



## COMBINING ABILITY STUDY AMONG LINES OF COWPEA (*Vigna unguiculata* L. Walp) FOR YIELD AND YIELD RELATED COMPONENTS

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### ABSTRACT

The study was carried out to determine the combining ability among lines of cowpea (*Vigna unguiculata* (L.) Walp) for yield and yield related component using (four male and five females) parents, that were mated in a line x tester mating design that generated 29 progenies, to determine mode of gene action, estimate heritability and the association of the measured traits. Significant differences were observed among the studied genotypes implying variation among the genotypes. Genotypes performance across location was significant ( $P \leq 0.05$ ) for plant height and yield. The genotype performance across location showed grain weight among the parent ranges from 239.67kg to 279.33kg with Dan'lla (IAR-17-2006) being the highest and the cross IAR-07-105-0 x Ex-Borno recorded highest mean weight of 279.33kg and the least (200kg) was recorded by Dan'lla (IAR-17-2006) x Dan Wuri-11 (IAR-07-023). This study also revealed that both additive and non-additive gene action were important in controlling yield and other agronomic traits. The male parent IT93K-452-1 is good general combiner for plant height (-3.93;  $P \leq 0.01$ ). IT93K-452-1 is good general combiner for number of branches (-3.30;  $P \leq 0.01$ ) and grain weight (-55.38;  $P \leq 0.01$ ). The female parent Itas Early was good general combiner for leaf area (-11.34;  $P \leq 0.01$ ), number of branches (-3.30  $P \leq 0.01$ ) and average pod length (-2.76;  $P \leq 0.01$ ) but for grain weight Dan Wuri-11 (IAR-07-023) (-55.34;  $P \leq 0.01$ ) is a good general combiner. The crosses IAR-07-105-0 x Itas Early, IAR-07-105-0 x Bahaushie IAR-17-008, IAR-07-105-0 x Kanannado White (IAR-011-084), and IAR-07-105-0 x Dan Wuri-11 (IAR-07-023) were good specific combiners for plant height were as IAR-07-105-0 x Bahaushie IAR-17-008 were the best specific combiners for number of leaves and IAR-07-105-0 x Bahaushie IAR-17-008, IAR-07-105-0 x Kanannado White (IAR-011-084), IAR-07-105-0 x Ex-Borno and IAR-07-105-0 x Dan Wuri-11 (IAR-07-023) for leaf area and so also IAR-07-105-0 x Itas Early, IAR-07-105-0 x Bahaushie IAR-17-008, IAR-07-105-0 x Kanannado White (IAR-011-084), IAR-07-105-0 x Ex-Borno and IAR-07-105-0 x Dan Wuri-11 (IAR-07-023) are thoroughly good specific combiner and also pod weight and average pod length are specific combiner were grain weight was significant and positively correlated with number of leaves chaff weight and average pod length, path coefficient analysis revealed that the only trait that had direct positive contributors to grain weight in was chaff weight (0.833).

**Keywords:** Action, Additive, Gene, Line and Testers.

### INTRODUCTION

Cowpea (*Vigna unguiculata* (L.) Walp) is grown in tropical Africa, Asia, North and South America mostly as a grain, but also as a vegetable and fodder crop. It is favored because of its wide adaptation and tolerance to several stresses. It is an important food source and is estimated to be the major protein source for more than 200 million people in sub-Saharan Africa and is in the top ten fresh vegetables in the People's Republic of China (hereafter "China"). Cowpea is generally adapted to poor soils and its tolerance to drought, which makes



its cultivation attractive to the drier parts of the Nigeria savannas. Production in Nigeria is increasing, and consumption is also at an all-time high, raising hopes over the sustainability of a key source of plant protein for millions of Nigerians (FAO, 2018). For instance, the area under cultivation in Nigeria has increased by about 2.9 times from 1.2 million ha for the period 1980–1984 to about 3.5 million ha between 2014 and 2018. During the same period, production increased from 524 thousand tons from 1980–1984 to about 3 million tons from the 2014–2018 period. The average yield/ha also followed the same trend from 409 kg/ha between 1980 and 1984 to about 900 kg/ha from 2014 to 2018 (FAO, 2018). Studies conducted by Atlin *et al.* (2017) revealed that in Nigeria more urban households (72%) consume cowpea than any other grain legume. This is an indication that there is a good domestic market, providing an important opportunity to increase incomes and employment and reduce poverty in rural areas.

The combination of these stresses can cause complete crop loss if not properly managed. Researchers in the sub-region have developed several varieties that are either resistant/or tolerant to these stresses. These varieties, along with improved management practices, have been found to substantially increase yield in Nigeria (Begna, 2021) this guide draws its lessons from the work and experience of IITA and partners in Research for Development on cowpea-based systems in Nigeria.

