CHAPTER 5

Preference of *Chilo partellus* (Swinhoe) (Lepidoptera: Crambidae) larvae for cultivated and wild graminaceous host plants

ABSTRACT

Freshly eclosed *Chilo partellus* (Swinhoe) (Lepidoptera: Crambidae) larvae must choose whether to feed on the plant on which oviposition occurred or not. Host plant preference of *C. partellus* first instar larvae for cultivated and wild host plants was evaluated in two-choice and multiple-choice tests under laboratory conditions. Larval response on leaf discs of each host plant was also determined under no-choice conditions. The host plants were *Hyparrhenia tamba* (Steud.) (Blue thatching grass), *Pennisetum purpureum* Schumach. (Napier grass), maize (*Zea mays* L.), sorghum (*Sorghum bicolor* (L.) Moench), sweet sorghum (*Sorghum bicolor* (L.) Moench) and pearl millet (*Pennisetum glaucum* (L.) R. Br.). Under no-choice conditions, significant differences were observed in number of larvae on leaf discs among host plants. The greatest number of larvae were recorded on sorghum and *P. purpureum*. *H. tamba* had the lowest number of larvae. Larval behavioural response did not differ between no-choice tests for *H. tamba* when compared to other host plants. These results indicate poor acceptance of this grass by *C. partellus* larvae. While insect behavioural response seemed to vary between choice-tests in other combinations of host plants, that was not the case for *P. purpureum* when compared to maize. Larvae were biased towards maize, one, four and 24 hours after infestation. Knowledge of insect behavioural response triggered by these grasses is important in the control of first instar larvae under field conditions. Therefore, non suitable grasses such as *P. purpureum* can play an important role in reducing establishment of first instar larvae in adjacent crop plants such as maize in a habitat management system.

Keywords: *Chilo partellus*, larval preference, *Pennisetum purpureum*, maize, habitat management.

INTRODUCTION

Upon hatching of eggs, laid by *Chilo partellus* (Swinhoe) (Lepidoptera: Crambidae) moths on the substrate of their choice, emerging larvae must choose whether to accept the plant or not (Khan 1997; Kumar 1997; Van den Berg & Van der Westhuisen 1997). When the larvae have oriented towards a suitable host plant it would remain settled and feed (Khan 1997). However, antixenosis which denotes the presence of chemical and/or morphological factors may influence larval orientation, settling and feeding response (Khan 1997).

Choice tests are often used to measure orientation and settling response which involves the process of selection of a suitable site in which the larvae have an option of whether to accept the plant or not (Smith *et al.* 1994; Khan 1997). Although no-choice tests have been used to determine the levels of larval antibiosis in maize hybrids (Davis *et al.* 1989), fodder grasses (Wiseman *et al.* 1982) and the extent of damage or amount of food ingested (Khan *et al.* 1997), it can also be used to determine settling response of larvae on host plants (Smith *et al.* 1994). The use of no-choice test in combination with choice tests can be of importance in confirming the presence of resistance in a wide variety of plants (Smith *et al.* 1994).

Antixenosis mechanism of resistance in plants inhibits feeding by *C. partellus* larvae on the host plant (Kumar 1997). Reduction in feeding by first instar larvae of *C. partellus* on resistant sorghum (Sorghum bicolor (L.) Moench) cultivars was ascribed to high concentration of Hydrogen cyanide (HCN) in the plants (Woodhead *et al.* 1980). This behavioural response could be used as a tool for the control of stem borers in pest management.

The objectives of the study were 1) to determine *C. partellus* larval response to leaf discs of single cultivated and wild host plant (no-choice test), 2) to determine preference of larvae for leaf disks of two different host plants, a cultivated and wild host plant (two-choice test), and 3) to determine the preference of larvae for leaf discs of more than two host plants, cultivated and wild host plants (multiple-choice test).

MATERIAL AND METHODS

No-choice test

Larval response to host plants was determined in the laboratory using a no-choice test. For this test the petri-dishes (9 cm diameter) were lined with 0.5 cm agar. Leaf discs (1.2 cm diameter) were obtained from whorls leaves of the following host plants: sorghum (*Sorghum bicolor* (L.) Moench) (Cultivar SNK3860), maize (*Zea mays* L.) (CRN3414), sweet sorghum (*Sorghum bicolor* (L.) Moench) (SA4479), pearl millet (*Pennisetum glaucum* (L.) R. Br.) (Okashana-1), (Blue thatching grass) (*Hyparrhenia tamba*) (Steud.) and Napier grass (*Pennisetum purpureum*) Schumach. Each leaf disc, for each host plant was placed in the centre of a petri-dish (Fig. 1). For each host plant, the experiment was repeated six times with eight replicates each time. Immediately after hatching from eggs, ten neonate larvae were placed on the leaf disc of each host plant in the prepared petri-dishes using a camel hair brush. Thereafter, the dishes were sealed with transparent gladrap plastic to prevent the larvae from escaping. To ensure air circulation and prevent the build up of moisture inside petri-dishes, small holes were made in the plastic using a sharp pin. To prevent the possible influence of light on the movement of neonate larvae (positive phototaxis), petri-dishes were placed in the dark at a constant temperature (26°C).

Host plant preference was determined by counting the number of larvae on and below the leaf disc of each host plant at one, four and 24 hours after inoculation.

Two-choice test

The experiment was conducted under the same conditions as the no-choice test. The following combinations of plant species were evaluated: maize vs. *P. purpureum*, maize vs. *H. tamba*; pearl millet vs. *P. purpureum*, pearl millet vs. *H. tamba*; sorghum vs. *P. purpureum*, sorghum vs. *H. tamba*; sweet sorghum vs. *P. purpureum*, sweet sorghum vs. *H. tamba*. The experiment was repeated six times with eight replicates each time. Leaf discs of the two host plants were placed at opposite ends along the edge of a petri dish (9 cm diameter) (Fig. 2). The number of larvae on each leaf disc were recorded at one, four, and 24 hours after inoculation.

Multiple-choice test

The experiment was conducted under the same conditions as no-choice and two-choice tests using the same six host plants. One leaf disc was used for each host plant. Leaf discs of all species were placed at equal distances from each other along the edge of each petri dish (15 cm diameter) (Fig. 3). The experiment was repeated six times with six replications for each time.

Thirty neonate larvae were carefully placed in the centre of each petri-dish. The number of larvae on different leaf discs were recorded at intervals of one, four and 24 hours after inoculation.

Analysis of variance was used in no-choice and multiple-choice tests to determine if there were significant differences in mean number of larvae on leaf discs among host plants. In two-choice tests, t-tests were used to determine differences between mean number of larvae per plant.

RESULTS

No-choice test

Significant differences were observed in the number of larvae on leaf discs of the different host plants one (F = 17.86, d.f. = 42, P = 0.0001) and four hours (F = 16.44, d.f. = 42, P = 0.0001) (Table 1). More larvae were recorded on sorghum and *P. purpureum* than other host plants, although the differences were not significant. Similar numbers of larvae settled on sweet sorghum, maize and pearl millet. The number of larvae observed on *H. tamba* was significantly lower than larvae recovered on any other host plant.

Twenty four hours after infestation, significant differences (F = 15.68, d.f. = 42, P = 0.0001) were again observed between the number of larvae on cultivated and wild host plants. Significantly more larvae were recorded on sorghum, followed by *P. purpureum*, maize, pearl millet and sweet sorghum. Significantly fewer larvae were again recorded on *H. tamba* than on any other host plant.

Two-choice test

Significantly fewer larvae were recovered on leaf discs of *H. tamba* when compared to maize (one hour: F = 10.92, d.f. = 14, P = 0.0052; four hours: F = 7.45, d.f. = 14, P

= 0.0001 and 24 hours: F = 50.42, d.f. = 14, P = 0.0001) sorghum (one hour: F = 5.21, d.f. = 14, P = 0.0386; four hours: F = 6.09, d.f. = 14, P = 0.0271 and 24 hours: F = 16.15, d.f. = 14, P = 0.0013), sweet sorghum (one hour: F = 58.65, d.f. = 14, P = 0.0001; four hours: F = 45.04, d.f. = 14, P = 0.0001, 24 hours: F = 17.99, d.f. = 14, P = 0.0001) and pearl millet (one hour: F = 6.25, d.f. = 14, P = 0.0254 and four hours: F = 5.11, d.f. = 14, P = 0.0402) (Table 2). Number of larvae between *H. tamba* and pearl millet were not significantly different (F = 1.69, d.f. = 14, P = 0.2146) 24 hours after inoculation. No significant differences (one hour: F = 0.078, d.f. = 14, P = 0.7845; four hours: F = 0.19, d.f. = 14, P = 0.6737 and 24 hours: F = 2.61, d.f. = 14, P = 0.1284) were observed in larval settling on maize when compared to *P. purpureum*. Larval settling was significantly higher on *P. purpureum* than on Sweet sorghum only at 24 hours (F = 6.07, d.f. = 14, P = 0.0273) after inoculation. No significant differences (one hour: F = 0.03, d.f. = 14, P = 0.8668; four hours: F = 0.01, d.f. = 14, P = 0.9258 and 24 hours: F = 0.27, d.f. = 14, P = 0.6147) were observed in larval settling on pearl millet versus *P. purpureum* (Table 2).

Multiple-choice test

No significant differences were observed in number of larvae on leaf discs of hosts plants one (F = 1.31, d.f. = 30, P = 0.2858) and four hours (F = 0.84, d.f. = 30, P = 0.5301) after infestation (Table 3). Twenty four hours after inoculation, significant differences (F = 2.89, d.f. 30, P = 0.0304) in the number of larvae on leaf discs of hosts plants were observed. Although *H. tamba* and *P. purpureum* had fewest larvae, while maize and sorghum had most, followed by sweet sorghum and pearl millet the differences were not significant.

DISCUSSION

The results of no-choice tests in which higher numbers of larvae were observed on *P. purpureum* than on maize were in contrast with the results obtained in two and multiple-choice tests, where fewer larvae were observed on maize. A similar pattern was observed between *P. purpureum* and pearl millet. Possible differences in insect behavioral response between choice and no-choice tests were reported by Smith *et al.* (1994). The results of no-choice tests may possibly indicate that in the absence of suitable host plants first instar larvae are likely to settle on *P. purpureum* for a while.

Therefore, if larvae could stay longer than 24 hours on *P. purpureum* this could possibly bring an added advantage to insect pest management. *Chilo partellus* larvae that fed on *P. purpureum* did not survive (Khan *et al.* 1997; Khan *et al.* 2000). Furthermore, this grass exhibited hairs on the leaf which may interfere with larval feeding (Bernays & Chapman 1994). The higher number of larvae on leaf discs of maize than on *P. purpureum*, when provided with a choice, indicated high preference for maize under choice conditions.

Chapman *et al.* (1983) observed that most *C. partellus* first instar larvae climbed off a plant within the first 24 hours after hatching. Assuming that this would be the case under field conditions larval antixenosis on grasses such as *H. tamba* and *P. purpureum* is likely to result in high mortality of first instar larvae. The insect must first locate and remain on a plant before it can feed and become established (Berger 1993, 1994). Therefore, the period between eclosion of eggs and larval establishment of *C. partellus* larvae at the feeding site appear to be a critical stage in the colonization process (Ampofo 1986), since, at this stage, larvae depend only on limited energy resources (Berger 1993). During this period plant characteristics which slows down larval movement or cause larvae to leave the plant (Berger 1994), exposes them for longer periods to predators, dehydration and other harsh environmental conditions (Chapman *et al.* 1983). Under field conditions, high mortality of migrating first instars was observed by Van Hamburg (1980) and 90% larval mortality was reported (Van Hamburg & Hassell 1984). Ross and Ostlie (1990) reported mortality of migrating first instar larvae of European corn borer, *Ostrinia nubilalis* (Hübner) (Lepidoptera: Pyralidae) to be between 76% and 83%. The mortality was said to be occurring mainly within the first 48 hours after egg hatch (Ross and Ostlie 1990).

