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Combining Ability and Heterosis for Grain Yield and Yield Related Components in Maize Resistant to *Striga hermonthica (Del.) Benth*. in Southern Guinea Savannah of Nigeria

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***Abstract*— Eight maize inbred lines resistant to Striga hermonthica (Del) Benth were crossed in 8 x 8 half diallel following Griffing mthod II model 1 in a Randomized Complete Block Design (RCBD) with three replications at two different Striga infested environments (Lafia and Makurdi) during the late cropping season of 2014 and 2015. The objectives were to evaluate the potential performance of inbred lines in hybrid combinations, and determine their combining abilities and heterosis in the development of new Striga resistant varieties Data collected were used to estimate combining ability and heterosis for grain yield and other yield components (plant height, days to 50%tasseling, days to 50% silking, Striga damage rating, Striga emergence count, ear length, ear diameter, 100 seed weight and grain yield per hectare.) The result of combined ANOVA revealed that means square were highly significant for all traits except Striga damage rating (SDR) at 8WAS and Striga emergence count (STEC) at 8WAS. P12 was the highest yielding parent and P12 x P14 was the highest yielding cross. Heterosis for grain yield was high in all parents except in those involving p4 and p24 as parents. Parents P2, P5, P12 and P14 shows significant ($p < 0.05$) positive GCA effects for grain yield while the rest had negative GCA effects for grain yield. ParentP2, P5, P12 and P14 could be used for initiating hybrid development. P12 x P14 cross was the best specific combiner followed byP2 x P14 and P2xP12 and P5x14. However, P5, P 12 and P14 manifested a high positive SCA effect with P2 indicating that these three inbreds combined better with P2.**

***Index Terms*— Combining ability, heterosis, Striga hermonthica, resistance.**

I. Introduction

Maize (Zea mays L.) occupies a prestigious place in world agriculture. It is an important crop in Africa providing over 30% of the calories in diets. Among the cereal crops of the world, maize ranks third to wheat and rice in terms of production [9]. Above 177 million hectares is grown globally to maize with a production of more than 800 million metric tons with an average maize yield of 4.9mt ha-1 [9]. In 2016, worldwide production of maize was around 1 billion ton, with America being the largest producer, which produces 51.6% equivalent to 547,416,865 tons and United States of America with 384,777,890 tons [10] . Africa produces 6.7% and Nigeria is the largest African producer with 10,414,012 million tons [10]. In terms of volume produced, maize is the third most important cereal grown in Nigeria after sorghum and millet [28]. These low yields can be attributed to various biotic and abiotic stresses. Striga weed (Striga hermonthica), which is a parasitic weed, is one of the major biotic stresses. Striga infestation is one of the most important constraints to cereal production by small holders farmers in Sub-Sahara Africa (SSA). Striga hermonthica (Del.) Benth has been found to affect two third of the 73 million hectares devoted to cereal production in Africa [13]. The annual yield loss due to Striga hermonthica in the savannas alone is estimated to worth US $7 billion, depending on the time of parasite infestation. This has a significant negative impact on the food supply to over 100 million people in Africa [16].

Maize varieties resistant to Striga weed remain the most viable solution to the problem since it is cost effective and sustainable [6]. This calls for the broadening of Striga resistant germplasm that can be deployed in variety development programme. After the identification of resistant inbred lines, they are then evaluated for other traits of agronomic importance like resistance to biotic and abiotic factors, grain yield, maturity, combining ability, heterosis performance of the inbred lines in hybrid combinations. Elite inbred lines are then deployed for development of superior varieties. Determination of combining abilities provides information on the nature of gene action involved in the expression of quantitative traits [8].The nature and magnitude of gene action is an important factor in developing an effective breeding programme. Combining ability analysis is useful to assess the potential inbredlines and also helps in identifying the nature of gene action involved in various quantitative characters. The performance of maize hybrid varieties for grain yield greatly depends on the level of heterosis expressed in their hybrids. Heterosis can be maximized by crossing genetically diverse inbred lines. The higher the genetic diversity between the inbred lines the higher the heterosis expressed by the hybrid variety [24]. This information is helpful to plant breeders for formulating hybrid breeding programme. Therefore, this study is to evaluate the potential performance of inbred lines in hybrid combinations, and determine their combining abilities and

