Yield Loss in Sorghum Caused by Sorghum Shoot fly and Maize Stalk Borer at Bako

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Abstract

A study was conducted for three years (1992-94) to determine the magnitude of grain yield losses caused by sorghum shoot fly (SSF), *Atherigona soccata*, and maize stalk borer (MSB), *Busseola fusca*, in sorghum at Bako. A range of planting time (April to June) were used to obtain different gradients of infestation. Each planting time was replicated four times in a randomized complete block design. Paired plant methods were used to estimate the loss. Variations in the level of SSF and MSB infestation were observed between the different planting times in all seasons. Infestation by SSF ranged from 1 to 36% and that by MSB from 5 to 64%, depending on the season, and time of planting, the highest being in sorghum planted in June in all seasons. Similarly, yield reduction by SSF varied from 1 to 33% while due to MSB from 2 to 27%, depending on the season, planting time and level of infestation. The yield reduction was proportional to the level of infestation and the association was highly significant ($r=0.9962$, $P< 0.001$) for SSF and ($r=0.815$, $P< 0.001$) for MSB.

Introduction

Sorghum shoot fly, *Atherigona soccata* Rondani (Diptera: Muscidae) and maize stalk borer, *Busseola fusca* (Fuller) (Lepidoptera: Noctuidae), are serious pests of sorghum in many countries (Schmutterer 1969, Granados *et al* 1972, Taneja *et al*. 1986). In Ethiopia sorghum shoot fly (SSF) is the major insect pest damaging the crop at seedling stage, and is particularly serious in late planted sorghum (Schmutterer 1971, Theodros 1983). On the other hand, maize stalk borer (MSB) attacks maize and sorghum from seedling to maturity stages (Schmutterer 1971, Assefa 1982).

Information on yield loss of different crops due to pests has been reported by various workers from time to time (Leclerg 1971, Teng 1987). The losses vary from crop to crop, insect to insect, location to location and season to season. According to Girma and Plothinkov (1986), infestation levels of about 9 to 15% by SSF on sorghum resulted in yield losses of 3-5% at Ambo. Assefa (1982) also reported yield reduction of 10-25% on maize due to maize stalk borer attack. At present, no information on the magnitude of yield losses due to SSF and MSB damage on sorghum is available for Bako condition. So far, efforts to control these pests depend on damage symptoms and general recommendations established by Assefa (1982) for MSB and by Theodros (1983) for SSF. Available information on quantitative crop loss assessment helps in research prioritization, and effective decision making in integrated pest management (IPM) strategies (Reddy & Sum 1993). Thus, this study was conducted to determine the magnitude of yield losses caused by SSF and MSB in sorghum planted at different time intervals at Bako, western Ethiopia.

Materials and Methods

The experiment was conducted for three years between 1992 and 1994 at Bako Research Center of the Institute of Agricultural Research. A range of planting dates were used in all seasons. For the 1992 crop season five planting dates including, April 23, May 7, May 21, June 4 and June 15 were used. For the 1993 and 1994 crop seasons, the planting dates were May 3, May 13, May 24, June 3 and June 13. The experiment was laid out in a randomized complete block design with four replications.

Plots of 6 m length and 5 m width at a spacing of 15 cm between plants and 75 cm between rows were used. The variety used was 'IS-9302'. Fertilizer was applied at the rate of 75/75 N/P_2O_5 as a split application at time of planting and at knee height. One month after emergence, all plots were thinned to the required number of plants per plot. SSF and MSB damage assessment and other related data were taken a month after emergence including number of seedlings per plot after thinning, and tillering , and damaged and undamaged seedlings (one month after emergence and after tillering). All seedlings that showed damage symptoms either by SSF or MSB attack were tagged separately. Similarly, 5-10 samples of the undamaged plants were also tagged in each plot. All tagged plants were observed throughout the growing season for any damage caused by other pests. Damaged plants by both SSF and MSB were excluded from the analysis. At harvest, the stalks were also closely observed for MSB damage. Actual grain yield of the plot, yields of damaged plants by SSF and MSB, respectively, and yield of undamaged plants per plot were collected. All parameters were subjected to statistical data analysis for determination of the magnitude of grain yield losses using paired plant methods (Judenko 1973). An attempt was also made to understand the yield-infestation relationship and loss-infestation relationship of both pests by testing the linear equation $Y=a+bX$ using grain yield or yield losses (Y) and percentage infestation (X) of the respective pest species in the regression analysis. Preceding the determination of economic losses, the net monetary losses due to varying levels of infestation of both pests for the different time of planting were computed for all seasons considering the 1995 market price of red sorghum around Bako at 66 birr per quintal.

