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# Diagnostic Study of Planting Time on Sorghum Stalk Borer Infestation and Damage in West Hararghe, Oromia Region, Ethiopia

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**Abstract:** Sorghum is the first most important cereal crop in West Hararghe. However, national figure of grain production still remains below than the world's average grain production per unit area due to different biotic and a biotic factor. Among the biotic factors, stalk borer was considered to be the most important insect pests of sorghum and maize in all areas of the country. As a management option different scholars were recommended sowing date. But there was conflicting report on the relationship between sowing time and borer infestation and damage. It was very crucial to identify the better days of sowing in the zone to reduce pest infestation and increase yield of the crop. Thus, this experiment was designed to evaluate the effect of sowing date on infestation of sorghum stalk borer. Chiro varieties was used for experimentation and sown at seven days interval for six weeks starting from 1st onset of rainfall. The treatments were arranged by RCBD design with three replications. Each treatment had a control plot that treated with insecticide chemicals such as carbaryle powders and Alpha cypermethrine. Based on combined analysis results, mean percent infestation was not shown significant variation ($P<0.05$) over location but highly significant at ($P< 0.001$) over years. The percent stalk borer incidence on untreated treatment was shown highly significant at ($P< 0.001$) on both over years and over location. Length of the feeding tunnel and exit holes in sorghum stem and leaves were significantly higher in earlier planted crop than delayed sorghum. As a general, chemicals treatment with early planting double the grain yield at Hirna sub site but, based on pest infestation status late planting was recommended at both location (Mechara and Hirna) to reduce pest infestation and damage.

**Keywords:** Sorghum (*Sorghum bicolor* L), Chiro, Sowing Date, *B. Fusca* and *C. Partellus*

## 1. Introduction

Sorghum is the fourth primary staple food crop in Ethiopia after teff, maize, and wheat, both in area coverage, and production [6]. In the country cereals comprise 78.23% (8.8 million ha) of the field crops of which sorghum accounts for 14.41%. In Ethiopia sorghum is grown in almost all regions occupying an estimated total land area of 1.6 million ha [6]. The productivity of sorghum in Ethiopia is low when compared to other African countries [9]. The national average sorghum productivity in Ethiopia is 2.0 tons/ha, which is far below the global average of 3.2 tons/ha [8]. Because, there are numbers of factor that hinder for sorghum production in Ethiopia. Along with the major constraints include drought, striga, insect pests (Stalk borer, midge and shoot fly), disease (grain mold, anthracnose and smut) and others.Among insect pests, stalk borers are considered to be the most important insect pests of sorghum and maize in all areas of the country [2]. Economically important species include the maize stalk borer (*Bussoel afusca*), the spotted stalk borer (*Chilo partellus*), and the pink stalk borer (*Sesamia calamistis*) [18]. *Bussoela* is important at higher altitudes (1700 meter above sea level and higher) whereas *Chilo* and *Sesamia* are important in the mid-altitudes (below

1700 m) [17].Contrary to these reports, *B. fusca* does occur in the lower altitudes in East Africa and it feeds on only a few host plant species [1]. Yield loss due to stem borers in Africa vary from 0-100% among ecological zones, regions and seasons. In Sub Saharan Africa, they can cause 20-40% losses during cultivation and 30-90% losses postharvest and during storage [15].

In Ethiopia, both B. *fusca* and *C. partellus* are considered to be the most damaging insect pests, with reported yield losses of 0 to 100, 39 to 100, 10 to 19 and 2 to 27% from South, North, East and Western Ethiopia, respectively "[13-14]". The average yield loss of maize caused by cereal stem borers in Ethiopia can be estimated between 20 - 50% [3]. The severity and nature of stem borer damage depends upon the borer species, the plant growth stage, the number of larvae feeding on the plant and the plant's reaction to the borer feeding. Feeding by borer larvae on sorghum and maize plants usually results in crop losses as a consequence of death of the growing point (dead heart), early leaf senescence, reduced translocation, lodging and direct damage to the ears [15].

