Damage assessment of *Sesamia cretica* Lederer (Lepidoptera – Noctuidae) on some varieties of sugarcane at Kenana Sugar Company

BY

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DEDICATION

To may Wife Raja,

my daughters Rania and Reem

my sons Walid, Abdu and Mohamed

Contents

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ABSTRACT

These studies were conducted to determine the effects of stem-borer, *Sesamia cretica* Lederer on plant cane and different ratoons of sugarcane, on sugarcane plots at different distances from sorghum fields, on susceptibility of some varieties of sugarcane and on yield of cane and quality of sugar. All experiments were carried out at the research farm and the commercial sugarcane fields at Kenana Sugar Company during 1997/1998 season.

The damage caused by the Larvae of *Sesamia cretica* i.e percent stalks bored, internodes bored and mean bored holes/stalk decreased with the advance of ratoons in both Co527 and Co6806 varieties. The damage caused to the plant cane or the first ratoon, was greater in Co527 compared to that in variety Co6806. Also the damage recorded in the second ratoon was nearly equal in both varieties, but the damage recorded on the ratoons 3---5 was greater in Co6806 than in Co527.

The percent damage of the shoots recorded in the sugarcane plots (10.84%) grown 50 metres away from the fields of rain fed dura at the time of dura harvest (Nov.), was significantly higher than that recorded from the other plots (2.32%) which lie 500 metres away from the rain fed

dura. Contrarily, this situation was reversed when the dura was grown in July, i.e the percentage of stalks or internodes bored was higher (18.66 , 1.08%, respectively) in the sugarcane plots which lie 500 metres from the dura fields compared to the nearer plot (11.03 , 0.54%, respectively).

Results of testing the susceptibility of 34 varieties of the plant cane to damage by the stem-borer showed that variety FR87288 was less susceptible to the stem-borer compared to varieties TUC 75-2 and BJ82156, respectively. However, the other varieties were medial in their susceptibility. The results of testing 23 varieties in the first ratoon showed that varieties BJ87109, Co6806, R572, Mex73523, Co527 and DB70279 were less susceptible compared to the variety B80251. The remaining varieties were also medial in their susceptibility.

The height and weight of the damaged cane were reduced by 7.89 and 13.46%, respectively compared to the undamaged ones. No significant differences were recorded between the percent of moisture, fibre, brix, pol, purity and estimated recoverable sucrose of the damaged cane compared to the undamaged one.

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1. INTRODUCTION

Sugarcane, *Saccharum officinarum L.* is a world wide crop which is grown in an intensive plantation scale in different parts of the World. In the Sudan, sugarcane production was started in 1963, at Gunnied Scheme on the eastern bank of the Blue Nile, approximately 31 miles north of Wad Medani town. The environmental conditions at this location are favourable for the cultivation of the crop. Similar conditions, also exist in some other parts of the country.

The agricultural policy of the Sudan is to achieve self-sufficiency in cash crops as well as in food crops. Hence, the efforts have been directed towards the development of the sugar industry. In addition to Gunnied, four sugar factories have been established at New Halfa (1965/66); north west Sennar (1976/1977); Assalaya (1979/1980) and at Kenana (1980/1981).

Kenana is the largest sugar factory in Africa. It's production exceeds that of the previously mentioned four factories collectively. Average annual production is approximatly 250,000 tonnes. The highest yield recorded was during 1986/87 and 1996/97 seasons (306,000 and 333,000 tonnes, respectively) (Ali, 1998).

In most countries, where sugarcane has been widely grown, the ravages of pests have threatened the existence of its industry. The insect species feeding on sugarcanes are diverse and are characteristically of limited geographical distribution. The regional character of pests of sugarcane, thier host plant relationships, the presumed origins of cultivated sugarcanes and the close botanical affinity of these wild canes and grasses of other genera, led to the conclusion that insect pests of sugarcane are generally local ones and that they invade sugarcane subsequent to its cultivation. Insect pests that attack sugarcane may have been introduced to a country with either the sugarcane, other plant materials, or independantly of plant materials (hitch- hiker) by means of transport. (Williams, 1969). The stem borers are the most widely prevalent pests, destructive and most difficult to control. The damage by individual species of borers is usually more pronounced at a particular stage of the crop growth and in certain specific portions of the shoot or cane, and hence they are grouped as stem, top and/or shoot borers (Karla, 1979 and Blackburn, 1984).

Different pests including stem borers were reported to attack sugarcane in Kenana. Because research work on pests attacking sugarcane is very scanty the present study was conducted with the aim to:

a- Conduct a field survey to study the magnitude of the stem-borers' damage to the plant cane and different ratoons of sugarcane.

b- Investigate the effects of distance between sugarcane and sorghum fields on the level of damage to sugarcane.

c- Study the relative susceptibility of some sugarcane varieties to stem- borers under natural infestation conditions at Kenana and.

d- Assess losses in yield and determine of the sugar quality of damaged compared to undamaged sugarcane.

2. Literature Review

2-1 Taxonomic Status

Sesamia cretica Lederer {Lepidoptern:Agrotidae (= Noctuidae) (Tams and Bowden, 1952; Jepson, 1954; Rao and Nagaraja, 1969) was first described and identified by Lederer in 1857. Hampson (1910) (c.f. Jepson, 1954) confirmed the name *Sesamia cretica* Lederer.

The genotype of *Sesamia*, has been described in 1852 by Guenee (Jepson, 1954).

A non-valid name, *Sesamia vuteria vuterioids* was given by Strand (1915). it was also described as *Sesamia cretica rufescens* (Schawerds, 1916); *Sesamia vuteria* Stoll (Mariani, 1934) and *Sesamia pecki* (Tams, 1938) (c.f. Tams and Bowden, 1952).

2.2 Distribution

Sesamia cretica is widely distributed throughout the Middle East, North and North East Africa, and Mediterranean Europe, except France and the Iberian Peninsula. (Tams and Bowden, 1952; Rao and Nagaraja, 1969; Williams, 1975).

The range of distribution of *Sesamia cretica* as reported by Schmutterer (1969) extends from Morocco in the west to north Algeria, Libya, Egypt and the Near East (Syria, Jordan, Israel, Irag, Iran, Saudi Arabia). It was also found in southern Italy, Corsica, Yugoslavia, Bulgaria and Greece. In east Africa the pest was recorded from Ethiopia and

Somalia. It was also recorded by Maes (1997) from Nigeria, Uganda and northern Kenya. In the Sudan *Sesamia cretica* dominates in the northern part of the Northern Province, where Gurier area represents the southern limit of it's distribution. (Siddig, 1966; 1971).

The pyralid, *Chilo partellus* Swinh and the noctuid, *sesamia cretica* Led. both are known stem borers on dura in the Gezira and in other dura growing areas in the country (Muddathir, 1970)

Williams (1975) reported that, little evidence of *sesamia cretica* was seen at Gunnied, Girba and Rabak. Young shoots killed by the borer were difficult to find although bored cane stalks were seen here and there at Rabak and Girba. This pest was not found on sorghum and millet at Rabak.

The stem- borer, *sesamia cretica* was observed attacking dura during September in the Nuba Mountains, but apart from the late sown and slow maturing varieties, little damage was caused (Bedford, 1936; Maxwell *et. al.*, 1948; Joyce, 1949).

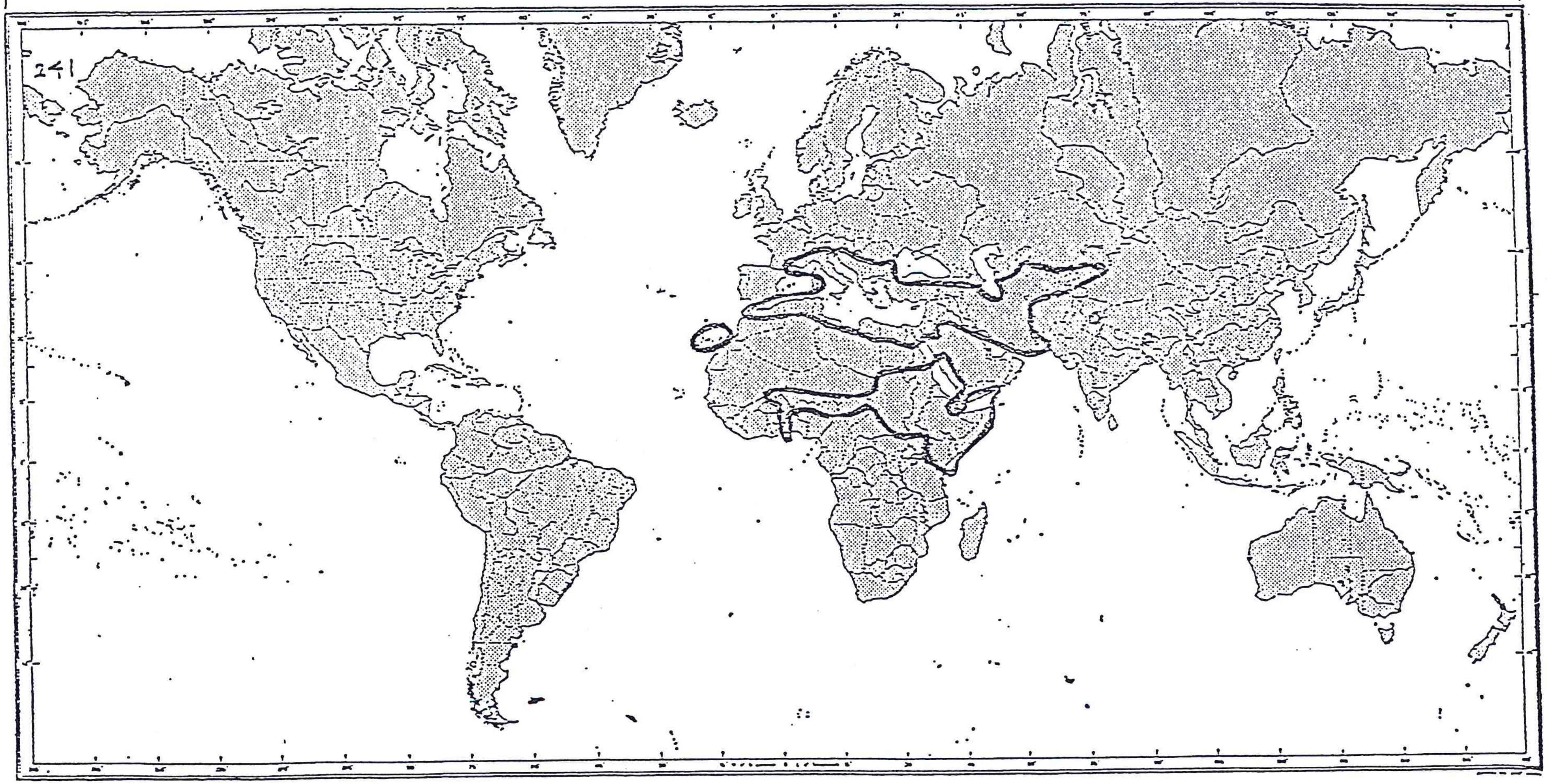
Sesamia cretica was observed attacking Dura in the Gash Delta and the Mechanized Crop Production Schemes by Maxwel *et. al.*, (1948).

The distribution of *Sesamia cretica* all over the world is shown on Fig. 1 which was prepared by the Common Wealth Institute of Entomology in 1968.

Fig 1: Map for distribution of *Sesamia cretica* in the World (prepared by the Commonwealth Institute of Entomology in 1968)

COMMONWEALTH INSTITUTE OF ENTOMOLOGY
DISTRIBUTION MAPS OF PESTS
Series A (Agricultural), Map No. 241 June 1968.
Published at:—56 Queen's Gate, London, S.W.7.

Pest: *Sesamia cretica* Led.
(=*S. vuteria* (Stoll))
(Lep., Noctuidae) (Durra Stem-borer)
Host Plants: Sorghum, maize, millet, wheat and sugar cane.



2-3 Host -Plants:

All the species of *Sesamia* attack several varieties of the family Graminaea such as sorghum, maize, sugarcane (Rao and Nagaraja, 1969; Williams, 1975); wheat, oats and barely (Rao and Nagaraja, 1969). And certain grass-weeds which serve as alternative host plants (Williams, 1975).

S.cretica was reported as a major pest of sorghum by many workers (Bedford, 1936, 1938; Malik, 1969; Williams, 1969; Schmutterer, 1969; Rao and Nagaraja, 1969; Muddathir, 1970; Ahmed, 1979; Elamin, 1978; Sampson, 1978). Five species of *Sesamia* including *S.cretica* have been reported attacking rice in West Africa (Heinrichs, 1998).

This species was recorded by Balachowsky and Mensil, (1936) as occuring in bamboo and even young palms in north Africa, (c.f. Tams and Bowden, 1952). It is also recorded on bullrush millet, (Bedford, 1936), and in much smaller numbers on rice (Sampson, 1978).

Bedford (1936) and Siddig (1971) reported the occurance of *S.cretica* on sorghum and maize. The former recorded it as a major pest of sorghum and to a lesser extent on maize, where as the latter reported that it preferes maize to sorghum. *Panicum reprns* followed by maize, proved to be the most preferred plants for *Sesamia cretica* (Ahmed, 1979)

Elamin (1978) showed that the late sown fodder grass (*Sorghum bicolor* var. Abu Sabein) and the grain sorghum varieties were preferred to sugarcane by *Sesamia cretica.*

William, (1975) reported that sugarcane does not seem to be a suitable host plant for *Sesamia* species. He added that *Sesamia clamistis* (Hmps) in Mauritius lays eggs on grasses, and the larvae which attack the cane shoot migrated from grasses in the near vicinity. The same observations were reported by Rao and Nagraja (1969) for *Sesamia inferens* (Wlk) and *Sesamia cretica* . On the other hand William (1975) stated that the eggs of *Sesamia cretica* are regularly laid on sugarcane in Iran and Irag.

Malik, (1969) recorded *Sesamia cretica* as a sorghum pest in the Sudan, although he reported the scarcity of the insect on sugarcane in the established plantation at Gunnied and Khashm El Girba.

In addition to grasses, Sedges (Cyperaceae) and Cat's-tails (Typhaceae) are important wild host plants for some stem-borers (Conlong, 1990).

2.4 Biology and life cycle

2.4.1 The Egg:

Generally, the eggs laid by the species which belong to the family Agrotidae are greater in number than those laid by the species which belong to the family Pyralidae. Eggs laid by species belonging to the former family are deposited in the inner side of the leaf sheath of sorghum, sugarcane or any host plant. Thus, the eggs and young larvae are well protected from parasites, and also from desiccation or heavy rains (Jepson, 1954; Williams, 1975). The eggs are layed in batches, each of 200 - 300 eggs and 3 - 5 batches may be layed at a time. Lespes and Jordan (1940) (c.f. Jepson, 1954) reported that *S. vuteria* Stoll (= *S. cretica*) laid 700-800 eggs under laboratory conditions. The colour of the eggs is creamy white and changes to pink and brown on the course of development (Jepson, 1954). The development of the eggs takes 3 - 6 days in tropical areas and may take longer, i.e 7 - 9 days in sub-tropical areas . However, this period may be prolonged to 26 days in the Mediteranean Region (Lespes and Jourdan, 1940). No diapause was recorded in the egg stage (Jepson, 1954). Gupta (1953) (c.f. Jepson, 1954) reported that the optimum conditions for the eggs of *Scirpophaga nivella*, F. hatching in the laboratory were 92% humidity and 22°C, and 30°C in the field.

2.4.2 The larva:

The larvae of *S.cretica* are large, stout Caterpillars, pink to violet in colour dorsally, and whitish ventrally. On reaching maturity the caterpillars make rough cocoons of silk and debris, either inside or outside the shoots, under the dry leaf-sheath (Rao and Nagaraja, 1969; Schmutterer, 1969; William, 1975). The larvae spend the first few days as leaf or sheath miners. They do not bore into the stem untill they reach the second or third instar (Kevan, 1944) (c.f Jepson, 1954). At pupation, the fully grown larvae return to the opennings of the tunnels, which are pluged with frass. One to twenty larvae may be found in one stem of sugarcane, maize or sorghum, but it is not uncommon to find two larvae in the same internode. The numbers of instars reported was five to eight instars. Both rainfall and relative humidity adversely affect the survival of young larvae (Jepson, 1954).

2.4.3 The pupa:

Pupation occurs either inside or outside the shoot. Prior to pupation, the larva makes a crude cocoon of silk and debris. The common site for pupation in the plant is on the inner surface of the dry leaf-sheath (Williams, 1975). The pupae of *S.cretica,* as reported by Schmutterer, (1969) are shiny brown in colour. The main diagnostic feature of the pupae is the form of the anal projection or cremaster, which is armed with as many as six tapering spines as in *S.cretica* (Jepson, 1954).

2.4.4 The adult:

The adults of *S.cretica* are stout-bodied moths, light brown in colour, and are nocturnal (Rao and Nagaraja, 1969). It is very rare to find the moth during the day even when a large population is present. The moths fly and mate in the evening. Their powers of flight are considerable where many species are attracted to light. The period of bright moon-light from 6 to 11 p.m. is said to reduce the effectiveness of the ordinary light trap (Jepson, 1954). On the other hand Elamin (1980) recorded high significant negative correlations of the moth catches with the mean monthly minimum temperature. He found no correlation with the mean maximum temperature.

The life span of the adult moth is short. It ranges from 1 - 2 weeks. Propably they do not feed. After short preoviposition period (2 - 3 days in some species) the female lays eggs for the next 4 - 5 days (Jepson, 1954).

2.4.5 Life cycle:

In general, the oviposition in *S.cretica* takes place at night. The incubation period takes 4 - 6 days at constant temperatures of 25 - 26° C. After hatching, the young larvae feed on tender leaves and in later instars burrow downwards in the heart or stem of the plant. Larval period may be completed in 6 - 7 weeks at temperatures of 27 - 28°C. Before pupation, the fully grown larva constructs an exit hole for the emergence of the adult. Pupation takes place in the stem and the pupal period lasts for one week or may be longer at temperatures of 26.5 - 27°c. In the Sudan, the whole life cycle is completed within a month. Several generations were observed when suitable conditions prevailled (Schmutterer, 1969). Moutia (1954) (c.f. Rao and Nagaraja, 1969) reported that the life cycle of *S.clamistis* Hmps. was 66 and 102 days at temperatures of 20 - 32°C and 17 - 19°C respectively. He added that at least five generations per year were recorded in Mauritius. Yanagihara (1934) (c.f. Rao and Nagaraja, 1969) gave the same number of generations for *S.inferens* (WLK.) in Taiwan. According to Krishnamurti and Usman (1952) there are four generations in India (c.f. Rao and Nagaraja, 1969). It was observed that the temperature and moisture conditions have an effect on the numbers of annual generations of the stem borers. (Lespes and Jordan, 1940) (c.f. Jepson, 1954).

