45.3 ± 1.0 A	49.8 ± 1.4 A	50.0 ± 13.6 A
	IS 18520	39.0 ± 1.5 B	32.8 ± 2.4 B	20.5 ± 6.1 ABC
	IS 1044	21.3 ± 1.8 D	11.9 ± 0.5 D	8.1 ± 5.3 C
30 L1	HYD 1	33.4 ± 3.2 BC	18.2 ± 1.1 C	15.7 ± 3.0 BC
	HYD 8	30.4 ± 2.5 C	15.1 ± 1.5 CD	12.4 ± 5.5 C
	HYD 9	30.7 ± 1.1 C	15.3 ± 1.1 CD	34.8 ± 6.4 ABC
	Tx 623B	31.9 ± 2.4 C	33.0 ± 1.8 B	44.9 ± 12.6 AB
	1441B	28.6 ± 2.0 C	30.4 ± 3.1 B	28.1 ± 5.9 ABC

TREATMENT	GENOTYPE	NO. OF ENTRY EXIT HOLES[4]	NO. OF PRODUCTIVE TILLERS[5]	% HEIGHT REDUCTION[6]	YIELD[7] (ton/ha.)	% YIELD REDUCTION[8]
	IS 18363	5.8 ± 1.4 AB	5.7 ± 2.6 CD		2.9 ± 0.3 B	
	IS 18520	5.8 ± 0.7 AB	43.3 ± 11.7 A		3.4 ± 0.2 AB	
	IS 1044	1.8 ± 0.4 B	28.7 ± 9.7 AB		4.6 ± 0.6 A	
$0L_1$	HYD 1	3.2 ± 0.7 A	8.3 ± 3.8 BCD		3.5 ± 0.2 AB	
	HYD 8	3.0 ± 0.6 AB	25.7 ± 1.2 AB		4.7 ± 0.3 A	
	HYD 9	6.7 ± 1.1 A	22.7 ± 3.5 ABC		4.6 ± 0.3 A	
	Tx 623B	3.0 ± 1.0 AB	2.3 ± 1.5 D		3.8 ± 0.2 AB	
	1441B	3.9 ± 0.9 AB	20.7 ± 6.0 ABC		2.8 ± 0.2 B	
	IS 18363	15.2 ± 3.7 A	4.0 ± 4.0 B	22.6 ± 7.3 A	1.2 ± 0.1 D	56.7 ± 4.2 A
	IS 18520	12.1 ± 1.5 ABC	43.3 ± 13.5 A	24.7 ± 1.7 A	3.2 ± 0.0 BC	6.8 ± 0.9 F
	IS 1044	5.7 ± 0.9 C	26.0 ± 7.8 AB	12.0 ± 2.6 A	3.6 ± 0.1 AB	20.3 ± 1.2 CDF
$15L_1$	HYD 1	8.4 ± 1.5 ABC	8.0 ± 4.0 AB	11.7 ± 3.7 A	3.0 ± 0.1 BC	15.4 ± 3.5 DF
	HYD 8	9.7 ± 0.9 ABC	14.3 ± 9.4 AB	12.5 ± 2.6 A	4.0 ± 0.3 A	14.7 ± 7.1 DF
	HYD 9	13.1 ± 1.5 AB	37.0 ± 3.5 A	17.0 ± 2.2 A	3.0 ± 0.1 BC	34.7 ± 1.7 BC
	Tx 623B	7.8 ± 1.1 ABC	6.0 ± 2.3 AB	12.8 ± 4.5 A	2.9 ± 0.1 C	24.0 ± 2.4 CD
	1441B	6.6 ± 0.9 BC	5.7 ± 4.3 AB	13.8 ± 6.2 A	1.6 ± 0.2 D	41.8 ± 7.4 B
	IS 18363	10.6 ± 0.1 AB	0.7 ± 0.7 C	47.5 ± 0.9 A	1.1 ± 0.2 E	58.9 ± 5.8 A
	IS 18520	9.7 ± 1.5 AB	49.3 ± 10.0 A	21.5 ± 5.3 B	2.8 ± 0.1 BC	18.9 ± 4.1 B
	IS 1044	4.6 ± 1.7 C	14.7 ± 7.1 BC	17.8 ± 4.1 B	3.4 ± 0.2 AB	25.9 ± 4.4 B
$30L_1$	HYD 1	8.4 ± 1.1 BC	10.7 ± 7.2 BC	19.4 ± 4.4 B	2.6 ± 0.3 C	27.8 ± 7.1 B
	HYD 8	9.6 ± 2.8 AB	10.0 ± 3.5 BC	14.2 ± 4.2 B	3.7 ± 0.2 A	21.5 ± 3.6 B
	HYD 9	14.7 ± 2.4 A	17.3 ± 5.7 B	20.2 ± 2.9 B	1.9 ± 0.3 D	59.3 ± 6.3 A
	Tx 623B	6.6 ± 1.0 BC	3.7 ± 2.0 BC	13.8 ± 8.0 B	2.9 ± 10.0 BC	23.6 ± 0.7 B
	1441B	8.3 ± 1.5 BC	4.3 ± 2.3 BC	21.8 ± 6.7 B	1.1 ± 0.1 E	59.5 ± 3.5 A

1, 7- untransformed data;
4- square root (x)

2, 3, 6, 8 Arcsine-square root transformed data;
5- square root (x + 0.5)

Figures are composed of means ± standard error. Means followed by the same letter within a column for each treatment are not significantly different ($P \leq 0.05$; SNK) on original or transformed data as indicated.

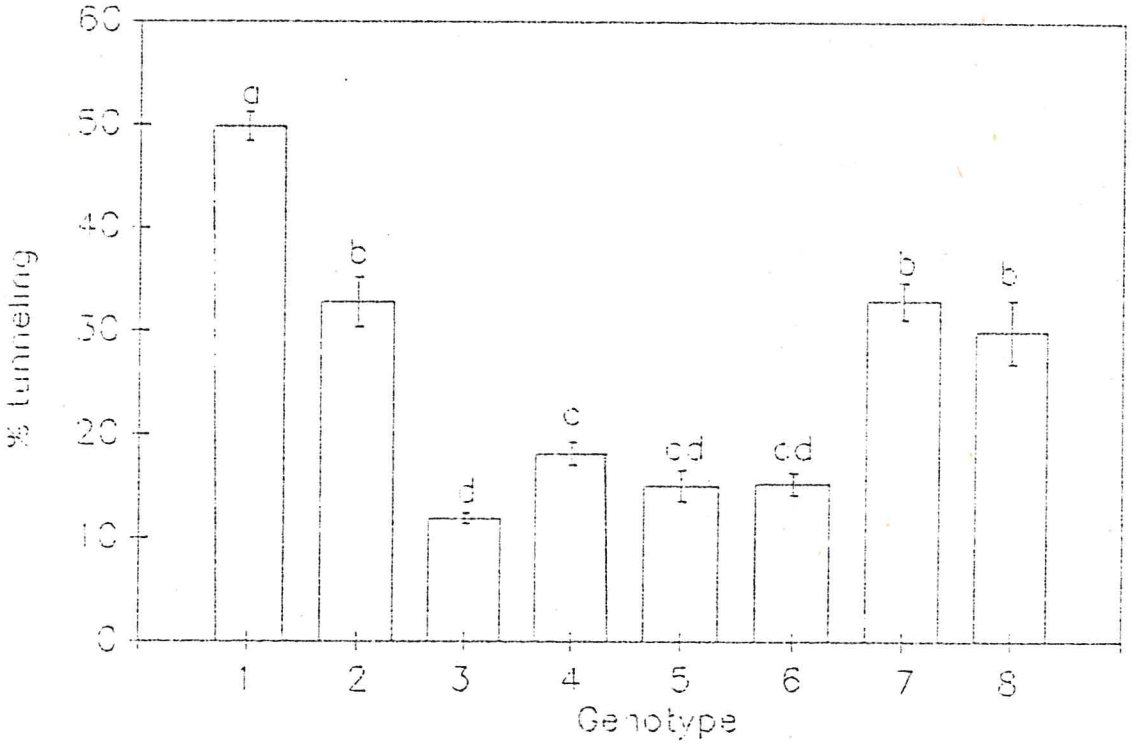


Key

1. IS 18363 2. IS 18520 3. IS 1044 4. HYD I 5. HYD 8

6. HYD 9 7. Tx 623B 8. 1441B

Fig 3. Effect of larval density (15 L1/plant) on percent stem tunneling of the various genotypes (Short Rains, 1993).



Key

1. IS 18363 2. IS 18520 3. IS 1044 4. HYD 1 5. HYD 8
6. HYD 9 7. Tx 623B 8. 1441B

Fig 4. Effect of larval density (30 L1/plant) on percent stem tunneling of the various genotypes (Short Rains, 1993).

Percent Tunneling

At 0 L1/plant level of infestation, IS 18520, IS 18363, Tx 623B and 1441B had the highest tunnelling. HYD 9 did not differ from all except IS 18520. The least percent tunnelling was observed in IS 1044, HYD 1, and HYD 8.

Infestation at 15 L1/plant resulted in IS 18363 having the highest percent tunnelling but it did not differ from IS 18520. IS 18520 in turn did not differ from Tx 623B. 1441B was next and it had significantly more tunnelling than the three hybrids. IS 1044 showed the least amount of percent tunnelling and was significantly lower than the values obtained for the three hybrids.

Similarly, at 30 L1/plant, IS 18363 had significantly more tunnelling than all the genotypes with almost 50 % of its stem tunnelled. Next were Tx 623B, IS 18520 and 1441B. The least percent tunnelling was recorded on IS 1044 but did not differ from the values obtained for HYD 8, and HYD 9. The latter two genotypes did not differ from HYD 1.

4.1.2 FOLIAR DAMAGE

Long Rains

For results, please refer to Table 4 and Appendices 1 and 2.

Mean percent foliar damage did not differ significantly for all genotypes at each infestation level.

Short Rains

Results are presented in Table 5 and Appendices 3 and 4

The genotypes did not differ in percent foliar damage at 0 L1/plant and 15 L1/plant infestation levels. Differences were observed at 30 L1/plant. IS 18363 suffered the highest percent foliar damage but it did not differ from IS 18520, HYD 9, Tx 623B and 1441B. IS 1044, HYD1, and HYD8 showed lower percent foliar damage than IS 18363.

4.1.3 ENTRY/EXIT HOLES

Long Rains

Results are shown in Table 4 and Appendices 1 and 2.

All genotypes did not differ significantly in mean number of entry/exit holes at 0 L1/plant. At 15 L1/plant, HYD 9 had significantly more entry holes than each of the other genotypes but these genotypes were not different from themselves A similar result was obtained at the density of 30 L1/plant except that this time, HYD 9 was not significantly different from HYD 8.

Short Rains

Results are found in Table 5 and Appendices 3 and 4.

For the uninfested control, IS 1044 had the least number of holes and significantly differed from values obtained for HYD 1 and HYD 9. It was not different from the other genotypes in terms of number of holes.

When plants were subjected to 15 L1/plant infestation level, IS 18363, had higher mean number of holes than IS 1044 but it did not differ from the other genotypes.

At 30 L1/plant, IS 1044 still showed the least mean number of holes although it was not significantly different from HYD 8, IS 18520 and IS 18363.

4.1.4 TILLERING

Long Rains

The results are presented in Table 4 and Appendices 1, 2 and 5.

When plots were not infested, IS 18520 had the highest number of productive tillers (11.3) but this was not significantly different from the values obtained for the three hybrids, IS 1044 and 1441B. At 15 L1/plant, a similar result was obtained but IS 18363 and Tx 623B had the least number of tillers.

When the genotypes were subjected to 30 L1/plant infestation, IS 18520, HYD 1, HYD 8, and HYD 9 had significantly more number of productive tillers than the remaining genotypes. IS 1044 followed while IS 18363, Tx 623B and 1441B had the lowest number of tillers producing mature heads. When each genotype was considered, irrespective of infestation level, tiller production did not differ (Table 6).

TABLE 6

TABLE COMPARING TILLER PRODUCTION AND YIELD OF THE VARIOUS GENOTYPES UNDER THE THREE INFESTATION LEVELS (LONG RAINS, 1993)

GENOTYPE	INFESTATION LEVEL (L1/Plant)	MEAN NO. OF PRODUCTIVE TILLERS	YIELD (t/ha)
IS 18363	0	1.00 A	1.67 A
	15	0.00 A	0.65 B
	30	0.00 A	0.12 C
IS 18520	0	11.33 A	3.81 A
	15	9.00 A	2.83 B
	30	11.00 A	2.46 B
IS 1044	0	5.00 A	3.74 A
	15	2.67 A	3.27 B
	30	4.67 A	2.75 C
HYD 1	0	5.67 A	3.80 A
	15	2.67 A	3.55 A
	30	8.33 A	2.90 A
HYD 8	0	10.67 A	3.06 A
	15	6.67 A	2.42 A
	30	9.33 A	2.45 A
HYD 9	0	10.33 A	3.33 A
	15	8.33 A	2.94 A
	30	9.00 A	2.71 A
Tx 623B	0	0.33 A	4.12 A
	15	0.67 A	2.46 B
	30	0.00 A	1.43 C
1441B	0	3.67 A	1.80 A
	15	1.33 A	1.06 B
	30	0.67 A	0.92 B

For each genotype, means followed by the same letters are not significantly different ($P \leq 0.05$; SNK).

Short Rains

Results are presented in Table 5, Figure 5, and Appendices 3, 4 and 6.

Control plots showed IS 18520 having the highest number of productive tillers but tiller production in this genotype was not significantly different from that in IS 1044, HYD 8, HYD 9, and 1441B. Tx 623B had the least number of tillers and was not significantly different from IS 18363 and HYD 1.

At 15 L1/plant infestation, IS 18520 and HYD 9 significantly differed from IS 18363 but not from the rest of the genotypes. IS 18363 differed only from IS 18520 and HYD 9.

IS 18520 still produced the highest number of tillers at 30 L1/plant infestation significantly differing from all the genotypes. It was followed by HYD 9 which had significantly higher number of tillers than IS 18363. Both genotypes were not different from the others.

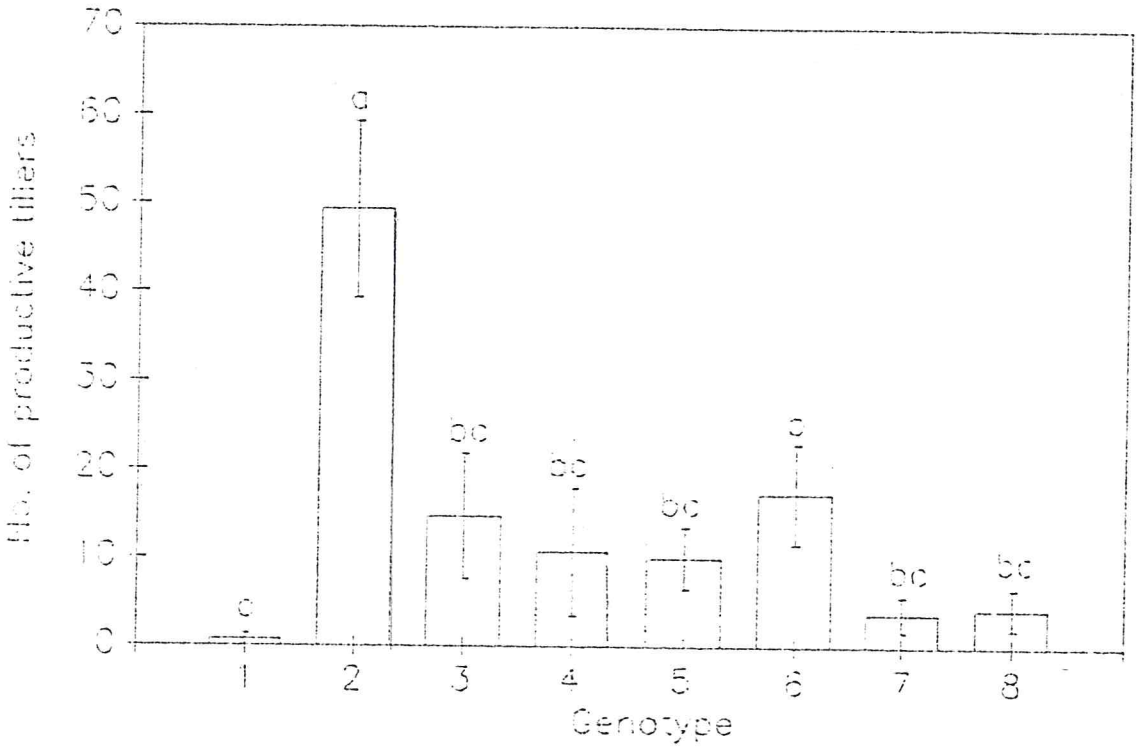
Irrespective of infestation level, each genotype maintained the same number of productive tillers (Table 7).

4.1.5 INTERNODE LENGTH AND GIRTH DIAMETER

Long Rains

Results are presented in Table 8.

Generally, infestation did not affect internode length (3rd internode from plant base) and the diameter of



Key

1. IS 18363 2. IS 18520 3. IS 1044 4. HYD 1 5. HYD 8

6. HYD 9 7. Tx 623B 8. 1441B

Fig 5. Effect of larval density (30 L1/plant) on number of productive tillers of the various genotypes. (Short Rains, 1993).

TABLE 7

TABLE COMPARING TILLER PRODUCTION AND YIELD OF THE VARIOUS GENOTYPES UNDER THE THREE INFESTATION LEVELS (SHORT RAINS, 1993)

GENOTYPE	INFESTATION LEVEL (L1/Plant)	MEAN NO. OF PRODUCTIVE TILLERS	YIELD (t/ha)
IS 18363	0	5.67 A	2.94 A
	15	4.00 A	1.20 B
	30	0.67 A	1.14 B
IS 18520	0	43.33 A	3.40 A
	15	43.33 A	3.17 A
	30	49.33 A	2.76 A
IS 1044	0	28.67 A	4.56 A
	15	26.00 A	3.63 A
	30	14.67 A	3.38 A
HYD 1	0	8.33 A	3.55 A
	15	8.00 A	3.00 B
	30	10.67 A	2.56 B
HYD 8	0	25.67 A	4.69 A
	15	14.33 A	4.03 B
	30	10.00 A	3.70 B
HYD 9	0	22.67 B	4.59 A
	15	37.00 A	3.00 B
	30	17.33 B	1.87 C
Tx 623B	0	2.33 A	2.82 A
	15	6.00 A	1.64 B
	30	3.67 A	1.14 B
1441B	0	3.67 A	1.80 A
	15	1.33 A	1.06 B
	30	0.67 A	0.92 B

For each genotype, means followed by the same letters are not significantly different ($P \leq 0.05$; SNK) .

TABLE 8

EFFECT OF LARVAL DENSITY (1st instar) ON INTERNODE LENGTH[1], GIRTH[2] AND PLANT HEIGHT (Long rains, 1993)*

GENOTYPE	NO. OF L_1 APPLIED	INTERNODE LENGTH (cm)	GIRTH (cm)	PLANT HEIGHT (cm)
IS 18363	0	18.0 ± 2.0 A	6.5 ± 0.4 A	202.0 ± 10.1 A
	15	12.1 ± 0.7 A	5.9 ± 0.2 B	134.5 ± 7.9 B
	30	14.6 ± 1.7 A	5.9 ± 0.2 B	143.3 ± 16.8 B
IS 18520	0	9.4 ± 0.3 A	7.3 ± 0.2 A	161.7 ± 2.7 A
	15	8.0 ± 0.6 A	6.6 ± 0.3 A	135.6 ± 9.1 A
	30	8.2 ± 0.2 A	6.6 ± 0.1 A	135.6 ± 7.2 A
IS 1044	0	31.2 ± 2.3 A	5.2 ± 0.3 A	229.3 ± 1.1 A
	15	28.6 ± 0.7 A	5.5 ± 0.2 A	196.1 ± 6.6 B
	30	27.4 ± 0.6 A	5.4 ± 0.1 A	192.4 ± 12.1 B
HYD 1	0	30.9 ± 1.7 A	5.8 ± 0.2 A	274.0 ± 5.4 A
	15	30.5 ± 0.8 A	6.0 ± 0.1 A	243.5 ± 6.0 B
	30	29.6 ± 0.9 A	5.9 ± 0.1 A	240.7 ± 10.3 B
HYD 8	0	25.6 ± 1.1 A	5.8 ± 0.3 A	260.1 ± 3.6 A
	15	24.1 ± 0.4 A	5.6 ± 0.2 A	200.5 ± 6.3 B
	30	24.9 ± 1.3 A	5.8 ± 0.1 A	217.2 ± 5.6 B
HYD 9	0	21.8 ± 1.2 A	6.0 ± 0.3 A	260.6 ± 5.8 A
	15	16.1 ± 0.3 B	5.9 ± 0.1 A	217.8 ± 25.2 A
	30	17.9 ± 0.2 B	6.2 ± 0.2 A	211.2 ± 16.3 A
Tx 623B	0	6.9 ± 0.7 A	7.7 ± 0.3 A	134.0 ± 5.6 A
	15	5.0 ± 0.2 A	6.8 ± 0.3 A	103.6 ± 3.8 B
	30	6.4 ± 0.7 A	6.4 ± 0.7 A	108.1 ± 7.0 B
1441B	0	5.2 ± 0.5 A	8.0 ± 0.3 A	135.8 ± 6.8 A
	15	5.1 ± 0.0 A	7.1 ± 0.0 B	84.2 ± 5.1 B
	30	4.5 ± 0.6 A	7.2 ± 0.0 B	86.8 ± 5.0 B

Figures are composed of means ± standard error. Means followed by the same letters within a column for each genotype are not significantly different ($P \leq 0.05$, SNK).
1 = 3rd internode ; 2 = girth of 3rd internode

* - Tx 623B and 1441B are naturally shorter than the other genotypes.

its girth. HYD 9 had its internode length reduced while IS 18363 and 1441B had reduced girth diameter.

