Management of Stalk Borers Using Sowing Date on Sorghum in Northeastern Ethiopia

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Abstract

A sowing date study for the management of maize stalk borers on sorghum was conducted at two locations, Sirinka and Girana, in northeastern Ethiopia during 2003. *Busseola fusca* was important at Sirinka and *Chilo partellus* at Girana. The experiment was laid out in split plot using randomized complete block design with three replications. The treatments included six sowing dates at seven-day intervals starting from 27 June. Higher number of larvae before and after harvest was recorded in untreated than treated plots. Similarly, significantly high proportion of infested plants (46–74%), number of chaffy heads (25–26), infested peduncles (84–87%) and infested internodes (40–52%) were recorded in the early three sowing dates at Sirinka. Moreover, infestation and damage levels were lower in the late than early sowings at Girana. These parameters in general did not significantly vary among sowing dates in chemical treated plots. There was no significant variation among sowing dates in grain yield at both locations. The lowest grain yield (34 q/ha) was obtained from sorghum sown on 11 July at Sirinka, while the highest yield loss of 13 q/ha (28%) occurred on sorghum sown on 4 July at Girana. In all sowing dates, grain yield losses due to stalk borer at Sirinka ranged 2–13 q/ha (5-28%) and at Girana 1–33q/ha (1–50%). The net benefit analysis showed that protection of sorghum by insecticide resulted in positive return. However, the amount of not return varied among different sowing dates in the range of 96–2057 Birr/ha at Sirinka and 1833.6–5359.6 Birr/ha at Girana.

Key words: Pest management, maize stalk borer, sorghum, sowing date, yield, Ethiopia

Introduction

Sorghum (*Sorghum bicolor L.*), a native African cereal that originated in Ethiopia at the border area with Sudan (Doggett 1988), is one of the important cereal crops in many parts of the world. The major sorghum producers in Africa are Nigeria, Sudan and Ethiopia (Van Rensburg et al. 1975). In Ethiopia, Sorghum is the second important cereal crop next to tef and it is grown in all administrative regions, mainly in lowlands. The grain of sorghum is used for food and beverage and the stalk for animal feed, fuel, construction, and for mulching.

In Ethiopia, many factors contribute to low yields in sorghum. These include: drought, low soil fertility, soil erosion, poor crop management practices, insect pests, diseases and weeds. Two lepidopterous stalk borers, namely, maize stalk borer (*Busseola fusca* (Fuller)) and spotted stalk borer (*Chilo partellus* (Swinhoe)), are economically important pests of sorghum and maize in Ethiopia and can cause up to 100% yield losses to these crops (Assefa et al. 1989). Assefa (1985) reported that *B. fusca* is the dominant stalk borer species at high altitudes (1160–2600 m) and in cooler areas; whereas, C. *partellus* is a predominant species at lower altitudes (<1700 m) and in warm areas of the country. In different districts of Wollo, northern Ethiopia, *C. partellus* and *B. fusca* were found to be the most common species at low (below 1500 m) and high (above 1600 m) altitudes, respectively (Asmare and Eshetu 2001).

In an effort to control stalk borers, different crop management practices are used. Some of these include time of planting, tillage, plant spacing, intercropping, field sanitation, use of resistant varieties, botanicals, and biological control methods. The advent of synthetic insecticides, which have quick effect and are easy to apply has made cultural control practices nearly obsolete (Harris 1963). Most of chemical pesticides have effect not only on pests but also on other organisms and the environment, and they could also be hazardous to human health. Moreover, pests may develop resistance to chemical pesticides. Due to the problems with pesticides, attention has been given to the environmentally friendly, economically sound, easy to use and socially acceptable cultural control practices. Therefore, the exploitation of different control strategies like sowing date that could be vital components of integrated management of maize stalk borers is imperative. The objective of the present study was, therefore, to investigate the relationship between dates of planting and stalk borer infestation and damage on sorghum.

