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COMBINING ABILITY STUDIES FOR YIELD AND YIELD COMPONENTS IN SOME OKRA GENOTYPES

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Abstract
Eleven genetically diverse Parents selected from Okra (Abelmoschus spp) germplasm collected from different parts of the Country and their four crosses generated using Line x Tester design were studied for their combining ability in the Guinea Savannah Agro- ecology of Nigeria(Makurdi, Garkawa and Kafanchan). The research materials comprised of eight females, three males and twenty four hybrids of okra which were evaluated in an alpha lattice Design replicated three times in each location. Data were recorded on pod yield and twelve other yield components. The individual wise and pool Analysis of variance showed the presence of significant variation among the studied population for almost all the studied traits portraying the existence of sufficient variability in the research materials. The pool analysis over locations indicated significant differences between the genotypes and the environment suggesting that the research materials were influenced by changes in the environment. The Combing ability effects showed that female parents 303 and ZCH-2 and male parent 326 were good general combiners for pod yield and yield contributing characters. The estimate of specific combining ability effects revealed significant and positive values for hybrids 303 x 326, 333 x 348 and ACH-1 x 452 for pod yield and other yield components across the three locations.

Key words: Combining Ability, Line x Tester, Mating Design, Okra, Germplasm.

Introduction
Okra is a fruit vegetable, originated from East-Africa (Thirupathi *et al.,* 2012; Tesfa and Yosef, 2016). The *Abelmoschus* genus belongs to the malvaceae family which includes a number of different species. The genus comprised of 14 (fourteen) species of which two (*Abelmoschus esculentus* and *Abelmoschus callei*) are cultivated forms while the rest are still in the wild (Tripathi *et al.,* 2011; Amitaaba, 2016). Although *Abelmoschus esculentus* (Common Okra) is exotic to Africa, it is the most widespread and well known while *Abelmoschus callei* (West African okra) is mainly distributed in west and central Africa (Grubben *et al.,* 2004). The plant has a lifespan of 60 – 120 days depending on species/varieties. The seeds are used as planting materials and it exhibits a strongly branched habit as the stem grows to a height of 60 – 180cm or more depending on varieties/species. Leaves are alternate with flowers being hermaphrodite. Okra is basically self-pollinating but out-crossing rate of 4 – 19% occurs in the plant (Anucheel, 2015).

Okra grows well in hot weather, particularly in regions with warm nights (>20ºC) (Tesfa and Yosef, 2016). It is sensitive to frost, water logging and drought conditions. It requires ample moisture for seed germination and moderate rainfall for growth and performance (Amitaaba, 2016). It’s a hardy crop that can be grown with considerable success in a wide range of soils.

The world leading producers of okra are India (70%), Nigeria (15%), Pakistan (2%), Ghana (2%), Egypt (1.7%) and Iraq (1.7%) (FAOSTAT, 2012). Okra is a multipurpose crop known for its nutritional and medicinal values. It is particularly valued for its tender and delicious edible pods which are rich sources of vitamins and minerals. Okra is one of the crops that have the potentials for improving food security, malnutrition and poverty alleviation in tropical and sub-tropical regions of the world (Amitaaba, 2016). Despite the potentials of Okra, there are inadequate improved varieties for cultivation by Okra farmers in Nigeria. The accessions under cultivation in Nigeria over the years are mostly land races or exotic varieties imported by agro-input dealers, which are associated with some challenges such as susceptibility to diseases, pests and nematodes (Amitaaba, 2016). The land races also exhibits long maturity periods, short harvest duration, poor nutritional quality, non-standard shape, colour, size etc making them unfit for export market (Oppong-Sekyere, 2012). On the other hand, the exotic varieties may have desirable quality characteristics but not adaptable to local growing conditions, hence low productivity. Thus, to turn okra into a perfect crop for sustainable agriculture, it should be made attractive to both producers and consumers in terms of yield and quality respectively (Thirupathi *et al.,* 2012). Morphological variation exists among the accessions of Okra, hence it is important to develop improved varieties for adoption by Nigerian vegetable farmers and for export market (Tesfa and Yosef, 2016; Amitaaba, 2016).