Short Rains

Results are shown in Table 9.

Internode length (3rd internode from plant base) length remained the same for all genotypes irrespective of infestation level.

Girth diameter of the internode remained the same for all the genotypes except HYD 9 where infested plants had significantly smaller diameter than control plants.

4.1.6 HEIGHT REDUCTION

Long Rains

Results are presented in Table 4 and Appendices 1 and 2.

Mean percent height reduction was highest in 1441B (62.5) when plants were infested at the rate of 15 L1/plant. It differed significantly only from IS 18520, IS 1044, HYD 1, and HYD 9. However, at 30 L1/plant, mean percent height reduction was the same for all the genotypes.

Short Rains

Results are shown in Table 5, Figure 6, and Appendices 3 and 4.

Mean percent height reduction of the genotypes was the same at 15 L1/plant infestation level. At 30 L1/plant, IS 18363 showed significantly more mean percent height

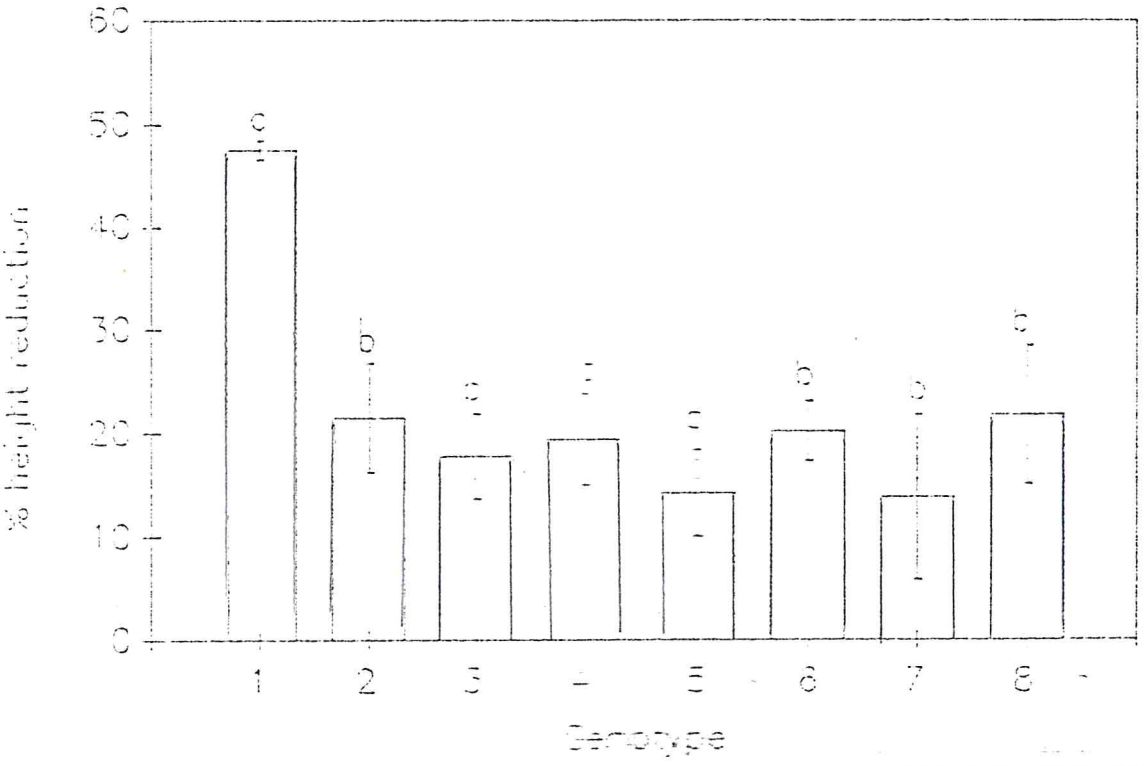
TABLE 9

EFFECT OF LARVAL DENSITY (1st instar) ON INTERNODE LENGTH[1], GIRTH[2] AND PLANT HEIGHT (Short rains, 1993)

GENOTYPE	NO. OF L_1 APPLIED	INTERNODE LENGTH (cm)	GIRTH (cm)	PLANT HEIGHT (cm)
IS 18363	0	13.9 ± 1.4 A	7.8 ± 0.3 A	173.3 ± 12.9 A
	15	12.8 ± 1.3 A	6.8 ± 0.1 A	134.1 ± 12.6 B
	30	13.2 ± 1.2 A	6.9 ± 0.5 A	92.7 ± 2.1 C
IS 18520	0	8.9 ± 0.2 A	6.5 ± 0.1 A	152.4 ± 6.6 A
	15	7.8 ± 0.1 A	6.3 ± 0.3 A	114.8 ± 2.6 B
	30	7.6 ± 0.7 A	6.6 ± 0.2 A	119.7 ± 8.1 B
IS 1044	0	24.2 ± 1.2 A	6.0 ± 0.3 A	214.7 ± 8.3 A
	15	25.2 ± 0.9 A	5.7 ± 0.0 A	188.9 ± 5.6 A
	30	22.4 ± 1.4 A	6.0 ± 0.5 A	176.5 ± 8.8 A
HYD 1	0	25.2 ± 0.5 A	6.6 ± 0.3 A	227.9 ± 9.7 A
	15	23.0 ± 1.4 A	6.6 ± 0.3 A	201.3 ± 8.5 AB
	30	23.0 ± 2.3 A	6.8 ± 0.5 A	183.7 ± 10.0 B
HYD 8	0	21.2 ± 1.2 A	6.6 ± 0.2 A	223.2 ± 4.9 A
	15	23.5 ± 1.1 A	6.4 ± 0.1 A	195.2 ± 5.8 A
	30	24.2 ± 0.1 A	6.9 ± 0.1 A	201.5 ± 3.7 A
HYD 9	0	16.2 ± 0.6 A	7.3 ± 0.3 A	253.3 ± 5.2 A
	15	19.5 ± 4.0 A	6.8 ± 0.1 B	210.3 ± 5.5 B
	30	13.8 ± 2.0 A	6.2 ± 0.1 C	202.2 ± 7.3 B
Tx 623B	0	4.4 ± 0.6 A	7.9 ± 0.7 A	117.8 ± 4.4 A
	15	4.8 ± 0.5 A	8.1 ± 0.4 A	102.8 ± 5.3 A
	30	4.4 ± 0.4 A	7.9 ± 0.3 A	101.6 ± 9.4 A
1441B	0	4.4 ± 0.2 A	8.3 ± 0.3 A	121.3 ± 3.9 A
	15	3.9 ± 0.5 A	7.8 ± 0.2 A	104.5 ± 7.5 A
	30	3.5 ± 0.2 A	7.6 ± 0.4 A	34.9 ± 8.1 A

Figures are composed of means ± standard error. Means followed by the same letters within a column for each genotype are not significantly different ($P \leq 0.05$; SNK).

1. 3rd Internode 2. Girth of 3rd internode



Key

1. IS 18363 2. IS 18521 3. IS 1044 4. HYD 1 5. HYD 8

6. HYD 9 7. Tx 623E 8. 1441B

Fig 6. Effect of larval density (30 L1/plant) on percent height reduction of the various genotypes. (Short Rains, 1993).

reduction than the remaining genotypes. All the other genotypes suffered the same mean percent height reduction.

4.1.7 YIELD

Long Rains

The results are presented in Table 4 and Appendices 1 and 2.

The highest yields were obtained from Tx 623B, HYD 9, HYD 1, IS 18520 and IS 1044 when plants were not infested. HYD 8 was next while IS 18363 and 1441B had the lowest yields. However, at 15 L1/plant infestation, the highest yield was obtained from HYD 1 and IS 1044 although the figures were not significantly different from those obtained for HYD 9 and IS 18520. Both HYD 1 and IS 1044 had significantly higher yields than HYD 8, Tx 623B, IS 18363, and 1441B. IS 18363 and 1441B had the least yields. At 30 L1/plant infestation rate, the best yields were obtained from HYD 1, HYD 9, IS 1044, HYD 8, and IS 18520. Next were Tx 623B, and 1441B while the least yield was obtained from IS 18363.

Yield Reduction

When plants were subjected to 15 L1/plant infestation , mean percent yield reduction was highest in IS 18363 (61.2) but was not significantly different from the values obtained for Tx 623B and 1441B. Mean percent yield reduction was least in IS 1044 (12.4) and HYD 1 (6.5) but was of the same degree in IS 18520, HYD 8, and HYD 9. At 30 L1/plant

infestation rate, the highest mean percent yield reduction was obtained on IS 18363 (93.1). Next were Tx 623B and 1441B. The least mean percent yield reduction was obtained from HYD 8 (19.8) but virtually the same degree of yield reduction was found on IS 1044, HYD 1, HYD 9, and IS 18520.

Short Rains

Results are shown in Table 5 and Appendices 3 and 4.

Without infestation, IS 18520, IS 1044, HYD 1, HYD 8, and HYD 9 were comparable in terms of yield. IS 18363 and 1441B had the lowest yields but did not differ from IS 18520, HYD 1, Tx 623B, and 1441B.

At 15 L1/plant, HYD 8 had the highest mean yield but did not significantly differ from IS 1044. IS 18520, HYD 1, and HYD 9 were next but they did not significantly differ from Tx 623B. Genotype 1441B and IS 18363 had the lowest yields.

The highest mean percent yield at 30 L1/plant infestation was obtained from HYD 8 but it did not significantly differ from the yield of IS 1044 which in turn was the same as those for IS 18520 and Tx 623B. HYD 9 was next while the least yields were got from IS 18363 and 1441B.

Yield Reduction

When plants were subjected to 15 L1/plant infestation level, mean percent yield reduction was highest in IS 18363 (56.7) and was followed by 1441B which did not differ

significantly from the yield reduction in HYD 9. IS 18520 had the lowest mean percent yield reduction (6.8) but it did not significantly differ from IS 1044, HYD 1, and HYD 8. When infestation level was increased from 15 to 30 L1/plant, IS 18363, HYD 9, and 1441B had significantly higher percent yield reduction than the other genotypes which did not differ from one another (Figures 7 and 8).

4.1.8 CORRELATION BETWEEN DAMAGE PARAMETERS AND YIELD

Long Rains

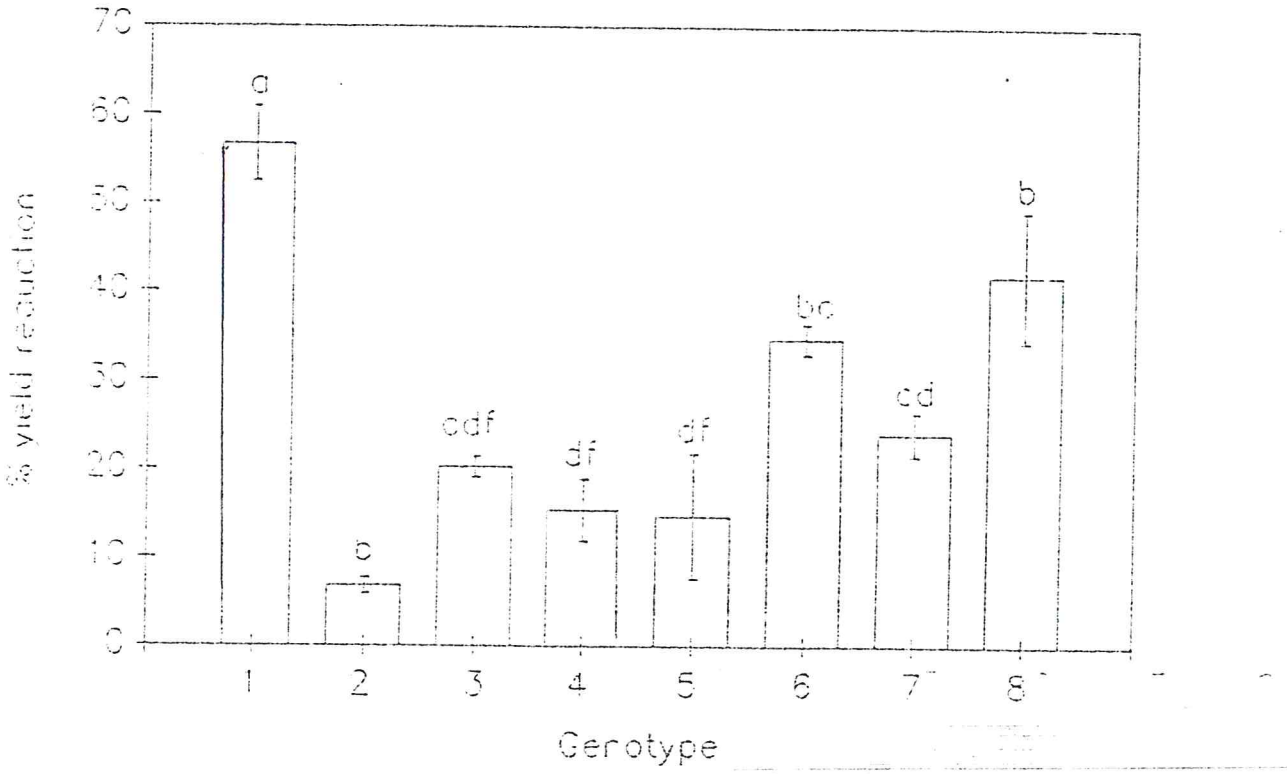
Results are shown in Table 10.

Correlation studies on long rains data showed significant positive relationship between percent yield reduction and percent tunneling only in the case of HYD 8, Tx 623B, and 1441B. For percent yield reduction and percent tunneling, a significant positive relationship was found in the case of IS 18363, IS 1044, HYD 8, Tx 623B and 1441B. No significant relationship was found between percent yield reduction and number of productive tillers in all genotypes. The relationship between percent height reduction and tillering was significant only with respect to IS 18363, HYD 8, Tx 623B, and 1441B.

Short Rains

Results are presented in Table 11.

Correlation studies on the Short Rains data showed a significant positive relationship between percent yield

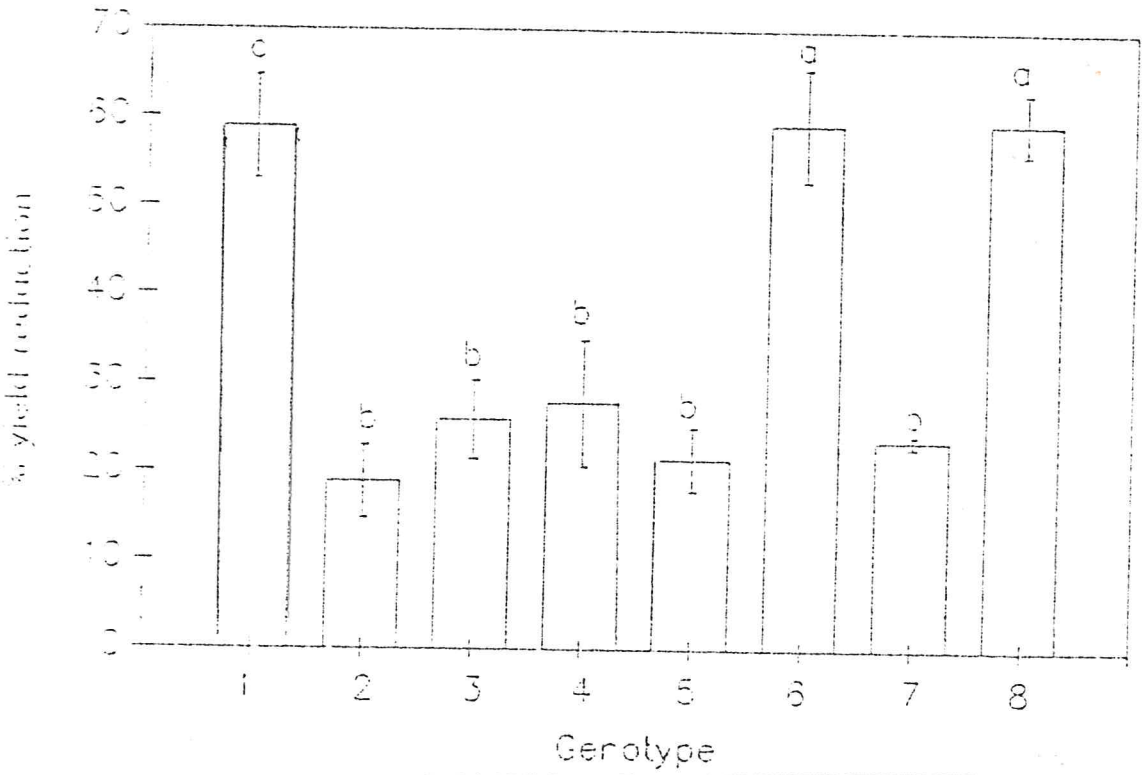


Key

1. IS 18363 2. IS 18520 3. IS 1044 4. HYD 1 5. HYD 8

6. HYD 9 7. Tx 623B 8. 1441B

Fig 7. Effect of larval density (15 L1/plant) on percent yield reduction of the various genotypes. (Short Rains, 1993).



Key

1. IS 18363 2. IS 18520 3. IS 1044 4. HYD 1 5. HYD 8

6. HYD 9 7. Tx 623B 8. 1441B

Fig 8. Effect of larval density (30 L1/plant) on percent yield reduction of the various genotypes. (Short Rains, 1993).

TABLE 10

CORRELATION BETWEEN PERCENT YIELD REDUCTION AND SELECTED PARAMETERS FOR DIFFERENT GENOTYPES (LONG RAINS, 1993)

	PARAMETER						
GENOTYPE	PTU	CTU	PFD	TL	HO	PHTR	N3
IS 18363	0.60^{ns}	0.50^{ns}	0.88^{**}	-0.47^{ns}	0.49^{ns}	0.75^{*}	-0.54^{ns}
IS 18520	0.12^{ns}	-0.02^{ns}	0.57^{ns}	-0.33^{ns}	0.43^{ns}	0.43^{ns}	-0.71^{*}
IS 1044	0.56^{ns}	0.55^{ns}	0.80^{**}	0.10^{ns}	0.66^{ns}	0.62^{ns}	-0.6^{ns}
HYD 1	0.44^{ns}	0.45^{ns}	0.64^{ns}	0.24^{ns}	0.64^{ns}	0.31^{ns}	-0.24^{ns}
HYD 8	0.74^{*}	0.68^{*}	0.67^{*}	-0.36^{ns}	0.77^{*}	0.79^{*}	-0.48^{ns}
HYD 9	0.43^{ns}	0.61^{ns}	0.57^{ns}	-0.03^{ns}	0.63^{ns}	0.20^{ns}	-0.72^{*}
Tx 623B	0.88^{**}	0.81^{**}	0.77^{*}	-0.03^{ns}	0.77^{*}	0.76^{*}	-0.39^{ns}
1441B	0.76^{*}	0.26^{ns}	0.91^{***}	-0.63^{ns}	0.78^{**}	0.95^{***}	-0.3^{ns}

^{ns} = not significant at 5 % level
* = P < 0.05 ; ** P < 0.01 ; *** = P < 0.001

PTU = percent tunneling
CTU = cummulative tunneling
PFD = percent foliar damage
TL = number of tillers
HO = number of holes
PHTR= percent heigth reduction
N3 = length of 3rd internode from plant base

TABLE 11

CORRELATION BETWEEN PERCENT YIELD REDUCTION AND SELECTED PARAMETERS FOR DIFFERENT GENOTYPES (SHORT RAINS, 1993)

	PARAMETER						
GENOTYPE	PTU	CTU	PFD	TL	HO	PHTR	N3
IS 18363	0.92***	0.93***	0.49ns	-0.38ns	0.59ns	0.84**	-0.20n
IS 18520	0.62ns	0.57ns	0.78**	-0.10ns	0.20ns	0.58ns	-0.71*
IS 1044	0.90***	0.85**	0.58ns	-0.47ns	0.43ns	0.92***	-0.3ns
HYD 1	0.73*	0.63ns	0.50ns	-0.28ns	0.65ns	0.89**	-0.27n
HYD 8	0.64ns	0.69*	0.17ns	-0.09ns	0.65ns	0.64ns	0.76*
HYD 9	0.78*	0.74*	0.85**	-0.18ns	0.69*	0.83**	-0.27n
Tx 623B	0.89**	0.90**	0.59ns	0.27ns	0.74*	0.58ns	0.17n
1441B	0.90***	0.91***	0.89**	-0.65ns	0.75*	0.81**	-0.53n

ns = not significant at 5 % level
* = P < 0.05 ; ** P < 0.01 ; *** = P < 0.001

PTU = percent tunneling
CTU = cummulative tunneling
PFD = percent foliar damage
TL = number of tillers
HO = number of holes
PHTR = percent heigth reduction
N3 = length of 3rd internode from plant base

reduction and percent tunnelling for all the genotypes except IS 18520 and HYD 8. Percent yield reduction was significantly positively correlated with percent foliar damage only in the case of IS 18520, HYD 9, and 1441B. No significant relationship was found between percent yield reduction and number of productive tillers in all genotypes. Percent yield reduction was significantly correlated with percent height reduction in all genotypes except IS 18363, HYD 8, and Tx 623B.

