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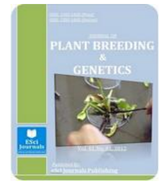

ESTIMATION OF HETEROSIS OF YIELD AND YIELD-RELATED TRAITS IN THE AFRICAN EGGPLANT (*SOLANUM AETHIOPICUM*) HYBRIDS

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ABSTRACT

African eggplant is an important fruit and leafy vegetable in Africa. Heterosis over mid and better parents was estimated in eight crosses of eggplant involving eight pure lines in a field experiment in 2012 and 2013 cropping seasons. The experiment was laid out using a randomized complete block design with three replications. Collected data was subjected to analysis of variance and significant differences were further subjected to Duncan Multiple Range Test. The aim of this study was to identify superior hybrids that can be advanced in the eggplant breeding program for improved yield and related traits. Significant variation was observed among all traits measured for the parents and hybrids. The highest fruit number was observed in NHS10-40 and in NHS 10-71 x NHS 10-40 among the parents and hybrids respectively. The highest heterosis was recorded in the cross between NHS10-71 x NHS10-40.

Keywords: African eggplant, better-parent heterosis, mid-parent heterosis, hybrid, yield.

INTRODUCTION

The eggplant, *Solanum aethiopicum, belongs* to the *Solanum* genus, family Solanaceae. There are four main recognized groups of cultivars of *S. aethiopicum*: the first three groups (Shum, Kumba and Gilo) are of African origin, whereas the fourth group (Aculeatum) is grown in Europe and its fruits are not edible (Lester and Seck, 2004; Eze *et al*., 2012). African eggplant is grown in Nigeria for the nutritional, medicinal and economic values of the leaves and fruits. African eggplant is an integral part of the dish during festivities such as weddings, funerals etc. in Africa. Traders get significant income from the sales of the fruits and leaf of the eggplant (Onunka *et al.,* 2011). African eggplants are generally highly heterogeneous due to cross-pollination and the Kumba group have a variability of forms, colour and fruit shape (Horna *et al*., 2007; Bationo-Kando *et al.,* 2015). Danquah and Ofori (2012) reported high phenotypic and genotypic coefficient of variation for fruit length, number of seeds per fruit, fruit weight and height at flowering. A high broad sense heritability estimate was reported for fruit length, fruit weight and days to flowering from the same study. Kumar *et al* (2012) identified good combiners among the parental lines used and some hybrids that out-performed the parental lines.

Exploitation of heterosis is important in plant breeding and it has contributed significantly to crop yield. The F_1 hybrids can either be used commercially or be exploited for selecting promising recombinants in advanced homozygous generations (Kumar *et al*., 2012). In order to know the potentiality of hybrids, the magnitude and direction of heterosis are important and useful for crop improvement depending on the objectives of the breeding program (Singh *et al*., 1995; Akhter *et al*., 2003). The heterogeneity nature of the eggplant presents a good opportunity for genetic improvement needed to increase its potential for commercial production. However, little information is available on the heterotic groupings in the eggplant which can be exploited for hybrid and variety development. Knowledge of the performance of the parental lines is important in parental selection. The objectives of this study therefore were to evaluate the performances of some selected

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lines of the African eggplant and their hybrids for yield and yield-related traits in order to identify superior hybrids that can be advanced in the eggplant breeding program.

Table 1: Parents and the crosses used in this experiment.

Parents	Hybrids
NHS 10-71	NHS 10-71 x NHS 10-22
NHS 10-40	NHS 10-71 x NHS 10-28
NHS 10-55	NHS 10-83 x NHGB/09/128
NHS 10-83	NHS 10-71 x NHS 10-40
NHS 10-42	NHS 10-83 x NHS 10-22
NHS 10-28	NHS 10-71 x NHS 10-55
NHS 10-22	NHS 10-71 x NHS 10-83
NHS 10-24	NHS 10-28 x NHS 10-22
NHGB/09/128	

MATERIALS AND METHODS

The research work was carried out at the Vegetable research field of National Horticultural Research Institute (NIHORT), Ibadan (latitude 7^0 45^1N and longitude $3^0 54^1$E). Eight F_1 hybrids were developed from a bi-parental cross of nine accessions of the African eggplant (Table 1). The successful hybrids and the parental lines were evaluated on the experimental field using a randomized complete block design (RCBD) with three replications. The seeds were grown in the nursery and later transplanted to the experimental field at a spacing of 0.5m x 0.75m on a plot of 2m x 0.75m giving ten plants on a plot. The field evaluation of parents and the hybrids was carried out in the dry season of 2012 and wet season of 2013. Cultural practices were appropriately done as when necessary.

