Effect of Sorghum–Cowpea Intercropping on Sorghum Stem Borers and Their Parasitoids in Northern Ethiopia

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Abstract

The influence of sorghum–cowpea intercropping on the occurrence of stem borers in sorghum and their parasitoids was investigated at Abergele in Tigray Region, northern Ethiopia. Four intercropping and two monocropping systems arranged in randomized complete block design in four replications were used. Abundance of egg masses, larval and pupal stages of stem borers were significantly greater in the monocropped sorghum than sorghum–cowpea intercropped plots. Among the identified stem borers, *Busseola fusca* accounted for 55%, *Chilo partellus* 31%, *Sesamia calamistis* 12%, and *Rynchaenus niger* 2%. *R. niger* was a new insect pest recorded on sorghum for northern Ethiopia. The population of *C. partellus* was higher early in the growing season, while *B. fusca* dominated lately. Whereas, *R. niger* occurred at the end of the growing season. *Cotesia sesamiae*, *C. flavipes*, and *Sturmiopsis parasitica* parasitized lepidopterous stem borers larvae at low levels, ranging from 0.4% in the monocropped to 0.7% in the intercropped plots. The levels of larval parasitism of stem borers were not different between the intercropped and monocropped plots. The sorghum–cowpea intercropping systems significantly reduced the density of stem borers. Therefore, the system can be used as an important component of stem borer management.

Key words: pest management, sorghum, cowpea, intercropping, stem borers, parasitoids

Introduction

Sorghum (*Sorghum bicolor* (Moench)) is one of the most important food crops in Ethiopia next to maize (*Zea mays* L.) and tef (*Eragrostis tef* (Zucc) Trotter). In Tigray Region, northern Ethiopia, sorghum is the second major cereal crop next to tef; the crop accounts for 14.5% of the total cultivated area in the region (CSA 2000). However, the yield of the crop in the region has not exceeded 1.3 t/ha which is by far below the world average of 2–3 t/ha (House 1985).

Lepidopterous stem borers are one of the major biotic constraints that contribute for the low yield in sorghum (Emana and Tsedeke 1999, Emana 2002). Yield losses due to stem borers that ranged from 10 to 100% were reported in sorghum and maize in Ethiopia (Assefa et al. 1989, Emana and Tsedeke 1999).Six species of stem borers are reported to be attacking sorghum in the country. These are: *Chilo partellus* (Swinhoe) (Lepidoptera: Crambidae), *Busseola fusca* Fuller, *Sesamia calamistis* Hampson, *Sesamia nonagroides* botanephaga Tams (Lepidoptera: Noctuidae), *Rynchaenus niger* (Horn) and *Pissodes dubius* (Strom) (Coleoptera: Rhynchophoridae) (Emana 2002). Among these, according to the author, *B. fusca* and *C. partellus* are the most important.

Management of stem borers is still a challenge. Chemical control has not been effective due to the cryptic feeding habit of the pest (Oloo and Ogeda 1990, Ampong-Nyarko et al. 1994). Environmental risks and pest resurgence are also important problems associated to the use of insecticides. Moreover, most of the sorghum varieties are susceptible to stem borer damage.

However, there are limited studies on cultural practices such as intercropping, which may influence stem borers directly by affecting their biology and indirectly by influencing the occurrence of their natural enemies (Emana 2002). Intercropping is a common cropping system of sorghum and maize in the tropics (Skovagard and Pats 1996, Ogol et al. 1999). Moreover, intercropping was found to be one of the cultural management methods of stem borers on sorghum and maize for small-scale farmers elsewhere (Ampong-Nyarko et al. 1994).

In Ethiopia, farmers intercrop sorghum with pulses such as common bean (*Phaseolus vulgaris* L.) and cowpea (*Vigna unguiculata* (L.) Walp) mainly for variety of harvest, risk aversion, livestock feed and other socio-economic reasons. Cowpea is grown in moisture stressed lowlands of Ethiopia in association with sorghum and millet for seed and foliage yields (Mesele 1998). In some parts of Tigray, for example at Abergele where the current study was conducted, intercropping of cowpea with sorghum is widely practiced.

Previous experiments focused mainly on crop yield (House 1985, Mesele 1998). However, despite the relevance of the cropping systems approach to insect pest management, little field-based experimental work was carried out on the effects of cropping systems on the occurrence of insect pests like stem borers and their parasitoids (Emana 2002). Therefore, the present study was conducted to assess the effect of sorghum–cowpea intercropping on the occurrence of sorghum stem borers and their parasitoids.