## **MATERIALS AND METHODS**

The experiment was conducted at two locations; Teaching and Research Farm, Bauchi State College of Agriculture, Bauchi State situated within latitude 10.28N, and longitude 9.1E of the Greenwich Meridian, Northern Guinea Savanna vegetation zone. Minimum temperature range of 37°C is experienced in the month of April and May with a maximum of 45°C. The area usually has relative humidity of 60 to 90 percent with an average rain fall of 600 mm at the extreme northern part of the state to 1008 – 1300 mm in the month of May/June and last for about 5 – 6 months. The second location was Babale community of Jos North local government area of Plateau State, which is situated at latitude 9.54N and longitude 8.54E on an altitude of about 180m above sea level. The annual rainfall for the area is about 1250 mm and a mean temperature of 35.50°C

A total of 9 genotypes with four inbred lines as males and five land race lines as females were selected as parents. The genotypes were obtained from the Ahmadu Bello University (ABU) Zaria, Nigeria. The inbred lines and the land races were planted on a 2 x 3 m, 6 rows plot with a planting spacing of 30 cm x 50 cm between and within rows respectively at Lushi village of Bauchi local government area the dry season 2018. Prior to Planting, land followed by harrowing to produce good tilth. At planting, two seeds were sown per hole and thinned to one after seedling establishment at 2 weeks after planting (WAP). Weeding was done manually when needed. 3% of Sypermethrine was applied into the whorls of the plants at the rate of 2kg/ha at 6WAP to prevent attack.

The field was laid out in a Randomized Complete Block Design (RCBD) with three replications. The experimental area measures 25m x 39m (975m<sup>2</sup>). The whole area was divided into block twenty-nine (29) treatments (Table 3.2) with an inter row spacing distance of 0.5m and intra row spacing distance of 0.3m with the row 2m long (Figure 1). All the F1 hybrids along with their parental lines were planted under rain-fed conditions on the 17th June, 2019 and 18th August, 2019 respectively. All agronomic practice vividly applied according to I.A.R recommendations. Samples were harvested by hand and dried for yield assessment.

### **Method of Data Analysis**

The data collected subjected to both separate and combined analysis of variance (ANOVA) the Generalized Linear Model (GLM) procedure of Statistical Analysis System



(SAS). Pair wise comparisons of means were made using Least Significant Differences (LSD) and Path coefficient were obtained using Path analysis in Analysis of Moment Structures (AMOS).

## RESULTS AND DISCUSSION

### Combined Result (Bauchi and Jos Locations)

#### Analysis of variance

The results of analysis of variance for combining ability, estimates of genetic variance and proportional contribution to total variance across location are presented in Table 1. The Treatment Variance ( $\sigma^2T$ ) estimates for all the studied traits were greater than the environmental variance ( $\sigma^2E$ ). The result indicated that, there was highly significant difference in Bauchi and Jos location combined in plant height (0.06;  $P \leq 0.01$ ), leaf area (0.01;  $P \leq 0.01$ ), pod length (4137.12;  $P \leq 0.01$ ), chaff weight (19482.01;  $P \leq 0.01$ ), 100 grain weight (132.04;  $P \leq 0.01$ ) and grain yield per plant (43.98;  $P \leq 0.01$ ). However, all other traits did not show any significant difference across location. The result also indicated the existence of significant difference in days to 50% flowering (3.90;  $P \leq 0.01$ ), plant height (0.10;  $P \leq 0.01$ ), number of branches per plant (0.38;  $P \leq 0.05$ ), pod weight per plot (0.03;  $P \leq 0.01$ ) and pod length (0.69;  $P \leq 0.01$ ) for line  $\times$  tester across location. On the other hand, the result revealed that there was significant difference among the location  $\times$  treatment only in plant height (0.10;  $P \leq 0.01$ ), leaf area (0.01;  $P \leq 0.01$ ), pod length (0.45;  $P \leq 0.01$ ), 100 grain weight (0.47;  $P \leq 0.01$ ) and grain yield per plant (1.55;  $P \leq 0.01$ ), all the other traits did not show any significant difference among the location  $\times$  treatment. However, the mean square of location  $\times$  line indicated that there was significant difference in number of leaves per plant (0.12;  $P \leq 0.01$ ), leaf area (0.02;  $P \leq 0.01$ ), number of branches per plant (0.50;  $P \leq 0.01$ ), pod length (3.75;  $P \leq 0.01$ ), chaff weight (10.74;  $P \leq 0.05$ ), 100 grain weight (0.53;  $P \leq 0.05$ ) and grain yield per plant (1.28;  $P \leq 0.01$ ). Location  $\times$  tester significant difference in days to 50% flowering (16.62;  $P \leq 0.01$ ), pod length (1.44;  $P \leq 0.01$ ), chaff weight (12.83;  $P \leq 0.01$ ), 100 grain weight (2.13;  $P \leq 0.01$ ) and grain yield per plant (2.20;  $P \leq 0.01$ ). There was however significant difference in days to 50% flowering (4.16;  $P \leq 0.01$ ), plant height (0.13;  $P \leq 0.01$ ), leaf area (0.01;  $P \leq 0.01$ ), pod length (0.70;  $P \leq 0.01$ ), 100 grain weight (0.47;  $P \leq 0.05$ ) and grain yield per plant (1.47;  $P \leq 0.01$ ) for location  $\times$  line  $\times$  tester interaction. All the other traits did not differ significantly among location and between line  $\times$  tester interactions.