Materials and Methods

The study was conducted at two locations, Sirinka and Girana, in northeastern Ethiopia during 2003 cropping season. Sirinka is located between 11^0 41' 13" and 11^0 45' 11" N latitude and 39^0 31' 15" and 39^0 43' 2"E longitude at an altitude of 1850 m. The annual rainfall of the area, based on a ten years average, is up to 980 mm. The area has bimodal rainfall, i.e, the main cropping season in June to August and the intermittent short rainfall known locally as *belg* in March and April. The common sowing dates of sorghum in the area extend from the end of June to mid July. *Busseola fusca* is common at Sirinka, while *Chilo partellus* is common at Girana.

Early maturing improved sorghum variety Teshale, released by Sirinka Agricultural Research Center in 2003, was used. The treatments consisted of six sowing dates at seven-day intervals starting from 27 June. For each sowing date, there were insecticide treated and untreated plots. The experiment was laid out in split plot using randomized complete block design with three replications. The sowing dates and insecticide treated plots were arranged as subplots and main plots, respectively.

For chemical treated plots, Endosulfan 5% dust at the rate of 8 kg/ha a.i. was applied at 30 and 45 DAE (days after emergence) and placed inside the central shoot of sorghum using hand pinch. A plot size of 4.5 m x 7 m and a spacing of 0.20 m between plants, 0.75 m between rows and 1 m between plots were used. Fertilizers were applied at the rate of 100 kg/ha DAP and 100 kg/ha UREA. Weeding and thinning were carried out as required.

Data on infested plants and plants with dead heart were recorded from the central rows. Counts on number of larvae were made from the border row on ten infested plants by removing or dissecting the rolled young sorghum shoot at 60 DAE. Percentages of infested plants or plants with dead heart were calculated as proportion of the total number of plants assessed in each plot. At harvest, number of chaffy heads, infested internodes, infested peduncles and peduncle breakage were counted from the three central rows. Similarly, number of larvae and pupae were recorded from ten infested plants from each plot by dissecting the stalks using a knife. Grain yield was recorded from the three central rows of each plot.

Analysis of variance (ANOVA) was made using MSTATC computer software. Mean separation was carried out using Duncan's Multiple Range Test (DMRT).

The percentage grain yield loss due to stalk borer was calculated using the formula:

$$\text{Yield loss (\%)} = \left[\frac{X - Y}{X}\right] x100$$

where, X = mean grain yield of treated plots and Y = mean grain yield of untreated plots.

Furthermore, the net return was computed by subtracting total protection costs (insecticide application cost and cost of insecticide for one hectare) from the gross return per hectare. The gross return per hectare was calculated by subtracting the yield obtained in untreated plots from the yield obtained in treated plots. The differences in yield were converted to monetary values by multiplying them by the sorghum price at the time of the study which was calculated as the average sorghum price of seven markets of two districts.

Results

Larvae density

Significant differences ($p < 0.5$) were observed among sowing dates with respect to number of larvae per plant in the untreated plots (Table 1). A large number of larvae per plant was recorded on sorghum planted on 11 July at Sirinka (Table 1) and on 27 June and 11 July at Girana ((Table 2). In the treated plots, large numbers of larvae were recorded in the three early sowings but at Girana more larvae (4–7) were found on the last two sowing dates. At harvest, relatively high number of larvae per plant was recorded in early sowings at Sirinka (Table 1) and late sowings at Girana (Table 2). Similarly, low number of larvae was observed on treated plots than on untreated plots at both locations.

Leaf infestation and plants with dead heart

There was a significant difference ($p < 0.05$) among sowing dates in percentage leaf infestation in untreated plots with high percentage infestation recorded on sorghum sown on 27 June, 4 July and 11 July at Sirinka. Similarly, high percentage infestation was recorded in early sown sorghum at Girana. However, in plots sown on 2 August, leaf infestation increased, which showed that there was an emergence of new generation. At Sirinka, significantly high percentage dead heart was recorded in the last two late sowings, but at Girana high percentage was recorded in the first three early sowings. The lower dead heart percentage was recorded at Girana than Sirinka. However, there was no significant difference between chemical treated and untreated plots in percentage of dead heart plants (tables 1 and 2).

Chaffy heads and peduncle breakage

Number of chaffy heads due to damage by stalk borer larvae were significantly ($p < 0.05$) higher in the three early sowing dates than the three late sown untreated plots at Sirinka (Table 3). Whereas, the highest chaffy heads were recorded in late sown sorghum at Girana (Table 4). Moreover, large number of peduncle breakage was recorded on sorghum sown on 4 July 11 July and 27 June, while less number of breakage was recorded in late sown sorghum at Sirinka (Table 3). At Girana, large number of peduncle breakage was recorded in the three early and the last sowing dates (Table 4). Thus, significantly more number of broken peduncles was recorded in the untreated than treated plots.

