

VARIATIONS IN THE SUSCEPTIBILITY OF SOME LOCAL AND IMPROVED MAIZE (*Zea mays* L.) GENOTYPES TO STEM BORER INFESTATION IN A SUB-HUMID ENVIRONMENT

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SUMMARY

Thirty maize varieties were evaluated for susceptibility to natural infestation of the stem borers for resistance to stem borers in the early and late seasons of 2012 at the Teaching and Research Farm, Federal University of Agriculture, Abeokuta. Borer-resistant variety - BR9928-DMRSR C1 - was used as the check, while resistance was established based on the population of the stem borers and level of damage induced by the insects on the maize plants. Among the stem borers, *S. calamistis* population was the largest both in the stem and cob during the early season, while that of *B. fusca* was the largest in the late season. *Chilo partellus* population was the least in the early season, and was not observed in the late season. Using resistance indices, local varieties: TZM 99, TZM 212 and TZM 137 were found susceptible. Borer-resistant accession, BR9928-DMRSR C1, had significantly lower larval population in the stem and percentage tunneled stem of 0.0 and 0.32% during the early while during late seasons, it had 1.0 and 0.62% respectively. However, the performance of the improved varieties: SUWAN 1, DMR LSR Y, 2000SYN EE-W STR, TZBR ELD-3 C5, TZE-WDTSTR C4 and EVDT-Y2008STR had statistically similar ($p < 0.05$) damage to the borer-resistant variety and were classified highly resistant. It is recommended that BR9928-DMRSR C1, SUWAN 1, DMR LSR Y, 2000SYN EE-W STR, and TZBR ELD-3 C5, which were found highly resistant to the stem borers, and produced statistically similar high grain yield, should be cultivated in stem borer-infested areas.

Keywords: Maize, Stem borers, Damage, Yield, Resistance

MAIZE (*Zea mays* L.), which originated from South America (15), is an important cereal which serves as fodder crop all over the world (8). It is essentially a crop of warm countries with adequate soil moisture (1). In Nigeria, maize is the most important staple food which accounts for about 43% of calorie intake (18). Studies on maize production in different parts of Nigeria have shown an increasing importance of maize other than its utilization by food processing industries and livestock feed mills. The crop has thus grown to be local 'cash crop' most especially in the southwestern part of Nigeria where at least 30% of the crop land has been devoted to maize production under various cropping systems (3). Growing maize in farms of 1-2 hectares can overcome hunger in the household and the aggregate effect could double food production in Africa (10). Production of maize in developed countries can be as high as 8.6 tonnes per hectare while in many sub-Saharan African countries, it is as low as 1.3 tonnes per hectare (14). Maize yield in Nigeria showed a 17.5% increment between 2000 and 2011 (7), yet this production is inadequate to meet maize demand quantitatively and qualitatively.

Among the several insect pests limiting the production of maize in Nigeria are stem borers which

damage the crop in the field (6). The African maize stalk borer - *Busseola fusca* Fuller (Lepidoptera: Noctuidae), Sugar cane stem borer- *Eldana saccharina* Walker (Lepidoptera: Pyralidae), pink stem borer - *Sesamia calamistis* Hampson (Lepidoptera: Noctuidae), and spotted stalk borer- *Chilo partellus* Swinhoe (Lepidoptera: Crambidae/Pyralidae) are the major species of stem borers associated with field-grown maize in Nigeria (19, 4), with yield losses ranging between 10 - 100 % (12).

The initial symptom of stem borer infestation is leaf feeding, followed by tunneling and feeding within the stem, and sometimes also within the maize ears (17). Stem borers lay their eggs at night on the underside of emerging leaves of young maize plants. The larvae that hatch from the eggs quickly make their way inside the plant, where they feed undisturbed by predators. Young larvae feed on foliar tissue in the whorl, leading to perforations in unfolding leaves, and potential destruction of the growing point known as 'dead heart' at the early stage of the maize plant. The older larvae burrow into the stem, where they starve the growing plant of nutrients and can cause lodging (5). They can also feed extensively on tassels, ears, and stems. The severity

and nature of stem borer damage depend upon the borer species, the plant growth stage, the number of larvae feeding on the plant, the season of the year and the plant's reaction to borer feeding (5, 9, 17).