Management practices for control of stem borers were manipulation of sowing dates, inter-cropping, natural enemies of stem borers, chemical control, botanical, host-plant resistance and genetically modified maize among the major stated [20]. In Ethiopia, a number of experiments on sowing date effects on stem borer damage were conducted. However, the results obtained were variable. In the past, early planting in Ethiopia averted stem borer damage. But, delays in planting decrease borer population damage in Addis Zemen areas of Amhara region [14]. This indicated that in northern Ethiopia where there was one effective rainy season and long dry season, the borer incidence behaved differently from regions receiving bimodal rain fall in the country such as Hawasa, Ziway, Adama, and Sirinka. Such a situation could also arise from current climate change. Therefore, early planting or late planting can be recommended in different areas. Even the term early is relatives as it is linked to the onset of rainfall. For example, early sowing for Hawasa and Arsi Nagele is in mid to the end of April, while sowing for Ziway, Melkassa and Meiso is in mid to end of June. But, in case of West Hararghe especially Mechara and Hirna early sowing is based on the onset of rainfall during sorghum planting in the area. Identification of proper time of sowing has long been recommended for various pest and disease problems. However, conflicting report on the relationship between sowing time and borer infestation and damage have made.

In general, most experiments recommended early planting while a few of them recommended late planting which suggests the need for optimizing sowing dates based on location [14].Even though sorghum was susceptible for stem borer insect pest in the area, there was no recommended sowing date that had been done so far. In spite that, it is very crucial to identify the better days of sowing in the study area to reduce pest infestation and increase yield of the crop. Therefore, this study was designed to evaluate the effect of sowing date on infestation of sorghum stalk borer.

# 2. Materials and Methods

A field experiment was conducted to study the appropriate time of sowing that reduce the infestation of sorghum stem borer on Chiro variety at Haramaya University research field, Hirna sub site and Mechara Agricultural Research main station. Chiro Sorghum variety was sown at seven days interval for six times starting from the onset of rainfall within the range of Sorghum sowing in the area. This might had been done starting from $1^{st}$ weeks of April in the first year and $1^{st}$ week of May in the second year because of rainfall problem. The treatments were sown in an area of 3.75 m x 4.5m =16.88$m^2$ by 75cm*25cm b/n row and b/n plant respectively. Each treatment has a control plot and replicated three times. In protected condition carbaryle powders was applied at the time of sowing and whorl application of carbaryle powders were done at 12 days after sowing to mange soil inhabitant insect pest. One spray with Alpha cypermethrin was also done on $35^{th}$ day after sowing, in order to protect the crop from stem borer and shoot fly. In unprotected condition, plots were kept free of management practices for stem borer and all other pests maintained below Economic Threshold Level (ETL). Observations were taken at regular intervals starting from fifteenth day of emergence of the crop for various pests. For stem borer incidence the observations on leaf scraping and pinhole damage was made at 35 DAE of the crop. The observations were made by counting the number of plants showing the symptoms and dividing to the total number of plants emerged per plot, then it was converted into percent leaf damage.

### *2.1. Data Collected*

Percent infestation, percent incidence, stem tunnel length (cm) and adjusted grain yield (Qt/ha).

### *2.2. Methods of Assessment*

$$\%\text{ age infestation} = \frac{\text{No.of larvae per plant}}{\text{Total no.of larvae per each sampled plot}} * 100$$

$$\%\text{ Incidence} = \frac{\text{No.of infected plant per plot}}{\text{Total no.of plant sampled per plot}} * 100$$

$$\%\text{ tunneling} = \frac{\text{Stem tunneled (cm)}}{\text{Total length of the plant sampled}} * 100$$

$$\text{Yield Difference (Qt/ha)} = \text{TMY-UMY}$$

Where, T= treated, U= untreated, M= Mean, Y= Yield

For exit hole and tunnel length measurement, five plants from each treatment were collected. Plant damage percentage was assessed during the vegetative stage just before butting stage visually by counting healthy and damaged plants of tested variety. However, the exit holes made by stem borer from the five sampled plants were counted visually after removing the intact leaves on stem, and then proceed for tunnel length measurement. The mean length of tunneling was taken from five randomly selected plants at harvest.