Materials and Methods

Description of the study site

A field experiment to assess the influence of cropping systems on stem borers and their parasitoids was conducted in 2002 cropping season under rain-fed condition at Abergele, Tigray, northern Ethiopia. Abergele is located at $13^{O}14'06''$N and $38^{O}58'50''$E and altitude of 1500 m. The area is a hot to warm sub-moist lowland agro-ecological zone, which is characterized by low and erratic rainfall (Legesse 1999). The annual rainfall of the area ranges from 350 to 750 mm. The soil is mainly sandy and poor in fertility (Legesse 1999).

Experimental design and treatments

Sorghum variety SRN-39 was planted in July 2002 in monocropping and intercropping systems. Cow pea variety Black Eye Bean was used as an intercrop. The treatments were: sorghum:cowpea 1:1 row intercropping, sorghum:cowpea 2:1 row intercropping, sorghum:cowpea 1:1 broadcast intercropping, sorghum:cowpea 3:1 broadcast intercropping, sorghum monocrop row planting, and sorghum monocrop broadcast. The experiment was laid in a randomized complete block design with four replications. The plot size was 6.75 m x 5.0 m. Spacings of 1.0 m between plots and 1.5 between blocks were used. Spacings between rows and between plants for monocropped and intercropped sorghum were 0.75 m and 0.15 m in the row-planting pattern, respectively. Spacing for cow pea was 0.75 m inter-row and 0.20 intra-row. Seed rates of 24 kg/ha for sorghum and 80 kg/ha for cowpea were used for the broadcast planting. Sorghum and cowpea were planted simultaneously. At planting all the treatments received DAP fertilizer at the rate of 50 kg/ha. In addition, 50 kg/ha UREA was applied at 30 days after emergence (DAE) as top dressing.

Field data collection

Presence-absence and destructive samplings were used for the assessment of stem borers. Ten randomly selected sorghum plants were destructively sampled on bi-weekly intervals, and assessed for the presence of egg masses, larvae and pupae of stem borers starting from 31 DAE until the cowpea plants reached senescence stage (78 DAE). At harvest (125 DAE) 10 sample sorghum plants were also selected and assessed for stem borers. The proportion of each species of stem borers in the experimental plots were computed for each sampling date separately and summed up for the total occurrence for the season.

Laboratory rearing of eggs, larvae and pupae of stem borers

The stem borers collected in each sampling date were further reared to the next stage and their states were recorded as dead, parasitized or emerged adults. Larvae of stem borers were reared individually on fresh pieces of sorghum stems in plastic cups of 15 cm diameter covered by muslin cloth in laboratory. The diet (sorghum stems) was changed every two days and the larvae were observed for any parasitoid emergence. Similarly, egg masses and pupae of stem borers were kept separately in Petri-dish in the laboratory and observed for parasitoid emergence. The overall incidence of parasitism was calculated based on the ratio of the total number of parasitised and unparasitised borers.

Identification of stem borers and their parasitoids

Identification of the stem borers' parasitoids was made using available keys (Van Achterberg and Walker 1998) and confirmation was made at the International Centre of Insect Physiology and Ecology (ICIPE), National Museum of Kenya. Species identification for stem borer larvae was made in accordance with Meijerman and Ulenberg (1996).

Data analysis

Data for each parameter was subjected to analysis of variance (ANOVA). After testing the data for normality, and computing the functional relationship between the mean and variance, appropriate data transformation was performed. Accordingly, data on stem borer egg masses, larval and pupal density, and percentage of plants with egg masses were transformed to square root transformation ($\sqrt{x+0.5}$) before analysis. Data collected on the same sampling date were averaged for individual plots and analyzed using GLM in SAS computer program. Significant means were separated using Tukeys Studentized Range Test (HSD) at 5% level of significance (SAS Institute 1999-2000). The means and their standard errors were back transformed for reporting (Gomez and Gomez 1984).

Results

Three lepidopterous and one coleopteran species of stem borers were found attacking sorghum in Abergele. The lepidopterous stem borers were *C. partellus*, *B. fusca* and *S. calamistis*. Among these, *B. fusca* and *C. partellus* were the major ones. The coleopteran stem borer *R. niger* was recorded at the end of the growing season. Among the identified stem borers, *B. fusca* accounted for 55%, *C. partellus* 31%, *S. calamistis* 12%, and *R. niger* 2% (Table 1). The population of *C. partellus* was higher in early sampling dates (56.5% at 45 DAE and 53.1% at 62 DAE) than the population of *B. fusca*, which was dominant late in the growing season (31% at 62 DAE, 55.1% at 78 DAE and 60.3% at 125 DAE) (Figure 1).