Data collection: Data were collected on days to 50% flowering, plant height at maturity (cm), stem diameter (cm), number of leaves per plant, number of branches per plant, number of fruits per plant, fruit weight per plant (g), seed weight per plant (g), 100-seed weight (g), unit fruit weight (g), number of fruits per cluster, fruit colour and fruit shape for parental lines and the hybrids.

Data analysis and heterosis estimation: For data analysis of phenotypic data, means of the measured traits of the parental lines and hybrids were subjected to ANOVA in RCBD using PROC GLM in SAS (SAS Institute, 2009).

Mid-parent heterosis (MP) and better-parent heterosis (BP) of each cross for the measured traits were calculated and expressed in percentages using trait means of parents and hybrids following the procedures of Falconer and Mackay (1996). For each trait, the mid-parent value of a cross was calculated as the mean of the two parental line means.

Hence,

MP was computed as: $\frac{F_1 - M_P}{M_P} \times 100$

Where F_1 is the mean performance of the cross; MP is the mid-parent value given by $\frac{P_1 + P_2}{2}$;

P_1 and P_2 are the mean values of parent 1 and parent 2 respectively.

BP was calculated as: $\frac{F_1 - B_P}{B_P} \times 100$

Test of significance: the significance of the percent estimate of heterosis was determined by comparing with critical difference (C.D.) value. If the value is equal to or greater than the C.D. value (irrespective of the sign), the heterosis is significant. If the difference is lower than the C.D. value, the heterosis is no-significant.

$$C.D. = \sqrt{\frac{2MSe}{r} \times t}$$

Where, MSe is the error mean square, r is a number of replications and t is the tabulated value at error degree of freedom (d.f.) at 5% level of significance.

RESULTS

Performance of parental lines: The analysis of variance revealed a significant difference for all the measured characters for the parents (Tables 2). Fruit yield of the lines varied from 2.52 for NHGB/09/128 fruits per plant to 84.58. Line NHS10-40 was the earliest to flower at 56 days after transplanting and had the highest number of fruits per cluster (Table 3).

Performance of F_1 hybrids and heterosis: The F_1 hybrids showed a significant difference for the measured traits (Table 4). NHS10-71 x NHS10-40 recorded the highest number of fruits (24.51). The earliest to flower among the F1s was NHS10-71 x NHS10-83 (79 days after transplanting (Table 5).

A wide variation was observed for the level of MP and BP for the measured traits among the hybrids. For the MP, a positive and significant MP varying between 4.54 and 33.33 was observed for a number of days to flowering for all the hybrids. For a number of fruits per plant, a negative but significant heterosis was observed among the hybrids.

Table 2. Means squares of yield and yield related characters in nine *Solanum aethiopicum* parental lines.

Source	*DF	DFL	PLTHT	NLVS	NBR	STD	NFCL	NFPLT	FWTPLT	SDWTPLT	100SDWT	UTFTWT
Block	2	1.00*	32.05	6074.64	1.11*	0.02*	$6x10^{-4}$	255.69	4231.28	2.29	$1x10^{-5}$	5.62
Genotype	8	1023.00**	1105.32**	41123.53**	2.17**	0.30**	2.33**	2761.54*	28796.20**	11170.12**	0.01**	352.80**
Error	16	1	9.77	2084.98	0.27	$4x10^{-3}$	$9x10^{-3}$	80.29	1582.16	27.13	$6x10^{-5}$	3.48
CV		1.36	5.08	28.32	9.42	5.67	4.27	29.52	27.21	7.1	2.9	14.88

*DFL=days to 50 percent flowering; pltht= plant height (cm); nlvs=number of leaves pler plant; nbr=number of branches; std= stem diameter (cm) nfcl= number of fruits per cluster; nfplt= number of fruits per plant; fwtplt= fruit weight per plant; sdwtplt= seed weight per plant; 100sdwt=100-seed weight (g); utftwt=unit fruit weight per plant. *, ** =Significant at p< 0.05 p< 0.01 probability level respectively.

