Original Research Article

Genetic Diversity and Responses of Some Selected Yellow Maize Genotypes to Stem Borer (*Sesamia calamistis* Hampson) infestation

ABSTRACT

Aims: Identification of promising resistant parents against stem borer infestation for the development of high yielding maize hybrids.

Study design: Ten yellow maize genotypes selected for yield potential and durable level of tolerance to stem borer infestation were used in this study. A stem borer resistant yellow maize variety was crossed with nine stem borer (not necessarily resistant) maize varieties in a top-cross mating design.

Place and Duration of Study: The study was conducted in 2017 and 2018 at the Institute of Agricultural Research and Training, OAU, Ibadan, Nigeria.

Methodology: The resulting nine F_1 hybrids along with the ten parents were evaluated under irrigation using a Randomized Complete Block Design (RCBD) with three replications in a stem borer endemic area. Data collected were subjected to combined analysis of variance (ANOVA), principal component analysis (PCA) and hierarchical clustering analyses.

Results: Results obtained showed significant differences for year and genotype, as well as their interaction for some traits measured. Maize varieties were delineated into three groups. The first two PCA with Eigen values greater than 1.0 accounted for 73.0% of the variation; where PC1 was responsible for 52.5% of the variation and was associated with percentage stem borer infestation, leaf damage, plant aspect, stem tunneling ratio and dead heart. PC2 accounted for 20.5% and associated with only grain yield (GY). Also, maize hybrids had higher GY and better resistance to stem borer than their parents by 24.3% and -14.3%, respectively. BR9928-DMR-SR-Y was identified as resistant to stem borer with high GY in hybrid combinations. Positive and significant correlation was obtained among infestation parameters.

Conclusion: Genes from promising donor parents may be introgressed into other desirable maize germplasm for the development of stem borer resistant maize hybrids.

Keywords: Maize; Resistance; Grain yield; Principal component analysis; Pearson's correlation; Top cross mating design; Hierarchical clustering analysis

1. INTRODUCTION

Maize (*Zea mays L*) is an important cereal crop in Africa serving as source of food and industrial raw material for industries such as brewery, confectionery, livestock and flour feed mills (Olakojo, 2001). Despite its importance, maize grain yield is severely constrained by biotic stress, especially stem-borer (*S. calamistis*) infestation.The activities of the stem-borers' larvae on maize plants result in leaf feeding and stem tunnelling, which in turn leads to reduced translocation of nutrients and assimilates to appropriate sinks, death of young plants (dead heart), lodging of older plants and direct damage to maize ears (Bosque-Perez and Mereck, 1990; Santiago *et al*, 2017).

The South western zone of Nigeria is characterized by bimodal rainfall pattern and high solar radiation, which favours maize production. However, tropical environments are also favourable to insect pest development, leading to rapid formation of several generations during the life of the host plant and can cause severe yield loss (Mailafiya *et al*., 2011; Rodriguez *et al*, 2018). The incidence of stem borer had become a major problem militating against increased maize production, resulting in low yield or no yield in some extreme cases. In Africa, yield loss of 20-40% have been recorded; and in Nigeria, about 14% yield loss was reported in 2012 (FAOSTAT, 2012).

Control measures advocated for stem borers include direct use of insecticides, cultural control practices especially intercropping, early planting as well as good farm health and sanitation such as burning of crop residue and the use of host plant resistance (Ngwuta *et al*., 2001; Gohole, 2003). However, there is limited germplasm with resistance to pests in maize (Derera *et al.,* 2016). Thus, breeding for stem borer resistance or tolerance offers an economically viable option compatible with the low input requirement of the subsistence farmers. Assessment of stem borer maize tolerant genotypes for the stem borer endemic zones will produce varieties that may either be used directly or further improved for use in planned breeding programme (Mwimali *et al*, 2016; Badji *et al,* 2018). Since the use of chemicals to control stem borers appears not to be environmentally safe and is quite expensive, host plant resistance is a cheap, sustainable and affordable option for control of stem borer (Jimenez-Galindo *et al*, 2017; Przystalski and Lenartowicz, 2017). Hence, the objective of this work was to evaluate and identify some stem borer resistant parents and cross with desirable materials for tolerance to stem borer infestation to produce breeding lines that can be used for further improvement and to expand the gene pool.

