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Effects of Foliar Applied Carbofuran on Damage and Yield of Some Sorghum Varieties/Cultivars Caused by Stem Borer, Busseola Fusca Fuller (Lepidoptera:Noctuidae) in Biu, Borno State, Nigeria

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ABSTRACT

The effect of carbofuran (3G) on yield loss assessment on some varieties/cultivars of sorghum (Sorghum bicolor) L. Moench, due to damage caused by stem borer (Busseola fusca) was conducted in Biu, Borno state under natural field infestation in 2008 and 2009 cropping seasons. The field experiment (split-plot design (SPD), consisted of ten sorghum cultivars sourced locally in Biu, and five sorghum varieties obtained from Institute for Agricultural Research (IAR), Zaria. Varieties/cultivars were the sub-plots while the untreated and insecticide treated plots were the main-plots replicated three times on $6m^2$ plots. Weight of grain recorded and yield reduction percentages was calculated using direct method (actual crop losses measured in the field) of estimating crop loss from insect pests. The result obtained in 2008 and 2009 showed that, grain yield ranged on untreated plots from 499 to 1519.17kg/ha, while on the fully treated plots yield ranged between 848.61 to $2497.50kgha^{-1}$. The percentage (%) avoidable loss of the varieties/cultivars ranged from 1–74% in 2008. However, 'Yungum' ranked 1st in losses, followed by 'Piltum vwa' (2nd) and least affected was Samsorg14 (15th), followed by NR-7114 (14th), while in 2009, yield reduction ranged between 2 and 92%, where 'kwakwai' ranked 1st, followed by 'Tiksha mopu' (2nd) and 'Perpelli' (15th) suffered least yield reduction, followed by Samsorg17 (14th). This result has clearly shown that carbofuran remains an effective and easy to apply insecticide on stem borer especially in case of epidemics. Unless farmers adopt various control measures, B. fusca is a serious threat and integrating insecticide, resistant cultivars/varieties and cultural practices such as partial burning of sorghum stalks, post harvest sorghum threshing before storage were suggested.

Keywords: *Carbofuran, Cultivars, Sorghum, Stem borer, Varieties, Yield loss.*

1. INTRODUCTION

Sorghum, Sorghum bicolor (L.) Moench, is the most widely cultivated cereal crop and the most important food crop in the savanna areas of West Africa. Its importance can be illustrated with the situation in Nigeria, the major producer, where it accounts for about 50% of the total cereal production and occupies about 46% of the total land area devoted to cereal production (other cereals are rice, maize, millet and wheat). It is the major food and cash crop of the people of West Africa with predominantly mixed crop-livestock farming system more specifically in the Northern part of Nigeria. Sorghum is mainly a rainy season crop (July to October), late rainy season (August to December) and post rainy season (dry season sorghum) known as "Firgi" or "Masakwa" (Marulasiddesha et al., [16]). Sorghum is grown on over 45 million hectares of land World wide as a rain-fed crop mostly by the subsistence farmers in the semi-arid tropics (SAT) of Africa, Asia and Latin America [19, 25].

The World annual production of sorghum was 69 million and the total area sown and the production of sorghum in the world in 1999 were 4.4 million hectares and 58 million tons respectively and in 2006 sorghum was cultivated over an area of about 43.7 hectares with production of about 62.8 million tones. Sorghum grain yields on peasant farms are generally low, 500 - 800kg/ha [18, 12], whereas yields of 1,800 - 3,000kg/ha are obtainable under improved technology [23, 17, 12, 13, 14]. World production in 1984 was 66 million metric tons (Mt), and major world producers were United, India, China, Argentina and Nigeria [7]. Among the sorghum growing countries, India ranks first in acreage (grown over an area of 10.4 million hectares) but second in production (with a total production of about 8.8 million tons), the USA being the largest producer in the world. Other important sorghum growing countries are China, Nigeria, Sudan, and Argentina [7].

There are over 150 insect species which damage the sorghum plant from sowing to crop harvest [24]. More than 100 insect pest species is recorded in Africa, leading to annual losses of over 1.0 billion US Dollars in the semi- tropical region [10]. Insect pests especially the Lepidopterous stem borers and other insect pests constitute the important biotic factors limiting grain sorghum yield and storability in the sub-Saharan Africa [23]. The losses of food crops such as sorghum to pests in the developing world are enormous; estimates generally are between 25% and 50% of the expected output. A large proportion of these losses could be prevented through improved plant protection methods [22, 13, 5, 25].