2.4.6 Diapause :

The stem-borer, *S.cretica* can survive from one crop to another. The larval and pupal stages are found in dura stalks (Bedford, 1936; Schmutterer, 1969). The larvae of the stem-borers, *Busseola fusca* (Fuller) and *chilo partellus* lose about 50% of their body mass during diapause under laboratory condition in south Africa (Kfir, 1991).

Pests at the extremes of their geographical range, such as *Diatreae saccharalis* (F.), passes the cool winter season in a state of hibernation. Apparently, this is not a physiological diapause, since the larvae may moult and even feed on warm days throughout the period. In some species, the larval diapause is induced by the dry conditions of the stalks, independently of temperature, as recorded for *Diatreae liveolata* (WLK) in maize in Trinidad and *S.cretica* in the Sudan (Jepson, 1954). Bedford (1938) observed that contact with water promotes the pupation of the diapausing larvae in the crop stubbles.

2.5 Damage and Economic Importanc:

2.5.1 Damage caused by the borers:

At any stage of growth, sugarcane stalks are liable to attack by different species of borers , which may be classified into four species according to the part of the stalk attacked viz. Shoot-, internode -, stalk -, stem , top - and root-borer. The species of the borer is not neccesserily restricted to one habit, thus *Chilo infuscatellus* Sn. is found as shoot, top and internode borer. The distinction between many shoot borers, top and internode borers, (being based on the stage of development of the stalk), is purely arbitrary (Metcalfe, 1969).

2.5.1.1 Shoot borer:

The young caterpillars of the shoot borer feed on the young rolled leaves. When the latter are fully developed, rows of irregular holes may be found in them (Schmutterer, 1969). Older larvae destroy the meristematic tissues of the shoot. This is followed by the death of the shoot, resulling in a condition known as "dead heart" (Sampson and Kumar, 1984). The borers enter the plant laterally through one or more holes in the stalk and bore downwards as well as upwards cutting off the central leaf spindle which dries up causing 'a dead heart' that can be pulled out easily. The damaged parts inside the stem rot and the dead heart emits an offensive odour when pulled out. The larvae feed on the soft tissues and make cavities extending to the setts. The injury of shoots after the formation of internodes, seldom results in dead hearts (Avasthy and Tiwari, 1986a).

The infestation during the germination phase results in killing the mother shoot and consequently the drying up of the entire clump, creating gaps in the field. But when the attack occur in the tillering phase, the clumps are not killed (Sampson and Kumar, 1984; Avasthy and Tiwari, 1986a). The damage caused by the shoot borer induces compensatory tillering if the mother shoot is not damaged. A positive correlation was recorded between mortality, which is due to the borer, infestation and tiller emergence. But as far as cane production is concerned, the late formed tillers show loss in weight and quality and do not compensate the loss by tillering (Avasthy and Tiwari, 1986a).

2.5.1.2 Internode -, stalk - and stem - borers:

Soon after hatching, the larvae move on the upper surface of the leaf for 15 minutes, feeding by scraping the inner surface of the leaf-sheath and after one week they reach the second instar. 2 - 6 were recorded in one leaf-sheath. Such infested leaf-sheaths rot and subsequently the whole leaf dries up (Chaudhary and Sharma, 1986). The third instar larvae bore into the shoots and internodes of the cane (Gupta, 1981) (c.f. Chaudhary and Sharma, 1986). Visual symptoms of damage are only noticed when the leaf-sheath of damaged cane are removed. In such a case the borer-holes are seen clearly on the internodes (Chaudhary and Sharma, 1986).

The internode - borers feed mainly in the internodes, but may also tunnel through the nodes and the damage may be seen in any part of the cane stalk. (Ruinard, 1958; Williams, 1961) (c.f. Metcalfe, 1969). Loss in weight of cane results from cane tissue being fed on, desiccation and impaired growth. Severe attack causes rottening and death of the whole stalk. Weakening of the nodes often results in breakage, development of side shoots and late tillers (Ruinard, 1958; William, 1961) (c.f. Metcalfe, 1969). As a result of infestation, the sucrose contents of the cane are seriously affected. Normal extraction, brix, pol and purity are decreased, and impurities such as nitrogen gum and ash are increased (Box, 1929; Ellis *et. al*, 1960; william, 1961; David and Karla, 1967) (c.f. Metcalfe, 1969). The tunnels made by the borers open ways to the bacteria, fungi and yeast infections. (Mayeux and Colmer, 1960) (c.f. Metcalfe, 1969). Olufolaji (1987) reported that 90% of the fungus of the sugarcane red-rot disease, enters through the tunnels caused by the sugarcane stem borer, *Diatreae saccharalis* (F.).

2.5.1.3 The top borer:

The larvae eat their way into to the central core of the spindle through the unfurled leaves, and as a result rows of shot-holes become visible when the leaves were unfold (Mukunthan, 1986). As the larvae feed by eating their way through the narrow central core towards the growing points, they also nibble the inner halves of the leaves, immediately surrounding the feeding region. The leaves dry up, become atrophied, their colour turns dark brown and finally forming the dead hearts. Such leaves can not be pulled out easily because they are never severed off transversally in the course of feeding by the larvae (Mukunthan, 1986). The formation of dead heart induces sprouting of the lateral buds giving rise to a bunchy top appearance. Occasionally, the infestation by the top borer iduces aerial root formation (Singh et al., 1980).

The sucrose content is usually adversely affected, but the attack after the ninth month may result in early ripening (Metcalfe, 1969).

2.5.1.4 The root-borer:

The root-borer generally infests the young shoots, though it is known to infest grown-up canes as well. When infestation occurs during the early stages of growth, dead hearts are formed. However, in the grown up canes, no external symptoms, except yellowing of leaves, are discernible and inorder to detect attack, the cane have to be dug out (Avasthy and Tiwari, 1986 b). The character for the differentiation between the dead heart caused by the root borers from that caused by other species is that, in the former case the dead heart cannot be pulled out easily and often, the plant itself is pulled out, with the larvae either hung out near the broken end of the shoot or they remain partly inside the stem under the soil surface and partly protruding outside. Also the dead heart does not emit any offensive smell and often one or more leaves which are adjacent to the central leaf whorl dry up. There is only one entry hole near the base of the shoot. (Rahman and Singh, 1942; Cheema, 1948) (c.f. Avasthy and Tiwari, 1986 b).

2.5.2 Economic importance and level of infestation:

Losses caused by the sugarcane borers may be divided into field losses and factory losses, i.e reduced cane tonnage and reduced sugar per unit weight of millable cane, respectively. Furthermore, losses due to the cost of processing of damaged canes in the factory also occur (Williams, 1969).

The importance of shoot borers comes from the heavy cane losses through gaps in the crop stand and losses in the yield due to the late-formed canes with reduced weights and sucrose contents. However, it is extremely difficult to determine the losses caused by the borers to the younger crop (Rao and Nigaraja, 1969; Avasthy and Tiwari, 1986 a).

A loss of 9% was reported by Haldane (1937) (c.f. Avasthy and Tiwari, 1986 a) while Sehgal *et.al.*(1942) (c.f. Avasthy and Tiwari, 1986a) have calculated a loss of 0.3% due to the shoot borer infestation. A decrease of 10 tonnes per hectare in yield has been calculated by Ramachandrachari (1959) (c.f. Avasthy and Tiwari, 1986a). In the Sudan, Elamin (1977) counted 55.2% dead hearts caused by *S.cretica*, in sugarcane, concluded that, despite this high percentage the final yield was not significantly affected.

Reduction in weight of cane due to the stalk-borer infestation was estimated to be 20 (Siddigi, 1956) and 16% (Kulshareshtha and Avasthy, 1957) (c.f. Chaudhary and Sharma, 1986). An estimation of the average loss of sugar caused by the stem-borer, *Sesamia spp.* was 8.6%, 10.6% and 3.1% for the bottom, middle and top parts of the field, respectively, which is equavalent to $ 332.1 per hectare. (Sampson and Kumar, 1984). The stalk - borer infestation reduces purity and estimated recoverable sucrose by 4.1 and 1.5%, respectively (Saeed and Isobe, 1981). The percentage drop in crop weight, recovery and pol, as a result of infestation, was 39, 21 and 16.9%, respectively (Elamin, 1978).

The damage and loss caused by the top-borer were due to the mortality of the shoots and also to the arrest of growth in the latter. The mortality of young shoots may reach up to 100 percent as observed in Punjab and Bihar. The losses in sugar-recovery due to top borer infestation varies from 0.2 - 4.1 units . The deterioration of the juice quality is more due to the top-borer infestation than to stalk - and stem - borer infestation (Mukunthan, 1986).

As a result of the damage caused by the larvae of the first brood of the root - borer, 52% of the shoots affected produced no tillers, 30% produced only one tiller and 18% produced two tillers (Cheema, 1953;

Tandom, 1957) (c.f. Avasthy and Tiwari, 1986a) . Though the plant damaged by the larvae of the second brood formed millable canes, it showed a decrease of 66.2% in length of stalk and 73% in weight compared to the healthy canes. Canes damaged later in the season by the larvae of the third brood showed a reduction of 14.3% in length and 17% in weight, whereas the decrease in the cane infested by the fourth brood was only 5.2% in length and 6.5% in weight (Gupta *et al.*, 1966). At harvest, it was observed that the decrease in yield was up to 10% and the reduction in sucrose was about 0.3% (Gupta and Avasthy, 1952) (c.f. Avasthy and Tiwari, 1986a).

2.6 Control:

The stalk-borers are difficult to control, largely because of the cryptic and nocturnal habits of the adult moths and the protection afforded by the stem of the host to the developing stages (Jepson, 1954). Different methods of control of moth borers were adopted depending upon the local conditions. These methods have been discussed by different workers (Rao and Nagaraja, 1969; Jepson, 1954; Schmutterer, 1969; William, 1975; Karla, 1979; Avasthy and Tiwari, 1986b; Bosque and Schulthess, 1998).

2.6.1 Cultural control:

The success of such measures cannot be assessed exactly, thus are seldom popular to the farmers, and often neglected in comparison to direct chemical control measures, although they are rather cheaper (Schmutterer, 1969).

2.6.1.1 Elimination of alternative hosts:

Grass weeds which serve as alternative host-plants during the early growth of cane, should be weeded and burnt to destroy eggs or larvae which they harbour (Rao and Nagaraja, 1969; William, 1969; Elamin, 1977).

Weeding significantly reduced the infestation of the sugarcane by *S.cretica* in Egypt (Maareg, 1990). The eggs oviposited directly on the sugarcane are questionable i.e were not confirmed (William, 1975).

In the Sudan, Elamin (1977) showed that graminaceous weeds harboured larvae of *S.cretica*. The lowest percentage of dead heart was consistantly recoreded from continously weeded treatment and the differences between treatment means were highly significant.

2.6.1.2 Removal of the damaged shoots:

Systematic removal of the damaged shoots was reported by Rao and Nagaraja (1969); William (1975); and Karla (1979) to minimize the shoot losses . In the Sudan Malik (1969) reported that cutting the infested shoots did not improve the final cane or sugar yield, although the insect population was much reduced.

2.6.1.3 Destruction of the crop residues:

The larvae and pupae of the stem borer, *S.cretica* survives from one crop to the other within the stalks left in the field after harvest. Collection and burning of such residues drastically reduced the population of this stem-borer (Bedford, 1938; Schmutterer, 1969).

To control *B.fusca* in Nigeria, one recommendation was to burn the stalks completely after harvesting the grain, or to spread them thinly to expose larvae to full effect of adverse weather conditions, (Ajayi, 1978).

2.6.1.4 Trapping:

Based on its attraction to the moths for oviposition i.e, as a trap crop, maize had been advocated against *S.clamistis* (Hmps). However, this method had never been used to any extent (Rao and Nagaraja, 1969; William, 1975).

Light traps have been used as method of control for the stem-borers, *Diatreae saccharalis* (F.) by Ingram *et.al.* (1951) and *Chilo fumidicostalis* (Hmps) by Gupta and Avasthy (1960). (c.f Leon and Mathes, 1969)

Sex phermone of females of *B.fusca* and that of *C.partellus* was isolated by Hall *et.al,* (1981) in Zimbabwi and byUnnithan and Saxena (1990) in Kenya, respectively for the purpose of phermone trapping.

2.6.1.5 Water management:

Elamin (1978) reported that the percentage of dead heart infestation decreased with shorter irrigation-intervals, when intervals of 7, 10, 14 and 21 days were adopted. This may be attributed to the fact that the short intervals met the water requirements of the sugarcane and resulted in vigrous growth of the plants which were relatively resistant to the borer infestation.

Frequent irrigation averages of 840, 1080 or 1320mm of the water applied, resulted in lower infestation by the stem-borer, *Chilo spp.* (Patel, 1984). It was also reported that continuous high soil moisture in dry land agriculture, resulting from irrigation, favoured the production of several generations of *Chilo agamemnon* in Israel and Egypt (Rivnany, 1967). Flooding of *C.agamemnon*, which infested sugarcane fields after harvest reduced damage of the subsequant crop (Ezzat and Atries, 1969)

2.6.1.6 Application of nitrogen fertilizers:

Adequate and timely application of nitrogen fertilizers helped the crop to withstand the borer attack (Karla, 1979; Nagavi, 1984). However, the infestation of maize by the stem borer, *Chilo partellus* and *S.cretica* increased due to the application of nitrogen (Siddig, 1969).

2.6.1.7 Sowing dates:

Results of the experiments conducted in Sennar scheme, using six sowing dates, which started from first July and ended on first December, 1976, revealed that the lowest percentages of dead heart were recorded in the plants sown during August and September, whereas the highest percentages were recorded in the plants grown during November and December. These results were confirmed by light-trap catches (Elamin, 1977). Simillar results were obtained by Malik, (1975).

2.6.1.8 Tillage:

Tillage may reduce borer population through mechanical damage, either by burying them deeply in the soil or by bringing them up to the surface, where they are exposed to adverse weather conditions as well as other natural enemies. (Reddy, 1998).

2.6.2 Legislative control:

In order to prevent the carryover of infestation of the stem-borer from one season to the other, the uprooting of dura and maize stubbles after the cutting of the stalks, was practised in the Northern Province (Bedford, 1938).

2.6.3 Chemical control:

The control of the stem-borers by the application of pesticides is neither feasible nor economical. In the cooler regions, as in Louisiana, although the chemical control was practised successfully, the problems of resistance and pollution of the environment were inevitable. Other methods of control, such as the cultural practices, removal of dead-hearts containing the larvae, development of resistant varieties, the use of natural enemies and the integrated pest management programmes, received considerable attention (Jepson, 1954).

Various insecticides, such as DDT, dieldrin, aldin, ryania and cryolite when used against *Sesamia sp,* attacking maize in India, have given a higher yield (Rao and Nagaraja, 1969). According to Ruinard (1958) (c.f. Rao and Nagaraja, 1969) the use of DDT, dieldin and aldrin, in sugarcane increased the borer populations.

Better yield of dura was obtained in the Sudan Gezira when different insecticides were used for the control of the stem - borers, *S.cretica* and *C.partellus* (Muddathir, 1970; Nasr Eldin, 1975 and 1977).

Studies on the use of the neem seeds (*Azadirachta indica*) for the control of maize and sorghum stem-borers at ICIPE, Kenya, revealed that neem reduced the stem-borer attack to the same magnitude as that of insecticide (R.C. Saxena, personal communication).

The use of insecticides for the control of the stem-borers in sugarcane was reported by different workers in most parts of the world e.g Siddigi (1956) in India; Hensley and Cancienne (1966) in Louisiana; Williams (1958) in Mauritius (c.f. Long, 1969) and by Elamin (1977 and 1980), Muddathir, (1970), Nasr Eldin (1975 and 1977), Saeed and Isobe (1981) in the Sudan, where insecticides were used to a limited extent, i.e only for treating young canes. In different parts of the world, except in Louisiana, where insecticides are used extensively, the sugarcane - borer, *Diatereae saccharalis* developed resistance against the chlorinated hydrocarbon insecticides, endrin and endosulfan, and for this reason such insecticides were replaced by the organophosphorus compounds (Hensley and Concienne, 1966).

Williams (1958) stated that the use of insecticides on sugarcane is disadvantageous because : (1) the borers are exposed to the insecticides only during the period between hatching and the penetration of early instars into the cane tissues (2) There is no distinct generation with which insecticide application can be synchronized (3) The degree of attack vary from one place to another and is unpredictable (4) Good control requires several applications during the growing of the crop (5) The cobs are used for cattle feed (6) Insecticides are expensive when applied in cane at an advanced stage of growth and (7) the use of insecticides may upset the balance of the natural enemies. (c.f. Long, 1969).

The use of insecticides for the control of *S.cretica* in young canes, significantly reduced the percentage of dead hearts; but at harvest that effect had not reflected an increase in yield (Elamin, 1977 and 1980; Saeed and Isobe, 1981).

2.6.4 Biological control:

Recently, the use of natural enemies (predators, parasites and pathogens) in the control of the borers recieved a considerable attention (Jepson, 1954). In the Sudan, where *S.cretica* is indigenous, the spectrum of the existing natural enemies does not indicate any significant gaps to be filled (Williams, 1975).

2..6.4.1 Predators:

A large number of predators occur in the sugarcane ecosystem and they play a great role in the regulation of phytophagous insects. However, there is less interest on predators because most of them feed on a wide range of hosts and may not be useful in regulating the population of a particular species.

Ants and spiders are implicated in the predation of eggs and young larvae. 64 species of spiders were recorded in the sugarcane ecosystem in India (Ananthanarayana and David, 1982; Easwaromoorthy *et al.*, 1984).

The arthropod predators are more important than the parasites in determining the population trend of *Chilo sacchariphagus* (Bojer) (Easwaramoorthy and Nondagopal, 1986). Ants, sometimes, attack various stages of the borer, adults and larvae of a soldier beetle are occasionally found attacking the borer larvae, the earwigs fed on both the eggs and larvae and the birds undoubtedly play a great role in the control of the borers (Ingram et al; 1951).

In South Africa, egg predators of *Elidana saccharina* have been identified in the fields of sugarcane; these predators include three *Acarina* species, two species of cockroaches, adults of unidentified beetles, collembola and four species of ants (Leslie, 1988). Earwings, green laceing, spiders, ants, several coleopteran, hemipteran and roaches were identified by ICIPE, Kenya as being predators of *C.partellus* (Dwumfour, 1990). Large larvae of stem borers are known to be attacked inside the stem, ants consume *B.fusca* larvae in maize and sorghum stems in south Africa (Kfir,1988).

2.6.4.2 Parasites:

The earlier attempts to control the sugarcane stem-borers in the old world were conducted by using different species of *Trichogramma* (Rao, 1969). He reviewed the work regarding the production and release of *T. minutum,* Riley in Mysore state, and showed that there was a marked increase in the percentage of egg parasitism, from 0 - 13.5% to 62 - 90% giving varying rates of increase in the tonnage, and showed that the parasite release is useful in reducing the pest incidence. However the parasite was found ineffective in other places, where the high temperature and low humidity during the summer months had adverse effects on the parasite. Moreover, in Punjab and Barbedos, this parasite proved to be ineffective for the control of the borers (Kapur, 1957 and Metcalfe, 1967).