2. MATERIAL AND METHODS

2.1 Site characteristics

The experiment was conducted at the experimental field of the Institute (I.A.R.&T) located in the Forest-savannah agro-ecology of South-western Nigeria (7°23'47"N 3°55'0"E and 275m above sea level). The location was chosen for its endemic nature to stem borer infestation.

2.2 Maize varieties used

Nine stem borer susceptible open pollinated maize varieties and a known stem borer resistant maize variety (BR9928 DMR SR-Y) were used as genetic materials in this study. These varieties were collected from the gene bank of the Institute of Agricultural Research and Training (I.A.R&T), Obafemi Awolowo University, Ibadan, Nigeria and International Institute of Tropical Agriculture (IITA), Nigeria (Table 1).

Table 1: list of the yellow maize varieties used as genetic materials and their source

S/N	Yellow maize varieties	Source
1	BR9928 DMR SR-Y	I.A.R.&T
2	ART 98-SW1-Y	I.A.R.&T
3	PRO VIT-A	I.A.R.&T
4	DMR-ESR-Y	IITA
5	DMR-LSR-Y	IITA
6	SUWAN-1-SR-Y	I.A.R.&T
7	LNTP-C6-Y	I.A.R.&T
8	DTSTR-Y-SYN 15	IITA
9	DTSTR-Y-SYN 14	IITA
10	STR-SYN-Y2	IITA

2.3 Experimental design and cropping conditions

The check (BR9928 DMR SR-Y) was used as donor parent in a top-cross mating design to nine stem borer susceptible yellow maize to generate 9 top cross hybrids in 2016. The 9 top cross hybrids were evaluated along with the 9 parents and a check under natural stem borer infestation in an earlier identified endemic location for two years (2017 and 2018) under sprinkler irrigation. Hot weather favors rapid stem borer multiplication and development, so evaluations were made towards the end of second season (October - December) in Nigeria. The experiment was laid out in a randomized complete block design with three replicates. Three seeds were sown and later thinned to two stands per hill two weeks after planting (2 WAP) to attain a plant population of 53,333 plants ha^{-1}. Hoe weeding was done when due, and N. P. K 15:15:15 fertilizer was applied at the rate of 100kg/ha at 3 WAP. Urea was applied at the rate of 100kg/ha for grain filling at 6 WAP.

2.4 Data collection

Yield data and insect damage rating were taken as follows:

$$\frac{\text{No of infected plants}}{\text{Total number of plants per plot}} \quad \text{X} \quad 100$$

- The percentage level of incidence was determined as follows:
- Leaf feeding damage: Plants were evaluated for leaf damage using scores of 1 (resistant: no visible leaf feeding damage) to 9 (Highly susceptible: plant dying as a result of foliar damage) at the V9 stage (Tefera *et al.,* 2011).
- Plant Aspect: This is a general appeal of plants in the whole plot. It entails assessment of plant and ear heights, uniformity of the stand, reaction to diseases and insects, and lodging resistance. This was taken at brown silk stage before harvesting when plants were still green and the ears were fully developed. Plant aspect was scored on a scale of 1 to 5, where 1 represents excellent appearance; and 5: represents very poor appearance (Olakojo and Olaoye, 2005).
- Stem tunneling ratio: This is the ratio of the total length of tunneling along the maize stalk to the plant height in cm at maturity before harvest.
- Dead heart: measured as the number of dead plants in a plot resulted from stem borrowing by the stem borer larvae.
- At maturity, all the crosses were harvested, bulked, shelled and dried to determine grain yield (t/ha) according to Olakojo and Olaoye (2005).
- A rank summation index (RSI) was constructed to determine the ranking of each line within the population for suitable response. An entry with the least value was ranked higher for the resistance traits. The rank selection index was determined as follows:

  $$\text{RSI}=\sum \text{Ri's}$$

  Where Ri is the rank of mean of each of the desired traits. Rank summation index is the mean performance of each of the desired traits of each genotype using the ranking of % incidence, leaf feeding damage score, plant aspect, stem tunneling ratio, number of dead-hearts and grain yield.