Busseola fusca (Fuller) is of great importance as a pest of maize in Africa but it also attacks other cereals, particularly sorghum, pearl millet and sugar cane and some wild grasses. Damage is caused by the larvae which at first feeds on the young leaves, but soon tunnel into the stems and during the early stages of crop growth, larvae may kill the growing points, resulting in the production of 'dead heart' and consequent loss of crop stands, while at later stages of growth extensive tunneling and the grain development of sorghum and pearl millet may be indirectly affected by tunneling and breakage of peduncles [8].

Stem borers are difficult to control largely because of the nocturnal habits of the adult moths and the cryptic feeding behavior of the larvae which reside inside the plant stems. Although the use of insecticides for sorghum stem borer management may be unattractive to the small scale farmers, but many members of large-scale sorghum farmers who require and can afford insecticides are recommended to use for the control of leaf-feeding stages of B. Fusca with Carbaryl 85WP, granular Endosulfan 5G; and granular Trichlorphon 5G applied into the whorl three times at weekly intervals have been recommended [3]. Granules of the systemic insecticide carbofuran, applied into the planting hole at sowing, followed by a side dressing 6 weeks later controls Sesamia and provide control to Busseola larvae which enter the stem at the base [9, 24, 2, 4], are imperative for improving crop grain quality and productivity in the burgeoning population. However, most of these granular insecticides if not used with caution are harmful to the user and environment, which most of them have been band, even though not properly documented. Although, it is generally accepted that B. fusca is a major pest of maize and an important pest of sorghum, few trials of insecticide usage were carried out against damage it causes. Most studies only reported on the screening of sorghum genotypes resistant to the stem borers, Chilo partellus (Swinhoe) in China [16] and B. fusca (Fuller) in India, South Africa, Zaria (Nigeria) reported by ICRISAT [11] and Malgwi [13], but none has been conducted in Borno state, Nigeria, especially Biu that produce and consume very large quantity of sorghum than maize as well as used as sustainable feed for livestock, hence the need to conduct such studies in sorghum growing area like Biu.

Therefore, the objective of this study was to determine the grain yield reduction of some sorghum varieties/cultivars in a naturally infested field with B. fusca and the effect of carbofuran on B. fusca control on the yield of sorghum.

2. MATERIALS AND METHODS

The estimation of yield losses in some sorghum varieties/cultivars due to B. fusca (Fuller) was conducted in Maraban Ja'ali, 8 km from Biu town (off Biu - Damaturu road), Borno state, Nigeria and the project was carried out in 2008 and 2009 cropping seasons. The experiment consisted of fifteen varieties/cultivars of sorghum and application of insecticide (Carbofuran (carbamic acid, methyl-2,3-dimethyl-7-benzofuranyl ester) 3G at the rate of 0.56 kg a.i ha^{-1} was used for the treated plots for the fifteen varieties/cultivars in two split doses [15]. Carbofuran granules (3G) were applied at 30 and 40 days after emergence (DAE) of plants. The application of carbofuran was done in the whorls of sorghum in order to prevent environmental pollution through spillage by running into water ways) in the leaf whorl, in a Split-Plot Design (SPD) replicated three times on $6m^2$ plots. The carbofuran application was the main treatment plot which formed the treated and untreated plots; while the varieties/cultivars of sorghum were the sub-plot.

The fifteen (12) sorghum varieties/cultivars of which five (5) varieties were obtained from the Institute for Agricultural Research (1AR) Samaru, Zaria: viz; (i) Samsorg41 (ICSV111), (ii) Samsorg17 (SK5912), (iii) Samsorg14 (KSV9), (iv) NR-7114, (v) KL-2 and ten (10) cultivars sourced from Biu local farmers were: (i) 'Yungum', (ii) 'Perpelli', (iii) 'Kwakwai', (iv) 'Piltum vwa', (v) 'Shalmadi', (vi) 'Yollom,' (vii) 'Yusuf yazara', (viii) 'Tiksha mopu', (ix) 'Ticksha mamza' and (x) 'Chaklari' .