Infestation of peduncle and internodes

Significantly high percentage of infested peduncle was recorded in the three early sowing dates in both locations. Among the three early sowing dates, the highest percentage infested peduncles was recorded in the third sowing date. Peduncle infestation of 84-87% and 52-69% were recorded in the three early sowing dates at Sirinka and Girana, respectively.

In chemical treated plots, the highest percentage infested peduncles was recorded in early sowing dates, but the level declined in the later sowings. Significantly higher number of infested peduncle was recorded in

Table 1. The effects of sowing dates and Endosulfan treatments on stalk borer larvae and damage of sorghum at Sirinka, northeastern Ethiopia, 2003

Sowing date	No. of larvae/plant at 60 DAE*		No. of larvae/plant at harvest		Dead heart at 60 DAE (%)		Leaf infestation (%)		Infested internodes (%)	
	UT†	T†	UT	T†	UT	T†	UT	T†	UT	T
27 June	19.6b	1.4	2.2abc	0.9	3.5c	5.0	74.3a	3.0	51.8a	9.7ab
4 July	15.5b	2.7	2.6ab	0.9	8.9b	3.5	46.2b	1.9	40.4abc	7.2b
11 July	27.9a	2.0	2.8a	1.0	6.0c	1.9	53.0b	0.0	45.8ab	16.8ab
18 July	17.0b	0	2.2abc	0.9	13.0b	4.4	17.0c	1.0	36.7bc	15.7ab
25 July	11.6b	0	1.9bc	1.3	41.3a	8.3	9.8d	1.0	32.0c	12.0ab
2 August	14.8b	0	1.7c	0.6	50.5a	3.7	28.8c	1.8	28.7c	21.8a
CV (%)	1.66	1.18	1.78	1.26	6.17	3.36	2.05	1.19	2.77	1.96

*DAE = Days after emergence of sorghum plants

† No significant difference between treatments

UT, untreated; T, treated

Values in each column followed by the same letter(s) are not significantly different (P < 0.05)

Table 2. The effects of sowing dates and Endosulfan treatments on stalk borer larvae and damage of sorghum at Girana, northeastern Ethiopia, 2003

Sowing date	No. of larvae/plant at 60 DAE*		No. of larvae/plant at harvest		Dead heart at 60 DAE (%)		Leaf infestation (%)		Infested internodes (%)	
	UT †	T†	UT†	T†	UT†	T†	UT	T	UT	T
27 June	25	0	19	11	13	1	82.5a	41.0a	31	7
4 July	17	0	16	13	8	0	28.9b	9.5b	19	8
11 July	24	0	18	8	9	0	31.8b	9.2b	23	9
18 July	8	0	23	17	0	0	13.7b	4.4b	24	7
25 July	18	7	19	12	4	4	29.2b	13.0b	15	13
2 August	15	4	25	11	2	1	18.1b	7.9b	20	8
CV (%)	25.6		32.49		52.06		20.5		15.9	

* DAE, days after emergence of sorghum plants; †UT, untreated; T, treated

†No significant difference between treatments

Values in each column followed by the same letter(s) are not significantly different (P < 0.05)

Table 3. The effect sof sowing dates and Endosulfan treatments on sorghum damage due to stalk borer at Sirinka

Sowing dates	Infested peduncle (%)		No. of peduncle breakage		No. of chaffy heads	
	Untreated	Treated	Untreated	Treated†	Untreated	Treated†
27 June	84.0a	55.5a	6.3b	3.0	25.3a	4.3
4 July	85.3a	56.6a	13.0a	0.7	26.0a	3.7
11 July	86.7a	60.3a	8.0ab	2.7	24.7a	3.3
18 July	62.7b	45.7ab	2.7bc	0.3	10.0b	0.7
25 July	53.0b	33.0bc	0.3c	0	3.7b	0.7
2 August	55.0b	26.7c	0.7c	0	6.7b	0.0
CV (%)	4.11	2.90	1.20	0.85	1.95	1.38