Although, chemical control has been reported as the most adequate of all the control methods evaluated against the stem borers (2, 13, 16), the side effects of synthetic insecticides on the environment necessitate more studies on non-chemical options. Host plant resistance (HPR) is an effective and safe method which could be deployed to control these borer pests (17). Therefore, the objectives of the study were to determine stem borer species composition, and the degree of stem borer-induced damage on thirty local and improved maize varieties in a sub-humid environment of Nigeria.

MATERIALS AND METHODS

The experiment was carried out during the early and late raining seasons at the Teaching and Research Farm of the Federal University of Agriculture, Abeokuta, Nigeria (7° 15'N, 3° 25'E, 159 m above sea level). The experiment was laid out in a randomized complete block design (RCBD) with three replicates. The treatments were the 30 varieties of maize total field size was 543.75 m². A row plot pattern (7 m long) was used with a planting distance of 75 cm (inter- row) x 50 cm (intra- row) and

a 2 m border between plots. The improved maize varieties were obtained from the International Institute of Tropical Agriculture (IITA), Institute of Agricultural Research and Training (IAR&T), and National Centre for Genetic Resources and Biotechnology (NACGRAB), Ibadan, while the local varieties were obtained from NACGRAB only. The maize varieties represented the treatments while BR9928-DMRSR-C1 which is borer-resistant was the check. Two seeds were planted per hole, and were later thinned to one plant stand at three weeks after planting (WAP) leaving 15 stands per row. Weeding was done at 4 WAP and 8 WAP, but neither pesticide nor fertilizer was applied.

In both seasons, data were collected from ten randomly selected plants from the middle portion of each row in the following manner: Maize stands with dead heart symptom were recorded at 4 WAP, while lodging was scored at 8 WAP. At maturity, all the stems were removed peeled to record the number of exit holes created by the exiting larvae. The stems were also dissected using a sharp knife in order to measure the length of tunnel made by the borer larvae. Total larvae found within each stem were also counted and each borer larva was identified. Number of stems in which the larvae were found was expressed in percentage of the

total stem (% bored stem). Number of cobs with either borer present or borer symptoms such as frass deposit and holes were considered as damaged and this was expressed in percentage of the total cobs harvested (% cob damage). Data were also collected on grain yield.

All data on larval number were transformed using square root transformation and all data presented in percentages were transformed using arc-sin transformation before subjecting them to analysis of variance, ANOVA using GENSTAT Linear Model (12th Edition). Significant mean values were separated using Tukey's Honestly Significant Difference (HSD) at 5% probability.

RESULTS

The stem borers recorded from the maize varieties tested were *Busseola fusca*, *Sesamia calamistis*, *Eldana saccharina* which were recorded in the early and late seasons and *Chilo partellus* in the early season only. In the stems during the early season, the relative abundance of *S. calamistis* was 53% which was the highest followed by *E. saccharina*, *B. fusca* and *C. partellus*. However, *B. fusca* density (42%) during the late season was the highest followed by those of *S. calamistis* and *E. saccharina*. In the early season in the cobs, *S. calamistis*

was the most abundant followed by *E. saccharina*, *B. fusca* and *C. partellus*, while in the late season, *B. fusca* was the most abundant followed by *S. calamistis* and *E. saccharina* (Table 1)

There were significant ($P < 0.05$) variations in the population densities of the stem borers recorded in the 30 maize varieties tested. Highest ($P < 0.05$) total borer population density during the early season was observed in TzM 217, TzM 43, TzM 1277, TzM 1273, TzM 1439, TzM 132, TzM 99, TzM 1353, TzM 157, TzM 224, TzM 148, TzM 232, TZEY-POP STR C4, LNTP-W C3, SUWAN 1-SR Y and ART/98/SW1. However, lowest total borer number ($p < 0.05$) was recorded in BR9928-DMRSR C1 stems (Table 2). Significant higher *S. calamistis* population density was recorded in TzM 217 than other varieties, while *E. saccharina* was not recorded on EVDT-Y2008STR, DTSR-W CO and BR9928-DMRSR C1. The population densities of *B. fusca* recorded in all the maize stems were statistically similar. On TzM 1439, was recorded the highest ($p < 0.05$) density of *C. partellus*, while on others, the density was significantly low (or nil).