2.5 Data analysis

Data analysis was done using the Statistical Tool for Agricultural Research (STAR) Version 2.0.1 (Nebular, 2017). Data obtained were subjected to combined analyses of variance (ANOVA). Differences between the treatments were made using Duncan Multiple Range Test (DMRT) at 5% levels of significance. Principal component analysis was carried out and components with Eigen values > 1.0 were considered. Contributing characters with values > 0.6 were considered relevant for principal components (Matus *et al.,* 1999). Maize varieties were clustered into groups based on hierarchical clustering using squared Euclidean distance. Pearson's coefficient of correlation between pair of traits was determined.

3. RESULTS

3.1 Pre-planting physical and chemical soil properties of experimental site

Table 2 shows the physicochemical soil properties before land clearing and preparation. The result indicated that the soil was slightly acidic with pH of 6.00, and soil total N (0.5g/kg) showing very low fertility and low organic carbon (8.6g/kg). Exchangeable K was also low (0.37cmolkg^{-1}).

Table 2. Physico-chemical soil properties of experimental site

Chemical property	
pH	6.00
Organic carbon (g/kg)	8.60
Total nitrogen (g/kg)	0.50
Available P (mg/kg)	7.00
Exchangeable cation (cmol kg-1)	
K^+	0.37
Na^+	0.63
Ca^{2+}	3.80
Exchangeable micronutrient(mg/kg)	
Fe^{2+}	0.06
Zn^{2+}	0.65
Cu^{2+}	0.15
Mn^{2+}	44.10
Soil particle analysis (%)	
Sand	84.20
Silt	8.60
Clay	7.20
Textural class	Sandy loam

3.2 Weather conditions

This location had a minimum and maximum mean annual temperature of 21.08°C and 32.83°C respectively in 2017 and 21.25°C and 32.58°C respectively in 2018. The annual mean rainfall for this location were 96.75mm and 101.58mm for 2017 and 2018 respectively. Irrigation was done at a calculated rate equivalent to 160mm/month of rainfall for November and December in 2017 and 2018. The weather data for the duration of the study is in the table below;

Table 3. Climatological information during the evaluation at the experimental site in Ibadan for years 2017 and 2018.

Year	Rainfall			Temperature			Relative Humidity		
	Oct.	Nov.	Dec.	Oct.	Nov.	Dec.	Oct.	Nov.	Dec.
2017	148	19	2	33	33	33	85	81	76
2018	162	0	0	32	32	32	87	84	77

3.3 Analysis of variance and mean performance of yellow maize genotypes

Table 4 shows the mean squares of the analysis of variance (ANOVA) for grain yield and infestation parameters from maize hybrids and ten parents evaluated in 2017 and 2018. Genotypes exhibited significant differences in all of the parameters measured which include grain yield, leaf damage, plant aspect and dead heart except percentage infestation and stem tunneling ratio (p= 0.05). Year effect only had significant effect on dead heart (P= 0.05). Y x G interaction had no significant effect on any of the parameters measured in this study. It was observed that parent BR9928 DMR SR-Y had the lowest percent infestation (11.47%) and tunneling ratio (2.17) but with low yield of 1.38t/ha whereas ART 98-SW1-Y had the highest percent infestation (29.84%) and dead heart (1.67) as well as low grain yield (1.42 t/ha). Highest grain yield was recorded in hybrid BR9928 DMR SR-Y x DMRLSR-Y (2.69 t/ha) followed by BR9928 DMR SR-Y x DTSTR-Y-SYN 14 with grain yield of 2.59 t/ha with relatively low level of infestation (<20%) while hybrid BR9928 DMR SR-Y x SUWAN-1-Y recorded lowest yield of 1.04 t/ha with percent infestation of 25.27%. The yellow maize hybrids had higher grain yield than their parents by 24.28% and better resistance to stem borer than their parents by -14.35%. The highest variability of 84.96% based on coefficient of variation (CV) was obtained in stem tunneling ratio whereas plant aspect had the lowest CV (13.36%) (Table 4).