Considerable efforts in the old world were exerted in the biological control of the moth borer in sugarcane, using *Trichagramma spp*. as a biological agent. Some workers were engaged in these efforts using exotic and indigenous species, with variable degrees of success, some of them mass produced and released the parasites, while the others conducted laboratory trials only. Such work was conducted by: Lee (1961) in China; Narayahan (1957) in India; Breniere (1965) in Malagasy; Jepson (1954) in Mauritius; Balthazar (1963) in Philippines; Chen (1967) in Taiwan. (c.f. Rao, 1969).

The parasitoid, *T.chilonis* when released against *Chilo infuscatellus*,Sn. led to 62% reduction of the shoot-borer population . The same species gave encouraging results in Behar (India) and increased the parasitism by 2.9 times when tested against *C.infuscatellus,* Sn. and *C. auricilius,* Dudg. (David and Easwaramoorthy, 1990).

Several species of the genus, *Trichogramma* were used as egg parasitoids in America in order to control *D.saccharalis*. Field studies showed that they were capable of exerting some control on the third but principally the fourth, generations of the pest (Monje, 1996). In New Guinea, *Trichogramma* was recored as a natural enemy, causing up to 98% parasitism of the egg masses (Young, 1992). In China the percentage of the eggs parasitized increased in areas where *Trichogramma* was released than in the areas where no parasitoids were released (Guo, 1989; Zhou, 1989).

Other parasitoids such as *Ipobracon spp., Apanteles spp., Bracon spp., Xanthopimpa spp., Telenomus alercto* and *Goniozus indicus* Ashm. were used in the biological control of the stem borer and their success was reported by several workers: Gupta (1953) in India; Vander Goot (1948) in Indonesia; Moutia (1954); Williams and Mamet (1962) in Mauritius; Chen (1967) in Taiwan (c.f. Rao, 1969).

The intensity of the stem borer was reduced from 15 to 5 % and from 45 to 7% over a period of three years when *Apanteles flavipes* (Cameron) was introduce to Malaysia and Indonesia, respectively (Tan and Koh, 1980). This parasite was also introduced against *C.partellus* in South Africa. (Breniere et al., 1985; Skoroszewski and Hamburg, 1987). And against *D.saccharalis* in the West Indies and the South American countries (Vignes, 1981; Macedo et. al., 1984; Araujo et al., 1984; Macedo and Botelho, 1986).

The braconid, *Cotesta flavipes* successfully controlled *Diatrae saccharalis in* Costa Rica (Badilla *et.al*, 1994); *C.partellus* and *B.fusca* in Kenya (Overholt, *et. al.*, 1997); *C. infuscatellus, C.sacchariphagus* and *C. inferens* in Thailand (Sausa and Charernsom, 1999).

The dipterous parasite, *Sturmiopsis intereus* Tns. Controlled *C.infuscatellus* Sn. and it's activity was not adversely affected by the insecticides used to control *C. infuscatellus,* Sn. (David and Easwaramoorthy, 1990). The egg parasite, *platytelenomus hylas,*Nixon, successfully parasistised the dura stem-borer, *S.cretica* particularly during the winter months in Gendeto village in northern Sudan (Bedford, 1936). The larvae and pupae of this pest were parasitised by *Apanteles flavipes* and *pediobius furvus* (Gahan), respectively in Sennar (Malik, 1975). The egg parasitoid, *platytelenomous hylas* (Nixon), the larval parasitoid, *Apanteles sesamiae* (Gahan) and the pupal parasitoid, *pediobius furvus* (Gahan) were recorded on *S.cretica* led. in the commercial fields of sugarcane in Kenana (Saeed and Isobe, 1981).

2.6.4.3 Pathogens:

The larvae of the sugarcane stem-borer are often attacked by virus, fungi, bacteria, nematode, protozoa. The bacteria, *Bacillus thuringiensis* (Berliner) and *Aspergillus sydowii* (Brain and Sartoris) have been recorded on *Busseola fusca* (Fuller) by Harris (1962). A slight mortality of *Chilotraea auricillia* (Dudg) and *Proceras indicus* (Kapur) was recorded when spore suspension of the bacterium *bacillus cereus* var. thuringeinsis was sprayed on infested cane (Karla and Kumar, 1963).

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The protozoa *Nosema partelli*, Walkers and Kfir, was recorded in field-collected from *C.partellus* in South Africa (Walkers and Kfir, 1993). *Nosema pyrausta* was recorded by Hill and Gary (1979) from *C.partellus* in North America.

2.7 The use of resistant varieties in the control of stem-borers:

A distinct advantage of using resistant varieties of plants is their compatibility with other methods of insect control. Insect feeding on resistant varieties of plants may be less vigorous and more affected by weather conditions, or so more easily controlled by small amounts of insecticides. Predation and parasitism have been shown to be greater on some resistant genotype (Duale and Nwanze, 1997). Resistant varieties slow down the rate of increase of the pest population, and also delay the time at which the insect pests reach the economic threshhold level (ETL) and consequently this level may be reached after the susceptible stage of the crop has escaped the infestation. The mechanisms of resistance increase the rate of mortality of the immature stages and also prolong the developmental period of the survivals. This delay results in the insect population reaching the ETL after the most susceptable stages of the crop have escaped the infestation and thus the need for using the insecticide is eliminated (Sharma, 1997). It was observed that the time-interval between hatching, boring, penetration of the larvae and larval mass are affected by the varietal resistance (Sharma *et al*, 1997).

2.7.1 Components of plant resistance to the stem-borer:-

Sharma (1997) stated that the components of plant resistance are antixenosis or non-preference, antibiosis and tolerence.

2.7.1.1 Antixenosis:-

Antixenosis is a term proposed by Kogan and Ortman (1978) to replace the term nonpreference proposed earlier by Painter (1951). Which described the inability of the plant to serve as a host-plant to an insect herbivore. Antixenosis may be due to morphological or chemical plant factor (c.f Sharma, 1997). Mathes and Charpentier (1969) described antixenosis or nonpreference as the unattractiveness of the host-plant for the oviposition by the moths of the stem borer.

Younger cane, of the same variety, was severely attacked by the stem borer compared to the mature cane (Mathes and Ingram, 1942; Rao, 1962) (c.f. Mathes and Charpentier, 1969). However, early maturing varieties always developed the heaviest top borer infestation (Agarwal, 1959) (c.f. Mathes and Charpentier, 1969).

Hairiness, including the shape and arrangement of hairs, and the roughness or depth or frequency of straition of cane leaves might affect oviposition behaviour of *D.saccharatis* (Tucker, 1933) (c.f. Mathes and Charpentier, 1969). However, Rao (1962) (c.f. Mathes and Charpentier, 1969) found no relationship between roughness (or hairiness) of the leaf surface and oviposition. On the other hand Chapman *et al* (1983) found that hairs act as a trap for young larvae, thus impeding their advance onwards and reduce the rate of final establishment.

Varieties with erect narrow leaves were found to be more susceptible to the borer attack (Agarwal, 1959) (c.f. Mathes and Charpentier, 1969).

2.7.1.2 Antibiosis:-

Antibiosis include the adverse effect of the physico-chemical characteristics of the plant on the biology of an insect attempting to use the plant as a host. Both chemical and morphological factors mediate antibiosis (Sharma, 1997).

Sugarcane varieties with strong and, hard leaf-midrib were considered to be less susceptible to top borer than those with week midribs, since top borer gain entery through the midrib of the leaf (Issac, 1939; Rao and Venkatraman, 1941) (c.f. Mathes and Charpentier, 1969). Tightness of leaf sheath is the first adverse barier for *Chilo indicus* entery in resistant varieties (David and Joseph, 1982).

Tucker (1933) (c.f. Mathes and Charpentier, 1969) found that the sugarcane varieties with high percentage of dry matter were more resistant to the borers attack. He claimed that this factor could be used at any stage of cane growth. This statment was confirmed by Jepson (1954) but, Rao

(1962) (c.f. Mathes and Charpentier, 1969) found no significant differences in the moisture contents of the susceptible and resistant varieties.

A high negative correlation was found between susceptibility of sugarcane varieties to attack by the top borer and length of its spindle, particularly of it's leaf, attributing that to the distance the larva has to burrow to reach the growing point (Khanna and Ramanathan, 1946) (c.f. Mathes and Charpentier, 1969).

The infestation by the stalk borers, in general, was found to be inversely related to hardness of rind which itself was positively correlated with fibre in the stalk. The third internode from top was generally the softest and formed the target internode for attack of *C.indicus*. (David and Karla, 1967) (David and Joseph, 1982).

The epicuticular layer of sorghum was found to affect the climping of *C.partellus* larvae (Bernays *et.al*, 1983).

Sugarcane varieties with white and pink stalks were recorded to suffer less injury from borers than varieties with green stalks (Mathes *et. al*, 1939). (c.f. Mathes and Charpentier, 1969).

David and Karla (1967) observed that the incidence of borer infestation is lower in self trashing varieities.

Resistance of sugarcane varieties to the borer attack was found to be positively related to fibre content and it's arrangement in cane (Cleare,1934) (c.f. Mathes and Charpentier, 1969). Stalks of sugarcane varieties with high fibre content are less subject to stalk breakage at weak points caused by borer injury. Sugarcane varieties having tall, thin stalks and with long joints were observed to be more resistant to the borers attack compared to short and thick stalks varieties. This was explained by the fact that tallness and thinness may be associated with high fibre content and high vigour. Mathes and Ingram (1942) (c.f. Mathes and Charpentier, 1969) reported that the injury caused by *D. saccharalis* to the sugarcane was in direct proportion to cane stalk diametre. This was advocated by the thick-stemmed varieties which are usually low in their fibre content. They added that the survival and development of *D.saccharalis* was found to be more higher in maize stalks, which have more pith, than in sugarcane. Generally, solid scored sugarcane varieties were less affected by borers compared to those which developed pith and cavity (Agarwal, 1959) (c.f. Mathes and Charpentier, 1969).

A high positive correlation between the extent of moth borer damage and the percentage of total sugar content of the cane was found by Cleare (1932) and Rao (1962) (c.f. Mathes and Charpentier, 1969). However, higher phenolic and sugar contents of sorghum were recorded in susceptible cultivars than in less susceptible cultivars (Sharma and

Nwanze, 1997). Resistance is consistantly associated with low brix%, dry matter, although some promising varieties have high sucrose content (Nuss, *et.al*, 1986). No significant association was observed between the total nitrogen (or phosphorus) content of sugarcane variety and it's resistance to the borers, although a high potassium content appeared to confer resistance (Rao, 1962) (c.f. Mathes and Charpentier, 1969).

2.7.1.3 Tolerance:

Tolerance is the ability of the plant to withstand or recover from the damage caused by insect abundance, in which case it is equivalent to that required to damage susceptible cultivar. From agronomic point of view, the plants of tolerant cultivars produce more yield than the plants of non tolerant (susceptible) cultivars, but tolerance often occurs in combination with antixenosis and antibiosis (Sharma, 1997).

Highly vigorous varieties are found to be resistant to attack by *Diatreae* (Mathes and Charpentier, 1969). David and Joseph (1984) reported that certain varieties of sugarcane inspite of borer damage, sustained only moderate yield loss.

Rao (1962) (c.f. Mathes and Charpentier, 1969) have discussed the ability of young cane growth to compensate the lost shoots by increased growth and tillering of undamaged shoots. Quick growing varieties were most able to with-stand heavy attacks by early shoot borers (Agarwal, 1959) (c.f. Mathes and Charpentier, 1969).

Significantly lower loss in grain yield was due to the stem-borers in resistant sorghums than in susceptible ones. This was attributed to the tolerance mechanism. In spite of the severe leaf injury and stem tunneling in these selections, the final plant stand was good and most of the plant produce panicles (Sharma and Nwanze, 1997).

3. Materials and Methods

3.1 Location of the study area:

The experimental work of this study was conducted at the research farm and the commercial sugarcane fields of the Kenana Sugar Company, 240 Km south of Khartoum, at latitude 13°N and longitude 33°E. All experiments, and data collected were carried out during season 1997/98.

3.2 Climatic conditions:

The site of the study lies within the tropical semi arid climatic zone. With summer rainy season of four months (June - September) with peak in August and mean annual rain fall of about 300 mm. Appendix Table 9 showed the metreological data collected at Kenana metreological station during the period of the study.

3.3 Cultural practices adopted:

The cultural and agronomic practices adopted were according to the standard practices followed at Kenana.

3.3.1 Land preparation:

Consist of deep ploughing at 50 cm, followed by across deep ploughing at 50 cm, then harrowing, leveling and finally ridging at 1.55 metres between ridges.

3.3.2 Planting:

Stem cuttings (setts), with two buds were generally used as planting materials. Setts were planted and covered manualy.

3.3.3 Fertilizers used:

Nitrogen in the form of urea and phosphorus in the form of triple super phosphate fertilizers were applied at rates of 476 and 238 kg/ha respectively.

3.3.4 Watering:

Irrigation was carried out immediatly after planting and subsequently at 10 days intervals.

3.3.5 Weeding:

In addition to manual weeding herbicides, like Gesapax, Gesaprim and stomp were used at rates of 2.38 kg/ha, 2.38 kg/ha and 2.98 lit/ha, respectivly.

3.4 Effects of stem-borer, *S.cretica* on sugarcane crop cycles :

The aim of this experiment was to investigate the effects of stem-borer, *S.cretica* on plant cane and ratoons (P.C, R_1 - R_5), and to see the response of the two dominant commercial sugarcane varieties Co6806 and Co527 to the damage.

A field survey was conducted during the period from mid October 1997 to the end of April 1998. 48 fields each of 50 -250 feddans were selected at random for sampling from six areas, grown with two dominant sugarcane varieties Co527 and Co6806 were sampled, these areas covered the existing crop cycles, (i.e plant cane (PC) and first ratoon (R_1)-- 5th ratoon (R_5)}. Four replicates each represented by one field were used in each crop cycle.

Sampling of the selected fields was arranged to follow the general harvesting programme of the estate to assure that all canes are sampled at the same age (harvest of cane was carried out at Kenana when the crop was 12 months old).

100 stalks per selected field were randomly selected across the field. Each stalk was examined separatly and the total number of internodes, borings, bored internodes and total bored stalks were counted and recorded. Bored stalks and bored internodes were expressed as percentage of total stalks and total internodes respectivly, the mean bored holes per stalk was also calculated.

All data was transformed to $\sqrt{\ } \log_{10} (x+0.5)+1$. Student Newman Keul (SNK) multiple range test was used to identify differences between means.

3.5 Effects of stem-borer, *S.cretica* on sugarcane grown at different distances from sorghum fields.

The aim of the experiment was to study the level of damage of the shoot borer in two locations 50 and 500 metres away from sorghum fields which were thought to be the sources of the borers. The experiment also aimed at studying the impact of damage on the final yield.

The experiment was conducted at the commercial sugarcane field number 52316, which was planted with the commercial variety Co997. Two locations (A and B) each of one feddan (50 furrows x 54.2 meters length x 1.55 meters space between furrows), were randomly selected for sampling. Metal tags were fixed at the four corners of each location.

3.5.1 Counts of dead hearts:

The counts started three weeks after planting, and continued at an interval of two weeks until the internodes started to form. At each sampling occasion the dead heart and plant population per location, were counted and recorded. The dead hearts at each sampling date were counted and pulled out so as not to be counted again in the coming sampling date.

3.5.2 Counts of the shoot number/feddan:

Five lines each of ten metres long per location were randomly selected. The total number of shoots per feddan were calculated as follows:

$$\text{shoot number /feddan} = \frac{\text{shoot counted in the 50 meters}}{50 \times 1.55 \text{ m (spacing)}} \times 4200$$

Dead hearts were expressed as a percentage of the total shoots present at the time of count.

3.5.3 Yield Estimate:

The canes were harvested when twelve months old. Ten lines, each of two metres long were randomly selected from each location. The lines were manually harvested, weighed and number of the stalks of the cane from each line were recorded.

Each stalk of the harvested cane was examined separetely, the number of internodes per stalk, bored stalks, bored internodes and total borings were counted and recorded. Bored stalks or internodes were expressed as a percentage of the total stalks and total internodes respectively. Mean bored holes/stalk was counted.

T-test was used to identify whether the shoot borers' damage differed in the two locations and to compare the data from the two locations collected at harvest time.

3.6 Relative susceptibility of sugarcane varieties to the damage caused by *Sesamia cretica* at Kenana during 1997/98 season:

The aim of the experiment was to study the relative susceptibility of 57 sugarcane varieties (including three check varieties) to the damage caused by *S.cretica* in the fields at Kenana.

The experiments used to determine the yield were used in this test to evaluate the relative susceptibility of different sugarcane varieties to the stalk borer, *S.cretica.*

A randomized complete block design with four replications was adopted in all experiments. Number of plots in each experiment depends on the number of varities to be tested. The plot size was two furrows, 1.55 metres a part and 10 metres long. Distance between blocks was two metres. The same practice was adopted in Kenana commercial field . No artificial infestation was carried out.

3.6.1 Plant cane crop cycle:

3.6.1.1 Experiment I:

Planted on 24/11/1996 and harvested on 10/11/1997. Twenty varieties including the three commercial varities (Co6806, Co527 and Co997 as check varieties) were tested in this experiment.

3.6.1.2 Experiment II:

Planted on 25/11/1996 and harvested on 12/11/1997. Twenty varieties including the three commercial varieties were tested in this experiment.

3.6.2 First ratoon crop cycle:

3.6.2.1 Experiment I:

Ratoon established on 4/12/1996 and harvested on 7/12/1997. The number of varieties tested in this experiment were ten including Co6806 and Co527 as check varieties.

3.6.2.2 Experiment II:

Ratoon established on 12/12/1996 and harvested on 10/12/1997. In this experiment fifteen varieties including the three commercial varieties were tested.

3.6.3 The study area:

Each of the experiments I and II were conducted in an area of 0.59 feddan (0.25 ha), and experiments III and IV in 0.3 feddan (0.124 ha) and 0.44 feddan (0.19 ha), respectively.

3.6.4 Harvest of experiment:

All experiments were harvested manually when the crop was 12 month old including a period of one month for drying off. Data related to the natural borer infestation in each experiment was collected at harvest as follows:

25 stalks per plot were randomly selected. Each stalk was examined separately and the total number of internodes, borings, bored internodes and total bored stalks were counted and recorded. The percentage of bored stalks and internodes were calculated as follows :

$$\text{\% bored stalks (or internodes)} = \frac{\text{bored stalks (or internodes)}}{\text{total stalks (or internodes)}} \times 100$$

The mean bores/stalks was also calculated.

Data from the two experiments in plant cane and those from the two experiments of first ratoon were each combined and results of each two experiments were analysed separately. Data was first transformed using $\sqrt{\log_{10}(x+0.5)+1}$. Ryan-Einot-Gabriel-Welsch multiple range test was employed to test the significance of the results.

3.7 Loss in both yield and quality of sugarcane:

The aim of this experiment was to determine the effect of damage caused by the stem-borer on the cane weight and height and consequently on the yield as well as the quality of the cane i.e pol, brix, purity, estimated recoverable sucrose, moisture and fibre.

