ISSN NO. 2320-5407

Journal homepage: http://www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH

RESEARCH ARTICLE

GENOTYPIC PERFORMANCE OF 15 MAIZE CULTIVARS FOR STEM BORER RESISTANCE IN OWERRI WEST, SOUTH EASTERN NIGERIA.

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Manuscript Info

Manuscript History:

Received: 15 June 2014
Final Accepted: 29 July 2014
Published Online: August 2014

Key words:

maize genotypes, stem borers, Host Plant Resistance(HPR), uni- and multivariate analyses, Rank Summation Index (RSI).

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Abstract

One of the major biotic constraints to increased maize production in Nigeria is the parasitic insect, stem borers which cause yield losses ranging from 50 – 75%. Genetic diversity for a range of agronomic and resistance attributes with 15 local maize collections from Abia and Imo states of Nigeria were evaluated in field trials in randomized complete block design (RCBD) with five replications in late season of 2010 and early season of 2011. Data collected from the evaluations were subjected to both uni- and multivariate analyses. Rank Summation Index (RSI) identified 3 best genotypes (Um-Dik, Oka-Aki and Oha-Gbem with RSI values of 58, 61 and 71 respectively) representing top 20% of the total as resistant. Out of the two principal component functions obtained, the two had significant (p = 0.05) values accounting for over 98.81% of the total variation. Also, out of a total of five discriminant clusters formed, the clustering pattern revealed that clusters; I, II and IV comprise of early emerging (52 days to silking), high productive (3.33t/ha) and resistant (5.83%) genotypes respectively. The correlation analysis result showed that the grain yield had significant and positive relationships with plant height, ear at harvest, ear per plant and field weight.

Introduction

Two planting seasons of maize are possible per year in Southeastern Nigeria: mid-March to first week of April for early planting and August- September for late planting (Obi, 1991). The maize produced in the early season is quickly consumed to avoid spoilage by fungi due to high humidity. Storage is best with late season maize production. Incidentally, late season maize production is seriously limited by the activities of stem borers which is one of the major biotic constraints to increased maize production in Nigeria and could cause yield losses ranging from 50-75% (Daramola, 1985). Stem borer infestation ranging from 30 to 40 percent and above have also been recorded during the late (second) cropping season by Daramola, (1985). In bad years, heavy borer infestation may lead to total crop failure. According to John (1979), in USA, yields reduction due to corn borer has led to replacement of corn by sorghum in Oklahoma and in some other states where sorghum is adapted. Anon (1981) divided Nigeria into three 'Stem borer ecological areas' viz: Southern area of *Sesamia calamistis*, Western area of *Eldana saccharina* and Northern area of *Busseola fusca*. *Sesamia calamistis* commonly called pink stalk borer is the most destructive field pests in southern Nigeria. The larvae bore in the stem of the various graminaceous crops, weakening the stem mechanically, and reducing the crop yield. Early damage results in maize 'dead heart' with the destruction of the central shoot. *Sesamia calamistis* and *E. saccharina* are polyphagous and can feed on maize, sugarcane and sorghum (Sekloka, 1996). The damages associated with stem borers include: ear damage, tassel breakage, stalk lodging, dead heart, ear dropping, leaves binding, excess tillering, window pane, etc. (Dennis, 1983 and Obi, 1991). According to Girling (1980), 10- 100 % yield loss has also been reported. Consequently, control measures advocated for stem borers are cultural, biological, chemical, and the use of host plant resistance (HPR). However, chemical insecticides are undesirable because of its effects on non-target organisms (Carson, 1962) and its problem of residues (carcinogenic and mutagenic) (Kaeman *et al*., 1972). Cultural control measures alone have also not provided the answer since these practices are generally labour intensive and the high cost of labour in some developed and developing world has led to their abandonment. Biological control is inexpensive and presents no health hazards or environmental pollution. However, the major shortcoming is the lengthy detailed ecological studies that are required before a successful package can be developed. The category of farmers in Africa cannot afford the cost of these control measures, but their aggregate production forms the bulk of maize produced in the continent to date. Host plant resistance (HPR), therefore hold the best promise and simplest potential for stem borer control as this comes as a package in the seed. Host plant resistance is a heritable characteristic by which a plant species may reduce the probability of successful utilization of that plant as a host by an insect species (Painter, 1951). Mechanism of resistance disrupts the normal behaviour pattern of pests or causes them to wander around which exposes them to predators. Resistant plants have special features which make it less attractive or unacceptable to the pest (Kogan and Ortman, 1978). Such plants are characterized by anatomical features such as thick cuticle, hairy stems and leaves, a thickened stem (cereals), a narrow diameter of the pith in cereal stem and tightness of husk in maize (Dennis, 1983). Biochemical features include differences in the chemical constitution of the plants with Gossypol, Dimboa, phenolic compounds and silicate deposits in leaves and stem of various graminaceous crop (Kumar, 1999). These features disrupt one or more stages of insect's establishment on plants (Noris and Kogan, 1980). Crop plants were domesticated over a very long period of time but the early germplasm resources accumulated in the process are being eroded very rapidly. The concept of collecting gene pool diversity is important to identify maize genotypes that can appropriately fit into the agro-environment which will ensure stability and satisfactory yields in the local area and for crop improvement (Onyishi *et al*.,2013). This study was carried out to determine the genetic diversity for a range of agronomic and resistance attributes of 15 local maize cultivars and to identify the maize cultivars of high yielding with stem borer resistance.

MATERIALS AND METHODS

The field experiment were conducted during the two planting seasons (early and late) of 2010 and 2011 at the Teaching and Research Farm, Federal University of Technology, Owerri, which is located at latitude $05^0 27^I$ N and longitude $07^0 2^I$ E with altitude 90.91m above sea level (ASL). The site has a mean annual rainfall of 21.9cm and relative humidity of 81.6%. At the site, the land was cleared and was not ploughed. This is to avoid the destruction and incorporation of the stubs of maize which serves as a potential carry-over and reservoir of stem borer from one season to another. Fields that were previously used for maize cultivation were used to optimally expose the genotypes to natural field condition in a stem borer endemic environment. The late season trials were established on 24^{th} August, 2010 in a field where maize was previously harvested (natural induced epiphytotics). Early season trial were established on 5^{th} of May, 2011, using the seeds from inbred lines obtained through controlled self-pollination in the same field where the late cropping maize was harvested. The experiments were laid out in a Randomized Complete Block Design with five replications. The 15 maize genotypes used in the research were sourced from different localities in Imo state and Abia state located in maize producing areas of South Eastern Nigeria where they are cultivated mainly by the local farmers (Table 1). The experimental plants were established using the plant spacing of 0.25 × 0.75m, within and between rows respectively, giving a plant population of 53,333 plants per hectare in all the planting seasons that the study lasted. Adequate field maintenance was carried out to ensure best crop performance.