The field was prepared by ploughing to destroy weeds and expose soil-borne organisms to desiccation to sun shine and predators three days to before sowing. The seeds were dressed with Apron Star 50DS - (Metal-axyl-lott carboxin 60% + Furathiocarb-34%) at the rate of 1 sachet (50g) per 10kg of sorghum seeds before sowing in order to give uniform plant establishment and protection against seed/soil-borne organisms. The 15 sorghum varieties/cultivars seeds were sown on the 28^{th} of July in both 2008 and 2009 cropping seasons at the rate of 5-7 seeds per hole with inter and intra row spacing of 45x75cm respectively [6, 12]. All other regular cultural practices such as thinning, weeding, fertilize application were carried out as recommended [18]. Total number of plants and those with productive/harvestable panicles (main and tiller heads separately) and Grain yield per plot (main and tiller heads together) on each plot at harvest were recorded, and the harvested panicles were sun dried and threshed, and grain mass was recorded.

2.1 Grain Yield and Yield loss Assessment

The yield of sorghum grains were assessed based on the weight obtained from the untreated and treated plots. The productive sorghum heads on both untreated and treated plots were harvested threshed and weighed. The direct method (actual crop losses measured in the field) of estimating crop loss from insect pests was used, defined as the difference between the potential yield (A) (yield that would have been obtained in the absence of the pest under study that is treated with insecticide) and the actual yield (a) of natural infested with stem borer as described by Malgwi [12, 1, 18] as shown below:

$$\text{Yield loss (\%)} = \frac{A-a}{A} X \frac{100}{1}$$

Where:
A = weight of treated panicles with carbofuran.
a = natural infested panicles.

3. RESULTS

3.1 Effects of Carbofuran on Stem borer Damages on Sorghum varieties/cultivars

This study showed that, stem borer feeding and tunneling by newly hatched larvae on rolled developing leaves and there after few days fed and tunneled sorghum stems, peduncle and panicles was associated with 'dead heart', leaf scrapping, stem or peduncle breakages and stunted growth or delayed maturity, and the resultant effects of this damage was chaffy heads (plate 1) or reduced yield (Table 1 & Figure 1). The overall symptoms of the effects of the larvae feeding were as follows:

3.2 The Productive Heads and Tillers

The result revealed that productive heads (PH) (Plates 1-15) ranged from 7.83-29.25, of which 'Kwakwai' scored highest mean number of PH, While Samsorg14 had the lowest (7.83), however productive tillers ranged from 0.67-10.92, and 'kwakwai' had the highest mean of 10.92 while NR-7114 had the lowest of 0.67 (Figure 2). Gain yield per plot ranged between 152 and 1911.2 kgha^{-1}, of which 'Kwakwai' gave the highest yield (1,911.2 kgha^{-1}) while 'Shalmadi' recorded lowest yield of 152 kgha^{-1} (Table 1).

3.3 Grain Yield (kgha^1)

Grain yield was obtained from the harvestable panicles of the 15 sorghum varieties per plot per variety. Table 3 revealed that, in 2008 yield ranged from 1,883–9,050 kgha^{-1} where 'Yungum' had the highest yield (9,050 kgha^{-1}), followed by 'Kwakwai' (4,833 kgha^{-1}) and 'Perpelli'(4,650 kgha^{-1}), while 'Chaklari' had the lowest (1883 kgha -^{1}) on the untreated plots, followed by 'Samsorg14 (1,900 kgha^{-1}) and 'Tiksha mopu'(1,950 kgha^{-1}). While on treated plots, yield ranged from 1,349-4,217 $^{-1}$, 'Kwakwai' had the highest (4,217 kgha^{-1}), followed by KL-1 (4,200 kgha^{-1}) and Samsorg17 (3,450 kgha^{-1}), meanwhile 'Piltum vwa' had the lowest (1,349 kgha^{-1}), Tiksha mopu (1400 kgha $^{-1}$) and Tiksha mamza (1450 kgha^{-1}). Similarly in 2009, yield ranged on untreated plots from 1,018–9,117 kgha^{-1}, 'Kwakwai' also maintained the highest yield (9,117 kgha^{-1}), which is followed by 'Yungum' (8,150 kgha^{-1}) and Samsorg14 (7,367 kgha^{-1}) whereas 'Yollom' had the lowest yield (1,018 kgha^{-1}) followed by Samsorg41 (1,750 kgha^{-1}) on the untreated area; While on the treated plots, yield ranged from 1083-7000 kgha^{-1}, 'Kwakwai' had the highest yield (7,000 kgha^{-1}), followed by 'Perpelli' (6,567 kgha^{-1}) and 'Yungum' (5,917 kgha^{-1}) and Samsorg41 had the lowest yield (1,083 kgha^{-1}), followed by 'Perpelli' and 'Chaklari' (2,933 kgha^{-1}) on the treated plots (Table 2).