Under no-choice conditions high number of larvae climbed off the leaf discs of *H. tamba* than on other host plants. Lack of differences in insect behavioural response in no-choice and choice tests where *H. tamba* were compared to other host plants confirm poor acceptance of this grass by *C. partellus* larvae. Movement of newly hatched larvae from one site to another is reported to be influenced by larval density and host plant species (Berger 1992). Since only a small number of larvae were used, the possible competition factor between larvae from large egg batches which may have had an influence on the dispersal of larvae (Berger 1992) was excluded in this study. Therefore, the differences between the number of first instar larvae that remain settled on leaf discs among host plants may be attributed to morphological and chemical characters at the feeding site. Since *H. tamba*, with smooth surfaces was less preferred by *C. partellus* larvae for feeding this could be ascribed to chemical compounds which inhibit feeding (Bernays & Chapman 1994). Berger (1994) reported that maxillary palpi or the sensilla styloconica of an insect could be able to help determine the complexity of chemical stimuli on the leaf surface, a factor which could aid in decision making by the larva. Leaf surface wax was shown to be important in establishment of neonate *C. partellus* larvae on sorghum however, on resistant plants neonate larvae spend more time walking and less time palpating eventually leaving without feeding (Bernays & Chapman 1994).

Chemical characteristics, an important factor in host plant selection, may affect the establishment of insects on a plant (Bernays & Chapman 1994). High concentrations of cyanide on sorghum deterred various grass-hoppers, first instar *C. partellus* larvae and the planthopper *Peregrinus maidis* (Ashm.) (Homoptera: Dephacidae) (Woodhead *et al.* 1980). Phenolic acid reduced feeding of all grass-hoppers and *P. maidis* (Woodhead *et al.* 1980). Choice tests done under laboratory conditions by Davis *et al.* (1989) revealed high preference by southwestern corn borer, *Diatraea grandiosella* Dyar (Lepidoptera: Pyralidae) and European corn borer, *O. nubilalis* for susceptible maize hybrids to resistant ones. Studies by Robinson *et al.* (1978) showed greater dispersal of first instar larvae *O. nubilalis*, from resistant maize lines than from susceptible lines. These differences were ascribed to high concentration of 4-benzoxazin-3 (4H)-one (DIMBOA) in resistant maize lines. Wiseman *et al.* (1982) evaluated preference of first instars of fall armyworm *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae) for excised leaf sections of centipedegrass *Eremochola ophiuroides* (Munro) Hack, Bermudagrass, *Cynodon dactylon* (L.) Pers and Carpetgrass *Axonopus affinis* Chase. These studies revealed that first instars of fall armyworm preferred carpetgrass or bermudagrass over the resistant centipedegrass. Field studies by Ampofo (1986) showed that first instar *C. partellus* larvae dispersed from resistant ICZ2-CM maize to a more susceptible cultivar, Inbred A. Significanly more larvae of fall armyworm, *S. frugiperda* crawled off the resistant maize Antigua 2D-118 to surrounding uninfested plants than susceptible Cacahuacintle X's (Wiseman *et al.* 1983). These results illustrate the ability of first instar larvae of *C. partellus* to determine differences in acceptability between suitable and non-suitable host plants. Female moths are known to lay their eggs on a suitable host plant for larval development, however, females do not always select an appropriate host (Bernays & Chapman 1994). This could be the reason why newly hatched larvae may have to reject the plant on which the eggs were oviposited (Bernays & Chapman 1994). In chapter 3 leaf damage was low on the grasses compared to the cultivated crops and some first instar larvae might have left the grasses due to larval antixenosis at the feeding site. Since larval migration off a plant could be considered a mortality factor (Robinson *et al.* 1978), the practical implications of this behavior could have some added advantages for pest management in a habitat management system. It could be predicted that first instar larvae that either settle or climb off a trap crop grown around maize or sorghum fields would die without establishing on the main crop.

H. tamba was less preferred by first instar larvae compared to other host plants. Knowledge of insect behavioural response triggered by these grasses is important in the control of first instar larvae under field conditions. Therefore, non suitable grasses such as *P. purpureum* can play an important role in reducing larval establishment of first instar larvae in adjacent crop plants such as maize.

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Table 1. Mean number of *Chilo partellus* larvae left per leaf disc in no-choice tests, one, four and 24 hours after inoculation (± S.D.). n = 10 larvae per host plant.

Host plant	1 hour	4 hours	24 hours
Hyparrhenia tamba	3.83±0.86 a	3.44±1.16 a	2.25±0.62 a
Pearl millet	5.58±1.00 b	5.19±0.80 b	4.31±0.67 bc
Maize	5.98±1.05 b	5.90±1.09 b	4.84±1.03 c
Sweet sorghum	6.06±0.50 bc	6.00±1.00 b	3.71±1.08 b
Pennisetum purpureum	6.88±0.80 cd	6.83±1.27 c	5.11±1.03 c
Sorghum	7.65±0.87 d	7.73±0.70 c	6.41±1.38 d

Means within each column followed by a different letter are significantly different ($P<0.05$).

Table 2. Mean number of *Chilo partellus* larvae found per plant leaf disc in two-choice tests, one, four and 24 hours after inoculation (± S.D.). n = 20 larvae for each two choice test.

Host plant combinations	1 hour	4 hours	24 hours
Hyparrhenia tamba	2.15±0.58 a	2.38±0.66 a	3.00±0.58 a
Pearl millet	2.94±0.68 b	3.21±0.80 b	2.56±0.76 a
Pennisetum purpureum	4.11±0.80 a	3.89±1.15 a	4.22±1.10 a
Pearl millet	4.19±1.06 a	3.83±1.27 a	4.56±1.50 a
Hyparrhenia tamba	2.10±0.69 a	3.12±0.70 a	3.46±1.36 a
Sorghum	2.98±0.83 b	4.71±1.68 b	5.79±0.92 b
Pennisetum purpureum	4.19±1.07 a	6.00±1.07 a	6.69±0.86 a
Sorghum	4.46±0.95 a	5.22±1.18 a	4.33±1.20 b
Hyparrhenia tamba	1.96±0.41 a	2.58±0.72 a	1.75±0.60 a
Maize	3.66±1.39 b	4.31±1.64 b	5.06±1.78 b
Pennisetum purpureum	2.25±0.53 a	2.64±0.77 a	2.73±0.56 a
Maize	2.35±0.89 a	2.83±0.96 a	3.73±1.66 a
Hyparrhenia tamba	1.77±0.70 a	2.29±0.68 a	2.46±0.97 a
Sweet sorgum	4.31±0.62 b	4.87±0.85 b	4.94±1.34 b
Pennisetum purpureum	3.52±0.90 a	3.88±1.00 a	3.83±0.74 b
Sweet sorgum	2.79±0.61 a	3.46±0.44 a	3.04±0.53 a

Means within each column, for each two-choice test followed by a different letter are significantly different (P<0.05).

Table 3. Mean number of *Chilo partellus* larvae per plant in multiple-choice tests, one, four and 24 hours after inoculation (± S.D.). n = 30 larvae per six host plants.

Host plants	1 hour	4 hours	24 hours
Hyparrhenia tamba	1.06±0.51 a	1.28±0.54 a	1.00±0.59 a
Pennisetum purpureum	1.17±0.26 a	1.19±0.46 a	1.42±0.23 ab
Pearl millet	1.31±0.44 a	1.75±0.74 a	1.53±0.65 ab
Sweet sorgum	0.83±0.39 a	1.25±0.74 a	1.75±0.57 ab
Sorghum	1.14±0.55 a	1.50±0.52 a	1.92±0.25 b
Maize	1.42±0.38 a	1.58±0.43 a	1.94±0.63 b

Means in each column followed by a different letter are significantly different ($P<0.05$).

Fig. 1. No-choice test to determine larval response on leaf discs of host plants. P = position in which *Chilo partellus* larvae were released.

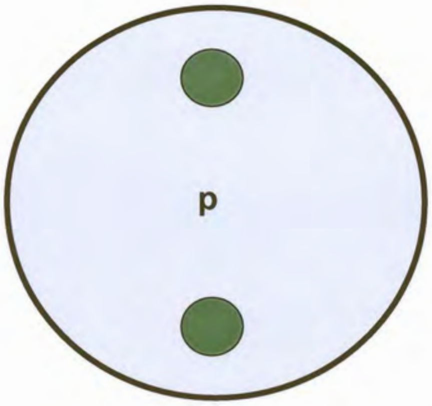

Fig. 2. Two-choice test to determine larval preference between leaf discs of two host plants. P = Position in which *Chilo partellus* larvae were released.

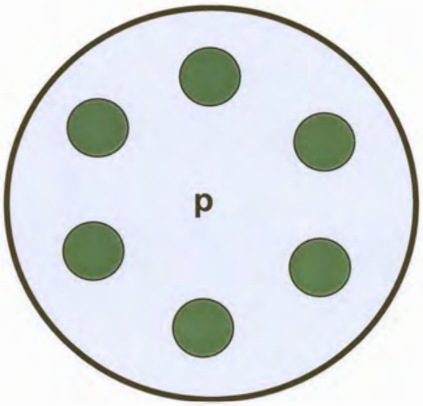

Fig. 3. Multiple-choice test to determine larval preference between leaf discs of six host plants. P = position in which *Chilo partellus* larvae were released.

CHAPTER 6

Growth and development of *Chilo partellus* (Swinhoe) (Lepidoptera: Crambidae) on cultivated and wild graminaceous host plants

ABSTRACT

Chilo partellus (Swinhoe) (Lepidoptera: Crambidae) is a stem borer of economic importance in Africa that attacks graminaceous crops such as maize, sorghum and pearl millet. This species is also known to survive on several wild host plants. Wild host plants which do not favour survival of stem borers could help reduce stem borer populations. This study investigates the growth and development of *C. partellus* on the following host plants, maize (*Zea mays* L.), sorghum (*Sorghum bicolor* (L.) Moench), pearl millet (*Pennisetum glaucum* (L.) R. Br.), sweet sorghum (*Sorghum bicolor* (L.) Moench), and the grasses, *Pennisetum purpureum* Schumach. (Napier grass) and *Hyparrhenia tamba* (Steud.) (Blue thatching grass). Head capsule width, larval weight, pupal weight, development period for larvae, development period for pupae, development period to adulthood and pupation were recorded. *Chilo partellus* performance was better on maize, sorghum, pearl millet and sweet sorghum than on *P. purpureum* and *H. tamba*. All larvae that fed on the two wild grasses did not survive until pupation, while eclosion was observed from the pupae collected from maize, sorghum, sweet sorghum and pearl millet. Eclosion of male and female moths was observed earlier on maize and sorghum than on pearl millet, indicating that these crops are better sources for the growth for *C. partellus* than pearl millet. This study established that *H. tamba* and *P. purpureum* are poor hosts complete development for *C. partellus* compared to the cultivated crops.

Key words: *Chilo partellus*, development, grasses, maize, sorghum, survival.

INTRODUCTION

Chilo partellus (Swinhoe) (Lepidoptera: Crambidae) is one of the most damaging stem borer species of cereal crops in southern Africa (Sithole 1990). *Chilo partellus*, indigenous to India (Kfir 1992), has become an important pest in South Africa (Kfir 1997) since it was first observed in 1958 (Van Hamburg 1979). This species has been reported to survive in grasses such as *Sorghum halepense* (L.) Pers. (Johnson grass), *S. verticilliflorum* (Steud.) Stapf. (Wild sorghum grass), *Panicum maximum* (Jacq.) (Guinea grass) and *Pennisetum purpureum* Schumach. (Napier grass) (Harris 1990). *Chilo partellus* also survives well on cultivated crops such as maize (*Zea mays* L.), sorghum (*Sorghum bicolor* (L.) Moench) and pearl millet (*Pennisetum glaucum* (L.) R. Br.) (Harris 1990).

Larval survival, growth and development of *C. partellus* have been described or studied to determine resistance levels of maize (Sharma & Chatterji 1971; Kumar 1993; Das & Agarwal 1993; Sekhon & Kanta 1997; Kumar 1997) and sorghum (Singh & Rana 1984; Chapman *et al.* 1983; Duale & Seshu Reddy 1995) to this pest. Ofomata *et al.* (2000) observed no survival of *C. partellus* in *P. purpureum* and *P. maximum* while it did survive and develop to adulthood in maize and sorghum. Grasses which do not favour survival of stem borers could be used in pest management systems (Khan *et al.* 2000) for maize. However, little information is available on the role of wild grasses in the biology of stem borers (Shanower *et al.* 1993), and the role of wild grasses in the life cycle of *C. partellus* is thus not well understood. The aim of this study was to determine and compare the growth and development of *C. partellus* on cultivated and wild host plants.