Data collection

Data on 2 agronomic and 6 stem borer damage parameters were collected in the two years and pooled. The mean from the two years data were subjected to statistical analyses.

Statistical analyses

Analysis of variance (ANOVA) was computed separately for the genotypes in each planting season (early and late) and then combined together. Several criteria have been used to select promising genotypes, with crop yield and yield components being the most important traits used (Mohammed *et al*., 2003). Ahmed *et al*. (1991) used early maturity while Bridge (2000) used crop resistance to select superior genotypes. Procedures used include; Principal Component Analysis (Falowo, 1982), Canonical Discriminant Analysis (Daogu and Lawes, 2000), Correlation

(Ofori, 1996) and Cluster Analysis (Kozak and Kang, 2007). Discriminant analysis was used to find a linear combination of the measured trait that maximizes differences among pre-existing population and to sort the genotypes into their appropriate group with minimum error (Daogu and Lawes, 2000). The canonical variables are essentially used for discriminating among the clusters. A rank summation index (RSI) method was also used to rank the genotypes for their overall performance (Ngwuta, 2008). To obtain the RSI, genotypes were first ranked for each parameter (that is 1 = best and 15 = poorest) and parameter ranks summed to generate overall performance of each genotype. Hence, the lower the RSI of any genotype, the greater is its resistance and the better is its agronomic performance. Using the RSI of the damage parameters and some important agronomic attributes as a selection index, selection among the cluster groups was made as proposed by Ajala *et al*. (1995). The analyses were performed using Genstat Discovery Edition 3 (Genstat, 2007) software, SAS and SPSS softwares.

RESULTS

The mean performances of the genotypes in the two seasons are presented in Table 2 to 4. Crop performance is a function of the genetic make-up and the season (environment), thus genetically healthy seeds perform best under favourable environment. Table 2 presents seedling survival (plant stand), stalk lodging and percentage dead heart. From the Table, plant establishment (plant stand) obtained in early planting season (32 plants) was greater than that obtained at the late season (26 plants). Aro-Egbema (V_7) had the highest mean plant stand (34 plants) whereas Ukworu (V_{13}) had the least number of plant stand (22 plants).The two seasons differed significantly among each other. With regards to stalk lodging, late season recorded higher mean stalk lodging of 5.24% which is greater than that recorded in early season (4.76%). Nse-Nguru (V_5) recorded the highest lodging of 7.33% whereas Um-Olok (V_2) and Ka-Eme (V_{11}) experienced the least lodging of 3.27% each. This indicates that Um-Olok and Ka-Eme possess special features such as thickened stem and narrow diameter of the hollow pith which made them less susceptible to lodging. There was no significant difference between the seasons in stalk lodging. The mean percentage dead heart was higher in late season (2.89%) as against 1.98% recorded in early season. Nse-Nguru (V_5) and Um-Dik (V_{12}) experienced least incidence of dead heart of 1.33 and 1.50% respectively. However, the genotypes; Um-Olok (V_2) and Aro-Egbema (V_7) were mostly affected with 4.0% each (Table 2). From Table 3, mean leaf feeding value at 9 point scale indicates that leaf feeding was high in late season (4.4) and low (2.47) in early season. Oka-Bende (V_1), Oha-Gbem (V_4) and Aro-Egbema (V_7) showed resistance to leaf feeding with 2.67 each. This is an indication of presence of hairy leaves, thick cuticle and biochemical constitution which made the genotypes less acceptable by leaf feeding insects. Conversely, Um-Olok (V_2) was mostly affected with the mean value of 4.67.

Table 1. Genotype code, names of the genotype and collection site of the maize genotype as potential source of resistance to stem borer.

Genotype code	Name of the genotype	Collection site
V_1	Oka-Bende	Bende, Abia State
V_2	Um-Olok	Umuahia, Abia State
V_3	Oka-Ngwa	Ngwa, Abia State
V_4	Oha-Gbem	Ohaji, Egbema, Imo State
V_5	Nse-Nguru	Mbaise, Imo State
V_6	Iku-Ukwuato	Ibeku Ukwuato, Imo State
V_7	Aro-Egbema	Aghoro, Imo State
V_8	Uk-Ibere	Ikwuano, Abia State
V_9	Ezi-Oka	Eziobodo, Imo State
V_{10}	Ag-Flat	Ndoro, Abia State
V_{11}	Ka-Eme	Emekuku, Imo State
V_{12}	Um-Dik	Umudike, Abia State
V_{13}	Ukworu	Obuohia, Abia State
V_{14}	Oka-Aki	Ibeku, Abia State
V_{15}	Awaka	Awaka, Imo State

Table 2. Mean number of plants that survived seedling stage, stalk lodging (%), and percentage dead heart (%) in two planting seasons.