Combined result indicated that yield ranged on treated plots from 1,52–1,911 kgha^{-1}, where 'Kwakwai' had the highest yield (1,911 kgha^{-1}) followed by 'Yungum' (1,617 kgha^{-1}) and 'Yollom' (1,609 kgha^{-1}) while 'Shalmadi' measured lowest (152 kgha^{-1}) on the untreated plots followed by Samsorg41 (690 kgha^{-1}) and Samsorg17 (743 kgha^{-1}) (Table 1).

There was significant difference among the varieties and in 2008, 'Perpeli' and 'Yollom' (1,038.6kgha^{-1} and 1,039.70^{-1}) respectively were not significantly different from each other and significantly different from other varieties statistically at p=0.05. While in 2009, 'kwakwai' and Samsorg41 were not significantly different from each other but significantly different from other varieties (Table 1). Combined results had shown that yield differed among the varieties significantly, thus 'kwakwai' (1,911.2kgha^{-1}) was different from Samsorg17 (734.9kgha^{-1}) and Samsorg 41 (690.2kgha^{-1}) on untreated yield differ significantly from the treated yield and grain yield in 2008 differed significantly from that of 2009. 'Kwakwai' yielded highest and differed from other varieties/cultivars significantly statistically at p=0.05. However in an interactive effect, untreated plots differed significantly from treated (Table 2).

Table 1: Effects of stemborer damage parameters on some sorghum varieties taken before carbofuran application in a combined analysis (2008 and 2009 cropping seasons)

Varieties	Unproductive Heads	Unproductive Tillers	Productive Heads	Productive Tillers	Grain yield (kg ha^{-1})
Shalmadi	2.67^{abc}	5.42^{ab}	20.08^{cd}	9.50^{ab}	152.00^{abc}
Yungum	0.92^{c}	6.58^{ab}	19.75^{cd}	8.42^{abc}	1617.60^{ab}
Perpeli	1.25^{bc}	4.33^{b}	26.33^{ab}	8.92^{ab}	1566.10^{ab}
Piltum vwa	1.58^{bc}	3.92^{b}	13.67^{e}	9.42^{ab}	1144.9^{bcde}
Yusuf yazara	2.83^{abc}	7.92^{a}	16.83^{cde}	7.08^{bc}	1170.00^{bcde}
Kwakwai	0.50^{c}	4.25^{b}	29.25^{a}	10.92^{a}	1911.20^{a}
Yollom	1.17^{c}	4.92^{b}	26.83^{ab}	9.25^{ab}	1609.9^{ab}
Samsorg14	1.25^{c}	4.33^{b}	19.58^{cd}	8.75^{abc}	1515.10^{abc}
Samsorg17	2.33^{abc}	4.33^{b}	17.17^{cde}	5.25^{cd}	734.9^{e}
Samsorg41	2.75^{abc}	4.08^{b}	7.83^{f}	3.17^{d}	690.60^{e}
NR- 714	3.58^{ab}	4.58^{b}	19.00^{cd}	0.67^{bc}	947.10^{e}
KL- 1	1.00^{b}	3.00^{b}	27.00^{ab}	10.25^{ab}	1170.00^{bcde}
Tikshamamza	1.92^{b}	5.33^{b}	19.00^{cd}	8.17^{abc}	1008.60^{de}
Tiksha mopu	4.80^{a}	3.33^{b}	22.17^{bc}	7.08^{bc}	1069.30^{cde}

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Chaklari	1.58^{bc}	4.50^{b}	13.67^{de}	5.33^{cd}	1072.50^{cde}
Mean	1.98	4.72	19.73	7.88	1254.53
C V (%)	39.70	22.61	10.66	35.08	9.6
S E	0.83	1.24	2.40	1.3	382.76

Figures followed by the same alphabets are not significantly different at P = 0.05 using Students- Neuman-Kuels (SNK) test for variables in a combined analysis.