4.2 ASSESSMENT OF ROOT MASS OF FIVE OF THE GENOTYPES FOR INDICATION OF TOLERANCE

The result of insect infestation (20 L1/plant) on the rootmass of the five genotypes (IS 1044, IS 18520, HYD 1, HYD 8 and HYD 9) employed in the study are presented in Table 12 and appendices 7 and 8.

Infested IS 18520 plants showed significant increase in rootmass (60 %) over the control. The rootmass of IS 1044 HYD 8 and HYD 9 neither increased nor decreased . However, a decrease in rootmass was observed on HYD 1.

TABLE 12

EFFECT OF *C. PARTELLUS* INFESTATION ON ROOTMASS OF FIVE GENOTYPES

GENOTYPE	TREATMENT	MEAN DRY WEIGHT OF ROOTS (g)
IS 18520	0 L1/Plant	5.01 ± 0.1 B
IS 18520	20 L1/Plant	8.12 ± 0.4 A
(cv=7.9)		
IS 1044	0 L1/Plant	8.13 ± 0.5 A
IS 1044	20 L1/Plant	9.07 ± 0.1 A
(cv=7.8)		
HYD 1	0 L1/Plant	9.09 ± 0.5 A
HYD 1	20 L1/Plant	5.31 ± 0.1 B
(cv=9.5)		
HYD 8	0 L1/Plant	9.36 ± 0.3 A
HYD 8	20 L1/Plant	8.31 ± 0.3 A
(cv=6.3)		
HYD 9	0 L1/Plant	9.82 ± 0.4 A
HYD 9	20 L1/Plant	8.46 ± 0.5 B
(cv=8.2)		

Figures are composed of means ± standard error.
Means followed by the same letters for each genotype are not significantly different ($P \leq 0.05$; LSD).

4.3 OVIPOSITIONAL RESPONSE

4.3.1 INFLUENCE OF THE SELECTED GENOTYPES ON OVIPOSITION

The results are presented in Table 13 and Appendix 9.

Analysis of the ovipositional preference values of *C. partellus* for the genotypes showed that the borer preferred all the genotypes to wax paper (a good ovipositional substrate, Kumar and Saxena, 1985) for oviposition, and no genotype was more preferred than the other.

4.3.2 ROLE OF DISTANCE-PERCEIVABLE STIMULI IN OVIPOSITION

The results of the analysis of the role of distance perceivable stimuli in oviposition are presented in Table 14 and appendix 10. Although number of eggs laid on the genotypes and on wax paper pieces did not differ, significantly more eggs were laid on wax paper pieces close to the test plant than on wax paper pieces away from the test plant in the case of the susceptible genotype, IS 18363 .

TABLE 13

OVIPOSITIONAL RESPONSE OF *C. PARTELLUS* TO DIFFERENT GENOTYPES *

GENOTYPE	NO. OF EGGS ON GENOTYPE	NO. OF EGGS ON WAX PAPER	OP[1] VALUE
IS 18363	453.0 ± 87.5 A	30.3 ± 30.3 A	89.46 ± 10.5 A
IS 18520	508.8 ± 175.9 A	4.5 ± 4.5 A	94.58 ± 5.4 A
IS 1044	561.0 ± 119.0 A	15.3 ± 15.3 A	92.16 ± 7.8 A
HYD 1	240.3 ± 117.9 A	0.0 ± 0.0 A	100.00 ± 0.0 A
HYD 8	258.8 ± 37.5 A	20.0 ± 13.1 A	84.12 ± 11.7 A
HYD 9	452.0 ± 95.3 A	0.0 ± 0.0 A	100.00 ± 0.0 A
Tx 623B	456.5 ± 160.1 A	49.5 ± 43.7 A	81.04 ± 17.7 A
1441B	579.3 ± 126.7 A	60.0 ± 34.7 A	76.91 ± 16.1 A
CV	10.14		24.58

1 OP=ovipositional preference

Figures are composed of means ± standard error. Means for plants are significantly different from those for blanks ($P \leq 0.05$; paired T test). Means followed by the same letter are not significantly different on log transformed data for the first two columns and on arcsine-square root tramsformed data for ovipositional preference.(OP) ($P \leq 0.05$; SNK).

* - DMRT showed some differences

TABLE 14

ROLE OF DISTANCE PERCEIVABLE STIMULI IN OVIPOSITION

GENOTYPE	NO. OF EGGS ON WAX PAPER CLOSE TO PLANT	NO. OF EGGS ON WAX PAPER AWAY FROM PLANT	OP VALUE
IS 18363	188.0 ± 30.1 A	65.5 ± 21.9 A	54.49 ± 15.50 A
IS 18520	155.0 ± 32.9 A	62.1 ± 13.4 A	32.68 ± 16.70 A
IS 1044	181.3 ± 39.0 A	99.1 ± 37.0 A	32.92 ± 20.66 A
HYD 1	87.6 ± 21.7 A	171.8 ± 42.2 A	-25.94 ± 22.16 A
HYD 8	147.0 ± 33.2 A	136.4 ± 29.5 A	3.19 ± 18.89 A
HYD 9	97.6 ± 44.2 A	84.6 ± 28.4 A	3.58 ± 30.86 A
Tx 623B	157.9 ± 27.8 A	188.1 ± 48.2 A	-3.23 ± 19.01 A
1441B	176.3 ± 52.9 A	97.8 ± 32.7 A	9.33 ± 20.01 A
CV	37.37	45.07	33.47

Figures are composed of means ± standard error. Means for blanks close to plants are significantly different from those for blanks away from plants only in the case of IS 18363 ($P < 0.05$; paired T test). Means followed by the same letter are not significantly different on log transformed data for the first two columns and on arcsine-square root tramsformed data for ovipositional preference ($P < 0.05$; SNK).

4.3.3 ROLE OF CONTACT-PERCEIVABLE STIMULI IN OVIPOSITION

The results of the study on the role of contact perceivable stimuli on oviposition are presented in Table 15 and Appendix 11. Significant differences were found between the number of eggs laid on various genotypes and on wax paper (non-plant ovipositional substrate) except in the case of IS 1044. *C. partellus* preferred to lay on the other genotypes than on wax paper. The ovipositional preference value of *C. partellus* for the test plant was negative (-38.4) for IS 1044 and was significantly lower than those for other genotypes.

4.4 LARVAL ORIENTATIONAL RESPONSE

4.4.1 ATTRACTION OF 1st INSTAR *C. PARTELLUS* LARVAE

4.4.1.1 **Attraction to single plants of the target genotypes**

Results are presented in Tables 16-18 and Appendices 12-14. Apart from HYD 1 which significantly attracted more 1st-instar *C. partellus* from 10 cm distance than IS 18520, the other genotypes were not really different from both (Table 16; Figure 9). However, all genotypes significantly attracted more insects than the blank control. From 20 cm distance, all genotypes were of the same attractancy, but were all significantly more attractive than the blank.

TABLE 15

ROLE OF CONTACT PERCEIVABLE STIMULI IN OVIPOSITION

GENOTYPE	NO. OF EGGS LAID ON GENOTYPE	NO. OF EGGS LAID ON WAX PAPER	OP VALUE
IS 18363	238.9 ± 34.1 A	60.9 ± 17.8 BC	65.7 ± 8.9 A
IS 18520	335.9 ± 36.7 A	19.8 ± 9.2 BC	87.7 ± 6.9 A
IS 1044	106.5 ± 30.9 B	179.8 ± 14.5 A	-38.4 ± 16.2 B
HYD 1	345.7 ± 30.8 A	56.4 ± 20.7 BC	75.5 ± 8.4 A
HYD 8	286.1 ± 43.2 A	92.1 ± 29.3 BC	56.2 ± 13.2 A
HYD 9	262.8 ± 40.5 A	69.6 ± 24.6 BC	57.3 ± 18.7 A
Tx 623B	355.1 ± 50.7 A	22.3 ± 17.9 C	85.2 ± 11.8 A
1441B	366.2 ± 33.2 A	103.0 ± 32.1 B	61.4 ± 7.4 A
CV	21.84	89.79	26.19

Figures are composed of means ± standard error. Means for plants are significantly different from those for blanks ($P \leq 0.05$; paired T test) except in the case of IS 1044. Means followed by the same letter are not significantly different on log transformed data for the first two columns and on arcsine-square root tramsformed data for ovipositional preference ($P \leq 0.05$; SNK).

TABLE 16

MEAN PERCENT 1st INSTAR *C. PARTELLUS* LARVAE (L1) REACHING THE GENOTYPES FROM DIFFERENT DISTANCES

GENOTYPE	DISTANCE (cm) 10	20	30	40
BLANK	6.9 ± 2.4 C	4.4 ± 2.0 B	3.8 ± 1.5 C	3.1 ± 1.2 B
IS 18363	55.6 ± 5.4 AB	51.3 ± 5.2 A	34.4 ± 5.1 AB	28.8 ± 3.9 A
IS 18520	43.8 ± 5.0 B	43.1 ± 6.0 A	26.9 ± 4.5 AB	15.0 ± 3.4 A
IS 1044	51.3 ± 5.0 AB	41.9 ± 3.3 A	21.9 ± 4.1 B	22.5 ± 3.8 A
HYD 1	63.8 ± 5.6 A	37.5 ± 4.5 A	23.8 ± 5.2 AB	23.8 ± 5.2 A
HYD 8	51.9 ± 4.2 AB	38.8 ± 5.0 A	38.8 ± 5.3 A	27.5 ± 3.5 A
HYD 9	57.5 ± 3.6 AB	43.8 ± 5.5 A	23.8 ± 4.7 AB	18.8 ± 3.0 A
Tx 623B	58.1 ± 5.8 AB	44.4 ± 4.4 A	30.0 ± 4.0 AB	28.1 ± 3.7 A
1441B	46.9 ± 4.3 AB	45.0 ± 6.5 A	26.9 ± 4.3 AB	25.0 ± 5.0 A
CV	26.73	33.1	38.1	46.1

Figures are composed of means ± standard error. Means followed by the same letters within a column are not significantly different ($P \leq 0.05$, SNK) on arcsine-square root transformed data.

TABLE 17

MEAN % LARVAE (L_1) REACHING CENTRE OF BOARD FOR DIFFERENT GENOTYPES AND DIRECTIONS

DIRECTION	BLANK	IS 18363	IS 18520	IS 1044
North	0.6 ± 0.6 B	51.9 ± 5.3 A	38.1 ± 6.8 A	31.3 ± 4.7 A
South	2.5 ± 1.1 B	35.6 ± 4.8 B	25.0 ± 4.2 B	33.8 ± 6.0 A
East	5.0 ± 1.6 AB	34.4 ± 5.9 B	21.9 ± 4.3 B	30.0 ± 4.4 A
West	10.0 ± 2.6 A	48.1 ± 5.3 AB	43.8 ± 5.2 A	42.5 ± 5.0 A
CV	78.7	27.3	33.9	29.4

	HYD 1	HYD 8	HYD 9	Tx 623B	1441B
North	38.8 ± 5.5AB	43.8 ± 5.2AB	36.9 ± 5.5 A	37.5 ± 5.6 B	36.9 ± 5.5 A
South	27.5 ± 4.7B	32.5 ± 5.2B	32.5 ± 5.1 A	35.6 ± 5.2 B	32.5 ± 4.8A
East	35.6 ± 6.8AB	33.8 ± 5.1B	30.6 ± 4.8 A	34.4 ± 4.7 B	31.3 ± 4.6A
West	46.9 ± 7.1A	46.9 ± 3.5A	43.8 ± 7.0 A	53.1 ± 5.1 A	43.1 ± 7.2A
CV	31.3	27.4	31.3	26.9	30.3

Figures are composed of means ± standard error. Means followed by the same letters within a column for each genotype are not significantly different on arcsine-square root transformed data ($P \leq 0.05$; SNK).

TABLE 18

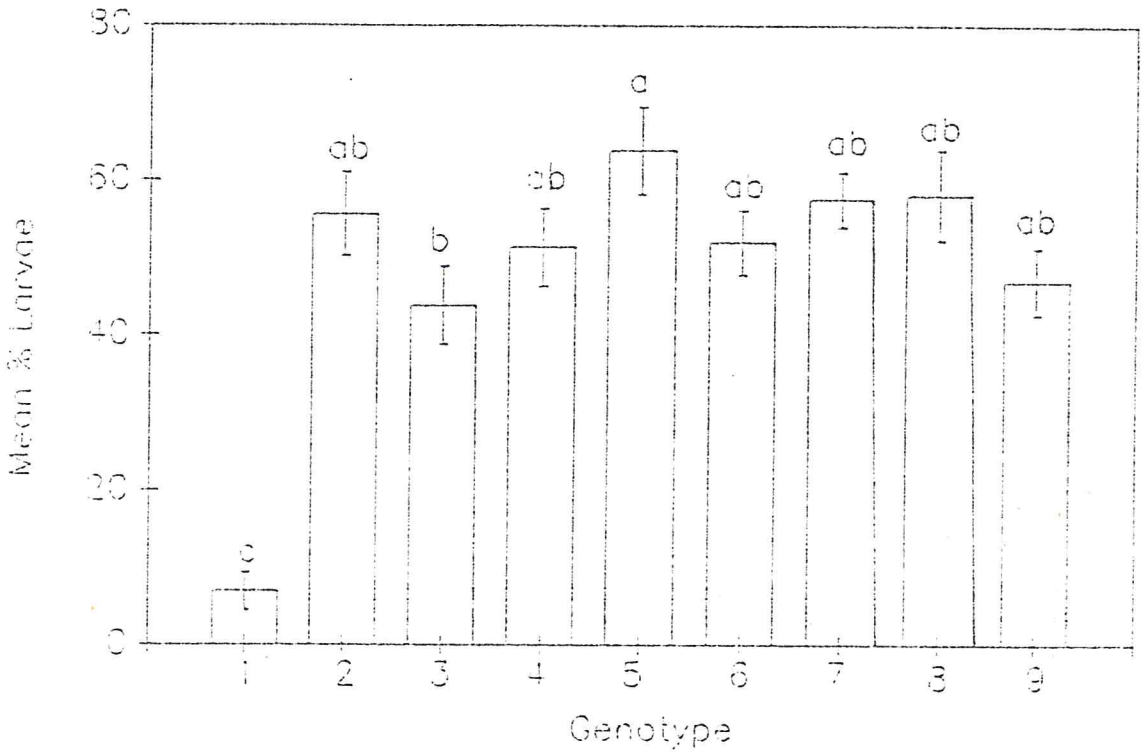
MEAN PERCENT 1st INSTAR LARVAE REACHING THE GENOTYPES FROM DIFFERENT DIRECTIONS*

	NORTH	SOUTH	WEST	EAST
BLANK	0.6 ± 0.6 C	2.5 ± 1.1 B	10.0 ± 2.6 B	5.0 ± 1.6B
IS 18363	51.9 ± 5.3 A	35.6 ± 4.8 A	48.1 ± 5.3 A	34.4 ± 5.9 A
IS 18520	38.1 ± 6.8 AB	25.0 ± 4.2 A	43.8 ± 5.2 A	21.9 ± 4.4A
IS 1044	31.3 ± 4.7 B	33.8 ± 6.0 A	42.5 ± 5.0 A	30.0 ± 4.4 A
HYD 1	38.8 ± 5.5 AB	27.5 ± 4.7 A	46.9 ± 7.1 A	35.6 ± 6.6A
HYD 8	43.8 ± 5.2 AB	32.5 ± 5.2 A	46.9 ± 3.5 A	33.8 ± 5.1 A
HYD 9	36.9 ± 5.5 AB	32.5 ± 5.1 A	43.8 ± 7.0 A	30.6 ± 4.8A
Tx 623B	37.5 ± 5.6 AB	35.6 ± 5.2 A	53.1 ± 5.1 A	34.4 ± 4.7 A
1441B	36.9 ± 5.5 AB	32.5 ± 4.8 A	43.1 ± 7.2 A	31.3 ± 4.6A
CV	32.8	31.0	38.6	34.4

Figures are composed of means ± standard error. Means followed by the same letters within a column are not significant different on arcsine-square root transformed data

($P \leq 0.05$; SNK).

* = pooled distances



Key

1. BLANK 2. IS 18363 3. IS 18520 4. IS 1044 5. HYD 1

6. HYD 8 7. HYD 9 8. 1441B 9. Tx 623B

Fig 9. Mean % larvae (L1) reaching different test genotypes from a distance of 10 cm.

At 30 cm distance, HYD 8 proved more attractive than IS 1044 but was not different from the other genotypes in attractancy (Figure 10). When insects were released 40 cm from the test plants, all genotypes were of the same attractancy and were all significantly different from the blank (Table 16)

There was a significant interaction between distance and direction, and generally more insects were attracted from the north and the west although in most genotypes differences were not significant (Tables 17 and 18).

4.4.1.2 **Attraction to groups of plants of the target genotypes**

The results of this study are presented in Table 19, Figure 11 and Appendix 15.

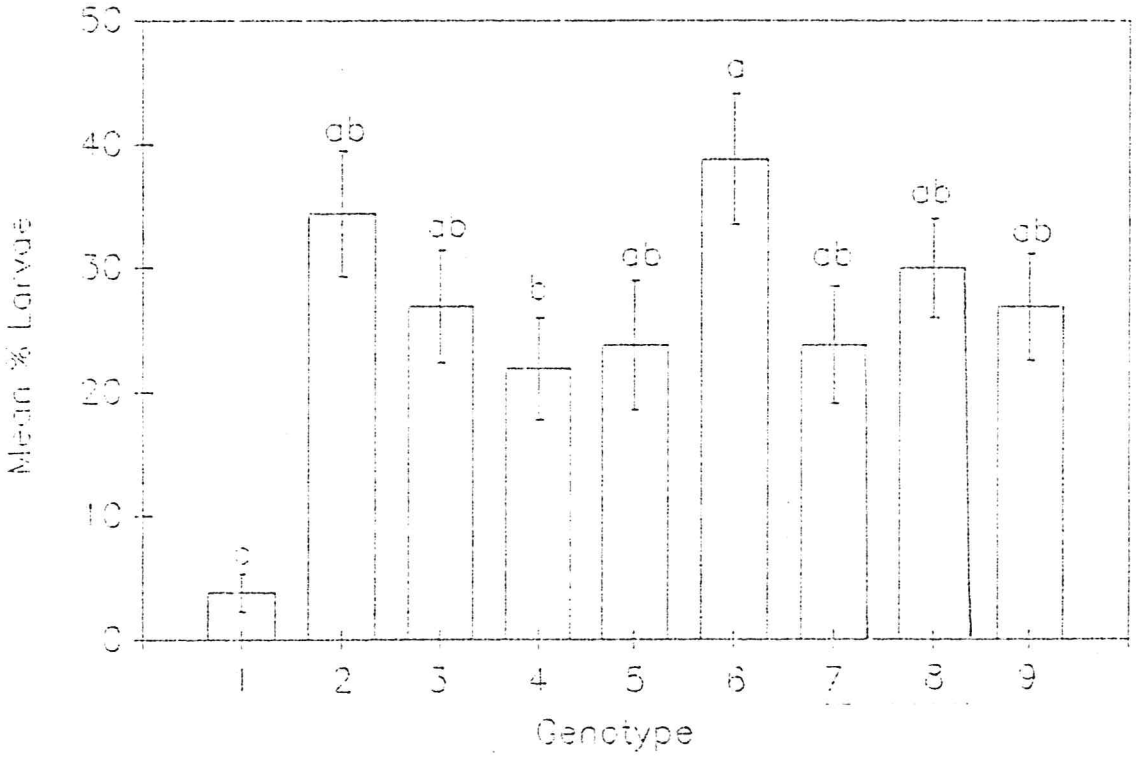
Analysis of variance of mean percent attraction showed that genotype 1441B was significantly more attractive than IS 1044 but was of the same attractancy as other genotypes.

4.4.2 LARVAL ARREST

4.4.2.1 ARREST OF 1st INSTAR LARVAE

Results are presented in Table 20.

Percent arrest of 1st-instar *C. partellus* was the same irrespective of genotype.



Key

1. BLANK 2. IS 18363 3. IS 18520 4. IS 1044 5. HYD 1

6. HYD 8 7. HYD 9 8. 1441B 9. Tx 623B

Fig 10. Mean % larvae (L1) reaching different test genotypes from a distance of 30 cm.