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heterosis in the development of new Striga resistant varieties

II. MATERIALS AND METHOD

Six Striga resistant and two susceptible early/late maturing maize inbred lines developed by the International Institute of Tropical Agriculture (IITA) maize improvements program were used to develop hybrids for this study (Table 1). The hybrids were evaluated for their agronomic performance under Striga endemic environments in Ukange, (Lat. 07o 4/N and long 08o 7'E) in Guma Local Government of Benue State and College of Agriculture, Lafia (Lat 8o 32'N and long 8o 32'E) in Nasarawa State, both in southern guinea savanna (SGS) of Nigeria during the 2014 and 2015 cropping season. In each trial, a Randomized Complete Block Design with three replications was used. At both environments, entries were made in three-row plots of 3x 1.5m. Two maize seeds were planted at inter-row spacing of 0.75m and within intra row spacing of 0.50m and were later thinned to one plant per hill at two weeks after sowing (WAS) to obtain a population of 2666,67 plants per hectare. Each plot was weeded at 4 and 8 weeks after planting while other weeds apart from Striga were hand weeded on the plots two days prior to Striga count to keep plots clean to enable accurate Striga count. Fertilizer (NPK 15:15:15) was applied at the rate of 30kg/hectare in split doses at three and six weeks after sowing (WAS).

A. Data Collection and Analysis.

Observations were made on the middle row of the three row plants in each plot. Striga related parameters such as Striga damage rating (SDR): (SDR1=8 WAP, and SDR2 = 10WAP). Visible striga damage rating (SDR) on host plants were taken two weeks after mid-silking and were evaluated on a scale of 1 to 9 as described by Kim, [14]. Details of the rating which are, 1. = Normal plant growth, no visible symptoms, 2 = Small and vague, purplish-brown leaf blotches visible 3 = Mild leaf blotching with some purplish brown necrotic spots, 4 = Extensive leaf blotching and wilting, slight but noticeable stunting and reduction in ear and tassel size. 5 = Extensive leaf blotching, wilting and some scorching. Moderate stunting ear and tassel size reduction, 6 = Extensive leaf scorching with mist gray necrotic spots. Some stunting and reduction in seed diameter, ear size, and tassel size. 7 = Definite leaf scorching, with mist gray necrotic spots, and leaf wilting and rolling. Severe stunting, reduction in stem diameter, ear size and often causing stalk lodging, brittleness, and husk opening at late growing stage. 8 = Definite leaf scorching with extensive gray necrotic spot, conspicuous stunting, leaf wilting, rolling, severe stalk lodging, brittleness, reduction in stem diameter, ear size and tassel size.9 = Complete leaf scorching of all leaves, causing premature death or collapse of host plant and no ear formation. Striga emergence count (STEC): (STEC1= 8WAP and STEC2= 10WAP). This is the number of Striga plants that emerged per plot at 8 and 10WAP. Other agronomic parameters collected were Days to 50% tasseling (DT) and Days to 50% silking (DS) were determined as a number of of days that 50% of the plants showed tassels and 50% of the plants extracted silks. Anthesis-silking interval: was calculated as the difference between days to anthesis (pollen shed) and silking. Plant height (PHT) and ear height (EHT) were measured from the base of the maize plant to the top of the largest leaf and ear leaf respectively using measuring tape [3]–[2]. Ear per plant (EPP) was recorded as the total number of ears which developed at least one full grain and divided by the total number of ears harvested per plot [4]. plant height, days to 50% tasseling, days to silking, ear length, ear diameter, 100 seed weight and seed yield per hectare.

Data collected at both environments were subjected to analysis of variance using statistical analysis SAS Proc.[23]. Significant genotypic variance of each trait was further partitioned to GCA, SCA and experimental error while mean separation was carried out using LSD (5%). Combining abilities analysis was performed according to [12] method II model I using the following mathematical model.