Table 4. ANOVA, Mean grain yield and stem borer parameters ratings from the trial across locations and year (2017 and 2018)

	Grain yield	% incidence	Leaf damage	Plant aspect	Stem tunnel	Number of dead

	(tha $^{-1}$)	(0-100)	(1-9)	(1-5)	ratio (TL: PH)	heart/plot
Parents						
BR9928 DMR SR-Y	1.38ef	11.465	2.12ab	3.50ab	2.17	0.83ab
ART 98-SW1-Y	1.42ef	29.84	4.68a	3.00b	11.50	1.67a
PRO VIT-A	1.38ef	25.475	1.39b	3.67ab	7.17	0.50b
DMR-ESR-Y	2.49abc	26.885	2.86ab	3.67ab	8.84	0.83ab
DMR-LSR-Y	1.61def	22.105	2.31ab	4.17a	5.67	0.50b
SUWAN-1-SR-Y	1.09f	23.645	3.47ab	3.83ab	6.67	1.33ab
LNTP-C6-Y	1.88bcde	16.005	2.63ab	3.67ab	3.83	1.00ab
DTSTR-Y-SYN 15	2.16abcde	22.07	3.20ab	3.83ab	8.84	1.17ab
DTSTR-Y-SYN 14	1.76cdef	14.985	2.37ab	3.67ab	6.50	0.67ab
STR-SYN-Y2	2.13abcde	21.55	2.69ab	3.17ab	5.83	1.17ab
Hybrids						
BR9928 DMR SR-Y*ART98-SW1-Y	2.44abc	22.315	3.86ab	3.83ab	9.67	1.67a
BR9928 DMR SR-Y*PROVIT-A	1.90bcde	17.43	2.45ab	3.67ab	3.84	0.83ab
BR9928 DMR SR-Y*DMR-ESR-Y	2.36abcd	14.11	2.73ab	4.00ab	3.83	1.00ab
BR9928 DMR SR-Y*DMR-LSR-Y	2.69a	16.735	2.46ab	3.67ab	3.84	1.00ab
BR9928 DMR SR-Y*SUWAN-1-SR-Y	1.07f	25.27	2.57ab	3.67ab	6.00	1.00ab
BR9928 DMR SR-Y*LNTP-C6-Y	1.88bcde	19.795	2.49ab	3.67ab	4.50	1.00ab
BR9928 DMR SR-Y*DTSTR-Y-SYN 15	2.21abcd	11.74	1.99b	4.17a	2.67	0.83ab
BR9928 DMR SR-Y*DTSTR-Y-SYN 14	2.59ab	19.35	2.63ab	3.67ab	4.17	1.00ab
BR9928 DMR SR-Y*STR-SYN-Y2	2.23abcd	18.225	3.10ab	3.33ab	5.50	1.17ab
ANOVA						
Year (df= 1)	0.06	903.64	0.5586	0.22	27.50	26.53*
Replicate within year (df= 4)	0.09	3390.09**	53.94**	0.83*	350.75**	1.98**
Genotype (18)	1.49**	156.48	55.65*	0.51*	37.30	0.60*
Year x Genotype (df= 18)	0.004	61.06	0.083	0.27	4.86	0.23
Pooled Errors (df= 72)	0.34	142.91	115.09	0.24	24.63	0.29
Parents mean	1.73	21.4	2.772	3.62	6.70	0.97
Hybrids mean	2.15	18.33	2.7	3.74	4.89	1.06
CV(%)	30.23	59.93	46.19	13.36	84.96	54.05

*TL:PH: ratio of tunnel length to plant height.

3.4. Principal component analysis of tested maize genotypes

Principal component analysis (PCA) of grain yield and stem borer infestation parameters showed that two component axes had Eigen values greater than 1.0 and accounted for 72.96% of the total variation. Relative discriminating power of the PCA as revealed by Eigen value was 3.15 and 1.23 for PC 1 and PC 2, respectively. PC 1 was responsible for 52.49% of the variation and was associated with percentage infestation, leaf damage, plant aspect, stem tunneling ratio and dead heart while PC 2 accounted for 20.47% and associated with only grain yield (Table 5).

Maize varieties evaluated were delineated into two main clusters at the rescaled distance of 20 units (Figure 1). Cluster 1 had eleven maize genotypes whereas second main cluster comprised of only one maize variety. Also, main cluster 1 was further subdivided into two sub-clusters or groups, where sub-cluster 1 had eight maize varieties such as BR9928 DMR SR-Y (check), LNTP-C6-Y, DTSTR-Y-SYN 14, DMR-LSR-Y, STR-SYN-Y2, SUWAN-1-SR-Y, DTSTR-Y-SYN 15 and DMR-ESR-Y. This group had low to high grain yield and moderate to high resistance to stem borer infestation. Also, sub-cluster 2 comprised of only PRO VIT-A. This variety is characterized by moderate grain yield with low resistance to stem borer infestation. On the other hand, the second main cluster had only ART 98-SW1-Y. This variety had lowest grain yield and was susceptible to stem borer infestation.

