Original Research Article

SORGHUM /LEGUME INTERCROP ON STEM BORER DAMAGE AND YIELD OF SORGHUM.

Abstract

Stem borer (chilo partellus) is one of the major pest of economic importance which affects sorghum production in the South eastern region of Zimbabwe. The experiment to establish the relationship between stem borer insect suppression by intercropping and grain yield in sorghum and six legumes was conducted under field conditions at Chiredzi research Station in the south eastern lowveld (21^{0}01'S, 31^{0}33'E) from 2013 to 2015. Treatments consisted of monocrops and intercrops of sorghum, monocrops of cowpea, groundnut, pigeon pea, bambara and an additional pair of sorghum sole crops with some sole plots protected by insecticides. In the monocropped, unprotected sorghum, yield was reduced by 28% compared to the protected monocrop, while reduction in the unprotected intercropped sorghum was 15% compared to the protected intercrop. Intercrops showed an incremental benefit of between 0.6 and 2. In intercropped combinations of sorghum/groundnut, sorghum/pigeon pea and sorghum/cowpea, an incremental benefit of 10-38% was observed than all other treatments while no benefit was observed in sorghum bambara combinations. Predators recorded in intercrops reduced insect pest density than in monocrops. Thus, these findings indicate that intercropping can form a component of an integrated pest management program

Key words

Sorghum, legume, intercropping, land equivalent ratio, stem borer, yield

1.0 INTRODUCTION

Intercropping legumes and non-legumes is an agricultural practice of cultivating two or more crops in the same place of land at the same time which is commonly practiced in many parts of the world in order to increase the productivity per unit area of the land (1). The crops are not necessarily sown at the same time and their harvest time may be quite different, but they are simultaneously grown for significant growing periods (2). Moreover, intercropping allows efficient use of both space and time to optimize beneficial effects (3). According to (4) intercropping promotes diversification and allows greater flexibility in adjusting to short- and long-term changes in the production and marketing situations, and also intercropping provides better weed control and reduces pest and disease incidence (5). Furthermore intercropping is a popular cropping system among small scale farmers in the tropics (6). Cereal/legume intercropping increased dry-matter production and grain yield more than their monocultures. The nitrogen transfer from legume to cereal increased the cropping system's yield and efficiency of nitrate uses. The taller cereal reduces biological nitrogen fixation and yield of the associated legume (7). According to (8), the competitive relationships between the non-legume and the legume affected the growth and yield of the leguminous crops in close proximity.

Sorghum (*Sorghum bicolor L.* Moench) belongs to the family Gramineae, including both wild and cultivated sorghum. Sorghum is the fifth important crop among the cereals in the world following rice, wheat, maize, and barley in total area planted and production [9]. Sorghum is a principal cereal that forms an important staple diet throughout the semi-arid Asian and African regions (10). It is grown in regions receiving 300–1200 mm rainfall and in soils of pH range 5.0–10.0 (11). Sorghum is grown for grain, forage, syrup, and sugar. In 2004 the total production of sorghum in the world was 57 924 thousand tones and in Sudan was 2 600 thousand tones (12). The total consumption of sorghum closely follows the global patterns of output, since most of it is consumed in the countries where it is grown. This is characterized by what most of smallholder farmers living the south east lowveld of Zimbabwe rely on. These farmers produce a number of crops ranging from vegetables, cash crops and mostly sorghum as a source of their livelihood for food security.

Production of this cereal crop is reclined by stem borer damage problems which salvage the crop to a mere fraction of the potential yield. Chilo partellus (Swinhoe) remains one of the economically important sorghum and maize stem borers in the dry areas of the south eastern Lowveld and East Africa (Seshu Reddy 1983, 1989; Warui &Kuria 1983). Stem borer damage to sorghum plants results primarily from leaf-feeding and stem tunnelling activities of the larvae. Characteristic leaf lesions and scarification caused by first and second larval instars of C. partellus are the first indications of infestation under natural field conditions (Sithole 1990). Yield reduction occurs as a result of leaf-feeding, dead hearts, stem tunnelling, direct damage to grain and increased susceptibility of attacked plants to stalk rots and lodging (Harris 1990). Control of stem borers includes the use of chemical insecticides, host-plant resistance, cultural practices and biological control. This problem is aggravated by poor rains which are experienced in the area.