Changes in the environment, production technology, pests pressure, consumer preferences as well as population growth all require new/improved varieties. Therefore, varieties come and go as the scene has been described as variety relay race, with one variety passing the production baton to next worthy one. Thus plant breeding is a never finish business with breeding and introduction of new varieties as central focus. The combining ability concept has become very vital as it provides valuable information on the genetic potentials of the genotypes under study. It is useful as a testing procedures desired to study and compare the performance of the lines in hybrid combinations. Thus selection of parents for hybridization has to be based on the complete genetic information and knowledge of combining ability of the potential parents. Among the several methods of studying combining ability/mode of gene action, Line x Tester Analysis actually helps in the evaluation of a large number of genotypes besides being a more comprehensive tool for understanding the genetic basis at a population level. Thus, the present study was conducted to identify best general and Specific Combiners for pod yield and its components in some Okra Genotypes.

Materials and Methods

In a study to determine the combining ability of some Okra genotypes, eleven (11) diverse parents were used in a Line x Tester fashion where eight of the parents were designated as females and 3 parents as males. The study was conducted at the Research Farm of the Plateau State College of Agriculture, Garkawa and crosses were made in a Line x Tester mating fashion where twenty four F1 hybrids were generated. Evaluation of the parents and the F_1 hybrids were conducted in three locations in the Southern Guinea Savanna agro-ecological of Nigeria. These includes: The Teaching and Research Farm of the Joseph Sarwuan Tarka University Makurdi (07^0 41' 01'N, 08^0 37' 17'E, 106 m abs), Plateau State College of Agriculture, Garkawa (8^o 93' 01'N, 9^o 78′ 84' E) 383 m abs and Kaduna State University Kafanchan Campus (9^0 43' 28' N and 8^0 42' 94'and 739 m abs). The experimental farm was manually tilled and ridged. Alpha Lattice Design with three replicates was adopted. Each plot measured 2.4m x 1.2m (2.88m^2) consisting of 4 rows. 1.0 m and 0.5 m spacing were allowed between each block and each plot respectively. Planting was done at 60cm and 40cm inter and intra row spacing. Three seeds were sown per hole and later thinned to one seedling per hole at two weeks after sowing to maintain 20 plants per plot. Weeding was done manually and a compound fertilizer, NPK 20:10:10 was applied at 150kg N/ha, kgP_2O_5/ha and kgk_2O_5/ha (Agba *et al.*2018). The control of insects was carried out with two sprays of cymbush (cypermetrin, 10% EC) at the rate of 20g a.i./ha (Oyetunde and Ariyo, 2015) at four weeks after planting and at flowering stage.

Data Collection

Ten randomly selected plants, excluding the border rows in the three replicates of each genotype were tagged and used for recording the following data.

Days to First Flowerig, Days to fifty percent flowering, Plant height (cm).,Number of primary branches per plant.,Number of leaves per plant maturity,Number of pods per plant, Pod yield per plant (g), Pod length (cm), Pod girth (cm) Pod weight (g),Pod yield (kg/plant),Number of seeds per pod and 100 seed weights

Data Analysis

The Analysis of Variance (ANOVA) for the combining Ability pooled over locations was computed using the procedure of General Linear Model of the Statistical Analysis Soft ware version 9.0 to determine the level of significance of each source of variation (Panse and Sukhatme1967).The variation among the studied parents and hybrids were partitioned further into genetic components attributed to general combining ability (GCA) and specific combining ability (SCA) following the method suggested by Kempthone (1957).