On TzM 99, TzM 212, TzM 43 and TzM 217, higher ($P < 0.05$) borer numbers were recorded load

compared to other varieties, while the lowest ($P < 0.05$) borer load was on BR9928-DMRSR C1 during the late season (Table 2). Whereas the lowest infestation intensity was found in BR9928-DMRSR C1, the highest ($P < 0.05$) number of *S. calamistis* was observed on TZM 217 which was not different from those of TZM 1273, TZM 157, TZM 1277, TZM 43, TZM 132, TZM 224, TZEE-Y POP STR C4, TZM 1353, TZM 99, TZM 212, LNTP-W C3, TZM 137, TZM 148, TZM 1439, TZM 232, ART/98/SW1. However, *C. partellus* was not recorded in the late season.

Total borer population in the cob of TZM 148, which was not statistically similar to TZM 132, SUWAN 1-SR Y and ART/98/SW1 were significantly ($P < 0.05$) higher than TZBR ELD-3 C5 during the early season (Table 2). Similarly, the number of *S. calamistis* found in the cob was higher ($P < 0.05$) on TZM 148 and ART/98/SW1 than on TZBR ELD-3 C5. Likewise, there were significantly higher numbers of *E. saccharina* and *B. fusca* on TZM 148 than others. *E. saccharina* was not recorded on TZEE-Y POP STR C4, AMA TZBR C3 W, TZBR ELD-3 C5 and LNTP-W C3.

The population of *E. saccharina* recorded in the cob of TZM 99 was significantly higher ($P < 0.05$) than others, while TZBR ELD-3 C5 had the lower infestation level ($P < 0.05$)

which is not significantly different from BR9928-DMRSR C1 (Table 3) during the late season. *B. fusca* density was higher on TZM 99 compared to TZBR ELD-3 C5 on which the lowest population ($P < 0.05$) was found.

Percentage bored stems in the early season were significantly higher on TZM 99 and TZM 238, while the lowest ($p < 0.05$) was recorded in BR9928-DMRSR C1 (Table 3). Similarly, the deepest ($p < 0.05$) tunnel made by stem borers was found on TZM 137, TZM 212 and TZM 99 compared to BR9928-DMRSR C1 with shallow tunnel. Significantly higher number of exit holes was found on TZM 99, TZM 137, TZM 212 TZM 1439, TZM 217 and TZBR ELD-3 C5 compared to BR9928-DMRSR C1. There was also significantly higher cob damage on SW6- OB-W, while the lowest damage was on AMA TZBR C3 W and BR9928-DMRSR C1 (Table 4).

Significantly higher number of exit holes was found on TZM 212, TZM 137 and TZM 99 which were statistically similar, compared to BR9928-DMRSR C1 which had the lowest number. Significantly lower cob damage was recorded on BR9928-DMRSR C1 and SUWAN 1-SR Y which suffered the least damage.

Total grain yield values for both seasons were significantly higher in accession BR9928-DMRSR C1 compared to TZM 137, TZM 99 and TZM 212 which had the lowest values (Table 5). Varieties TZM 1439, TZM 157, TZM 232 which had

relatively high stem borer population densities and damage in both stem and cob were found comparable in terms of yield with accession BR9928-DMRSR C1 during the early season.

Table 1: Stem borer species composition in the maize stems and cobs in the early and late seasons

Stem borer	Early Season		Late Season	
	Stem	Cob	Stem	Cob
<i>Sesamia calamistis</i>	53.0	55.0	38.0	35.0
<i>Busseola fusca</i> ;	16.0	25.0	42.0	42.0
<i>Eldana saccharina</i>	30.0	18.0	20.0	23.0
<i>Chilo partellus</i>	1.0	2.0	-	-

DISCUSSION

This study revealed four stem borers associated with maize in a rainforest transition environment and the level of damage induced by them. The borers recorded were the *S. calamistis* (pink stem borer), *B. fusca* (African maize stem borer), *E. saccharina* (sugarcane borer) and *C. partellus* (spotted stem borer). These pests have been reported earlier as most important and widely distributed lepidopterous maize borers. Relative to one another, with *S. calamistis* was the most abundant in the early season and *B. fusca* in the late season while, *C. partellus* which recorded the lowest density was found only in the early season. This suggests that stem

borer abundance could be influenced by season and that *C. partellus* is a minor pest on maize which could have probably preferred other plants (9).

In this study, damage induced on maize plant such as tunnel length, exit holes and bored stems were used to measure susceptibility rather than borer density alone. Among the 30 varieties tested, BR9928-DMRSR C1 recorded significantly lower borer population density in the stem and lower stem damage. It also recorded the lowest number of bored stems, length of tunnel, and exit holes. This implies that BR9928-DMRSR C1, which is an established borer-

resistant variety, showed high levels of feeding resistance to all the borer insects observed. The outstanding low level of borer-induced damage, low borer population density and high yield of BR9928-DMRSR C1 therefore, shows that the variety is still stable with a high level of durability of resistance many years after its release.