These resource marginalized farmers lack capital to purchase modern chemicals that are sold in most retail outlets/shops, to effectively fight the problem. Escalating costs and unavailability of chemicals (at times) has forced many smallholder farmers to use cheaper means such as intercropping. Surveys carried out in some parts of south eastern lowveld districts have revealed that most smallholder farmers have resorted to the use of different intercropping systems to alleviate the stem borer attacks on their crops. Whilst some of the farmers say that some of these control measures are effective, others have reservations on their efficacy. They only resort to these indigenous systems because they cannot afford or access the recommended pesticides. Adoption of effective intercrop practices for natural regulation of insect pests including stem borers remains crucial (13) (14), especially by these resource-poor farmers that lack the capacity of input-intensive plant protection measures. Groundnut (*Arachis hypogea*) is a short-duration legume crop grown by farmers in the savannah regions of Africa, and is readily intercropped with other medium duration crops such as pearl millet (15). The objective of this trial was therefore to evaluate the efficacy of different cultural indigenous intercropping knowledge systems for the control of stem borer in sorghum which is commonly grown in the marginalized low lying areas.

1.2 Methods and materials

1.2.1 Study site

The study was carried out at Chiredzi Research Station *(21^{0}01'S, 31^{0}33'E* 429 m above sea level*)* located in the southeastern lowveld (agro-ecological region 5) of Zimbabwe. It experiences temperatures ranging from 29 – 39^{0}C and can reach up to 42^{0}C and receive rainfall totals of 450-650 year round and are common during the summer months and these are the favourable temperature requirements for stem borer multiplication. Triangle PE1 series such as shallow sandy clay soils dominate. The low latitude of 1200-1500 ft a.s.l is an effective safeguard against frost in all but the extreme circumstances. Minimum temperatures tend to run low in winter and frost can occur in low lying areas.

1.2.2 Experimental procedure and treatments

The trial was implemented at Chiredzi Research Station in the rain fed area. Treatment combinations of soghum/cowpea, sorghum/groundnut, sorghum/bambara, sorghum/pigeon pea and sole crops of groundnut, cowpea, bambara and pigeon pea, replicated three times were laid on furrows spaced 0.90m wide in randomized complete blocks. Treatment controls comprised of sole sorghum plots where chemicals were applied and where no chemical was applied. Plantings were done with the first effective rains received in the area for the three seasons. Plot size was 8m long and 7 rows/ridges spaced at 0.9 m. Three seeds of sorghum variety SV4 were sown per hill and later thinned to one, with 20 × 90 cm spacing between plants and between rows, respectively. Commercially available phosphate fertilizer at a rate of 150 kg/ha (18% P_2O_5) was applied at planting and nitrogen at the rate of 34.5 kg/ha as ammonium nitrate was applied at three weeks after crop emergence. Ten sorghum plants were randomly selected weekly from day of nitrogen fertilizer application until harvesting. Data on plant height, leaf damage, stem tunneling length, borer density and grain yield at harvest were recorded. Foliar damage ratings used for analysis were assessed at 8 weeks after emergence. Leaf damage based on a nine point visual rating scale (1, slightly visible damage; 9 severe foliar damage) was used using standardized chilo leaf damage scoring system (16) and (17). Plants were dissected and length of tunnel resulting from larval feeding recorded. Stem tunnel were expressed as the total length of stem tunneled as a % of plant height. Number of pupae, larvae and pupal cases from dissected plants were recorded. Data was subjected to GENSTAT version 14. Means were separated at α=0.05 by least squared differences (LSD) (18). Where percentages were used, the data was transformed using arc-sine transformation after adding 0.5 to each value. The data pertaining to the numbers of stem borers was transformed after adding 0.5 to each value by square-root transformation.