Table 3. Mean performance of nine African eggplant accessions for yield and yield related characters.

Accessions	*DFL	PLTHT	NLVS	NBR	STD	NFCL	NFPLT	FWTPLT	SDWTPLT	100SDWT	UTFTWT
NHS 10-71	90.00b	70.67bc	52.87c	5.84a	1.45b	1.00e	10.63cd	295.55a	48.67e	0.29b	27.83a
NHS 10-40	56.00f	45.00ef	323.67a	5.83b	0.72f	3.84a	84.58a	71.90bc	83.70c	0.25c	0.86f
NHS 10-55	58.00e	65.67cd	275.17a	4.50c	0.95de	2.42c	39.07b	133.92b	126.61b	0.33a	3.47ef
NHS 10-83	106.00a	101.50a	71.84c	6.67a	1.73a	2.50c	18.37cd	327.33a	212.49a	0.17e	17.60c
NHS 10-42	58.00e	41.34f	325.50a	5.17bc	0.87e	2.59bc	75.73a	88.33bc	37.72f	0.20d	1.22f
NHS 10-28	64.00d	73.67b	106.50bc	5.67b	0.94de	2.50c	16.38cd	145.33b	34.00f	0.33a	8.90d
NHS 10-22	86.00c	46.08ef	63.67c	4.50c	1.14c	2.00d	3.46d	78.98bc	30.01f	0.25c	22.97b
NHS 10-24	59.00e	48.04e	57.17c	4.67c	1.05cd	1.00e	22.42c	111.43bc	58.08d	0.28b	5.00e
NHGB/09/128	86.00c	61.20d	175.00b	6.67a	0.97de	2.75b	2.52d	62.98f	29.26f	0.33a	25.02ab

*DFL=days to 50 percent flowering; pltht= plant height (cm); nlvs=number of leaves pler plant; nbr=number of branches; std= stem diameter (cm) nfcl= number of fruits per cluster; nfplt= number of fruits per plant; fwtplt= fruit weight per plant; sdwtplt= seed weight per plant; 100sdwt=100-seed weight(g); utftwt=unit fruit weight per plant. *,** Means followed by same alphabets along the column are not significantly different from one another at 5% probability level.

Table 4. Means square values of F1 hybrids of the African eggplant for yield and yield related characters.

Source	*DF	DFL	PLTHT	NLVS	NBR	STD	NFCL	NFPLT	FWTPLT	SDWTPLT	100SDWT	UTFTWT
Block	2	0	57.98	508.04	2.14	0	0.03	4.9	43.28**	24.28**	0	345.63
Genotype	7	456.38**	589.90**	5705.59**	70.67**	0.17**	0.46**	150.51**	36951.01**	120.97**	0.01**	1012.54**
Error	14	1.14	16.38	281.36	4.6	0.01	0.02	1.87	4.64	0.71	0	122.29
CV		1.13	6.55	22.01	20.58	10.23	5.7	15.7	1.09	7.28	8.98	32.87

*DFL=days to 50 percent flowering; pltht= plant height (cm); nlvs=number of leaves pler plant; nbr=number of branches; std= stem diameter (cm) nfcl= number of fruits per cluster; nfplt= number of fruits per plant; fwtplt= fruit weight per plant; sdwtplt= seed weight per plant; 100sdwt=100-seed weight(g); utftwt=unit fruit weight per plant. *,** =Significant at p< 0.05 p< 0.01 probability level respectively. *,** =Significant at p< 0.05 p< 0.01 probability level respectively.

Table 5. Mean performance of F1 hybrids for yield and yield related characters.