The population of stem borer egg masses was not significantly different in the intercropped and monocropped plots at 31 and 46 DAE (Figure 2A). However, significantly ($p < 0.01$) fewer egg masses were found in the intercropped than in monocropped plots at 62 DAE. The total egg masses count for all the sampling dates also showed significantly higher number of egg masses in the monocropped sorghum than in the intercropped. Similarly, regardless of planting pattern, percentage of plants with egg masses was significantly higher in the sorghum monocropped than sorghum–cowpea intercropped plots (Figure 2B).

The sorghum–cowpea intercrop had significantly ($p < 0.001$) lower number of larvae and pupae than the sorghum monocrop at 46, 62, 78 and 125 DAE (Table 2). The mean borer population for the five sampling dates in the sorghum–cowpea intercropped plots ranged from 28 to 38 larvae and pupae per 10 plants. According to the results, the borer population in the sorghum monocrop was over two-folds more than that of the sorghum–cowpea intercropped plots. There was higher larvae and pupae density per 10 plants in the sorghum monocrop in broadcast (104) in row planting (106) (Table 2). The mean reduction in larvae and adult moth was 16% in both sorghum:cowpea 1:1 row intercropping and in the sorghum:cowpea 2:1 row intercropping, while there was 18% reduction in both sorghum:cowpea 1:1 broadcast intercropping and sorghum:cowpea 3:1 broadcast intercropping (Table 1).

Table 1. Effect of cropping systems on population of different stem borer species

Cropping system	Stem borers/10 plants				Total
	Busseola fusca	*Chilo partellus*	*Sesamia calamistis*	*Rynchaenus niger*	
Sorghum:cowpea 1:1 row intercropping	99 b	56b	22b	3a	180(12.3)
Sorghum:cowpea 2:1 row intercropping	98 b	58b	20b	3a	179(12.2)
Sorghum:cowpea 1:1 broadcast intercropping	68 b	51b	19b	5a	143(9.8)
Sorghum:cowpea 3:1 broadcast intercropping	73 b	50b	15b	4a	142(9.7)
Sorghum monocrop (row planting)	240a	120a	51a	5a	416(28.4)
Sorghum monocrop (broadcast)	232a	119a	50a	6a	407(27.8)
Total	**810**	**454**	**177**	**26**	**1462**
Percentage	(55.4)	(31.1)	(12.0)	(1.8)	(100)
CV (%)	10.3	8.1	9.7	24.0	

Values in parentheses are percentages and means followed by the same letter (s) within a column are not significantly different at 5% level (HSD).

Table 2. Effect of cropping systems on the population of lepidopterous stem borer species (*B. fusca*, *C. partellus* and *S. calamistis*) at different days after crop emergence (DAE) in sorghum

Cropping system	Larvae and pupae density/10 plants					Mean
	31 DAE	46 DAE	62 DAE	78 DAE	125 DAE	
Sorghum:cowpea 1:1 row intercropping	-	2.1 ± 0.2b	13.6 ± 0.1c	50.2 ± 0.2b	114.4 ± 0.4b	36.1b
Sorghum:cowpea 2:1 row intercropping	-	2.5 ± 0.2b	14.2 ± 0.1bc	79.8 ± 0.4b	95.8 ± 0.2b	38.4b
Sorghum:cowpea 1:1 broadcast intercropping	-	2.7 ± 0.1b	13.7 ± 0.1c	49.0 ± 0.2b	76.2 ± 0.1b	28.3b
Sorghum:cowpea 3:1 broadcast intercropping	0.2 ± 0.1a	2.4 ± 0.2b	14.3 ± 0.2bc	58.5 ± 0.3b	72.8 ± 4b	29.5b
Sorghum monocrop (row planting)	0.2 ± 0.1a	6.0 ± 0.1a	32.2 ± 0.1ab	220.1 ± 0.2a	273.9 ± 0.6a	106.4a
Sorghum monocrop (broadcasting)	0.4 ± 0.2a	7.0 ± 0.1a	38.2 ± 0.2	197.5 ± 0.2a	280.2 ± 0.3a	104.6a
CV (%)	24.0	17.3	7.7	10.4	14.5	6.5