	Number of seedling survival			Stalk Lodging (%)			Dead Heart (%)		
Genotype	Late season	Early season	mean	Late season	Early season	mean	Late season	Early season	Mean
Oka-Bende (V_1)	27.67	34.33	31.00	7.33	5.67	6.50	1.67	1.67	1.67
Um-Olok (V_2)	25.00	31.00	28.00	3.67	2.67	3.17	5.00	3.00	4.00
Oka-Ngwa (V_3)	24.00	30.00	27.00	6.00	5.67	5.83	2.33	1.67	2.00
Oha-Gbem (V_4)	24.00	30.33	27.00	5.00	3.33	4.17	2.33	1.00	1.67
Nse-Nguru (V_5)	28.67	34.33	31.50	7.33	7.33	7.33	1.67	1.00	1.33
Iku-Ukwuato (V_6)	25.67	31.67	28.67	6.00	6.33	6.17	3.33	2.33	2.83
Aro-Egbema (V_7)	31.33	37.67	34.54	7.33	5.00	6.17	4.47	3.33	4.00
Uk-Ibere (V_8)	23.00	29.00	26.00	4.00	5.00	4.50	2.00	1.33	1.67
Ezi-Oka (V_9)	20.33	26.33	23.33	4.33	4.00	4.17	3.33	2.33	2.83
Ag-Flat (V_{10})	23.67	29.67	26.67	5.00	4.00	4.50	2.67	2.00	2.33
Ka-Eme (V_{11})	29.67	35.67	32.67	2.67	3.67	3.17	4.00	3.00	3.50
Um-Dik (V_{12})	29.00	35.00	32.00	4.00	3.67	3.83	2.00	1.00	1.50
Ukworu (V_{13})	19.33	25.33	22.33	3.67	4.33	4.00	2.33	1.67	2.00
Oka-Aki (V_{14})	27.33	30.33	28.83	5.00	4.67	4.83	2.00	1.33	1.67
Awaka (V_{15})	30.33	36.33	33.17	7.33	6.00	6.67	4.00	3.00	3.50
Mean	25.91	31.78	28.84	5.24	4.76	5.00	2.89	1.98	2.45
CV%	8.6	6.9		141.7	29.9		26.7	33.2	
$LSD_{(0.05)}$ for genotype			2.76			1.48			0.81
$LSD_{(0.05)}$ for season			1.01			0.54			0.30
$LSD_{(0.05)}$ for genotype by season			3.91			2.09			1.15

Borers' incidence at 9WAE showed that infestation is higher in the late season compared to early season. Late season recorded 24.09% while early season had 16.29%. Um-Dik (V_{12}) experienced the least incidence of stem borer attack (13.33%). Uk-Ibere (V_8) however, was severely affected with the mean value of 26.67%. The seasons differed significantly in 9WAE (Table 3). From the same Table, the proportion of ear damage was higher in early season (13.46%) compared to the late season which was 6.0%. severe damage occurred in Ka-Eme (V_{11}) (10.5%) and Nse-Nguru (V_5) had the least ear damage (8.67%). The seasons also differed significantly. In Table 4, mean plant height was higher (173.0cm) in early season and 168.4cm in late season. Oha-Gbem (V_4) and Awaka (V_{15}) were the tallest with mean values of 203.6 and 203.8cm respectively, whereas Oka-Ngwa (V_3) was the shortest (120.4cm). This great variation in height obtained in Oka-Ngwa (V_3) is an evidence of why only the genotype was found in cluster III, an indication of outlier. With respect to grain yield, the weight showed that early season harvest (1.83t/ha) weighed higher than the late season (0.69t/ha) harvest with significance between the two seasons. Nse-Nguru (V_5) produced the highest yields (3.33t/ha). Oka-Ngwa (V_3) gave the least yields of 2.1t/ha. Also, the two seasons differed significantly (Table 4). Average maize grain yield of 15 maize genotypes evaluated in late planting season varied with borers incidence at 9WAE (infestation at 9WAE).

Table 3.Leaf feeding values, percentage borers incidence at 9WAE and ear damage (%) in two planting seasons

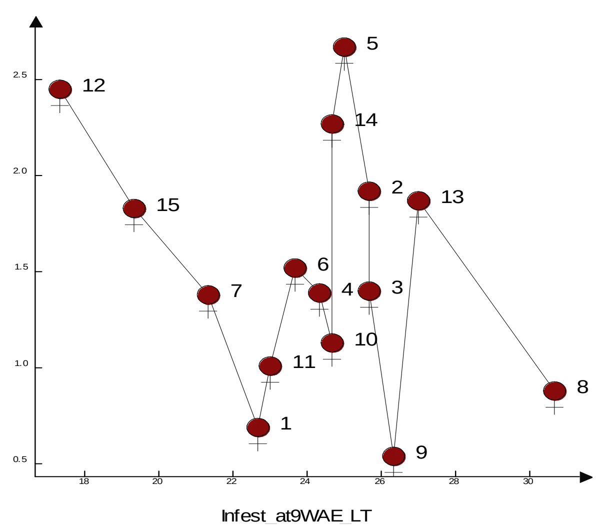
	Leaf feeding (1-9 scale)			Borer s incidence(%) At 9WAE			Ear Damage (%)		
Genotype	Late season	Early season	mean	Late season	Early season	mean	Late season	Early season	Mean
Oka-Bende (V_1)	3.67	1.67	2.67	22.67	14.67	18.67	55.33	13.17	9.25
Um-Olok (V_2)	5.67	3.67	4.67	25.67	17.67	21.67	55.33	13.17	9.25
Oka-Ngwa (V_3)	4.67	2.67	3.67	25.67	17.67	21.67	6.00	13.67	9.83
Oha-Gbem (V_4)	3.67	1.67	2.67	24.33	16.33	20.33	6.00	13.17	9.75
Nse-Nguru (V_5)	4.00	2.00	3.00	25.00	17.00	21.00	5.33	12.00	8.67
Iku-Ukwuato (V_6)	4.67	2.67	3.67	23.67	15.67	5.83	6.00	13.50	9.75
Aro-Egbema (V_7)	3.67	1.67	2.67	21.33	13.33	19.67	5.33	13.83	8.83
Uk-Ibere (V_8)	4.00	2.00	3.33	30.67	22.67	17.33	6.33	13.83	10.08
Ezi-Oka (V_9)	4.33	2.33	2.83	26.33	18.33	26.67	6.33	12.50	8.75
Ag-Flat (V_{10})	5.00	2.67	3.33	24.67	16.67	23.33	6.33	13.83	10.08
Ka-Eme (V_{11})	5.00	3.33	4.17	23.00	15.00	20.67	6.67	14.33	10.50
Um-Dik (V_{12})	5.00	3.00	4.00	17.33	9.33	19.00	6.00	13.83	9.92
Ukworu (V_{13})	5.33	3.33	4.33	27.00	22.00	13.33	6.67	14.00	10.33
Oka-Aki (V_{14})	4.00	2.00	3.00	24.67	16.67	24.50	6.33	14.00	10.33
Awaka (V_{15})	4.30	2.33	3.33	19.33	11.33	15.33	6.67	14.17	10.42
Mean	4.47	2.47	3.47	24.09	16.29	20.19	6.00	13.46	9.71
CV%	15.5	27.4		7.4	11.0		10.2	5.6	
$LSD_{(0.05)}$ for genotype			0.78			2.03			0.83
$LSD_{(0.05)}$ for season			0.28			0.74			0.30
$LSD_{(0.05)}$ for genotype by season			1.10			2.88	1		0.18