3.7.1 Sampling method:

Loss of sugarcane caused by the stem-borer, *S.cretica* is determined by using the methods described by Metcalfe (1969) in which the bored and unbored cane stalks taken from the same field were compared.

A commercial sugarcane field grown with cane variety Co527 was randomly selected, sampling started when the cane was 12 months old. 500 cane stalks were randomly selected throughout the field. Selected stalks were inspected and catigorized into damaged and undamaged canes (damaged canes were those having one or more bores on any part of the stalk). Ten samples, each of five stalks, were selected at random from damaged and undamaged stalk. The samples were weighed separately.

The height of cane stalk and the number of internodes in each sample were recorded.

3.7.2 Determination of Juice quality:

3.7.2.1 Moisture content:

Samples taken in part (3.7.1) were used in this test. The stalks in each sample were cut into small pieces by means of knives and crushed by a jeffco cutter grinder, 100 gms of the thoroughly crushed cane were weighed and dried in an oven running at 105°C for five hours. Percent moisture content was determined as follows:

$$\% \text{ moisture content} = \frac{\text{Wt. of wet sample - Wt. of dry sample}}{\text{Wt. of wet sample}} \times 100$$

3.7.2.2 Fibre content:

Fibre contents was determined by the disintegrator method described by John (1968). 100 gms of the crushed cane were transferred in a cloth sac, weighed and washed thoroughly by hot and cold water in order to remove the sugar and other materials in the sample. The sample was then transferred to an oven running at 105°C for 5 hours. The % fibre content was calculated as follows :

$$\% \text{ fibre content} = \frac{\text{weight of fibre}}{\text{weight of sample}} \times 100$$

3.7.2.3 Determination of pol, brix and purity:

One kilogramme of the crushed cane was transferred to a wet disintegrator. Two litres of water were added and the mixture was blended for twenty minutes. 400 mls of juice were filtered. From this filterate 5 mls were taken by a dropper, placed in the polarometre and the reading of the pol percent was taken. 2 mls were also taken and transferred to the refractometre and the reading of the brix percent was taken. The purity of the juice was calculated as follows:

$$\text{Purity \%} = \frac{\text{Pol \%}}{\text{Brix \%}} \times 100$$

The procedures followed was described in the Laboratory Manual of Queen Land Sugar Mills (1970).

T-test was used to determine whether mean differences in parametres of damaged and undamaged cane existed.

4. Results

4.1 Effects of stem-broer, *S.cretica* on sugarcane crop cycles :

The means of the percents of the stalks bored, internodes bored and bores per stalk caused by the stem-borer, *Sesamia cretica* to the sugarcane, variety Co527, are presented in Table 1, Fig. 2, 3 and 4 and Appendix 1.

The mean percent stalks bored in the plant cane (PC) was significantly higher than in any of the five ratoons tested (R_1 - R_5). Significant differences in the percent stalks bored were also recorded between the 5th. ratoon (R_5) and the remaining ones. No significant differences in the percent of stalks bored were recorded between the first four ratoons. The mean percent internodes bored of the plant cane was also significantly higher than that of any of the five ratoons. However, no significant differences in the percent of internodes bored were recorded between R_1 and R_2 or between R_2 and any of the successive ratoons, i.e. R_3 - R_5. The mean number of bored holes/stalk in the plant cane was significantly higher than any of those in the ratoon 2-5. However, no significant differences in the mean number of bored holes/stalk were recorded between the plant cane (PC) and the first ratoon (R_1), between the first ratoon and those of the 2nd and 3rd ratoons, or between the ratoons (R_2 - R_5) (Table 1 and Appendix 1).

Table 1: Percents of stalks and internodes bored and number of bored holes/stalk caused by *S. cretica* to six crop cycles of the sugarcane variety, CO527 grown at Kenana, during 1997/1998 season.

Crop Cycle	Mean (± S.E)		
	Percent stalks bored	Percent internodes bored	number of bored holes per stalk
Plant cane (PC)	24.00 ± 8.50 (1.51 ± 0.056) a	1.36 ± 0.56 (1.20 ± 0.119) d	0.41 ± 0.15 (0.92 ± 0.087) g
First ratoon (R1)	6.00 ± 0.82 (1.34 ± 0.021) b	0.51 ± 0.10 (0.99 ± 0.046) e	0.21 ± 0.05 (0.8 ± 0.041) gh
Second ratoon (R2)	3.50 ± 0.50 (1.26 ± 0.026) b	0.21 ± 0.01 (0.81 ± 0.010) ef	0.09 ± 0.01 (0.68 ± 0.014) hk
Third ratoon (R3)	2.67 ± 1.20 (1.20 ± 0.068) b	0.16 ± 0.08 (0.75 ± 0.078) f	0.06 ± 0.02 (0.65 ± 0.024) hk
Fourth ratoon (R4)	1.75 ± 0.48 (1.15 ± 0.039) b	0.11 ± 0.03 (0.70 ± 0.031) f	0.03 ± 0.01 (0.60 ± 0.020) k
Fifth ratoon (R5)	0.75 ± 0.48 (0.98 ± 0.098) c	0.05 ± 0.03 (0.62 ± 0.039) f	0.02 ± 0.01 (0.59 ± 0.0201) k
C.V.	8.5%	14.6%	12.2%

Figures in parentheses are the transformed data. $\text{Log}_{10}(x + 0.5) + 1$
Means in the same column, followed by the same letter are not significantly different according to Student Newman – Keuls Test. (SNKT)

The results of the same respective damages caused by *S.cretica* to the variety Co6806 are shown in Table 2, Figs.2, 3 and 4 and Appendix 2.

No significant differences in the means of percent stalks bored or in the means of number of bored holes/stalk were recorded between the plant cane and any of the five ratoons tested. Also no significant differences in the means of percent internodes bored were recorded between the plant cane and any of the first four ratoons ($R_{1---}R_4$) or between R_1---R_5. However, significant differences were recorded only between the mean percent of plant cane (PC) and the fifth ratoon (R_5).

The results presented for the two varieties indicated that the mean percent of stalks bored, internodes bored or mean number of bored holes/stalk decreased with the advance of ratoons of the crop, i.e being highest in the first ratoon and lower in the succeeding ones (Tables 1, 2 and Figs 2, 3 and 4). The results obtained for the two varieties also showed that the damage caused by *S.cretica* to the plant cane or to the first ratoon of variety Co527 was higher than that caused to variety Co6806. However, the damage, i.e percent stalk bored, percent internode bored and number of bored holes/stalk caused to R_2 in both varieties were nearly equal. This situation was reversed in ratoons R_3 - R_5, i.e the damage recorded in variety Co6806 was higher than in the other variety. Tables 1,2 and Figs. 2,3 and 4.

Table 2: Percents of stalk and internodes bored and number of bored holes/stalk caused by *S. cretica* to six crop cycles of the sugarcane variety, CO6806 grown at Kenana, during 1997/1998 season.

Crop Cycle	Mean (± S.E)		
	Percent stalks bored	Percent internodes Bored	number of bored holes per stalk
Plant cane (PC)	7.00 ± 1.22 (1.36 ± 0.029) n	0.41 ± 0.10 (0.94 ± 0.060) r	0.12 ± 0.04 (0.72 ± 0.045) y
First ratoon (R1)	5.00 ± 1.22 (1.31 ± 0.037) n	0.28 ± 0.04 (0.86 ± 0.024) rt	0.11 ± 0.02 (0.70 ± 0.021) y
Second Ratoon (R2)	3.50 ± 0.65 (1.26 ± 0.030) n	0.21 ± 0.04 (0.81 ± 0.041) rt	0.10 ± 0.05 (0.69 ± 0.052) y
Third ratoon (R3)	3.25 ± 1.44 (1.20 ± 0.116) n	0.19 ± 0.10 (0.76 ± 0.087) rt	0.06 ± 0.04 (0.64 ± 0.053) y
Fourth ratoon (R4)	2.50 ± 0.66 (1.17 ± 0.044) n	0.12 ± 0.03 (0.72 ± 0.034) rt	0.05 ± 0.01 (0.63 ± 0.012) y
Fifth ratoon (R5)	2.00 ± 0.91 (1.11 ± 0.101) n	0.10 ± 0.04 (0.68 ± 0.055) t	0.03 ± 0.01 (0.60 ± 0.017) y
C.V.	11.2%	13.8%	11.3%

Legend as in Table (1)

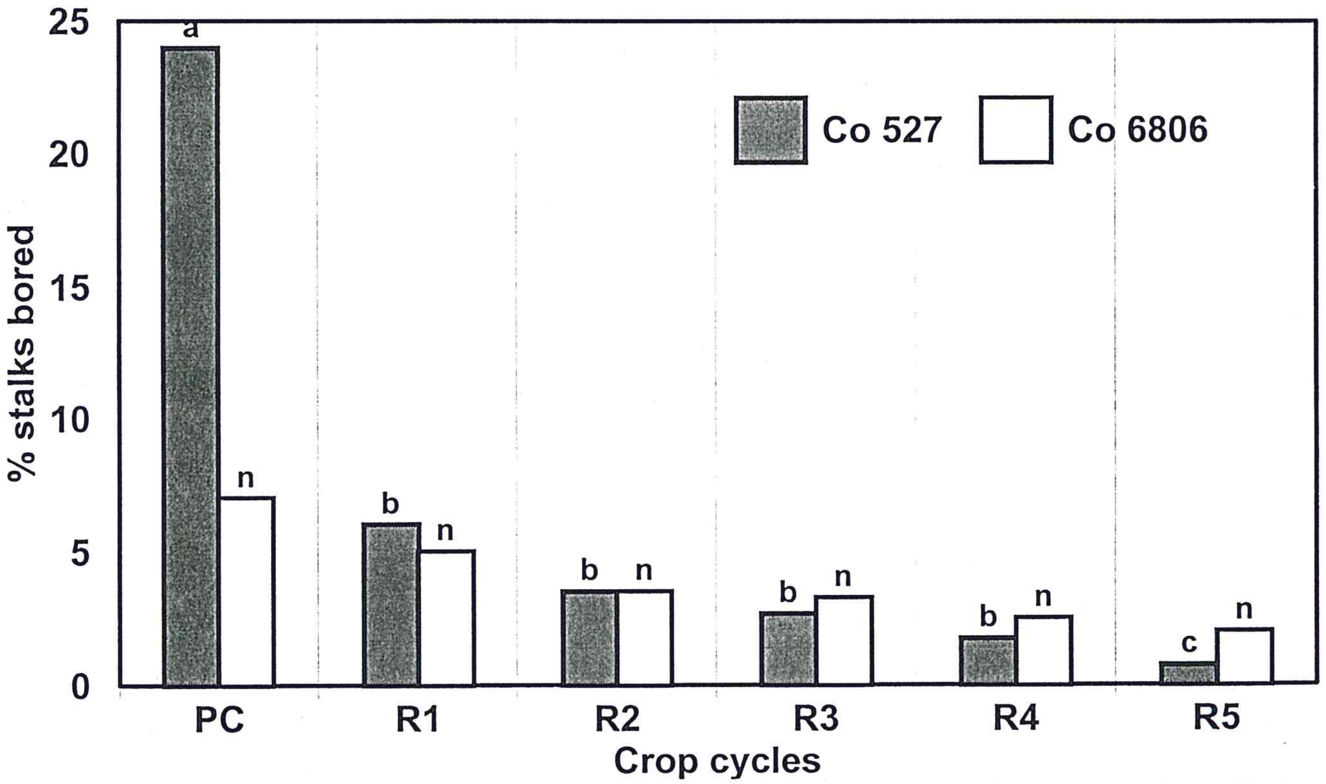


Fig.2:: Percentage of stalks bored caused by S. cretica to plant cane (PC) and five ratoons (R1......R5) of two varietiies of sugarcane . Means folllowed by the same letter (s) were not significant . (SNK Multiple Range Test)

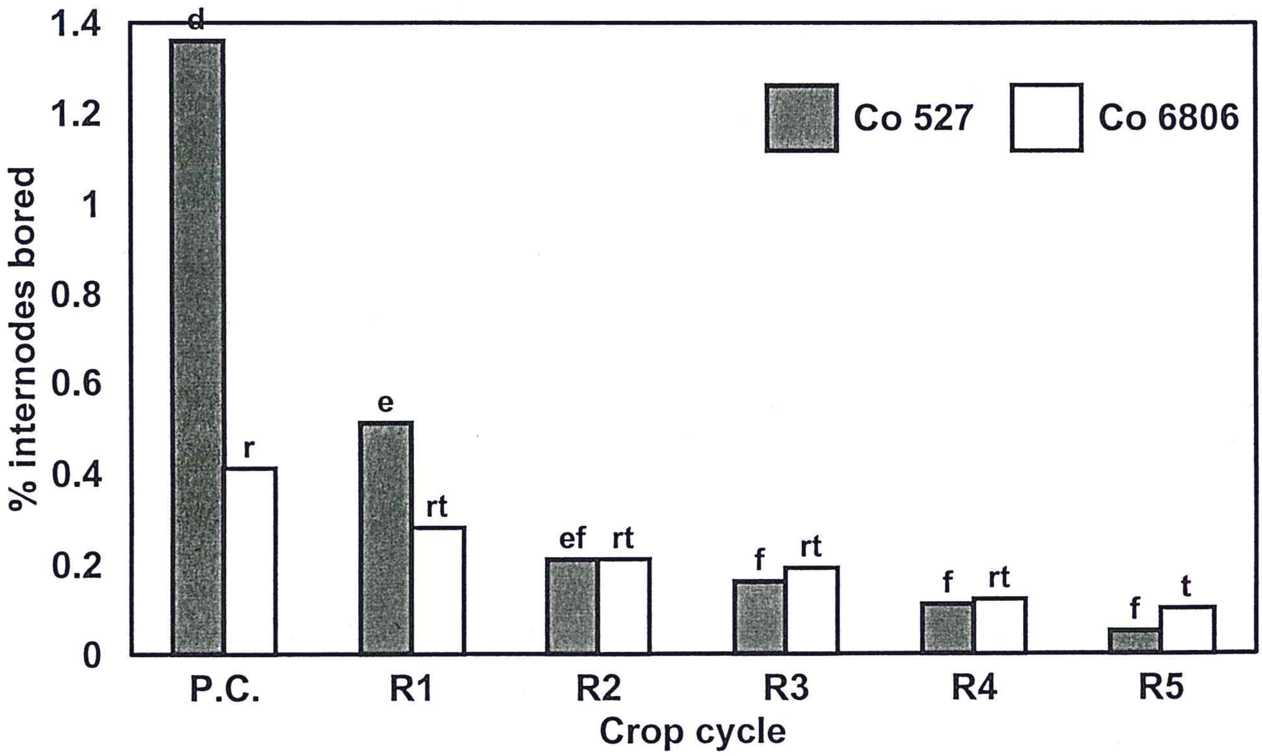


Fig 3: Percentages of internodes bored caused by S.. cretica to plant cane (PC) and to five ratoons (R1.....R5) of two varieties of sugarcane (Legend as in Fig 2) .

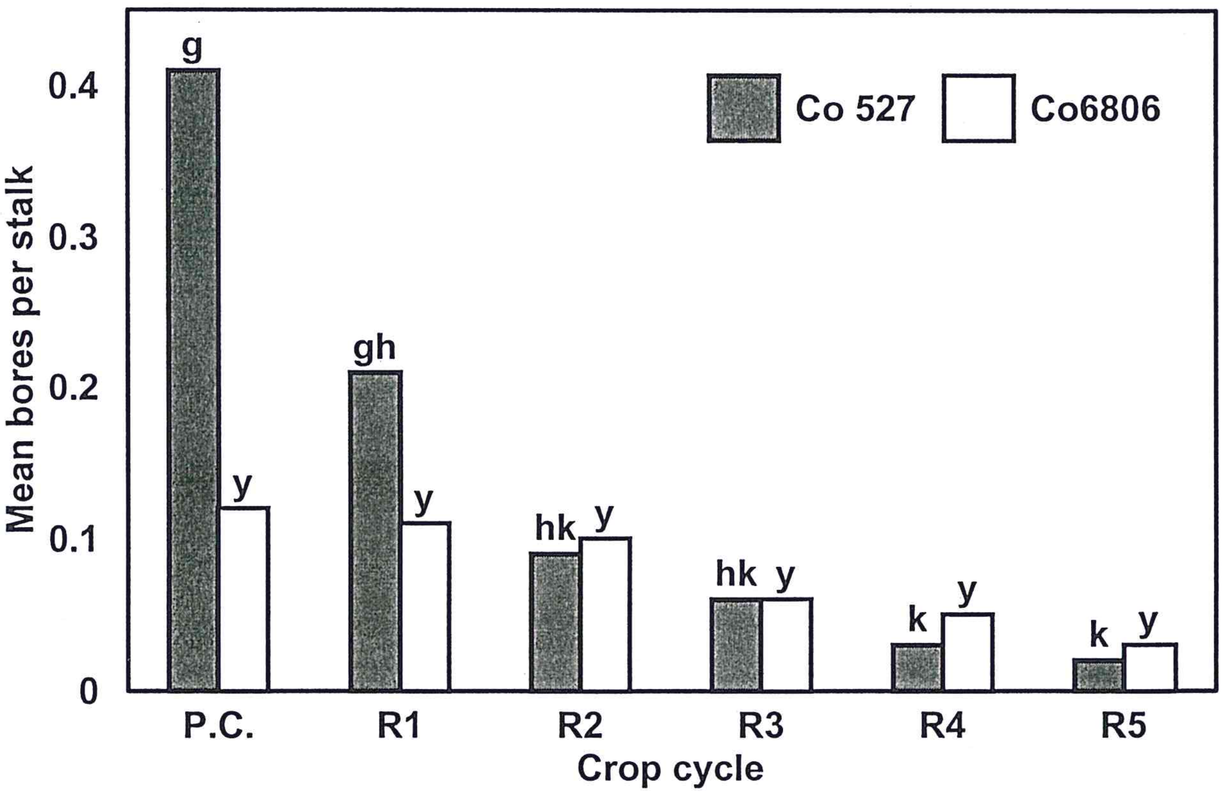


Fig. 4 : Mean bored holes / stalk caused by S. cretica to plant cane (PC) and five ratoons (R1 .....R5) of two varieties of sugarcane . (Legend as in Fig. 2) .

4.2 Effects of stem-borer, *S.cretica* on sugarcane grown at different distances from sorghum fields :

4.2.1 Effects of damage caused by the shoot borer on sugarcane:

The mean percent damage, i.e % shoots bored were significantly higher in location A (which lies only 50 metres from the sorghum fields) than that in location B(which lies a long distance away, i.e 500 metres from sorghum fields) (Table 3, Fig. 5 and Appendix 3).

The peak of the damage caused by *S.cretica* was recorded during December in both locations (Fig 5, Appendix 3).

4.2.2 Impact of damage on yield:

The mean percent internodes or stalks bored were significantly higher in location B than in location A (Table 4 and Appendix 4). No significant differences in mean bored holes/stalk were recorded between location A and B.