Table 5. Principal component, Eigen values and variation

Parameters	PC 1	PC 2
Grain Yield (t ha^{-1})	0.05	0.62*
% Infestation (0-100)	0.74*	0.49
Leaf damage (1-9)	0.90*	-0.18
Plant aspect (1-5)	-0.60*	0.44
Stem tunneling Ratio (TL:PH)	0.83*	0.46
Number of dead heart	0.86*	-0.41
Eigen values	3.15	1.23
percentage variation	52.49	20.47
Cumulative	52.49	72.96

* Significant contribution traits; PC: Principal components

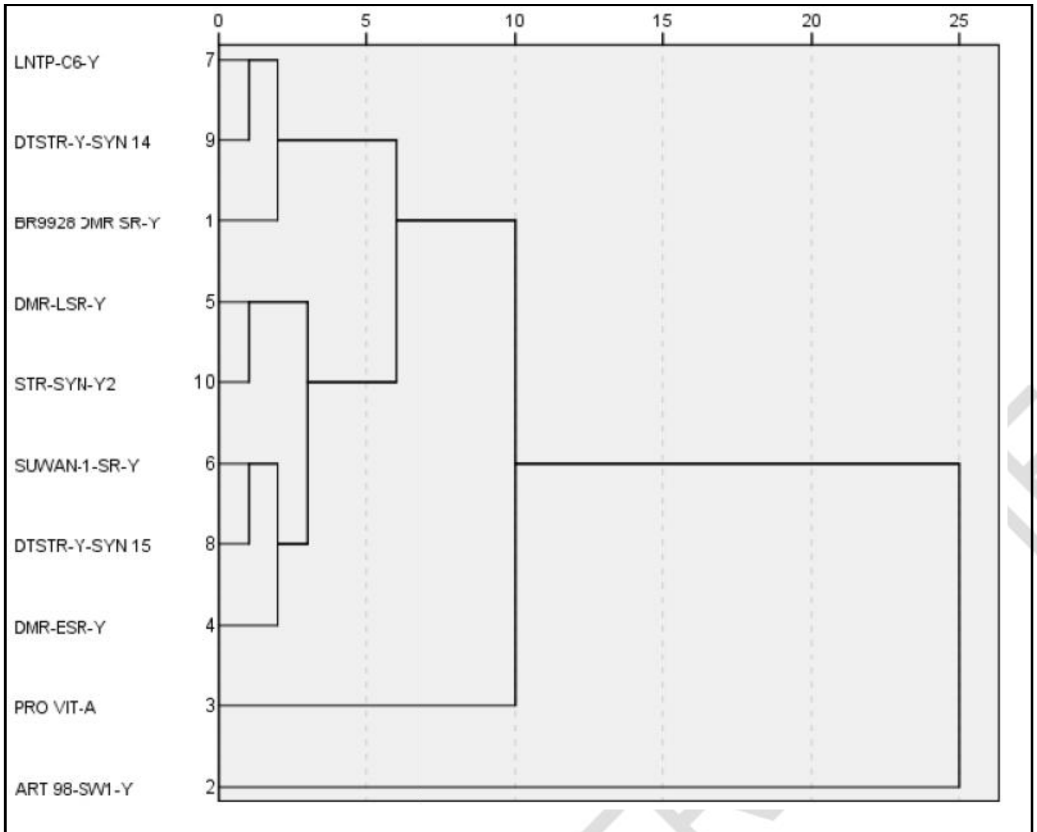

Figure 1. Dendrogram cluster of the 10 yellow open pollinated maize varieties evaluated in stem borer endemic location based on hierarchical clustering using squared Euclidean distance at the rescaled distance of 20 units.