For the genetic components of variance, the result for the variance GCA was consistently higher than other components for days to 50% flowering (0.04), pod weight (0.78) pod length (0.15) and chaff weight (0.41). The result for the variance SCA indicated higher component for plant height only (0.003), number of leaves per plant (0.01), leaf area (0.002), 100 grain weight (0.02) and grain yield per plant (0.3). The result for the ( $\sigma^2GCA / \sigma^2SCA$ ) for all the traits were less than unity except for days to 50% flowering (1.33), number of branches per plant (1.00), pod weight per plot (9.75), pod length (7.5) and chaff weight (1.08).

The result for the proportional contribution of lines to the total variance was higher than that of line  $\times$  tester in plant height (55) and number of leaves per plant (43). On the other hand, the result for line  $\times$  tester contribution to total variance was higher than that of lines in days to 50% flowering (57), leaf area (55), number of branches per plant (66), pod weight per plot (52), pod length (62), chaff weight (63), 100 grain weight (57) and grain yield per plant (43) in Bauchi and Jos location combined.



**Table 1:** Analysis of variance for combining ability, estimates of genetic variance and proportional contribution to total variance evaluated across location (Bauchi and Jos), 2019 rainy season

SOV	Df	DFF	PHT	NLP	LAR (cm <sup>2</sup> )	NBP	PDW (kg/plot)	PDL (cm)	CFW (g)	HGW (g)	GYP(g)
Location	1	1.20	0.06**	0.007	0.01**	0.13	0.01	4137.12**	19482.01**	132.04**	43.98**
Replicate	4	0.69	0.01	0.08*	0.02**	0.31*	0.02**	0.23	8.74	0.74**	0.12**
Treatment	19	4.28**	0.09**	0.08	0.01*	0.41**	0.80*	2.14	7.45	0.80**	1.12
Lines (GCA)	4	7.47**	0.13**	0.04	0.01**	0.16	3.68**	6.95**	19.36**	1.46**	2.04*
Testers (GCA)	3	1.54	0.02	0.21**	0.02**	0.84**	0.03**	1.52**	7.76	1.81**	1.30**
Line × tester(SCA)	12	3.90**	0.10**	0.06	0.01	0.38*	0.03**	0.69**	3.40	0.33	0.77
Location × Treatment	19	5.55	0.10**	0.06	0.01**	0.30	0.01	0.45**	8.29	0.74**	1.55**
Location × Line	4	1.43	0.05	0.12**	0.02**	0.50**	0.01	3.75**	10.74*	0.53*	1.28**
Location × Testers	3	16.62**	0.03	0.002	0.004	0.18	0.01	1.44**	12.83**	2.13*	2.20**
Location × Line × tester	12	4.16**	0.13**	0.05	0.01**	0.26	0.01	0.70**	6.34	0.47*	1.47**
Error	76	5.120	0.08	0.11	0.01	0.40	0.03	0.60	14.03	0.56	1.20
<b>Genetic Components of Variance</b>											
$\sigma^2$ Treatment		13.35	0.29	0.25	0.03	1.30	2.53	6.78	23.58	2.53	3.55
$\sigma^2$ Line		0.15	0.001	0.0	0.0001	0.0	0.15	0.26	0.67	0.05	0.05
$\sigma^2$ Tester		0.0	0.0	0.005	0.0004	0.02	1.39	0.03	0.15	0.05	0.02
$\sigma^2$ GCA		0.04	0.002	0.002	0.0003	0.0003	0.78	0.15	0.41	0.05	0.04
$\sigma^2$ SCA		0.03	0.003	0.01	0.002	0.0003	0.08	0.02	0.38	0.2	0.03
GCA:SCA		1.33	0.67	0.02	0.15	1.00	9.75	7.5	1.08	0.25	0.13
$\sigma^2$ A		0.16	0.0	0.008	0.001	0.01	0.31	0.59	1.66	0.19	0.14
$\sigma^2$ D		0.0	0.01	0.0	0.0	0.0	0.003	0.06	0.0	0.0	0.0
$\sigma^2$ E		1.07	0.02	0.02	0.003	0.07	0.004	0.53	2.34	0.19	0.38
<b>Proportional Contribution to Total Variance</b>											
Line	37		55	43	19	5	38	29	7	38	38
Tester	6		23	17	26	29	10	9	30	5	19
Line × Tester	57		22	40	55	66	52	62	63	57	43

#### 2019 Rainy Season

#### KEYS

DF = Degree of freedom  
 DFF = Days to 50% flowering  
 PHT = Plant height

NLP = Number of leaves per plant  
 LAR = Leaf area  
 NBP = Number of branches per plant

PDW = Pod weight per plot  
 PDL = Pod length  
 CFW = Chaff weight per plot

HGW = 100 Grain weight  
 GYP = Grain yield per plant

\*\* = Significant at 1% level of probability  
 \* = Significant at 5% level of probability