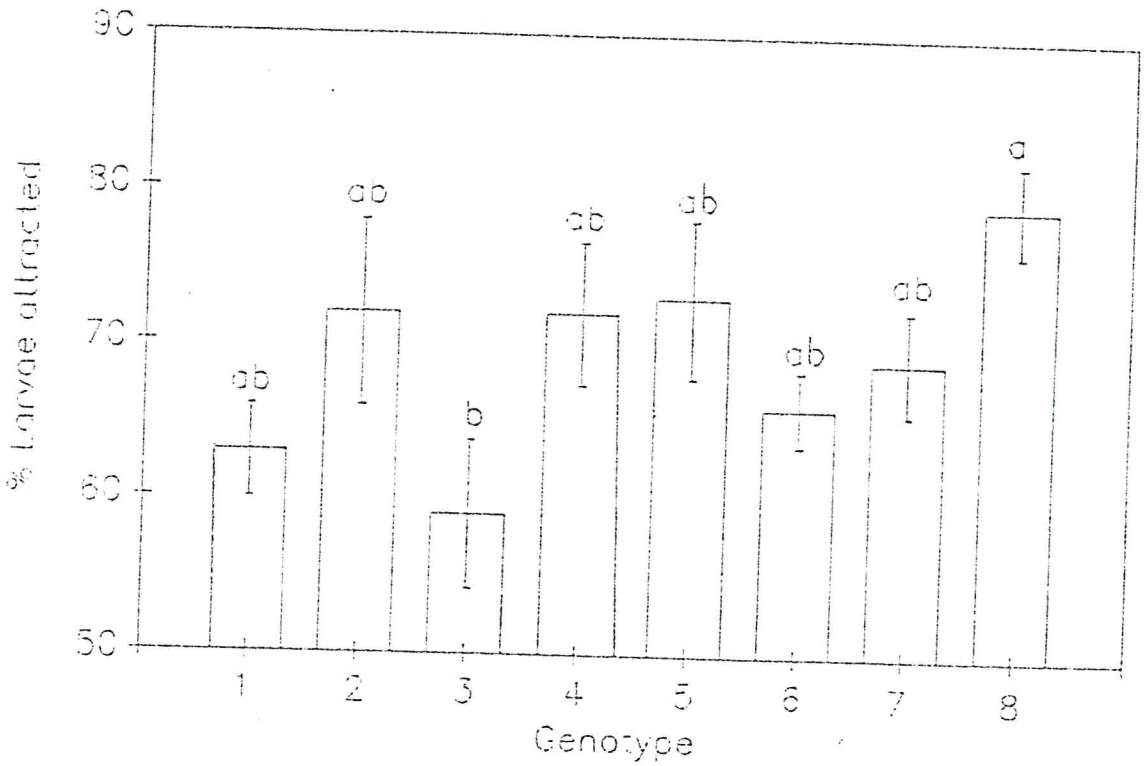
TABLE 19

MEAN PERCENT ATTRACTION OF 1st INSTAR *C. PARTELLUS* LARVAE TO DIFFERENT GENOTYPES (GROUP TESTS)

GENOTYPE	PERCENT ATTRACTION *
IS 18363	63.0 ± 3.0 AB
IS 18520	72.0 ± 6.0 AB
IS 1044	59.0 ± 4.8 B
HYD 1	72.0 ± 4.6 AB
HYD 8	73.0 ± 5.1 AB
HYD 9	66.0 ± 2.4 AB
Tx 623B	69.0 ± 3.3 AB
1441B	79.0 ± 2.9 A
CV	10.67

Figures are composed of means ± standard error.
Means followed by the same letters are not significantly different ($P \leq 0.05$; SNK) on arcsine-square root transformed data.

* = Ten insects were released per replicate .Means were derived from 10 replicates.



Key

1. IS 18363	2. IS 18520	3. IS 1044	4. HYD 1
5. HYD 8	6. HYD 9	8. Tx 623B	9. 1441B

Fig 11. Mean percent attraction of 1st instar *C. partellus* larvae to different genotypes (group tests).

TABLE 20

PERCENT ARREST OF 1st INSTAR LARVAE *C. PARTELLUS* BY DIFFERENT GENOTYPES

GENOTYPE	PERCENT LARVAE ARRESTED
IS 18363	65.4 ± 4.6 A
IS 18520	62.4 ± 4.0 A
IS 1044	49.9 ± 6.2 A
HYD 1	69.0 ± 3.9 A
HYD 8	58.9 ± 6.5 A
HYD 9	68.3 ± 1.8 A
Tx 623B	68.6 ± 4.6 A
1441B	62.8 ± 2.7 A
CV	10.55

Figures are composed of means ± standard error. Means followed by the same letter are not significantly different ($P \leq 0.05$; SNK) on arcsine-square root transformed data.

4.4.2.2 ARREST OF 4th INSTAR LARVAE

The results are presented in Table 21, Figure 12 and Appendix 16.

Mean percent arrest was highest on the susceptible check, IS 18363, but was not significantly different from arrest on Tx 623B and 1441B. Mean percent arrest was significantly lower on IS 1044, HYD 1, HYD 8, HYD 9 and to some extent IS 18520.

4.5 LARVAL DEVELOPMENT

4.5.1 LARVAL DEVELOPMENT OF 1st INSTAR *C.PARTELLUS* ON FRESH LEAVES AND STEM PIECES

Results are presented in Tables 22-23 and Appendices 17-21.

Percent pupation was lowest in the case of larvae raised on fresh leaves and stems of IS 1044. The other genotypes did not differ from one another.

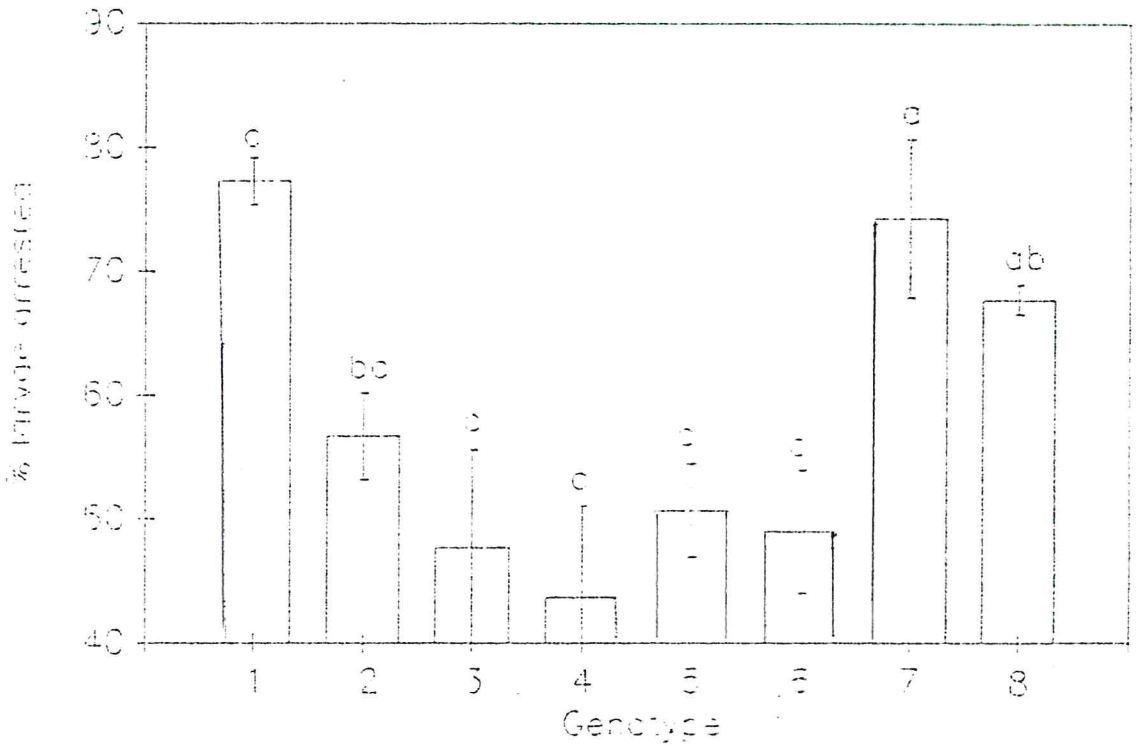
Larval period was longest for insects raised on IS 1044 (37.7 days). It was followed by HYD 1 (33.1 days). The larval period of insects raised on HYD 1 was in turn significantly longer than the period for insects raised on other genotypes.

TABLE 21

MEAN PERCENT ARREST OF 4th INSTAR *C. PARTELLUS* ON DIFFERENT GENOTYPES

GENOTYPE	PERCENT ARREST
IS 18363	77.3 ± 1.9 A
IS 18520	56.7 ± 3.5 BC
IS 1044	47.7 ± 7.9 C
HYD 1	43.7 ± 7.4 C
HYD 8	50.7 ± 3.8 C
HYD 9	49.0 ± 5.0 C
Tx 623B	74.3 ± 6.4 A
1441B	67.7 ± 1.2 AB
CV	8.73

Figures are composed of means ± standard error. Means followed by the same letters are not significantly different ($P \leq 0.05$; SNK) on arcsine-square root transformed data.



Key

1. IS 18363 2. IS 18520 3. IS 1044 4. HYD 1

5. HYD 8 6. HYD 9 7. Tx 623B 8. 1441B

Fig 12. Mean percent arrest of 4th instar *C. partellus* larvae on different genotypes.

TABLE 22

DEVELOPMENT OF Ist INSTAR *C. PARTELLUS* LARVAE ON FRESH LEAVES AND STEM PIECES IN THE LABORATORY (A)

GENOTYPE	MEAN LARVAL PERIOD	MEAN PERCENT PUPATION	MEAN DEVELOPMENT INDEX
IS 18363	27.7 ± 0.4 C	90.0 ± 4.1 A	3.3 ± 0.2 A
IS 18520	28.6 ± 0.6 C	82.5 ± 2.5 A	2.9 ± 0.1 A
IS 1044	37.7 ± 1.4 A	65.0 ± 8.7 B	1.7 ± 0.2 C
HYD 1	33.1 ± 0.6 B	80.0 ± 4.1 A	2.4 ± 0.2 B
HYD 8	27.4 ± 0.6 C	90.0 ± 4.1 A	3.3 ± 0.1 A
HYD 9	26.7 ± 0.3 C	85.0 ± 5.0 A	3.2 ± 0.2 A
Tx 623B	26.5 ± 0.4 C	92.5 ± 2.5 A	3.5 ± 0.1 A
1441B	27.2 ± 0.4 C	87.5 ± 2.5 A	3.2 ± 0.1 A
CV	4.6	10.93	10.4

Figures are composed of means ± standard error. Means followed by the same letters within a column are not significantly different ($P < 0.05$, SNK).

TABLE 23

DEVELOPMENT OF 1st INSTAR *C. PARTELLUS* LARVAE ON FRESH LEAVES AND STEM PIECES IN THE LABORATORY (B)

GENOTYPE	PERCENT ADULT		DAYS TO ADULT EMERGENCE	
IS 18363	90.0 ± 4.1	A	34.9 ± 0.5	C
IS 18520	82.5 ± 2.5	AB	35.8 ± 0.4	C
IS 1044	62.5 ± 10.3	B	45.8 ± 1.7	A
HYD 1	80.0 ± 4.1	AB	41.5 ± 0.8	B
HYD 8	90.0 ± 4.1	A	34.8 ± 0.8	C
HYD 9	85.0 ± 5.0	A	33.6 ± 0.3	C
Tx 623B	92.5 ± 2.5	A	33.2 ± 0.4	C
1441B	82.5 ± 4.8	AB	34.5 ± 0.4	C
CV	12.52		4.29	

Figures are composed of means ± standard error.
Means followed by the same letters within a column are not significantly different ($P \leq 0.05$, SNK).

The larval development index was lowest for insects raised on IS 1044 and was followed by HYD 1. All the other genotypes were significantly higher than HYD 1 (Figure 13).

Similarly, days to adult emergence was longest in the case of larvae raised on IS 1044 (45.8 days) and followed by larvae raised on HYD 1 (41.5 days) (Table 23).

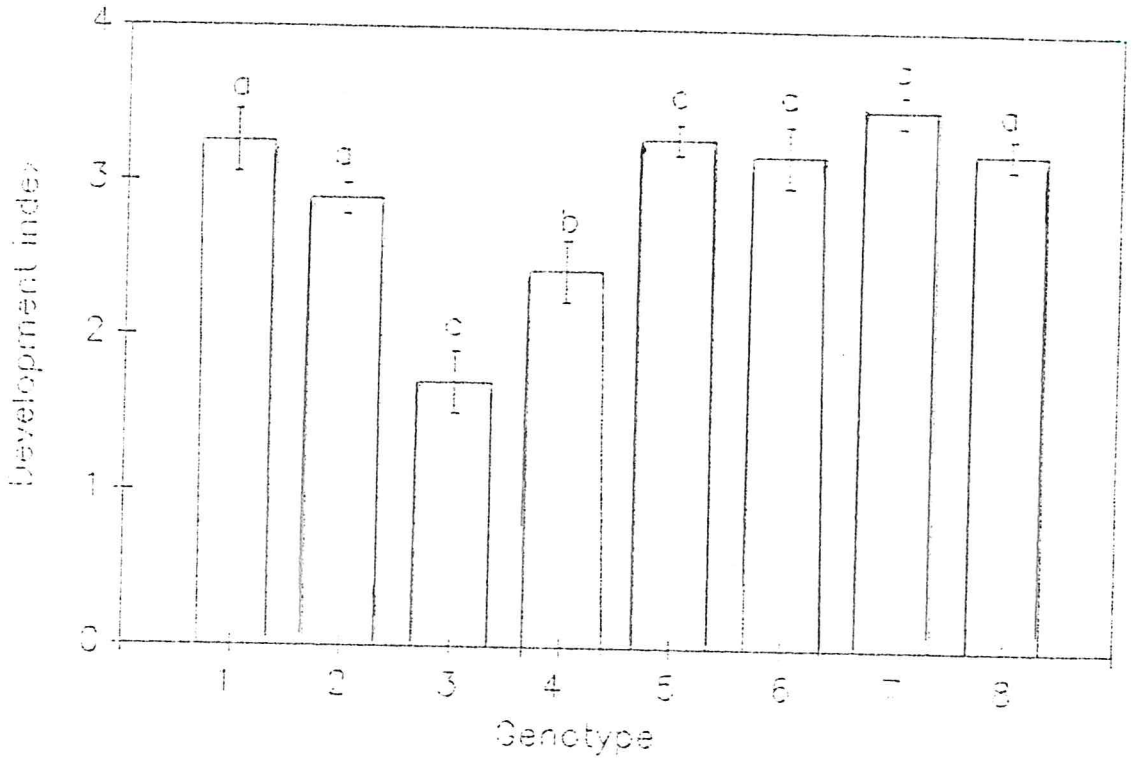
4.5.2 LARVAL DEVELOPMENT ON LIVE PLANTS IN THE SCREEN HOUSE

The results of this study are presented in Table 24 and Appendices 22-24.

Out of the total number of larvae recovered, IS 1044 had a significantly higher percentage in the 3rd instar than other genotypes. On HYD 9, no larvae were found in the 3rd - instar stage. IS 1044 and HYD 1 had a higher percentage of larvae in the 4th-instar than the other genotypes while HYD 9 had the least, being significantly lower than all the genotypes.

In the 5th/6th instar category, HYD 9 had the highest percentage of larvae and this was significantly higher than the figures for IS 18520 and HYD 8. IS 1044 and HYD 1 had the least percentage in this category (Figure 14).

At the time of data collection (24 days after infestation), generally, the larvae were just advancing to the pupal stage, and there no significant differences between genotypes in this category.



Key

1. IS 18363	2. IS 18520	3. IS 1044	4. HYD 1
5. HYD 8	6. HYD 9	7. Tx 623B	8. 1441B

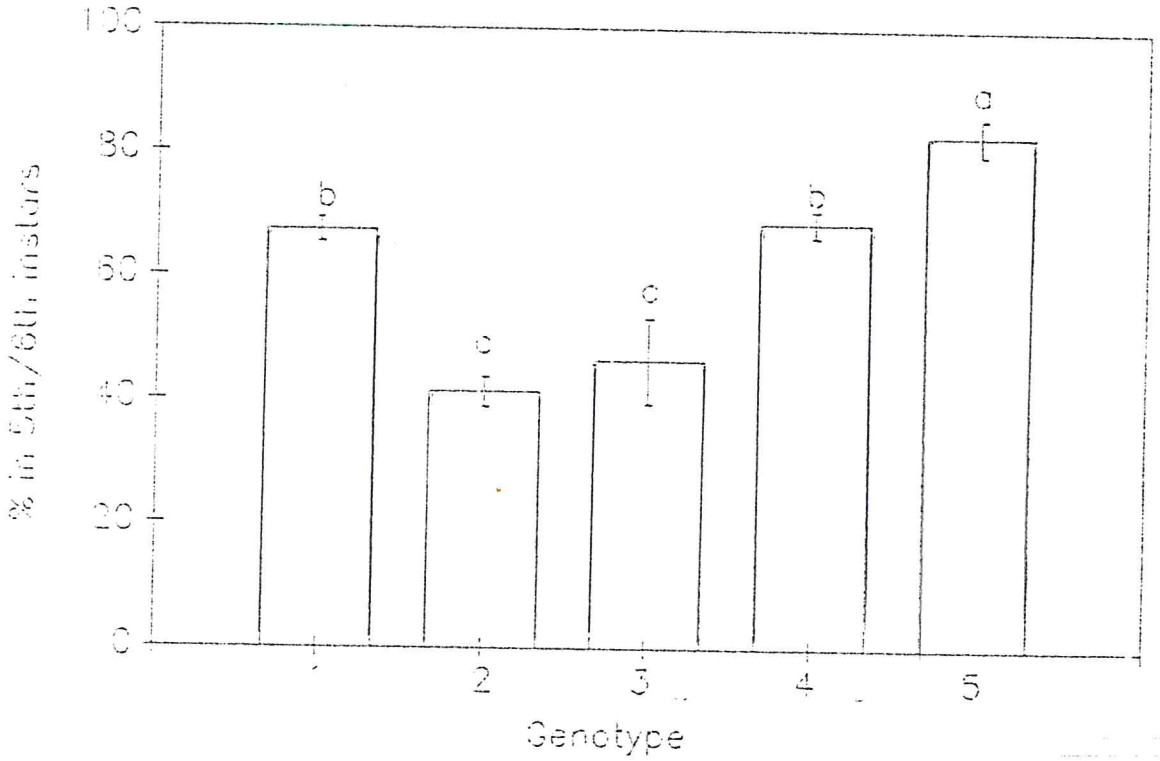
Fig 13. Mean development indices of *C. partellus* larvae on fresh leaves and stem of different genotypes.

TABLE 24

DEVELOPMENT OF *C. PARTELLUS* ON LIVE PLANTS IN THE SCREENHOUSE

GENOTYPE	MEAN NO. RECOVERED	MEAN % IN 3rd INSTAR	MEAN % IN 4th INSTAR	MEAN % IN 5th & 6th INSTAR	MEAN % IN PUPAL STAGE
IS 18520	5.30 ± 0.4A	0.61 ± 0.6B	27.80 ± 3.0B	67.39 ± 1.9B	4.20 ± 2.2A
IS 1044	5.47 ± 0.2A	8.64 ± 2.4A	48.79 ± 0.6A	41.36 ± 2.4C	1.21 ± 0.6A
HYD 1	1.83 ± 0.3B	2.08 ± 2.1B	51.53 ± 5.8A	46.39 ± 6.9C	0.00 ± 0.0 A
HYD 8	3.90 ± 0.6A	0.74 ± 0.7B	29.88 ± 1.9B	68.64 ± 2.1B	0.74 ± 0.7A
HYD 9	3.87 ± 0.7A	0 00 ± 0.0B	15.83 ± 2.7C	82.88 ± 2.9A	1.28 ± 1.3 A
cv	19.73	47.44	9.92	7.62	49.53

Figures are composed of means ± standard error. Means followed by the same letters within a column are not significantly different($P \leq 0.05$; SNK) on arcsine-square root transformed data for all columns except "mean no. recovered".



Key

1. IS 18520 2. IS 1044 3. HYD 1 4. HYD 8
5. HYD 9

Fig 14. Mean percent development of *C. partellus* larvae on life plants to the 5th/6th instar.

4.5.3 LARVAL DEVELOPMENT ON ARTIFICIAL DIET

The results are presented in Tables 25-27 and Appendices 25-30.

Percent pupation was lowest on IS 1044 (66.7 %) and HYD 1 (65.0 %) diets (Figure 15) and significantly different from the other genotypes including the sorghum deficient diet. Percent pupation in the other genotypes was 90-100.

Similarly, larval period was longest for larvae raised on IS 1044, HYD 1, and `no sorghum' diets ; the IS 1044 diet being significantly different from HYD 1 and `no sorghum' diets (Figure 16). Larvae raised on IS 18520 and the standard diets had the shortest larval period.

Further, larval development index was lowest for insects raised on HYD 1 and IS 1044 incorporated diets. The percentage of insects reaching the adult stage was lowest on IS 1044 diet and was followed by HYD 1 diet (Figure 17). It was highest on HYD 8, HYD 9, and 1441B incorporated diets (100 %) but these values were not different from those obtained for IS 18520, Tx 623B and the standard diets.

Similarly, days to adult emergence was longest for insects raised on IS 1044 and HYD 1 incorporated diets but was lowest on IS 18363, Tx 623B, and 1441B although they were not significantly different from HYD 8, HYD 9, and IS 18520 diets. Fewer larvae reached adult stage on HYD 1 and IS 1044 incorporated diets (Table 26; Figure 18).