The yield of TZM varieties was statistically similar with those of the improved varieties except TZM 212, TZM 137 and TZM 99 that produced significantly lower yields. The three varieties - TZM 212, TZM 137 and TZM 99 had high borer-induced damage resulting in the low yield recorded. The high level of damage recorded in these varieties compared with the improved accession (resistant check) can also be regarded as a measure of susceptibility (17). However, SUWAN 1, DMR LSR Y, 2000SYN EE-W STR, TZBR ELD-3 C5, TZE-WDTSTR C4 and EVDT-Y2008STR which are also improved varieties displayed as well, high level of resistance which is comparable to BR9928-DMRSR C1 in terms of damage induced. Moreover, among these improved varieties, SUWAN 1 recorded significantly higher borer larval density and lower damage relative to others. This suggests that

the variety may be tolerant, while those varieties with lower borer density may likely be showing antixenosis or antibiosis. However, TZM 99, TZM 212 and TZM 137 are considered most susceptible due to significantly higher larval density and damage recorded on it.

CONCLUSION

From this study, *Busseola fusca*, *Sesamia calamistis*, *Eldana saccharina* were the stem borers recorded in both seasons, while *Chilo partellus* was recorded only in the early season. Also, there were variations in the susceptibility of the thirty maize varieties tested against the stem borers. Varieties BR9928-DMRSR C1, SUWAN 1, DMR LSR Y, 2000SYN EE-W STR, TZBR ELD-3 C5, TZE-WDTSTR C4 and EVDT-Y2008STR recorded lower borer damage, while TZM 99, TZM 212 and TZM 137 were the most susceptible. However, although TZE-WDTSTR C4 and EVDT-Y2008STR recorded lower borer damage, they produced lower grain yield compared to others.

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Table 2: Population densities of maize stem borers in stems of thirty maize varieties during the early and late seasons