Results and Discussion

The analysis of variance for parents and their resultant hybrids for the different characters revealed significant difference ($P<0.05$) between parents, hybrids and locations for most of the characters studied indicating phenotypic diversity for these characters which could be attributed to the diversity of their origin, genetic variation and/or varied environmental conditions. The proportional contribution of GCA (General Combining Ability) of Lines to the variability was higher than that of the Testers for all the traits studied. This result concurred with the result obtained by Hassan *et al*. 2016 and Kang *et al.*2015 in their respective studies on AMMI and GGE Biplot Analysis of Yield Stability and Drought Tolerance in *Brassca napus* L. and Interpretation of Genotype x Environment Interaction of Sesame Yield Using GGE Biplot Analysis. Partitioning of the genotype variance into lines, testers and lines by testers indicated that mean squares due to lines and hybrids were significant for all characters studied while the mean squares due to tester was non-significant with regards to pod girth, suggesting that sufficient variability existed among the lines, testers parents and the hybrids. This agreed with the result obtained by Medagam *et al,*.2013 who reported a wide range of variability in the okra genotypes for all the characters studied.

General Combining Ability Effects of Parents in Individual and Across Locations

The general combining ability effects due to each parent for each character pooled over locations as presented in table2 revealed that female parents (lines), 303 and 396 and tester 348 exhibited positive and significant gca effects with regard to plant height average over the three locations, thus seemed to be good general combiners for tallness.Female parents ZCH-2 which showed negative and significant gca effect for this trait across the three environments suggests that it was a poor general combiner for height but good general combiner for dwarfness. Highest number of primary branches per plant was recorded by 304 in all the tested locations except for Kafanchan location where 303 was highest (althrough non-significant), which showed that 304 was an outstanding performer while tester 452 also recorded highest but non-significant value for this trait. The highest number of leaves per plant recorded in female line ACH-1 and 304 while male tester 348 and 452 which outperformed others in all the studied locations indicated that these parents were good general combiners for number of leaves/plant in this study. Results from these findings were in agreement with the result obtained by Medagam *et al.* 2013 in their study on different genotypes of okra.

The estimate of GCA effects with respect to days to flowering, days to 50% flowering and days to harvestable pods maturity on a pooled basis showed that line ZCH-2 and Male tester 348 expressed significant and negative GCA effects in these traits, hence these Parents have potential for earliness which can be harnessed to achieve early maturity in Okra pods. Findings from this study are in agreement with the result obtained by Arun *et al.*2019.

With respect to number of pods per plant, and pod length, line ZCH-2 and male testers 326 and 348 were preferred as they exhibited positive and significant GCA effects across the three locations. Estimates of GCA for thickness of pods (pod girth) are important in determination of pod weight and thus pod yield in Okra. Although lines 359, 396, ACH-1 and ZCH-2 recorded negative values as poor general combiners, parental lines 303, 304, 333 and 297 recorded positive values for pod girth, although non-significant, indicating that these lines were moderate combiners as none of them had positive and significant gca estimates across the study locations. However, male tester 452 recorded positive and significant GCA estimates in Makurdi and Garkawa locations expressing it as good general combiner for this trait in these locations.

The expression of positive and significant GCA effects by 303, 297 and 333 lines and male parents 452 326 and 348 for pod weight, number of seeds per pod and 100 seed weight demonstrates that these parents are good general combiners for these traits across the study locations.

The estimate of GCA effects for pod yield pool over locations showed that line 303 with highly significant and positive GCA effects across locations and ranked 1st over the three locations indicated that this line (303) has good prospects in okra future breeding for pod yield. Other promising lines were ACH-1, ZCH-2 and 304 portraying that these lines have desirable genes that could be harnessed for okra improvement. Thus parent 303 and ZCH-2 were the top ranking general combiners across locations in this study. The results obtained in this study are in agreement with the report of Olayiwola and Ariyo, 2015 in their studies on twelve genotypes of okra.

Estimates of Specific Combining Ability (SCA) Effects for Various Characters across Locations (Makurdi, Garkawa and Kafanchan)

The 24 okra hybrids (Table3) varied in their specific combining ability effects for plant height in the range of -10-29*(ACH -1x348*) to 14.28*(ACH -1x326) across the three locations (Makurdi, Garkawa and Kafanchan). The result depicted that hybrids 297x326 (9.85*), 304x348 (12.03*), and ACH -1x326 (14.82*) registered positive and significant Sca effects for plant height whereas 304x326 (-9.80*), 359x326 (-9.11*), ACH -1x348 (-10.29*) and ZCH -2x326 (-9.45*) had negative significant Sca effects for this trait across the three studied locations.