MATERIAL AND METHODS

Growth and development of *C. partellus* larvae were studied on six host plants. These were maize (Cultivar CRN3414), sorghum (SNK3860), pearl millet (Okashana-1), sweet sorghum (SA4479), *P. purpureum* and *Hyparrhenia tamba* (Steud.) (Blue thatching grass). Plants of each species were grown in 4 litre pots to provide actively growing plants as a food source for larvae (Fig. 1). Wild hosts plants were grown from root-stalk while cultivated crops were seeded. As a result of the differences in growth rate of the host plant, planting dates were manipulated to provide larvae with plants of almost the same size. This was done to ensure that larvae were exposed to the same amount of food. *Pennisetum purpureum* and *H. tamba* were planted first and allowed to establish in pots. Sweet sorghum, pearl millet and sorghum were planted six weeks later, followed by maize ten days later. Six plants, one of each host plant, were placed in groups and the positions of these groups were completely randomised. Each group was replicated six times. The plants were kept in a cage and watered twice a week.

Plants were thinned to one plant per pot three weeks after germination. Grasses were thinned to four tillers per pot. At a plant height of approximately 30 cm each plant was artificially infested with 20 first instar *C. partellus* larvae. The larvae were abtained from the colony which is The larvae were placed at the midrib of the second lower leaf of each plant using a fine camel hair brush.

Larval development and survival was monitored by dissecting plants at one, two, three, five, six and seven weeks after inoculation. The larvae recovered were weighed and recorded separately for each host plant.

The following growth measurements were determined for larvae and pupae recovered from each host plant: Larval instars were determined by measuring the head capsule of larvae recovered and results were compared to the head capsule widths (mm) as recorded by Alghali (1985) for *C. partellus* on sorghum (Table 1). The total mass of larvae from each host plant species at each sampling was used to calculate the mean larval mass. The larval period was recorded from the date of inoculation to the date of pupation. Larvae that did not pupate after 49 days were fed on stems of their respective host plants and monitored daily until they pupated. The moist tissue papers were placed at opposite ends of the 10 cm stems to prevent moisture loss. The stems were kept for two to three days. Larval survival and/or establishment was determined by counting the number of larvae per plant at each sampling period. The fresh mass of pupae recovered from host plants at each sampling was used to calculate the mean pupal mass. Pupal period was determined by subtracting the period in days that larvae had taken to pupate from the total number of days to eclosion of moths. Pupation was determined in the sixth and seventh week after inoculation and the number of larvae that pupated was recorded for each host plant. Size of pupae was used to determine sex. Male pupae are small and light while females are large and heavy (Bughio & Qureshi 1976). Development period to adulthood was taken from the date of inoculation of host plants to eclosion of moths.

Data on normal growth measurements of *C. partellus* were subjected to analyses of variance. Due to slow growth, small larvae collected seven and 14 days after inoculation, were weighed collectively and data on mean larval mass were not subjected to statistical analysis. Data on pupation i.e. larvae that pupated 42 and 49 days after inoculation were log transformed before analysis of variance.

RESULTS

Head capsule measurements showed progressive growth of larvae on all crop hosts. At five weeks after inoculation head capsule width was widest in the larvae that fed on maize, followed by sorghum, sweet sorghum and pearl millet (Table 2).

Significant differences (F = 3.15, d.f. = 15, P = 0.046) were observed between the mean larval mass of *C. partellus* on different host plants 21 days after infestation (Table 3). However, no significant differences were found between mean larval mass for larvae that fed on sorghum, sweet sorghum, maize and pearl millet 35 (F = 1.76, d.f. = 16, P = 0.1962), 42 (F = 0.48, d.f. = 16, P = 0.703) and 49 (F = 1.04, d.f. = 6, P = 0.4404) days after infestation. The mass of larvae was highest on sweet sorghum although it was not significantly higher than sorghum and pearl millet 21 days after inoculation. In the two samplings after 21 days, the highest larval mass was observed on maize, although it was not significantly higher than other crops. Although the mass of *C. partellus* larva on *P. purpureum* was similar to other crops low numbers of larvae were recovered from this grass species.

Significant differences in the number of larvae recovered from host plants were observed at all sampling dates (Sample 1: F = 16.89, d.f. = 30, P = 0.0001; 2: F = 23.18, d.f. = 30, P = 0.0001; 3: F = 4.87, d.f. = 30, P = 0.0001; 4: F = 4.53, d.f. = 30, P = 0.0034; 5: F = 14.73, d.f. = 30, P = 0.0001; 6: F = 2.68, d.f. = 30, P = 0.0409) (Fig. 2). A drastic decline in larval numbers was observed within the first week after inoculation, with only 0.85% of the initial number (120) recovered from *P. purpureum* and *H. tamba*. Sixty eight percent, 54%, 42% and 4% larvae was recovered from sorghum, sweet sorghum, pearl millet and maize respectively, one week after inoculation. No larvae were recovered on *H. tamba* and *P. purpureum* at 14 and 42 days onwards respectively. Results indicate that sweet sorghum was the most suitable host since the highest numbers of larvae from 14 days after inoculation were recovered on this crop at every sampling date. By day 49 the number of larvae found feeding per plant was 3%, 7%, 8% and 14% of those inoculated on maize, sorghum, pearl millet, and sweet sorghum respectively, while no larvae were recorded on the grasses.

The larval development period of *C. partellus* males did not differ significantly (F = 0.93, d.f. = 6, P = 0.4821) between host plants (Table 4). Female larval development time in maize and sorghum was significantly shorter than in sweet sorghum and pearl millet.

Significant differences were found in the number of pupae between host plants (F = 4.09, d.f. = 30, P = 0.0060) (Table 5). No pupation was observed on the wild grasses, *P. purpureum* and *H. tamba* (Table 5). Pupation was highest on sweet sorghum compared to other crops, however, it was not significantly different from sorghum and maize. No significant (F = 0.39, d.f. = 6, P = 0.7630) differences were observed in pupal mass between males on different host plants (Table 6). Significant differences were observed in pupal mass between females on different host plants (F = 8.35, d.f. = 8, P = 0.0076). The mean pupal mass for females on maize was significantly higher than female pupae collected from other host plants. The mean pupal mass differed between males and females. The female pupae were about twice as heavy as male pupae.

Pupal period was shorter for males and females in sorghum and sweet sorghum compared to maize and pearl millet. The mean pupal period for males was 15, 6, 13, and 14 days in maize, sorghum, sweet sorghum and pearl millet respectively. The pupal period for females was 15, 12, 7 and 14 days in maize, sorghum, sweet sorghum and pearl millet respectively.

No significant differences were observed in development time to adulthood for males (F = 0.83, d.f. = 5, P = 0.5319) and females (F = 0.81, d.f. = 7, P = 0.5284) found on different host plants Development period to adulthood was longest in pearl millet (Table 4). However, it was not significantly different from all other crops.

DISCUSSION

In this study the differences observed in larval survival and development between host plants indicate differences in their suitability as larval hosts. Larvae were unable to survive past the second instar on *H. tamba* and *P. purpureum* in this study. In contrast, the stem borer *C. partellus* was able to develop on another grass species, *Sorghum vulgare* Pers. Var. *sudanense* (Sudan grass) (Khan e*t al*. 2000) indicating that some wild grass species are suitable hosts for this species.

The higher level of survival and better development of *C. partellus* on cultivated crops than on the wild grasses indicate that food consumption was better on crops than on the grasses. Similar results were obtained by Shanower *et al*. (1993) in which larval survival of *Sesamia calamistis* Hampson (Lepidoptera: Noctuidae) and *Eldana saccharina* Walker (Lepidoptera: Pyralidae) was less than 10% and 5% on the grasses respectively, while larval survival on maize was 30% and 19% respectively. In this study *C. partellus* larvae were allowed to grow and develop on cultivated and wild grasses under the same environmental conditions. Ofomata *et al*. (2000) further reported that survival to reproduction and time required for development to maturity of the pest is modified by environmental conditions such as temperature, humidity, food quality, quantity and inter-specific competition. Ofomata *et al*. (2000) reported that the quality of plants for survival and development of stem borers is determined by differences in the morphology, physiology and biochemistry of the plant. Shanower *et al*. (1993) ascribed poor survival of the stem borer *E. saccharina* on the grasses *Andropogon* sp., *Pennisetum polystachion* (L.) Schultes, *P. purpureum*, *P. maximum* and *Sorghum arundinaceum* (Desv.) to host plant quality. This possibly suggests that the high survival of *C. partellus* in maize and sorghum compared to the grasses could be ascribed to improved plant qualities of these crops (Kfir 1997). Shanower *et al*. (1993) reported that plant quality may influence factors such as physiological age, water or nutrient stress and possibly the presence of abiotic factors such as plant pathogens which in turn may influence mortality of the pest. In studies on the survival and development of *C. partellus* on different maize germplasms, the adverse effects on the measures of developmental success of the present insect were probably ascribed to nutrient deficiency abnormalities (Sharma & Chatterji 1971). In this study *C. partellus* was able to survive to pupation on maize, indicating that the susceptible maize crop is a good source of energy for *C. partellus* (Das & Agrawal 1993). The results of this study also suggest that crop hosts were better food sources of *C. partellus* compared to the wild grasses.

High silica content may also explain differences in survival of larvae between the grasses and the crop hosts (Ofomata *et al*. 2000). High silica content in the grasses which hardens epidermal cells causing dislodgement of early instars could have also been responsible for the high mortality of first instars (Setamou *et al*. 1993).

Furthermore *H. tamba* has thin stems which could be another factor in determining larval survival due to limited food availability. Poor survival of *C. partellus* on these grasses could influence fecundity since the presence of low numbers of males and females could result in low production of eggs.

Khan *et al.* (2000) reported that poor survival of first instars on the grass *P. purpureum* was caused by a sticky sap produced by the plant in reaction to penetration by the larvae. This substance was reported to trap and drown the larvae. Since *P. purpureum* leaves are hairy, and there is a negative correlation between trichome density and insect feeding, long and dense trichomes may hinder normal feeding of the insect (Khan 1997). While trichomes are also expected to influence larval movement, ligular hairs act as traps for young larvae (Sharma 1993), thus reducing the rate of establishment in a plant (Bernays *et al.* 1983). The establishment of first instar larvae of *C. partellus* was also reported to be influenced by leaf surface waxes in sorghum (Bernays and Chapman 1994). In this study only one first instar larvae was found on *H. tamba* and *P. purpureum* seven days after inoculation compared to cultivated crops in which a higher number of larvae were found. These results could be ascribed to high larval antixenosis at the feeding site in these grasses.

Ofomata *et al.* (2000) observed shorter larval development period of *C. partellus* in maize and sorghum compared to *C. orichalcociliellus* in the same crops. Similar reports of *C. partellus* having a shorter life cycle when on maize and sorghum compared to *Busseola fusca* (Ingram 1958) were provided. This faster development process of *C. partellus* in maize and sorghum compared to *B. fusca* and *C. orichalcociliellus* may be an important factor in competitive displacement (Kfir 1997; Ofomata *et al.* 2000).

The lack of significance of difference between mean mass of larvae that fed on different host plants from day 35 onward could possibly be ascribed to the fact that larvae were mainly recovered from inside stems and were feeding on stem tissue with more or less equal nutrient status.

Different results although not significant from other crops were obtained in the case of pearl millet. While larval mass in pearl millet increased steadily and was highest 49 days after infestation compared to other crops development period to adulthood was adversely affected. The longer development period possibly indicate that *C. partellus* could have fewer generations per season in pearl millet. This delayed development period could further negatively affect population dynamics of *C. partellus* (Kumar *et* *al.* 1993) suggesting that stem borer densities within a growing season is likely to be less in pearl millet than in maize or sorghum fields.

The mass of pupae for females was about twice that of males on all crops. This is ascribed to greater energy and protein demand which is needed for egg production (Setamou *et al.* 1993) since *C. partellus* moths do not feed during their life time (Berger 1989; Das & Agrawal 1993). Large females are known to lay more eggs compared to smaller females (Berger 1989). Since the female pupal mass of *C. partellus* found on maize was significantly greater than the female pupal mass found on all other cultivated host plants, this possibly indicate greater fecundity for moths that come from maize compared to moths from other host plants.