S/N	Accession	<i>Sesamia calamistis</i>		<i>Eldana saccharina</i>		<i>Busseola fusca</i>		<i>Chilo partellus</i>		TLDS	
		Early	Late	Early	Late	Early	Late	Early	Late	Early	Late
1	TZM 238	1.00f	1.33fgh	0.33ab	0.67cde	1.67a	1.67efg	0.00b	0.00	3.00b-e	3.60fg
2	TZM 43	8.00b-f	8.33a-d	5.33ab	6.00a-d	1.00a	10.0abc	0.00b	0.00	14.3 3a-e	24.3a
3	TZM 1277	12.00abc	10.00a-d	2.67ab	3.00a-e	3.00a	10.67abc	0.00b	0.00	17.67ab	23.6ab
4	TZM 1273	12.33ab	12.67ab	2.33ab	3.00a-e	0.00a	8.33b-f	0.00b	0.00	14.67abc	24.0ab
5	TZM 1438	4.33b-f	5.00a-h	5.33ab	6.00a-e	3.67a	3.33d-g	0.00b	0.00	13.33a-d	14.3a-f
6	TZM 217	18.33a	13.33a	3.33ab	3.67a-e	4.33a	7.00b-e	0.00b	0.00	26.00a	24.0a
7	TZM 132	9.67a-d	8.67a-d	5.33ab	2.00a-e	1.33a	10.0abc	0.33ab	0.00	16.33ab	20.6abc
8	TZM 99	5.67b-f	6.67a-f	6.00ab	4.67a-e	3.33a	17.33a	0.00b	0.00	15.00abc	28.6a
9	TZM 1353	6.00a-f	6.67a-f	1.00ab	5.67a-e	1.67a	7.33cd	0.00b	0.00	8.67a-e	19.6abc
10	TZM 157	10.0a-e	10.0abc	4.33ab	4.33a-e	4.33a	8.00bcd	0.00b	0.00	18.67ab	22.3ab
11	TZM 1439	4.33b-f	5.00c-h	0.67ab	1.67a-e	1.67a	6.67b-e	1.00a	0.00	7.67b-e	13.3a-f
12	TZM 224	8.00a-f	8.00a-e	8.00a	7.00ab	2.67a	8.33bcd	0.00b	0.00	18.67ab	23.3ab
13	TZM 148	4.67b-f	5.33a-h	3.00ab	3.67a-e	0.00a	6.67b-e	0.00b	0.00	7.67a-e	15.6a-d
14	TZM 232	5.00b-f	5.33a-h	0.33ab	2.67a-e	2.33a	6.67b-e	0.00b	0.00	7.67a-e	14.6a-e
15	TZM 137	2.00c-f	6.00a-g	1.00ab	2.67a-e	0.00a	11.67ab	0.00b	0.00	3.00b-e	20.3abc
16	TZM 212	3.33c-f	6.67a-f	4.33ab	8.33a	0.00a	10.00abc	0.00b	0.00	7.67b-e	25.0a
17	TZM 223	1.67def	2.33c-h	1.67ab	2.00a-e	2.33a	4.00b-g	0.00b	0.00	5.67b-e	8.30c-g
18	EVDT-Y2008STR	2.67c-f	2.33d-h	0.00b	0.67cde	1.67a	3.33c-g	0.00b	0.00	4.33b-e	6.30d-g
19	TZEE-Y POP STR C4	7.00a-f	7.67a-e	0.67ab	0.33de	0.33a	7.33b-e	0.00b	0.00	8.00a-e	15.3a-d
20	TZE-WDTSTR C4	1.33def	1.00gh	4.67ab	1.00b-e	0.67a	1.67efg	0.00b	0.00	6.67b-e	3.60efg
21	DTSR-W CO	1.33def	2.33d-h	0.00b	1.00b-e	0.00a	2.00d-g	0.00b	0.00	1.33de	5.30d-g
22	AMA TZBR C3 W	2.00c-f	2.67c-h	1.00ab	1.00b-e	0.33a	5.00b-f	0.00b	0.00	3.33b-e	8.60c-g
23	TZBR ELD-3 C5	1.33ef	1.67fgh	0.67ab	0.33de	0.00a	2.00d-g	0.00b	0.00	2.00cde	4.00efg
24	BR9928-DMRSR C1	0.33f	0.67h	0.00b	0.00e	0.00a	0.33g	0.00b	0.00	0.33e	1.00g
25	2000SYN EE-W STR	1.00ef	1.67e-h	5.67ab	1.00b-e	2.33a	1.00fg	0.00b	0.00	9.00b-e	3.60efg
26	LNTP-W C3	5.33b-f	6.33a-g	5.00ab	1.67a-e	0.00a	6.67b-f	0.33ab	0.00	10.67a-e	14.6a-f
27	SUWAN 1-SR Y	5.33b-f	5.33b-h	6.67ab	6.00abc	4.67a	2.00d-g	0.00b	0.00	16.67ab	13.3a-f
28	DMR LSR Y	3.33b-f	3.00c-h	4.67ab	0.67cde	0.67a	3.33d-g	0.66ab	0.00	9.33a-e	7.00d-g
29	SW6- OB-W	1.67c-f	2.67c-h	1.33ab	4.00a-e	0.33a	3.33c-g	0.00b	0.00	3.33b-e	10.0b-g
30	ART/98/SW1	4.00b-f	5.00a-h	5.67ab	5.00a-e	3.00a	6.67b-e	0.33ab	0.00	13.00a-d	16.6a-d

Means along a column with the same letters are not significantly different according to Tukey's HSD ($p < 0.05$)
Total Larval Density in the Stem.

Table 3: Population densities of maize stem borers in the cobs of thirty maize varieties during the early and late seasons