### **Mean performance of parental lines, testers and their hybrids across location (Bauchi and Jos)**

The mean performance in traits of lines, testers and their hybrid across location during 2019 rainy season are presented in Table 2. The results indicated that significant differences were found in all traits among lines, testers and their hybrids except pod weight per plot which show no significant difference. The result showed that Bahausha AR-17-008 had the highest days to 50% flowering with value of 5.38 among the lines, while Dan'Ila (IAR-17-2006) had the highest days to 50% flowering among the testers. On the other hand, the hybrid Dan'Ila (IAR-17-2006) × Bahausha AR-17-008 had the highest days to 50% flowering (33.00). These values did not differ significantly among themselves, but significantly higher and different to the other values. The least number of days to 50% flowering were obtained from line Dan Wuri-11(IAR-07-023) with 0.57, tester IT98K-205-8 (10.65) and hybrid IT98K-205-8 × Kanannado White (IAR-011-084) with 0.55. The result for plant height indicated that the line Itas Early was the tallest plant with 18.68cm. The tallest plant among the testers was IT93K-452-1 with 20.51cm. The result that the tallest hybrid was IAR-07-105-0 × Itas Early with 17.77cm. The lines and testers with the highest number of leaves per plant were IT93K-452-1 and Itas Early with values of 71cm and 64cm respectively. The lowest hybrid in terms of number of leaves per plant was Dan'Ila (IAR-17-2006) × Ex-Borno (13). On the other hand, IT93K-452-1 and IT98K-205-8 had the highest number of branches (33) among the parents, while IAR-07-105-0 × Dan Wuri-11(IAR-07-023) had the highest number of branches per plant among the hybrid with 22. Dan Wuri-11(IAR-07-023) was the heaviest among the parents in terms of 100 grain yield per plant with 1.58g followed by IT93K-452-1 (1.20g), while IT98K-205-8 × Kanannado White (IAR-011-084) was the heaviest in terms of 100 grain weight among the hybrid followed by IT93K-452-1 × Itas Early and Dan'Ila (IAR-17-2006) × Itas Early with 1.20g respectively. The result further indicated that IT98K-205-8 was the best yielder among the parents with 13.10g per plant while IT98K-205-8 × Kanannado White (IAR-011-084) was the best yielder in terms of grain yield per plant with 13.07g per plant under combined result.

### **General combined ability and specific combined ability effect's estimates**

Table 4 presented the GCA of both male and female parents for Plateau. All the parents recorded significant negative GCA effects for all the growth and yield parameters. SCA effects are presented in Table 3. All cross combinations recorded significant positive SCA effects for all the growth and yield parameters.

### **Estimates of general combining ability effect of parents in Bauchi and Jos locations combined**

The analysis of GCA effects of lines and testers are presented in Table 4. The results indicated that the lines Kanannado White (IAR-011-084) and Dan Wuri-11(IAR-07-023) had highly significant positive GCA effect for 100 grain weight and grain yield per plant. Among the testers, IAR-07-105-0 and Dan'Ila (IAR-17-2006) significant positive GCA effect for 100 grain weight and grain yield per plant. All other parents recorded significant negative GCA effects for all the growth and yield parameters across locations.





**Table 2: Mean performance of cowpea parental lines and their hybrids for ten traits of cowpea at Bauchi and Jos combined, 2019 rainy season**

Parents	DFP	PHT (cm)	NLP	LAR (cm <sup>2</sup> )	NBP	PDW (kg/plot)	PDL (cm)	CFW (g)	HGW (g)	GYP (g)
<b>Testers</b>										
IAR-07-105-0	22.27	18.04	35	27.21	27	0.70	12.96	0.27	0.23	11.98
IT93K-452-1	24.90*	20.51**	71**	32.10**	33**	0.63	14.25**	0.25	1.20**	5.87
IT98K-205-8	10.65	17.71	52	29.46	33*	0.62	12.70	0.24	0.79*	13.10*
Dan'Ila(IAR-17-2006)	34.00**	16.59	58	31.30*	30	0.67	12.50**	0.26	0.52	9.21
Mean	22.83	18.21	53	29.66	30	0.66	13.38	0.26	0.72	9.79
CV (%)	24.05	6.98	13	8.11	17	10.04	7.18	13.06	18.05	12.91
<b>Lines</b>										
Itas Early	4.31	18.64*	64**	38.94	17*	0.66	12.20	0.25	0.91*	10.99**
Bahaushe IAR-17-008	5.38*	18.43	48	31.86	17*	0.66	12.60*	0.26	0.22	6.23
Kanannado White (IAR-011-084)	2.99	17.72	49	32.27	13	0.71	11.89	0.27	0.41	9.26
Ex-Borno	1.49	18.43	58	38.99	16	0.71	12.36	0.26	0.99*	10.76
Dan Wuri-11(IAR-07-023)	0.57	17.69	58	32.99	15	0.67	12.53*	0.25	1.58**	4.59
Mean	3.44	18.17	56	35.43	15	0.69	12.25	0.26	0.90	7.71
CV (%)	13.23	8.43	19	15.11	18	22.01	11.03	12.61	7.10	8.72
<b>Hybrid</b>										
IAR-07-105-0 × Itas Early	21.41**	17.77*	59**	27.03	16	0.65	12.37	0.24	1.03**	11.54**
IAR-07-105-0 × Bahaushe IAR-17-008	9.18	16.08	57	33.41	16	0.67	12.57	0.25	0.77	5.91
IAR-07-105-0 × Kanannado White (IAR-011-084)	3.89	15.04	51	33.32	14	0.70	12.65	0.26	0.31	8.79
IAR-07-105-0 × Ex-Borno	1.61	14.76	44	30.20	12	0.70	12.35	0.25	1.15**	3.14
IAR-07-105-0 × Dan Wuri-11(IAR-07-023)	2.19**	16.55	53	34.40	22**	0.67	12.55	0.26	0.23	3.25
IT93K-452-1 × Itas Early	1.31	15.47	50	33.07	15	0.68	12.92*	0.25	1.20**	10.83*
IT93K-452-1 × Bahaushe IAR-17-008	2.78**	15.09	52	32.24	15	0.70	12.39	0.27**	0.79	7.23
IT93K-452-1 × Kanannado White (IAR-011-084)	2.22	15.73**	51	53.63	15	0.67	12.23	0.25	0.52	9.26
IT93K-452-1 × Ex-Borno	4.29**	17.99**	48	34.04	14	0.66	12.46	0.26	0.91*	10.76*
IT93K-452-1 × Dan Wuri-11(IAR-07-023)	5.36**	16.27	68*	32.10	20*	0.66	12.93**	0.24	0.22	4.59
IT98K-205-8 × Itas Early	3.97**	14.96	68*	40.92	18	0.69	12.35	0.26	0.41	11.28**
IT98K-205-8 × Bahaushe IAR-17-008	1.47	15.56	54	27.64	16	0.58	11.09	0.24	0.99*	6.87
IT98K-205-8 × Kanannado White (IAR-011-084)	0.55	13.89	35	27.67	11	0.55	11.21	0.24	1.58**	13.07**
IT98K-205-8 × Ex-Borno	20.27**	14.77	59	28.74	19**	0.54	11.11	0.22	1.15**	9.21
IT98K-205-8 × Dan Wuri-11(IAR-07-023)	22.90**	15.43	47	29.68	17	0.58	11.35	0.22	0.23	11.54**
Dan'Ila(IAR-17-2006) × Itas Early	8.65**	14.83	63**	34.03	17	0.58	11.31	0.23	1.20**	5.91
Dan'Ila(IAR-17-2006) × Bahaushe IAR-17-008	33.00**	16.08	62*	31.92	17	0.56	11.25	0.22	0.79	8.79