$$Xij = u + gi + gi + sij + 1 \quad \Sigma\Sigma eijkl$$

Where, u is the population mean, gi (gi) is the gca effect, sij is the sca effect such that sij = sji, and eijkl is the environmental effect associated with ijkl individual observation, b is the blocks and c observation. The gca, sca variance components were calculated using [12] formulae as elaborated by [24]:

$$Gca = 1/n\text{-}\Sigma ig2i = (Mg - M'e)/n{+}2$$

$$Sca = \frac{2}{n(n-1)} \quad \Sigma\ \Sigma\ S2ij = Ms - M'e$$

while estimation of gca and sca effects are given as:

$$gi = \frac{1}{n+2} \quad [\Sigma(Yi + Yii) - 2/n\ Y\text{-}]$$

Estimate of heterosis (%) was calculated using better parent according to Singh and [24]. Heterosis over better parent (heterobeltiosis) =

Where F1 is the mean of the F1 hybrid performance calculated as

Bp = P1 + P2 / 2. Where P1 and P2 are the means of the inbred lines.

Table 1: Code name, pedigree and some agronomic description of parental inbred lines used in an 8-parent diallel crosses.

S NO.	Code names	Pedigree	Plant height	Maturity period	Haustorium attachment	Reaction of striga
P1	TZSTR 166	TZS-Y09C6060	117.3	Late	2.00	Resistant
P2	TZEI 114	WEC-STRS7	122.0	Early	12.00	Susceptible
P3	TZEI 80	TZE-WPOPx1368STRS7	137.8	Early	2.00	Resistant

P4	TZEI- 188	TZE-WPOPSTRCO56.	118.2	Early	4.00	Resistant
P5	TZSTR 190	TZS-W10C110608	142.3	Late	0.00	Resistant
P6	TZSTR 193	TZS-W10110611	123.4	Late	0.00	Resistant
P7	IITATZST 1159	IITATZI-W110130	141.8	Late	5.00	Susceptible
P8	TZEI25	TZE-YPOPC056	116.4	Early	6.00	Resistant

III. RESULTS

Combined analysis across locations was computed for characters that showed significances among genotypes at either locations after testing for homogeneity of error variances by using variance ratio as calculated by the Bartlett's test [27]. Results from pooled analysis of variance over environments were presented in Table 2. General combining ability (GCA) and specific combining ability (SCA) variance were significant for all traits studied except 100-kernel weight (100-kw). This indicated that these characters were controlled by additive and non-additive gene action except 100-kw. The mean square due to SCA were much higher than GCA for ear length and ear diameter and grain yield which revealed the predominance of non-additive gene action for controlling these characters.

Table 2: combining ability effect of parental inbred and hybrids for different characters of maize pool over two environment

SOV	DF	PHT	DYTS	DYSK	STR	STEC	ELT	EDM	100kw	Gyt/ha
Year	1	13.93**	194.56	24.00**	1.33	573.63	1.01	27.72	570.23	2.87**
GCA	7	4.48**	55.59*	34.26**	67.57**	890.13*	1.32*	0.99*	1637.41	1.33**
SCA	28	6.01**	17.33**	11.17*	10.98**	637.16**	3.09**	1.02**	173.18	0.98**
GCA x location	7	1.77**	12.72**	2.54ns	2.74	156.58	0.46	0.27	1129.51	1.08*
SCA x location	28	1.07**	6.23	4.52*	3.48	168.59	0.37	0.26	1191.65	0.59*
Pooled error	140	634.87	1.78	2.05	4.49	145.34	0.48	0.70	0.34	0.22
Sca/gca	-	1.34	0.31	0.33	0.163	0.72	2.43	1.03	1.02	0.216

** =Significant at P< 0.01, * = Significant at P< 0.05, PHT= Plant height, DYTS = days to 50% tasseling, DYSK=days to 50%silking, SDR = Striga damage rating, STEC = Striga emergence count, ELT = ear length, EDM = ear diameter, 100kw= 100- kernel weight(g) and GYT/HA= grain yield per hectare.