Means followed by the same letter (s) within a column are not significantly different at 5% level (HSD).
= No larvae and pupae recorded
+ = Standard error of the mean

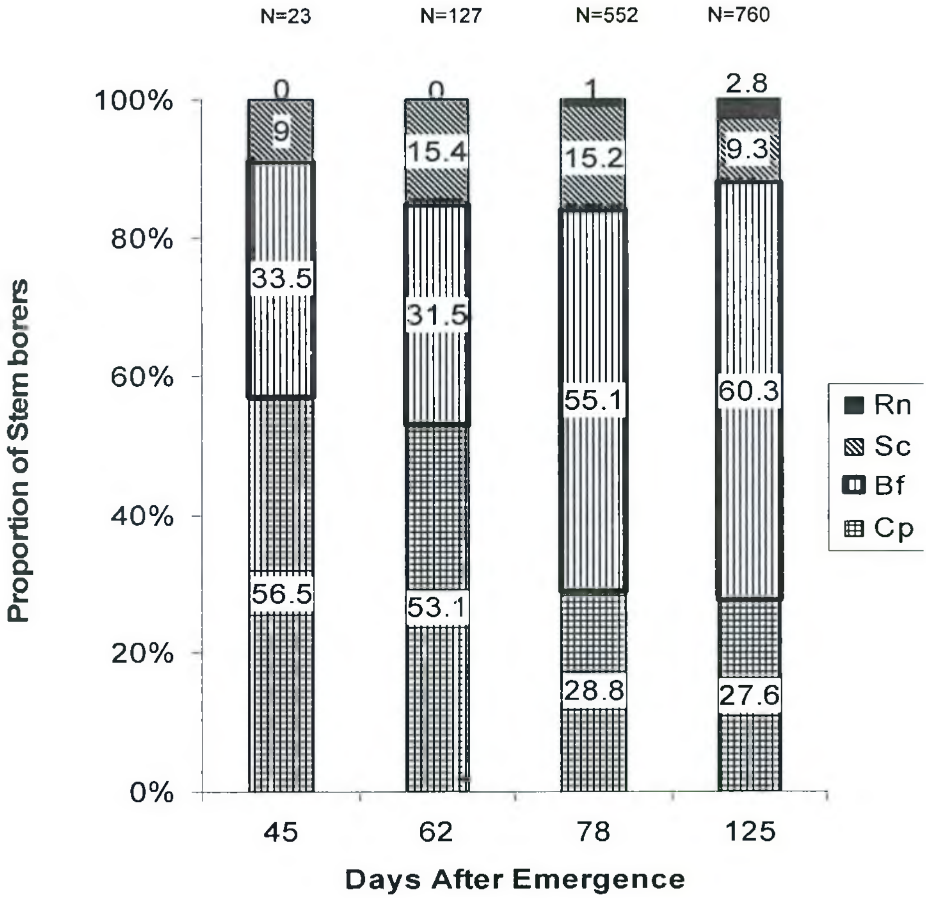


Figure 1. Proportion (%) of lepidopterous and coleopteran stem borer species recorded attacking sorghum at different days after crop emergence

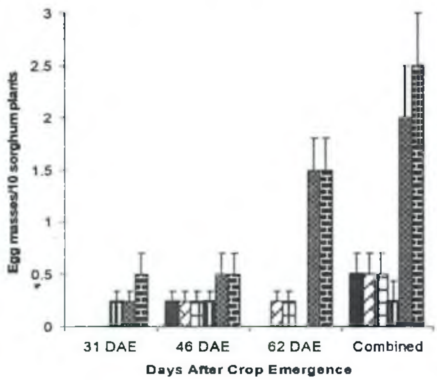
Bf = Busseola fusca; Cp = Chilo partellus; Sc = Sesamia calamistis; Rn = Rynchaenus niger

Parasitoids

Cotesia sesamiae and *C. flavipes* Cameron (Hymenoptera: Braconidae) and *Sturmiopsis parasitica* (Diptera: Tachinidae) were the only parasitoids recorded on the larvae of *B. fusca*, *C. partellus* and *S. calamistis* during the study period. From a single parasitized larva up to 18 *Cotesia* individuals were recorded, but few *S. parastica* emerged per larvae (not more than four).

The mean percentage parasitism of larvae by *Cotesia* spp. was generally low in intercropped (0.7%) and monocropped (0.4%) plots. The percentage parasitism by *S. parasitica* was also low (0.4%) in both intercropped and monocropped plots. Though the assessment for parasitism was carried out on borers collected on each sampling date, larval parasitoids occurred late in the growing season after 78 DAE. However, egg and pupal parasitoids were not recorded.