This illustration in figure 1 and 2, distributes the genotypes according to their grain yields at different damage levels at 9WAE in late season and early season respectively. The result in figure 1 shows that Um-Dik (V_{12}) is the most resistance with only 17.3% stem borer damage. This is followed by Awaka (V_{15}) with mean value of 19.3% stem borer damage. Uk-Ibere (V_8) and Ezi-Oka (V_9) are highly susceptible to stem borer damage with average value of 30.7 and 26.3% respective stem borer damage. Incidentally, Nguru(V_5) which suffered 25% damage gave the highest grain yield of 2.67t/ha. This implies that the genotype produced heavier ear weight to compensate for the damage. Um-Dik (V_{12}) is the second highest yielding with grain yield of 2.45t/ha. However, lowest grain yield was recorded in Ezi-Oka (V_9) and Oka-Bende (V_1) with the mean values of 0.54 and 0.69t/ha respectively. Results in figure 2 follow the same trend except that Oka-Bende (V_1) recorded the lowest grain yield and Oka-Aki (V_{14}) recorded the second largest grain yield. From Tables 2, 3 and 4, the coefficient of variation (CV) of the parameters studied were all moderate except CV for stalk lodging in early season which was 141.7%. This is in agreement with Wahua (1999) report which maintained that for parameters whose estimation is difficult, either because of non-standardized techniques, delicate instrument or because of many uncontrollable factors affecting measurement, CV is usually high.

TABLE 4.Mean plant height (cm) and grain yield (t/ha) in two planting seasons

	Plant height (cm)			Grain yield (t/ha)		
Genotype	Late season	Early season	mean	Late season	Early season	Mean
Oka-Bende (V_1)	181.50	185.00	183.20	0.69	1.83	1.26
Um-Olok (V_2)	162.40	163.30	162.90	1.92	2.53	2.23
Oka-Ngwa (V_3)	117.80	123.00	120.40	1.40	2.80	2.10
Oha-Gbem (V_4)	201.90	205.30	203.60	1.39	2.43	1.91
Nse-Nguru (V_5)	187.20	191.31	189.20	2.67	4.00	3.33
Iku-Ukwuato (V_6)	180.60	186.30	183.50	1.52	3.00	2.26
Aro-Egbema (V_7)	154.80	162.30	158.60	1.38	2.27	1.82
Uk-Ibere (V_8)	182.70	188.00	185.30	0.88	2.27	1.58
Ezi-Oka (V_9)	164.70	170.00	167.30	0.54	2.03	1.29
Ag-Flat (V_{10})	151.80	157.30	154.60	1.13	2.20	1.67
Ka-Eme (V_{11})	168.30	172.00	170.10	1.01	2.23	1.62
Um-Dik (V_{12})	154.90	158.00	156.50	2.45	3.47	2.96
Ukworu (V_{13})	156.60	160.00	158.30	1.87	3.03	2.45
Oka-Aki (V_{14})	160.80	166.00	163.40	2.27	3.67	2.97
Awaka (V_{15})	200.50	207.00	203.80	1.83	3.63	2.73
Mean	168.4	173.00	170.70	0.69	1.83	2.15
CV%	14.8	14.2		25.1	18.00	
$LSD_{(0.05)}$ for genotype			28.14			0.51
$LSD_{(0.05)}$ for season			10.28			0.19
$LSD_{(0.05)}$ for genotype by season			39.80			0.72

Figure 1.Effect of stem borers incidence at 9WAE (Infest. 9WAE) on grain yield (t/ha) of 15 maize genotypes evaluated in late planting season



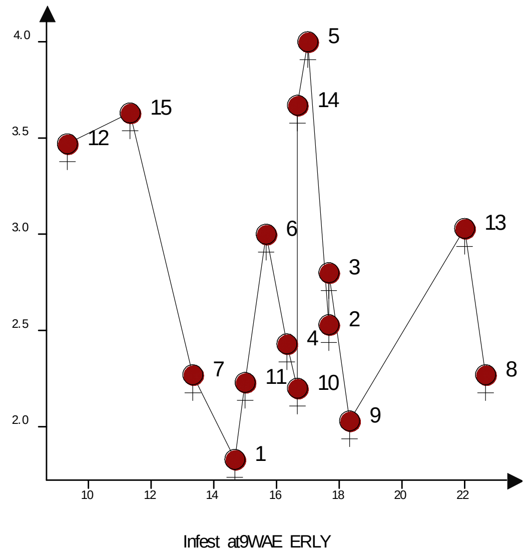


Figure 2. Effect of stem borers incidence at 9WAE (Infest. 9WAE) on grain yield (t/ha) of 15 maize genotypes evaluated in early planting season