Results

Sorghum shootfly

Infestation levels of 1 to 36% were observed from SSF on the different seasons and time of planting (Table 1). The highest infestation was recorded in late planted sorghum in all seasons. Similar trends have been observed by Theodros (1983) at Alemaya.

Significantly lower grain yields were obtained from late June planted sorghum in all seasons. In this study sorghum planted in late April to late May resulted in grain yields higher than 33 q ha^{-1} (Table 2).

The percentage grain yield losses were used to express the magnitude of direct loss on sorghum yield. It is the loss (L) in the presence of the pest and is expressed as a reduction in potential pest-free yield (W) as a percentage of it, i.e. $L = ((W - AY)/W) *100$, where AY is the actual yield realized (Judenko 1973, Walker 1987). The amount of losses were actually influenced by the time of planting and level of infestation. Late planting which had greater infestations of SSF also showed the highest percent yield losses (Table 3). Sorghum planted early to late May suffered significantly lower grain yield reduction due to SSF in all seasons although the amount varied from year to year.

Decision on pest control is based on the relationship between yield (Y) and infestation (I), *i.e.* $Y=f(I)$ (Walker 1987). In order to achieve this, a regression of infestation level of SSF (X) on grain yield (Y) was made using all the 3 years' data. The regression analysis indicated that the infestation levels of SSF were associated negatively with grain yield of sorghum and the association was highly significant (Table 4). Similarly, yield reduction was proportional to infestation levels by SSF and the association was also highly significant ($r= 0.99$, $P<0.001$). However, the association seemed to be influenced by the season, which affected the level of infestation and damage. The net monetary or grain loss was dependent on the level of infestation of SSF, time of planting and the season. Monetary losses were highest in June planted sorghum than late April to late May planted sorghum. Monetary loss due to SSF attack ranged from 20 to 942.48 birr ha^{-1}, and the highest monetary loss was noted during the 1993 crop season (Table 5).

Table 1. Percentage infestation levels of *Atherigona soccata* and *Busseola fusca* on sorghum planted at different dates (values are means of four replications)[@].

Planting date	*A. soccata*			*B. fusca*		
	1992	1993	1994	1992	1993	1994
April 23	1.8b	-	-	16.4bc	-	-
May 03/07	1.0b	3.7c	6.1b	11.8c	54.6a	7.0b
May 13/21	0.8b	7.9c	7.8b	23.5ab	59.5a	4.8
May 24	-	8.3c	6.3b	-	61.0a	19.3ab
June 3/4	2.4b	21.6b	16.9a	13.6bc	64.1a	24.6a
June 13/14/15	12.0a	35.7a	24.3a	27.5a	58.2a	29.3a
SE(±)	1.1	1.3	1.9	2.4	4.5	3.5
CV (%)	23.3	11.7	13.5	13.6	10.5	22.9

@Analysis was made on square-root and arsine transformed values for SSF and MSB, respectively. Means followed by the same letter within a column are not significantly different from each other (DMRT [p<0.001).