Thereafter, the sampled plants were dissected longitudinally, and then measure the groove made by stem borer by using simple measuring scale in centimeter.

### 2.3. Data Analysis

All data were transformed before analysis, using the square-root transformation formula $\sqrt{(x+0.5)}$. Genstat Statistical package 15th edition was used for the data analysis. LSD at 5% was used to separate the means where differences were significant.

## 3. Results

Over year mean percentage of stem borer infestation and Tunneling were not shows significant difference at ($P< 0.05$) on both parameters while percent incidence was shows significant difference on untreated plot but not treated at Mechara (Table 1). At Hirna, all parameters under consideration % (Infestation, Incidence and Tunneling) on both treated and untreated treatment were not significant at ($P< 0.05$) as shown at (Table 2). Even if it was not significant in all parameters in all location, the mean percentage of the first three (1-4) weeks sown sorghum crop were recorded higher than the last two (5 and 6) weeks cropped sorghum. As shown on (Figure 1A) below the number of larvae exist in the stalk to form exit hole were highly observed at Hirna than Mechara , while the length of stem tunneled by borer as (Figure 1B) and damaged leave sheath by larvae as (Figure 1C) wasn't showed difference at both location.

***Table 1.*** *Over year mean percentage of (Infestation, Incidence and tunneling) by stem borers at Mechara*

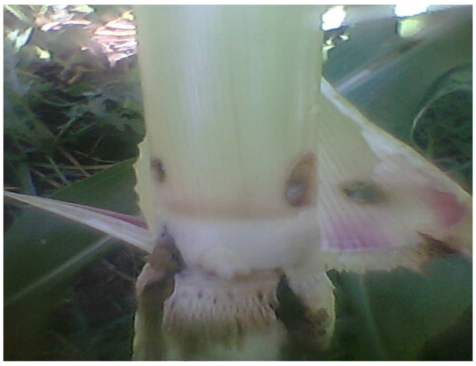
| Sowing date | % Infestation | | % Incidence | | % Tunneling | |
|---|---|---|---|---|---|---|
| | Treated | Untreated | Treated | Untreated | Treated | Untreated |
| 1 week | 8.2 | 19.70 | 2.22 | 6.95a* | 24.62 | 33.68 |
| 2 week | 6.4 | 23.10 | 0.77 | 6.93a* | 18.67 | 26.07 |
| 3 week | 11.1 | 21.83 | 1.99 | 5.11ab | 11.73 | 25.50 |
| 4 week | 7.9 | 20.15 | 2.64 | 3.37ab | 12.15 | 22.32 |
| 5 week | 13.0 | 0.67 | 1.88 | 1.62b | 12.97 | 23.73 |
| 6 week | 0.0 | 0.33 | 0.81 | 0.95b | 11.92 | 14.60 |
| Mean | 7.8 | 14.3 | 1.72 | 4.16 | 15.3 | 24.3 |
| LSD (5%) | Ns | Ns | Ns | 4.07* | Ns | Ns |
| S.E. | 5.88 | 18.71 | 2.25 | 3.44 | 13.84 | 3.95 |

Note: 1 week (Mechara 4/10/2014 ,10/5/2015) , 2 week(Mechara 4/17/2014 , 17/5/2015),3 week (Mechara 4/24/2014, 24/5/2015), 4 week (Mechara 5/1/2014,31/5/2015), 5 week (Mechara 5/8/2014,6/6/2015) 6 week (Mechara5/15/2014, 13/6/2015), ***-very highly significant,** - highly significant, *-significant, Ns –not significant, LSD- Least significant Difference