Emergence of male moths occurred earlier than female moths in all the crops tested. Similar results were reported by Päts (1991) in which he stated that male moths were always older and more active than females at the time of mating. This difference enables the moths to mate on the night of eclosion of females (Päts 1991, 1992).

This study has established that *H. tamba* and *P. purpureum* are non-suitable hosts for complete development of *C. partellus* compared to the cultivated crops. These grasses are highly preferred for oviposition by *C. partellus* moths (Chapter 5) compared to maize and sorghum. Therefore, when used as trap crops for *C. partellus* it could be predicted that these grasses could cause a reduction in infestation in maize and sorghum fields. Further studies on identifying a suitable trap crop should be carried out in order to develop a low cost management system for the control of *C. partellus* for resource-poor farmers.

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Table 1. Head capsule widths (mm) for *Chilo partellus* larval instars determined on sorghum by Alghali (1985).

Larval instar	Range	Mean±S.D.
First	0.28-0.47	0.37±0.03
Second	0.66-0.80	0.72±0.03
Third	1.11-1.28	1.15±0.03
Fourth	1.55-1.57	1.56±0.01
Fifth	1.87-2.09	1.96±0.02

Table 2. Head capsule widths (Mean±S.D.) (mm) for *Chilo partellus* measured from different host plants. n = number of larvae in parenthesis. DAI = Days after inoculation.

Host plant	7 DAI	14 DAI	21 DAI	33 DAI
Maize	0.35±0.06 (20)	0.49±0.07 (4)	0.62±0.13 (3)	1.83±0.30 (2)
Sorghum	0.43±0.10 (40)	0.57±0.10 (7)	0.85±0.22 (12)	1.70±0.28 (7)
Sweet sorghum	0.48±0.08 (44)	0.64±0.12 (37)	0.91±0.14 (18)	1.60±0.22 (9)
Pearl millet	0.40±0.06 (34)	0.64±0.10 (23)	0.79±0.18 (10)	1.38±0.31 (12)
H. tamba	0.43 (1)	-	-	-
P. purpureum	0.47 (1)	-	0.71±0.10 (3)	-

Table 3. Mean mass (±S.D.) of *Chilo partellus* larvae found on different host plants used in the study. (n = number of larvae found on each occasion in parenthesis).

	Mean mass (mg)					
	Days after infestation					
Host plants	7	14	21	35	42	49
Maize	0.14 (25)	0.43 (6)	1.08±0.41ab (4)	73.25±52.82ab (2)	75.00±33.51a (9)	78.00a (1)
Sorghum	0.30 (81)	0.92 (9)	1.99±2.08ab (19)	42.73±34.92ab (9)	53.13±10.69a (15)	60.06±9.58a (5)
S sorghum	0.58 (67)	1.08 (54)	3.74±1.14c (33)	25.67±9.86ab (15)	66.66±20.36a (35)	82.30±15.70a (12)
Pearl millet	0.33 (52)	1.17 (36)	2.34±1.29abc (11)	18.74±17.74a (15)	46.49±20.58a (7)	94.41±31.03a (8)
P. purpureum	- (1)	- -	1.00±0.00a (2)	27.25ab (1)	-	-
H. tamba	- (1)	-	-	-	-	-

Means within each column followed by the same letter are not significantly different (P>0.05).

Table 4. Growth period of *Chilo partellus* larvae (Mean± S.D) on different host plants. (n = number of larvae surviving). (DAI = Days after inoculation).

Host plant	n		Larval period (days)		Adult emergence (DAI)	
	Male	Female	Male	Female	Male	Female
Maize	4	2	43.50±3.00a	43.50±4.24a	58.00±2.65a	58.67±2.53a
Sorghum	5	6	47.09±0.83a	44.58±5.03a	53.50±3.54a	56.57±6.24a
Sweet sorghum	10	6	46.20±1.97a	55.13±5.10c	59.67±2.08a	61.70±9.06a
Pearl millet	3	2	49.75±8.84a	51.25±6.72bc	64.00±6.56a	65.00±4.58a
H. tamba	-	-	-	-	-	-
P. purpureum	-	-	-	-	-	-

Means within each column followed by the same letter are not significantly different (P>0.05)

Table 5. *Chilo partellus* larvae successfully pupating (Mean±S.D.) on different host plants used in this study. (n = 240 larvae used for both samplings, 42 and 49 days after inoculation). (Table reflect real numbers).

	Pupation
Hyparrhenia tamba	0.0a
Pennisetum purpureum	0.0a
Pearl millet	0.83±1.33ab
Maize	1.00±1.26abc
Sorghum	1.67±2.23bc
Sweet sorghum	2.67±1.97c

Means within each column followed by the same letter are not significantly different (P>0.05)

Table 6. Mean pupal mass (±S.D.) of *Chilo partellus* on different host plants used in the study. (n = number of pupae used).

	n		Pupal mass (mg)	
Host plant	Male	Female	Male	Female
Maize	4	2	59.95±14.79a	170.00±2.83b
Sorghum	5	6	62.92±12.50a	98.93±22.93a
Sweet sorghum	10	6	64.26±15.64a	115.15±26.35a
Pearl millet	3	2	61.63±16.31a	104.15±17.18a
H. tamba	-	-	-	-
P. purpureum	-	-	-	-

Means within each column followed by the same letter are not significantly different (P>0.05)

Fig. 1. Host plants before they were infested with *C. partellus* larvae.

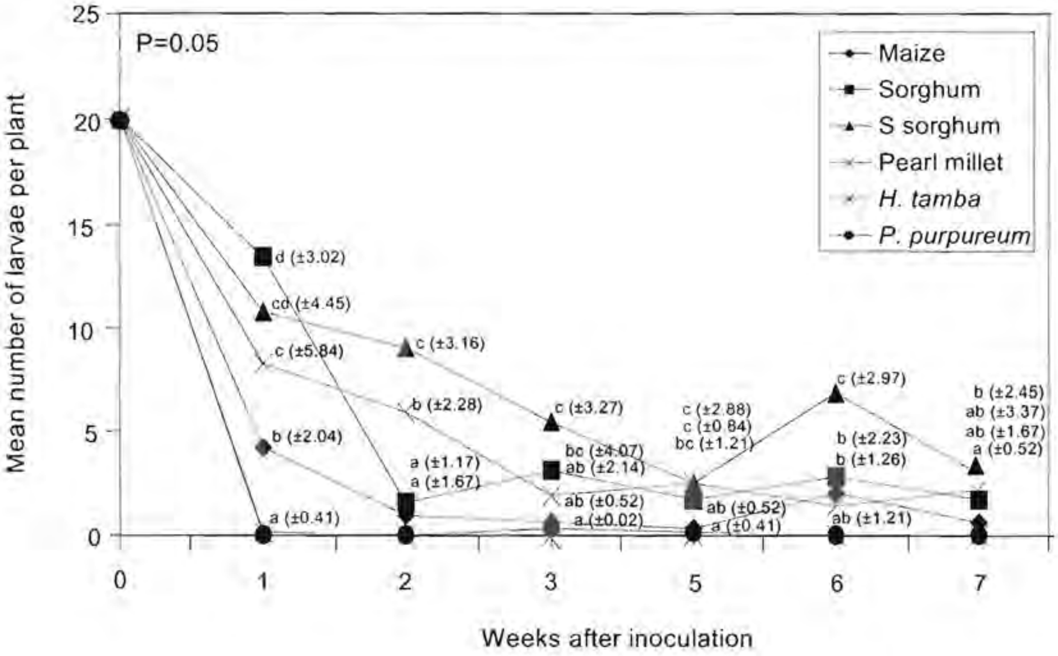

Fig. 2. Mean number of *Chilo partellus* larvae found per host plant over time at each sampling. Means with the same letter within each sampling week are not significantly different (P>0.05). All points on the x-axis indicate that alive larvae were not found on host plants. S sorghum = sweet sorghum. (Mean±S.D.).

CHAPTER 7

Leaf feeding resistance and oviposition preference of *Busseola fusca* Fuller (Lepidoptera: Noctuidae) and *Chilo partellus* (Swinhoe) (Lepidoptera: Crambidae) for sweet sorghum (*Sorghum bicolor* (L.) Moench) landraces

ABSTRACT

Sweet sorghums (*Sorghum bicolor* (L.) Moench), readily attacked by *Chilo partellus* (Swinhoe) (Lepidoptera: Crambidae) and *Busseola fusca* Fuller (Lepidoptera: Noctuidae) have a potential for use as trap crops for these species. Four greenhouse experiments were conducted during the 1998/99 and 1999/2000 growing seasons to evaluate indigenous sweet sorghum landraces for resistance to larval feeding by *C. partellus* and *B. fusca*. Choice tests were also conducted to determine preference of moths for different landraces. To evaluate leaf feeding resistance, plants were artificially infested with first instar larvae of *C. partellus* and *B. fusca*. Larval mass and numbers were recorded seven days after inoculation to assess levels of antibiosis and antixenosis. Significant differences were observed in larval numbers and mean larval mass on different landraces. The response of *B. fusca* and *C. partellus* with regard to larval numbers and mass on sweet sorghum landraces varied over seasons. These variations were ascribed to high variability of the genetic material of the indigenous landraces. The sweet sorghum landrace, Pateletso exhibited low levels of larval antixenosis and antibiosis for *B. fusca* and *C. partellus* in both seasons. Multiple-choice tests were conducted to determine oviposition preference for the landraces, Mariri, Maatla, Motale, Pateletso, SA4481, and SA4479. The greatest number of eggs were laid on SA4481. The results of two-choice oviposition tests showed no significant differences between maize (Cultivar CRN3414) and SA4481 or Pateletso in the number of eggs per plant laid by *C. partellus*, number of egg batches per plant and number of eggs per batch. Maize was significantly preferred for oviposition by *B. fusca* when it was paired with SA4481 or Pateletso.

Key words: Antibiosis, antixenosis, *Busseola fusca*, *Chilo partellus*, oviposition, trap crop.

INTRODUCTION

Sweet sorghum (*Sorghum bicolor* L. Moench) is a versatile crop and may be grown for grain, forage, silage, syrup, sugar production (Ghanekar *et al.* 1992; Schaffert 1992) as well as energy production (Schaffert & Gourley 1982). Field observations indicated that one of the major drawbacks to cultivation of sweet sorghum cultivars is their susceptibility and attractiveness to insect pests (Ghanekar *et al.* 1992).

In the Limpopo Province of South Africa, sweet sorghum is planted in mixed farming systems with maize and grain sorghum and eaten as "sweet reed", sold as a cash crop or used in production of syrup for household use. Stems are cut and boiled to produce the syrup. However, damage by stem borers to stems of these plants results in a characteristic red colour, caused by anthocianins produced by the plant. These unwanted colours reduce the quality of products such as syrup produced from the stems and are therefore a constraint to development of small industries involved in utilisation of sweet sorghum.

Apart from the uses of sweet sorghum mentioned, it also has potential to be used as a trap crop in a stem borer habitat management system (Wahl 1926). Such a stem borer management system was developed in East Africa where the wild grasses, *Pennisetum purpureum* (Schumach) (Napier grass) and *Sorghum vulgare sudanense* (Sudan grass) ere used as trap crops around maize fields (Khan *et al.* 1997; Khan *et al.* 2000).

In such a habitat management system sweet sorghum could be planted in close proximity to maize to attract gravid moths of *Busseola fusca* Fuller (Lepidoptera: Noctuidae) and *Chilo partellus* (Swinhoe) (Lepidoptera: Crambidae). and reduce infestations and concomitant damage to the main crop.

This study aimed to identify sweet sorghum landraces that have low ovipositional and larval antixenosis and high levels of larval antibiosis in order to reduce population levels of stem borers and concomitant damage to the commercial crop. A landrace is a crop cultivar that evolved with and has been genetically improved by traditional agriculturalists, but has not been influenced by modern practices. Antixenosis denotes the presence of plant characters such as morphological (trichomes) and chemical plant factors (surface waxes) that affect the behaviour of insects, orientation, oviposition and feeding of insects (Kumar 1997). Antibiosis is used when plants cause adverse effects on the biology of insects e.g. survival, development and reproduction (Kumar 1997).