Four hybrids viz: 303x348 (0.53*), 304x326 (0.34*), 333x452 (0.34*) and 359x452 (0.51*) recorded positive and significant Sca effects where as the other four viz: 303x452 (-0.41*), 304x348 (-0.48*), 359x326 (-0.35*) and ZCH -2x452 (-0.43*) had negative and significant Sca effects for the number of branches/plant.

The specific combining ability effects ranged from -3-53*(396x326) to 6.13**(396x348) in number of leaves per plant. Three hybrids viz: 304x3226(3.6*), 333x348 (2.98*) and 396x348 (6.13**) expressed positive and significant Sca effects where by five of them viz: 304x348 (-2.93*), 333x326 (-3.08*), 396x326 (-3.53*), 396x452 (-2.60*) and ACH -1x348 (-2.85*) expressed negative and significant Sca effects for the trait across the three locations.

Estimates of sca effects for days to flowering showed that hybrid 303x326 (4.79*), 304x348 (3.70*) and 333x326 (3.94*) recorded positive and significant Sca effects as against 297x326 (-4.73*), 303x452 (-4.49*), 304x326 (-6.10**), 333x348 (-4.48*) and 396x348 (-3.04*) which displayed negative and significant Sca effects in desired direction.

Similarly, hybrids 303x326 (3.06*), 304x348 (3.59*), 333x452 (7.57**) and 359x348 (3.33*) displayed positive and significant Sca effects for days to 50% flowering where as 304x326 (-3.01*), and 333x348 (-8.15**) had negative and significant Sca effects for this trait across the three locations.

Similarly, two hybrids: 304x348(4.30*) and 333x452(-3.36*) expressed negative and significant Sca effects for days to harvestable pods maturity across locations. Five and two hybrids each (297x348(2.93*), 303x326(2.65*), 304x452(3.04*), 333x348(2.37*) and ZCH -2x326(2.37*) While 297x326(-5.09*) and 303x452(-2.63*) exhibited positive and significant and negative significant Sca effects respectively for number of pods per plants.

The sca effects for pod length revealed that five hybrids viz: 297x326 (0.47*), 303x326 (0.47*), 333x452 (0.59*), 396x452 (0.47*) and ACH -1x348(0.53*) recorded positive and significant effects where by the other five viz: 297x452 (-0.71*), 303x452 (-0.62*), 333x326 (-0.62*), 396x348 (-0.50*) and ACH -1x452 (-0.52*) recorded negative and significant effects across the three studied locations.

The sca effects for pod girth across locations were positive and significant in two (303x326(0.16*) and ACH -1x452(0.17*) and negative and significant in the other hybrid (303x452(-0.53*) over locations.

Estimates of sca was positive and significant for 303x326(11.93**) and ACH -1x452(9.84*) while 303x452(-12.49**) and ACH -1x348 (-5.91*) exhibited negative and significant Sca values for pod weights. Hybrids 297x348(13.92*), 359x326(12.97*) 396 x 326 (17.30*) and ZCH-2x348(22.35*) recorded positive and significant Sca effects as 297x452(-19.00*), 396x348(-22.89*) and ZCH -2x326 (-31.88**) showed negative and significant Sca for number of seeds per pod pool over locations.

Crossed hybrids 303x452 (0.36**), 297x348 (0.29*), and ZCH-2x348 (0.31*) were in the positive and significant direction, whereas 297x452 (-0.22*), 303x348 (-0.36**), 359x326 (-0.22*), ACH-1x348 (-0.28*) and ZCH-2x452 (-0.31*) expressed negative and significant sca effects for 100 seed weight across the three study locations.

With respect to pod yield (kg/ha) over the three locations, sca effect was only positive and significant in 303x326 (3018.18*) whereby 303x452 (-4452.24**), 304x326 (-1944.90*) and ACH -1x348 (-1838.69*) exhibited negative and significant effects.