MULTIVARIATE AND CLUSTER ANALYSIS: USING DATA FROM LATE AND EARLY SEASON PLANTING

The results from multivariate analysis of the data from the late season are presented in Table 5 to 8 and figure 3 and 4. When data for plants characteristics were subjected to uni- and multivariate analyses, eleven (11) traits showed significant differences among the genotypes. Table 5 shows the linear correlation coefficient (r) for the inter-relationships among eleven (11) plant characteristics, using data from late planting season. The 11 traits which showed significant differences also showed significant ($p < 0.05$) relationships amongst them. Significant and positive correlations were found between grain yield and ear at harvest (r = 0.35**), field weight (r = 0.52**), plant stand (r = 0.34*) and plant at harvest (r = 0.35*). However, grain yield was also found to be negatively correlated between 50% emergence (r = -0.04), dead heart (r = -0.03), borer incidence at 3WAE (r = -0.44**) and borer incidence at 9WAE (r = -0.31*). The plant at harvest had a significant positive correlation with plant height (r = 0.36*), ear at harvest (r = 0.64**), ear per plant (r = 0.35*), field weight (r = 0.68**) and plant stand (r = 0.30**) but negatively correlated with 50% emergence (r = -0.05), dead heart (r = -0.02), borer incidence at 3WAE (r = -0.36*), and borer incidence at 9WAE (r = -0.33*). The results also revealed significant positive relationship between field weight and plant height (r = 0.51**), ear at harvest (r = 0.76**) and ear per plant (r = 0.39**). Conversely, negative correlation was observed between field weight and dead heart. Also the results obtained in early season (Table 6) showed that grain yield is significantly and positively correlated with plant height (r = 0.31), ear at harvest (r = 0.29*), ear per plant (r = 0.35*), field weight (r = 0.15*) and negatively related with 50% emergence (r = -0.04), dead heart (r = -0.16), borer incidence at 3WAE (r = -0.49**) and borer incidence at 9WAE (r = -0.22). The grouping of the genotypes by the Fastclus Procedure (SAS, 1999) is summarized in Table 7 and 8 using data from early and late season planting respectively. The intra-population variability evaluated by hierarchical cluster analysis conducted on the agronomic and stem borer damage parameters, grouped the genotypes into five clusters. From Table 7, cluster I comprised of 3 genotypes. Cluster II however, however, comprised of 4 genotypes which were all collected from Abia state. This indicates a close similarity between the genotypes grown in the state.

Table 5: Correlation matrix of some agronomic and damage parameters of the 15 maize genotypes obtained using data from the late planting season.

Plant traits	1	2	3	4	5	6	7	8	9	10	11
1) 50% emergence	1										
2) Dead heart(%)	-0.07	1									
3) Plant height(cm)	-0.08	0.02	1								
4) Ear at harvest	0.07	-0.12	0.16	1							
5) Ear per plant	0.01	-0.03	0.25	0.45**	1						
6) Field weight(t/ha)	0.01	-0.07	0.51**	0.76**	0.39**	1					
7) Plant stand	0.21	-0.22	0.25	0.42**	0.20	0.45**	1				
8) Borer incidence @3WAE(%)	-0.11	-0.01	-0.31*	-0.54*	-0.25	-0.50**	-0.85**	1			
9) Borer incidence @9WAE(%)	-0.11	0.20	-0.10	-0.45**	-0.32*	-0.51**	-0.67**	0.59**	1		
10) Plant at harvest	-0.05	-0.20	0.36**	0.64**	0.35*	0.68**	0.30**	-0.36*	-0.33*	1	
11) Grain yield(t/ha)	-0.04	-0.03	0.22	0.53**	0.29	0.52**	0.34*	-0.44**	-0.31*	0.33*	1

* Correlation is significant at the 0.05 level (2-tailed), ** Correlation is significant at the 0.01 level (2-tailed).

Table 6: Correlation matrix of some agronomic and damage parameters of the 15 maize genotypes obtained using data from the early planting season.

Plant traits	1	2	3	4	5	6	7	8	9	10	11
1) 50% emergence	1										
2) Dead heart(%)	-0.28	1									
3) Plant height(cm)	0.04	-0.03	1								
4) Ear at harvest	0.19	-0.30*	0.03	1							
5) Ear per plant	0.24	-0.14	-0.18	0.43**	1						
6) Field weight(t/ha)	0.04	-0.08	0.50**	065**	0.38**	1					
7) Plant stand	0.10	-0.27	0.42**	0.21	0.17	0.48**	1				
8)Borer incidence @3WAE(%)	-0.15	0.05	-0.30*	-0.38*	-0.22	-0.42**	-0.74**	1			
9)Borer incidence @9WAE(%)	-0.35*	-0.11	-0.19	-0.36*	-0.35*	-0.54**	-0.70**	0.62**	1		
10) Plant at harvest	-0.19	-0.02	0.39**	0.43**	0.32*	0.43**	0.42**	-0.40**	-0.37*	1	
11) Grain yield(t/ha)	-0.04	-0.16	0.31*	0.29*	0.35*	0.15*	0.27	-0.49**	-0.22	0.15	1

* Correlation is significant at the 0.05 level (2-tailed), ** Correlation is significant at the 0.01 level (2-tailed)

Cluster II was therefore regarded as high yielding genotype. The genotype; Oka-Ngwa (V_3) which formed cluster III was an outlier and therefore was the only member of the cluster. All the 3 genotypes that occurred in cluster IV were collected from Imo state except Ukworu (V_{13}) which may have been introduced accidentally to Abia state. They are however associated with earliness. The five clusters appear to maintain some level of distance from each other. The grouping shows that; cluster I is most affected by dead heart damage (3.58%). Clusters I, II and III comprised of early silking genotypes, while clusters IV and V are late silking. More number of ears at harvest was obtained in cluster II and IV (7.58 and 7.78). Grain yield which is a very important attributes reflects the combined effects of other measured traits, shows that clusters II and IV genotypes are high yielding (1.94 and 1.96). In husk cover rating, cluster II genotypes had the best rating (1.75) while cluster III genotypes had the poorest rating (3.0). The genotypes in cluster I are essentially best rated (1.78) with regards to plant aspect. Cluster III genotype had the poorest rating of 3.0, while clusters II, IV and V are moderate in rating. Clusters I and IV contain very tall genotypes (181.6 to 196.5cm), clusters II and V genotypes are of medium height (157.5 to 161.1cm) and cluster III contains relatively short genotype (117.8cm). In stalk lodging, clusters I, III and IV genotypes are more susceptible compared to clusters II and V genotypes that are not susceptible. In ear aspect rating, cluster III genotype had the best rating of 1.67. Using data from early season planting (Table 8), the same results were observed except little variation that occurred in cluster membership. Cluster I consisted of 4 genotypes while cluster II is made up of 5 genotypes. Conversely, all the 3 genotypes which occurred in cluster V were all sourced from Imo state. The five clusters maintain some level of distance from each other.