Table 2: Interactive effects of control method on stem borer damage symptoms and grain yield of some sorghum varieties/cultivars

Yield parameters	Untreated	Treated	Mean	CV (%)	SE
Unproductive heads	2.95^{a}	1.42^{b}	4.37	42.38	1.85
Unproductive tillers	5.04^{a}	1.57^{b}	6.60	46.48	3.07
Productive heads	22.20^{a}	18.62^{b}	40.82	12.47	5.09
Productive tillers	3.20^{b}	6.96^{a}	10.17	25.20	2.56
Grain yield (kgha^{-1})	1292.0^{b}	2149.10^{a}	3441.1	15.13	52.60

Figures followed by the same alphabets are not significantly different at P = 0.05 using Students- Neuman-Kuels (SNK) test for variables in a combined analysis.

Plate 1.1: Shalmadi
Top - productive head.
Bottom - chaffy heads.

Plate 1.2: Yungum
Top - productive head.
Bottom - chaffy head.

Plate 1.3: Perpeli
Top - productive head
Bottom - chaffy head

Plate 1.4: Pilthum vwa
Top - productive head
Bottom - chaffy head

Plate 1.5: Yusuf yazara
Top - productive head
Bottom - chaffy head

Plate 1.6: Kwakwai
Top - productive head
Bottom - productive head

Plate 1.7: Yollom
Top -productive head
Bottom- chaffy heads

Plate 1.8: Samsorg 14
Top -productive head
Bottom- chaffy head

Plate 1.9: Samsorg 17
Top -productive head
Bottom- chaffy head

Plate 1.10: Samsorg 41
Top -productive head
Bottom- chaffy head

Plate 1.11: NR-7114
Top -productive head
Bottom- chaffy head

Plate 1.12: KL-1
Top -productive head
Bottom- chaffy head

Plate 1.13: Tiksha mamza
Top -productive head
Bottom- chaffy head

Plate 1.14: Tiksha mopu
Top -productive head
Bottom- chaffy head

Plate 1.15: Chaklari
Top -productive head
Bottom- chaffy head

Plates 1.1-1.15: The 15 sorghum varieties/cultivars with chaffy/unproductive and productive heads together after harvest.

3.4 Crop Losses / Percentage Reduction of some Sorghum Varieties/cultivars due to Stem Borer Damage

During 2008 and 2009, stem borer damages ranged from 44 – 89%. Grain yield ranged on untreated plots between 499 and 1519.17kg/ha, while on the fully treated plots yield ranged between 848.61 and 2497.50kgha^{-1}. The percentage (%) yield reduction of the varieties ranged from 1–74% in 2008 and was generally less in 2009. Meanwhile 'Yungum' had the highest yield loss of 74% ranked as 1st, followed by 'Piltum vwa' (54%) as 2nd and the lowest crop loss was on Samsorg14 of only 1% ranked 15th, followed by NR-714 of just 2% as 14th (Figure 2), while in 2009, yield reduction ranged between 2 and 92%, where 'kwakwai' had the highest losses (92%) ranked as first, followed by 'Tiksha mopu' (68%) positioned as second and lowest percentage losses was on 'Perpelli' of only 2% ranked 15th, followed by Samsorg17 with just 18% as 14th (Table 3). There was significant difference among the varieties in both 2008 and 2009 cropping seasons (Table 4) as well as in a combined result.