Hybrid means were generally higher and significantly different from parental means for all traits (Table 3). Mean yield of parents ranged from 1.29 to 3.17 gy t/ha. P12 was the highest yielding parent. Mean grain yield among crosses ranged from 3.85 to 6.76 gy tons/ ha. The highest yield was obtained from the P12 x P14 cross, and the lowest yield from P4x P25. These results show potential of these specific hybrid combinations for ear yield. For days to silking, cross P12 x P24 was the latest (60.83 days), and P4 x P5 was the earliest (51.50 days). For plant height, crosses fell in wide ranges, as did the parents. P12 x P14 was the tallest cross (178.13 cm) and P4 x P25 was the shortest (133.43 cm) (Table 3). For ear length, P12 x P14 was the tallest cross (14.45 cm); while P2 x P5 was the shortest (13.08 cm). Ear diameter p12 x p14 was biggest cross (6.48cm) while p4 x p24 was the smallest 4.10cm (Table 3). For days to tasseling, the means of crosses overall environments ranged from 52.33 days for P2 x P5, to 59.00 days for P12 x P24. There were significant differences among genotypes for Striga damage rating (SDR). Mean SDR at ten weeks after planting ranged from 3.67 to 7.50 with an average of 4.58 for hybrids and 5.88 for inbred lines. Significant differences were observed for Striga count at ten weeks after planting among the genotypes. S. hermonthica emergence on maize plants were first observed at 8 weeks after planting. The highest number of emerged Striga plants was observed at 10 weeks after planting. The number of emerged Striga plants observed at 10 weeks after planting ranged from 3.67to 40.33 plants for hybrids and with 4.00 to .44.33 for inbred lines.(Table 3)

Table 3: Means of maize hybrids and parents for grain yield and yield components.

Hybrid	PHT	DYTS	DYSK	SSR	STEC	ELT	EDM	100kw (g)	Gy/t/ha
2x4	156.34	52.67	55.17	5.33	33.00	13.62	4.89	57.4	5.41
2x5	150.45	52.33	54.00	4.00	21.33	13.08	5.05	54.5	5.44
2x10	150.34	57.00	56.00	5.67	31.33	14.15	5.36	54.23	4.60
2x12	162.11	57.51	58.33	4.00	30.33	14.35	5.13	66.00	5.81
2x14	163.32	55.67	58.33	5.33	23.33	13.92	5.09	60.3	5.86
2x24	159	56.67	59.33	5.67	39.00	14.3	5.29	57.4	5.01
2x25	168.14	55.00	57.17	4.33	6.33	13.4	4.91	58.97	5.00
4x5	154.12	52.67	51.5	8.67	40.67	12.33	4.06	46.50	4.54
4x10	151.11	54.00	55.33	9.00	47.33	13.41	4.35	57.5	4.38
4x12	158.35	55.33	56.83	4.67	25.67	13.30	4.47	53.13	4.31
4x14	155.16	55.33	57.67	9.00	40.33	13.27	4.68	55.03	4.37
4x24	167.24	55.67	55.83	9.00	35.33	13.67	4.01	35.30	5.14
4x25	133.43	54.67	56.00	7.33	29.00	13.4	4.69	48.93	3.85
5x10	153.16	53.67	52.67	4.67	18.00	13.30	5.29	58.00	5.22
5x12	147.43	54.00	55.17	4.33	15.67	13.89	5.38	64.90	5.56

5x14	177.17	53.33	54.67	7.67	40.33	13.4	5.59	60.77	5.39
5x24	155.12	55.00	56.00	3.67	26.67	13.4	4.97	61.13	5.41
5x25	151.18	53.67	54.67	4.33	23.33	13.81	5.10	60.40	5.19
10x12	163.22	54.33	56.00	4.00	8.00	13.77	5.14	61.57	5.37
10x14	153.14	54.67	56.83	4.67	19.66	13.75	5.02	61.59	5.46
10x24	147.12	57.00	58.67	9.00	43.00	14.20	5.06	55.70	5.18
10x25	144.16	56.67	57.67	5.33	25.00	13.95	5.13	58.00	4.82
12x14	178.13	58.00	58.67	4.33	3.67	14.45	6.48	66.47	6.76
12x24	158.15	59.00	60.83	4.33	20.67	14.02	5.38	58.71	5.60
12x25	162.11	55.00	59.5	4.00	24.33	14.13	5.19	66.90	5.31
14x24	137.17	53.67	58.83	5.00	25.67	12.91	5.03	56.50	4.92
14x25	162.19	54.00	57.67	4.33	13.33	13.08	5.00	55.60	5.23
24x25	151.11	58.67	58.67	5.33	23.00	13.37	4.81	51.50	4.37
Means	130.75	54.80	55.91	4.58	21.31	13.34	4.89	58.91	4.96
LSD	53.76	2.33	1.94	3.30	25.61	1.34	1.83	6.17	0.75
P2	130.15	56.00	58.00	3.67	8.33	12.17	4.61	52.30	2.47
P4	108.88	54.33	54.83	9.0	1.00	11.38	3.42	40.01	1.29
P5	111.35	45.56	55.5	4.0	13.33	12.42	4.02	49.81	2.55
P10	131.5	56.33	55.5	9.00	44.33	12.92	4.35	55.1	2.90
P12	146.97	60.67	59.33	3.00	10.67	12.89	4.75	56.94	3.17
P14	141.07	59.33	58.18	5.00	22.00	13.22	4.99	53.5	2.8
P24	130.13	62.57	63.00	9.00	28.77	11.83	3.98	45.5	2.03
P25	161.25	56.00	55.83	4.33	23.67	12.55	4.01	50.70	2.54
Means	132.66	56.36	57.72	5.88	16.46	12.42	4.20	50.49	2.41