TABLE 25

DEVELOPMENT OF 1st INSTAR *C. PARTELLUS* ON ARTIFICIAL DIETS (A)

GENOTYPE	MEAN PERCENT PUPATION	MEAN LARVAL PERIOD	MEAN DEVELOPMENT INDEX
NO SORGHUM	90.0 ± 10.0 A	38.1 ± 0.2 B	2.4 ± 0.3 C
STANDARD	97.5 ± 2.5 A	27.2 ± 0.2 F	3.6 ± O.1 A
IS 18363	97.7 ± 3.3 A	31.7 ± 0.2 CD	3.1 ± 0.1 B
IS 18520	100.0 ± 0.0 A	28.7 ± 0.1 FE	3.5 ± 0.0 AB
IS 1044	66.7 ± 3.3 B	47.5 ± 1.7 A	1.4 ± 0.1 D
HYD 1	65.0 ± 5.0 B	38.3 ± 0.5 B	1.7 ± 0.1 D
HYD 8	100.0 ± 0.0 A	31.5 ± 0.2 CD	3.2 ± 0.0 AB
HYD 9	100.0 ± 0.0 A	29.7 ± 0.1 DE	3.4 ± 0.0 AB
Tx 623B	100.0 ± 0.0 A	31.6 ± 0.4 CD	3.2 ± 0.0 AB
1441B	100.0 ± 0.0 A	32.9 ± 0.6 C	3.0 ± 0.1 B
cv	7.4	3.1	6.8

Figures are composed of means ± standard error. Means followedby the same letters within a column are not significantly different ($P \leq 0.05$; SNK).

TABLE 26

DEVELOPMENT OF 1st INSTAR *C. PARTELLUS* ON ARTIFICIAL DIET (B)

GENOTYPE	PERCENT ADULT	DAYS TO ADULT EMERGENCE
NO SORGHUM	70.0 ± 0.0 C	46.0 ± 0.4 B
STANDARD	92.5 ± 2.5 AB	35.9 ± 0.2 D
IS 18363	83.3 ± 3.3 B	39.8 ± 0.2 C
IS 18520	95.0 ± 2.9 AB	37.8 ± 0.3 CD
IS 1044	36.7 ± 6.7 E	56.3 ± 2.3 A
HYD 1	47.5 ± 6.3 D	46.0 ± 0.9 B
HYD 8	100.0 ± 0.0 A	39.0 ± 0.3 CD
HYD 9	100.0 ± 0.0 A	38.5 ± 0.4 CD
Tx 623B	96.7 ± 3.3 AB	39.8 ± 0.3 C
1441B	100.0 ± 0.0 A	41.0 ± 0.6 C
cv	8.0	3.5

Figures are composed of means ± standard error. Means followedby the same letters within a column are not significantly different ($P \leq 0.05$; SNK).

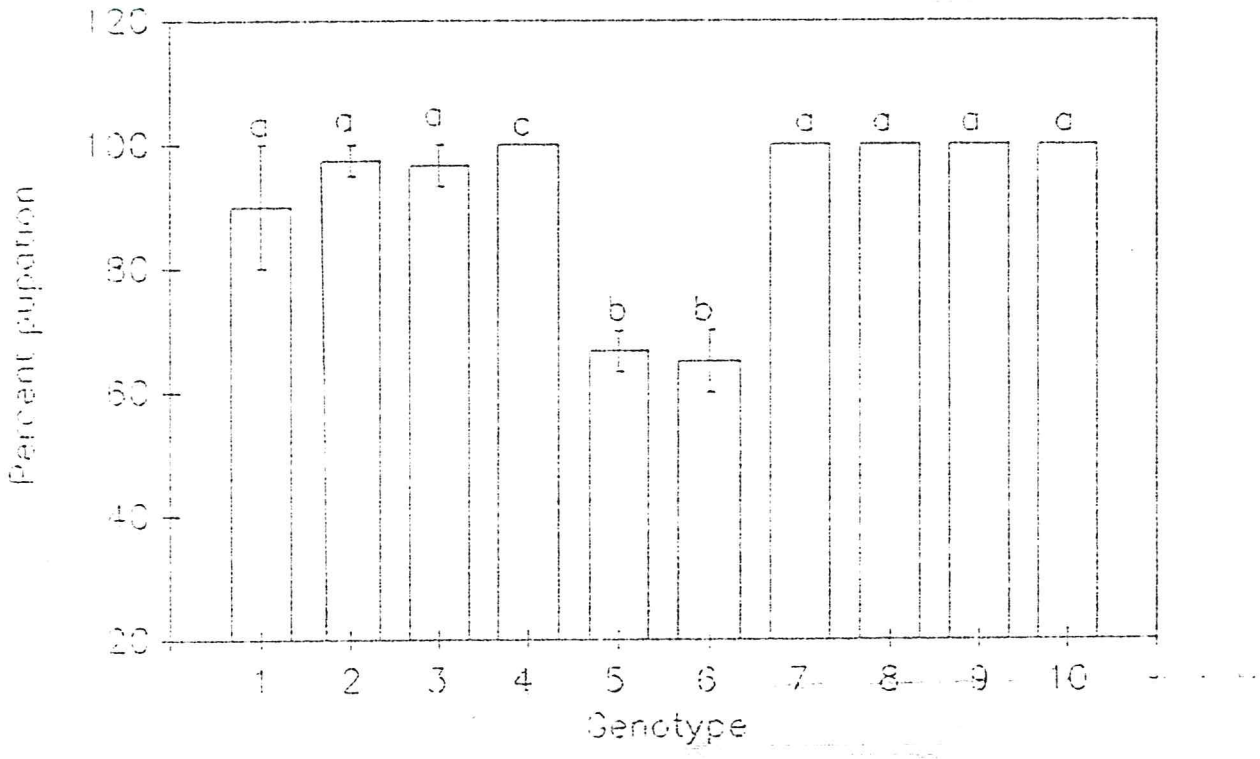
TABLE 27

MEAN NUMBER OF EGGS LAID BY *C. PARTELLUS* RAISED ON ARTIFICIAL DIET INCORPORATING VARIOUS GENOTYPES

GENOTYPE INCORPORATED	NO. OF EGGS
STANDARD	354.0 ± 22.8 AB
IS 18363	261.6 ± 13.5 B
IS 18520	308.6 ± 34.0 AB
IS 1044	174.2 ± 13.8 C
HYD 1	197.6 ± 9.9 C
HYD 8	366.0 ± 5.5 A
HYD 9	344.4 ± 29.5 AB
Tx 623B	356.8 ± 31.8 AB
1441B	329.2 ± 17.4 AB

cv = 2.91

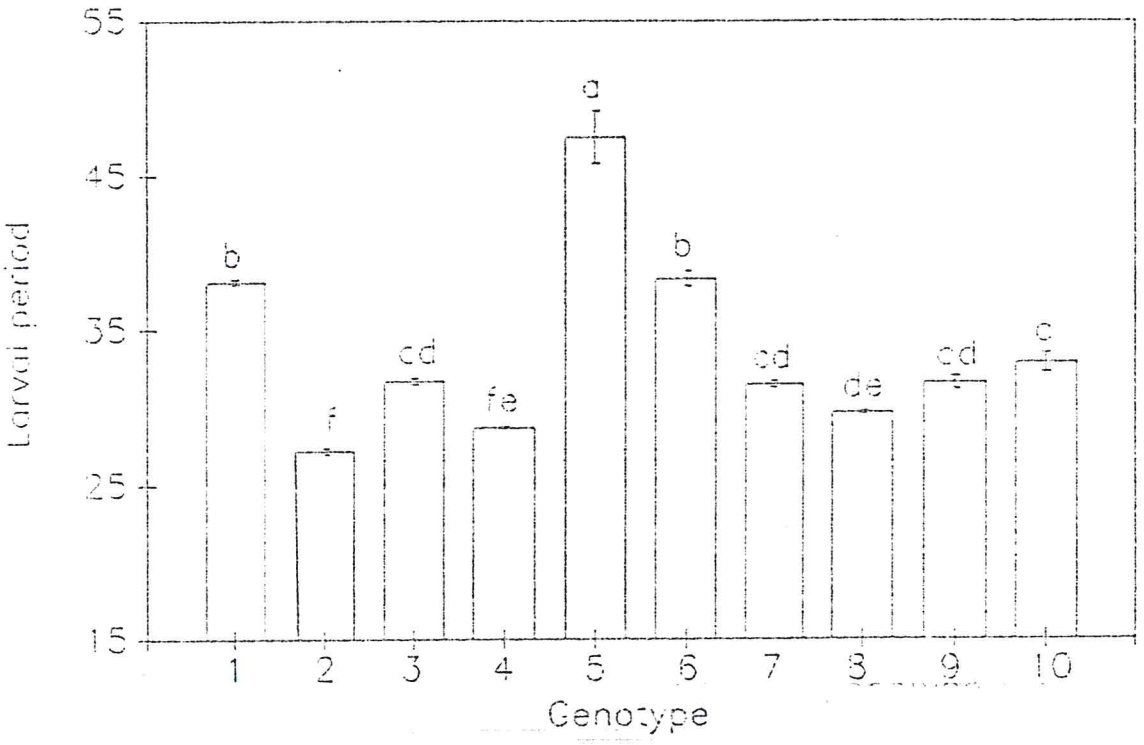
Figures are composed of means ± standard error. Means followed by the same letters are not significantly different on log(x) transformed data ($P \leq 0.05$; SNK).



Key

1. NO SORGHUM 2. STANDARD 3. IS 18363 4. IS 18520
5. IS 1044 6. HYD 1 7. HYD 8 8. HYD 9
9. Tx 623B 10. 1441B

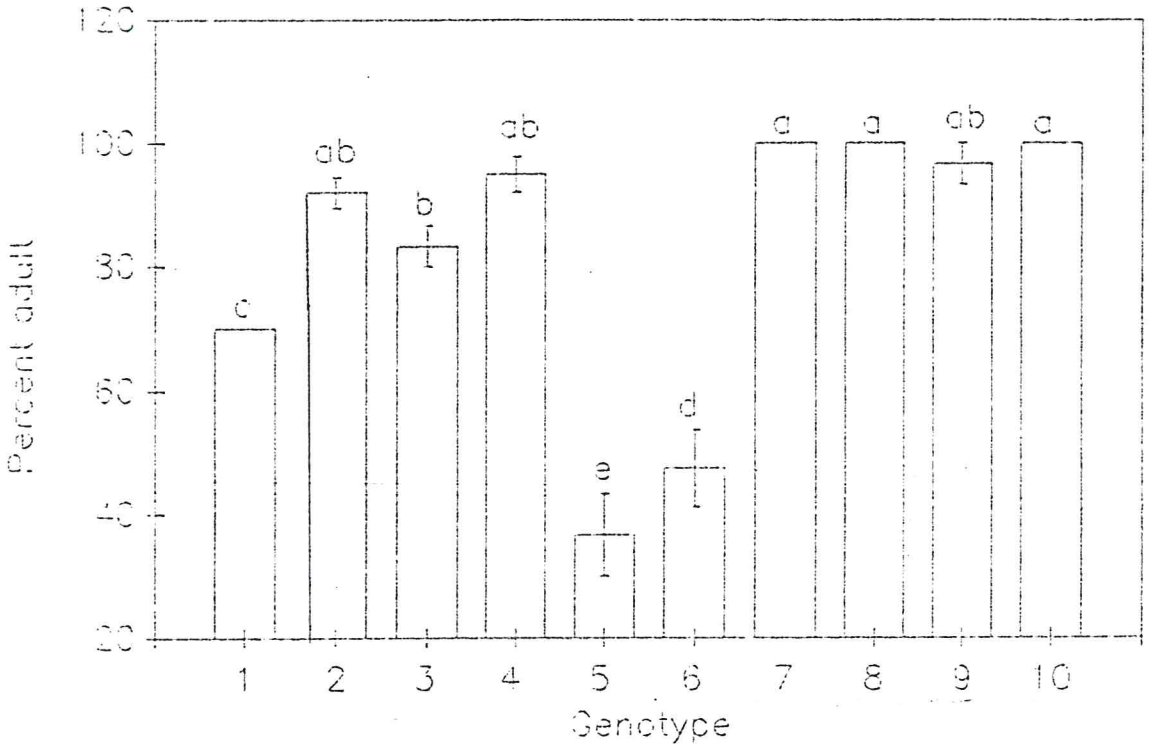
Fig 15. Mean percentage of 1st instar *C. partellus* reaching pupal stage on different diets.



Key

1. NO SORGHUM 2. STANDARD 3. IS 18363 4. IS 18520
5. IS 1044 6. HYD 1 7. HYD 8 8. HYD 9
9. Tx 623B 10. 1441B

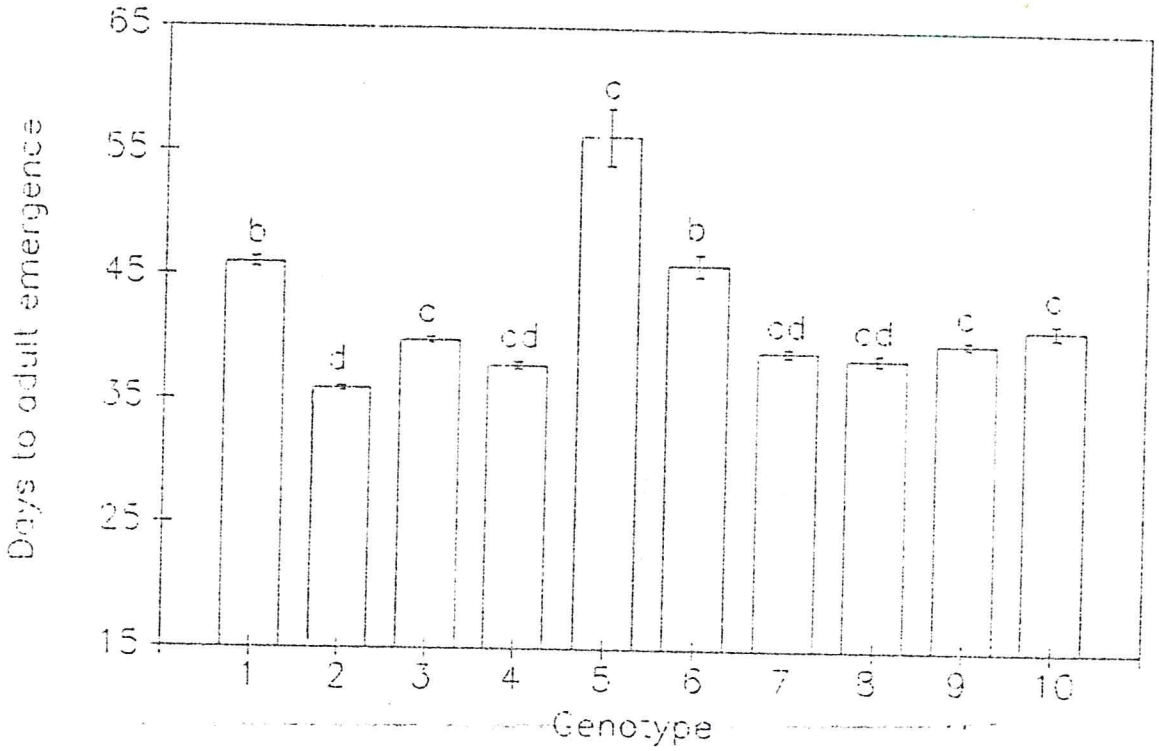
Fig 16. Mean larval period of *C. partellus* raised on different diets.



Key

1. NO SORGHUM 2. STANDARD 3. IS 18363 4. IS 18520
5. IS 1044 6. HYD 1 7. HYD 8 8. HYD 9
9. Tx 623B 10. 1441B

Fig 17. Mean percentage of 1st instar *C. partellus* reaching adult stage on different diets.

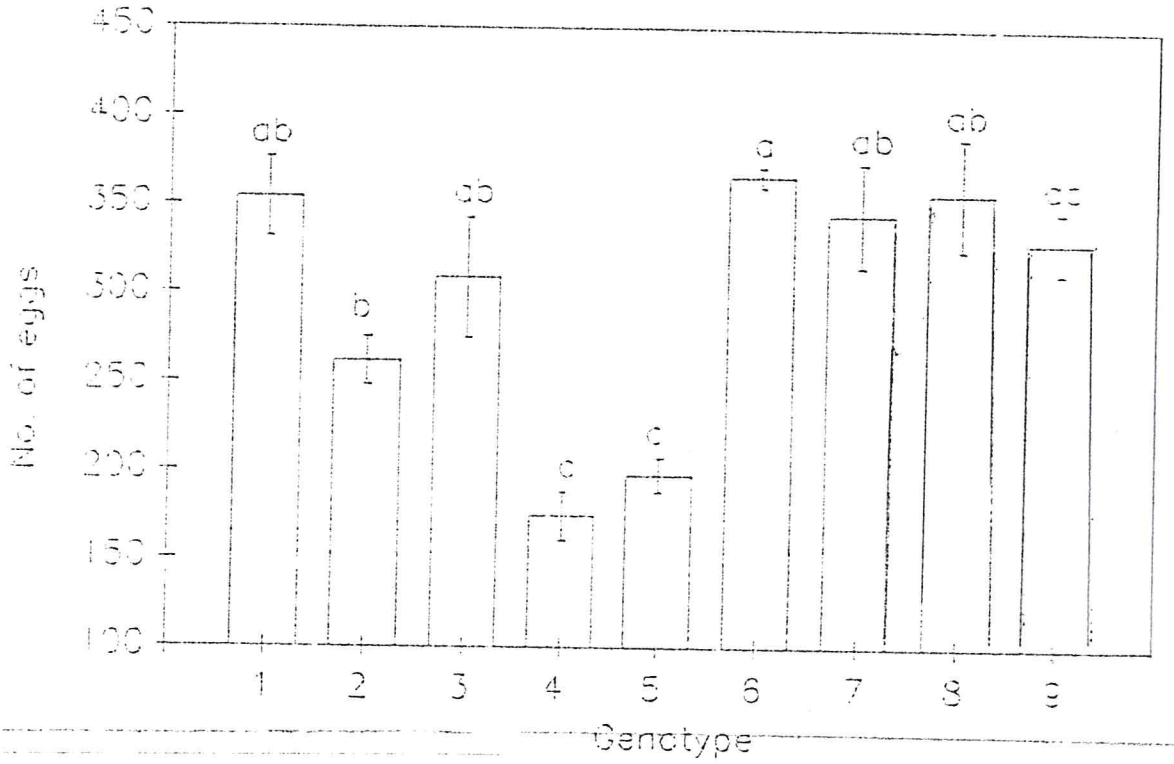


Key

1. NO SORGHUM 2. STANDARD 3. IS 18363 4. IS 18520
5. IS 1044 6. HYD 1 7. HYD 8 8. HYD 9
9. Tx 623B 10. 1441B

Fig 18. Mean days to adult emergence of *C. partellus* raised on different diets.

Further, fecundity was lowest for adults raised on HYD 1 and IS 1044 incorporated diets (Table 27; Figure 19).



Key

1. STANDARD 2. IS 18363 3. IS 18520 4. IS 1044 5. [illegible] 1

6. HYD 8 7. HYD 9 8. Tx 623B 9. 1441B

Fig 19. Mean number of eggs laid by *C. partellus* reared on artificial diet.

CHAPTER FIVE

5 DISCUSSION

5.1 EVALUATION OF TOLERANCE AND/OR RESISTANCE OF THE GENOTYPES TO THE STEM BORER IN THE FIELD (LONG AND SHORT RAINS, 1993)

Parameters such as cummulative tunneling, percent tunneling, percent foliar damage, mean number of holes, number of productive tillers, percent height reduction, yield and percent yield reduction are invaluable in helping the entomologist to properly categorise genotypes into the susceptible or resistant/tolerant classes. Each genotype that is being evaluated needs to be examined in the light of the above parameters and compared with known standard susceptible and resistant cultivars.

5.1.1 STEM TUNNELING

The high degree of cummulative tunneling during the long rains in some genotypes notably HYD 8 and HYD 9 which is comparable to that observed in the susceptible check IS 18363 to a considerable extent indicates that they were nutritionally adequate for the borers. Conversely, the lower amount of tunneling in IS 1044 at the 15 L1/plant

infestation level would tend to suggest inadequacy of the cultivar nutritionally.

During the short rains, the hybrids were not as heavilly tunnelled as the susceptible check IS 18363 suggesting that they were probably made more vulnerable during the long rains due to weather effect. The resistant check, IS 1044, showed lower amount of tunneling than the hybrids, Tx 623B, and 1441B an indication that IS 1044 has an antibiotic factor that reduces feeding, and/or the number of larvae feeding by causing mortality.

This observation on the susceptible and resistant checks (IS 18363 and IS 1044 respectively) is in agreement with the findings of Saxena (1986) and Pathak (1990) who both showed that IS 1044 was much less heavilly tunnelled than IS 18363, the former author attributing this difference to antibiosis in IS 1044.

Percent tunneling probably demonstrates more vividly the impact of infestation since it shows the actual amount of plant material lost to the borer relative to plant height. The lower percent tunneling (11.1) exhibited by IS 1044 at the infestation level of 15 L1/plant and to some extent at 30 L1/plant points again to the lower amount of tissue consumption by *C. partellus*. The high percent tunneling in IS 18363 and IS 18520 on the other hand would indicate that there is no feeding inhibition nor antibiosis in these genotypes. The relatively lower percent tunneling in Tx 623B and 1441B compared to IS 18363 and the tolerant

check IS 18520 may be due to the comparatively shorter heights of these genotypes.