Ranking of the 24 hybrids based on their fresh pod yield performance pooled over the three locations also revealed that hybrids 303x326 (3018.18**) was the best performer followed by 303x348 (1434.06) and ACH-1x452 (1368.56) in that order.

Conclusion and Recommendation

Significant (P≤0.05) genetic differences were observed among the studied genotypes pooled across the test locations for pod yield and yield components. Parents 303 and ZCH-2 and hybrids 303x326, 333x348 and ACH-1x452 were identified as the best general and specific combiners respectively for yield and its components in this study and are therefore recommended for use in these environments because of their outstanding performance.

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TABLE 1: Mean Square Values from Analysis of Variance for Fresh Pod Yield and Yield components across Sites

SOV	DF	PHT (cm)	NOB	NOL	DFF	D50%F	DHP	NP/P	PL (cm)	PG (cm)	PWT (g)	NS/P	100 SW (g)	YIELD (kg/ha)
SITE	2	47970.75**	968.20**	34430.4**	107.64**	1.98	125.17**	44.80**	20.08**	4.95**	483.22**	4132.28**	0.63**	7523.26*
REP (SITE)	6	154.68**	1.40**	36.92**	37.96*	17.50*	36.64**	6.49**	2.17	0.03	10.71*	87.64*	0.44*	930127.70
GENOTYPE	23	5166.48**	8.19**	183.22**	1763.27**	1771.74**	1860.74**	64.47**	35.37**	0.54*	627.29**	4950.29**	1.08*	54043444.00**
LINE	7	14963.78**	22.73**	423.07**	5458.76**	5435.99**	5653.57**	69.88**	105.88**	1.48*	1281.81**	11305.01**	2.29**	89299073.00**
TESTER	2	262.19**	5.91**	28.97*	311.91**	495.06**	596.80**	33.15**	20.26**	0.01	290.67**	499.58**	0.54*	63643246.00**
LINE X TESTER	14	968.44**	1.25*	85.32**	122.85**	121.99**	144.89**	66.24**	2.27*	0.14*	348.13**	2408.75**	0.55*	35044229.00**
SITE X GENOTYPE	46	990.52**	5.27**	158.86**	50.50*	18.42*	27.12**	5.24*	1.42	0.12*	94.21**	655.45**	0.31	13027375.00**
SITE X LINE	14	2328.79**	10.79**	361.42**	28.23*	12.21	42.19**	5.80*	0.98	0.09	139.80**	1079.70**	0.31	19512747.00*
SITE X TESTER	4	399.58**	7.92**	129.83**	55.30**	1.28	11.04	3.84	2.23*	0.18*	96.73**	286.04**	0.11	17941362.00*
SITE X LINE X TESTER	28	405.80**	2.13**	61.73**	60.89**	23.97*	21.89**	5.15*	1.52	0.11	71.06**	496.09**	0.33	9082692.00**
ERROR	138	59.33	0.64	13.49	19.69	12.78	8.75	2.69	1.62	0.07	5.94	78.99	0.25	1309278.00
Proportional Contributions of GCA due to Lines, Testers and L X T (Sca)														
LINE (GCA)		88.15	84.44	70.28	94.22	93.40	92.47	32.99	91.12	83.57	30.43	69.50	64.41	50.29
TESTER (GCA)		0.44	6.27	1.37	1.54	2.43	2.79	4.47	4.98	0.10	8.70	0.88	4.37	10.24
LINE X TESTER (SCA)		11.41	9.29	28.35	4.24	4.19	4.74	62.54	3.90	16.33	60.87	29.64	31.23	39.47

*, ** = 5% and 1% level of probability respectively.

PHT = Plant Height, NOB = Number of Branches/plant, NOL= Number of Leaves/Plant, DFF=Days to first flowering, D50%F= Days to 50% flowering, DHP=Days to harvestable pods maturity, NP/P=Number of pods/plant, PL=Pod length, PG= Pod girth, PWT= Pod weight, NS/P= Number of seeds/pod, 100SW= 100 Seed weight and YIELD/ha= Yield/Hectare

TABLE 2: Estimates of General Combining ability (GCA) Effects for Various Characters in Okra, Grown Across Locations (Makurdi, Garkawa and Kafanchan).