† No significant difference between treatments

Values in each column followed by the same letter (s) are not significantly different ($p<0.05$)

Table 4. The effects of sowing dates and Endosulfan treatments on sorghum damage due to stalk borer at Girana

Sowing dates	Infested peduncle (%)		No. of peduncle breakage		No. chaffy heads	
	Untreated	Treated†	Untreated	Treated†	Untreated	Treated†
27 June	69a	42	7ab	3	7b	2
4 July	52ab	49	7ab	0	6b	2
11 July	68a	31	9a	0	7b	1
18 July	27c	25	3bc	0	8ab	1
25 July	31bc	25	1c	0	10ab	2
2 August	31ab	27	10a	0	11a	2
CV (%)	30.78			26.7		45.5

†= No significant difference between treatments

Values in the same column followed by the same letter are not significantly different (p,0.05)

the untreated plots as compared to treated plots (tables 3 and 4). There was a highly significant ($p < 0.05$) difference among sowing dates in percentage infested internodes (tables 3 & 4). Percentages of infested internodes were higher in early than late sowing dates of sorghum. The insecticide-treated plots had lower percentage infested internodes than untreated plots.

Grain yield and yield loss

There was no statistically significant difference among sowing dates in grain yield in both treated and untreated plots. The sowing dates 27 June, 4 July and 11 July fell within the period of most common sowing time of sorghum in the area, which ultimately depends upon the onset of rainfall, availability of labor, oxen and seeds. The

Table 5. Grain yield and yield advantage of sorghum sown at different dates and economic return of Endosulfan application at Sirinka, 2003

Sowing dates	Grain yield (q/ha)		Grain yield loss		Cost of insecticide application (birr/ha)	Net benefit or loss (Birr/ha)
	Untreated[†]	Treated[†]	%	q/ha		
27 June	43.5	48.1	10.0	4.6	282	509.2
4 July	38.1	40.3	5.0	2.2	282	96.4
11 July	34.7	48.3	28.0	13.6	282	2057.2
18 July	44.5	47.2	6.00	2.7	282	182.4
25 July	47.9	52.5	9.0	4.6	282	509.2
2 August	43.3	48.1	10.0	4.8	282	543.6
CV (%)	16.27	16.27				

[†] No significant difference between treatments

Values in each column followed by the same letter is not significantly different P<0.05

Cost of Endosulfan = 132 Birr/ha (16.50 Birr/kg)

Cost of sorghum = 172 Birr/ha

Cost of labor = 150 Birr/ha (10 individual/ha/3times/5 Birr/day)

Table 6. Grain yield and yield loss of sorghum sown at different dates and economic return of Endosulfan application at Girana

Sowing dates	Grain yield (qt/ha)		Grain yield loss		Cost of application	Net benefit or loss (Birr/ha)
	Untreated[†]	Treated[†]	%	q/ha		
27 June	5759.8	5872.1	1.9	1.1	282	-92.8
4 July	5271.8	8553.6	49.9	32.8	2822	5359.6
11 July	7414.6	7126.3	--	--	282	--
18 July	6752.9	7427.3	9.2	6.8	282	1283.2
25 July	5856.1	7368.2	20.5	15.1	282	2298.0
2 August	5368.3	6598.9	18.7	12.3	282	1833.6
CV (%)	21.7					

†= No significant difference between treatments

Values in each column followed by the same letter are not significantly different (P<0.05)

present study showed that application of Endosulfan in all sowing dates at 30–60 DAE of the crop reduced infestation and damage levels of stalk borers and increased the economic return that ranged from 96.4 to 2057.2 Birr/ha at Sirinka (Table 5) and 1283.2 to 5359.6 Birr/ha at Girana (Table 6). The highest monetary net return was obtained on plots sown on 11 July and at Sirinka and on 4 July at Girana. The results indicated that all the sowing dates except on 27 June and 11 July at Girana needed protection with insecticide as the insecticide application resulted in positive return.

Discussion

In the current study, the earliest planting date was on 27 June, and the first three sowing dates until 11 July were considered as early plantings according to the sowing date practice in the study area. Related studies in other parts of the country (Adane and Abraham 1998, Emana and Tsedeke 1999) included early plantings much earlier than the first sowing date of the current study. Therefore, early plantings in the present and other studies elsewhere in the country do not necessarily refer to the same sowing dates.