PHT= Plant height, DYTS = days to 50% tasseling, DYSK=days to 50%silking, SSR = Striga syndrome rating, STEC = Striga emergence count, ELT = ear length, EDM = ear diameter, 100kw= 100- kernel weight(g) and GYT/HA= grain yield per hectare.

Positive heterosis values were observed for plant height only on some hybrids with P5xP14 and P12xP14 recording the highest heterosis of 23.65 and 22.76% (Table 4). Negative heterotic values were observed for days to 50% tasseling and silking for all the hybrids with 2x10, 2x14 and P12xP14 recording the highest heterosis of (-0.07%, -0.43% and -1.45%) and(-0.57% and – 1.13%) respectively. High parent heterosis for *Striga* damage rating were positive only for hybrids P4xP25, P4xP24 and P12xP24 having the highest values of 40.90%, 33.40% and 15.65%.

High parent heterosis for *Striga* emergence count (STEC) were positive for some hybrids with p2xp5, p4xp5, p4xp14 having the highest values of 169.38%, 173.56% and 125.45% respectively. Positive heterotic values were observed for ear length, ear diameter for all the hybrids. However, crosses that involved parent P4 and P24 recorded the least ear length and ear diameter values. Only two hybrids p2xp14 and p12 x p14 recorded high positive heteross values for ear diameter (26.10 and 37.37), ear length (13.76 and 11.31) and grain yield (10.6 and 11.7) tons per hectare. High parent heterosis values were observed for grain yield with p5xp12, p2xp4, p12xp14, p2xp12, p5xp10, p5xp25 and p10xp24 having 121.6%, 120.10%, 117.45%, 106.38%, 103.72%, 102.11% and 101.24% accordingly (Table 4).

Estimate of gca effect of *Striga* resistant maize are presented in Table 5. P12 had the highest gca effect for yield and showed high resistance to *Striga* effect, while P2 was the best combiner for earliness (days to silking) as well as plant height P14 had the highest gca effect for plant height and also possessed positive values for all the agronomic traits except ear length and ear diameter. Thirteen of the crosses showed high SCA effect for yield Table 6 with p2xp12, p12xp14 and p2xp4 recording the highest values (1.69t/ha, 1.65t/ha and 1.49t/ha) while 12x14 has high resistance to *Striga* effect than the two high yielding hybrids. Hybrids 5x14 as well as p12xp14 recorded the highest Sca effect for days to silking and SCA effect for plant height respectively. However these hybrids showed resistance to *Striga* effect. Hybrids p5xp25 as well as p10xp24 recorded the highest values of *Striga* effect and subsequently low yield Table 6.