1.3 RESULTS

1.3.1. Effect of stem borer damage on different cropping system of sorghum

Cropping system	Stem tunnel Length (cm/plant)	Sorghum yield	Leaf severity score	Stover yield (kg)/plot	Larvae/plant
s/groundnut	50.4^{a}	5.18^{b}	2	18.67^{b}	1.469^{a}
s/cowpea	46.9^{a}	2.52^{a}	1.67	9.670^{a}	1.344^{a}
s/bambara	52.6^{a}	4.96^{b}	1.67	18.00^{b}	1.500^{a}
s/pigeon pea	48.8^{a}	4.33^{b}	1.67	14.17^{b}	1.431^{a}
s/sole (no sprays)	59.6^{a}	4.46^{b}	2	17.33^{b}	1.703^{a}
s/sole (sprayed)	44.3^{a}	5.65^{b}	1.67	23.67^{c}	1.153^{a}

Grand mean	**50.43**	**4.52**	**1.78**	**16.92**	**1.43**
Lsd	**17.94**	**1.721**	**1.135**	**4.403**	**0.6015**
Cv %	**24.1**	**15**	**35.1**	**10.3**	**28.6**
Se	**12.57**	**0.692**	**0.624**	**1.75**	**0.4215**
pValue	**0.537**	**0.030**	**0.942**	**<.001**	**0.801**

Table 1: Effect of stem borer damage on different cropping systems of sorghum

1.3.2 Effect of stem borer damage on sorghum stem on different cropping systems

No significant results on stem tunnel length at $p<0.05$ were noted among combinations. The sprayed control and the sorghum/cowpea combinations recorded shorter tunnel lengths than all other treatments. The unsprayed control recorded the longer tunnel length of 59 cm.

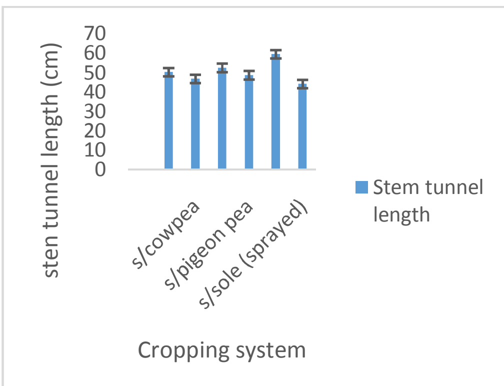

Fig 1: Effect of stem borer damage on sorghum stem on different cropping systems

1.3.4 Effect of stem borer damage on sorghum stover and grain yield among cropping systems

Significant lower mean stover and grain yield at ($p<0.05$) was observed (Fig 2 and 3) in plots where sorghum was combined with cowpea.

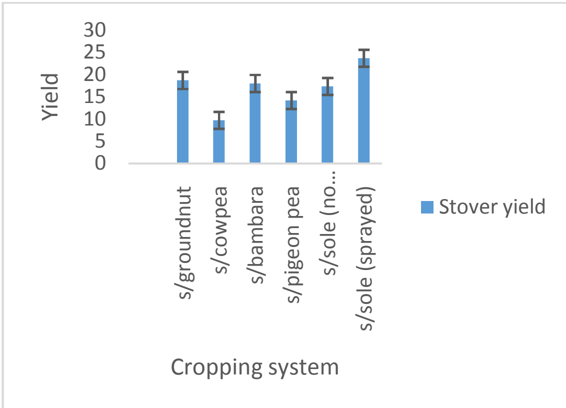

Fig 2: Effect of stem borer damage on sorghum stover yield among different cropping systems

Sorghum intercropped with groundnut, bambara and pigeon pea showed recorded almost the same yield of around 16.9 kg per plot. The sprayed sole sorghum control out yielded all other treatments on both stover and grain yield.

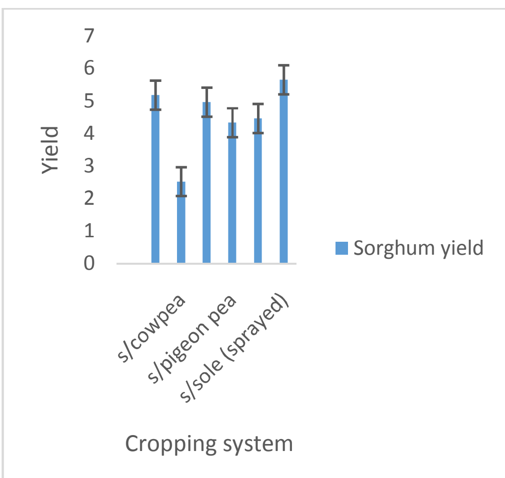

Fig 3: Effect of stem borer damage on sorghum grain yield among cropping systems

Significant lower mean yield of 2.5kg/plot (Fig 3) at $p<0.05$ were recorded in plots where sorghum was intercropped with cowpea. Other combinations recorded the same grain yield of around 4.82 kg per plot. No significant differences were recorded on the two sorghum sole plots.