5.1.2 PERCENT FOLIAR DAMAGE

The fact that all genotypes were equally affected during the long rains irrespective of infestation level in terms of amount of leaves damaged probably suggests a weather effect since a clearer picture was obtained during the short rains. During the latter season, and especially at 30 L1/plant infestation level, lower amounts of leaves were damaged on IS 1044, HYD 8, and HYD 1 compared to IS 18363 argueably because the larvae exhibited some degree of non-preference for feeding in the case of IS 1044 and HYD 1 (since they showed lower amount of stem tunneling indicating resistance to stem feeding) and presumably because of compensation in the case of HYD 8 . *C. partellus* has been shown to feed less on IS 1044 than on some other genotypes (Saxena,1986).

5.1.3 ENTRY/EXIT HOLES

During the long rains, HYD 9 and HYD 8 appeared to support the development of more borers up to the adult stage than any other genotype since they clearly had more entry/exit holes. Again, during the short rains, some other genotypes including IS 18520 and Serena (IS 18520) had

significantly more holes than IS 1044 and and to some extent HYD 1; this reveals that both IS 1044 and HYD 1 promoted the development of fewer larvae to the adult stage . This therefore means that both genotypes have some antibiotic factors in their tissues. IS 1044 has been previously shown to have antibiosis (Saxena, (1986).

5.1.4 TILLERING

The production of higher number of mature tillers than other genotypes by IS 18520, IS 1044 and HYD 9 is probably not in response to infestation but inheritance since irrespective of infestation level, number of tillers produced was the same. Tillering has always been associated with tolerance. Pathak (1990), who probably considered all tillers found, rather than those that were mature, attributed tolerance in IS 18520 to extra tiller production at early plant growth stages and later, on repair of plant injuries such as stem tunneling.

In this study, no significant correlation was found between percent yield reduction and tillering thus suggesting that tillers were not produced in response to infestation. Further, since no differences were found between uninfested plants and infested ones, the higher numbers of productive tillers found in IS 18520, IS 1044 and HYD 9 are simply inherent in these genotypes. However, since

many of these tillers became productive, they no doubt contributed to the yields of these genotypes.

5.1.5 INTERNODE LENGTH AND GIRTH DIAMETER

The effect of *C. partellus* infestation on internode length and girth was generally minimal during the two seasons thus suggesting that internode length and girth may not be useful parameters in establishing resistance/tolerance of the sorghum genotypes to *C. partellus*.

5.1.6 HEIGHT REDUCTION

The susceptible check, IS 18363, suffered more percent height reduction than other genotypes during both seasons , an indication that any genotype that can be able to prevent much height reduction might be able to tolerate attack by *C. partellus* to some extent.

5.1.7 YIELD AND PERCENT YIELD REDUCTION

The effect of *C. partellus* on the yield of any genotype can be assessed by considering the percentage of yield reduction caused. Low percent yield reduction suggests that the genotype is either resistant to attack or is tolerant or both. Percent yield reduction was quite low in

the case of IS 18520, IS 1044, HYD 1 and HYD 8 during both seasons.

For maize, (*Zea mays L.*), opinion differs as to the most important factor causing yield loss. Ampofo (1986) concluded that leaf feeding was the most important factor. Deadheart was regarded as most important by Mohyuddin and Attique (1978) while Ajala and Saxena (1993) concluded that stem tunneling was the most important factor causing yield loss.

In this study on sorghum, although correlation analysis showed percent yield reduction increasing as percent tunneling increased for only 3 genotypes during the long rains, this relationship was true of all genotypes except IS 18520 and HYD 8 during the short rains. This result agrees with the findings of Ajala and Saxena (1993) on maize. IS 18520 and to some extent HYD 8 stood out as genotypes whose yields appeared not to be affected by stem tunneling during this season.

Percent yield reduction significantly increased as percent foliar damage increased in five genotypes during the long rains and in three genotypes during the short rains an indication that foliar damage to a great extent also affect yield in sorghum. This finding is consistent with the report of Ampofo (1986) on maize in which foliar damage was associated with yield loss.

From the fore-going therefore, it appears that in sorghum both stem tunneling and to a great extent foliar damage contribute to yield loss.

Therefore, the low percent yield reduction in IS 18520, IS 1044, HYD 1 and HYD 8 must be due to either resistance to stem tunneling and/or leaf feeding, or tolerance of damage by the genotypes.

Percent tunneling, foliar damage and number of entry/exit holes were high in IS 18520 and HYD 8 compared to IS 1044 and HYD 1. As in IS 1044, HYD 1 may possess an antibiotic factor(s) that caused reduced leaf and stem feeding. In view of this and the low percent yield reduction, HYD 1 is considered resistant to *C. partellus*. The hybrid HYD 8 is considered tolerant because of its high level of stem tunneling and leaf feeding, but low percent yield reduction. Both IS 18520 and HYD 8 are tolerant probably because of a faster and more efficient uptake of nutrients from the soil arising from increased root production and thus compensating for damage by *C. partellus*. According to Jotwani (1976 ; 1978) and Kalode and Pant (1967) tolerant cultivars show a superior capacity to regenerate or replace damaged tissues or organs after attack.

Since HYD 9 and Tx 623B had high degrees of the damage parameters including moderate to high percent yield reduction but produced quite reasonable yields, they are considered moderately tolerant. Wiseman et al. (1972) stated

that the tolerance component of resistance involves the plant more than the insect in the insect-plant interaction. Similarly, Beck (1965) described tolerance as an important agronomic characteristic which implies a biological relationship between insects and plants that is quite different from resistance in the strict sense. Therefore, as long as the plant is able to produce a reasonable yield despite severe damge, tolerance cannot be overlooked. In fact, Painter (1968) considered tolerance to be present when the plant is able to produce well despite an insect populatiom equal to that which damages a susceptible host. The considerable damage (including collapse and toppling of some stems) and extremely great yield loss sustained by IS 18363 compared to HYD 9 and Tx 623B place these genotypes in the moderately resistant class.

On the other hand, since 1441B suffered high tunneling, high foliar damage, high percent yield reduction and produced very low yield like the susceptible check IS 18363, it is considered susceptible at least in the study area.

Smith (1989) cautioned that the terms antibiosis, antixenosis and tolerance are not biologically discrete entities and that combinations of each category may be responsible for resistance. Thus a genotype that shows antibiosis may also exhibit some tolerance.

5.2 EFFECT OF INSECT INFESTATION ON ROOTMASS OF FIVE GENOTYPES

Four of the genotypes involved in this study showed an indication of tolerance to *C. partellus*. IS 18520, the tolerant check is particularly note worthy as there was a 60 % increase in rootmass of infested plants over the control ones. Also, IS 1044, HYD 8 and HYD 9 did not suffer a reduction in rootmass as a result of infestation. On the other hand HYD 1 suffered a reduction in rootmass because of infestation.

Tolerance in sorghum had always been associated with extra tiller production at early plant growth stages and later on repair of plant injury (Pathak, 1990). However, from the previous study, since no significant differences were found in number of productive tillers of IS 18520 at the three infestation levels, tolerance in this genotype appears to be dependent on increased efficiency of the root system at obtaining nutrients from the soil rather than on number of tillers. Thus, by producing more roots (main plant plus tillers), a greater surface area is available to the infested plants for nutrient extraction from the soil, thereby giving it a greater potential to compensate for damage inflicted on it. This confirms the report by Wiseman et al.(1972) that the tolerance component of resistance involves the plant more than the insect in the insect-plant interaction. A similar observation had been reported on

maize (*Zea mays* L.) by Zuber et al.(1971) who showed that tolerance in maize to the western corn rootworm results from the greatly increased root volume of tolerant cultivars compared to that of susceptible ones.

The same argument is applicable to HYD 8 which maintained its rootmass despite infestation. The constant rootmass of IS 1044 may be due to antibiosis(Saxena,1986). HYD 1 and HYD 9 appear to possess a low degree of tolerance since infested plants had reduced rootmass, a factor that would definitely limit their chances of extracting more nutrients from the soil for compensational purposes.

5.3 OVIPOSITION

5.3.1 INFLUENCE OF THE SELECTED GENOTYPES ON OVIPOSITION

Norris and Kogan (1980) pointed out that differences in the ovipositional responses of an insect on two cultivars could be determined by either characters that were perceived at a distance (visual, hygro, or olfactory) or by contact (mechanical or chemical). In view of the observation that the ovipositional preference (OP) of *C. partellus* was the same for all genotypes including the resistant check IS 1044 none of the genotypes had any special adaptation or character that promoted or deterred oviposition and were all of the same attractancy. The positive OP values reveal that all the genotypes attracted *C. partellus* while the absence of negative values show that there was no contact inhibition (Saxena, 1987).

Non-preference for oviposition in IS 1044 due to lack of adequate olfactory stimuli had been reported (Saxena, 1987). However, in this study, non-preference for oviposition by *C. partellus* was not observed in any of the genotypes tested including IS 1044. The departure of IS 1044 from what was reported by Saxena (1987) could be due to the fact that eggs were deposited by *C. partellus* on even small dying older leaves as well as on the stem and midrib concavity of leaves. In this connection, Ampofo (1985) noted that the lower leaf surface and midrib concavity were preferred for

oviposition by *C. partellus* . He further observed that lower leaves, of 3-4 weeks old plants, were significantly preferred over the upper leaves for oviposition.

5.3.2 ROLE OF DISTANCE PERCEIVABLE STIMULI IN OVIPOSITION

According to the report of Norris and Kogan (1980), characters that promote the laying of more eggs on a genotype than another from a distance may be visual, hygro or olfactory. Since the test plants were screened from *C. partellus* by the nylon mesh, it follows that only the olfactory factor(s) would be operating. Therefore, IS 18363 elicited more egg laying by *C. partellus* because of an olfactory stimulus perceived by the insect from a distance. This stimulus may be absent in other genotypes or where present it may be in lower concentration or not of the right blend. It would promote more colonization of IS 18363 by the borer and would be one of the factors responsible for its susceptibility. On the other hand, the other genotypes would not be so quickly colonized by *C. partellus* and this would contibute to their overall resistance

5.3.3 ROLE OF CONTACT PERCEIVABLE STIMULI IN OVIPOSITION

The results of this study indicate that all the genotypes employed excluding IS 1044 had no characters/factors on the leaf surface that inhibited oviposition. On examination of leaf surfaces under the microscope, all genotypes including IS 1044 had smooth leaves, an indication that no mechanical factors (such as trichomes) that could inhibit oviposition existed on the leaves. Saxena (1987) found that non-preference for oviposition by *C. partellus* in sorghum cultivar IS 23175 was due to presence of hairs on the leaves. Similarly, Durbey and Sarup (1984) showed that trichomes inhibited egg-laying by this insect.
The low and negative OP value recorded for IS 1044 indicate non-preference for oviposition and this accounted for the significantly lower number of eggs laid on IS 1044.

Non-preference for oviposition by *C. partellus* on IS 1044 had been previously shown and was attributed to lack of adequate olfactory stimuli (Saxena, 1987).

The other genotypes used in this study elicited the same degree of response from *C. partellus* for oviposition on contact with the leaf surface.

5.4 LARVAL ORIENTATIONAL RESPONSE

5.4.1 ATTRACTION OF 1st INSTAR LARVAE

5.4.1.1 **Attraction to single plants of the target genotypes**

Virtually all genotypes showed the same attractancy from the 10 cm release point presumably because single plants of all genotypes emitted about the same quantity/concentration of plant odour. This explanation also stands for the 20 cm release point. When insects were released farther away (30 cm), all genotypes remained of the same attractancy except HYD 8 which was more attractive than IS 1044. Possibly, from this release point, in addition to plant odour, larvae received another cue (may be vision), that gave HYD 8 an edge over IS 1044. Visual and chemical stimuli are known to be perceived simultaneously during the orientation of an insect to a potential host plant (Shifriss, 1981).

From 40 cm release point, no genotype seemed to have an advantage over the other in terms of attractancy to *C. partellus*.

However, the fact that from all release points, the number of larvae that reached the centre of the board was significantly greater for all genotypes than the blank show that first instar *C. partellus* are attracted to sorghum. Further, from this study, more larvae were attracted from the North and West than the South and East because in the study area (on the shores of lake Victoria) the wind blew

approximately from the South-East to the North-West in the morning. Thus, plant odour was carried North-West. The result of this study conflicts with the report of Chapman and Woodhead (1985) who said that attraction of insects to sorghum was not known to occur, and that arrival on the plant may be the result of a random process. This study has shown that rather, *C. partellus* carry out directed movement toward odour source. Guerin (1987) suggested that phytophagous insects use olfactory stimuli to locate host loci and that numerous herbivorous insects employ odour conditioned anemotaxis as a mechanism of host location. Also, studies by Ishikawa et al. (1969) pointed out that in lepidopterous larvae, stimulation of the antennal olfactory receptors by plant odours may evoke short range orientation of an insect to a potential host plant.

5.4.1.2 **Attraction to groups of plants of the target genotypes**

The resistant check IS 1044 was least attractive to *C. partellus* larvae. It follows that the larvae received more olfactory cues from the other genotypes than IS 1044, and this would contribute to its resistance. Genotype 1441B was the most attractive and this would it make more vulnerable to colonization and damage by the borer.

This study, as in the previous one, shows that the borer is attracted to sorghum and differs from the speculation of Chapman and Woodhead (1985) that arrival of insects on

sorghum is a result of a random process and that attraction is not known to occur. This finding is consistent with that of Saxena (1990) who explained the differences between the percentages of *C. partellus* larvae moving towards different sorghum cultivars on the basis of differences in the attractancy of the plant. Further, his finding on IS 1044 is similar to that obtained in this study.

In an intercropping experiment, Ampong-Nyarko et al. (1994) found that 1st instar *C. partellus* that were hatched from eggs laid on non-host plants found their way to sorghum. This could only be efficiently done through use of olfactory cues, the larvae being attracted to sorghum. In this connection, Schoonhoven (1973) discussed the ability of lepidopteran larvae to select their food plants in an environment of several plant species.

This study therefore shows that 1st instar *C. partellus* perceive olfactory cues which help them to seek out and maintain contact with host material.

5.4.2 LARVAL ARREST

5.4.2.1 **Arrest of 1st Instar larvae**

Since all genotypes used in this study did not differ in the number of 1st instar *C. partellus* arrested, their leaf surfaces do not possess physical and chemical factors that impede settling or non-phagostimulatory factors that inhibit

feeding. Further, microscopic examination of the leaf surfaces of all the genotypes did not reveal any physical factors that could prevent larvae from settling. Therefore, larvae that are hatched from eggs laid on these genotypes would remain on them and would attempt to colonise them. Saxena (1990) reported lower percent arrest of 1st instar *C. partellus* on IS 1044 than on IS 18520 and IS 18363 but these three genotypes (all used as checks) did not differ in percent arrest of 1st instar larvae in this study. Roome (1980)

5.4.2.2 **Arrest of 4th instar larvae**

When the larvae feeding within a leaf whorl develop to late 3rd or 4th instar, they may bore into the stem for further feeding or move out of that plant (Saxena and Onyango, 1990). Larvae that move out would look for alternate plants and would need to get arrested to continue their development. Any genotype that promotes arrest of such larvae would increase the chances of its being damaged by the pest and this may make the difference between resistance and susceptibility. In this study, the low percent arrest of 4th instar larvae on IS 1044, HYD 1, HYD 8 and HYD 9 would contribute to their resistance against *C. partellus*. On the other hand, Tx 623B and 1441B would be rendered more susceptible. According to Smith (1989), both antixenosis and non-preference denote the presence of morphological or chemical plant factors that adversely alter

insect behaviour, resulting in the selection of an alternative host plant. Further, he stated that insect resistant crop plants may be devoid of or lack sufficient levels of phytochemicals that stimulate feeding or oviposition, or may possess unique phytochemicals that repel or deter insect herbivours from feeding. Kumar et al. (1993) indicated that low levels of larval arrest reflect the insects non-preference for a cultivar and hamper its colonization by the insect. Mechanical factors cannot be implicated in the poor arrest of 4^{th}-instar larvae by IS 1044 and to some extent HYD 8 since microscopic examination of the leaf surfaces of all genotypes employed in this study did not reveal morphological structures, such as trichomes,that could inhibit settling. The poor arrest of 4^{th} instar larvae by these genotypes must therefore be due to some chemical factors.

Poor larval arrest as reflected in dispersal of larvae from host plant has been observed in a number of sorghum cultivars. For example, Roome (1980) observed greater larval dispersal from the more resistant sorghum cultivars than from the susceptible ones. Similarly, greater movement of larvae from the more resistant IS 2205 to surrounding susceptible plants (CSH-1) than from the relatively susceptible IS 1151 was observed by Roome and Padgham (1980). Also, in maize, Ampofo (1986) reported more dispersal of *C. partellus* larvae from the resistant ICZ2-CM cultivar to the susceptible inbred A. Likewise, Robinson et

al. (1978) reported movement of *Ostrinia nubilalis* larvae off the host plant (dent corn; *Zea mays*) and attributed this to the presence of DIMBOA. It has been reported that DIMBOA could act as a feeding deterrent or repellent (Klun et al. 1967 ; Reed et al. 1972).

5.5 LARVAL DEVELOPMENT

5.5.1 LARVAL DEVELOPMENT OF 1st INSTAR *C. PARTELLUS* ON FRESH LEAVES AND STEM PIECES

As reflected by mortality, long larval period and days to adult emergence, and low larval development indices, both IS 1044 and HYD 1 clearly have antibiosis mechanism of resistance. On the other hand, the high larval development indices, the much shorter larval period and days to adult emergence, and low mortality point to the fact that the remaining genotypes were nutritionally adequate for the development of *C. partellus* larvae and do not contain any antibiotic factor.

Reports on larval development on certain sorghum cultivars (Jotwani et al. 1978; Jotwani, 1981) showed that the survival of *C. partellus* larvae was poor and their development slower on resistant than on susceptible cultivars. Saxena (1990) also reported antibiosis in IS 1044.

In this study, HYD 1 has also been shown to have antibiosis mechanism of resistance. Although the antibiotic effect of HYD 1 does not appear to be as lethal as IS 1044, its effect in prolonging larval period is note worthy. Smith (1989) stated that by decreasing the vigour and physiological state of the pest insect, resistant cultivars improve the search efficiency of predators and parasites and enhance the effectiveness of insect pathogens. He gave the example of the brown plant hopper, *Nilaparvata lugens* Stl.,on rice, which double the efficiency of hopper predators. Hence, resistant genotypes such as IS 1044 and HYD 1 could synergise the effects of biological control agents that suppress pest insect populations since they prolong larval period, and thus increase the chances of predation of larvae. Therefore, genotypes of this nature would readilly fit into an integrated pest management system.

5.5.2 LARVAL DEVELOPMENT ON LIVE PLANTS IN THE SCREEN HOUSE

The result suggest that larvae raised on IS 1044, the resistant check, and HYD 1 had the slowest rate of development. At 24 days after infestation, approximately 83 percent of larvae raised on HYD 9 were already in the $5^{th}/6^{th}$ instar stage compared to only 41% and 46% respectively in the case of IS 1044 and HYD 1 respectively. Like HYD 9, the other genotypes promoted good larval

development. At this same time, more larvae raised on IS 1044 and HYD 1 were in the 4th instar category than the case of other genotypes, with HYD 9 having the least number. Therefore, this result implies that HYD 1 and IS 1044 both have antibiotic factor(s) that slow down the rate of development of larvae. IS 1044 had been previously reported to have antibiosis (Saxena, 1990).

5.5.3 LARVAL DEVELOPMENT ON ARTIFICIAL DIET

Genotypes IS 1044 and HYD 1 possess antibiotic factor(s) which caused mortality of larvae resulting in lowest percent pupation of insects raised on artificial diet in which they were incorporated. Since larval development was being affected, insects raised on IS 1044 and HYD 1 incorporated diets also had the longest larval period as well as days to adult emergence. The growth indices of insects raised on diets containing these genotypes clearly show that larval development was being hampered. This report is consistent with that of Saxena (1992) on diets containing different genotypes including IS 1044, IS 18363 and IS 18520.

As suggested by their growth indices, genotypes Tx 623B, HYD 9, HYD 8 and IS 18520 diets (the tolerant check) were as good as the standard diet in promoting larval development. However, IS 18363 and 1441B were comparable to them in terms of adequacy for larval development.

The effect of antibiosis in HYD 1 and IS 1044 is again illustrated by its influence on fecundity. It explains why fecundity was lowest on IS 1044 and HYD 1, thus suggesting that the antibiotic factor(s) had a debilitating effect on adult *C. partellus*.

5.6 INTERACTION AND PROFILES OF THE COLONISING RESPONSES TO DIFFERENT GENOTYPES

The studies on the colonising responses show that the genotypes differed in the degree of one response or the other. Some responses were higher and others lower toward one genotype than toward another. Therefore, the net resistance or susceptibility of the genotypes would be determined by an interaction of the different colonising responses of the insect. This interaction can be better understood by comparing the profiles of the responses to different genotypes.

The profile for each genotype was developed by calculating the ratio of the mean value for each type of response in each genotype to that for the tolerant check IS 18520 (Serena). The response was then categorised into one of five grades (Saxena, 1990):

1. $\geq 0.0 < 0.4$ - very low (VL)
2. $\geq 0.4 < 0.8$ - low (L)
3. $\geq 0.8 < 1.2$ - medium (M)
4. $\geq 1.2 < 1.6$ - high (H)
5. ≥ 1.6 - very high (VH)

The profile for each genotype is shown in Table 28 . IS 1044 and HYD 1 had the highest number of responses in the low category. For IS 1044, three of the responses were in the very low grade, one in the low grade and the rest in the medium category. Similarly, HYD 1 had five of the responses in the low category. These low responses together would contribute to the overall resistance of these genotypes.