Table 2. Mean grain yield (q ha^{-1}) of sorghum planted at different dates at Bako (values are means of four replications)

Planting date	Actual yield			Expected yield in the absence of					
				A. soccata			*B. fusca*		
	1992	1993	1994	1992	1993^{ns}	1994	1992	1993	1994
April 23	33.1b	-	-	37.7b	-	-	36.6b	-	-
May 03/07	50.2a	33.0a	36.7ab	50.7a	34.1a	39.1a	52.6a	43.1ab	38.0a
May 13/21	30.2b	28.0ab	40.5a	30.6b	29.9a	43.9a	31.1b	34.0bc	41.3a
May 24	-	34.0a	36.5ab	-	36.9a	39.0a	-	46.7a	39.0a
June 3/4	36.1b	30.0a	31.1b	36.9b	37.1a	37.0a	37.8b	37.1abc	34.0a
June13/14/15	14.4c	23.6b	18.3c	16.3c	35.3a	24.0b	16.3c	28.5c	19.7b
SE(±)	2.9	1.8	1.5	3.0	2.1	1.5	2.9	2.4	1.8
CV(%)	17.7	12.3	9.0	17.7	12.3	8.3	16.7	12.6	10.5

Values followed by the same letter within a column are not significantly different from each other (DMRT [P<0.001]).

Maize stalk borer

Infestation levels ranging from 5 to 64% were observed by MSB during the three seasons and time of planting (Table 1). The highest infestation of MSB was recorded on late June followed by mid May planted sorghum in 1992 while early and mid June in 1994 crop season (Table 1). In 1993, infestation by MSB was above 50% throughout the season; however, there was no significant infestation variation between planting dates (Table 1). In general, late planted sorghum suffered from high levels of infestation by MSB. Similar trends have been observed by Assefa (1991) and SPL (1979) on maize stalk borer on maize and sorghum.

The amount of loss was actually influenced by the time of planting and level of infestation. Late planting which had greater infestations of MSB also showed the highest percent yield loss. In 1993 losses due to MSB were high throughout the season (Table 3). Significantly lower grain yield reduction due to MSB was recorded in mid May planted sorghum in all seasons. In the 1992 crop season mid May planted sorghum suffered from relatively higher infestation of MSB (Table 1), but the corresponding yield losses were very low (Table 3). During the 1993 and 1994 crop seasons significant differences in grain yield reduction were not detected between planting dates due to MSB damage and in some cases highest infestation levels showed lower grain yield reduction and lower infestation levels resulted in relatively higher grain yield reduction (Tables 1 and 3). These might be attributed to the time, age of the crop, the number and stages of MSB larvae when infestation started.

Studies made on maize in Kenya indicated that grain yield reduction is directly proportional to the larval densities and inversely proportional to crop growth stages. The inverse relationship is associated with the increase in the toughness of the plant with age (Reddy & Sum 1993, Sharma & Sharma 1994) which makes it difficult for the larvae to feed on. The regression analysis indicated that infestation levels of MSB are associated negatively with grain yield of sorghum and the association was highly significant (Table 4). This suggested that yield reduction is proportional to infestation level by MSB and the association was also highly significant ($r=0.8148$, $P<0.001$). However, like that of SSF, the association seemed to be influenced by the season. The net monetary or grain loss was also dependent on the level of infestation, time of planting and the season. Monetary losses from MSB were highest in late April to early May in 1992. In 1994 late May and early June plantings resulted in higher monetary losses. However, planting dates of 1993 invariably showed higher monetary losses (Table 5). Monetary losses due to MSB ranged from 54.8 to 942.5 birr ha^{-1}.

Table 3. Percentage loss caused *Atherigona soccata* and *Busseola fusca* on sorghum planted at dates (values are means of four replications)[¥].

Planting date	*A. soccata*			*B. fusca*		
	1992	1993	1994	1992	1993	1994
April 23	1.7b	-	-	9.6ab	-	-
May 03/07	1.0b	2.9c	6.1b	4.5ab	23.2a	3.5a
May 13/21	0.8b	6.5c	7.8b	2.9b	17.4a	2.0a
May 24	-	7.4c	6.3b	-	27.0a	6.4a
June 3/4	2.2b	19.2b	16.1a	4.3ab	18.7a	7.8a
June 13/14/15	11.6a	33.1a	23.8a	11.1a	16.8a	7.0
SE(±)	1.1	1.5	1.9	1.5	4.4	1.6
CV(%)	23.7	13.9	14.3	23.8	27.3	29.0

¥Analysis was made on square-root transformed values for both pests; means followed by the same letter within a column are not significantly different from each other (DMRT [P<0.001]).