3.5 Rank Summation Index (RSI) for the maize populations

The RSI of the maize varieties and population in relation to stem borer infestation is shown in Table 4. BR9928 DMR SR-Y had the highest ranking of 21.46, while cross BR9928 DMR SR-Y x DTSTR-Y-SYN 15 had the lowest ranking of 52.11. BR9928 DMR SR-Y, BR9928 DMR SR-Y x ART 98-SW1-Y, BR9928 DMR SR-Y x SUWAN-1-SR-Y, BR9928 DMR SR-Y x DMR-LSR-Y and BR9928 DMR SR-Y x DTSTR-Y-SYN 14 were the top five in ranking for stem borer resistance with RSIs of 21.46, 23.61, 28.04, 29.01 and 29.95 respectively (Table 4). The poorest was the hybrid BR9928 DMR SR-Y x DTSTR-Y-SYN 15 with RSI 52.11.

Table 6. Rank Summation Index (RSI) for the maize populations

S/N	Populations	Rank Summation Index (RSI)
1	BR9928 DMR SR-Y	21.46
2	BR9928 DMR SR-Y x ART 98-SW1-Y	23.61
3	BR9928 DMR SR-Y x SUWAN-1-SR-Y	28.04
4	BR9928 DMR SR-Y x DMR-LSR-Y	29.01
5	BR9928 DMR SR-Y x DTSTR-Y-SYN 14	29.95
6	STR-SYN-Y2	30.11
7	PRO VIT-A	30.39
8	DTSTR-Y-SYN 15	33.33
9	DMR-ESR-Y	33.40
10	ART 98-SW1-Y	33.55
11	DTSTR-Y-SYN 14	36.36
12	BR9928 DMR SR-Y x STR-SYN-Y2	36.54
13	SUWAN-1-SR-Y	39.58
14	BR9928 DMR SR-Y x DMR-ESR-Y	39.58
15	BR9928 DMR SR-Y x PRO VIT-A	40.04
16	BR9928 DMR SR-Y x LNTP C6-Y	41.27
17	DMR-LSR-Y	43.78
18	LNTP-C6-Y	45.56
19	BR9928 DMR SR-Y x DTSTR-Y-SYN 15	52.11

*The lower the RSI score the better

3.6 Correlation between maize grain yield with stem borer infestation parameters

Results revealed positive and non-significant associations between grain yield (GY) with percentage incidence (r= 0.004), leaf damage (r= 0.09), dead heart (r= 0.06) and stem tunneling ratio (0.02), but GY was inversely correlated with plant aspect (-0.01). Also, among the stem borer infestation parameters, it was observed that there was positive and highly significant correlation between percentage incidence with leaf damage (r= 0.53**) and stem tunneling ratio (r = 0.86**). Positive and significant relationship also existed between leaf damage and dead heart (r = 0.65**) and stem tunneling ratio (0.74**). Positive and significant correlation was obtained between dead heart and stem tunneling ratio with a coefficient of correlation r= 0.32** (Table 7).

Table 7. Pearson coefficient of correlation (r) between pairs of grain yield with stem borer resistance traits in the yellow maize population

	% incidence	leaf damage	Plant aspect	Number of dead heart	Stem tunneling ratio	Grain yield
% Infestation	-	0.53**	-0.26	0.15	0.86**	0.004
Leaf damage		-	-0.37	0.65**	0.74**	0.09
Plant aspect			-	-0.13	-0.23	-0.01
Dead heart				-	0.32*	0.06
Stem tunneling ratio					-	0.02
Grain yield						-

Significant at P<0.05, and 0.01 respectively

4. DISCUSSION

Genetic variation is a prerequisite for a successful crop improvement program. Knowledge of genetic variation and relationships between accessions or genotypes is important to appreciate the available variability and its potential for use in breeding programs (Yoseph *et al.,* 2005; Akinyosoye *et al.,* 2017).

The array of genetic diversity observed in most of the traits measured may be attributed to different genetic backgrounds of the genotypes evaluated in this study. Significant differences obtained for year, genotype as well as their interaction in some of the traits measured, means that the performances of the maize genotypes were not consistent across the years of evaluation as a result of unmeasured environmental influences. This might provide an opportunity for selecting for varied agro-ecologies and traits of interest under endemic stem borer conditions. Grzesiak (2001) reported considerable genotypic variability for traits studied in different maize populations. Hence, genetic variability in this study will be an opportunity for breeders selecting for stem borer resistance, especially for varied agro-ecologies like Nigeria.