All the other genoypes had a maximum of two responses or none at all in the low category, and at least one in the high (or very high) category except HYD 8 which is highly tolerant. This therefore accounts for their moderate to low level of resistance, the latter being clearly illustrated by IS 18363 with four responses in the high or very high grade.

TABLE 28

INTERACTION AND PROFILES OF THE COLONISING RESPONSES OF *C. PARTELLUS* TO THE DIFFERENT GENOTYPES

GENOTYPE	OVIPOSITION		ATTRACTION OF 1st INSTAR		LARVAL ARREST		FOLIAR FEEDING (sr,30 L1/plant)	LARVAL DEVELOPMENT INDEX
					1st Instar	4th Instar		
	1	2	3	4				
IS 18363	M	L	H	M	M	H	VH	M
IS 18520	M	M	M	M	M	M	M	M
IS 1044	M	VL	M	M	L	M	VL	VL
HYD 1	L	M	H	M	M	L	L	L
HYD 8	L	M	M	M	M	M	L	M
HYD 9	M	L	H	M	M	M	VH	M
Tx 623B	M	M	H	M	M	H	VH	M
1441B	M	M	M	M	M	M	H	M

L1/plant- 1st instar per plant; SR- Short Rains
VH- very high; H- high; M- medium; L- low; VL- very low
1- Oviposition by female moths on the genotypes within oviposition chamber.
2- Ovipositon by female moths when restricted on the leaf surface of the genotypes.
3- Attraction of 1st instar larvae to single plants from 10 cm distance.
4- Attraction of 1st instar larvae to a group of plants.

CONCLUSIONS

All selected genotypes exhibited moderate to high resistance to *C. partellus* except the susceptible check IS 18363 and 1441B. The environment here at Mbita Point is probably not suitable for the production of this genotype. The significant interaction between genotypes and season (Appendix 31) showed that genotypes responded differently to infestation during the two seasons. One of the reasons for the poor performance of 1441B therefore could be the weather effect.

Evaluation of tolerance/resistance in the field showed that like IS 18520, HYD 8 was highly tolerant to attack by *C. partellus* since it suffered low percent yield reduction and thus was able to produce good yield despite high damage. Tolerance in IS 18520 is due to increased root volume rather than arising from tiller production since irrespective of infestation level (including 0 L1/plant), number of productive tillers did not change. In effect, tiller production in IS 18520 was not in response to infestation but hereditary. Tx 623B and HYD 9 were moderately tolerant since although they suffered serious damage yield reduction in this genotypes was much lower than the case with the susceptible check.

Field studies indicated that HYD 1, as in IS 1044 had the antibiosis mechanism of resistance since foliar damage and

percent tunneling were low thus resulting in low percent yield reduction.

Studies on larval development on artificial diet, on fresh leaves and stem pieces as well as on life plants in the screen house revealed that the rate of development of larvae on IS 1044 and HYD 1 was slower compared to other genotypes. Further, larval mortality was higher on these genotypes than any other one. This is an indication that like IS 1044, HYD 1 possessed an antibiotic factor (or factors) that was detrimental to the development of *C. partellus*. Although the effect of HYD 1 was not as lethal as IS 1044, the tremendously prolonged larval period would be advantageous in an integrated pest management system involving use of parasitoids since the search efficiency of these parasitoids would be increased. The reduced fecundity of female moths raised on these genotypes further confirm antibiosis.

The behavioural tests revealed that *C. partellus* larvae showed positive directed movement toward all genotypes (single plant test), suggesting that larvae that hatch from eggs laid away from the host plant or even on non-host plants do not arrive on the host plant as a result of random movement.

The results of the study on attraction of *C. partellus* larvae to a group of test plants revealed that these larvae showed non-preference for IS 1044 plants, and this indicated that the group of IS 1044 plants together emmitted a

concentration of plant odour that repelled the larvae. Therefore, in addition to antibiosis, this factor would contibute to the resistance of IS 1044 in a monoculture. On the other hand, the very high preference of the larvae for 1441B would further contribute to its susceptibility.

Since IS 1044, HYD 1, HYD 8, HYD 9 and to some extent IS 18520 were not as attractive to 4th instar larvae as the remaining genotypes, these larvae would disperse from them in search of alternate host plants and in the process may be exposed to harsh environmental conditions that may lead to their death. This factor would further contribute to the resistance of these genotypes.

Arriving 1st instar on a host plant or even those hatched directly on it would successfully colonize it only if there is no feeding inhibition or antibiosis. IS 1044 exhibited low percent foliar feeding compared to the other genotypes possibly due to antibiosis. While the slightly higher foliar feeding observed in HYD 1 may be attributed to antibiosis, that of HYD 8 and HYD 9 may be due to rapid compensation by the genotypes for damage inflicted by the larvae. The very high degree of foliar feeding in IS 18363, Tx 623B, and 1441B would promote their rapid colonization by *C. partellus* larvae.

Female moths laid equal number of eggs on all genotypes within the oviposition chamber because they had the option to lay anywhere on the plant including the stem and dying older but smaller leaves toward the base of the stem. The

differences in the number of eggs laid by the moths on different genotypes in the test to determine role of distance-perceivable stimuli showed that from a distance, the moths received more stimuli from some genotypes than others. Since the moths were screened from the genotypes (nylon mesh), some genotypes (IS 18520 and IS 18363) elicited more oviposition than others possibly because they emmitted a higher concentration of phytochemicals.

On direct contact with the surface of heathy, mature leaves, all genotypes except IS 1044 elicited oviposition than the non-plant ovipositional substrate because IS 1044 lacked adequate olfactory stimuli (Saxena,1987).

SUMMARY

1. All three mechanisms of resistance (non-preference, antibiosis and tolerance) were observed in the genotypes studied.
2. Field studies showed that IS 18520 (check) and HYD 8 were tolerant to attack by *C. partellus* . Tolerance in IS 18520 and possibly in HYD 8 was found to be associated with increased efficiency of the root system at extracting nutrients from the soil. HYD 9 and Tx 623B were moderately tolerant.
3. Yield reduction in sorghum appears to be due to both stem tunneling and leaf feeding.
4. As in IS 1044 (check), the primary mechanism of resistance in HYD 1 is antibiosis. It was reflected in low foliar and stem feeding, prolonged larval period and mortality.
5. First instar *C. partellus* larvae showed significant directed movement (single plant test) toward all genotypes over the control (blank). Presentation of larvae with a group of plants elicited non-preference for orientation toward IS 1044.
6. The genotypes tested did not differ in percentage of 1^{st} instar larvae arrested. IS 1044, HYD 1, HYD 8 and HYD 9 arrested significantly fewer 4^{th} instar larvae than other genotypes except IS 18520. This would contibute to their resistance.

7. When moths were restricted on the test plants, the susceptible check, IS 18363, elicited more egg-laying than other genotypes, and this would render it more suceptible.

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APPENDIX 1

ANOVA ON EFFECT OF LARVAL DENSITY ON DAMAGE CHARACTERS, TILLERING AND YIELD (LR, 1993)

INFESTATION LEVEL 0 L1/PLANT

PARAMETER	SOURCE	DF	SS	MS	F	Pr > F
Cum. Tunn	Rep	2	229.68	114.84	2.96	0.0849^{ns}
	Genotype	7	460.43	65.78	1.69	0.1902^{ns}
	Error	14	543.90	38.85		
Yield	Rep	2	0.85	0.42	5.49	0.0173*
	Genotype	7	19.69	2.81	36.45	0.0001***
	Error	14	1.12	0.08		
% Tunn	Rep	2	35.41	17.70	1.62	0.2337^{ns}
	Genotype	7	127.61	18.23	1.66	0.1977^{ns}
	Error	14	153.44	10.96		
Holes	Rep	2	0.89	0.44	1.72	0.2153^{ns}
	Genotype	7	2.32	0.33	1.29	0.3242^{ns}
	Error	14	3.64	0.26		
% Fol.Dam.	Rep	2	11.40	5.70	1.42	0.2741^{ns}
	Genotype	7	21.71	3.10	0.77	0.6190^{ns}
	Error	14	56.14	4.01		
Tillers	Rep	2	0.33	0.17	0.33	0.7213^{ns}
	Genotype	7	20.40	2.91	5.86	0.0025**
	Error	14	7.00	0.50		

INFESTATION LEVEL 15 L1/PLANT

PARAMETER	SOURCE	DF	SS	MS	F	Pr > F
Cum. Tunn	Rep	2	311.66	155.83	2.34	0.1326^{ns}
	Genotype	7	3425.61	489.37	7.36	0.0008***
	Error	14	931.28	66.52		
Yield	Rep	2	0.26	0.13	1.39	0.2824^{ns}
	Genotype	7	22.33	3.19	33.90	0.0001***
	Error	14	1.26	0.09		
% Tunn	Rep	2	103.23	51.61	2.20	0.1473^{ns}
	Genotype	7	167.01	23.89	1.02	0.4599^{ns}
	Error	14	328.02	23.43		
Holes	Rep	2	0.36	0.18	1.01	0.3910^{ns}
	Genotype	7	8.33	1.19	6.60	0.0014**
	Error	14	2.52	0.18		
% Fol.Dam.	Rep	2	133.00	66.48	1.29	0.3064^{ns}
	Genotype	7	682.63	97.52	1.89	0.1471^{ns}
	Error	14	722.26	51.59		
Tillers	Rep	2	0.64	0.32	0.95	0.4121^{ns}
	Genotype	7	16.89	2.41	7.12	0.0010**
	Error	14	4.76	0.34		
% Yldr	Rep	2	153.71	76.85	1.99	0.1741^{ns}
	Genotype	7	2953.47	421.92	10.90	0.0001***
	Error	14	541.80	38.70		
% Htr	Rep	2	390.38	195.19	2.56	0.1131^{ns}
	Genotype	7	2563.46	366.21	4.80	0.0062**
	Error	14	1068.48	76.32		

INFESTATION LEVEL 30 L1/PLANT

PARAMETER	SOURCE	DF	SS	MS	F	Pr > F
Cum. Tunn	Rep	2	2.35	1.17	0.01	0.9913^{ns}
	Genotype	7	3392.16	484.59	3.59	0.0199*
	Error	14	1887.76	134.84		
Yield	Rep	2	0.31	0.16	1.49	0.2586^{ns}
	Genotype	7	22.01	3.14	29.80	0.0001***
	Error	14	1.54	0.11		
% Tunn	Rep	2	3.47	1.74	0.05	0.9547^{ns}
	Genotype	7	305.52	43.65	1.17	0.3788^{ns}
	Error	14	522.62	37.33		
Holes	Rep	2	0.22	0.11	0.33	0.7261^{ns}
	Genotype	7	10.72	1.53	4.52	0.0080**
	Error	14	4.76	0.34		
% Fol.Dam.	Rep	2	247.42	123.71	2.72	0.1007^{ns}
	Genotype	7	705.11	100.73	2.21	0.0977^{ns}
	Error	14	637.70	45.55		
Tillers	Rep	2	0.96	0.48	4.45	0.0319*
	Genotype	7	28.01	4.00	37.23	0.0001***
	Error	14	1.54	0.11		
% Yldr	Rep	2	86.93	43.47	1.07	0.3691^{ns}
	Genotype	7	5844.75	834.96	20.58	0.0001***
	Error	14	568.12	40.58		
% Htr	Rep	2	390.38	195.19	2.56	0.1131^{ns}
	Genotype	7	2563.46	366.21	4.80	0.0062**
	Error	14	1068.48	76.32		

^{ns} = not significant at 5 % level

* = $P \leq 0.05$; ** $P \leq 0.01$; *** = $P \leq 0.001$

APPENDIX 2

ANOVA SHOWING INTERACTION BETWEEN GENOTYPE AND INFESTATION WITH RESPECT TO DAMAGE PARAMETERS, TILLERING AND YIELD

(LR, 1993)

PARAMETER	SOURCE	DF	SS	MS	F	Pr > F
Cum Tun	Rep	2	231.93	115.97	1.45	0.2447^{ns}
	Genotype	7	5256.02	746.57	9.35	0.0001***
	Infestation	2	3861.61	1930.80	24.20	0.0001***
	Gen.* Infe.	14	2052.29	146.58	1.80	0.0618^{ns}
	Error	46	3674.94	79.89		
Yield	Rep	2	0.68	0.34	3.40	0.0421^{ns}
	Genotype	7	59.08	8.44	84.09	0.0001***
	Infestation	2	19.72	9.86	98.23	0.0001***
	Gen.* Infe.	14	4.95	0.35	3.52	0.0006***
	Error	46	4.60	0.10		
% Tunn	Rep	2	48.38	24.19	1.01	0.3708^{ns}
	Genotype	7	342.80	48.97	2.05	0.0684^{ns}
	Infestation	2	1426.95	713.47	29.90	0.0001***
	Gen.* Infe.	14	254.33	18.38	0.77	0.6941^{ns}
	Error	46	1304.56	28.36		
Holes	Rep	2	0.24	0.12	0.45	0.6419^{ns}
	Genotype	7	15.47	2.21	8.39	0.0001***
	Infestation	2	25.48	12.74	48.38	0.0001***
	Gen.* Infe.	14	5.91	0.42	1.60	0.1147^{ns}
	Error	46	11.96	0.26		
% F.Dam.	Rep	2	94.63	47.31	1.27	0.2904^{ns}
	Genotype	7	713.87	101.98	2.74	0.0184*
	Infestation	2	11486.31	5743.15	154.20	0.0001***
	Gen.* Infe.	14	695.58	49.68	1.33	0.2252^{ns}
	Error	46	1713.04	37.24		

PARAMETER	SOURCE	DF	SS	MS	F	Pr > F
Tillers	Rep	2	0.07	0.04	0.11	0.8948^{ns}
	Genotype	7	62.20	8.89	27.12	0.0001***
	Infestation	2	2.42	1.21	3.69	0.0325*
	Gen.* Infe.	14	3.10	0.22	0.67	0.7860^{ns}
	Error	46	15.18	0.33		
% Yldr	Rep	2	126.99	63.49	2.39	0.1032^{ns}
	Genotype	7	5441.49	777.36	29.23	0.0001***
	Infestation	2	17857.14	8928.57	335.70	0.0001***
	Gen.* Infe.	14	3356.72	239.77	9.01	0.0001***
	Error	46	1223.60	26.60		
% Htr	Rep	2	182.94	91.47	1.45	0.2459^{ns}
	Genotype	7	2867.27	409.61	6.48	0.0001***
	Infestation	2	12690.96	6345.48	100.34	0.0001***
	Gen.* Infe.	14	1543.44	110.25	1.74	0.0791^{ns}
	Error	46	2909.04	63.24		

^{ns} = not significant at 5 % level

* = P ≤ 0.05 ; ** P ≤ 0.01 ; *** = P ≤ 0.001

APPENDIX 3

ANOVA ON EFFECT OF LARVAL DENSITY ON DAMAGE CHARACTERS, TILLERING AND YIELD (SR, 1993)

INFESTATION LEVEL 0 L1/PLANT

PARAMETER	SOURCE	DF	SS	MS	F	Pr > F
Cum. Tunn	Rep	2	12.07	6.03	0.44	0.6520^{ns}
	Genotype	7	625.96	89.42	6.54	0.0015**
	Error	14	191.52	13.68		
Yield	Rep	2	0.12	0.06	0.20	0.8179^{ns}
	Genotype	7	11.71	1.67	5.54	0.0032**
	Error	14	4.20	0.30		
% Tunn	Rep	2	2.61	1.30	0.23	0.8010^{ns}
	Genotype	7	415.72	59.39	10.26	0.0001***
	Error	14	81.06	5.79		
Holes	Rep	2	0.32	0.16	0.99	0.3946^{ns}
	Genotype	7	3.98	0.57	3.56	0.0207*
	Error	14	2.24	0.16		
% Fol.Dam.	Rep	2	137.06	68.53	1.50	0.2562^{ns}
	Genotype	7	233.89	33.41	0.73	0.6482^{ns}
	Error	14	638.12	45.58		
Tillers	Rep	2	5.29	2.65	2.42	0.1253^{ns}
	Genotype	7	60.52	8.65	7.90	0.0006***
	Error	14	15.26	1.09		

INFESTATION LEVEL 15 L1/PLANT

PARAMETER	SOURCE	DF	SS	MS	F	Pr > F
Cum. Tunn	Rep	2	49.01	24.51	1.83	0.1967^{ns}
	Genotype	7	1432.10	204.59	15.28	0.0001***
	Error	14	187.46	13.39		
Yield	Rep	2	0.22	0.11	1.49	0.2582^{ns}
	Genotype	7	18.96	2.71	37.59	0.0001***
	Error	14	0.98	0.07		
% Tunn	Rep	2	18.91	9.46	2.78	0.0963^{ns}
	Genotype	7	859.90	122.84	36.11	0.0001***
	Error	14	47.60	3.40		
Holes	Rep	2	0.69	0.34	1.84	0.1946^{ns}
	Genotype	7	5.64	0.81	4.31	0.0097**
	Error	14	2.66	0.19		
% Fol.Dam.	Rep	2	426.83	213.41	2.22	0.1457^{ns}
	Genotype	7	302.58	43.23	0.45	0.8549^{ns}
	Error	14	1347.50	96.25		
Tillers	Rep	2	4.90	2.45	0.97	0.4029^{ns}
	Genotype	7	74.40	10.63	4.21	0.0010**
	Error	14	35.28	2.52		
% Yldr	Rep	2	73.10	36.55	1.55	0.2464^{ns}
	Genotype	7	2523.73	360.53	15.30	0.0001***
	Error	14	329.98	23.57		
% Htr	Rep	2	92.61	46.30	1.29	0.3070^{ns}
	Genotype	7	315.91	45.13	1.25	0.3392**
	Error	14	503.86	35.99		

INFESTATION LEVEL 30 L1/PLANT

PARAMETER	SOURCE	DF	SS	MS	F	Pr > F
Cum. Tunn	Rep	2	55.84	27.92	2.61	0.1087^{ns}
	Genotype	7	1061.60	151.66	14.18	0.0001***
	Error	14	149.66	10.69		
Yield	Rep	2	0.12	0.05	0.49	0.6221^{ns}
	Genotype	7	19.55	2.79	25.69	0.0001***
	Error	14	1.54	0.11		
% Tunn	Rep	2	5.57	2.78	0.66	0.5314^{ns}
	Genotype	7	1486.21	212.32	50.48	0.0001***
	Error	14	58.94	4.21		
Holes	Rep	2	2.36	1.18	10.03	0.0020**
	Genotype	7	5.30	0.76	6.43	0.0016**
	Error	14	1.68	0.12		
% Fol.Dam.	Rep	2	598.90	299.45	5.41	0.0181*
	Genotype	7	2388.82	341.26	6.17	0.0020**
	Error	14	774.20	55.30		
Tillers	Rep	2	9.50	4.75	4.14	0.0386*
	Genotype	7	70.54	10.08	8.78	0.0003***
	Error	14	16.10	1.15		
% Yldr	Rep	2	35.56	17.78	0.60	0.5618^{ns}
	Genotype	7	2682.75	383.25	12.96	0.0001***
	Error	14	414.12	29.58		
% Htr	Rep	2	49.86	24.93	0.53	0.6007^{ns}
	Genotype	7	1055.60	150.80	3.20	0.0305*
	Error	14	660.10	47.15		

^{ns} = not significant at 5 % level

* = $P \leq 0.05$; ** $P \leq 0.01$; *** = $P \leq 0.001$

APPENDIX 4

ANOVA SHOWING INTERACTION BETWEEN GENOTYPE AND INFESTATION WITH RESPECT TO DAMAGE PARAMETERS, TILLERING AND YIELD (SR, 1993)

PARAMETER	SOURCE	DF	SS	MS	F	Pr > F
Cum Tun	Rep	2	82.33	41.16	3.36	0.0434*
	Genotype	7	2675.96	382.28	31.22	0.0001***
	Infestation	2	5578.90	2789.45	227.79	0.0001***
	Gen.* Infe.	14	443.69	31.69	2.59	0.0078**
	Error	46	563.50	12.25		
Yield	Rep	2	0.08	0.04	0.27	0.7641ns
	Genotype	7	44.29	6.33	40.88	0.0001***
	Infestation	2	23.66	11.83	76.44	0.0001***
	Gen.* Infe.	14	5.92	0.42	2.73	0.0052**
	Error	46	6.90	0.15		
% Tun	Rep	2	14.25	7.12	1.64	0.2059ns
	Genotype	7	2421.62	345.95	79.43	0.0001***
	Infestation	2	2629.85	1314.93	301.93	0.0001***
	Gen.* Infe.	14	340.21	24.30	5.58	0.0001***
	Error	46	200.56	4.36		
Holes	Rep	2	1.20	0.60	3.18	0.0509ns
	Genotype	7	13.49	1.93	10.22	0.0001***
	Infestation	2	17.46	8.73	46.28	0.0001***
	Gen.* Infe.	14	1.44	0.10	0.54	0.8922ns
	Error	46	8.74	0.19		
% F.Dam.	Rep	2	972.69	486.35	7.58	0.0014**
	Genotype	7	1745.46	249.35	3.89	0.0021**
	Infestation	2	7067.95	3533.97	55.10	0.0001***
	Gen.* Infe.	14	1179.82	84.27	1.31	0.2362ns
	Error	46	2949.98	64.13		