1.3.4 Effect of sorghum legume intercropping on incidences of other pests among cropping systems

1.3.4.1 Effect of legume intercrops on pest incidences

There were significant aphid scores at $p<0.05$ that was recorded among treatments (Table 2). Higher aphid mean scores were recorded in plots where sorghum was intercropped with groundnut and in plots where there was a cowpea sole crop (Fig 4). Lower scores were recorded in the cowpea and bambara combinations. In these respective treatments, higher ladybird populations were also recorded among treatments.

Cropping system	Ant	Aphid	Ladybird	Grasshopper
s/groundnut	1.194 [b]	1.1454 [c]	0	0 [a]
s/cowpea	1.213 [b]	0.2357 [ab]	0.71	0.236 [ab]
s/bambara	0.408 [ab]	0.3333 [ab]	0	0 [a]
s/pigeon pea	0.236 [ab]	0.9024 [bc]	0.71	0 [a]
Sorghum sole (no sprays)	0.742 [ab]	0.7416 [abc]	0.24	0 [a]
Sorghum sole (sprayed)	0.408 [ab]	0.5690 [abc]	0.24	0 [a]
Groundnut sole	0.333 [ab]	0 [a]	0.41	O [a]
Cowpea (sole)	1.040 [b]	0 [a]	0.86	0.569 [b]
Bambara (sole)	0.236 [ab]	0 [a]	0	0.236 [ab]
Pigeon pea (sole)	0 a	0.2357 [ab]	0.47	0.236 [ab]
Grand mean	**0.581**	**0.413**	**0.36**	**0.128**
Lsd	**0.8653**	**0.6697**	**1.113**	**0.467**
Cv %	**86.8**	**94.5**	**178.9**	**213.4**
Se	**0.5044**	**0.3904**	**0.649**	**0.2723**
pValue	**0.070**	**0.018**	**0.675**	**0.231**

Table 2: Other pest incidences among cropping systems

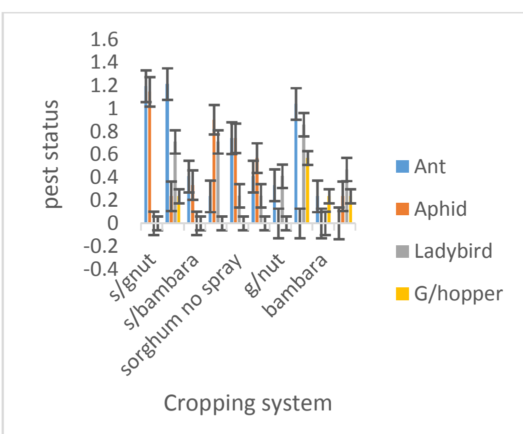

Fig 4: Effect of legume intercrops on pest incidences

1.3.4.2 Increamental benefit of intercropping among cropping systems.

An incremental benefit (Table 3) of between 9 -10 % was recorded in plots where sorghum was intercropped with groundnut and cowpea. A much higher incremental benefit was recorded in plots where sorghum was intercropped with pigeon pea. Over the seasons, no benefit was recorded in sorghum Bambara combinations.

Cropping System	Sorghum yield	Cowpea yield	g/nut yield	p/pea yield	Cow pea LER	G/Nut LER	P/Pea LER	Total
S/groundnut	0.83		0.87			1.0		1.0
S/cowpea	0.97	1.66			1.0			1.0
S/bambara	1.07							0
S/pigeon pea	1.25			0.65			1.0	1.0
Sole sorghum (no spray)	2.02							1.0
Sole sorghum (sprayed)	2.48							1
Groundnut			1.75			2.02		1
Cowpea		2.79			1.9			1.0
Bambara								0
Pigeon pea				1.33			1	1