Dan'Ila(IAR-17-2006 × Kanannado White (IAR-011-084)	22.41	16.24	48	33.23	13	0.55	11.27	0.23	0.52	3.14
Dan'Ila(IAR-17-2006) × Ex-Borno	8.18	17.48*	14	50.13	17	2.35	11.22	0.22	0.91*	3.25
Dan'Ila(IAR-17-2006) × Dan Wuri-11(IAR-07-023)	2.89**	15.44	16	45.20	16	0.53	11.23	0.21	0.53	10.83*
Mean	11.73	15.94	52	38.58	17	1.37	12.02	0.24	0.90	7.34
CV (%)	7.21	10.25	8.0	8.58	16	20.36	83.95	6.6	12.21	9.04

**KEYS:** 2019 Rainy Season\* = Significant at 5% level of probability \*\* = Significant at 1% level of probability

DFF = Days to 50% flowering

LAR = Leaf area

PDL = Pod length

GYP = Grain yield per plant

PHT = Plant height

NBP= Number of branches per plant

CFW = Chaff weight per plot

CV = Coefficient of variation

NLP<sup>-1</sup> = Number of leaves per plant

PDW = Pod weight per plot

HGW = 100 Grain weight



**Table 3: Mean performance of parents, F<sub>1</sub> for Growth and Yield traits of cowpea genotypes from combined data during 2018/2019 dry season**