The means of the numbers of stalks of sugarcane or weight of cane/2metres line were both higher in location A than in B but the differences were not significant (Table 4 & Appendix 4).

Table 3: Effects of the distance between sugarcane and sorghum fields on the level of shoot damage caused by *S. cretica* to sugarcane, at Kenana, during 1997/98 season.

Dates of Sampling	Mean (± S.E) % of damage in	
	Location A(50m)	Location B (500m)
Nov 97	0.98 ± 0.88	0.38 ± 0.28
Dec 97	4.69 ± 1.62	0.83 ± 0.38
Jan 98	1.81 ± 0.06	0.24 ± 0.06
Feb 98	1.45 ± 0.10	0.12 ± 0.03
Mar 98	1.01 ± 0.20	0.14 ± 0.01
Apr 98	0.63 ± 0.01	0.20 ± 0.08
May 98	0.27 ± 0.00	0.32 ± 0.00
Total	10.84	2.23
Total Mean	1.55	0.32

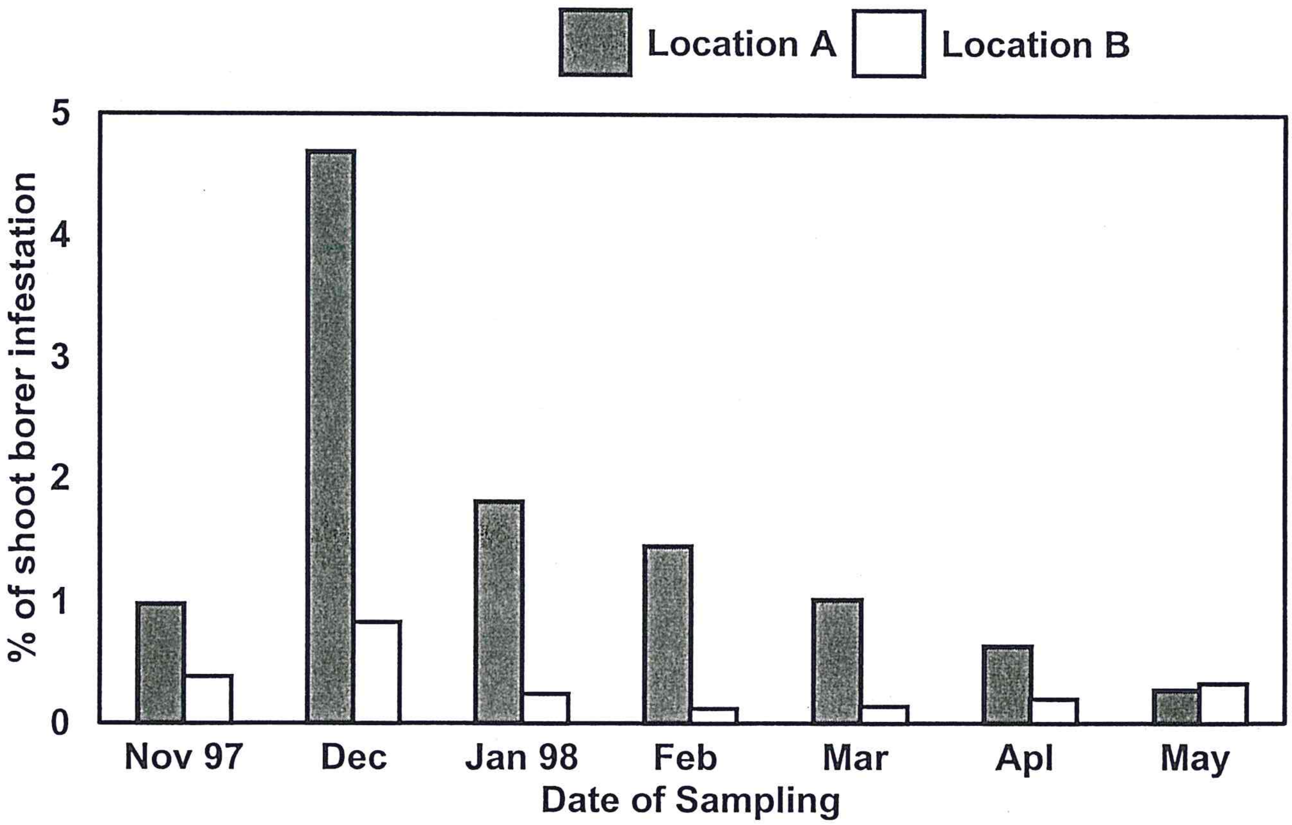


Fig. 5 : Percentage of shoot damage caused by S. cretica to sugarcane at two locations from sorghum fields .

Table 4: Stalk damage and yield parameters assessed at harvest from two locations (A & B) caused by *S. cretica*.

Locations	Mean (± S.E)				
	Percent internodes bored	Percent stalks bored	Av. Boreholes per stalk	No of Stalks/ 2m	Weight (kg/2m)
A	0.54 ± 0.12	11.03 ± 2.17	0.18 ± 0.04	39.8 ± 2.12	50.07 ± 1.96
B	1.08 ± 0.14	18.66 ± 2.27	0.31 ± 0.04	37.3 ± 1.49	46.24 ± 2.03

4.3 Relative susceptibility of sugarcane varieties to the damage of the stem-borer *S.cretica*:

4.3.1 Results of testing the plant cane crop of 34 varieties of sugarcane:

No significant differences were recorded in mean percent stalks bored between the tested varieties (Table 5 and Fig. 6). However, significant differences were recorded between the mean percents of internodes bored for the varieties TUC75-2 or BJ82156 and that of the variety FR87288 (Table 5 and Fig. 7). The mean bored holes/stalk of the variety TUC75-2 was significantly different from that of the variety FR87288. No significant differences in the mean number of bored holes/stalk were recorded between the remaining varieties (Table 5 and Fig. 8). The results obtained indicated that the mean internodes bored or the mean bored holes/stalk were highest in the variety TUC75-2 compared to the variety FR87288 (Figs. 7, 8 and Appendix 5).

4.3.2 Results of testing the first ratoon crop in 23 varieties of sugarcane:

No significant differences were recorded between the means of the percent of stalks bored of all tested varieties (Table 6 and Fig. 9). The means of the percent internodes bored of the variety B80251 was significantly different from those of the varieties DB70279, Co527, Mex73523, R572, Co6806 and BJ87109. However, no significant

Table 5: **Percent stalks bored, internodes bored and bored holes/stalk caused by *S.cretica* to 34 varieties of sugarcane plant crop cycle grown at Kenana during 1997/1998 season.**

% stalks bored		% internodes bored		bored holes/stalk	
Variety	Mean ± S.E	Variety	Mean ± S.E	Variety	Mean ± S.E
BJ82156	1.5213 ± 0.04 a	TUC75-2	1.1465 ± 0.05 a	TUC75-2	1.0624 ± 0.05 a
DB8103	1.5074 ± 0.03 a	BJ82156	1.1439 ± 0.04 a	DB8103	1.0345 ± 0.04 ab
SP791230	1.5043 ± 0.04 a	TUC72-15	1.1261 ± 0.05 ab	BJ8717	1.0325 ± 0.07 ab
SP753046	1.5033 ± 0.05 a	SP753046	1.1165 ± 0.06 ab	R572	1.0275 ± 0.05 ab
R572	1.4983 ± 0.02 a	R571	1.1152 ± 0.05 ab	TUC72-15	1.0262 ± 0.04 ab
TUC72-15	1.4977 ± 0.04 a	R572	1.1136 ± 0.04 ab	BJ82156	1.0153 ±0.04 ab
TUC75-2	1.4931 ± 0.05 a	DB8103	1.1110 ± 0.04 ab	SP753046	1.0000 ±0.05 ab
Co527	1.4875 ± 0.03 a	BJ87117	1.1087 ± 0.07 ab	SP791230	0.9975 ±0.02 ab
BJ83139	1.4733 ± 0.04 a	SP791230	1.1070 ± 0.05 ab	DB73415	0.9880 ±0.06 ab
BJ8717	1.4701 ± 0.07 a	Co527	1.0920 ± 0.03 ab	R571	0.9840 ±0.04 ab
BJ8251	1.4532 ± 0.04 a	BJ83139	1.0854 ± 0.05 ab	BJ8374	0.9794 ±0.03 ab
BJ8374	1.4514 ± 0.02 a	BJ8374	1.0744 ± 0.03 ab	BJ83139	0.9785 ±0.03 ab
BJ82119	1.4274 ± 0.06 a	DB73416	1.0708 ± 0.08 ab	TUC75-3	0.9752 ±0.03 ab
TUC75-3	1.4178 ± 0.05 a	TUC75-3	1.0651 ± 0.05 ab	Co527	0.9671 ±0.02 ab
R571	1.4030 ± 0.04 a	R572	1.0515 ± 0.03 ab	SP718210	0.9421 ±0.04 ab
R575	1.3927 ± 0.04 a	BJ8251	1.0473 ± 0.04 ab	KnH80-41	0.9408 ±0.02 ab
KnH80-41	1.3581 ± 0.08 a	SP741103	1.0330 ± 0.07 ab	SP741103	0.9401 ±0.04 ab
BJ84119	1.3508 ± 0.06 a	SP718210	1.0302 ± 0.07 ab	B63349	0.9338 ±0.03 ab
SP741103	1.3313 ± 0.17 a	KnH80-41	1.0292 ± 0.03 ab	BJ87124	0.9337 ±0.07 ab
B63349	1.3265 ± 0.08 a	BJ82119	1.0172 ± 0.05 ab	SP701173	0.9332 ±0.05 ab
DB73415	1.3234 ± 0.06 a	BJ84119	1.0029 ± 0.07 ab	BJ82119	0.9311 ±0.03 ab
SP718210	1.3087 ± 0.16 a	B63349	1.0004 ± 0.04 ab	Co671	0.9289 ±0.03 ab
FR87421	1.2648 ± 0.20 a	Co671	0.9949 ± 0.04 ab	BJ84119	0.9278 ±0.08 ab
SP701123	1.2648 ± 0.05 a	SP701123	0.9914 ± 0.07 ab	DB7532	0.9180 ±0.05 ab
CoC671	1.2500 ± 0.09 a	FR87421	0.9768 ± 0.06 ab	BJ8215	0.9162 ±0.03 ab
DB7532	1.1846 ± 0.20 a	DB7532	0.9700 ± 0.08 ab	Co997	0.9052 ±0.03 ab
BJ87124	1.1273 ± 0.14 a	BJ87124	0.9612 ± 0.07 ab	B85764	0.8977 ±0.04 ab
B85764	1.1273 ± 0.17 a	B85764	0.9395 ± 0.06 ab	FR87421	0.8974 ±0.03 ab
FR86208	1.1196 ± 0.17 a	Co997	0.9308 ± 0.04 ab	BJ8751	0.8807 ±0.03 ab
BJ851	1.1125 ± 0.16 a	FR86208	0.9269 ± 0.07 ab	R575	0.8718 ±0.02 ab
Co997	1.1070 ± 0.10 a	BJ8751	0.9180 ± 0.05 ab	FR86208	0.8681 ±0.03 ab
BJ87109	0.9743 ± 0.14 a	BJ87109	0.8917 ± 0.06 ab	BJ87109	0.8632 ±0.03 ab
Co6806	0.9614 ± 0.08 a	Co6806	0.8651 ± 0.02 ab	Co6806	0.8472 ±0.01 ab
FR87288	0.9485 ± 0.01 a	FR87288	0.8577 ± 0.02 b	FR87288	0.8455 ±0.01 b

* All data are transformed $\sqrt{\log_{10}(x+0.5)+1}$

- Means in the same column followed by the same letter (s) were not significantly different at 5% level according to Ryan-Einot-Gobriel- Walsch multiple range test.

Fig. 6 : Relative susceptibility of 34 sugarcane varieties to damage caused by the stem borer *S. cretica* in plant cane cycle grown at Kenana during 1997/98 season

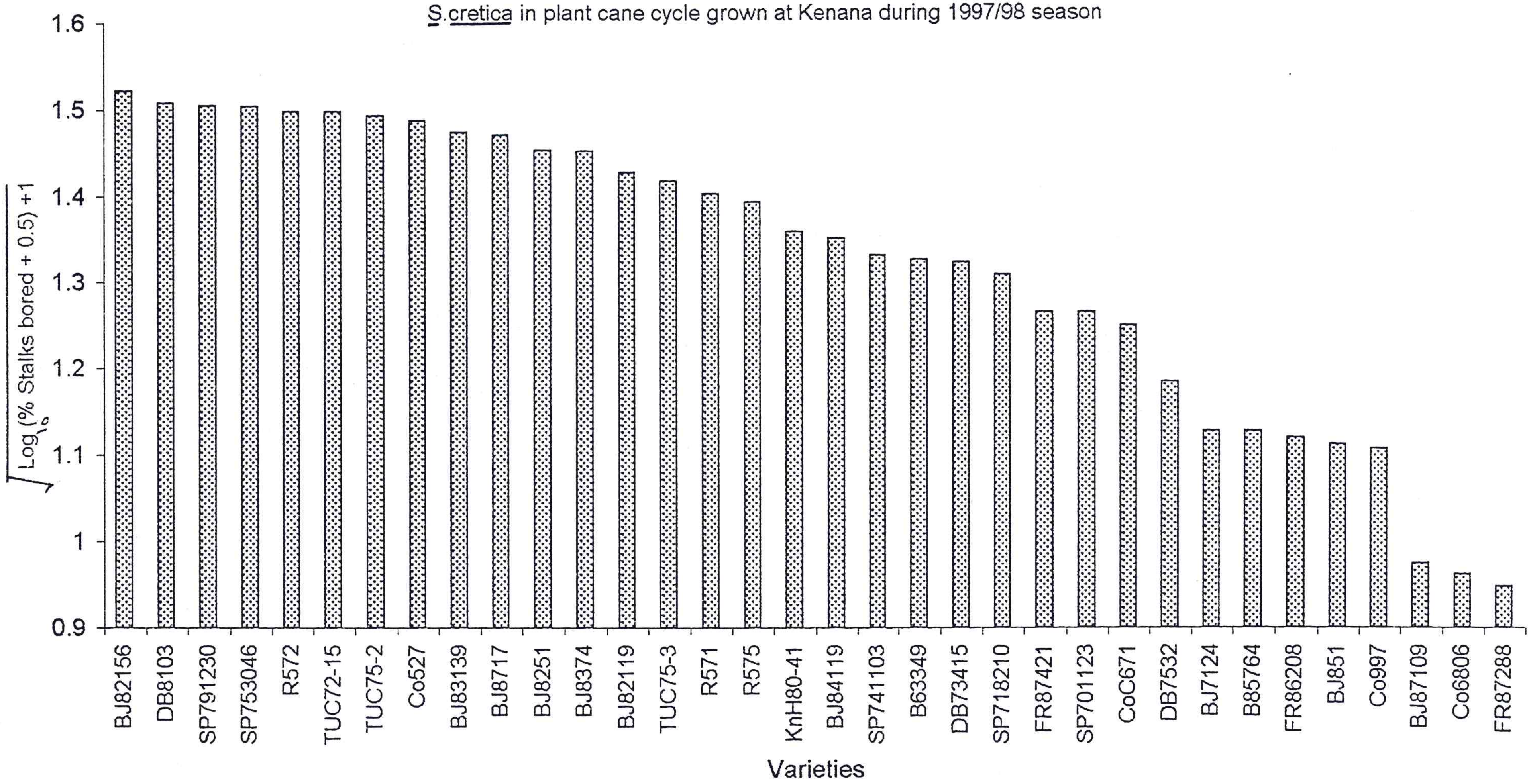
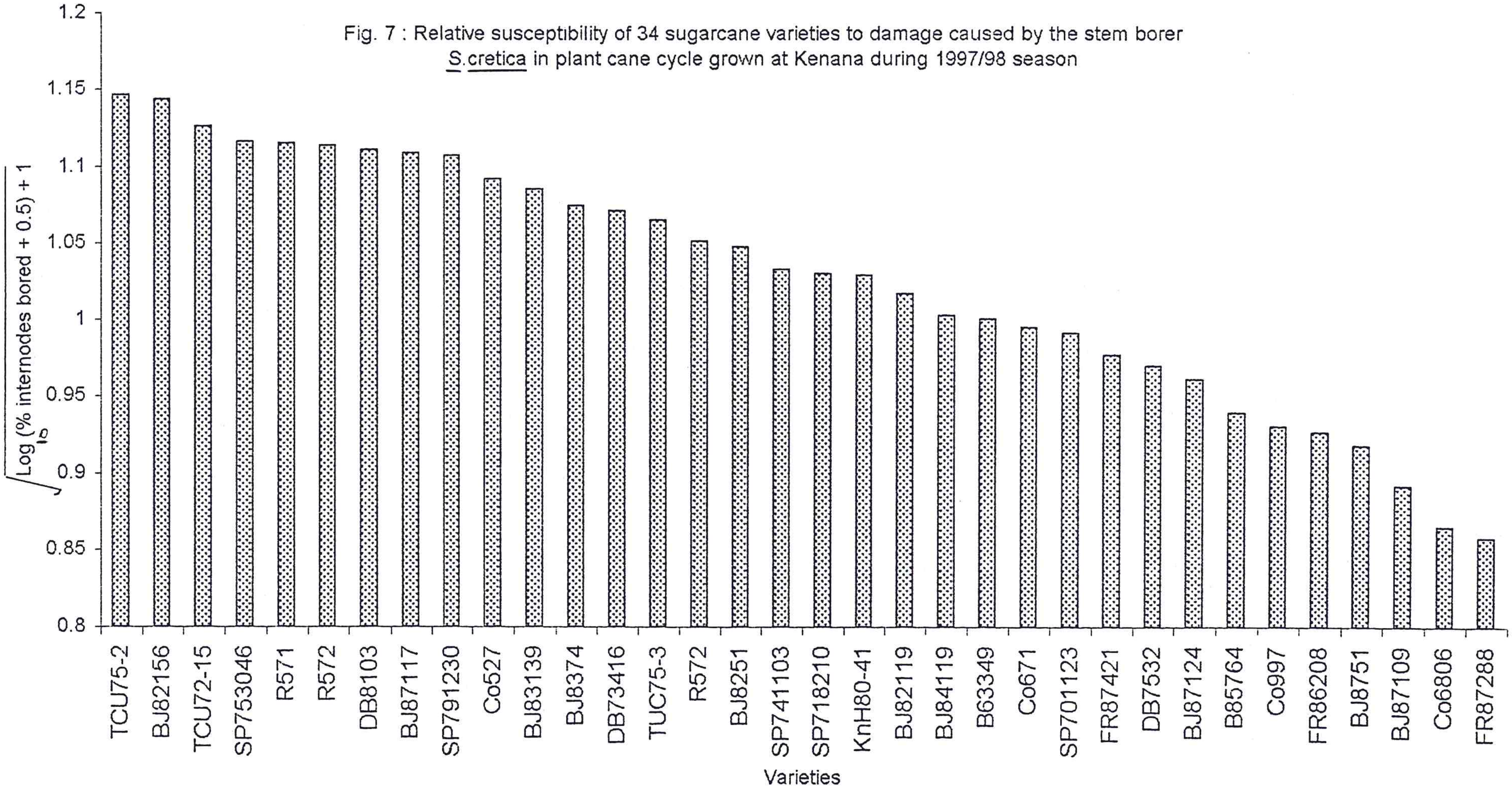