Table 3: Yield kg ha^{-1} and percentage (%) yield due to stem borer infestation of some sorghum varieties before and after carbofuran application yields in two cropping seasons

	2008 cropping seasons				**2009 cropping seasons**			
Varieties	**Untreated**	**Treated**	**(%) loss**	**ranking**	**Untreated**	**Treated**	**(%) loss**	**Ranking**
Shalmadi	3,433	1,788	48	3	9,017	4,067	55	**4**
Yungum	9,050	2,333	74	1	8,150	5,917	27	10
Perpelli	4,650	2,433	48	3	6,667	6,567	2	15
Piltum vwa	2,900	1,349	54	2	4,816	3,767	22	12
Yusuf yazar	2,267	2,083	8	12	5,867	3,084	47	6
Kwakwai	4,833	4,217	13	9	9,117	7,000	92	1
Yollom	3,567	2,667	34	6	1,018	3,650	64	3
Samsorg14	3,483	3,450	1	15	7,367	5,650	23	11
Samsorg17	2,600	1,783	31	7	4,583	3,767	18	14
Samsorg41	1,900	1,800	5	13	1,750	1,083	38	7
NR-7114	2,000	1,967	2	14	4,367	3,067	30	9
KL- 1	4,200	4,200	13	9	6,067	3,983	34	8
Tiksha mam	1,950	1,450	26	8	4,367	3,467	21	13
Tiksha mop	2,200	1,400	36	5	6,683	2,150	68	2
Chaklari	1,883	1,717	9	11	6,550	2,933	55	4

Combined results indicated that, losses ranged from 0.16–0.65 corresponding to 16–65%. The most heavily affected was 'kwakwai' (52%) and Samsorg14 (12%) was least affected. In 2008 cropping season, yield lost on 'Yungum', 'Piltum vwa' and 'Shalmadi' were highest (1, 2 and 3 respectively), when compared to Samsorg 14, NR-7114 and Samsorg41 with less losses (ranked 15, 14 and 13 respectively). In the following year, percentage losses were highest on 'Kwakwai', 'Tiksha Mopu' and 'Yollom' ranked 1, 2 and 3 respectively. While least losses were obtained on 'Perpelli', Samsorg17 and 'Tiksha mamza' ranked 15, 14 and respectively (Table 3).

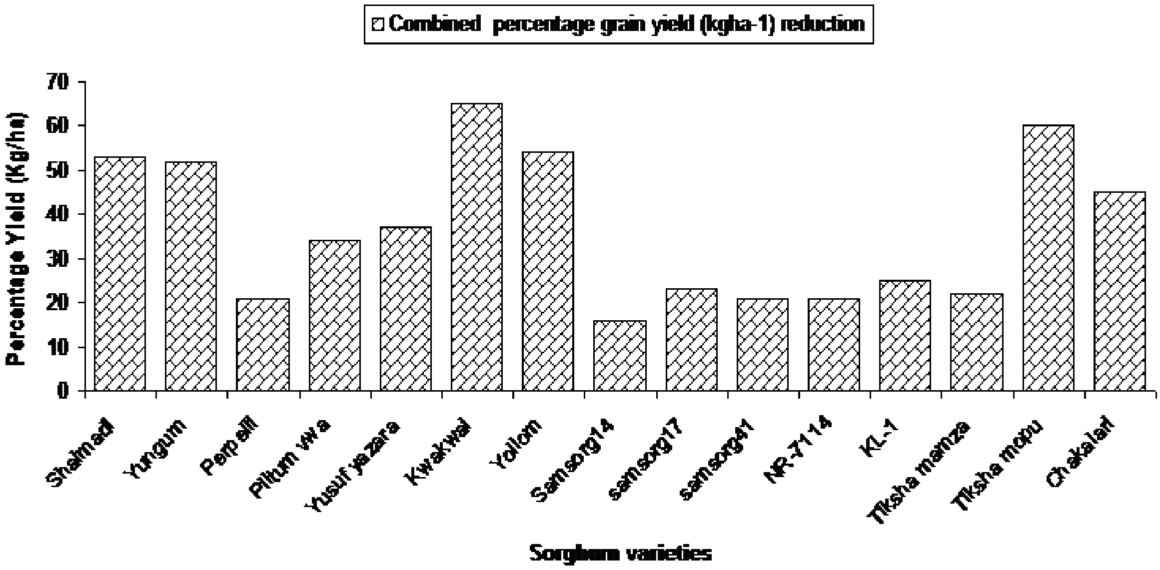

Fig 1: Average effects of stem borers on yield reduction of some sorghum varieties in two years.