***Table 2.*** *Over year mean percentage of (Infestation, Incidence and tunneling) by stem borers at Hirna.*

| Sowing date | % infestation | | %incidence | | % Tunneling | |
|---|---|---|---|---|---|---|
| | Treated | Untreated | Treated | Untreated | Treated | Untreated |
| 1 week | 3.95 | 14.13 | 6.58 | 10.60 | 44.33 | 40.33 |
| 2 week | 9.50 | 18.31 | 7.87 | 10.15 | 25.33 | 41.50 |
| 3 week | 6.12 | 14.68 | 3.35 | 6.63 | 26.17 | 39.33 |
| 4 week | 11.33 | 13.97 | 3.10 | 10.03 | 32.50 | 40.33 |
| 5 week | 9.18 | 11.62 | 6.28 | 3.55 | 34.33 | 41.33 |
| 6 week | 10.55 | 13.67 | 6.95 | 5.92 | 25.00 | 37.17 |
| Mean | 8.4 | 14.4 | 5.7 | 7.81 | 31.3 | 40.0 |
| LSD (5%) | Ns | Ns | Ns | Ns | Ns | Ns |
| S.E. | 11.29 | 13.78 | 2.00 | 5.44 | 35.09 | 2.46 |

Note: 1 week (Hirna4/16/2014, 11/5/15), 2 week(Hirna4/23/2014, 18/5/2015), 3 week(Hirna4/30/2014, 25/5/2015) , 4 week (Hirna5/7/2014,1/6/2015) ,5 week (Hirna5/14/2014, 8/6/2015), 6 week (Hirna5/21/2014, 15/6/2015), ***-very highly significant,** - highly significant, *-significant, Ns –not significant, LSD- Least significant Difference , S.E. – Standard Errors



(A)

(B)

(C)

***Figures 1.*** *Larvae in the stalk to form exit hole (A) , length of stem tunneled by borer (B) and Damaged leave sheath by larvae (C).*

Based on combined analysis, mean percent infestation was not shown significant variation (P<0.05) over location but highly significant at (P< 0.001) over years. The percent stalk borer incidence on untreated treatment was shown highly significant at (P< 0.001) on both over years and over location. These variations also were shown significant at (P< 0.05) on percent stem tunnel length on untreated experimental plot over location while not significant on treated experimental plot (Table 3). The highest score of combined mean of untreated treatment were observed on the sorghum plants sown at the first fourth (1-4) weeks after the onset of rainfall. While the minimum score were observed on the last two weeks (5 and 6) of sowing date (Table 3).

Statistically grain yield was highly significant at (p<0.001) on untreated treatment while significant at (p< 0.05) on the treated treatment at Hirna experimental site. While not shows significant variation on both treated and untreated treatment at Mechara. Even though there were not significant variation between the treatments but there was variation between treatments mean. The highest positive yield difference of (10.66) was recorded on the 4 weeks sown sorghum crop at Hirna experimental site. While the negative yield difference of (-4.57) were recorded on the 6 week cropped sorghum at Mechara (Table 4).

***Table 3.*** *Combined analysis of percent (infestation, incidence, tunneling and grain yield) Qt/ha over years and over location.*

| Sowing date | | % Infestation | | % Incidence | | % Tunneling | | Grain Yield Qt/ha | |
|---|---|---|---|---|---|---|---|---|---|
| | | Treated | Untreated | Treated | Untreated | Treated | Untreated | Treated | Untreated |
| 1 week | | 6.1 | 16.9 | 4.4 | 8.8a | 6.2 | 20.0ab | 22.3a | 16.9a |
| 2 week | | 7.9 | 20.7 | 4.3 | 8.5a | 3.5 | 22.7a | 16.4abc | 17.4a |
| 3 week | | 8.6 | 18.3 | 2.6 | 5.8ab | 3.3 | 19.5ab | 17.4ab | 13.1ab |
| 4 week | | 9.6 | 17.0 | 2.8 | 6.7ab | 6.5 | 15.0ab | 19.0ab | 11.7ab |
| 5 week | | 11.1 | 6.1 | 4.1 | 2.6b | 4.8 | 12.8ab | 9.1bc | 6.9b |
| 6 week | | 5.3 | 7.0 | 3.9 | 3.4b | 5.0 | 9.1b | 7.4c | 8.2b |
| Mean | | 8.1 | 12.4 | 3.7 | 5.98 | 4.9 | | 15.2 | 12.4* |
| | Trt | Ns | Ns | Ns | 3.9** | Ns | 10.0* | 9.1* | 7.4 |
| LSD (5%) | Location | Ns | 7.8* | 2.4** | 2.3** | Ns | 5.7* | Ns | Ns |
| | Year | 5.5** | 6.4** | Ns | 2.4* | Ns | Ns | 4.7*** | 3.9*** |
| CV% | | 29.3 | 24.9 | 25.5 | 21.1 | 18.2 | 26.2 | 9.9 | 8.2 |