Fig. 7 : Relative susceptibility of 34 sugarcane varieties to damage caused by the stem borer *S. cretica* in plant cane cycle grown at Kenana during 1997/98 season



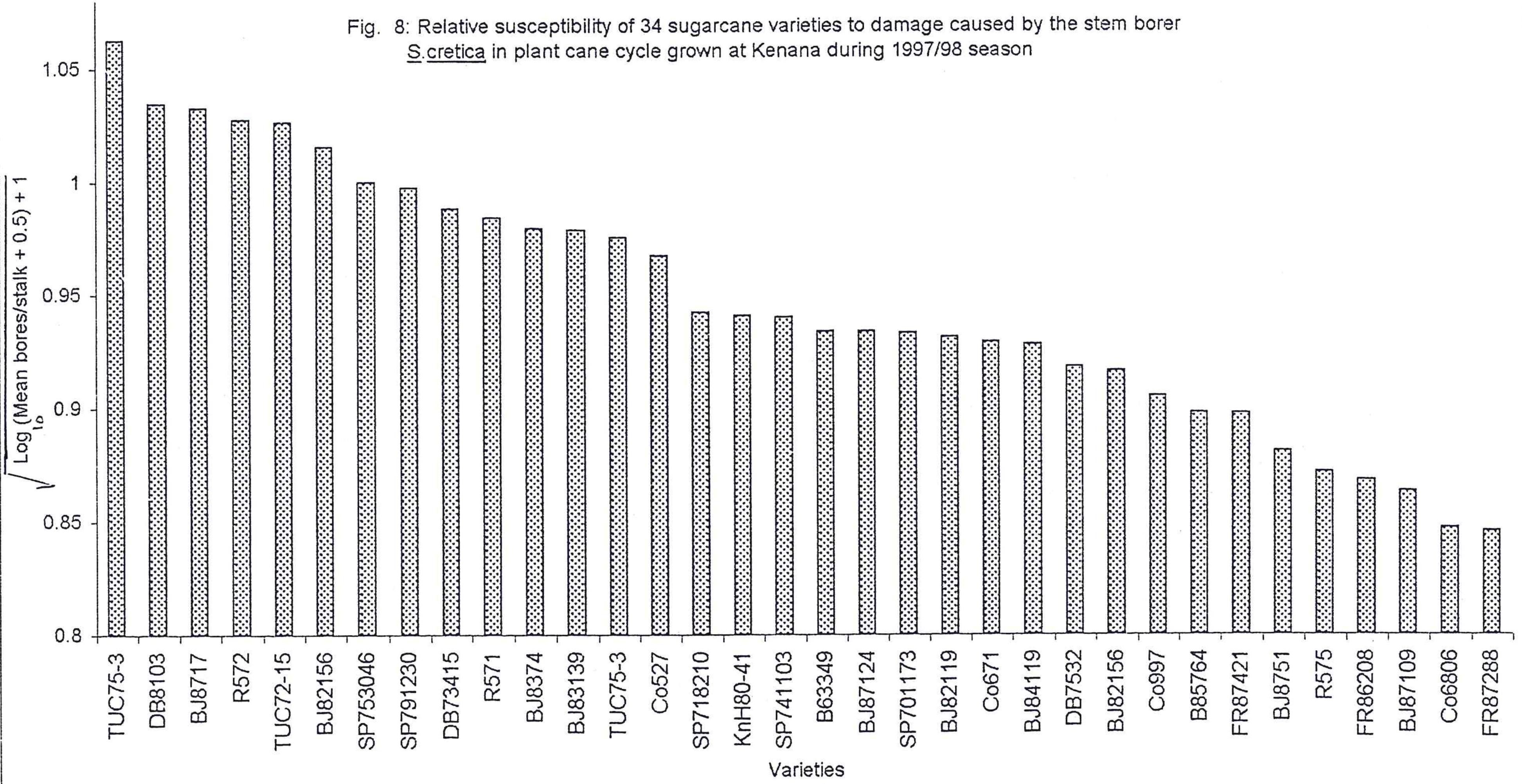


Fig. 8: Relative susceptibility of 34 sugarcane varieties to damage caused by the stem borer *S.cretica* in plant cane cycle grown at Kenana during 1997/98 season

differences were observed in the internodes bored between the remaining varieties (Table 6 and Fig. 10)

The mean bored holes/stalk of the variety B80251 was significantly different from those of the varieties Co997, BJ84111, BJ8536, BJ83139, Co527, Mex 73523, R572, Co6806 and BJ87109 (Table 6 and Fig. 11).

The variety B80251 was the highly damaged variety while BJ87109 was the least damaged one (Figs. 9, 10 and 11, Appendix 6).

4.4 Effects of the damage of stem-borer *S.cretica* on yield and quality of sugarcane:

The mean height and weight of undamaged cane was significantly taller and heavier, respectively than those of the damaged ones (Table 7 and Appendix 7). The percent decrease in the stalk heights and weights of the cane damaged by *S.cretica* was 7.89 and 13.46, respectively (Table 7).

The decrease in the mean number of internodes of the damaged cane was not significantly different from that of the undamaged one (Table 7).No significant differences were recorded between the mean percent of moisture, fibre, brix, pol, purity and estimated recoverable sucrose (E.R.S.C) of the damaged and undamaged cane (Table 7 and Appendix 8).

Table 6: Percent stalks bored, internodes bored and bored holes/stalk caused by *S.cretica* to 23varieties of sugarcane first ratoon crop cycle grownat Kenana during 1997/1998 season

% stalks bored		% internodes bored		bored holes/stalk	
Variety	Mean ± S.E	Variety	Mean ± S.E	Variety	Mean ± S.E
B80251	1.5181 ± 0.04 a	B80251	1.1546 ± 0.03 a	B80251	1.0428 ±0.05 a
BJ8536	1.3780 ± 0.03 a	B82289	1.0093 ± 0.04 ab	Missan	0.9277 ±0.03 ab
B82289	1.3772 ± 0.05 a	TUC72-15	1.0075 ± 0.06 ab	DB73415	0.9258 ±0.03 ab
TUC85-3	1.3632 ± 0.03 a	DB73415	1.0059 ± 0.05 ab	B82289	0.9206 ±0.03 ab
DB73415	1.3522 ± 0.04 a	DB71105	0.9929 ± 0.05 ab	DB71105	0.9157 ±0.03 ab
B82171	1.3374 ± 0.03 a	Darfour	0.9817 ± 0.05 ab	Darfour	0.9154 ±0.05 ab
TUC72-15	1.2951 ± 0.15 a	TUC75-3	0.9813 ± 0.03 ab	TUC72-15	0.9131 ±0.03 ab
Co997	1.2858 ± 0.00 a	BJ8536	0.9778 ± 0.02 ab	BJ8251	0.9111 ±0.04 ab
DB71105	1.2803 ± 0.15 a	B76251	0.9771 ± 0.05 ab	BJ8717	0.9023 ±0.05 ab
B76251	1.2803 ± 0.15 a	BJ8251	0.9751 ± 0.08 ab	B76251	0.8977 ±0.02 ab
Missan	1.2500 ± 0.14 a	BJ8717	0.9680 ± 0.08 ab	TUC74-1-	0.8970 ±0.05 ab
BJ8717	1.2436 ± 0.15 a	BJ84111	0.9584 ± 0.05 ab	TUC75-3	0.8953 ±0.02 ab
Darfour	1.2397 ± 0.14 a	Missan	0.9563 ± 0.05 ab	DB70279	0.8925 ±0.06 ab
BJ84111	1.2397 ± 0.14 a	B82171	0.9466 ± 0.02 ab	B82171	0.8911 ±0.02 ab
BJ8251	1.1846 ± 0.20 a	Co997	0.9410 ± 0.03 ab	Co997	0.8853 ±0.02 b
BJ83139	1.1733 ± 0.11 a	TUC74-10	0.9169 ± 0.08 ab	BJ84111	0.8791 ±0.02 b
Mex73523	1.0867 ± 0.15 a	BJ83139	0.9075 ± 0.03 ab	BJ8536	0.8734 ±0.01 b
R572	1.0609 ± 0.15 a	DB70279	0.9052 ± 0.07 b	BJ83139	0.8667 ±0.02 b
Co527	1.0609 ± 0.08 a	Co527	0.9046 ± 0.03 b	Co527	0.8593 ±0.01 b
TUC74-10	1.0071 ± 0.17 a	Mex73523	0.8996 ± 0.04 b	Mex73523	0.8583 ±0.02 b
Co6806	1.0047 ± 0.08 a	R572	0.8831 ± 0.03 b	R572	0.8504 ±0.01 b
DB70279	0.9891 ± 0.15 a	Co6806	0.8736 ± 0.02 b	Co6806	0.8479 ±0.01 b
BJ87109	0.9485 ± 0.11 a	BJ87109	0.8560 ± 0.02 b	BJ87109	0.8410 ±0.01 b

Legend as in Table 1.

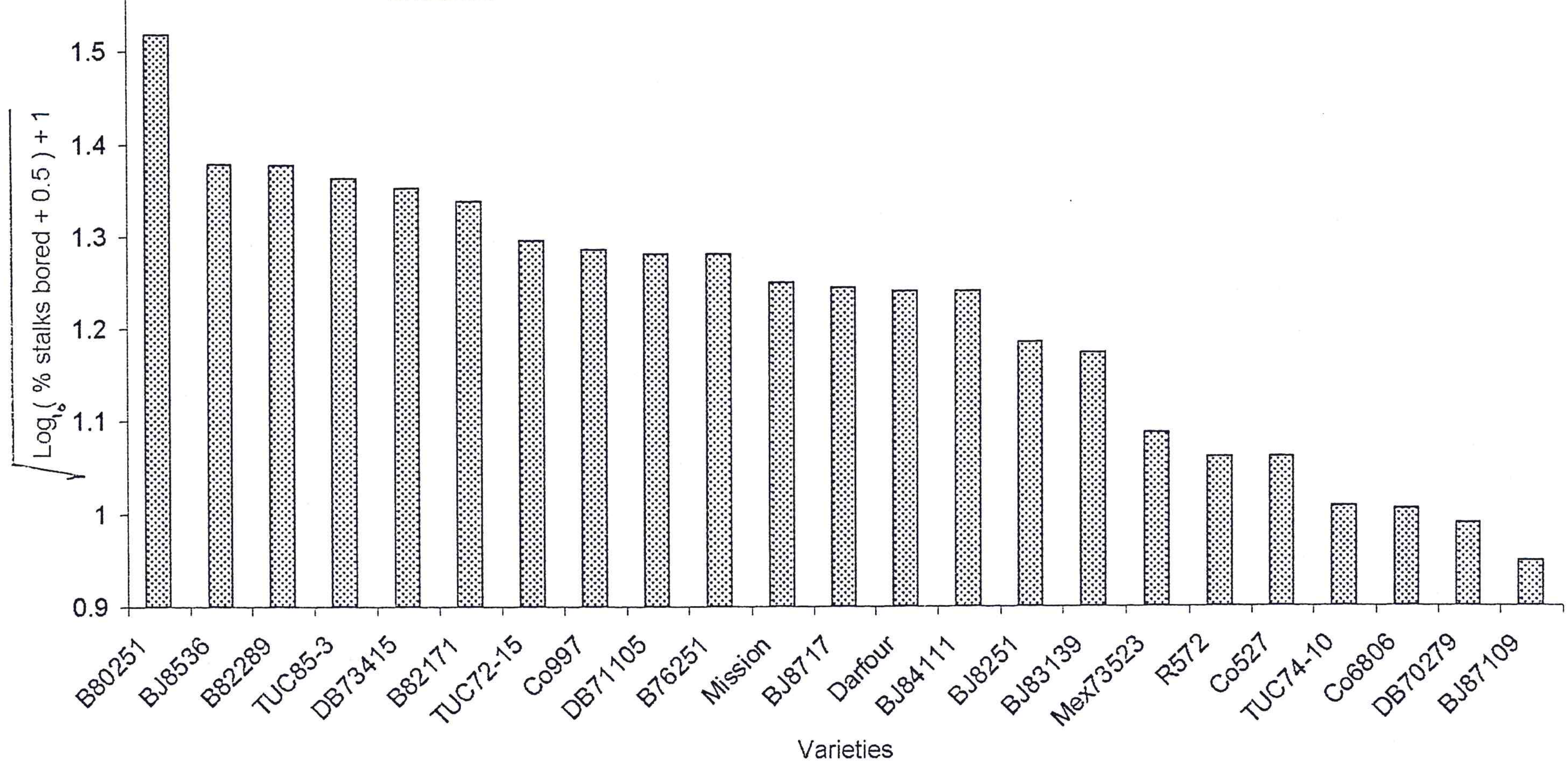


Fig.9: Relative susceptibility of 23 sugarcane varieties to damage caused by the stem borer *S.cretica* in first ratoon cycle grown at Kenana during 1997/98 season

Fig. 10 : Relative susceptibility of 23 sugarcane varieties to damage caused by the stem borer *S.cretica* in first ratoon cycle grown at Kenana during 1997/98 season

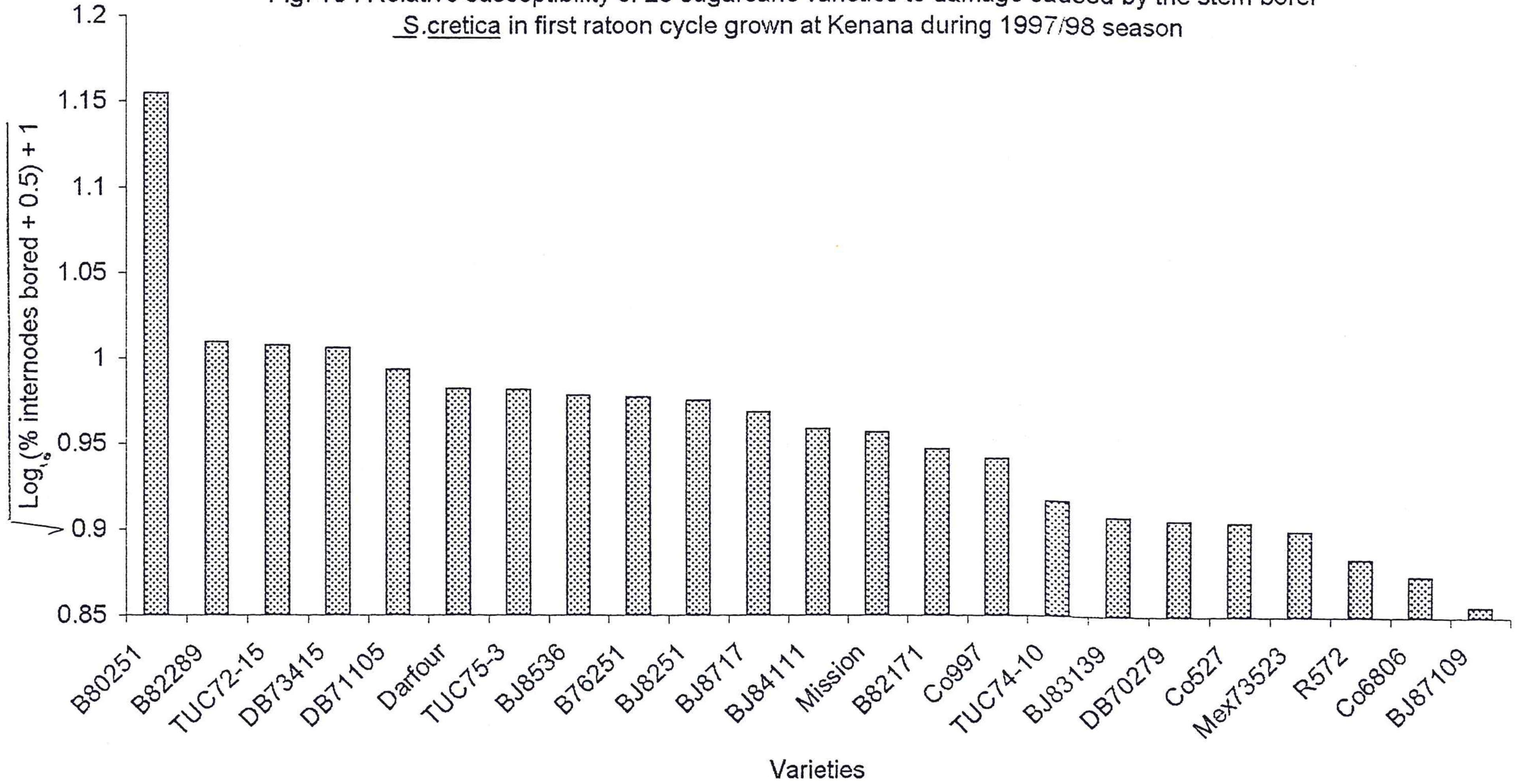


Fig. 11: Relative susceptibility of 23 sugarcane varieties to damage caused by the stem borer *S. cretica* in first ratoon cycle grown at Kenana during 1997/98 season