Lines	PHT (cm)	NOB	NOL	DFF	D50%F	DHP	NP/PL	PL (cm)	PG (cm)	PWT (g)	Seeds/P	100SW (g)	Yield (kg/ha)
297	-3.07	0.18	0.40	-1.88	-2.47	-2.10	0.70	-1.34	0.15	-2.19	9.00	-0.13	-1642.69
303	33.78*	-0.06	-1.52	1.71	0.38	0.60	-0.11	2.59*	0.19	14.12**	25.73*	0.52*	3396.51*
304	8.99	1.24*	0.67	28.16**	26.79**	27.79**	-0.43	-0.10	0.23	4.16	-28.41*	-0.37	1473.98
333	2.28	0.79	-3.18	12.01	14.08	14.01	-0.22	-1.58	0.15	1.63	-34.12*	0.33	311.21
359	-3.08	-0.90	1.95	-10.32	-5.51	-8.14	-1.38	-0.88	-0.27*	-7.75*	10.53	-0.15	-2199.47*
396	22.35*	0.43	2.45	-3.32	-0.44	-4.36	-2.62*	-0.07	-0.01	-0.16	4.22	0.11	-1345.22
ACH – 1	-19.28	-0.02	6.19*	-11.32	-11.14	-10.66	1.63*	-1.32	-0.02	-5.08	5.26	0.06	-2.84
ZCH – 2	-41.98*	-1.65*	-6.97**	-15.02*	-17.69*	-17.14*	2.43*	3.59*	-0.42*	-4.73	7.79	-0.15	8.51
SE	22.02	0.86	3.70	13.30	13.27	13.54	1.50	1.85	0.22	6.45	19.14	0.27	1701.16
Testers													
326	-1.98*	-0.19	-0.35	-0.90	-1.66	-1.62	0.60*	0.46	-0.00	1.54	0.17	-0.04	826.12*
348	1.83*	-0.14	0.73*	-1.48	-1.37	-1.70	0.14	0.13	0.01	0.73*	-2.72*	0.10*	196.92
452	0.15	0.33*	-0.38	2.38*	3.02*	3.32*	-0.74*	-0.58*	-0.00	-2.27*	2.55*	-0.06	-1023.04*
SE	1.56	0.23	0.52	1.70	2.14	2.35	0.55	0.43	0.00	1.64	2.15	0.07	717.65

*, ** = 5% and 1% level of probability respectively.

PHT = Plant Height, NOB = Number of Branches/plant, NOL= Number of Leaves/Plant, DFF=Days to first flowering, D50%F= Days to 50% flowering, DHP=Days to harvestable pods maturity, NP/P=Number of pods/plant, PL=Pod length, PG= Pod girth, PWT= Pod weight, NS/P= Number of seeds/pod, 100SW= 100 Seed weight and YIELD/ha= Yield/Hectare, YR= Yield ranking

TABLE 3: Estimates of Specific Combining Ability (SCA) Effect for Various Characters of Okra across Locations (Makurdi, Garkawa and Kafanchan)