S/N	Accession	<i>Sesamia calamistis</i>		<i>Eldana saccharina</i>		<i>Busseola fusca</i>		<i>Chilo partellus</i>		TLDC	
		Early	Late	Early	Late	Early	Late	Early	Late	Early	Late
1	TZM 238	2.33bcd	2.00h-k	0.67ab	1.67bcd	0.00c	3.00b-g	0.00b	0.00	3.00efg	6.60f-j
2	TZM 43	4.33a-d	4.00d-I	1.67ab	3.00a-d	1.67bc	5.33b-g	0.00b	0.00	7.67b-f	5.33b-g
3	TZM 1277	9.33ab	6.33a-e	1.00ab	2.00bcd	0.00c	10.0ab	0.33ab	0.00	10.67b-f	18.30bc
4	TZM 1273	4.33a-d	7.33a-d	1.33ab	2.00bcd	2.00bc	6.67a-e	0.00b	0.00	7.67b-f	16.0bcd
5	TZM 1438	8.33abc	9.00ab	1.67ab	2.67a-d	2.00bc	8.33abc	0.00b	0.00	12.00b-e	20.0b
6	TZM 217	7.67abc	10.00a	1.67ab	2.33bcd	2.33bc	8.33abc	0.00b	0.00	11.67b-e	20.6b
7	TZM 132	11.00a	3.67e-j	3.00ab	4.00ab	3.33bc	5.67b-f	0.00b	0.00	17.33ab	5.67b-f
8	TZM 99	5.67a-d	8.33abc	2.33ab	7.00a	3.33bc	15.33a	0.33ab	0.00	11.67b-f	30.6a
9	TZM 1353	4.33a-d	4.33c-i	0.33b	2.67a-d	5.67bc	5.67b-g	0.33ab	0.00	10.67b-f	5.67b-g
10	TZM 157	3.67a-d	6.00a-g	2.67ab	3.67abc	1.67bc	5.00b-g	0.00b	0.00	8.00b-f	14.6b-e
11	TZM 1439	1.33cd	2.33g-j	0.33b	3.00a-d	2.00bc	2.00d-g	0.00b	0.00	3.67d-g	7.30e-j
12	TZM 224	1.33cd	2.67f-j	1.67ab	3.33abc	4.67ab	2.33c-g	0.00b	0.00	7.67b-f	8.30d-i
13	TZM 148	11.33a	4.67d-i	5.33a	2.33bcd	11.00a	5.00b-g	0.00b	0.00	27.67a	5.00b-g
14	TZM 232	7.33abc	7.33a-d	2.00ab	3.00a-d	2.00bc	8.33a-d	0.00b	0.00	11.33b-f	8.33a-d
15	TZM 137	3.33a-d	4.00d-i	1.67ab	3.00a-d	4.67bc	6.67b-f	1.66a	0.00	11.33b-f	13.6b-f
16	TZM 212	3.67a-d	5.00b-h	0.33b	4.33ab	2.33bc	7.00b-e	0.00b	0.00	6.33c-g	16.3bcd
17	TZM 223	1.67cd	3.00e-j	1.00ab	1.67bcd	0.00c	3.67b-g	0.00b	0.00	2.67efg	8.30d-i
18	EVDT-Y2008STR	1.33cd	2.00h-k	0.67ab	1.00cd	2.33bc	0.67fg	0.00b	0.00	4.33c-g	3.6hij
19	TZEE-Y POP STR C4	3.33a-d	5.00b-h	3.33a-d	1.00cd	0.00b	4.00b-g	2.67bc	0.00	0.33g	10.0c-i
20	TZE-WDTSTR C4	4.00a-d	1.67ijk	1.67ab	1.33cd	1.67bc	2.33c-g	0.00b	0.00	7.33b-g	5.30g-j
21	DTSR-W CO	1.67cd	3.00e-j	1.33ab	2.00bcd	0.33bc	2.33d-g	0.00b	0.00	3.33efg	7.30e-j
22	AMA TZBR C3 W	4.00a-d	4.00d-i	0.00b	1.00cd	0.00c	5.33bg	0.00b	0.00	4.00efg	10.3c-i
23	TZBR ELD-3 C5	0.33d	1.33jk	0.00b	0.67d	0.00c	0.33g	0.00b	0.00	0.33g	3.60ij
24	BR9928-DMRSR C1	1.33cd	0.33k	0.67ab	0.67d	0.00c	1.00efg	0.00b	0.00	2.00fg	2.00j

25	2000SYN EE-W STR	3.00bcd	1.00jk	0.67ab	1.00cd	0.00c	2.33c-g	0.00b	0.00	3.67efg	4.30ij
26	LNTP-W C3	3.33a-d	3.67d-i	0.00b	1.33bcd	0.00c	4.67b-g	0.00b	0.00	3.33efg	9.60d-i
27	SUWAN 1-SR Y	7.67abc	4.00d-i	3.67ab	4.33ab	3.00bc	2.00c-g	0.33ab	0.00	14.67a-d	10.3c-h
28	DMR LSR Y	7.33abc	3.00e-j	3.00ab	3.67abc	1.00bc	2.67cg	0.00b	0.00	11.33b-e	9.30d-i
29	SW6- OB-W	2.00bcd	3.00e-j	1.00ab	3.67abc	0.67bc	3.33b-g	0.33ab	0.00	4.00c-g	10.0c-i
30	ART/98/SW1	11.33ab	6.00a-f	2.67ab	3.33abc	2.67bc	6.67b-f	0.00b	0.00	16.67abc	16.0bcd

Means along a column with the same letters are not significantly different according to Tukey's HSD ($p < 0.05$); TLPD= TLPC=Total Larval Population in cob per plot.