Yellow maize varieties were delineated into three groups based on hierarchical clustering using squared Euclidean distance at the rescaled distance of 20 units. This points out that genotypes within the same cluster exhibit high homogeneity and high heterogeneity between the clusters (Akinyosoye *et al.*, 2017). The results obtained from the PCA showed that PC1 and PC2 accounted for 72.96% of the variation, where PC 1 was responsible for 52.49% of the variation and was associated with percentage incidence, leaf damage, plant aspect, stem tunneling ratio and dead heart while PC 2 accounted for 20.47% and associated with only grain yield. These identified parameters had PC values > 0.6 and could be regarded as major contributors to the total variation. Matus *et al*. (1999) and Akinyosoye *et al*. (2017) had earlier reported that PC values > 0.6 could be regarded as major contributors to the total variation. Hence, effective selection could be carried out based on the identified traits among maize genotypes when screening for stem borer resistant maize genotypes.

Five crosses (BR9928-DMR SR-Y x ART 98-SW1-Y, BR9928 DMR SR-Y x DMR-ESR-Y, BR9928 DMR SR-Y x DMR-LSR-Y, BR9928 DMR SR-Y x DTSTR-Y-SYN 15, BR9928 DMR SR-Y x DTSTR-Y-SYN 14 and BR9928 DMR SR-Y x STR-SYN-Y2) with the check (BR9928 DMR SR-Y) had considerable higher yields and were fairly resistant to stem borer infestation. For instance, BR9928 DMR SR-Y apparently possessed dominant resistant gene(s) for stem borer infestation and also contributed higher grain yield in hybrid combinations. It could be used for the development of stem borer resistant maize inbreds with high grain yield. Also, maize hybrids had higher grain yield and better resistance to stem borer than their parents by 24.28% and -14.35%, respectively. This indicates occurrence of heterosis among the maize genotypes used in this study. This is also a clear indication that the parental lines used for hybrid development contributed significantly to genetic components of the hybrid vigor observed in this work.

Selection indices (RSI) for stem borer resistant traits provide effective selection in the improvement of quantitatively inherited traits as earlier reported by Mulamba and Mock (1978). In this study, four of the crosses BR9928 DMR SR-Y x ART 98-SW1-Y, BR9928 DMR SR-Y x SUWAN-1-SR-Y, BR9928 DMR SR-Y x DMR-LSR-Y, BR9928 DMR SR-Y x DTSTR-Y-SYN 14 and the check (BR9928 DMR SR-Y) were the best five in the ranking of the maize hybrids. The level of tolerance exhibited by the crosses in this study conforms to CIMMYT (1989) report.

Grain yield is a complex character which is a product of the interaction between many plant traits that are influenced genetically and the environment where grown (Malik *et al.,* 2009**).** Direct evaluation of yield can be misleading because it is a complex trait and the effect of environment can contribute to actual yield. Positive and significant correlation obtained among stem borer infestation parameters (percent stem borer infestation, leaf damage, stem tunneling ratio and dead heart) in these yellow maize, suggests that the selection for one will lead to improvement of others due to their mutual relationship. The non-significant correlations obtained between grain yield with percent stem borer infestation, leaf damage, stem tunneling ratio and dead heart in yellow maize population shows that they do not have a noticeable direct relationship with grain yield and cannot be used as selection criteria for enhanced maize grain yield.

The result obtained in this study corroborates the earlier report of Odiyi (2007) who reported positive and significant correlations between grain yield, leaf damage and stem tunneling. He then suggested that leaf feeding damage and dead heart formation did not lead to a significant reduction in maize yield due to stem borer damage. This perhaps calls for a better maize stem borer parameter(s) for assessing maize genotypes in breeding for stem borer resistance, rather than total reliance on the above listed parameters.

5. CONCLUSION

In this study, hybrids BR9928 DMR SR-YxART 98-SW1-Y, BR9928 DMR SR-YxDMR LSR Y, and BR9928 DMR SR-YxDTSTR-Y-SYN 14 may further be tested for resistance to stem borer in multi-locations in stem borer endemic areas as promising top cross hybrids for release to farmers. Also, promising parent BR9928-DMR-SR-Y (check) possessed resistant gene against stem borer infestation and also contributed to high grain yield in hybrid combinations. Hence, gene from this promising parent may be introgressed into other maize germplasm in the development of stem borer resistant maize hybrids for enhanced grain yield.

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