Table 4: Heterosis (%) over high parent for yield and yield related traits

Crosses	PHT	DYTS	DYTS	SSR	STEC	EDM	ELT	100kw(g)	Gy(kg/ha)
2x4	-13.12**	-3.40**	-6.16**	-49.56**	96.12*	13.40**	12.57*	10.52	2117.45**
2x5	-13.29**	-4.82**	-8.69**	-40.90**	169.38*	24.81**	9.06	14.24*	168.89**
2x10	-16.37	-0.07**	-1.13**	-52.19**	-64.80**	21.93	10.69	13.23	69.29**
2x12	0.36**	-5.15**	1.76**	-19.14**	69.35**	25.12**	13.76*	19.92*	1106.38**
2x14	-6.80**	-0.43**	1.18**	-31.79*	-24.16**	16.10	8.88	14	281.95**
2x24	-9.03**	-9.00**	-1.54**	-53.85*	-45.76**	20.58	12.32	17.88	284.88**
2x25	-4.50**	-2.59**	-2.81**	-42.04**	-55.45**	21.31**	12.08	15.20	172.20**
4x5	17.11**	-4.55**	-3.75**	-7.27**	173.56**	21.14**	4.0	9.75	182.97**
4x10	13.79**	-4.29**	-1.60**	3.55	-29.68**	16.47**	4.91	21.76	44.79**
4x12	6.77**	-4.78**	-3.68**	-35.20	77.39**	10.18	3.65	8.3	14.89
4x14	0.09**	-3.44**	-2.93**	-55.73*	125.45**	12.54	1.60	10.93	37.40**

4x24	4.57**	-11.11**	-10.15*	15.65*	-9.59**	12.56**	4.33**	11.88	8.76
4x25	-8.04**	-4.46**	-4.20**	40.90*	26.68**	10.33	5.49**	12.62	22.87**
5x10	14.45**	-5.16**	-4.10**	-48.64*	-71.54**	15.53**	6.36**	18.23	1103.72**
5x12	6.22**	-4.64**	-4.94**	1.71**	28.29**	19.38**	4.13	8.16	232.71*
5x14	23.65**	-3.41**	-3.29**	-2.18*	21.05****	19.23**	12.90	19.11*	1121.61**
5x24	-2.71**	-14.92**	-5.24**	-25.00**	-62.17**	16.01	7.38	22.31*	191.40**
5x25	6.47**	-5.19**	-2.72**	-17.83*	80.68**	17.28**	9.29	11.69	1102.11**
10x12	14.10**	-3.00**	-2.65**	-50.42*	-78.46	18.12**	6.15	10.63	144.15*
10x14	11.18**	-9.55**	-7.66**	-34.76**	-60.78**	16.90**	5.57	11.81	96.03**
10x24	-13.77**	-4.17**	-9.58**	-7.83**	-40.05**	15.76**	10.04	14.91	1101.24**
10x25	-5.10**	-4.35**	-2.44**	-33.92**	-66.05*	13.18	7.32	19.43	91.32**
12x14	22.76**	-1.45**	-0.57	12.28	-40.50**	37.37	11.31*	17.60*	2420.00**
12x24	1.71**	-6.48**	-3.67**	33.4	41.83**	28.16	11.37*	17.23*	160.37**
12x25	6.90**	-2.87**	-2.72**	-9.32**	28.83**	13.88	7.17**	12.67	138.56*
14x24	-8.38**	-11.24**	-9.92**	-37.52**	-25.97**	12.30	1.07	17.18	185.20**
14x25	8.84**	-4.46**	-3.16**	-35.47**	-4.99**	11.68**	1.83	16.92	191.34**
24x25	-2.39**	-6.98**	-6.35**	-29.85**	-22.22**	17.24**	6.22**	11.63	46.27**

PHT= Plant height, DYTS = days to 50% tasseling, DYSK=days to 50%silking, SDR = Striga damage rating, STEC = Striga emergence count, ELT = ear length, EDM = ear diameter, 10 0kw= 100- kernel weight(g) and GYT/HA= grain yield per hectare.

Table 5: Estimates of general combining ability (GCA) effects for maize inbred lines

Parents	PHT	DYTS	DYSK	SSR	STEC	ELT	EDM	100kw	Gy/t/ha
P2	11.39	0.39	-2.52**	0.17	-0.76	0.48	0.32	9.13	0.49*
P4	-18.46*	0.48	-1.98*	-0.50	-3.84	0.13	-0.04	-13.60	0.49*
P5	-1.82	-1.05	0.48	-0.50	-1.84	0.15	0.64	-2.57	0.411
P10	-12.75	1.34	0.31	1.42	29.46	-0.43	-10.09	1.20	0.164
P12	4.08	0.87	1.31	0.52	1.73	0.29	0.8	13.06	1.95*
P14	68.85*	0.34	4.31**	-0.08	-1.60	-0.20	-0.18	13.61	0.94*
P24	-33.9**	0.49	-2.69*	3.63	16.16	-0.28	0.09	-5.67	-0.41
P25	-31.54*	-1.55	2.19*	0.19	-1.89	-0.32	0.08	-0.17	-0.15

** =Significant at P< 0.01, * = Significant at P< 0.05, PHT= Plant height, DYTS = days to 50% tasseling, DYSK=days to 50%silking, SSR = Striga syndrome rating, STEC = Striga emergence count, ELT = ear length, EDM = ear diameter, 100kw= 100- kernel weight(g) and GYT/HA= grain yield per hectare.