PARAMETER	SOURCE	DF	SS	MS	F	Pr > F
Tillers	Rep	2	18.78	9.39	6.38	0.0036**
	Genotype	7	180.10	25.73	17.49	0.0001***
	Infestation	2	9.41	4.70	3.20	0.0501ns
	Gen.* Infe.	14	25.36	1.81	1.23	0.2865ns
	Error	46	67.62	1.47		
% Yldr	Rep	2	57.93	28.97	1.68	0.1983ns
	Genotype	7	3296.23	470.89	27.25	0.0001***
	Infestation	2	14723.00	7361.50	426.02	0.0001***
	Gen.* Infe.	14	1910.25	136.45	7.90	0.0001***
	Error	46	792.58	17.23		
% Htr	Rep	2	4.06	2.03	0.07	0.5308ns
	Genotype	7	695.83	99.40	3.51	0.0042**
	Infestation	2	7485.18	3742.59	132.18	0.0001***
	Gen.* Infe.	14	675.68	48.26	1.70	0.0877ns
	Error	46	1302.26	28.31		

ns = not significant at 5 % level

* = P ≤ 0.05 ; ** P ≤ 0.01 ; *** = P ≤ 0.001

APPENDIX 5

ANOVA (MEAN SQUARES) ON TILLER PRODUCTION AND YIELD OF THE GENOTYPES

(LONG RAINS, 1993)

Tiller Production

SOURCE	DF	IS 18363	IS 18520	IS 1044	HYD 1	HYD 8	HYD 9	Tx 623B	1441B
REP	2	0.15^{ns}	0.17^{ns}	0.62^{ns}	0.08^{ns}	0.17^{ns}	0.18^{ns}	0.06^{ns}	0.63^{ns}
TRT	2	0.15^{ns}	0.10^{ns}	0.40^{ns}	0.10^{ns}	0.42^{ns}	0.08^{ns}	0.06^{ns}	0.52^{ns}
ERROR	4	0.15	0.10	0.60	0.38	0.69	0.25	0.14	0.44

Yield

SOURCE	DF	IS 18363	IS 18520	IS 1044	HYD 1	HYD 8	HYD 9	Tx 623B	1441B
REP	2	0.03^{ns}	0.20^{ns}	0.16^{ns}	0.004^{ns}	0.17^{ns}	0.19^{ns}	0.06^{ns}	0.04^{ns}
TRT	2	1.87^{***}	1.45^{*}	0.74^{**}	0.65^{ns}	0.39^{ns}	1.04^{ns}	5.52^{***}	0.68^{***}
ERROR	4	0.02	0.09	0.03	0.32	0.07	0.28	0.08	0.01

ns- not significant at 0.05 level; * $P \leq 0.05$; ** $P \leq 0.01$; $P \leq 0.001$

APPENDIX 6

ANOVA (MEAN SQUARES) ON TILLER PRODUCTION AND YIELD OF THE GENOTYPES

(SHORT RAINS, 1993)

Tiller Production

SOURCE	DF	IS 18363	IS 18520	IS 1044	HYD 1	HYD 8	HYD 9	Tx 623B	1441B
REP	2	1.96^{ns}	0.22^{ns}	6.08^{*}	5.67^{ns}	3.64^{ns}	1.90^{*}	0.34^{ns}	0.81^{ns}
TRT	2	1.35^{ns}	0.26^{ns}	2.19^{ns}	0.14^{ns}	3.71^{ns}	3.19^{*}	0.65^{ns}	5.91^{ns}
ERROR	4	1.01	3.34	0.50	0.98	1.91	0.27	1.04	2.25

Yield

SOURCE	DF	IS 18363	IS 18520	IS 1044	HYD 1	HYD 8	HYD 9	Tx 623B	1441B
REP	2	0.12^{ns}	0.09^{ns}	0.13^{ns}	0.23^{ns}	0.64^{*}	0.34^{ns}	0.05^{ns}	0.02^{ns}
TRT	2	3.16^{**}	0.32^{*}	0.16^{ns}	0.73^{*}	0.76^{*}	5.62^{***}	0.82^{**}	2.23^{*}
ERROR	4	0.15	0.07	0.46	0.06	0.06	0.08	0.03	0.13

ns- not significant at 0.05 level; * $P \leq 0.05$; ** $P \leq 0.01$; $P \leq 0.001$

APPENDIX 7

ANOVA ON EFFECT OF *C. PARTELLUS* INFESTATION ON ROOTMASS OF FIVE GENOTYPES

GENOTYPE	SOURCE	DF	SS	MS	F	Pr > F
HYD 1	Trt	1	21.39	21.39	46.10	0.0025**
	Error	4	1.86	0.46		
HYD 8	Trt	1	1.65	1.65	5.29	0.0829ns
	Error	4	1.00	0.50		
HYD 9	Trt	1	2.75	2.75	4.90	0.0913*
	Error	4	2.24	0.56		
IS 1044	Trt	1	1.33	1.33	3.00	0.1582ns
	Error	4	1.79	0.44		
IS 18520	Trt	1	14.45	14.45	53.38	0.0019**
	Error	4	1.08	0.27		

* $P \leq 0.05$;** $P \leq 0.01$
ns = not significant at 5 % level

APPENDIX 8

ANOVA SHOWING INTERACTION BETWEEN GENOTYPE AND *C. PARTELLUS* INFESTATION ON ROOTMASS OF FIVE GENOTYPES

Source	DF	SS	MS	F	Pr > F
Genotype	4	30.20	7.55	18.39	0.0001***
Trt	1	1.37	1.37	3.33	0.0832ns
Genotype * Trt	4	40.21	10.05	24.49	0.0001***
Error	20	8.21	0.41		

ns = not significant ; *** $P \leq 0.001$

APPENDIX 9a

ANOVA ON OVIPOSITIONAL RESPONSE OF *C. PARTELLUS* TO THE DIFFERENT GENOTYPES WITHIN OVIPOSITION CHAMBER

1. Ovipositional preference

Source	DF	SS	MS	F	Pr > F
Rep	3	409.86	136.62	0.35	0.7865^{ns}
Genotype	7	1747.95	249.71	0.65	0.7124^{ns}
Error	21	8098.44	385.64		

2. Number of eggs laid on genotypes

Source	DF	SS	MS	F	Pr > F
Rep	3	0.31	0.10	0.28	0.84^{ns}
Genotype	7	3.88	0.55	1.54	0.21^{ns}
Error	21	7.56	0.36		

3. Number of eggs laid on wax paper

Source	DF	SS	MS	F	Pr > F
Rep	3	38.37	12.79	0.80	0.5090^{ns}
Genotype	7	96.58	13.80	0.86	0.5524^{ns}
Error	21	336.76	16.04		

^{ns} = not significant at 5 % level

APPENDIX 9b

OVIPOSITIONAL RESPONSE OF *C. PARTELLUS* TO DIFFERENT GENOTYPES

GENOTYPE	NO. OF EGGS ON GENOTYPE	NO. OF EGGS ON WAX PAPER	PROB. >|T| OF DIFFERENCE
IS 18363	453.0 ± 87.5	30.3 ± 30.3	0.0113*
IS 18520	508.8 ± 175.9	4.5 ± 4.5	0.0258*
IS 1044	561.0 ± 119.0	15.3 ± 15.3	0.0130*
HYD 1	240.3 ± 117.9	0.0 ± 0.0	0.0265*
HYD 8	258.8 ± 37.5	20.0 ± 13.1	0.0145*
HYD 9	452.0 ± 95.3	0.0 ± 0.0	0.0026**
Tx 623B	456.5 ± 160.1	49.5 ± 43.7	0.0420*
1441B	579.3 ± 126.7	60.0 ± 34.7	0.0322*

* $P \leq 0.05$; ** $P \leq 0.01$

APPENDIX 10a

ANOVA ON ROLE OF DISTANCE-PERCEIVABLE STIMULI IN OVIPOSITION BY *C. PARTELLUS*

1. Anova on number of eggs laid on wax paper close to plant

Source	DF	SS	MS	F	Pr > F
Rep	7	37.19	5.31	1.98	0.08^{ns}
Genotype	7	28.54	4.08	1.52	0.18^{ns}
Error	49	131.64	2.69		

2. Anova on number of eggs laid on wax paper away from plant

Source	DF	SS	MS	F	Pr > F
Rep	7	20.30	2.90	0.90	0.5140^{ns}
Genotype	7	30.93	4.42	1.37	0.2383^{ns}
Error	49	157.82	3.22		

3. Anova on ovipositional preference for wax paper close to plant

Source	DF	SS	MS	F	Pr > F
Rep	7	2239.8	319.97	1.31	0.2664^{ns}
Genotype	7	2417.5	345.35	1.41	0.2219^{ns}
Error	49	11982.18	244.53		

^{ns} = not significant at 5 % level

APPENDIX 10b

ROLE OF DISTANCE PERCEIVABLE STIMULI IN OVIPOSITION

GENOTYPE	NO. OF EGGS ON WAX PAPER CLOSE TO PLANT	NO. OF EGGS ON WAX PAPER AWAY FROM PLANT	PROB.>|T| OF DIFFERENCE
IS 18363	188.0 ± 30.1	65.5 ± 21.9	0.0082**
IS 18520	155.0 ± 32.9	62.1 ± 13.4	0.0787*
IS 1044	181.3 ± 39.0	99.1 ± 37.0	0.1294ns
HYD 1	87.6 ± 21.7	171.8 ± 42.2	0.1851ns
HYD 8	147.0 ± 33.2	136.4 ± 29.5	0.9952ns
HYD 9	97.6 ± 44.2	84.6 ± 28.4	0.9601ns
Tx 623B	157.9 ± 27.8	188.1 ± 48.2	0.8313ns
1441B	176.3 ± 52.9	97.8 ± 32.7	0.5140ns

ns - not significant; **- P ≤ 0.01

APPENDIX 11a

ANOVA ON ROLE OF CONTACT PERCEIVABLE STIMULI IN OVIPOSITION BY *C. PARTELLUS*

1. Anova on number of eggs laid on genotypes

Source	DF	SS	MS	F	Pr > F
Genotype	7	45.06	6.44	4.75	0.0002***
Error	72	97.52	1.35		

2. Anova on number of eggs laid on wax paper

Source	DF	SS	MS	F	Pr > F
Genotype	7	107.26	15.32	5.36	0.0001***
Error	72	205.97	2.86		

3. Anova on ovipositional preference for genotype

Source	DF	SS	MS	F	Pr > F
Genotype	7	18944.3	2706.3	8.8	0.0001***
Error	72	22150.2	307.6		

*** $P \leq 0.0001$

APPENDIX 11b

ROLE OF CONTACT PERCEIVABLE STIMULI IN OVIPOSITION

GENOTYPE	NO. OF EGGS LAID ON GENOTYPE	NO. OF EGGS LAID ON WAX PAPER	PROB.>|T| OF DIFFERENCE
IS 18363	238.9 ± 34.1	60.9 ± 17.8	0.0001***
IS 18520	335.9 ± 36.7	19.8 ± 9.2	0.0001***
IS 1044	106.5 ± 30.9	179.8 ± 14.5	0.0513ns
HYD 1	345.7 ± 30.8	56.4 ± 20.7	0.0001***
HYD 8	286.1 ± 43.2	92.1 ± 29.3	0.0025**
HYD 9	262.8 ± 40.5	69.6 ± 24.6	0.0139*
Tx 623B	355.1 ± 50.7	22.3 ± 17.9	0.0001***
1441B	366.2 ± 33.2	103.0 ± 32.1	0.0001***

ns - not significant; * - $P \leq 0.05$; ** - $P \leq 0.01$
*** - $P \leq 0.001$

APPENDIX 12

ANOVA ON MEAN PERCENT 1st INSTAR *C. PARTELLUS* LARVAE REACHING THE GENOTYPES FROM DIFFERENT DISTANCES

SOURCE	DF	SS	MS	F	Pr > F
10 cm					
Rep	3	1270.85	423.62	3.11	0.0294*
Genotype	8	19386.03	2423.25	17.82	0.0001***
Genotype * Direction	27	4204.64	155.73	1.15	0.3058ns
Error	105	14280.49	136.00		
20 cm					
Rep	3	589.79	196.60	1.27	0.2881ns
Genotype	8	14744.90	1843.11	11.92	0.0001***
Genotype * Direction	27	4550.52	168.54	1.09	0.3655ns
Error	105	16235.47	154.62		
30 cm					
Rep	3	1663.15	554.38	4.70	0.0041**
Genotype	8	8429.41	1053.68	8.93	0.0001***
Genotype * Direction	27	6705.11	248.34	2.10	0.0040**
Error	105	12387.97	117.98		
40 cm					
Rep	3	523.73	174.58	1.25	0.2969ns
Genotype	8	6902.73	862.84	6.16	0.0001***
Genotype * Direction	27	2399.78	88.88	0.63	0.9126ns
Error	105	14709.93	140.09		

ns- not significant at 5 % level;* $P \leq 0.05$ ** $P \leq 0.01$; *** $P \leq 0.001$

APPENDIX 13

ANOVA ON MEAN PERCENT 1st INSTAR *C. PARTELLUS* LARVAE REACHING THE GENOTYPES FROM DIFFERENT DIRECTIONS

SOURCE	DF	SS	MS	F	Pr > F
North					
Rep	3	721.64	240.55	2.07	0.1081^{ns}
Genotype	8	17557.33	2194.67	18.93	0.0001***
Genotype * Distance	27	11992.80	444.18	3.83	0.0001***
Error	105	12176.35	115.97		
South					
Rep	3	807.63	269.21	1.94	0.1273^{ns}
Genotype	8	10135.27	1266.91	9.14	0.0001***
Genotype * Distance	27	8644.54	320.17	2.31	0.0013**
Error	105	14555.76	138.63		
East					
Rep	3	1414.71	471.57	4.27	0.0069**
Genotype	8	8061.24	1007.65	9.13	0.0001***
Genotype * Distance	27	12664.46	469.05	4.25	0.0001***
Error	105	11586.42	110.35		
West					
Rep	3	2625.46	875.15	5.17	0.0023**
Genotype	8	10502.44	1312.80	7.76	0.0001***
Genotype * Distance	27	9017.67	333.99	1.97	0.0078**
Error	105	17773.41	169.27		

ns- not significant at 5 % level; ** P ≤ 0.01; *** P ≤ 0.001

APPENDIX 14

ANOVA SHOWING THE VARIOUS INTERACTIONS IN THE STUDY ON LARVAL ATTRACTION.

SOURCE	DF	SS	MS	F	Pr > F
Rep	3	3262.74	1087.58	7.99	0.0001***
Genotype	8	43360.30	5420.04	39.82	0.0001***
Direction	3	8129.60	2709.87	19.91	0.0001***
Distance	3	29382.24	9794.08	71.95	0.0001***
Genotype * Direction	24	2895.98	120.67	0.89	0.6215ns
Genotype * Distance	24	6102.76	254.28	1.87	0.0082**
Direction * Distance	9	1135.94	126.22	0.93	0.5011ns
Gen. * Direc.* Dist	72	5698.53	79.15	0.58	0.9972ns
Error	429	58398.65	136.13		

ns- not at 5 % level; ** P ≤ 0.01; *** P ≤ 0.001

APPENDIX 15

ANOVA ON PERCENT ATTRACTION OF 1st INSTAR *C. PARTELLUS* LARVAE TO DIFFERENT GENOTYPES (GROUP TESTS).

Source	DF	SS	MS	F	Pr > F
Genotype	7	575.80	82.3	2.3	0.0550ns
Error	32	1166.08	36.44		

ns = not significant at 5 % level

APPENDIX 16

ANOVA ON PERCENT ARREST OF 4th INSTAR *C. PARTELLUS* ON DIFFERENT GENOTYPES.

Source	DF	SS	MS	F	Pr > F
Rep	2	200.20	100.10	5.25	0.0199*
Genotype	7	1301.50	185.90	9.75	0.0002***
Error	14	266.98	19.07		

* $P \leq 0.05$; *** $P \leq 0.001$

APPENDIX 17

ANOVA ON DEVELOPMENT OF *C. PARTELLUS* LARVAE ON FRESH LEAVES AND STEM PIECES IN THE LABORATORY: PERCENT PUPATION.

Source	DF	SS	MS	F	Pr > F
Genotype	7	1445.1	206.50	2.37	0.0544^{ns}
Error	24	2091.6	87.15		

^{ns} = not significant at 5 % level

APPENDIX 18

ANOVA ON DEVELOPMENT ON *C. PARTELLUS* LARVAE ON FRESH LEAVES AND STEM PIECES IN THE LABORATORY: LARVAL PERIOD.

Source	DF	SS	MS	F	Pr > F
Genotype	7	440.10	62.89	34.55	0.0001***
Error	24	25.92	1.82		

*** $P \leq 0.001$

APPENDIX 19

ANOVA ON DEVELOPMENT ON *C. PARTELLUS* LARVAE ON FRESH LEAVES AND STEM PIECES IN THE LABORATORY: DEVELOPMENT INDEX.

Source	DF	SS	MS	F	Pr > F
Genotype	7	9.76	1.39	14.83	0.0001***
Error	24	2.16	0.09		

*** $P \leq 0.001$

APPENDIX 20

ANOVA ON DEVELOPMENT ON *C. PARTELLUS* LARVAE ON FRESH LEAVES AND STEM PIECES IN THE LABORATORY: PERCENT ADULT

Source	DF	SS	MS	F	Pr > F
Genotype	7	2487.50	355.36	3.28	0.0137*
Error	24	2599.92	108.33		

* $P \leq 0.05$

APPENDIX 21

ANOVA ON DEVELOPMENT ON *C. PARTELLUS* LARVAE ON FRESH LEAVES AND STEM PIECES IN THE LABORATORY : DAYS TO ADULT EMERGENCE.

Source	DF	SS	MS	F	Pr > F
Genotype	7	560.70	80.10	32.21	0.0001***
Error	24	59.76	2.49		

*** $P \leq 0.001$

APPENDIX 22

ANOVA ON DEVELOPMENT OF *C. PARTELLUS* ON LIVE PLANTS IN THE SCREEN HOUSE: MEAN PERCENT IN 3rd INSTAR

Source	DF	SS	MS	F	Pr > F
Genotype	4	338.18	84.54	5.70	0.0118*
Error	10	148.30	14.83		

* $P \leq 0.05$

APPENDIX 23

ANOVA ON DEVELOPMENT OF *C. PARTELLUS* ON LIVE PLANTS IN THE SCREEN HOOUSE: MEAN PERCENT IN 4^{th} INSTAR

Source	DF	SS	MS	F	Pr > F
Genotype	4	1060.48	265.11	21.16	0.0001***
Error	10	125.30	12.53		

*** $p \leq 0.001$

APPENDIX 24

ANOVA ON DEVELOPMENT OF *C. PARTELLUS* ON LIVE PLANTS IN THE SCREEN HOOUSE: MEAN PERCENT IN $5^{th}/6^{th}$ INSTAR

Source	DF	SS	MS	F	Pr > F
Genotype	4	1321.91	330.48	21.07	0.0001***
Error	10	156.80	15.68		

*** $p \leq 0.001$

APPENDIX 25

ANOVA ON DEVELOPMENT *C. PARTELLUS* ON ARTIFICIAL DIET: PERCENT PUPATION.

Source	DF	SS	MS	F	Pr > F
Genotype	9	6118.14	679.80	14.72	0.0001***
Error	24	1108.32	46.18		

*** $p \leq 0.001$

APPENDIX 26

ANOVA ON DEVELOPMENT *C. PARTELLUS* ON ARTIFICIAL DIET: LARVAL PERIOD.

Source	DF	SS	MS	F	Pr > F
Genotype	9	1082.24	120.25	114.58	0.0001***
Error	24	25.20	1.05		

*** $p \leq 0.001$

APPENDIX 27

ANOVA ON DEVELOPMENT *C. PARTELLUS* ON ARTIFICIAL DIET: LARVAL DEVELOPMENT INDEX.

Source	DF	SS	MS	F	Pr > F
Genotype	9	17.92	1.99	52.79	0.0001***
Error	24	0.89	0.037		

*** $p \leq 0.001$

APPENDIX 28

ANOVA ON DEVELOPMENT *C. PARTELLUS* ON ARTIFICIAL DIET: PERCENT ADULT EMERGENCE.

Source	DF	SS	MS	F	Pr > F
Genotype	9	16361.76	1817.97	41.55	0.0001***
Error	24	1146.00	47.75		

*** $p \leq 0.001$

APPENDIX 29

ANOVA ON DEVELOPMENT *C. PARTELLUS* ON ARTIFICIAL DIET: DAYS TO ADULT EMERGENCE

Source	DF	SS	MS	F	Pr > F
Genotype	9	1050.39	116.71	55.82	0.0001***
Error	24	50.16	2.09		

*** $P \leq 0.001$

APPENDIX 30

ANOVA ON MEAN NUMBER OF EGGS LAID BY *C. PARTELLUS* RAISED ON DIFFERENT ARTIFICIAL DIET.

Source	DF	SS	MS	F	Pr > F
Genotype	8	3.01	0.38	13.85	0.0001***
Error	36	1.08	0.03		

*** $P \leq 0.001$