MATERIAL AND METHODS

Larval antixenosis and antibiosis

Four greenhouse experiments were conducted at the ARC-Grain Crops Institute in Potchefstroom (25° 09S, 28° 41E). The first two experiments were conducted in the 1998/1999 season. Thirteen and eighteen sweet sorghum landraces were evaluated for resistance to *B. fusca* and *C. partellus* larvae respectively (Table 1 and 2 respectively). In the 1999/2000 season 17 landraces were evaluated for resistance to larval feeding of both borer species (See Table 1 and 2). All sweet sorghum landraces used were collected from resource-poor farmers in the Limpopo Province.

The plants were hydroponically grown (Fig. 1) at temperatures of 25°C (day) and 18°C (night) with a 14 L : 10 D photoperiod. In the 1998/1999 season sixteen plants of each landrace were grown in four containers of 38 cm x 38 cm x 39 cm i.e. four plants per container. In the second season twenty plants were grown of each landrace. The plants of each landrace were separated to avoid migration of larvae to other plants. Each plant was artificially inoculated with 10-12 neonate larvae by means of a "bazooka" dispenser, five weeks after plant emergence.

Plants were dissected eight days after inoculation with *C. partellus* (1998/1999) and *B. fusca* (1999/2000) and eleven days after inoculation with *B. fusca* (1998/1999) and *C. partellus* (1999/2000). Larval antixenosis and antibiosis were evaluated for each landrace by determining the number of surviving larvae and the total biomass of larvae per plant obtained from larvae recovered from the leaf whorls (Van Rensburg & Malan 1990).

Oviposition preference

Two-choice test

Two experiments were conducted to determine the oviposition preference of *B. fusca* and *C. partellus* moths for maize and sweet sorghum. The following combinations of plants were used: maize (Cultivar CRN3414) vs. sweet sorghum (SA4481), and maize vs. sweet sorghum (Pateletso). Plants were grown in the greenhouse in 2 litre (l) pots. As a result of differences in the growth rate between maize and sweet sorghum different planting dates were used to ensure that plants were approximately the same size and height during the experiment (Van Rensburg & Van den Berg 1990). Pateletso and SA4481 were planted first followed by maize ten days later.

At 30 cm height the plants were transferred to the laboratory. For each combination of host plants the positions of pots inside the cages were completely randomized. Five pairs of one day old female and male moths were released in each cage, which contained one plant each of maize and the one of the sweet sorghum landraces located at opposite ends of the cage. Plants were removed and checked for egg batches two days after release of the moths. The total number of batches and eggs per batch were recorded on each host plant. For each combination of host plants the experiment was replicated six times.

Multiple-choice test:

Two experiments were conducted to determine the oviposition preference of *B. fusca* and *C. partellus* moths when provided with a number of sweet sorghum landraces. The sweet sorghum landraces used were Mariri, Maatla, Motale, Pateletso, SA4481 and SA4479. The plants were first grown in the greenhouse. Six pots, one of each landrace, were transferred to a cage (80 cm x 70 cm x 110 cm) and placed in a circular arrangement at equal distances apart. Fifteen pairs of one day old female and male moths were released in each cage and the female moths were allowed to oviposit on plants. To eliminate positional bias by the moths the positions of plants inside the cages were completely randomized. The number of batches and eggs per batch on each plant was determined 48 hours after release of moths. Each experiment was replicated six times.

The differences in means of the number and mass of larvae recorded were separated by means of analysis of variance. Significance of difference between the mean number of egg batches per plant, mean number of eggs per batch and mean number of eggs on different host plants were determined by means of analysis of variance and t-test. Spearman Rank correlation was used to determine if larval reaction to different landraces was similar over seasons with regard to larval mass and numbers.

RESULTS

Larval antixenosis and antibiosis

Significant differences were found in larval numbers (1998/1999 season: F = 3.90, d.f. = 35, P = 0.001; 1999/2000: F = 1.88, d.f. = 51, P = 0.0453) and mean larval mass (1998/1999: F = 7.46, d.f. = 35, P = 0.0001, 1999/2000: F = 4.57, d.f. = 51, P = 0.0001) of *B. fusca* (Table 1). The landraces SA4481 and Maatla had the lowest number of *B. fusca* larvae in the first and second seasons respectively (Table 1). Significant differences were also found in larval numbers (1998/1999: F = 2.55, d.f. = 48, P = 0.0057) and mean larval mass (1998/1999: F = 4.22, d.f. = 48, P = 0.0001, 1999/2000: F = 4.67, d.f. = 51, P = 0.0001) of *C. partellus*. No significant differences were found in number of larvae of *C. partellus* per plant (1999/2000: F = 1.50, d.f. = 51, P = 0.1368) (Table 2). The lowest number of *C. partellus* larvae were recorded on SA4492 during the first season and on SA4481 and Khukhunas during the second season (Table 2). The number of *C. partellus* larvae recovered on Maatla were amongst the lowest. The majority of sweet sorghum landraces evaluated showed varying levels of resistance over seasons for example, SA4481, which showed high levels of larval antixenosis and antibiosis for *B. fusca* in the first season did not have the same levels of resistance in the second season (Table 1). SA4492 showed a similar tendency between seasons for *C. partellus* (Table 2). The landrace Motale, which was not evaluated in the second season, showed low levels of larval antixenosis and antibiosis for *B. fusca* and *C. partellus* (Table 1 & 2 respectively). High larval numbers and high larval mass were recorded on Pateletso in both seasons for *B. fusca* and *C. partellus* (Table 1 & 2 respectively). The results also showed high larval numbers and high larval mass for *B. fusca* that fed on SA4487 and Bigred (Table 1). Moderately high numbers of *C. partellus* larvae (Table 2) and the low mean larval mass were recorded on Mariri (Table 1 & 2).

Oviposition preference

Two-choice test

No significant differences were observed in the number of *C. partellus* eggs per plant(F = 0.00, d.f. = 10, P = 0.9860), egg batches per plant (F = 0.00, d.f. = 10, P = 1.00) and number of eggs per batch (F = 0.07, d.f. = 10, P = 0.800) between maize and sweet sorghum, SA 4481 (Table 3). No significant differences were found between maize and sweet sorghum (Pateletso) in the number of *C. partellus* eggs per plant (F = 1.65, d.f. = 10, P = 0.2277), egg batches per plant (F = 2.12, d.f. = 10, P = 0.1763) and number of eggs per batch (F = 0.35, d.f. = 10, P = 0.5762) between maize and sweet sorghum, SA 4481 (Table 3).

There was a significant difference between the number of eggs per plant laid by *B. fusca* (F = 9.25, d.f. = 6, P = 0.0228) and number of egg batches per plant (F = 13.88, d.f. = 6, P = 0.0098) and eggs per batch (F = 6.44, d.f. = 6, P = 0.0443) between maize and SA 4481 (Table 4). More eggs and egg batches per plant were recorded on maize than that on the sweet sorghum landrace SA4481.

Significant differences were found between Pateletso and maize in the number of eggs laid by *B. fusca* (F = 10.13, d.f. = 6, P = 0.0190), number of eggs per batch (F = 5.918, d.f. = 6, P = 0.050), and the number of egg batches per plant (F = 12.09, d.f. = 6, P = 0.0132) (Table 4).

Multiple-choice test

Significant differences were observed in the number of eggs (F = 2.23, d.f. 30, P = 0.05) laid by *C. partellus*, number of egg batches per plant (F = 2.38, d.f. 30, P = 0.05) and number of eggs per batch (F = 2.06, d.f. = 30, P = 0.05) among sweet sorghum landraces (Table 5). The greatest number of eggs and egg batches per plant was recorded on SA4481 (Table 5). The lowest number of eggs and egg batches per plant, recorded on SA4479, was not significantly (P>0.05) different from most of the other sweet sorghum landraces.

No significant (P>0.05) differences were observed in the number of eggs (F = 0.81, d.f. = 30, P = 0.5503), number of egg batches per plant (F = 0.26, d.f. = 30, P = 0.9312) and number of eggs per batch (F = 2.10, d.f. = 30, P = 0.0935) laid by *B. fusca* on the different sweet sorghum landraces (Table 6). The greatest number of eggs per batch was recorded on SA4481 followed by Pateletso.

Correlation analysis

Spearman rank correlation coefficients indicated no similarity in larval response over seasons for *B. fusca* with regard to larval numbers (r = 0.3636, P = 0.2278) and larval mass (r = 0.1538, P = 0.6099) and *C. partellus* larval numbers (r = -0.1912, P = 0.4590) and larval mass (r = 0.0235, P = 0.9274) on sweet sorghum landraces.

DISCUSSION

During inoculation first instar larvae were placed directly at the feeding site in leaf whorls and factors which could have influenced movement of the first instar larvae into the whorls were therefore excluded (Van den Berg & Van der Westhuizen 1997). The possibility exists that more larvae survived than would have been the case if larvae were placed on the stems and left to migrate upwards to the leaf whorls. Therefore, the low number of larvae of either *B. fusca* or *C. partellus* recovered on SA4481, Maatla, SA4492 and Khukhunas indicated high levels of larval antixenosis at the feeding site.

The differences in larval response between seasons with regard to larval numbers and larval mass indicated a variation in resistance within the same sweet sorghum landraces. Although some landraces appeared to maintain their levels of resistance over the two seasons the variations in the levels of resistance was ascribed to instability of the genetic material since these open pollinated landraces were also characterised by phenotypic variation.

The low levels of larval antixenosis and antibiosis observed on Motale indicated high levels of susceptibility to larval feeding. Low levels of larval antixenosis and antibiosis for *B. fusca* and *C. partellus* observed in both seasons suggested that Pateletso was the landrace that was most preferred by *B. fusca* and *C. partellus* larvae. SA 4487 and Bigred were also suitable hosts for *B. fusca* as indicated by the high numbers of larvae and high larval mass recorded. However, a sweet sorghum landrace which show both the low levels of antixenosis and high larval antibiosis could have a negative effect on stem borer populations. Under field conditions this would result in increased levels of oviposition but low levels of larval survival on this crop.

Provided that such sweet sorghum landraces are highly preferred for oviposition they could be recommended for use as trap crops around maize since the ultimate infestation levels will be determined by the levels of antibiosis (Sharma & Chatterji 1971). Pronounced oviposition preference by *C. partellus* moths on certain sorghum landraces followed by poor larval survival on these preferred sorghum plants have been observed by Van den Berg & Van der Westhuizen (1997). Previous studies revealed that high levels of larval antibiosis adversely affected survival and development of the larvae (Sharma & Chatterji 1971; Durbey & Sarup 1984; Khan

1997) suppressing the population build-up of *C. partellus* in maize (Sajjan & Sekhon 1992).

The sweet sorghum landraces, SA4481 and Pateletso were highly preferred for oviposition by *B. fusca* and *C. partellus*. However, the absence of significant differences in ovipositional preference between maize and SA4481 or Pateletso indicated that these host plants were more or less equally preferred for egg laying by *C. partellus*. The higher numbers of eggs laid by *B. fusca* on maize than that on sweet sorghum was expected since *B. fusca* is the stem borer most often associated with maize (Polaszek & Khan 1998).

Maatla and Mariri, which were relatively resistant to larval feeding and oviposition by both *B. fusca* and *C. partellus* could be planted by farmers for food production or as a cash crop.

In this study no sweet sorghum landrace with pronounced resistance to larval feeding was identified although some landraces which exhibited relatively high levels of antibiosis can be recommended for planting as food or cash crops. However, the levels of antibiosis was not such that it would have a pronounced negative effect on larval survival and two-choice tests showed it not to be preferred to maize for oviposition. Sweet sorghum therefore do not seem to be a viable option for use as a trap crop for stem borers around maize fields.

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Table 1. Number of surviving larvae and mean larval mass of *Busseola fusca* larvae recovered 10 days after inoculation on local sweet sorghum landraces. (Mean ±S.D.).