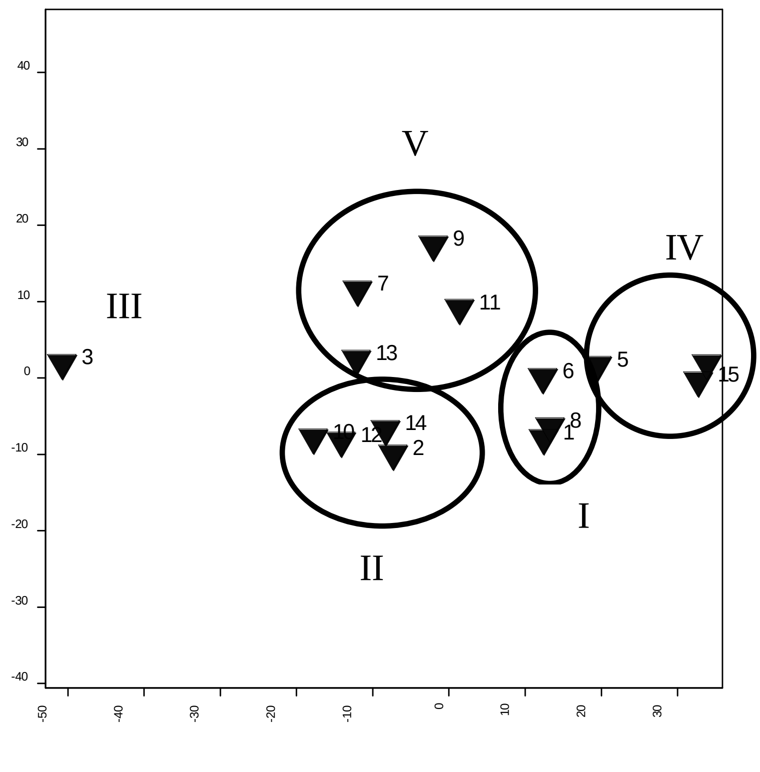


Figure 3: First and second principal component scores (PC1 and PC2) for the identification of 15 maize genotypes performance evaluated in late planting season.

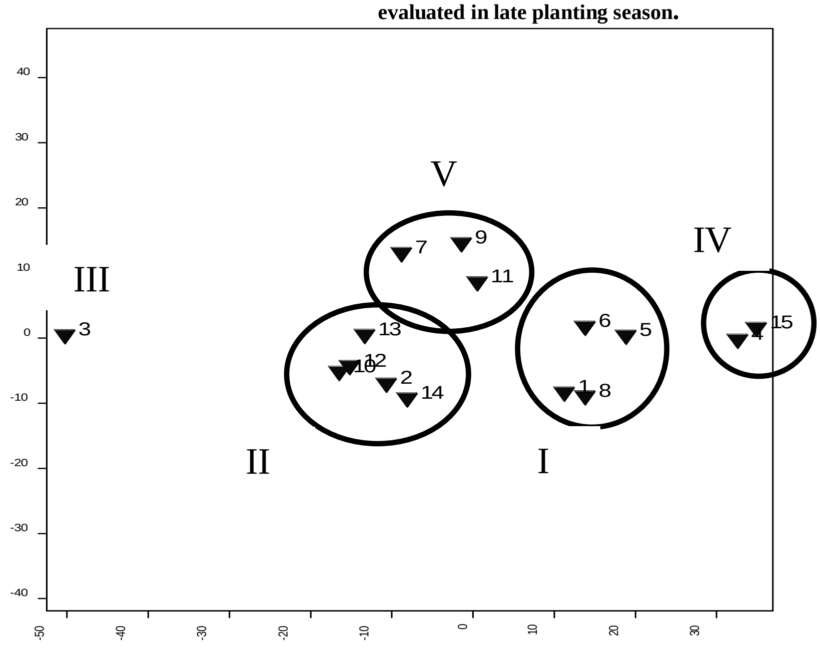


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Figure 4: First and second principal component scores (PC1 and PC2) for the identification of 15 maize genotypes performance evaluated in early planting season.

Cluster IV showed moderate resistance to borer incidence at 9WAE (13.8%), compared to other clusters that appeared to be susceptible. Also the proportion of plants that that suffered stalk lodging was highest in cluster I and

III (6.1 and 5.7% respectively). However, least number of plants suffered stalk lodging in cluster II (3.9%). The plot of the first two principal component axis (PC1 and PC2) shows the relative distribution of the genotypes in clusters (figure 4).

Table 7: Number of genotype, genotypes and collection sites of the 15 maize genotypes shown according to the clusters obtained from the cluster analysis using data from late season planting.

Group	Number of Genotype	Genotype	Collection site
CLUSTER I	3	Oka-Bende (V_1)	Bende, Abia State
		Iku-Ukwuato (V_6)	IbekuUkwuato, Imo State
		Uk-Ibere (V_8)	Ikwuano, Abia State
CLUSTER II	4	Um-Olok (V_2)	Umuahia, Abia State
		Ag-Flat (V_{10})	Ndoro, Abia State
		Um-Dik (V_{12})	Umudike, Abia State
		Oka-Aki (V_{14})	IbekuUkwuato, Imo State
CLUSTER III	1	Oka-Ngwa (V_3)	Ngwa, Abia State
CLUSTER IV	3	Oha-Gbem (V_4)	OhajiEgbema, Imo State
		Nse-Nguru (V_5)	Mbaise, Imo State
		Awaka (V_{15})	Owerri North (Awaka), Imo State
CLUSTER V	4	Aro-Egbema (V_7)	Aghoro, Imo State
		Ezi-Oka (V_9)	Eziobodo, Imo State
		Ka-Eme (V_{11})	Emekuku, Imo State
		Ukworu (V_{13})	ObuohiaIbere, Abia State

From the uni- and multivariate studies, it is obvious that the grain yield apart from being the most important agronomic parameter had strong correlations with the stem borer traits and is the strongest in accounting for the variation existing among the genotypes. Hence grain yield was included in constructing a selection index for selecting stem borer resistance maize genotypes. The ranking of the 15 maize genotypes (Table 9) for stem borer resistance parameters namely; dead heart, leaf feeding, root lodging, stalk lodging, ear damage and grain yield showed that genotype Um-Dik (V_{12}) (from Umudike, Abia State) had the best overall resistance levels with a Rank Summation Index (RSI) value of 58. This was followed by genotypes Oka- Aki (V_{14}) (from Ibeku, Abia State) and Oha-Gbem (V_4) (from OhajiEgbema, Imo State), Nse- Nguru (V_5) (from Mbaise, Imo State) and Uk- Ibere (V_8) (from Ikwuano, Abia State) in that order. Selection of the top 20% (3 genotypes in all) includes genotypes Um-Dik (V_{12}), Oka- Aki (V_4) and Oha-Gbem (V_4). Genotype Awaka (V15) (from Imo State) is the worst with the RSI value of 124.