	Plant Height (cm)			Number of Leaves			Leaf Area (cm <sup>2</sup> )			Number of Branches		Pod weight (Kg/plot)	Average pod length (cm)	Chaff weight (kg/plot)	Grain weight (Kg/ha)
Genotypes	4 WAP	6 WAP	8 WAP	4 WAP	6 WAP	8 WAP	4 WAP	6 WAP	8 WAP	6 WAP	8 WAP				
M1	15.34a-j	18.33a-g	18.75c	22.88b	40.17c-h	42.52hi	29.52b-g	35.95ab	30.2de	6.58c-h	11.72g	0.67b	13.03abc	0.26abc	258.5abc
M2	16.57abc	17.86b-h	17.80cd	19.63b	44a-f	59.28ab	32.19ab	32.22bcd	32.72cde	5.65g-n	17.38abc	0.63b	13.69a	0.24bcd	239.83bc
M3	14.64f-j	17.88a-g	18.19cd	17.35b	46.95abc	53.5a-f	22.02l	31.2bcd	31.36cde	6.4c-j	13.98efg	0.62b	12.58a-d	0.24bcd	236.5cd
M4	14.08ij	17.72b-h	17.93cd	15.65b	47.82ab	56.45a-d	23.65jkl	29.34bcd	32.17cde	7.3a-d	14.38d-g	0.64b	12.75a-d	0.25abc	261.33abc
F1	15.94a-h	18.40a-g	18.46cd	17.47b	50.03a	59.63ab	27.89d-g	34.60bcd	33.83b-e	7.37abc	16.22a-f	0.65b	12.47a-d	0.25abc	250.83abc
F2	16.38a-d	18.51a-f	18.00cd	17.98b	49.65a	52.5a-f	31.25abc	31.23bcd	36.13bcd	6.67b-g	15.72a-f	0.64b	12.32b-e	0.25abc	246.83abc
F3	15.51a-j	18.48a-f	17.58cde	18.22b	42.13b-h	45.17f-i	30.27a-e	31.50bcd	30.92de	7b-f	13.67efg	0.69b	12.33b-e	0.26abc	264.67ab
F4	16.33a-e	18.73a-e	18.15cd	18.32b	46a-d	49.8d-h	30.62a-d	35.73abc	31.48cde	7.33a-d	15.63b-f	0.69b	12.81a-d	0.26ab	266.83a
F5	16.14a-f	18.78a-e	17.47cde	16.97b	44.1a-f	54.88a-e	28.27c-h	31.81bcd	30.71de	6.65b-g	14.25d-g	0.66b	13.02abc	0.25abc	258.17abc
Crosses															
X <sub>1,1</sub>	16.92a	19.43a	18.31cd	18b	42.33b-h	46.37e-i	28.18c-h	32.58bcd	28.9e	5.92g-m	17a-d	0.64b	13.25ab	0.24cde	249.33abc
X <sub>1,2</sub>	16.04a-g	18.74a-e	17.93cd	22b	45.27a-e	54.2a-e	32.86a	29.56bcd	32.87cde	6.33d-j	16.5a-e	0.66b	12.65a-d	0.25abc	261.5abc
X <sub>1,3</sub>	14.70e-j	17.35c-h	18.1cd	16.9b	42.55b-h	53.05a-f	25.59i-k	30.43bcd	31.59cde	7.37abc	13.5fg	0.68b	12.54a-d	0.25abc	265.83ab
X <sub>1,4</sub>	14.41g-j	18.06a-g	18.49cd	21.47b	42.07b-h	51.22b-g	26.77g-j	29.9bcd	30.95de	7.07b-e	13.43fg	0.68b	12.08b-f	0.25abc	265.83ab
X <sub>1,5</sub>	15.19b-j	18.79a-d	18.27cd	142.18a	43.68a-g	48.82d-i	31.62ab	29.1bcd	34.61b-e	8.18a	18.7a	0.66b	11.81c-f	0.26abc	257.33abc
X <sub>2,1</sub>	14.35hij	17.22e-h	18.47c-d	16.37b	38.35e-h	52.92a-f	27.13e-i	31.65bcd	35.47b-e	5.67g-n	14.47c-g	0.67b	12.98abc	0.25abc	257.33abc
X <sub>2,2</sub>	14.61f-j	16.88gh	17.95cd	16.57b	39.52d-h	49.23d-i	29.68a-g	29.04bcd	32.74cde	6.05e-l	14.6c-g	0.69b	12.3b-e	0.27a	265.67ab
X <sub>2,3</sub>	15.83a-h	18.33a-g	18.39c-d	17.07b	44.53a-f	49.85d-h	30.67a-d	32.34bcd	43.45a	7.33a-d	15.98a-f	0.65b	12.75a-d	0.24bcd	251abc
X <sub>2,4</sub>	15.49a-j	17.83b-h	18.38cd	18.1b	45.85a-d	49.92d-h	30.08a-f	35.72abc	33.19b-e	6.48c-i	13.65efg	0.65b	13.3ab	0.26ab	250.17abc
X <sub>2,5</sub>	15.64a-i	18.90abc	18.12cd	16.28b	35.88h	59.77a	23.86i-l	26.02d	32.8cde	6.08e-k	17.97ab	0.65b	13.33ab	0.25abc	255.33abc
X <sub>3,1</sub>	15.03c-j	19.21ab	18.56cd	16.42b	41.42b-h	58.85abc	23.76jkl	30.39bcd	36.19bcd	7.62ab	16.17a-f	0.67b	12.99abc	0.25abc	259.5abc
X <sub>3,2</sub>	14.91d-j	16.98fgh	18.14cd	16.28b	36.23h	52.15a-f	24.00i-l	27.69bcd	29.95de	5.62h-n	16.5a-e	0.56b	11.5def	0.23def	211.5de
X <sub>3,3</sub>	13.98i	17.73b-h	17.53cde	16.08b	40.52c-h	40.98i	25.56i-k	30.05bcd	30.34de	5.53i-n	13.37fg	0.55b	11.9c-f	0.23d-g	207.5e
X <sub>3,4</sub>	14.32hij	17.51c-h	17.60cde	16.37b	40.88b-h	51.68a-f	22.95kl	28.6bcd	31.34de	6f-l	16.13a-f	0.54b	11.54def	0.22fg	202.17e
X <sub>3,5</sub>	14.98c-j	17.38c-h	17.03de	16.05b	36.3h	42.78ghi	24.09i-l	43.91a	30.74de	5.03lmn	15.73a-f	0.56b	11.04ef	0.22fg	211.5de
X <sub>4,1</sub>	15.03c-j	17.61c-h	17.25cde	15.82b	38.93d-h	50.7c-h	25.36i-k	27.96bcd	31.7cde	5.4j-n	15.4b-f	0.56b	10.96f	0.22fg	209.5e
X <sub>4,2</sub>	15.57a-j	17.17fgh	17.05de	17.45b	36.7gh	52.7a-f	26.8f-j	26.70cd	32.78cde	5.17k-n	15.97a-f	0.56b	11.79c-f	0.22fg	206.5e
X <sub>4,3</sub>	15.84a-h	17.33d-h	16.07e	14.98b	36.32h	50.07d-h	25.62h-k	26.5d	32.48cde	4.95mn	13.55efg	0.56b	12.4a-d	0.23efg	208.67e
X <sub>4,4</sub>	16.74ab	16.31h	26.71a	16.2b	37.77fgh	22.8j	28.12c-h	26.55d	39.92ab	4.7n	15.43b-f	1.45a	12.56a-d	0.22fg	208.33e
X <sub>4,5</sub>	14.87d-j	16.89gh	24.64b	15.39b	39.57d-h	24.69j	23.34kl	28.44bcd	38.4abc	5.25k-n	13.72efg	0.53b	11.6def	0.21g	200.17e
<b>SE±</b>	<b>9.4</b>	<b>7.61</b>	<b>7.32</b>	<b>259.65</b>	<b>14.81</b>	<b>15.09</b>	<b>10.55</b>	<b>25.72</b>	<b>18.6</b>	<b>14.21</b>	<b>17.24</b>	<b>63.57</b>	<b>9.38</b>	<b>6.49</b>	<b>9.69</b>