1998/1999 season			1999/2000 season		
Local landrace	Number of larvae per plant	Mean larval mass (mg)	Local landrace	Number of larvae per plant	Mean larval mass (mg)
Hlopha	10.44±1.55 cde	1.80±0.16 a	Maatla	3. 65±0.77 a	0.67±0.09 a
SA4481	5.50±1.95 a	2.14±0.14 ab	Mariri	5.80±0.43 bcd	0.67±0.20 a
Mariri	5.75±0.35 a	2.21±0.21 abc	Khukhunas	4.85±1.18 abcd	0.68±0.11 a
Thethekhubesdu	10.75±3.01 cde	2.37±0.17 bcd	Monamosa	4.05±1.19 abc	0.70±0.08 a
Khukhunas	6.94±4.25 ab	2.39±0.39 bcd	SA4479	5.85±0.90 bcd	0.70±0.08 a
Samahose	9.69±2.51 bcd	2.51±0.23 bcde	Marega	5.79±1.54 bcd	0.75±0.15 ab
Bigred	10.00±2.59 bcd	2.64±o.66 cde	Bigred	5.75±0.84 bcd	0.75±0.09 ab
SA4479	10.69±1.07 cde	2.75±0.40 def	Hlopha	6.35±1.75 bcd	0.80±0.15 ab
Pateletso	13.13±3.26 e	2.91±0.49 ef	Thethekhubesdu	5.70±1.10 bcd	0.81±0.09 ab
SA4482	11.25±2.25 cde	3.14±0.30 ef	Pateletso	6.30±1.65 cd	0.81±0.11 ab
SA4487	12.13±1.55 de	3.16±0.26 ef	SA4482	5.05±1.57 abcd	0.85±0.13 bc
Marega	8.44±1.03 abc	3.21±0.56 ef	SA4492	6.30±1.44 cd	0.86±0.16 bcd
Motale	12.25±0.00 de	3.79±0.00 f	SA4481	5.05±1.08 abcd	0.86±0.11 cd
			SA4491	4.90±1.06 abc	0.90±0.20 cde
			SA 4490	5.95±1.10 cd	1.00±0.11 de
			SA 4487	6.85±1.41 d	1.01±0.12 de
			Samahose	6.45±1.69 cd	1.03±0.16 e

Means within columns followed by the same letter do not differ significantly at P>0.05 (LSD).

Table 2. Number of surviving larvae and mean larval mass of *Chilo partellus* larvae recovered 10 days after inoculation on local sweet sorghum landraces. (Mean ±S.D.).

1998/1999 season			1999/2000 season		
Local landrace	Number of larvae per plant	Mean larval mass (mg)	Local land race	Number of larvae per plant	Mean larval mass (mg)
Mariri	7.56±1.71 abcd	0.45±0.01 a	Maatla	6.05±1.49 abcd	0.45±0.07 a
SA 4481	8.06±3.07 bcde	0.55±0.14 ab	Monamosa	6.15±2.22 abcd	0.49±0.05 ab
Maatla	5.56±2.69 ab	0.58±0.10 abc	Mariri	6.50±1.16 abcd	0.50±0.09 abc
Khukhunas	10.13±1.36 cdef	0.63±0.90 bcd	SA 4491	7.60±0.25 d	0.52±0.07 abcd
SA 4479	7.31±2.29 abcd	0.63±0.18 bcd	Marega	5.35±1.61 ab	0.52±0.10 abcd
Hlopha	9.25±1.14 cdef	0.65±0.20 bcd	SA 4490	6.50±0.66 abcd	0.53±0.05 abcde
Pateletso	11.38±5.37 ef	0.65±0.01 bcd	SA 4492	7.25±0.66 bcd	0.54±0.05 abcdef
Bigred	11.88±5.37 f	0.66±0.30 bcd	Samahose	7.47±2.00 cd	0.56±0.08 abcde
Marega	9.75±2.97 cdef	0.66±0.21 bcd	Hlopha	5.70±0.43 abcd	0.59±0.04 bcdef
SA 4490	7.13±2.33 abcd	0.67±0.13 bcd	SA 4482	6.45±0.64 abcd	0.61±0.07 bcdef
Monamosa	7.19±1.46 abcd	0.68±0.08 bcde	SA 4487	6.65±1.82 abcd	0.61±0.14 cdef
SA 4482	10.38±1.33 def	0.69±0.14 cde	SA 4481	4.95±1,40 a	0.62±0.09 cdef
SA 4491	9.75±0.00 cdef	0.69±0.00 bcde	SA 4479	5.20±1.51 a	0.64±0.13 def
Thethekhubesdu	8.94±1.48 bcdef	0.71±0.08 cde	Khukhunas	4.95±0.74 a	0.65±0.06 efg
SA 4487	6.88±1.27 abc	0.72±0.04 de	Thethekhubesdu	6.20±1.21 abcd	0.69±0.08 fg
SA 4492	4.44±1.01 a	0.74±0.04 de	Bigred	5.45±0.30 abc	0.77±0.04 g
Motale	10.00±0.00 cdef	0.89±0.00 ef	Pateletso	7.20±2.22 bcd	0.78±0.23 g
Samahose	7.13±2.39 abcd	0.94±0.16 f			

Means within columns followed by the same letter do not differ significantly at P>0.05 (LSD).

Table 3. Oviposition preference of *Chilo partellus* for maize and sweet sorghum landraces in two-choice tests. (Mean± S.D.).

Host plant	Mean number of eggs/plant	Mean number of egg batches/plant	Mean number of eggs/batch
SA4481	136.17±131.60a	45.41±29.88a	2.67±2.34a
Maize	135.00±85.87a	41.28±26.20a	2.67±1.63a
Pateletso	109.67±95.59a	36.07±37.78a	2.83±2.32a
Maize	195.33±223.18a	26.83±7.68a	6.67±6.02a

Means within columns for each two-choice test followed by the same letter do not differ significantly at $P<0.05$ (LSD).

Table 4. Oviposition preference of *Busseola fusca* for maize and sweet sorghum landraces in two-choice tests. (Mean± S.D.).

Host plant	Mean number of eggs/plant	Mean number of egg batches/plant	Mean number of eggs/batch
SA4481	3.75±7.50a	0.25±0.50a	3.75±7.50a
Maize	30.75±20.42b	2.25±1.26b	12.88±6.20b
Pateletso	5.25±10.50a	0.25±0.5a	5.25±10.50a
Maize	90.56±67.89b	3.75±2.63b	29.96±34.21b

Means within columns for each two-choice test followed by the same letter do not differ significantly at P<0.05 (LSD).

Table 5. Oviposition preference of *Chilo partellus* for sweet sorghum landraces in a multiple-choice test. (Mean± S.D.).

Host plant	Mean number of eggs/plant	Mean number of egg batches/plant	Mean number of eggs/batch
SA4479	174.67±63.86a	6.33±2.88a	28.95±7.92ab
Motale	237.50±171.86a	6.50±5.28a	39.17±14.98ab
Mariri	242.50±198.72a	6.33±5.20a	42.61±12.38b
Maatla	254.00±173.16a	6.17±4.12a	43.49±19.49b
Pateletso	290.00±216.45ab	10.00±7.56ab	24.95±6.66a
SA4481	526.67±307.51b	15.33±8.24b	32.26±5.35ab

Means within columns for each multiple-choice test followed by the same letter do not differ significantly at $P<0.05$ (LSD).

Table 6. Oviposition preference of *Busseola fusca* for sweet sorghum landraces in a multiple-choice test (Mean± S.D.).

Host plant	Mean number of eggs/plant	Mean number of egg batches/plant	Mean number of eggs/batch
Maatla	181.17±154.75a	4.67±3.20a	36.25±12.69a
Mariri	242.83±248.00a	5.33±3.32a	38.58±20.92a
Motale	267.83±234.17a	5.00±3.63a	50.61±22.56ab
SA4481	339.83±177.13a	6.00±4.10a	68.34±29.45b
SA4479	348.00±171.72a	6.33±2.34a	53.66±11.74ab
Pateletso	383.83±237.69a	6.17±2.71a	58.41±20.30ab

Means within columns for each multiple-choice test followed by the same letter do not differ significantly at $P<0.05$ (LSD).

Fig. 1. Screening sweet sorghum landraces for resistance to *Chilo partellus* and *Busseola fusca*.

CHAPTER 8

Field evaluation of forage sorghum (*Sorghum bicolor* x *S. sudanensis*) and *Pennisetum purpureum* (Napier grass) as trap crops in a habitat management system

ABSTRACT

The stem borers *Busseola fusca* Fuller (Lepidoptera: Noctuidae) and *Chilo partellus* (Swinhoe) (Lepidoptera: Crambidae) are the most serious pests of maize in South Africa. The use of wild grasses as trap crops for stem borers is an economical way of controlling stem borers for resource-poor farmers. To evaluate the role of forage sorghum and Napier grass trap crops in the control of stem borers, a field trial with maize was conducted. Control and Maize blocks in which forage sorghum was evaluated as a trap crop was replicated three times. Maize blocks not surrounded by a trap crop, were compared to that in a maize block surrounded by forage sorghum or Napier grass. In each block approximately 2000 plants were examined for whorl damage and dead heart symptoms at 4, 7 and 9 weeks after emergence. The data, collected over time, presented the cumulative damage and spatial distribution of stem borers in the fields. The incidence of whorl damage and dead heart symptoms increased over time in maize plots. The incidence of whorl damage and dead heart symptoms in maize plots surrounded by forage sorghum was similar to that in maize mono-cropped plots. This was ascribed to larval migration from forage sorghum to maize and to possible re-infestation by moths that completed their life cycle on sorghum. No significant differences were observed between number of ears per plant, percentage damaged ears per hectare and yield per hectare between maize plots surrounded by forage sorghum and maize mono-crop. Percentage damaged ears per hectare was higher, although not significant, on maize blocks surrounded by forage sorghum than that on maize mono-crop. The incidence of whorl damage and dead heart symptoms on the maize crop surrounded by Napier grass was lower than that on maize mono-crop while it was higher on maize with forage sorghum.

Key words: Forage sorghum, habitat management, Napier grass, stem borers, trap crop.

INTRODUCTION

The control of insects by trap cropping is a principle that has been known for centuries (Hokkanen 1991) and has been used in the control of pests with varying success (Hill & Mayo 1974). There are however, still few practical applications of trap cropping in modern agriculture (Mensah & Khan 1997).

In South Africa *Chilo partellus* (Swinhoe) (Lepidoptera: Crambidae) and *Busseola fusca* Fuller (Lepidoptera: Noctuidae) are stem borers of economic importance (Kfir 1997). These stem borers are a real cause for concern especially in the Limpopo Province where maize is grown widely by resource poor-farmers. Studies are underway to develop a low-cost pest management system for resource-poor farmers (Van den Berg *et al.* 2001). The aim is to develop a habitat management system in which indigenous grasses with economic importance are used as trap crops (Khan *et al.* 1997).

Pennisetum purpureum (Schumach) Napier grass and (*Sorghum vulgare* Pers. vars. *sudanense*) Sudan grass have been used as trap crops around maize in Kenya (Khan *et al.* 2000). Napier grass is known to be highly attractive to stem borer moths which oviposit on Napier grass instead of maize (Khan *et al.* 2000, Van den Berg *et al.* 2001). The use of trap crops around maize has also been suggested by Wall (1926) who suggested the use of sweet sorghum to trap *B. fusca*.

Apart from enhancing biological control, trap crops offer economic benefits as a result of reduced labour and pesticide use (Saxena *et al.* 1988, Hokkanen 1991). Pesticides have been used to a limited extent in trap cropping systems (Scholl & Medler 1947; Rust 1977). This is done by growing the trap crop around the main crop so that insect pests are concentrated on the trap crop where they may be destroyed by the pesticides (Scholl & Medler 1947, Rust 1977). However, this option may not be economically viable for use by resource-poor farmers. Hence the process of identification of trap crops which could be used as animal feed (Rust 1977; Khan *et al.* 1997, Khan *et al.* 2000) is currently taking place in South Africa.

A trap crop is usually planted earlier than the main crop and must be highly attractive to the insect pests to prevent economic damage on the main crop (Hill & Mayo 1974, Rust 1977). In such a habitat management system the diversity of natural enemies in the field is increased and biological control is enhanced (Landis *et al.*

2000). A study was conducted at the Agricultural Research Council-Grain Crops Institute in Potchefstroom (25° 09S, 28° 41E) to determine whether maize fields, surrounded by either of the two commercial fodder crops, forage sorghum or *Pennisetum purpureum* (Napier grass) would suffer less damage by stem borers compared to maize in a mono-crop system where these trap crops were not used.