Table 9: Plant characteristics, their ranks and rank summation index of the 15 maize genotypes evaluated in late and early planting season.

	LATE SEASON (2010)												EARLY SEASON (2011)												
Genotype	DH(%)	R_1	LF	R_2	RL(%)	R_3	SL(%)	R_4	ED(%)	R_5	GY(t/ha)	R_6	DH(%)	R_1	LF	R_2	RL(%)	R_3	SL(%)	R_4	ED(%)	R_5	GY(t/ha)	R_6	RSI
Um-Dik (V_{12})	2.0	3	5.0	11	0	1	4.0	4	6.0	7	2.5	2	1.0	1	3.0	1	0	1	3.7	3	13.8	9	3.5	4	58
Oka-Aki (V_{14})	2.0	3	4.0	4	0	1	5.0	9	6.3	10	2.3	3	1.3	4	2.0	4	0	1	4.7	8	14.0	12	3.7	2	61
Oha-Gbem (V_4)	2.3	6	3.7	1	1.3	12	5.0	7	6.0	7	1.4	8	1.0	1	1.7	1	0.7	11	3.3	2	13.5	6	2.4	9	71
Nse-Nguru (V_5)	1.7	1	4.0	4	2.3	15	7.3	13	5.0	1	2.7	1	1.0	1	2.0	1	1.3	15	7.3	15	12.0	1	4.0	1	72
Uk-Ibere (V_8)	2.0	3	4.0	4	0.3	4	4.0	4	6.3	10	0.9	13	1.3	4	2.0	4	0.3	6	5.0	9	13.8	9	2.3	10	80
Ukworu (V_{13})	2.3	6	5.3	14	0	1	3.7	2	6.7	13	1.9	5	1.7	6	3.3	6	0	1	4.3	7	14.0	12	3.0	5	85
Ezi-Oka (V_9)	3.3	10	4.3	7	0.7	7	4.3	6	5.0	1	0.54	15	1.3	10	2.3	10	0.33	6	4.0	5	12.2	2	2.0	14	90
Oka-Bende (V_1)	1.7	1	3.7	1	1.0	10	7.3	13	5.3	3	0.69	14	1.7	6	1.7	6	0.67	11	5.7	12	3.2	4	1.8	15	91
Um-Olok (V_2)	5.0	15	5.7	15	0.7	7	3.7	2	5.6	5	1.92	4	3.0	12	3.7	12	0.33	6	2.7	1	3.3	4	2.5	8	94
Ag-Flat (V_{10})	2.7	7	5.0	11	0.3	4	5.0	7	6.3	10	1.13	11	2.0	9	2.7	9	0	1	4.0	5	13.8	9	2.2	13	98
Oka-Ngwa (V_3)	2.3	6	4.7	9	1.0	10	6.0	10	6.0	7	1.38	9	1.7	6	2.7	6	0.33	6	5.3	11	13.7	8	2.8	7	98
Iku-Ukwuato (V_6)	3.3	10	4.7	9	0.7	7	6.0	10	5.6	5	1.5	7	2.3	10	2.7	10	0.3	6	6.3	14	13.5	7	3.0	6	100
Aro-Egbema (V_7)	4.7	14	3.7	1	1.3	12	7.3	13	5.3	3	1.4	10	3.3	15	1.7	15	1.0	14	5.0	9	12.3	3	2.3	10	105
Ka-Eme (V_{11})	4.0	12	5.0	11	0.3	4	2.7	1	6.7	13	1.0	12	3.0	12	3.3	12	0	1	3.7	3	14.3	14	2.2	12	108
Awaka (V_{15})	4.0	12	4.3	7	1.3	12	7.3	13	6.7	13	1.8	6	3.0	12	2.3	12	0.7	11	6.0	13	14.7	15	3.6	3	124

DH= Dead heart, LF = Leaf feeding, RL = Root lodging, SL = Stalk lodging, ED = Ear damage, GY = Grain yield, R_1 to R_6 = Rank 1 to Rank 6, RSI = Rank summation index.

Table 8: Number of genotype, genotypes and collection sites of the 15 maize genotypes shown according to the clusters obtained from the cluster analysis using data from early season planting.

Group	Number of Genotype	Genotype	Collection site
CLUSTER I	4	Oka-Bende (V_1)	Bende, Abia State
		Nse-Nguru (V_5)	Mbaise, Imo State
		Iku-Ukwuato (V_6)	Ibeku Ukwuato, Imo State
		Uk-Ibere (V_8)	Ikwuano, Abia State
CLUSTER II	5	Um-Olok (V_2)	Umuahia, Abia State
		Ag-Flat (V_{10})	Ndoro, Abia State
		Um-Dik (V_{12})	Umudike, Abia State
		Ukworu (V_{13})	Obuohia Ibere, Abia State
		Oka-Aki (V_{14})	Ibeku Ukwuato, Imo State
CLUSTER III	1	Oka-Ngwa (V_3)	Ngwa, Abia State
CLUSTER IV	2	Oha-Gbem (V_4)	Ohaji Egbema, Imo State
		Awaka (V_{15})	Owerri North (Awaka), Imo State
CLUSTER V	3	Aro-Egbema (V_7)	Aghoro, Imo State
		Ezi-Oka (V_9)	Eziobodo, Imo State
		Ka-Eme (V_{11})	Emekuku, Imo State