The combined results showed that, 'Tiksha Mopu' suffered most followed by 'Kwakwai', 'Shalmadi' and then 'Yungum' suffered the losses most and Samsorg14 maintained its first position in 2008 (Figure 2). This result is similar to the work by Rao (unpublished) that losses in grain sorghum yield can range from 50–60% due to Chilo partellus. Samsorg14 is still the best variety with high relative resistance to stem borer which gave significantly less unproductive heads and tillers.

4. DISCUSSION

Among the sorghum cultivar/varieties, 'kwakwai' gave the highest yield, which was significantly different from the other varieties in an interactive effect. 'Yollom' which ranked first in yield and Samsorg17 on the treated fields were far below the standard expected yield of 1,800-3,000kg/ha obtainable under improved technology as reported by Uvah and Alabi [23]; NAERLS [17]; Malgwi [12]; Malgwi and Ajayi [14]. Which justify the need to combined cultivars that are resistant to stem borer damage to avoid losses in this hot-spot zone area like Waka-Biu infested with B. fusca. In the two seasons of cultivation, 'Perpelli' and 'kwakwai' yielded highest on both the untreated and treated plots. 'Tiksha mopu' and Samsorg17 gave the lowest yield out of the fifteen varieties/cultivars cultivated. Therefore, these two sets form the extreme positions on which we can draw or suggest a logical conclusion. 'Perpeli' and 'kwakwai' could be said that they tolerated the stem borer damage better than the rest which could be recommended to farmers in Borno state and its neighboring states.

In a combined analysis, the result revealed that, yield ranged from 557.22-1,519.17kgha^{-1} and 'Perpeli' gave the highest yield on the untreated. Meanwhile, on the treated, yield ranged from 621.17 – 2497.50 kgha^{-1} and 'kwakwai' had the highest grain yield per hectare (2497.50kgha^{-1}). This result agrees with trails conducted in Hisar, India on plots under intensive protection which was compared with non-protected plots [14]. 'Perpeli' and 'Yollom' were not significantly different as their yields were highest (1473.33kg/ha) in both 2008 and 2009, 'kwakwai' had the highest yield (2497.50kg/ha), hence was significantly different from the other varieties in an interactive effects. It may therefore hold promise as a resistant variety in Sorghum improvement research. 'Shalmadi', 'Yollom', 'Yungum', 'Kwakwai', 'Tiksha mopu' and 'Chaklari' were relatively resistant promising local cultivars and revealed high percentage yields in a stem borer "hot-spot" field; which might be used as resistant varieties/cultivars or be incorporated into sorghum search programme with the aim of obtaining high yield and greater economic benefit. They can be sown in stem borer 'hot spot' zones of the sorghum growing areas of Nigeria especially Biu, Borno state and its neighbouring states like Adamawa, Yobe, Bauchi, Gombe and Taraba states where sorghum is produced as a staple food (cereal).

Biu, is a "hot-spot" zone for stem borers which conforms the interactions made with the local farmers. The stem borer damages at seedling stages caused 'dead hearts' which increased plant population by producing tillers that reached maturity and increased grain yield per hectare. Stem borer damages sorghum stems by causing peduncle breakage, chaffy or unproductive panicles that reduced yields in susceptible varieties/cultivars. Sorghum straws and panicles were rendered useless in terms of utilization in fencing, animal feeding and thatching. In addition to yield reduction, there is reduction in grain quality like moldiness and poor seed germination.

Although carbofuran (a carbamate) is very toxic to man, livestock and environment if not properly used in terms of application in the whorls of sorghum leaves at a lower dosage, treated fields still gave higher yields than untreated ones significantly. Damage on the treated plots was still recorded after three weeks, but significantly lower than the untreated plots. Thus insecticide control gave a better yield, yet inconclusive in estimating yield loss in sorghum so, additional work in this aspect might be useful. However, Carbofuran is still a good, easy to apply pesticide in case of emergency outbreak of stem borers; because it can be applied at all stages of sorghum growth, of which it will targets the vulnerable stages of sorghum stem borer and its development.

This experiment is very important in providing a good base for assessing the level of damage by all stem borer species to sorghum in “hot spot” zones and effort should be geared toward undertaking natural host plants survey. This could be used in IPM to improve the quantity and quality of sorghum, which is an important food and livestock crop that could improve the economy and hence alleviate hunger and poverty level of farmers, especially the early maturing sorghum cultivars/varieties that are vulnerable to stem borer damage.

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