MATERIAL AND METHODS

To evaluate the role of forage sorghum and Napier grass in the control of stem borers, a field trial with maize was conducted at the ARC-Grain Crops Institute in Potchefstroom. Stem borer infestation levels in a maize block not surrounded by a trap crop, was compared to that in a maize block surrounded by forage sorghum (Fig. 1) or Napier grass (Bana grass variety) (Fig. 2). There were three replicates for the mono-cropped maize block (n = 3) and the block surrounded by the forage sorghum. Due to lack of space in the field only one block of maize surrounded by Napier grass was established (n = 1) (Costat 1995). Each plot of maize (CRN 3414) was 35 m x 35 m with an inter-row spacing of 1 m and an intra-row spacing of 0.30 m, equivalent to a population of 34 000 plants/ha. Plots in which fodder sorghum was used were surrounded by three parallel rows of the trap crop. The distance from the trap crop to the inner row of maize was 1 m. The distance between each of the three parallel rows of trap crop was 0.5 m. The plot in which Napier grass was used was surrounded by two parallel rows of the trap crop. The space between rows of Napier grass was 0.75 m while distance between plants was 0.5 m. The control treatment (maize without a trap crop) was planted 10 m away from the plots surrounded by the trap crop. Spatial arrangement of plots is provided in Fig. 3. Trap crops were planted early September, two months prior to maize. This was done to ensure that forage sorghum and Napier grass were fully established and growing well at the time that maize was planted. Maize was planted in mid-November and natural infestation by stem borers was allowed to take place.

Sampling for stem borer damage was done in every second row in each plot. Non-destructive sampling technique was done in the field by examining plants four, seven and nine weeks after emergence of the maize crop. Each plant in the row was examined for dead heart symptoms or whorl damage caused by stem borer larvae.

Since the number of plants per row were known the position of each plant was noted and the damage at each sampling period was recorded for the same plants. Approximately 2000 plants were examined individually in each plot at each sampling date. Spatial distribution of maize plants with whorl damage and dead heart symptoms in control maize plots, and maize plots surrounded by sorghum and Napier grass were plotted using the COSTAT program (Costat 1995).

The incidence of plants with dead heart and whorl damage symptoms was determined and expressed as cumulative percentage damage over time.

The incidence of ear damage and yield were determined in the plots surrounded by forage sorghum and plots in which no trap crop was used. In each plots of maize three alternate inner rows were harvested separately as replicates. The number of ears damaged by borers was then calculated and expressed as a percentage of the total number of ears harvested.

Fifty stems of forage sorghum were selected randomly at each sampling date to determine stem borer infestation levels and species composition.

Differences between incidence of whorl damage, dead heart symptoms, yield, number of ears per plant and percentage damaged ears per hectare between maize plots surrounded by forage sorghum and the maize mono-crop was determined by means of t-tests.

RESULTS

Infestation by stem borers commenced four weeks after emergence (WAE) of the maize crop and the incidence of damage symptoms increased with time. No significant differences were found in the incidence of whorl damage (4WAE: F = 4.45, d.f. = 4, P = 0.103; 7WAE: F = 2.40, d.f. = 4, P = 0.196 and 9WAE: F = 0.28, d.f. = 4, P = 0.281) (Table 1) and dead heart symptoms (4WAE: F = 5.21, d.f. = 4, P = 0.08; 7WAE: F = 3.70, d.f. = 4, P = 0.127 and 9WAE: F = 4.87, d.f. = 4, P = 0.09) (Table 2) between maize plots surrounded by forage sorghum and maize mono-crop. Percentage stem borer infestation on forage sorghum was 90 % four and seven weeks after emergence and 96 % nine weeks after emergence. The stem borer species found on forage sorghum stems were *B. fusca* and *C. partellus*. *Busseola fusca* was the predominating species making up to 91 %, 100 % and 59 % of the population four, seven and nine weeks after emergence respectively.

The spatial and temporal distribution of plants exhibiting whorl damage symptoms in maize plots are presented (Figs 4 & 5). No significant differences were observed between number of ears per plant (F = 0.72, d.f. = 4, P = 0.4531), percentage damaged ears per hectare (F = 3.58, d.f. = 4, P = 0.1313) and yield per hectare (F = 1.35, d.f. = 4, P = 0.3105) between maize plots surrounded by forage sorghum and the maize mono-crop (Table 3).

The incidence of whorl damage and dead heart symptoms (Table 4) on maize crop surrounded by Napier grass was lower than that on maize mono-crop. The spatial distribution of plants exhibiting whorl damage (Fig. 6) and dead heart symptoms (Fig. 7) are compared.

DISCUSSION

Forage sorghum planted as a trap crop did not reduce stem borer infestation in maize. This is indicated by the absence of significant difference in whorl damage, dead heart symptoms and yield parameters measured between the blocks surrounded by forage sorghum and the blocks in which forage sorghum was not used as a trap crop. The high percentage of stem borer especially *B. fusca* infestation in forage sorghum stems was ascribed to higher incidence of stem borer infestation and high larval survival on this grass. The high numbers of *B. fusca* compared to *C. partellus* larvae found on this grass possibly suggest that more infestation on the grass and the maize fields might have been caused by *B. fusca*. *Sorghum vulgare sudanense* (Sudan grass), another popular trap crop known to support high larval survival may cause re-infestation of the maize field if the trap crop if not managed properly (Khan *et al.* 1997). Therefore, it is necessary to remove such a trap crop before the borers can develop into moths (Wahl 1926). Destruction by timely cutting away of the trap crop may help lessen the attack by insect pest on the main crop (Martin 1948). Khan *et al.* (1997) suggested harvesting of Sudan grass at six weeks intervals in order to prevent the stem borers from completing their life cycle. In this study it can therefore be concluded that the moths which emerged from the forage sorghum stems may have moved to the maize field causing re-infestation and the high incidence of infestation in this treatment.

The incidence of dead heart symptoms on maize surrounded by forage sorghum may also have been intensified by the migration of late instar larvae from the grass to maize. The movement of stalk borer larvae *Papaipema nebris* (Guenée) (Lepidoptera: Noctuidae) from grassy areas to adjacent maize rows was observed by Lasack & Pedigo (1986). The migration of the larvae to new plants was ascribed to the small stems of the grasses which could not accommodate a mature larvae (Bowden 1976, Lasack & Pedigo 1986). Pupal cases observed in the stems of forage sorghum indicated that some stems of this grass were thick enough to enable the stem borers to reach maturity (Ingram 1958). The results possibly suggest that forage sorghum plants with thick stems acted as a reservoir for stem borers larvae which later left the grass and attacked the maize crops. In contrast Sudan grass which supported high larval survival at an equal rate as maize significantly reduced stem borer infestation in maize fields in Kenya (Khan *et al*. 1997, Khan *et al*. 2000). This was ascribed to the ability of this grass to attract natural enemies thereby enhancing naturally occurring biological control of stem borers (Khan *et al* 1997, Khan *et al*. 2000).

The plots in which Napier grass was used as a trap crop was not replicated and therefore no valid conclusions could be made. However, the incidence of stem borer infested plants in this plot was lower than on the plots without trap crops. Similar results were reported by Khan *et al*. (1997), Khan *at al*. (2000) and Kfir *et al*. (2002). Laboratory studies on ovipositional preference by Van Rensburg and Van den Berg (1990) also showed that some wild host plants could be preferred for oviposition in the presence of crops such as maize. The low level of stem borer infestation observed on Napier grass could be ascribed to larval antixenosis by first instar larvae at the feeding site. Khan *et al*. (2000) reported that poor survival of first instars on the Napier grass was caused by a gummy substance produced by the plant in reaction to penetration by the larvae.

In this study, maize plots surrounded by forage sorghum had low maize crop yields while it can be tentatively concluded that Napier grass reduced population of stem borers and caused a significant increase in the maize crop yields. While forage sorghum failed to reduce stem borer infestation in the maize field this study indicated that Napier grass holds promise as a trap crop.

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Table 1. Cumulative percentage (Mean±S.D.) whorl damage observed in maize plots surrounded by forage sorghum and control blocks of maize.

Sampling dates	Maize + forage sorghum	Maize control	Difference
4 WAE	10.39±1.67	6.39±2.82	4.00 ns
7 WAE	26.99±6.72	19.68±4.65	7.31 ns
9 WAE*	40.02±14.40	33.66±15.00	6.36 ns

ns = not significant. * = reflects total number of plants with leaf feeding damage.

Table 2. Cumulative percentage (Mean±S.D.) dead heart symptoms observed in maize plots surrounded by forage and control blocks of maize.

Sampling dates	Maize + forage sorghum	Maize control	Difference
4 WAE	0.94±0.31	0.36±0.31	0.58 ns
7 WAE	14.69±4.57	7.99±3.92	6.70 ns
9 WAE*	19.25±5.80	9.41±5.12	9.84 ns

ns = not significant. * = reflects total number of plants with dead heart symptoms.

Table 3. Yield and yield parameters (Mean±S.D.) of maize blocks surrounded by forage sorghum and maize blocks with no trap crop.

Yield parameters	Maize + forage sorghum	Maize control	Difference
Ear number/plant	2.83±0.22	3.27±0.87	0.44 ns
Damaged ears/ha (%)	8.03±3.58	3.90±1.22	4.13 ns
Tonnes/ha	5.81±2.28	7.60±1.36	1.8 ns

ns = not significant.

Table 4. Percentage (Mean±S.D.) whorl damage and dead heart on maize block surrounded by Napier grass and maize block with no trap crop.

Sampling dates	Maize + Napier grass	Maize control	Difference
9 WAE*	10.53	33.66	23.13
9 WAE**	1.13	9.41	8.28

* = whorl damage, ** = dead heart.

Fig. 1. A forage sorghum border around a maize plot.

Fig. 2. A Napier grass border around a maize plot.