CROSSES	PHT (cm)	NOB	NOL	DFF	D50%F	DHP	NP/PL	PL (cm)	PG (cm)	PWT (g)	Seeds/P	100SW (g)	Yield (kg/ha)
297 X 326	9.85*	0.05	0.87	-4.73*	0.69	-1.79	-5.09**	0.47*	-4.09	-1.33	5.09	-0.07	-1502.68
297 X 348	-15.14	0.08	-2.14	2.19	0.70	0.07	2.93*	0.83	0.02	-2.30	13.92*	0.29*	394.21
297 X 452	5.29	-0.13	1.28	2.55	-0.76	1.71	2.16	-0.71*	0.06	3.63	-19.00*	-0.22*	1108.48
303 X 326	7.30	-0.12	1.87	4.79*	3.06*	2.73	2.65*	0.47*	0.16*	11.97**	6.74	0.00	3018.18**
303 X 348	-6.14	0.53*	0.00	-0.30	-1.23	-0.07	-0.02	0.15	0.06	0.52	-2.01	-0.36**	1434.06
303 X 452	-1.16	-0.41*	-1.87	-4.49*	-1.84	-2.66	-2.63*	-0.62*	-0.53*	-12.49**	-4.73	0.36**	-4452.24**
304 X 326	-9.80*	0.34*	3.61*	-6.10**	-3.01*	-6.34**	-2.03	-0.15	0.04	1.72	-1.87	0.00	-1944.90*
304 X 348	12.03*	-0.48*	-2.93*	3.70*	3.59*	4.30*	-1.01	-0.15	-0.10	1.29	3.12	0.09	737.29
304 X 452	-2.23	0.14	-069	2.40	-0.58	2.05	3.04*	0.30	0.06	-3.02	-1.25	-0.09	1207.61
333 X 326	0.49	-0.19	-3.08*	3.94*	0.58	2.21	-1.73	-0.62*	0.04	-3.06	-7.32	-0.03	-944.24
333 X 348	6.52	-0.15	2.98*	-4.48*	-8.15**	-7.93**	2.79*	0.03	0.06	1.20	4.32	0.05	-5.21
333 X 452	-7.01	0.34*	0.10	0.55	7.57**	5.71*	-1.06	0.59*	-0.10	1.86	3.00	-0.01	949.45
359 X 326	-9.11*	-0.35*	-1.47	-0.62	-1.27	0.47	0.30	-0.20	-0.04	-3.60	12.97*	-0.22*	-1027.93
359 X 348	1.32	-0.17	0.48	0.30	3.33*	2.89	-1.52	-0.19	-0.02	2.52	-7.45	0.09	199.56
359 X 452	7.79	0.51*	0.99	0.32	-2.06	-3.36*	1.25	0.38	0.05	1.07	-5.52	0.13	828.36
396 X 326	-4.10	-0.23	-3.53*	1.94	1.32	2.47	1.53	0.02	-0.00	1.30	17.30*	0.19	1273.10
396 X 348	7.95	0.11	6.13**	-3.04*	-0.08	-0.78	-0.57	-0.50*	0.10	1.47	-22.89*	-0.17	86.48
396 X 452	-3.84	0.12	-2.60*	1.10	-1.25	-1.69	-0.10	0.47*	-0.10	-2.77	5.59	-0.01	-1359.58
ACH – 1 X 326	14.82*	0.31	1.79	0.60	-1.42	-0.34	2.02	-0.01	-0.01	-3.93	-1.03	0.13	470.14
ACH – 1 X 348	-10.29*	-0.17	-2.85*	-0.04	0.96	-0.48	-0.60	0.53*	-0.06	-5.91*	-11.36	-0.28*	-1838.69*
ACH – 1 X 452	-4.53	-0.14	1.06	-0.56	0.46	0.82	-1.42	-0.52*	0.17*	9.84**	12.39	0.15	1368.56
ZCH – 2 X 326	-9.45*	0.20	-0.07	0.19	0.03	0.58	2.37*	0.00	-0.11	-3.08	-31.88**	0.00	658.33
ZCH – 2 X 348	3.75	0.23	-1.66	1.67	1.51	2.00	-1.10	-0.10	0.03	1.20	22.35*	0.31*	-1007.70
ZCH – 2 X 452	5.70	-0.43*	1.73	-1.86	-1.54	-2.58	-0.37	0.10	0.08	1.87	9.53	-0.31*	349.37
SE	7.92	0.28	2.35	2.82	2.81	3.06	2.07	0.38	0.10	4.75	12.49	0.19	1507.11

*, ** = 5% and 1% level of probability respectively.
PHT = Plant Height, NOB = Number of Branches/plant, NOL= Number of Leaves/Plant, DFF=Days to first flowering, D50%F= Days to 50% flowering, DHP=Days to harvestable pods maturity, NP/P=Number of pods/plant, PL=Pod length, PG= Pod girth, PWT= Pod weight, NS/P= Number of seeds/pod, 100SW= 100 Seed weight and YIELD/ha= Yield/Hectare, YR= Yield ranking