Note: M stands for male, F stands for female, X stands for crosses, and SE stands for standard error.





### **Estimates of SCA effects for cowpea genotypes in Bauchi and Jos location**

The analysis of specific combining ability effects of the hybrids for ten traits in cowpea evaluated in Bauchi and Jos location are presented in Table 5. The result revealed that IT98K-205-8 × Bahaushie IAR-17-008 and Dan'Ila(IAR-17-2006) × Dan Wuri-11(IAR-07-023) recorded significant positive SCA effect for days to 50% flowering. On the other hand, IAR-07-105-0 × Kanannado White (IAR-011-084), IT93K-452-1 × Dan Wuri-11(IAR-07-023), IT98K-205-8 × Bahaushie IAR-17-008 and Dan'Ila (IAR-17-2006) × Ex-Borno recorded significant negative SCA effect for days to 50% flowering. All cross combinations recorded a significant positive SCA effect for plant height, number of leaves per plant, number of branches per plant, pod weight per plot, pod length and chaff weight. In terms of grain yield, all the traits under study recorded a significant positive SCA effect for grain yield per plant except IT98K-205-8 × Bahaushie IAR-17-008 and IT98K-205-8 × Ex-Borno.

### **CONCLUSION AND RECOMMENDATIONS**

The cowpea traits studied were controlled by both additive and non-additive gene action, however, it was also recorded that the values of variance additive were larger than that of variance dominant for all the five yield parameters examined in the study namely: grain weight, pod weight, chaff weight, and average pod length.

For immediate use by the Farmers at Bauchi, it may be recommended that it was found to be very high yielding variety, so farmer may use it directly whenever IT93K-452-1 (maternal) was crossed with each of the four varieties, it gets very high yielding per plant. This could suggest high breed seed may be produced from variety.



**Table 4:** Estimates of GCA effects in Bauchi and Jos combined, 2019 rainy season

Parents	DFF	PHT (cm)	NLP	LAR (cm <sup>2</sup> )	NBP	PDW (kg/plot)	PDL (cm)	CFW (g)	HGW (g)	GYP (g)
<b>Testers</b>										
IAR-07-105-0	-0.49*	-2.93**	-11.79**	-7.27*	-3.27**	-0.15**	-2.72**	-0.06**	0.15*	1.06*
IT93K-452-1	-2.13*	-3.94**	-11.80**	-7.27*	-3.27**	-0.15**	-2.72**	-0.06**	-0.22*	-2.16**
IT98K-205-8	-1.06**	-2.93**	-11.84**	-7.26*	-3.26**	-0.15**	-2.72**	-0.06**	-0.15*	-0.75*
Dan'Ila(IAR-17-2006)	-5.63**	-2.93**	-11.78**	-7.21*	-3.26**	-0.15**	-2.72**	-0.06**	0.15*	3.49**
S.D Error	<b>0.82</b>	<b>0.24</b>	<b>2.27</b>	<b>2.46</b>	<b>0.82</b>	<b>0.02</b>	<b>0.24</b>	<b>0.01</b>	<b>0.10</b>	<b>0.19</b>
<b>Lines</b>										
Itas Early	-1.46*	-3.83**	-11.86**	-6.26*	-3.37**	-0.15**	-2.72**	-0.06**	-0.08*	-1.05*
Bahaushe IAR-17-008	-1.05*	-3.83**	-11.80**	-6.22*	-3.37**	-0.15**	-2.72**	-0.06**	-0.28*	-2.14**
Kanannado White (IAR-011-084)	-3.13**	-3.83**	-11.84**	-6.27*	-3.38**	-0.15**	-2.72**	-0.06**	0.13*	2.24**
Ex-Borno	-4.70*	-3.83**	-11.76**	-6.27*	-3.34**	-0.15**	-2.72**	-0.06**	-0.04*	-1.68**
Dan Wuri-11(IAR-07-023)	-2.10**	-3.83**	-11.75**	-6.25*	-3.36**	-0.15**	-2.72**	-0.06**	0.10*	0.18*
S.D Error	<b>0.78</b>	<b>0.28</b>	<b>2.54</b>	<b>1.75</b>	<b>1.03</b>	<b>0.02</b>	<b>0.27</b>	<b>0.01</b>	<b>0.11</b>	<b>0.20</b>

2019 Rainy Season\* = Significant at 5% level of probability      \*\* = Significant at 1% level of probability

**KEYS:**

DFF = Days to 50% flowering  
 PHT = Plant height  
 NLP<sup>-1</sup> = Number of leaves per plant

LAR = Leaf area  
 NBP = Number of branches per plant  
 PDW = Pod weight per plot

PDL = Pod length  
 CFW = Chaff weight per plot  
 HGW = 100 Grain weight

GYP = Grain yield per plant



**Table 5:** Estimates of specific combining ability effects for cowpea genotypes in Bauchi and Jos location, 2019 rainy season.