Note: 1 week (Hirna4/16/2014, 11/5/15, Mechara 4/10/2014, 10/5/2015), 2 week (Hirna4/23/2014, 18/5/2015,Mechara 4/17/2014 , 17/5/2015) 3 week(Hirna4/30/2014, 25/5/2015, Mechara 4/24/2014, 24/5/2015),4 week (Hirna5/7/2014,1/6/2015, Mechara 5/1/2014,31/5/2015) 5 week (Hirna5/14/2014, 8/6/2015, Mechara 5/8/2014,6/6/2015) 6 week(Hirna5/21/2014, 8/6/2015, Mechara5/15/2014, 6/13/2015), ***-very highly significant,** - highly significant, *-significant, Ns –not significant, LSD- Least significant Difference , CV- Coefficient of variation, Trt- Treatment, Qt/ha-quintals per hectare

***Table 4.*** *Over year mean grain yield difference from cypermethrine treated and untreated treatment at both Hirna and Mechara.*

| Sowing date | Grain Yield (Qt/ha) | | | | | |
|---|---|---|---|---|---|---|
| | Place Mechara | | | Place Hirna | | |
| | Treated | Untreated | Difference | Treated | Untreated | Difference |
| 1 week | 17.75 | 16.03 | 1.72 | 26.74a* | 17.91a** | 8.83 |
| 2 week | 18.36 | 18.28 | 0.08 | 14.35ab | 16.56a** | -2.21 |
| 3 week | 19.37 | 13.23 | 6.14 | 15.44ab | 12.96ab | 2.48 |
| 4 week | 17.09 | 17.06 | 0.03 | 20.93ab | 10.27abc | 10.66 |
| 5 week | 8.78 | 7.72 | 1.06 | 9.40b | 6.86bc | 2.54 |
| 6 week | 7.26 | 11.83 | -4.57 | 7.48b | 4.50c | 2.98 |
| Mean | 14.8 | 14.0 | 0.74 | 15.7 | 11.5 | 4.21 |
| LSD (5%) | Ns | Ns | | 12.92* | 7.22** | |
| CV% | 9.7 | 9 | | 8.7 | 8.7 | |

Note: 1 week (Hirna4/16/2014, 11/5/15, Mechara 4/10/2014 ,10/5/2015), 2 week (Hirna4/23/2014, 18/5/2015,Mechara 4/17/2014 , 17/5/2015) 3 week (Hirna4/30/2014, 25/5/2015, Mechara 4/24/2014, 24/5/2015), 4 week (Hirna5/7/2014,1/6/2015, Mechara 5/1/2014,31/5/2015) 5 week (Hirna5/14/2014, 8/6/2015, Mechara 5/8/2014,6/6/2015) 6 week(Hirna5/21/2014, 8/6/2015, Mechara5/15/2014, 6/13/2015), ***-very highly significant,** - highly significant, * significant, Ns –not significant, LSD- Least significant Difference , CV- Coefficient of variation, Qt/ha-quintals per hectare