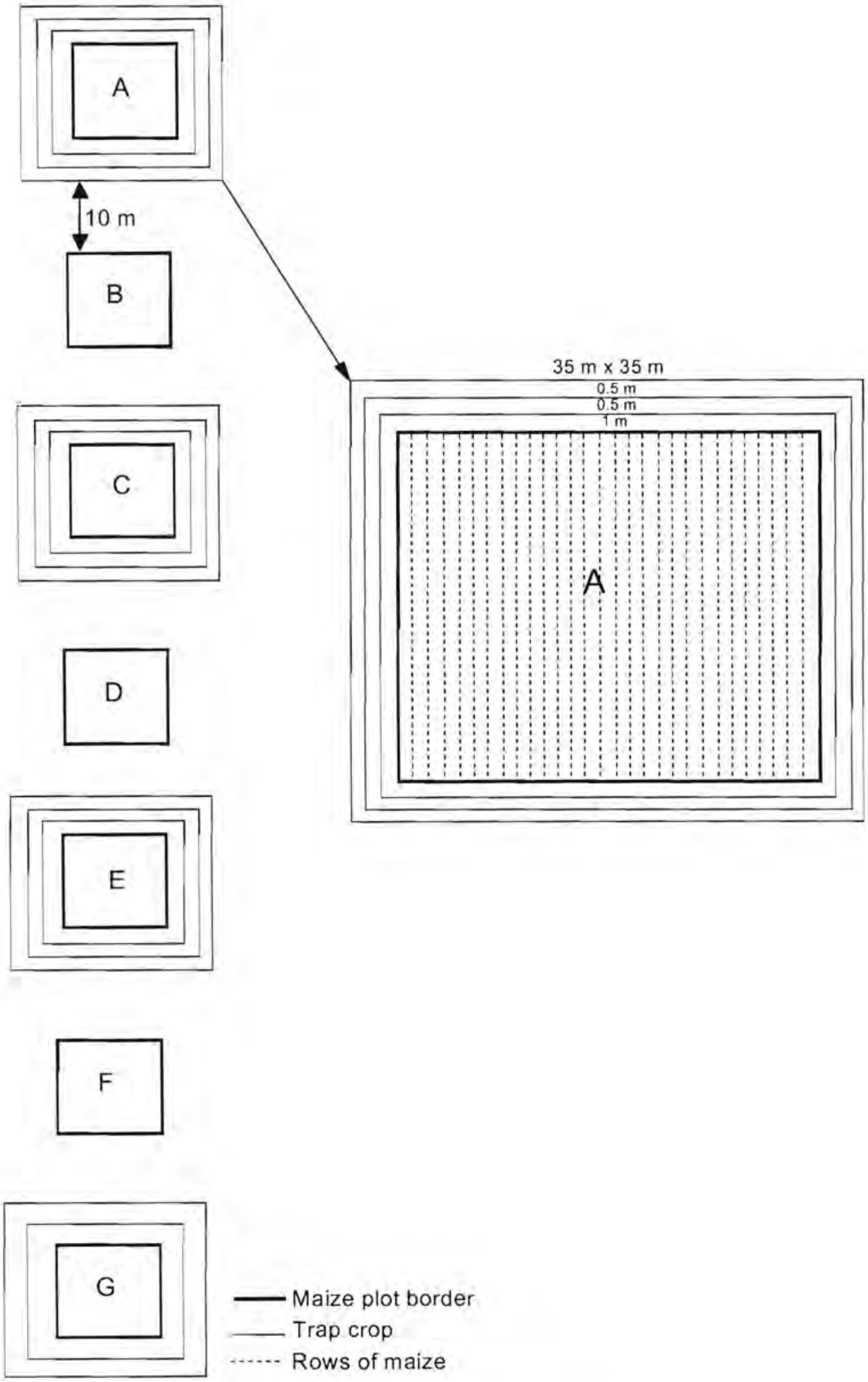

Fig. 3. Diagram showing spatial arrangement of plots in which forage sorghum and Napier grass were evaluated as trap crops for stem borers. A, C & E = maize blocks surrounded by forage sorghum; B, D, F = control plots; G = maize block surrounded by Napier grass.

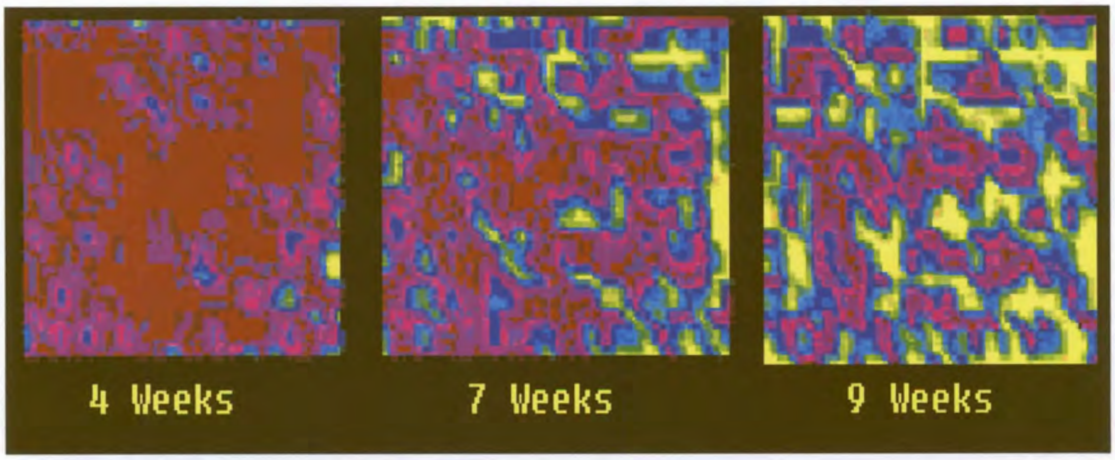

Fig. 4. Distribution of whorl damage symptoms in maize over time in blocks surrounded by forage sorghum. Yellow/pink/purple colours = area of damaged plants, reddish = area of undamaged plants.

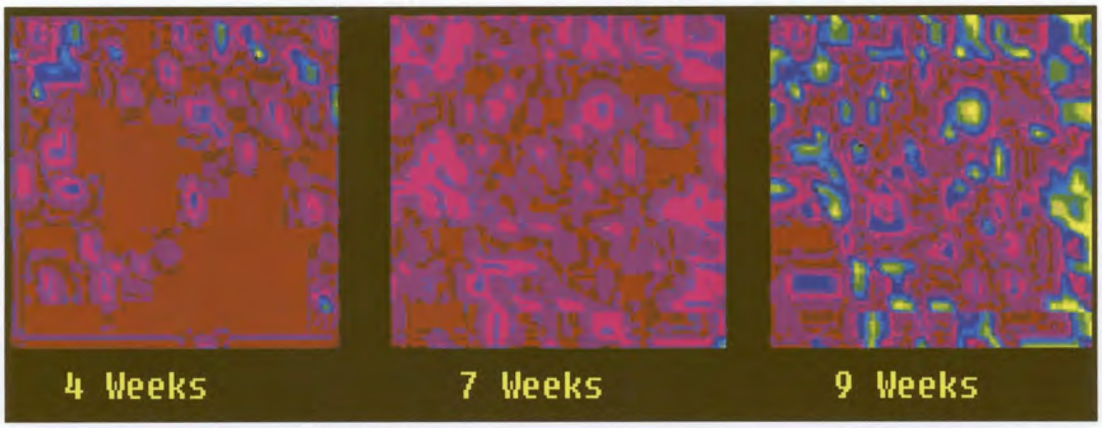

Fig. 5. Distribution of whorl damage symptoms in maize over time in blocks not surrounded by a trap crop. Yellow/pink/purple colours = area of damaged plants, reddish = area of undamaged plants.

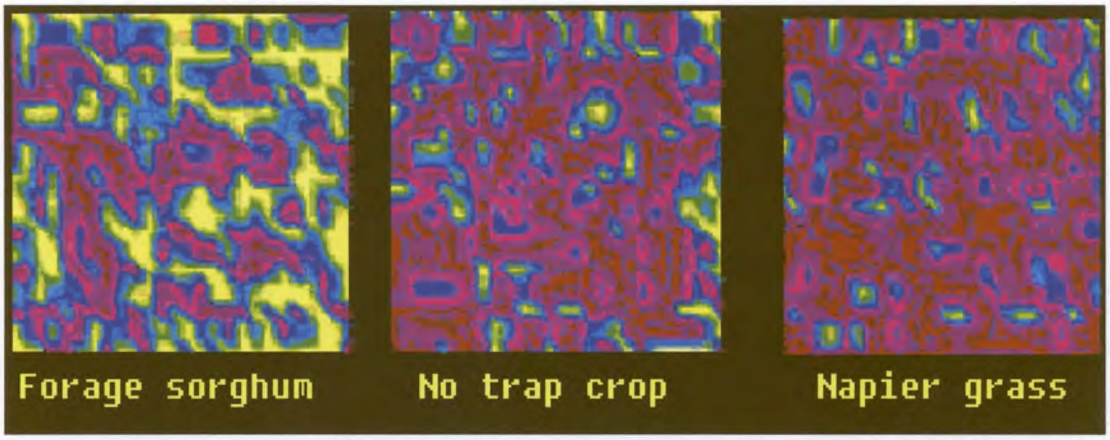

Fig. 6. Distribution of whorl damage in mono-cropped maize block and in maize blocks surrounded by forage sorghum and Napier grass (9 weeks after emergence). Yellow/pink/purple colours = area of damaged plants, reddish = area of undamaged plants.

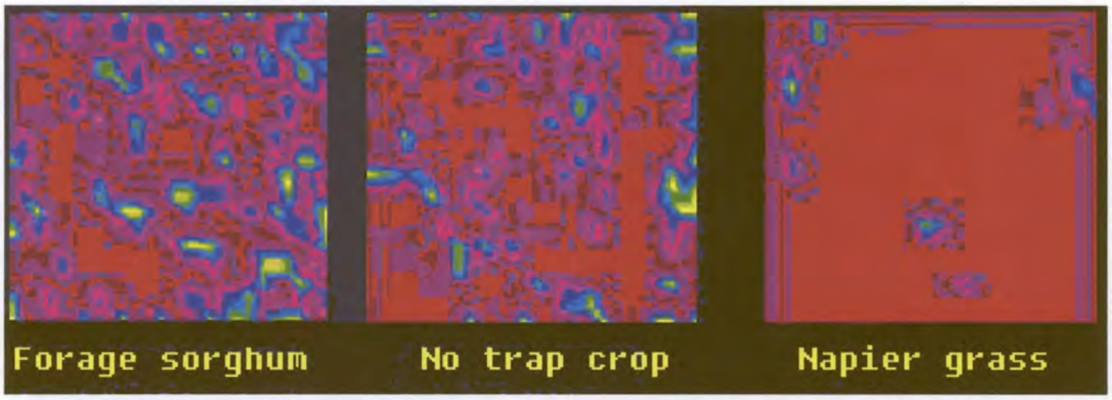

Fig. 7. Distribution of dead hearts in mono-cropped maize block and in maize blocks surrounded by forage sorghum and Napier grass (9 weeks after emergence). Yellow/pink/purple colours = area of damaged plants, reddish = area of undamaged plants.

CHAPTER 9

SUMMARY

Destructive sampling surveys have shown that some grass species belonging to two families, Gramineae and Typhaceae, were host plants to one or more species of stem borers. Three species of stem borers, *Busseola fusca*, *Chilo partellus* and *Sesamia calamistis* were associated with one or more than two wild host plant species. During the survey *B. fusca* was found to be restricted to high altitudes while *C. partellus* and *S. calamistis* were found from low to high lying regions.

Colonisation of cultivated and wild host plants by stem borers was studied under field conditions. The stem borers of economic importance recorded on host plants were *C. partellus* and *B. fusca*. The populations of *S. calamistis* were insignificant hence this species was declared to be of no economic importance in the areas surveyed. The incidence of whorl damage, dead heart and stem damage observed indicated that all host plants were susceptible to stem borer attack. The high incidence of whorl and stem damage and the improved development of stem borers on cultivated crops than the grasses indicated that cultivated crops were more readily colonised by stem borers than the grasses.

There was a general preference of grasses for oviposition by *C. partellus* moths in the presence of crops such as maize and sorghum. However, the studies on larval preference have shown that these grasses may not be preferred by newly hatched larvae. As a result of the existing non-preference under field conditions larvae would climb off the plant in search of a suitable host plant. Since larval migration off a plant is considered a mortality factor the practical implications of this behaviour could have some added advantages for pest management in a habitat management system. Larvae would die without establishing on the crops.

Oviposition studies in the laboratory indicated that sweet sorghum varieties did not significantly attract oviposition by both *B. fusca* and *C. partellus* moths in the presence of maize to warrant their use as a trap crops around maize fields.

Larval weight, pupal weight, larval development, development time for pupae, development to adulthood and pupation of *C. partellus* were adversely affected when this pest fed on *H. tamba* and *P. purpureum*. This indicated that these grasses were non-suitable hosts for the development and survival of this pest compared to the crop

hosts. When used as trap crops for *C. partellus* it could be predicted that such grasses could cause a reduction in infestation in maize fields.

Two fodder grasses, forage sorghum and Napier grass were evaluated as trap crops under field conditions. While forage sorghum failed to reduce stem borer infestation in the maize field, infestation on maize monocrop was higher than that on maize crop surrounded by Napier grass. Therefore, further research is needed to investigate the suitability of forage sorghum for use as trap crop for stem borers

Sweet sorghum, forage sorghum and *H. tamba*, the latter which is too hard and unpalatable to be used as a grazing grass, are poor candidates for use as trap crops for stem borers compared to the Napier grass. The studies showed that *H. tamba* was better preferred for oviposition by *C. partellus* than the Napier grass and that both grasses did not favour survival of *C. partellus*. However, these results did not suggest that *H. tamba* is a suitable candidate for use as trap. Napier grass has a wide range of advantages and besides being grown as a trap crop for stem borers in maize fields it could be used by resource-poor farmers as fodder or grown to prevent soil erosion. While *H. tamba* is sometimes used as a thatching grass an activity which seems to be fast disappearing over time it is also too hard and unpalatable to be used as a grazing grass. Therefore, further research should focus on evaluating a grass species for use as trap crop that has a high possibility for being adopted in resource poor farming systems. However, in this regard Napier grass is a better candidate.