Table 6: Estimate of specific combining ability (SCA) effect for striga resistant hybrid maize

Hybrid	PHT	DYTs	DYSK	SDR	STEC	ELT	EDM	100kw(g)	Gy/t/ha
2x4	-4.58	0.27	0.27	-1.96	-3.45	-0.07	-0.30	2.67	1.49*
2x5	-6.38	-0.17	-0.17*	1.82	-1.71	-0.47	-0.08	5.12	0.28
2x10	-18.41	0.25	0.25	-0.65	4.65	0.07	0.27	3.43	-10.61*
2x12	15.19*	1.53	1.85*	2.67	10.59	0.13	0.14	9.12	1.69*
2x14	2.06	-0.13	-0.01	0.01	-4.24	-0.11	-0.04	-9.25	0.67*
2x24	2.17	0.27	0.27	-0.71	1.79	0.32	0.06	3.03	0.78*
2x25	19.95*	-0.09	0.09	-1.82	-13.49	0.16	0.14	1.03	-0.14
4x5	-7.24	-1.81	-1.81**	-0.24	-6.71	0.26	0.12	-0.28	-0.07
4x10	-2.24	0.11	0.11	2.79	9.04	-0.18	-0.05	-7.46	-0.05
4x12	5.84	1.53	-0.50	2.41	3.76	-0.23	-0.10	6.78	-0.54
4x14	-5.33	1.37	0.85	0.45	8.09	0.01	0.03	-2.47	-0.09
4x24	24.47*	55.16	0.80	2.96	12.80	0.16	0.05	-3.03	-0.43
4x25	-10.15	1.64	0.27	-0.43	-4.83	0.06	0.28	5.22	0.59
5x10	9.84	-1.36	-1.50*	-2.10	-11.46	-0.17	0.13	-10.50	-0.10
5x12	-15.58	2.06	1.88*	-0.93	-8.41	-0.51	-0.44	2.42	-0.15
5x14	10.28	1.03	1.17*	2.23	-12.25	0.27	0.35	6.79	0.87*
5x24	3.44	0.78	0.52	-1.85	12.30	0.03	0.25	-8.64	0.69*
5x25	-2.36	0.06	-0.01	1.07	16.68	0.60	0.16	2.27	-0.14
10x12	7.80	0.39	-0.20	-1.57	7.83	-0.15	-0.27	-7.47	0.40
10x14	1.58	1.39	1.16*	-1.40	2.11	0.09	0.13	2.67	-0.49
10x24	2.72	2.49	-0.39	4.01	14.34	0.31	-0.12	-11.69	-0.13
10x25	-1.28	0.62	0.57	-1.07	-1.74	0.03	-0.09	3.85	-0.02
12x14	21.42*	1.98	0.88*	2.74	14.94	0.81	0.19	9.69	1.75*
12x24	15.81*	0.25	0.59	2.92	8.01	0.20	1.04	-6.26	0.47
12x25	-3.09	-1.96	-2.20*	0.32	8.81	-0.23	-0.28	-9.25	0.17
14x24	-23.46*	-3.80	-3.68**	1.84	3.24	-0.74	-0.65	-10.25	-0.80
14x25	0.45	-0.69	-0.34	-1.40	-6.85	-0.32	-0.09	6.44	0.01

24x25	-3.52	1.75	1.77**	0.35	1.42	-0.27	-0.14	-9.54	0.31

** =Significant at P< 0.01, * = Significant at P< 0.05, PHT= Plant height, DYTS = days to 50% tasseling, DYSK=days to 50%silking, SSR = Striga syndrome rating, STEC = Striga emergence count, ELT = ear length, EDM = ear diameter, 100kw= 100- kernel weight(g) and GYT/HA= grain yield per hectare.