## 4. Discussion

Combined mean percent (infestation, incidence and stem tunnel) on treated and untreated plots screened for stem borers damage is shown in (Table 3). The result shows that the highest mean percent (infestation, incidence and stem tunnel) were scouted on the sorghum planted at the first fourth (1-4) weeks on the onset of rainfall. In this case sorghum crop sown some weeks later after the first and second rain was less infected than immediately sown sorghum crop in both location and years. Iowa State University were also reported that later sowing of maize is less affected by stem borer larvae than earlier sowing as it disrupts their seasonal cycle [10]. It is thought that at the start of the rainy season, borer populations arising from diapausing-generation larvae will still be building up and cause heavy damage to the crop. In addition to that delays in planting were decreased borer population damage at Addis zemen area [14]. The highest numbers of larvae (Figure 1c), exit hole and stem tunnel length by stalk borer (Figure 1A & B) were recorded on earlier than late planted sorghum (Figure 1). During late planting there were enough alternate preferable grassy weeds and other cereal crop than earlier planted sorghum that made adult insects to distribute theirs over and reduce population density of ovipositor adults and minimize the damage of the main crops. In fact the African maize stalk borer is primarily a pest of maize and sorghum; other hosts include pearl millet, finger millet, sugarcane and many wild grasses are also hosts, including Johnson grass (*Sorghum halepense*), elephant grass, wild Sudan grass and Guinea grass comparably preferred for ovipositor [7]. Because of this stalk borer infestation were reduced by halve in such area. In addition to that as adult population in the field fluctuates in response to ambient condition; the degree of damage by larvae may also be fluctuated [4].

Symptoms of stem borer damage were first observed on the leaves and stalk in all treatments, and the differences between their combine means were significant on both over years and location. Damage is caused by the larvae which at first feed on the young leaves but soon tunnel into the stems and produce about 22.7% tunnel length. This result was accordance with, [12] stem borers initial damage is caused by feeding on the leaf tissues, followed by tunneling and feeding within the stem. In addition to this, [19] observed that stem borers damage greatly reduced maize yield with tunnel lengths greater than 20 cm causing a 40% potential yield loss. During the early stages of crop growth, larvae may kill the growing points, resulting in the production of ‘dead hearts’ with a consequent loss of crop stand. At later stages of growth, extensive tunneling inside the stems weakens the plant but the crop can tolerate than the earlier growth stage. Similarly, a survey conducted by Walker in East-Africa indicated that infestation at an early stage of plant growth will reduce the yield up to 36 kg grain per ha for every 1% plant infestation in high potential plantings [21]. An infestation at a later stage is less injurious. A 33% yield loss was found in plants with more than one stem borers exit hole [19]. In this experiment the highest positive yield difference of (10.27) was observed on the fourth week planted sorghum crop at Hirna. While the large negative yield difference of (-4.57) scored on the sixth weeks planted sorghum crop at Mechara. Weeks with (+ve) yield difference record means insecticide is important for the area for sorghum production whereas (-ve) yield difference record shows no need of wasting the chemical for control.

## 5. Conclusion

The combined analyzed results of these studies confirm that the percent infestation was not shown significant variation ($P<0.05$) over location but highly significant at ($P< 0.001$) over years. Grain yield was highly significant at ($p<0.001$) on untreated treatment at Hirna while not significant at Mechara. It confirmed that manipulation of sowing date was also more effective in the reduction of stalk borer infestation and damages from one location to another. As a result, the sorghum crop which had been sown at 5 week (Hirna5/14/2014, 8/6/2015, Mechara 5/8/2014,6/6/2015), and 6 week (Hirna5/21/2014, 8/6/2015, Mechara5/15/2014, 6/13/2015) were less infected than earlier planted at (1 week (Hirna4/16/2014, 11/5/15, Mechara 4/10/2014,10/5/2015), 2 week (Hirna4/23/2014, 18/5/2015,Mechara 4/17/2014 , 17/5/2015) and 3 week (Hirna4/30/2014, 25/5/2015, Mechara 4/24/2014, 24/5/2015)) planting date. The highest numbers of larvae and exit hole were recorded on earlier than late planted sorghum. This study, therefore, showed that the leave and stems of sorghum planted at the 1- 4 weeks more damaged than the 5 – 6 weeks cropped. Yield was also influenced by plant stand, bird pest and rainfall distribution in the study area.

As recommendation, late planting was recommended for both location (Mechara and Hirna) to reduce pest infestations and damage if there is enough rainfall. Based on the yield difference for Hirna area 1 and 4 weeks sowing with cypermethrin treatment doubled the yield of sorghum grain. While for Mechara area 2, 4 and 6 weeks sowing without chemical treatment were recommended starting from the onset of rainfall.

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