Table 4: Stem borer-induced stem and cob damage on thirty maize varieties in the early and late seas

S/N	Accession	%BS		%TL		DH		%LS		MNEP		%CDP	
		Early	Late	Early	Late	Early	Late	Early	Late	Early	Late	Early	Late
1	TZM 238	93.3a	91.7ab	3.40a-e	4.33f-j	0.00e	0.33e	0.00d	0.00e	2.83b	2.93b-f	89.0a	90.0ab
2	TZM 43	84.3ab	82.3a-d	3.22a-e	4.13f-j	2.33ab	2.33a	16.67a	26.67a	3.19b	3.40b-e	86.7a	87.0ab
3	TZM 1277	90.3ab	75.0a-d	5.40a-d	5.87d-h	1.33abc	2.33ab	13.33ab	20.00ab	3.79b	3.83bcd	70.7abc	96.0ab
4	TZM 1273	45.3bc	72.3a-d	3.73a-e	4.87f-i	0.00e	0.00e	0.00d	0.00e	2.68b	3.00b-f	62.7abc	94.0ab
5	TZM 1438	84.3ab	80.7a-d	6.20a-d	10.06a-e	0.00e	0.00de	0.00d	3.33de	4.82ab	4.63b	91.7a	92.0ab
6	TZM 217	85.7ab	79.0a-d	3.93a-e	4.72f-i	2.33ab	2.66a	16.67ab	26.67a	4.65ab	4.29bc	61.0abc	80.3ab
7	TZM 132	83.3ab	72.7a-d	7.43a-d	11.43abc	1.33bc	2.00bc	10.00abc	10.00bc	2.65b	2.73b-f	77.0abc	80.0ab
8	TZM 99	96.0a	97.3a	11.42ab	10.08a-e	2.66a	3.33a	20.00a	30.00a	8.82a	8.89a	93.7a	99.3a
9	TZM 1353	70.3ab	65.7a-d	4.64a-e	4.79f-i	0.00e	0.33e	3.33d	0.00e	3.66b	3.21b-f	80.0ab	76.7ab
10	TZM 157	73.3ab	83.3a-d	3.46a-e	4.01g-j	0.00e	0.00e	0.00d	0.00e	2.94b	3.08b-f	66.7abc	70.0abc
11	TZM 1439	58.4ab	75.0a-d	7.57a-d	10.40a-e	0.00e	0.66e	0.00d	0.00e	3.61b	3.63bcd	99.3a	95.0ab
12	TZM 224	63.7ab	85.7a-d	5.21a-e	5.61e-i	1.66abc	2.00bc	13.33ab	16.67bc	3.34b	3.60bcd	63.0abc	68.3abc
13	TZM 148	67.7ab	75.7a-d	6.86a-d	7.06c-g	1.00cd	1.66e	6.67bcd	0.00e	2.82b	3.08b-f	66.7abc	83.3ab
14	TZM 232	52.7ab	90.0ab	6.80a-d	7.41b-g	0.00e	0.00e	0.00d	0.00e	2.29b	3.08b-f	73.3abc	79.7ab
15	TZM 137	78.0ab	90.0ab	11.84abc	12.58ab	0.33de	0.00de	0.00d	3.33de	8.67a	8.82a	97.7a	93.3ab
16	TZM 212	88.0ab	92.7ab	11.82a	13.22a	2.00ab	2.00cd	13.33ab	10.00cd	8.49a	8.91a	87.3a	91.3ab
17	TZM 223	53.3ab	65.0a-d	4.98a-e	5.35f-i	0.00e	0.00e	3.33cd	0.00e	3.53b	3.50bcd	72.7abc	90.0ab
18	EVDT-Y2008STR	69.3ab	51.7de	2.91a-e	2.23jk	0.33de	0.33e	0.00d	0.00e	1.53b	1.97c-g	81.0ab	51.7cde
19	TZEE-Y POP STR C4	74.3ab	72.3a-d	9.68a-d	10.44a-d	0.00e	0.00e	0.00d	0.00e	3.78b	3.48bcd	81.0ab	78.3ab
20	TZE-WDTSTR C4	50.3ab	53.3de	2.39de	2.14ij	0.00e	0.00e	0.00d	0.00e	0.94b	0.93fg	87.0a	46.7cde
21	DTSR-W CO	86.7ab	90.0abc	8.03a-d	8.42a-f	0.00e	0.33e	0.00d	0.00e	2.57b	2.48b-g	63.0abc	74.0ab
22	AMA TZBR C3 W	89.0ab	90.0ab	4.24a-e	6.66c-g	0.33de	0.00e	0.00d	0.00e	3.00b	3.61bcd	50.0bc	76.7ab
23	TZBR ELD-3 C5	50.0bc	53.3de	6.68a-e	3.23g-j	0.00e	0.00e	0.00d	0.00e	4.42ab	0.84fg	68.7abc	42.3de
24	BR9928-DMRSR C1	25.0c	34.3e	0.32e	0.62k	0.00e	0.00e	0.00d	0.00e	0.25b	0.30g	41.7c	26.7e
25	2000SYN EE-W STR	55.0ab	58.3b-e	2.64b-e	2.52hij	0.00e	0.33e	3.33cd	0.00e	2.32b	1.03efg	73.3abc	43.3de