IV. DISCUSSION

The present study provides a good understanding of the performance of six *Striga* resistant and two susceptible maize inbred lines in a daillel mating design. The significant variation among the inbreds indicates considerable genetic diversity among the parents and their respective crosses, this is appropriate for further assessment of the traits under consideration. The significant GCA mean squares for all traits except 100kernel weight indicated variability of GCA among the parents and this suggests that genetic gain is achievable through selection over the segregate population. The significant GCA and SCA mean square for these traits showed the importance of both additive and dominance gene effects. This agrees with the findings of [17]−[1] and [22]. This shows that it is possible to select parent pairs with breeding potential [6] to exploit heterosis to increase productivity in maize. The observation that GCA x location interaction was higher than SCA x location interaction which also agreed with other authors findings [17] − [21]−[5]. However, SCA X environment interaction was significant, thus there was no stability in SCA effects across environments which disagrees with the findings of [18]. Significant GCA, GCA x location effect suggests the need for selecting different parental lines for hybrid in specific environments. This finding agreed with the report of [18]−[11] that both GCA and SCA can interact with environment in response to yield of maize. They reported the significance of the sources of variation of GCA x environment and SCA x environment which indicated that both the GCA and the SCA effects varies in the environments assessed. The findings of other researchers[21]−[5] that GCA x location interaction was highly significant and greater than SCA x location interaction is also in agreement with this present study.

However, SCA x environment (E) interaction was significant for only few traits which infer that specific hybrid combinations were stable across environments as observed by [18]. This disagrees with [26] who observed that SCAx environment interaction was significant for all traits. In respect to yield traits, hybrids 12 x 14 and 2 x 4 exhibited the highest significant positive values and were better yielding having 2420 kg/ha to 2117.45kg/ha respectively. In general, this result indicate that most hybrids were significantly earlier and high yielding suggesting the role of non-additive gene action in the inheritance of the studied traits. This results are in agreement with those reports of [20] − [31] There was inconsistency of this current work compared to the previous ones [19]−[30]. This may be due to differences in testing locations and the genetic materials studied.

GCA effects for *Striga* damage rating (SDR) and *Striga* emergence count (STEC) were generally low with some parents recording negative values. The GCA effect for this value is in the range of -0.50 and 3.63 showing tolerance/resistance levels of the parents to *Striga* damage rating. Parents such as P2, P5, P14 and P25 are exceptionally resistant to *Striga* emergence count with GCA effect of -0.76, -1.84, -1.60 and -1.89. Parents P2, P5 and P14 were also resistant to *Striga* damage rating. These parents are good sources of genes for *Striga hermonthica* resistance. [28] revealed similar negative effects while breeding for gray leaf resistant in maize genotypes. Also, parent P2, P5, P12 and P14 are good source of genes for higher grain yield. The SCA effects were generally low for all the hybrids with respect to *Striga* damage rating showing good resistance with the exception of hybrid 2x12, 4x10, 4x12, 5x14, 10x24 and 12x24 which seems to be tolerant with high potential to increase kernel weight. Similarly SCA effects were also low for most hybrids with respect to STEC showing good resistance to *Striga* emergence count (STEC). Although 16 out of 28 F1 hybrids were moderately susceptible with SCA effect of between 1:42 and 16.68 the rest were resistant to *S. hermonthica* infestation with SCA effect of -14.94 to -1.74.

V. CONCLUSION

The physical expression of the *Striga* hermonthica parasite in this study showed great differentiation which was most probably reflective of the diverse nature of the inbred lines used. The result indicated that both additive and non-additive gene effect played major roles in the inheritance of resistance to *Striga* in the inbreds and hybrids. Additive variance was larger than non–additive genetic variance for *Striga* emergence count and should be taken into consideration in future selection programs. Considering the overall performances, the inbred lines, P2, P5 and P12 and 14 can be used for hybrid maize resistant to *Striga* to increase maize production. Hybrids 2 x 4 and 2 x 5 performed best in Lafia location while in Makurdi location, hybrids 2 x 5, 2 x 12 and 12 x 14 performed best in respect to yield and resistance to *Striga hermonthica.* However, selection based on low *Striga* damage rating, reduced *Striga* emergence count and high yield be adopted.

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