Table 3: Increamental benefit of intercropping among cropping systems

1.4 DISCUSSION

The effect of sorghum legume and insecticide applications in reducing stem borer activity and and the resultant stem tunnelling in the level of crop damages by this stem borer was reflected in an appreciable non-significant relationships observed on stem tunneling (Table 1). This is in line with the findings of (19) who found out that green parts of legumes have dense covers of glandular hairs which are thought to exude a very acidic liquid. This, with a ph. of approximately 1.3 and a high content of malic acid produce a rancid smell and thus is thought to be a factor that repel stem borer or limit its ability to continue with stem tunnelling activities. Significant sorghum lower yield (p=0.030) was recorded on plots where sorghum was combined with cowpea. This was also corroborated by (20), (21) who concluded that cowpea outcompete sorghum for water, light and nutrients (at few weeks after thinning) may result in lower sorghum yields and higher cowpea yield. Higher stover yield were recorded on sorghum/groundnut and sorghum/bambara combinations. This results in sorghum accumulating a lot of biomass during the growing season. This is in line with the work by

(22), and (23) who found out that sorghum out compete groundnut and bambara in intercropping systems and the reverse for cowpea.

No statistical significant ($p < 0.05$) on pest incidences were recorded among treatments. This might be due to diversity in the crop field that might have a profound effect on colonisation by insects (24), (25). It is also in line with (26) and (27) who found intercropping, an important cultural practice in crop pest management, primarily involves increasing the plant diversity of a given agro-ecosystem to aid reducing insect pest populations, and consequently, their attack. Populations of aphid predators (Table 2) such as ladybird were recorded among treatmnts. This goes in line with the findings of Dobson and Russell (unknown sources) who carried out an analysis of natural enemy impact on chilo partellus populations in 2005. Studies in Kenya by (28) also indicated that Anthocorid bugs (mainly *Orius* spp.) and ants (*Pheidole* spp., *Myrmicaria* spp. and *Camponotus* spp.) play the most important natural regulatory role on chilo partellus. This was also further explained by (29) who found out that intercrops facilitated the natural proliferation of predators.

Pest reduction in intercropping systems could be due to the “natural enemy effect” (30). Some plant combinations, for instance, with non-hosts lower the spread of pests within crops (31), (17). Non-host plants in such mixtures may emit chemicals or odours that adversely affect the pests, thereby conferring some level of protection to the host plant (32), (33). This might be due to green parts of legume (22) (*25*). Studies indicate that crop diversification through intercropping, such as cereals with legumes, is effective in reducing insect pest damage (34), (35). Even plant diseases are believed to be less in intercropped agroecosystems due to increased crop diversity than those in sole crops (36), (37). Also, the intercropping of groundnut with pearl millet (*Pennisetum glaucum* L.) has particularly been found to increase the population of *Goniozus* sp., a parasitoid species that effectively manages leaf miner pest populations in ground nut (*Arachis hypogaea L.*) (38).

Results that were recorded on leaf severity, stem tunnelling and the number of larvae per plant were not significant among treatments. These are yield components and thus yield reduction due to stem borers occur as a result of leaf feeding, stem tunnelling, direct damage to cereal grain (39), (40). However, depending on the season and nutritional status of plant, crop yield reduction by stem borer feeding and tunnelling activities in Africa can fall between 10% - 100% (26), (27). The unsprayed control recorded the longest tunnel length of 59 cm while in intercrops it ranged from 30-50 cm. This is in line with (27) who found out that three to eight times more stems tunnelling and one to three times more cob damage were also recorded in monocropped maize with high stem borer larval densities (21% - 48%) and yield loss (1.8 - 3.0 times greater) than in the intercropped counterparts. In contrast however, (27), in West Africa, found a considerably reduced amount of noctuid eggs laid by *Sesamia calamistis* Hampson and *Busseola fusca* Fuller due to reduced host found by the ovipositing adult moths in maize intercropped with grain legumes or cassava than those in the monocrop.

1.5 CONCLUSION

Intercropping, particularly with ground nut, pigeon pea and cowpea seems to encourage less stem borer infestation and abundance in sorghum, whilst additionally support high stover and grain yield. As such, the cultural practice is greatly encouraged over mono-cropping for stem borer pest management in sorghum grown in the south eastern Lowveld. Being an uncomplicated method of control and not capital-intensive, the practice should be readily adopted especially by resource-poor-farmers.

1.7 RECOMMENDATION

Farmers in the south eastern Lowveld should intercrop using legumes in sorghum since intercrops have an incremental benefit. Legumes also provide nutrition to the soils as well as a source of relish. Legumes repel or attract other pests such as predators of aphid which is a pest of economic importance in drought stricken crops due to its sap sucking feeding habbit.

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