26	LNTP-W C3	64.3ab	75.0a-d	2.46cde	4.43f-j	0.00e	0.00e	0.00d	0.00e	1.87b	1.66d-g	69.7abc	78.7ab
27	SUWAN 1-SR Y	59.0ab	53.3cde	6.22a-d	5.33e-i	0.33de	1.00e	3.33cd	0.00e	2.63b	1.76d-g	78.3abc	35.0e
28	DMR LSR Y	79.0ab	51.7de	4.42a-e	4.45f-j	0.00e	0.00de	0.00d	3.33de	3.71b	1.92c-g	76.3abc	43.7cde
29	SW6- OB-W	45.3ab	66.7a-d	4.36a-e	4.26f-j	0.00e	0.00e	3.33cd	0.00e	1.21b	1.38d-g	99.3a	78.3ab
30	ART/98/SW1	60.0ab	61.0b-e	2.79a-e	3.55g-j	0.66cde	1.00de	3.33cd	3.33de	1.83b	2.00c-g	87.7a	66.0bcd

Means along a column with the same letters are not significantly different according to Tukey's HSD ($p < 0.05$)

%BS = Percentage bored stem; %TL = Percentage Tunnel Length; DH = Dead heart; %LS = Percentage lodged stem;

%CDP = Percentage cob damage; MNEP = Mean number of exit hole per plant

Table 5: Maize grain yield in the early and late seasons

S/N	Accession	Total Grain Wt. (g)	
		Early	Late
1	TZM 238	41.47b-f	42.93hi
2	TZM 43	53.74a-f	53.67fgh
3	TZM 1277	56.74a-f	55.95fgh
4	TZM 1273	58.87a-e	62.34d-g
5	TZM 1438	50.41a-f	51.87fgh
6	TZM 217	56.43a-f	57.51fg
7	TZM 132	59.66a-e	60.29efg
8	TZM 99	25.69ef	27.97j
9	TZM 1353	38.43b-f	42.22hi
10	TZM 157	62.73a-d	62.33d-g
11	TZM 1439	68.90abc	51.81fgh
12	TZM 224	55.70a-f	52.91fgh
13	TZM 148	59.98a-e	59.21fg
14	TZM 232	62.98a-d	65.81c-f
15	TZM 137	21.27f	23.29j
16	TZM 212	28.46def	30.80ij
17	TZM 223	57.56a-e	60.79efg
18	EVDT-Y2008STR	47.22b-f	56.80fgh
19	TZEE-Y POP STR C4	71.11ab	60.47efg
20	TZE-WDTSTR C4	33.80c-f	60.20efg
21	DTSR-W CO	54.23a-f	42.66hi
22	AMA TZBR C3 W	25.11ef	48.29gh
23	TZBR ELD-3 C5	74.84ab	75.33a-d
24	BR9928-DMRSR C1	85.42 ^a	88.33a
25	2000SYN EE-W STR	66.85 ^{abc}	73.54b-e
26	LNTP-W C3	48.47 ^{b-f}	51.35fgh
27	SUWAN 1-SR Y	68.79 ^{abc}	76.64abc
28	DMR LSR Y	70.09 ^{abc}	80.29ab
29	SW6- OB-W	65.97 ^{abc}	52.25fgh
30	ART/98/SW1	56.76 ^{a-f}	54.50fgh

Means along a column with the same letters are not significantly different according` to Tukey`s HSD ($p < 0.05$)