Table 4. Regressions for yield-infestation relationships at Bako (n=20 for years and 60 for averages).

Year	r	r^2	Y=a+bX	t value	Probability
			Atherigona soccata		
1992	-0.687	0.472	Y=39.536-1.85X	4.015	<0.001
1993	-0.580	0.336	Y=33.609-0.25X	3.031	0.007
1994	-0.890	0.792	Y=44.015-0.925X	8.274	<0.001
Average	-0.537	0.288	Y=36.895-0.493X	4.8472	<0.001
			Busseola fusca		
1992	-0.570	0.325	Y=48.625-0.849X	2.942	0.009
1993	-0.265	0.070ns	Y=38.015-0.144X	1.164[ns]	0.026
1994	-0.635	0.403	Y=40.619-0.469X	3.492	0.003
Average	-0.359	0.129	Y=36.623-0.157X	2.928	0.005

ns: Nonsignificant (P=0.05).

Table 5. Monetary loss (Birr ha^{-1}) due to *Atherigona soccata* and *Busseola fusca* attack on sorghum planted at dates at Bako (values are means of four replications).

Planting date	*A. soccata*			*B. fusca*		
	1992	1993	1994	1992	1993	1994
April 23	42.24	-	-	231.00	-	-
May 03/07	35.54	91.74	164.34	163.02	688.38	93.72
May 13/21	19.80	154.44	231.66	54.78	432.30	59.40
May 24	-	255.42	173.58	-	900.24	174.24
June 3/4	54.12	590.70	413.82	111.54	591.36	217.80
June 13/14/15	137.28	942.48	406.56	137.28	496.98	120.62
Mean	57.80	406.96	277.99	139.52	621.85	133.16

Discussion

In all the seasons planting date was observed to be a significant source for the variation in infestation levels and actual yield obtained. In all cases late planting of sorghum (June for SSF and mid May to June for MSB) resulted in higher levels of infestation and grain yield reduction. Pest-loss relationships may vary with variety of crop, strain of pests and environment in which the pest develops (Leclerg 1972). The same author stated that the regression of pest damage on yield will have a direct application only under similar conditions in which the observations were made. The estimates in yield reduction obtained in this manner are more reliable than subjective estimates without the benefits of field experimentation (Leclerg 1972).

In this study, infestation by SSF and the corresponding yield losses within the recommended time of planting (April to late May) ranged from 1-8%, depending on the season. Infestation and loss by SSF increased with the delay in planting date May (Table 1 and 3). Studies made at Ambo indicated that infestation levels of about 9 to 15% by sorghum shoot fly on sorghum resulted in yield losses of 3 to 5%, respectively, (Girma & Plothinkov 1988). Theodros (1983) also reported higher levels of damage by SSF in late planted sorghum. From this one can possibly say that SSF might not be a main season pest that requires control measures provided that planting is done earlier than late May and provided that there is no outbreak of the pest in the area.

MSB was common from seedling to harvesting in all seasons, and infestation and loss varied from 5 to 60% and 2 to 27%, respectively, (Table 1 and 3) within the planting dates that farmers usually practise for sorghum. Assefa (1982) recommended early April sowing to reduce stalk borer damage on maize in the Awassa area. Similar studies made at Ambo suggested that early sowing of maize and sorghum is important to reduce MSB infestation (SPL 1979). According to this study, infestation levels of greater than 10% by MSB could justify application of control measures. However, the extent of damage and yield losses could possibly be affected by time, age of the crop, number and age of MSB larvae when infestation started. This may be the reason for the variation in the extent of yield losses by the different level of infestation throughout the experimental period. This suggests that sorghum yield loss and MSB infestation relationship should be studied in the future by considering all the above conditions to establish the economic injury level.

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