DISCUSSION

The highly significant genotypic effect obtained for the stem borer damage and agronomic parameters and the level of variability among the genotypes observed in this study indicates that enough genetic variability exists to allow selection and identification of landraces (local germplasm) with high level of stem borer resistance and desirable agronomic traits. This observations support the earlier reports by Ngwuta *et al*. (2001) that locally available germplasm can serve as sources of resistance to stem borers. The genotypes are morphologically differentiated and identified using morphological traits. The significance differences recorded in the number of plant stand could be attributed to the variability in the level of resistance among the genotypes. This is in agreement with Guthrie *et al*. (1982) reports on land races. However, the variation observed on the stalk lodging was largely due to genetic variations between vigorous and weak shoot system of the genotypes. This supports the earlier findings on maize (John, 1979). The differences in stalk lodging is also supported by Kumar (1999) finding that Gossypol, Dimboa and Phenolic compounds present in some crop varieties inhibit the establishment of insect pests on such strains. This also is in support of Dennis (1983) studies that reported that inherent sturdier stalks are less susceptible to lodging. Similarly, the variations recorded on the leaf feeding are largely due to genetic differences. Again, this supported Dennis (1983) that maintained that reasonable silicate deposits in leaves of some cereals make them unattractive to leaf feeding insect pests since it slows down the rate of digestion of pests. Kumar (1999) also reported that a chemically based resistance is a major component of the plant's total defense armament against herbivores. The dissimilarities observed in plant height are attributed to inherent genetic factor existing among the genotypes. In the same vein, the significant difference recorded among the genotypes in husk cover and ear damage indicated that the traits are genetically and environmentally controlled as observed by John (1979) who reported that strains with long husks have good characters associated with the adaptation of the varieties in their environment. Grain yield which recorded significant difference is the most complex objective with which the maize breeder works. Basically, it is determined by the expression and interaction of numerous genes which affect vital processes within the plant such as nutrition, photosynthesis, transpiration, translocation and storage of food materials. This observation is supported by Kumar (1999) who stated that yield is determined directly or indirectly by genes affecting maturity, lodging resistance, disease and pest resistance. However, it can be generalized that no two plant are alike. Variation within a crop specie are variation due to environment (seasons) and variation due to hereditary (genetic). Environmental variations are variation in size, shape, composition or development among plants resulting from environmental influences. A variety that exhibits resistance in one season may be susceptible in another, hence the need for investigating the genotypes in two different planting seasons. It is observed that most of the agronomic and stem borer damage parameters measured differed significantly within the two environments (seasons). Plant height, ear damage, field weight, number of plant stand and grain yield are observed to be significantly higher in early season planting. This observation is in support of Daramola (1985) earlier findings. Conversely, stalk lodging, dead heart, leaf feeding, borer incidence at 9WAE were observed to be more intense and severe in late planting season. This result corresponds with that reported by Ajala *et al*. (1995) and Girling (1980). Among the discriminating variables, grain yield was more important than others put together. Borer damage parameters were second to the grain yield in determining which genotype belongs to which cluster. However, the genotypes were highly variable resulting in their being scattered in the groups. From the principal component analysis, many agronomic and stem borer damage parameters showed some reasonable contribution towards total variation among the maize genotypes, thus was used to group the genotypes into cluster. The intra-population genetic variability observed by hierarchical cluster analysis carried out on the parameters grouped the genotypes into five clusters, indicating sufficient heritable variation that could be harnessed for resistant breeding programme. Clustering allows breeders to concentrate selection to the best varieties or inbred in each cluster. The clustering pattern of the genotypes revealed that all the genotypes in cluster IV and V were sourced from Imo State. Similarly, five genotypes that occurred in cluster II were collected from Abia State. Cluster III [Oka-Ngwa (V_3)], however, isolated itself from the clusters which could suggest that it is genetically different and independent from the other genotypes. Cluster II consists of genotypes with high production and grain yield capacities. Cluster I comprises of early emerging genotypes. However, genotypes in cluster IV shows reasonable level of resistance and therefore, could be recommended with cluster II for a cross for production of high yielding and resistant varieties and for further crop resistance improvement programme. The genotypes were separated clearly into five groups by the characters. All the traits which were used to group the genotypes indicate that the characters made significant contribution in the diversity and would therefore provide useful information in selection programme for further varietal improvement. The result of the correlation studies indicated that borer damage parameters are important in selecting the genotypes to be included in subsequent improvement studies. Grain yield was positively and significantly correlated with plant height, ear at harvest, ear per plant and field weight. However, negative correlations were obtained between grain yield and 50% emergence, dead heart, borer incidence at 3 and 9WAE. The identification of the best genotypes within the best groups supports the usefulness of selection index, in this case rank summation index (RSI) for selection purpose (Ngwuta *et al*., 2001). Results from this study show that useful variability exists in the local germplasm from Imo State and Abia State of Nigeria with regards to agronomic and stem borer resistance attributes. Such variability when exploited can be used to develop resistant maize variety for the area. Using similar methods, Omolo (1991) identified some tropical maize genotypes with good potential for development of high yielding inbred lines.

CONCLUSION

Stem borers attack maize in all ecological zones of Nigeria, although severity of infestation may be more in some ecological zones than others. The identification of maize populations resistant to stem borer for Abia and Imo States of Nigeria was accomplished in two planting seasons of 2010 and 2011. A total of 15 open pollinated genotypes were assembled comprising eight (8) and seven (7) landraces from Abia and Imo State respectively since without good base populations, high combining and stable inbred would not be developed. Using the rank summation involving the yield and borer damage parameters, 3 populations were selected representing a top 20% of the genotypes. Results of the late season and early season studies indicated that the best genotypes were Um-Dik (V_{12}) and Oka-Aki (V_{14}) with average grain yield of 2.96 and 2.97t/ha respectively in the two seasons. However, the mean borer incidence damage at 9WAE for Um-Dik (V_{12}) and Oka-Aki (V_{14}) in the two seasons was only 13.33 and 20.67% respectively. There is also evident that there was an average yield increase of 62.3% between the seasons. Higher yield was recorded in the early season as against the late season. So far the main sources of stem borer resistance used in this study were the adapted tropical germplasms. These materials have the value added advantage of the stem borer resistance and grain yield production and therefore, should be subjected to further improvement programme or introgressed into breeding population.

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