A



B

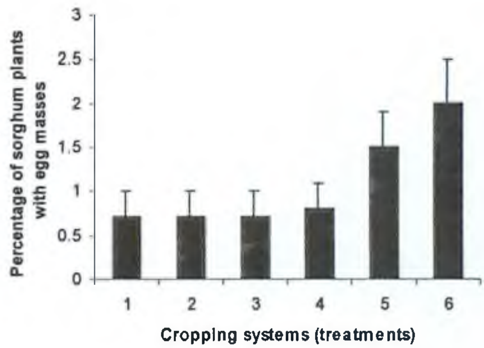


Figure 2. Effect of cropping systems on lepidopterous stem borer egg mass count at different DAE in sorghum (A) and proportion of plants with egg masses (B).
Values are mean of four replicates assessed per 10 plants in each assessment date

1 = sorghum:cowpea 1:1 row intercropping
2 = sorghum:cowpea 2:1 row intercropping
3 = sorghum:cowpea 1:1 broadcast intercropping
4 = sorghum:cowpea 3:1 broadcast intercropping
5 = sorghum monocrop (row planting)
6 = sorghum monocrop (broadcast)

Discussion

Four stem borer species, namely, *B. fusca*, *C. partellus*, *S. calamistsis* and *R. niger* were recorded at Abergele attacking sorghum. *R. niger* is a new insect pest recorded on sorghum for northern Ethiopia although it has been recorded in other localities (Emana 2002). *C. partellus* was found dominant in the early growing season, while *B. fusca* was dominant late in the season which could be explained by the nature of diapause in the two species. In case of *B. fusca* diapause is compulsory, while it is facultative in *C. partellus* (Emana 2002). This means that all the first generation of *B. fusca* population which attacks the crop early in the season come from the diapause larvae which is less in fecundity. In case of *C. partellus*, the first generation which attacks the crop early in the season come both from the diapause and non-diapause larvae which might have favored *C. partellus* dominance early in the season. The population shift of the two species late in the season could be explained by the high fecundity of *B. fusca* in the locations having similar physical factors like Abergele (Emana 2002).

Abundance of sorghum stem borers was significantly reduced in the sorghum–cowpea intercropped plots compared with the sorghum monocropped plots. Moreover, the percentage of total larvae and pupae collected from different intercropped sorghum was lower than the sorghum monocrop regardless of planting pattern. The number of stem borer egg masses deposited and proportion of plants with egg masses was significantly more in the monocropped plots. These results agree with the resource concentration hypothesis, which states the occurrence of higher herbivore numbers in simple habitat than in the diverse (Root 1973, Banks and Ekbom 1999). Host location was probably affected by the presence of cowpea plants, which reduced the borers ability to locate their host efficiently as shown by the lower number of egg masses in the sorghum-cowpea intercrop than in the sorghum monocrop. Other studies also showed that intercropped sorghum consistently had fewer egg masses than monocropped sorghum

(Amopong-Nyarko et al. 1994, Ogol et al. 1999). Ogol et al. (1999) reported that stem borers like *Chilo* sp. are more or less specialist herbivores on crops like maize and sorghum (and other grasses) and are less likely to locate their host plant efficiently in diverse habitats because of the masking and dilution of the attractant stimuli by non-host plants. They further observed that stem borer egg batches were often deposited on weeds and non-host crops, suggesting that non-host plants may have physically obstructed the herbivore's mobility during the host-seeking process. Similarly, Ampong-Nyarko et al. (1994) reported about one third of *C. partellus* eggs were laid on non-host crops of cowpea and cassava in a study on ovipositional behavior of *C. partellus* in maize–sorghum–cowpea, sorghum–cowpea and maize–cassava intercropping systems.