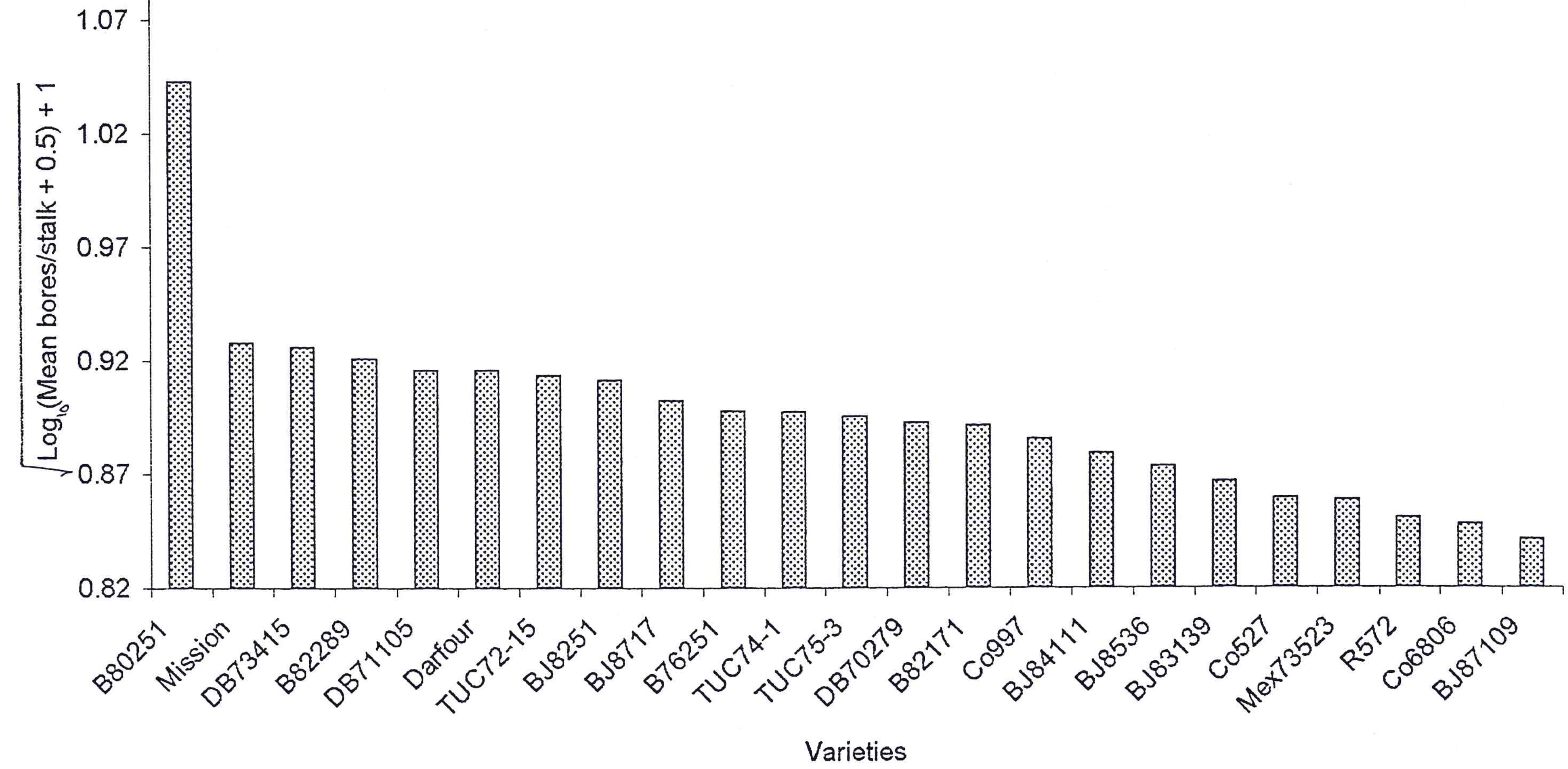


Table 7: The effects of damage caused by stem-borer, *S. cretica* on yield and quality of sugarcane at Kenana during 1997/98 season

Parameter tested	Mean (± S.E)		Percent decrease	T-Calculated	Pr>ITI
	Un damaged cane	damaged cane			
Number of internodes per stalk	26.56 ± 0.49	25.06 ± 0.60	5.65	- 1.931 ns	0.5334
Stalk height (cm)	215.40 ± 2.07	198.40 ± 3.72	7.89	- 3.996***	0.0008
Stalk weight (kg)	1.04 ± 0.07	0.90 ± 0.04	13.46	- 3.250 ***	0.0045
Moisture %	61.69 ± 0.36	61.67 ± 0.35	0.03	- 0.040 ns	0.9684
Fibre %	18.49 ± 0.23	19.04 ± 0.42	- 2.97	1.151 ns	0.2649
Brix %	19.821 ± 0.16	19.29 ± 0.2	3.04	-2.058ns	0.0544
Pol %	15.27 ± 0.15	14.95 ± 0.19	2.08	-1.282 ns	0.2161
Purity %	77.08 ± 0.66	77.55 ± 0.51	-0.60	0.552 ns	0.5878
E.R.Sc%	11.83 ± 0.191	11.62 ± 0.22	1.78	- 0.726 ns	0.4774

5. DISCUSSION

5.1 Effects of stem-borer, *S.cretica* on sugarcane crop cycles:

The percent of internodes bored was significantly greater in plant cane than in ratoons of the two varieties. This agrees with the results obtained by Motia (1954) and Ellis *et.al.* (1960) (c.f. Jepson, 1954). Contrarily Elamin (1984) mentioned that the infestation was generally higher in ratoon compared to that in the plant cane.

Mohyuddin and Greathead (1970) noticed that the practice of ratooning sorghum was responsible for the carryover and build up of borer population. This may not apply to sugarcane, as the normal cultural practice adopted in Kenana, and other sugarcane schemes is burning of the cane before harvest which usually destroys the moths and the immature stages of the pest. Furthermore, sugarcane cultural practices like raking and ploughing reduce the population of the pest.

The number of bored holes per stalk was significantly greater in the plant cane than in the ratoon of the variety Co527 compared to Co6806. Because the variety Co6806 was less attacked by the borer, it is assumed that the former variety was more resistant to the stem-borer. This agreed fully with the findings of David and Alexander (1986) who recorded Co6806 as a resistant variety.

Generally, the level of damage i.e the percent stalks bored, percent internodes bored and mean bored holes per stalk recorded during this study were comparatively lower than those recorded by Saeed and Isobi (1981 and 1983) in Kenana, this may be related to the following:

1. Extension of the area under sugarcane to the boundries of the nearby rainfed dura plantation.
2. Adoption of new more effective cultural practices such as raking, burning, ploughing, ratooning ...etc.
3. The existance of sugarcane, as an alternative host after the harvest of dura may have enabled the pests to spend the dry season on it and consequently the continuation of their natural enemies.
4. Introduction of new resistant sugarcane varieties.

5.2 Effects of stem-borer, *S.cretica* on sugarcane grown at different distances from sorghum fields.

Results showed that the migration of the pests from adjacent rainfed sorghum to the cane field after harvest of dura, and back to sorghum after establishing the new crop of dura is possible, this is indicated by the high level of damage of the shoots in plots of cane adjacent to the sorghum, and also of stalks and internodes bored in areas away from the newly grown dura.

The lower damage in the plots of cane near to sorghum may be related to the fact that dura is preferred to cane. Elamin (1980) reported that, fodder grass and grain sorghum varieties are known to be preferred to sorghum by *S.cretica.*

Shoot of cane grown near sorghum were highly damaged compared to those grown in far locations. The total number of shoots per feddan recorded in the last count conducted were greater in the location nearer to the dura than in the far location. This may be related to the fact that the more the cane are damaged by the borer the more shoots arise. This is in agreement with the finding of Jepson (1954) who reported that, if a shoot of sugarcane is attacked by borers soon after sprouting, the central shoot withers, and turns brown, forming a characteristic "dead heart", and the formation of 2 to 3 tillers may succeed each shoot so killed.

The peak damage of shoot was recorded in December & January in the two locations. These results were in full agreement with the findings of Elamin (1980), who reported that, the flight activities of the moths of *S.cretica* and consequently the damage was generally highest during winter months (Nov. --- Jan.) and lowest during autumn months (July --- Oct.)

Lower number of sugarcane stalks per plot and lower weight were recorded in the far location than in the nearer one. The reason may be attributed to the lower number of tillers produced and the higher percentage of stalks and internodes damaged.

5.3 Relative susceptibility of sugarcane varieties to the damage caused by the stem borer *S.cretica*.

5.3.1 Testing the plant cane of 34 sugarcane varieties:

Varieties TUC75-2 and BJ82156 tested were highly damaged compared to variety FR87288 which was less damaged. Ahmed and Doka (Unpublished data) found that variety FR87288 is higher in sugar and fibre contents compared to either TUC75-2 or BJ82156 variety. Mathes and Ingram (1942) (c.f. Mathes and Charpentier, 1969) mentioned that varieties of sugarcane with high percent of sucrose are less damaged by *D.saccharalis* compared to those with low percent of sucrose. Also Cleare (1934) (c.f. Mathes and Charpentier, 1969) reported that resistance to borers is probably due to fibre contents and its arrangement in cane. Accordingly, the tested varieties which proved to be less damaged and also high in sucrose and fibre contents are assumed to be less susceptible.

Morphological observations revealed that the variety FR87288 has hairy leaf surface and normally it's leaves were shed, while the varieties TUC75-2 and BJ82156 did not. This was in agreement with the earlier findings of Tucker (1938) (c.f. Mathes and Charpentier, 1969) who found that hairiness of cane leaves might affect oviposition of *D.saccharalis*, and that more eggs were layed on the smooth surfaces. David and Karla (1967) pointed out that, the incidence of *C.indicus* is less in selftrashing varieties, and consequently damage is less.

Mathes *et.al,* (1939) (c.f. Mathes and Charpentier, 1969) found that, the varieties with pink stalks suffer less injury from *D.saccharalis* than the varieties with green stalks. The tested variety FR87288 has pink stalk.

5.3.2 Testing the first ratoon of 23 sugarcane variety:

Variety B80251 was highly damaged compared to varieties DB70279, Co527, Mex73523, R572, Co6806 and BJ87109.

Ahmed & Doka (unpuplished data) reported that varieties DB70279, Co527, Mex73523, R572, Co6806 and BJ87109 were taller compared to the highly damaged variety B80251. This finding agreed with that of Mathes and Ingram (1942) (c.f. Mathes and Charpentier, 1969) who found that the varieties with shorter stalks to be severely attacked by *D.saccharalis*. Morphological observations revealed that the less damaged varieties possess desirble characters such as pink stalks, hairy leaves and long leaf spindle which pose them resistant compared to B80251 variety which was highly damaged.

5.4 Effects of damage of the stem-borer *S.cretica* on yield and quality of sugarcane:

In this study decrease in height and weight of damaged canes, compared to the undamaged ones, may be related to the same factors mentioned by Gubta and Avasthy (1960) and Williams (1969) who reported that, reduction in weight of damaged cane was mainly due to the consumption of plant tissues by larvae, and also the destruction of the vessels that transport water and nutrients to the plant resulted in the desiccation of injured tissues. Moreover, secondary infection caused by fungi and bacteria might have contributed to the reduction in weight. Bennet (1961) added that, the destruction of the inner tissues of sugarcane by the stem-borer caused a loss of weight and retarded the growth. The same results were recorded in Sudan by Elamin (1980) and Mohamed (1992) who reported a decrease of 45 and 14% in cane weight in the varieties Co527 and Co6806, respectively. The percent decrease of moisture, brix, pol and estimated recoverable sucrose of sugarcane recorded during this study between the damaged and undamaged cane were not significantly different. This may be due to the sampling method followed. Contrarily, Williams (1961), Bennet (1961),David and Karla (1967), Elamin (1980, 1990), Saeed and Isobi (1981) and Mohamed (1992) recorded significant differences in these parametres between damaged and undamaged cane.

6. CONCLUSIONS & RECOMMENDATIONS

From the studies conducted, it was concluded that :

1. Any control measures to be designed should be directed towards the plant cane because it is the most damaged.
2. It is suggested that varieties FR87288, BJ87109, Co6806, R572, Mex73523, Co527 and DB70279 which were found less susceptible to damage by *S.cretica* are to be grown in areas heavily infested by stem borers.
3. As sorghum is preferred to sugarcane, sorghum may be grown on the boundries of sugarcane fields, as a trap crop.
4. Future work should include the following suggestions:
   a) Because the work on susceptibility and resistance of sugarcane to stem-borer attack is scantly, it is suggested that future work should cover this topic.
   b) The mechanism of relative susceptibility or tolerences of sugarcane to stem-borer attack also needs further investigation.
   c) The intensity of damage, varietal difference and the stage of plant are to be considered, with regard to effects of damage on yield and quality of sugarcane.

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Appendix 1: Percents of stalks and internodes bored and number of bored holes per stalk caused by *S. critica* to the sugarcane variety Co 527, at Kenana, during 1997/98 season

Parameter Tested	Crop Cycle	Percent of damage				
		Replications				
		I	II	III	IV	Mean ± SE
Stalks bored	PC	17.00	25.00	7.00	47.00	24.00 ± 8.50 a
	R1	8.00	4.00	6.00	6.00	6.0 ± 0.82 b
	R2	4.00	3.00	2.00	4.00	3.50 ± 0.50 b
	R3	1.00	5.00	-	2.00	2.67 ±1.20 b
	R4	3.00	1.00	1.00	2.00	1.75 ± 0.48 b
	R5	2.00	0.00	1.00	0.00	0.75 ± 0.48 c
Internodes bored	PC	0.79	1.35	0.38	2.93	1.36 ± 0.56 d
	R1	0.49	0.79	0.34	0.41	0.51 ± 0.10 e
	R2	0.18	0.19	0.23	0.22	0.21 ± 0.01 ef
	R3	0.04	0.31	-	0.14	0.16 ± 0.08 f
	R4	0.18	0.05	0.09	0.10	0.11 ± 0.03 f
	R5	0.09	0.00	0.09	0.00	0.05 ± 0.03 f
Mean bores/stalk	PC	0.31	0.41	0.11	0.82	0.41 ± 0.15 g
	R1	0.21	0.34	0.10	0.19	0.21 ± 0.05 gh
	R2	0.06	0.11	0.09	0.10	0.09 ± 0.01 hk
	R3	0.03	0.09	-	0.06	0.06 ± 0.02 hk
	R4	0.07	0.01	0.02	0.02	0.03 ± 0.01 k
	R5	0.05	0.00	0.00	0.00	0.02 ± 0.01 k

Mean followed by the same letter(s) were not significantly different Pr>0.05
P C = Plant cane
R1 – R5 = first ratoon to fifth ratoon.

Appendix 2: Percents of stalks and internodes bored and number of bored holes per stalk caused by *S. critica* to the sugarcane variety Co 6806, at Kenana, during 1997/98 season

Parameter Tested	Crop Cycle	Percent of damage				
		Replications				
		I	II	III	IV	Mean ± SE
Stalks bored	PC	9.00	6.00	9.00	4.00	7.00 ± 1.22 n
	R1	8.00	6.00	3.00	3.00	5.00 ± 1.22 n
	R2	3.00	5.00	4.00	2.00	3.50 ± 0.65 n
	R3	7.00	3.00	3.00	0.00	3.25 ± 1.44 n
	R4	3.00	2.00	4.00	1.00	2.50 ± 0.66 n
	R5	0.00	4.00	3.00	1.00	2.00 ± 0.91 n
Internodes bored	PC	0.55	0.32	0.59	0.18	0.41 ± 0.10 r
	R1	0.36	0.32	0.21	0.22	0.28 ± 0.04 rt
	R2	0.23	0.25	0.28	0.09	0.21 ± 0.40 rt
	R3	0.46	0.13	0.15	0.00	0.19 ± 0.10 rt
	R4	0.13	0.09	0.21	0.05	0.12 ± 0.03 rt
	R5	0.00	0.20	0.13	0.05	0.10 ± 0.04 t
Mean bores/stalk	PC	0.23	0.08	0.14	0.04	0.12 ± 0.04 y
	R1	0.11	0.16	0.07	0.10	0.11 ± 0.02 y
	R2	0.07	0.08	0.24	0.02	0.10 ± 0.05 y
	R3	0.19	0.03	0.03	0.00	0.06 ± 0.04 y
	R4	0.04	0.04	0.07	0.03	0.05 ± 0.01 y
	R5	0.00	0.05	0.03	0.03	0.03 ± 0.01 y

Legend as in Appendix Table (1)

Appendix 3: **Effects of distance between sugarcane and sorghum fields on the level of shoot borer damage caused by *S.cretica* to sugarcane, at Kenana, during 1997/98 season.**

Count No	Date of count	Location A			Location B		
		No. of shoots / F	damaged shoot / F	% of damage	No. of shoots / F	Damaged shoot / F	% of damage
1	01/11/97	20845	0	0	22276	1	0.004
2	15/11/97	27555	27	0.20	36531	72	0.20
3	29/11/97	36355	997	2.73	46395	432	0.93
	Total			2.93			1.134
	Mean ± SE			0.98 ± 0.88			0.36 ± 0.28
4	13/12/97	48617	3068	6.31	58861	710	1.2
5	27/12/97	61896	1898	3.07	67642	305	0.45
	Total			9.38			1.65
	Mean ± SE			4.69 ± 1.62			0.83 ± 0.38
6	10/01/98	71273	1242	1.74	70405	215	0.30
7	24/01/98	78590	1470	1.87	83631	148	0.18
	Total			3.61			0.48
	Mean ± SE			1.81 ± 0.06			0.24 ± 0.06
8	07/02/98	93712	1446	1.54	93061	135	0.15
9	21/02/98	76314	1032	1.35	69972	57	0.08
	Total			2.89			0.23
	Mean ± SE			1.48 ± 0.10			0.12 ± 0.03
10	07/03/98	77994	938	1.20	69322	104	0.15
11	21/03/98	65799	532	0.81	62330	78	0.13
	Total			2.01			0.28
	Mean ± SE			1.01 ± 0.20			0.14 ± 0.01
12	04/04/98	65419	413	0.63	62059	77	0.12
13	18/04/98	66419	412	0.62	63739	180	0.28
	Total			1.25			0.40
	Mean ± SE			0.63 ± 0.01			0.20 ± 0.08
14	02/05/98	64064	172	0.27	59349	192	0.32

Appendix 4 : Effects of distance between sugarcane and sorghum fields on the level of damage caused by *S.cretica* and its impact on yield of sugarcane.

Plot No	Location A					Location B				
	%		Average	Population	Weight	%		Average	Population	Weight
	Inter-bored	Stalk-bored	Bore/stalk	Stalk-2n	Kg/2m	Inter-bored	Stalk-bored	Bores/stalk	Stalk/2m	Kg/2m
1	0.15	3.85	0.04	26	44.0	1.05	23.33	0.30	30	37.2
2	0.62	14.89	0.17	47	59.7	0.34	2.14	0.10	42	47.0
3	0.92	15.79	0.37	38	43.8	1.10	15.15	0.27	33	45.5
4	0.35	7.32	0.1	41	45.6	1.16	21.62	0.43	37	54.6
5	0.78	15.00	0.33	40	57.0	1.93	32.35	0.53	34	48.6
6	0.14	3.45	0.07	29	46.2	0.41	9.38	0.13	32	35.5
7	0.34	7.32	0.07	41	51.6	1.33	18.60	0.42	43	50.5
8	0.53	11.90	0.14	42	55.6	1.20	21.95	0.29	41	54.8
9	1.27	25.00	0.41	32	43.2	1.27	20.00	0.30	40	46.8
10	0.33	7.14	0.14	42	54.0	1.01	17.07	0.29	41	42.4
Total	543	111.66	1.84	39.8	500.7	10.80	186.59	3.06	373	462.4
Mean ± S.E	0.54 ± 0.12	11.03 ± 2.17	0.18 ± 0.04	39.8 ± 2.12	50.07 ± 1.96	1.08 ± 0.14	18.66 ± 2.27	0.31 ± 0.04	37.3 ± 1.49	46.24 ± 2.03

Appendix 5: Mean percent stalks or internodes bored and average bore-holes/stalk assessed at harvest of 34 sugarcane varieties at Kenana, during 1997/98 season.