Hybrid	DFD	PHT (cm)	NLP	LAR (cm <sup>2</sup> )	NBP	PDW(kg/ plot)	PDL (cm)	CFW (g)	HGW (g)	GYP (g)
IAR-07-105-0 × Itas Early	0.87	6.77**	20.35**	12.58*	5.82*	0.25	4.69**	0.10**	-0.15	11.26**
IAR-07-105-0 × Bahaushie IAR-17-008	-0.13	6.78**	20.36**	12.57*	5.83*	0.25	4.69**	0.10**	0.01	5.93**
IAR-07-105-0 × Kanannado White (IAR-011-084)	-2.63*	6.77**	20.36**	12.59*	5.83*	0.25	4.69**	0.10**	-0.71	6.85**
IAR-07-105-0 × Ex-Borno	1.54	6.77**	20.34**	12.59*	5.82*	0.25	4.69**	0.10**	-0.77	2.65
IAR-07-105-0 × Dan Wuri-11(IAR-07-023)	1.21	6.77**	20.34**	12.59*	5.82*	0.25	4.69**	0.10**	-0.84	4.19*
IT93K-452-1 × Itas Early	1.04	6.56**	19.78**	12.14*	5.64*	0.24	4.54**	0.09**	1.18	-2.70
IT93K-452-1 × Bahaushie IAR-17-008	-2.21*	6.57**	19.66**	12.07*	5.62*	0.24	4.53**	0.09**	2.53**	4.87*
IT93K-452-1 × Kanannado White (IAR-011-084)	-1.29	6.56**	19.74**	12.16*	5.64*	0.24	4.54**	0.09**	-0.29	12.79**
IT93K-452-1 × Ex-Borno	0.04	6.57**	19.61**	12.15*	5.58*	0.24	4.54**	0.09**	-0.27	2.56
IT93K-452-1 × Dan Wuri-11(IAR-07-023)	-2.13*	6.56**	19.59**	12.12*	5.61*	0.24	4.54**	0.09**	-0.49	2.61
IT98K-205-8 × Itas Early	-4.04	6.55**	19.88**	12.11*	5.62*	0.24	4.53**	0.09**	-0.35	7.02**
IT98K-205-8 × Bahaushie IAR-17-008	2.13*	6.55**	19.76**	12.04*	5.61*	0.24	4.53**	0.09**	1.12	-9.03**
IT98K-205-8 × Kanannado White (IAR-011-084)	-0.63	6.55**	19.82**	12.13*	5.63*	0.24	4.53**	0.09**	0.86	-3.51
IT98K-205-8 × Ex-Borno	1.38	6.55**	19.70**	12.13*	5.58*	0.24	4.53**	0.09**	0.97	-5.60*
IT98K-205-8 × Dan Wuri-11(IAR-07-023)	1.38	6.55**	19.68**	12.10*	5.59*	0.24	4.53**	0.09**	0.70	-1.62
Dan'Ila(IAR-17-2006) × Itas Early	-0.96	6.54**	19.71**	11.97*	5.60*	0.24	4.53**	0.09**	-0.44	0.45
Dan'Ila(IAR-17-2006) × Bahaushie IAR-17-008	0.21	6.55**	19.59**	11.92*	5.60*	0.24	4.53**	0.09**	0.64	6.84*
Dan'Ila(IAR-17-2006) × Kanannado White (IAR-011-084)	-0.96	6.54**	19.66**	11.99*	5.61*	0.24	4.54**	0.09**	-0.33	4.38*
Dan'Ila(IAR-17-2006) × Ex-Borno	-2.46*	6.54**	19.55**	11.98*	5.56*	0.24	4.53**	0.09**	-0.42	5.73*
Dan'Ila(IAR-17-2006) × Dan Wuri-11(IAR-07-023)	2.88*	6.54**	19.53**	11.96*	5.58*	0.24	4.54**	0.09**	0.1	3.67
S.D Error	<b>0.95</b>	<b>0.76</b>	<b>5.07</b>	<b>5.49</b>	<b>2.05</b>	<b>0.04</b>	<b>0.54</b>	<b>0.01</b>	<b>2.67</b>	<b>1.81</b>

2019 Rainy Season\* = Significant at 5% level of probability

\*\* = Significant at 1% level of probability

**KEYS:**

DFD = Days to 50% flowering  
 PHT = Plant height  
 NLP = Number of leaves per plant

LAR = Leaf area  
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PDL = Pod length  
 CFW = Chaff weight per plot  
 HGW = 100 Grain weight

GYP = Grain yield per plant



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