In the present study, three species of parasitoids were recorded; nevertheless, their level of parasitism was low to suppress population of stem borers. Stem borer parasitism level was not affected by intercropping of sorghum with cowpea. Abergele, the study area, is typically dry land area, and it lacks wild annual grasses and extended rainy period. In such cases, parasitoids might not get favorable conditions for over-seasoning. These conditions might be the reasons for the low level of parasitism in the study area. Oloo and Ogeda (1990) reported that parasitoids might have a greater impact on stem borer populations residing in wild grass communities than on populations that periodically invade annual crops. Stem borers migrate from sorghum to wild grasses when the crop matures/dries up. The presence of stem borers in wild grasses may allow parasitoids to survive dry periods between cropping seasons. Wild grasses and other plants may also provide shelter and alternative food source for stem borer natural enemies (Oloo and Ogeda 1990). Skovgard and Pats (1996) had reported greater impact of parasitoids (egg parasitism) in maize–cowpea intercrop than in maize monocrop. However, the effect was higher in the long rainy season, indicating that factors other than habitat diversification such as time of planting or season are important for occurrence of the parasitoids.

Results of the current study showed that sorghum–cowpea intercropping production system could form a useful component of an integrated management program of stem borers. It would appear that in order to achieve effective stem borer management by integrating intercropping with other cultural practices such as planting date, and crop residue management (Assefa et al. 1989). In addition, sorghum–cowpea intercropping is advantageous for optimizing use of available land, improving soil fertility and reducing weed infestation.

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References

Ampong-Nyarko KK., Reddy VS., Saxena KN., and Reddy KV. 1994. *Chilo partellus* (Swinhoe) (Lepidoptera: Pyralidae) oviposition on non-hosts: a mechanism for the reduced pest incidence in intercropping. *Acta-oecologica* **15**: 469–475.

Assefa G., Roland S. and Jan P. 1989. The relationship between sowing date, infestation and damage by the maize stalk borer, *Busseola fusca* (Noctuidae), on maize in Awassa, Ethiopia. *Tropical Pest Management* **35**: 143–145.

Banks JK. And Ekbom B. 1999. Modeling herbivore movement and colonization pest management potential of intercropping and trap cropping. *Agricultural and Forest Entomology* **1**: 165–170.

CSA (Central Statistical Authority). 2000. *Agricultural sample survey 1999/2000*. Report on area and production for major crops (private peasant holdings, main season). Statistical Bulletin No. 227. CSA: Addis Ababa, Ethiopia. 73 pp.

Emana G. and Tsedeke A. 1999. Management of maize stem borer using sowing date at Arsi Negele. *Pest Management Journal of Ethiopia* **3**: 47–52.

Emana G. 2002. *Ecological analyses of cereal stem borers and their natural enemies under maize and sorghum based agro-ecosystems in Ethiopia.* PhD dissertation, Kenyatta University.

House LR. 1985. *A guide to sorghum Breeding.* 2nd ed. International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, India. 238 pp.

Gomez KA and Gomez AA. 1984. *Statistical procedures for Agricultural Research* 2nd ed, International Rice Research Institute, John Willey & Sons, New York. 472 pp.

Legesse Y. 1999. *Agro-ecological zones of Tigray.* Land Use Planning Division of Tigray Bureau of Agriculture and Natural Resources (BOANR), Mekele. 65 pp.

Mesele A. 1999. *Genetic variation and interrelationships of agronomic trials in cowpea* (*Vigna uniguiculata* (L.) Walp.). M.Sc. thesis, Alemaya University of Agriculture, Ethiopia. 83 pp.

Meijerman L. and Ulenberg SA. 1996. *Identification of African stem borer larvae* (Lepidoptera: Noctuidae, Pyralidae) based on morphology. *Bulletin of Entomological Research* **86**: 567–578.

Ogol Ck., Spence JR. and Eddie A. 1999. Maize stem borer colonization, establishment and crop damage levels in a maize-leucaena agro forestry system in Kenya. *Agriculture, Ecosystem, and Environment* **76**: 1–15.

Oloo GW. and Ogeda K. 1990. The incidence of *Chilo partellus* (Swinhoe) (Pyralidae) and the contribution of natural enemies to its mortality under intercropping systems in Kenya. *Tropical Pest Management* **36**: 244–248.

Root RB. 1973. Organization of a plant-arthropod association in simple and diverse habitats: the fauna of collards (*Brassica olerace*). *Ecological Monographs* **43**: 95–124.

SAS Institute. 1999-2000. Cary, NC, USA.

Skovgard H. and Pats P. 1996. Effects of intercropping on maize stem borers and their natural enemies. *Bulletin of Entomological Research* **86**: 599–607.

Van Achterberg C. and Walker AK. 1998. Braconidae, Natural enemies of stem borers. In: African cereal stem borers: *Economic Importance, Taxonomy, Natural Enemies and Control*, Polaszek (ed). The Natural History Museum, London, UK, CAB and ACP-EU CTA. 137–185 pp.