Code No	Variety	No of reps	(Mean ± SE)		
			%		
			Stalk bored	Internode bored	Bore-holes/stalk
1	CoC671	8	7.00 ± 2.24	0.61 ± 0.17	0.30 ± 0.12
			(1.25 ± 0.09)	(0.99 ± 0.04)	(0.93 ± 0.03)
2	BJ8374	4	13.00 ± 2.52	0.99 ± 0.26	0.45 ± 0.16
			(1.45 ± 0.02)	(1.07 ± 0.03)	(0.98 ± 0.03)
3	R571	4	10.00 ± 2.58	1.53 ± 0.67	0.50 ± 0.21
			(1.40 ± 0.04)	(1.12 ± 0.05)	(0.98 ± 0.04)
4	FR86208	4	6.00 ± 4.76	0.36 ± 0.30	0.08 ± 0.07
			(1.12 ± 0.17)	(0.98 ± 0.07)	(0.87 ± 0.03)
5	B63349	4	8.50 ± 2.060	0.66 ± 0.22	0.33 ± 0.15
			(1.33 ± 0.08)	(1.00 ± 0.04)	(0.93 ± 0.03)
6	TU75-3	8	11.00 ± 2.52	1.00 ± 0.29	0.44 ± 0.14
			(1.42 ± 0.05)	(1.07 ± 0.05)	(0.98 ± 0.04)
7	KnH80-412	4	10.50 ± 2.26	0.74 ± 0.15	0.30 ± 0.07
			(1.36 ± 0.08)	(1.03 ± 0.03)	('0.94 ± 0.02)
8	BJ82156	4	23.00 ± 7.19	1.74 ± 0.51	0.62 ± 0.16
			(1.52 ± 0.04)	(1.14 ± 0.04)	(1.02 ± 0.04)
9	R575	8	9.00 ± 1.91	0.83 ± 0.20	0.08 ± 0.04
			(1.40 ± 0.04	(1.05 ± 0.03)	(0.87 ± 0.02)
10	BJ8251	4	14.00 ± 3.83	0.82 ± 0.29	0.21 ± 0.09
			(1.45 ± 0.04)	(1.04 ± 0.04)	(0.92 ± 0.03)
11	FR87421	4	8.00 ± 3.65	0.52 ± 0.25	0.15 ± 0.08
			(1.26 ± 0.20)	(0.98 ± 0.06)	(0.90 ± 0.03)
12	SP741103	4	13.00 ± 4.73	0.86 ± 0.33	31.00 ± 0.14
			(1.33 ± 0.17)	(1.03 ± 0.07)	('0.94 ± 0.04)
13	BJ8717	4	19.00 ± 7.00	1.61 ± 0.70	0.94 ± 0.45
			(1.47 ± 0.07)	(1.11 ± 0.07)	(1.03 ± 0.07)
14	BJ87109	4	2.00 ± 2.00	0.21 ± 0.21	0.07 ± 0.07
			(0.97 ± 0.14)	(0.89 ± 0.06)	(0.86 ± 0.03)
15	Co6806 *	8	1.50 ± 1.05	0.08 ± 0.06	0.03 ± 0.02
			(0.96 ± 0.08)	(0.86 ± 0.02)	(0.85 ± 0.01)
16	Co997 *	8	4.00 ± 1.69	0.35 ± 0.16	0.23 ± 0.12
			(1.11 ± 0.10)	(0.93 ± 0.04)	(0.96 ± 0.03)
17	TUC75-2	4	20.00 ± 7.12	1.79 ± 0.61	1.05 ± 0.49
			(1.99 ± 0.05)	(1.15 ± 0.04)	(1.06 ± 0.05)
18	DB8103	4	20.00 ± 4.62	1.35 ± 0.38	0.77 ± 0.26
			(1.51 ± 0.03)	(1.11 ± 0.04)	(1.03 ± 0.04)
19	Co527 *	8	17.00 ± 2.38	1.67 ± 0.18	0.39 ± 0.07
			(1.48 ± 0.03)	(1.09 ± 0.03)	(0.97 ± 0.02)
20	BJ87124	4	5.00 ± 3.00	0.53 ± 0.34	0.39 ± 0.31
			(0.97 ± 0.14)	(0.96 ± 0.07)	(0.93 ± 0.07)
21	DB73415	4	12.00 ± 4.32	1.29 ± 0.47	0.61 ± 0.32
			(1.32 ± 0.06)	(1.07 ± 0.08)	(0.99 ± 0.06)
22	FR87288	4	1.00 ± 1.00	0.05 ± 0.05	0.02 ± 0.02
			(0.95 ± 0.01)	(0.86 ± 0.02)	(0.85 ± 0.01)

Appendix 5: Continue

23	BJ82119	4	13.00 ± 4.43 (1.43 ± 0.06)	0.70 ± 0.29 (1.02 ± 0.05)	0.27 ±0.13 (0.93 ± 0.03)
24	BJ84111	4	9.00 ± 5.00 (1.35 ± 0.06)	0.74 ± 0.47 (1.00 ± 0.07)	0.26 ± 0.13 (0.93 ± 0.08)
25	SP753046	4	21.00 ± 6.81 (1.50 ± 0.05)	1.54 ± 0.58 (1.12 ± 0.06)	0.61 ±0.26 (1.00 ± 0.05)
26	BJ83139	4	16.00 ± 4.32 (1.47 ± 0.04)	1.21 ± 0.51 (1.09 ± 0.05)	0.45 ± 0.16 (0.98 ± 0.03)
27	R572	4	18.00 ± 3.46 (1.50 ± 0.02)	1.41 ± 0.49 (1.11 ± 0.04)	0.75 ± 0.29 (1.03 ± 0.05)
28	SP701123	4	8.00 ± 3.65 (1.26 ± 0.05)	0.64 ± 0.32 (0.98 ± 0.07)	0.31 ± 0.17 (0.93 ± 0.05)
29	SP791230	4	20.00 ± 5.66 (1.50 ± 0.04)	1.38 ± 0.43 (1.11 ± 0.05)	0.51 ± 0.11 (1.00 ± 0.02)
30	B85764	4	5.00 ± 3.00 (1.31 ± 0.17)	0.36 ± 0.22 (0.94 ± 0.06)	0.17 ± 0.11 (0.90 ± 0.04)
31	BJ8751	4	4.00 ± 2.31 (1.11 ± 0.16)	0.25 ± 0.15 (0.92 ± 0.05)	0.12 ± 0.10 (0.88 ± 0.03)
32	TUC72-15	4	19.00 ± 4.43 (1.50 ± 0.04)	1.57 ± 0.48 (1.13 ± 0.05)	0.72 ± 0.24 (1.03 ± 0.04)
33	SP718210	4	11.00 ± 4.43 (1.31 ± 0.16)	0.81 ± 0.28 (1.03 ± 0.07)	0.31 ± 0.12 (0.94 ± 0.04)
34	DB7532	4	11.00 ± 6.40 (1.18 ± 0.20)	0.60 ± 0.38 (0.97 ± 0.08)	0.27 ± 0.19 (0.92 ±0.05)

± Figure in parenthesis are the transformed data

* Check varieties

Appendix 6: Mean percent stalks or internodes bored and average bore-holes/stalk assessed at harvest of 23 sugarcane varieties at Kenana, during 1997/98 season.

Code No	Variety	No of reps	('mean + SE)		
			%		
			stalk bored	Internode bored	bore holes/stalk
1	B80251	4	22.00 + 6.22 (1.52 + 0.04)	1.74 + 0.30 (1.15 + 0.03)	0.83 + 0.27 (1.04 + 0.05)
2	Missan	4	7.00 + 3.42 (1.25 + 0.14)	0.41 + 0.22 (0.96 + 0.05)	0.25 + 0.09 (0.93 + 0.03)
3	B82389	4	9.00 + 3.00 (1.38 + 0.05)	0.61 + 0.20 (1.01 + 0.04)	0.22 + 0.08 (0.92 + 0.03)
4	BJ8251	4	11.00 + 6.40 (1.18 + 0.20)	0.62 + 0.37 (0.98 + 0.08)	0.22 + 0.13 (0.91 + 0.04)
5	DARFOUR	4	6.00 + 2.59 (1.24 + 0.14)	0.52 + 0.22 (0.98 + 0.05)	0.26 + 0.19 (0.92 + 0.05)
6	C06806 *	8	1.50 + 0.73 (1.00 + 0.08)	0.10 + 0.05 (0.87 + 0.02)	0.03 + 0.01 (0.85 + 0.01)
7	DB70279	4	3.00 + 3.00 (0.99 + 0.15)	0.30 + 0.30 (0.91 + 0.07)	0.21 + 0.21 (0.89 + 0.06)
8	DB73415	4	7.00 + 1.91 (1.35 + 0.04)	0.66 + 0.32 (1.01 + 0.05)	0.24 + 0.09 (0.93 + 0.03)
9	Co527 *	8	2.00 + 0.76 (1.06 + 0.08)	0.23 + 0.14 (0.9 + 0.03)	0.06 + 0.03 (0.86 + 0.01)
10	DB71105	4	8.00 + 2.83 (1.28 + 0.15)	0.56 + 0.19 (0.99 + 0.05)	0.21 + 0.09 (0.92 + 0.03)
11	BJ87109	4	1.00 + 1.00 (0.95 + 0.11)	0.05 + 0.05 (0.85 + 0.02)	0.01 + 0.01 (0.84 + 0.01)
12	TUC75-3	4	7.00 + 1.00 (1.36 + 0.03)	0.45 + 0.12 (0.98 + 0.03)	0.14 + 0.05 (0.90 + 0.02)
13	Mex73523	4	3.00 + 1.91 (1.09 + 0.15)	0.19 + 0.13 (0.90 + 0.04)	0.05 + 0.04 (0.86 + 0.02)
14	TUC72-15	4	9.00 + 3.00 (1.30 + 0.15)	0.67 + 0.25 (1.01 + 0.06)	0.20 + 0.01 (0.91 + 0.03)
15	R572	4	2.00 + 1.15 (1.09 + 0.15)	0.12 + 0.08 (0.88 + 0.03)	0.03 + 0.02 (0.85 + 0.01)
16	B82171	4	6.00 + 1.15 (1.34 + 0.03)	0.30 + 0.06 (0.95 + 0.02)	0.13 + 0.05 (0.89 + 0.02)
17	TUC74-10	4	5.00 + 5.00 (1.01 + 0.17)	0.43 + 0.43 (0.92 + 0.08)	0.20 + 0.17 (0.90 + 0.05)
18	Co997 *	4	4.00 + 0.00 (1.26 + 0.00)	0.29 + 0.10 (0.94 + 0.03)	0.12 + 0.07 (0.89 + 0.02)
19	BJ8536	4	8.00 + 1.63 (1.38 + 0.03)	0.42 + 0.09 (0.98 + 0.02)	0.08 + 0.02 (0.87 + 0.01)

Appendix 6: continue

20	BJ83139	4	3.00 ± 1.00 (1.17 ± 0.11)	0.18 ± 0.08 (0.91 ± 0.03)	0.07 ± 0.04 (0.87 ± 0.02)
21	BJ84111	4	6.00 ± 2.58 (1.24 ± 0.14)	0.41 ± 0.20 (0.96 ± 0.05)	0.10 ± 0.05 (0.88 ± 0.02)
22	B76251	4	8.00 ± 2.83 (1.28 ± 0.15)	0.48 ± 0.18 (0.98 ± 0.05)	0.15 ± 0.06 (0.90 ± 0.02)
23	BJ8717	4	9.00 ± 6.40 (1.24 ± 0.15)	0.70 ± 0.58 (0.97 ± 0.08)	0.23 ± 0.20 (0.90 ± 0.05)

± Figures in parentheses are the transformed data

* Check varieties

Appendix 7: Effects of damage caused by *S.cretica* on yield of Sugarcane at Kenana, during 1997/98 season.

Samples	Number of internodes		Stalk height (cm)		Stalk weight (kg)	
	Un damaged	damaged	Undamaged	damaged	Undamaged	Damaged
1	27.60	24.60	216.00	202.00	1.02	0.90
2	23.40	23.20	213.00	190.00	1.04	0.84
3	28.60	22.60	213.00	184.00	1.06	0.92
4	27.00	25.80	208.00	197.00	1.20	0.82
5	27.00	26.60	209.00	190.00	1.00	0.78
6	25.80	23.40	227.00	196.00	0.90	0.92
7	27.20	24.00	223.00	213.00	1.10	0.98
8	28.00	26.60	208.00	210.00	0.94	0.74
9	26.00	25.00	216.00	185.00	1.08	0.96
10	25.00	28.80	221.00	217.00	1.10	1.14
Total	265.6	250.6	2154.0	1984.0	104.4	89.8
Mean ±SE	26.56 ± 0.49	25.06±0.60	215.4 ± 2/07	198.4±3.72	1.04 ±0.03	0.90 ± 0.04

Appendix 8: Effects of damage caused by *S. cretica* on quality of sugarcane, at Kenana, druing 1997/98 season.

Samples	Moisture %		Fibre %		Brix %		Pol %		Purity %		E.R.S.C %	
	Un damaged	damaged	Un damaged	damaged	Un damaged	damaged	Un damaged	damaged	Un damaged	damaged	Un damaged	damaged
1	60.44	61.32	19.13	18.77	20.43	19.91	16.21	15.71	79.32	78.89	12.86	12.40
2	60.60	62.46	19.56	18.13	19.84	19.41	15.68	14.50	79.03	74.71	12.34	10.90
3	63.56	63.52	17.53	16.35	18.91	20.13	14.32	15.54	75.74	77.22	10.91	12.18
4	60.68	62.64	18.87	18.54	20.45	18.82	15.34	14.53	77.00	77.21	11.59	11.21
5	62.56	61.06	18.02	20.86	19.42	18.08	15.04	13.67	77.43	75.61	11.69	10.18
6	61.12	62.82	18.69	18.34	20.19	18.84	15.27	14.74	75.62	78.24	11.63	11.51
7	60.84	60.34	19.30	20.54	19.86	19.21	15.09	14.98	75.97	78.00	11.49	11.57
8	61.64	60.66	18.42	20.10	19.94	19.24	15.26	15.09	76.53	78.57	11.74	11.74
9	62.30	61.20	17.69	19.51	20.01	19.29	15.03	15.42	75.14	80.29	11.42	12.23
10	63.12	66.64	17.71	19.35	19.17	20.01	15.56	15.35	81.15	76.71	12.59	12.23
Total	492.53	616.66	178.79	190.49	198.22	192.94	152.80	149.53	772.93	775.45	118.26	116.15
Mean ±SE	61.69±0.36	61.67±0.35	18.49±0.23	19.04±0.42	19.82±0.16	19.29±0.20	15.27±0.15	14.94±0.19	77.08±0.66	77.55±0.51	11.83	11.62

Appendix 9 : Metreological data collected at Kenana Metreological station during the period of the study

month	1997					1998				
	Temperature			R.H.	Rain fall	Temperature			R.H.	Rain Faill
	Max	Min	Mean			Max	Min	Mean		
Jan.	33.1	15.6	24.4	37	-	34.1	12.9	23.5	31	-
Feb.	32.5	13.4	23.0	26	-	34.7	15.3	25.0	23	-
March	37.8	19.1	28.5	24	-	36.6	18.6	27.6	25	-
April	39.9	23.5	31.7	35	-	41.9	23.0	32.5	27	-
May	37.5	23.9	30.7	53	2.0	41.3	25.0	33.2	38	6.5
June	36.6	23.1	29.9	68	26.5	39.7	25.7	32.7	49	30.8
July	33.4	21.1	27.3	79	76.0	34.0	23.4	28.7	72	145.7
Aug.	32.7	21.9	27.3	79	131.5	31.8	23.0	27.4	80	136.7
Sept.	35.7	22.2	29.0	71	44.0	32.8	22.3	27.5	76	121.5
Oct.	37.2	22.5	29.9	61	9.0	36.0	22.9	29.5	71	5.5
Nov.	36.7	18.6	27.7	40	4.8	38.1	20.5	29.3	36	-
Dec.	33.4	15.1	24.3	31	-	34.6	17.5	26.1	40	-
Total					293.8					446.7

ملخص الاطروحة

هدف هذا البحث الى دراسة تأثير ثاقبة الساق *Sesamia cretica* Lederer علــــى غرس وخلف قصب السكر المختلفة ، على قصب السكر المزروع على مسافات مختلفة مــن الذرة المطرى و على قابلية بعض اصناف قصب السكر للاصابة . أيضا تم بحث اثر تلك الآفة على إنتاج القصب ونوعية السكر. وقد أجريت هذه الدراســـة بمزرعـة البحـوث وحقول قصب السكر التجارية لشركة سكر كنانة فى موسم ١٩٩٧/١٩٩٨ .

وجد أن الضرر الذى تسببه يرقـــات *S. cretica* أى النســبة المئويــة للســيقان والسلاميات المصابة ومتوسط عدد الثقوب فى الساق الواحد تنقص بزيادة عدد الخلـف فى كل من الصنفين Co527 , Co 6806 . كانت نسبة الاصابة فى القصب الغرس أو الخلفـة الاولى اكبر فى الصنف Co527 مقارنا بالصنف Co 6806 . الاصابة فى الخلفة الثانية كـلنت متساوية فى الصنفين ولكن الاصابة التى سجلت على الخلفات الثالثة حتى الخامسة كـــانت اكبر فى الصنف Co 6806 مقارنا بالصنف Co527 .

كانت النسبة المئوية لاصابة النموءات الاولى فى قصب السكر (١٠,٨٤%) الـــتى تقع على مقربة ٥٠ متر من حقول الذره المطرى اكبر من النسبة (٢,٣٢ %) التى ســجلت فى الحقول التى تقع على بعد ٥٠٠ متر من الذرة وفى نفس الاتجاه وذلــك عنــد حصــاد محصول الذرة (نوفمبر). وعلى النقيض من ذلك فانه عند زراعة محصول الذرة الجديــــد (يوليو) ارتفعت نسبة اصابة السيقان والسلاميات فى القصب البعيد عـــن حقـــول الـــذرة

(١٨,٦٦ و ١,٠٨ % على التوالى) وانخفضت فى القصب المزروع على مقربة من حقول الذرة (١١,٠٣ و ٠,٥٤ % على التوالى).

عند اختبار قابلية ٣٤ صنفا من قصب السكر الغرس للاصابة بثاقبة الساق. اوضحت النتائج ان الاصناف TUC 75-2 و BJ 82156 كانت اكثر قابلية للاصابة مقارنة بالصنف FR 87288 . أما بقية الاصناف فقد كانت درجة اصابتها متوسطة. وعند اختبار الاصناف الاخرى (٢٣ صنفا فى الخلفة الاولى) إتضح ان الصنف B80251 اكثر اصابة مقارنا بالاصناف Co527, Mex73523, R572, Co6806, BJ87109 و DB70279 . أما بقية الاصناف فقد كانت اصابتها متوسطة.

النسب المئوية للنقص فى طول ووزن قصب السكر المصاب كانت ٧,٨٩ و ١٣,٤٦ على التوالى مقارنا بالقصب غير المصاب . أيضا لم تسجل فروقات معنوية بين القصب المصاب وغير المصاب فى النسب المئوية للرطوبة ، الالياف ، المواد الصلبة الذائبة ، السكر الذائب ، درجة النقاوة ونسبة استخلاص السكر.