The current study revealed that high grain yield loss was obtained in sowing dates, which sustained 2–3 larvae per plant at harvest that caused 5–28% losses on grain yield at Sirinka. The result was in agreement with earlier reports that the presence of one or two larvae of *B. fusca* per plant reduced sorghum yield as much as 25–90% (Ferdu 1991). Relatively high yield loss was recorded in the early sowing dates, which had high percentage infestation (29–83%). In Ethiopia, different reports also indicated that late June and early July sown sorghum suffered from heavy attack of stalk borer (Emana and Tsedeke 1999). Moreover, grain yield loss of 67–100% was obtained in plots where 46–100% infestation was recorded in maize sown in June and July at Awassa (Assefa et al. 1989). The authors also stated that the first peak, which represents the first generation larvae, was recorded on the first sowing date (April 10) and infestation by the second generation larvae started on the sixth sowing date (May 30) reaching a peak in June plantings.

At Sirinka, because of large number of tillers development and adequate rainfall, relatively high yield was obtained in late sown sorghum in which high percentage dead heart was recorded. Leuschner (1987) reported that dead heart formation leads to tillering, and the earlier (35 and 45 DAE) tillers are formed the greater their chance to catch up with the main stem and produce high yield. The author also noted that late tillers usually give little yield unless there is an adequate amount of extended rainfall. Although large number of larvae in leaf whorl could cause dead heart, a single larva that fed in the leaf whorl can also result in dead heart. Although dead heart is one of the most important yield limiting factors, it did not affect yield in the present study. The reason was more tiller development due to extended adequate rainfall in the season, and the tillers provided the same yield as the main plant.

According to observations made in the present study, peduncle breakage after physiological maturity did not reduce yield provided that the peduncle remained attached to the stem. Similar observation was reported by Leuschner (1987). Otherwise, peduncle breakage caused yield loss as long as grain filling was not normal and heads dropped to the ground by wind after severe attack of peduncle by stalk borer larvae.

Among the three early sowing dates, the highest percentage infested peduncle was recorded in the third sowing date of both untreated and treated plots. Very high peduncle infestation was recorded in the three early (52–87%) and late (27–63%) sowings in both locations. Field observation during the current study indicated that early infestation of peduncle by stalk borer larvae resulted in poor exertion and the leaf whorl remained attached to the head. That could interfere with peduncle elongation and the head remained lodged in the whorl. Hence, incomplete grain filling and partial or complete chaffiness of the head was observed.

Similar result was reported by Leuschner (1987). Moreover, peduncle weakened by tunneling was not able to support the weight of the head and became susceptible to wind breakage. At Sirinka, the appearance of larvae late in the season might be the main reason for the presence of high peduncle infestation in both insecticide treated and untreated plots.

In the first three early sowings, more than 40% of the internodes were damaged, while less than 37% of the internode were damaged in the three late sowings. The high level of internodes infestation might be due to the occurrence of infestation at later stages. In the early sowing dates, the chemical treatment successfully controlled larvae starting to feed in the leaf whorl. However, the later planting on 2 August with chemical treatment sustained high internodes attack by stalk borer larvae. This could be due to the coincidence of a new generation of larvae with the advanced stage of the crop.

Obviously, internodes attacked severely by stalk borer larvae hampered translocation of water, nutrients and photosynthetic materials to heads during grain filling. Yield losses varied with time of infestation; percentage of internodes bored in the lower half of the stalk had negative correlation with grain yield. Less percentage of infested internodes was recorded at Girana than Sirinka in both treated and untreated plots.

Many authors in Ethiopia stated that yield of late sown (June and July) maize or sorghum was significantly lower than that of early sown (April and May) sorghum or maize (Assefa et al. 1989, Assefa 1985, Adane and Abraham 1998, Emana and Tsedeke 1999). At Awassa, the first generation larvae starts in March and April and the second generation larvae in July and August. The damage observed in the current study was most probably from the second generation. That might be the reason for higher level of infestation in all sowing dates and the resultant yield loss as compared to the protected plots.

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