Hybrids	*DFL	PLTHT	NLVS	NBR	STD	NFCL	NFPLT	FWTPLT	SDWTPLT	100SDWT	UTFTWT
NHS 10-71 x NHS 10-22	92.00c	58.83c	54.40d	5.50d	1.17a	1.83cd	4.27de	222.71d	9.84e	0.34a	56.81a
NHS 10-71 x NHS 10-28	89.00d	71.80b	108.97b	12.53b	1.32a	2.65a	12.34b	354.34a	22.28a	0.32a	29.81bc
NHS 10-83 x NHGB/09/128	110.00a	80.18a	85.83bc	11.93b	1.30a	2.10b	7.86c	287.37c	14.38c	0.34a	37.53ab
NHS 10-71 x NHS 10-40	86.00e	55.31c	161.33a	19.97a	0.87b	2.44a	24.51a	90.47f	11.95d	0.26b	3.70d
NHS 10-83 x NHS 10-22	106.00b	70.65b	61.71cd	10.76bc	1.12a	2.55a	6.55de	307.34b	17.95b	0.25b	50.08ab
NHS 10-71 x NHS10-55	79.00f	40.88d	47.57d	10.53bc	0.68b	1.64d	7.75c	78.33g	4.82g	0.35a	10.54cd
NHS 10-71 x NHS 10-83	111.00a	71.72b	49.47d	7.73cd	1.12a	2.02bc	4.11de	157.47e	6.39f	0.25b	42.12ab
NHS 10-28 x NHS 10-22	86.00e	45.27d	40.43d	4.47d	0.82b	1.70d	2.29e	80.95g	4.98fg	0.36a	38.52ab

*DFL=days to 50 percent flowering; pltht= plant height (cm); nlvs=number of leaves pler plant; nbr=number of branches; std= stem diameter (cm) nfcl= number of fruits per cluster; nfplt= number of fruits per plant; fwtplt= fruit weight per plant; sdwtplt= seed weight per plant; 100sdwt=100-seed weight (g); utftwt=unit fruit weight per plant. *, ** Means followed by same alphabets along the column are not significantly different from one another at 5% probability level.

For a number of fruits per plant, a negative but significant heterosis was observed among the hybrids. MP heterosis for a number of branches was positive and significant for the hybrids except for NHS10-28 x NHS10-22 (-0.12). Same trend was observed for number of fruits per cluster except for NHS10-71 x NHS10-55 (-4.09) and NHS10-28 x NHS10-22 (-24.44) (Table 6). The better parent heterosis ranged between 0 and 4.44 for days to flowering and 24.66 and 86.02 for a number of fruits per plant. The BP for fruit yield was negative but significant for all the hybrids. A number of branches BP was positive and significant for all hybrids except for NHS10-71 x NHS10-22 (-5.82) and NHS10-28 x NHS10-22 (-21.16) which was not significant. Positive and significant BP was only observed in two hybrids for a number of fruits per cluster while other hybrids had negative but significant BP (Table 6).

Table 6(a). Estimates of Mid-parent (average) heterosis (%) for seed yield and related traits in eight crosses of African eggplant.

Hybrids	*DFL		PLTHT		NLVS		NBR		NFCL	
	[a]MP	BP	MP	BP	MP	BP	MP	BP	MP	BP
NHS 10-71 x NHS 10-22	4.54*	2.22*	0.77	-16.75*	-6.48	-14.6	6.38*	-5.82*	22*	-8.5*
NHS 10-71 x NHS 10-28	15.58*	-1.11	-0.51	-2.54	36.91*	2.32	117.53*	114.55*	51.43*	6*
NHS 10-83 x NHGB/09/128	33.33*	3.77*	7.24*	-21*	33.04*	19.47*	110.41*	78.86*	20*	-16*
NHS 10-71 x NHS 10-40	17.8*	-4.44*	-4.37	-21.73*	36.52*	-50.16*	241.95*	241.95*	0.83*	-0.36*
NHS 10-83 x NHS 10-22	10.42*	0	-4.26	-30.39*	-8.93	-14.1	92.49*	61.32*	13.33*	2*
NHS 10-71 x NHS10-55	6.76*	-12.22*	-40.03*	-42.15*	-70.98*	-82.71*	103.68*	80.31*	-4.09*	-32.23*
NHS 10-71 x NHS 10-83	13.27	2.78*	-16.69*	-29.34*	-20.51*	-31.14*	23.48*	15.89*	15.43*	-19.2*
NHS 10-28 x NHS 10-22	14.67	0	-24.4*	-38.55*	-52.49*	-62.04*	-0.12	-21.16*	-24.44*	-32*

*DFL=days to 50 percent flowering; pltht= plant height (cm); nlvs=number of leaves pler plant; nbr=number of branches; nfcl= number of fruits per cluster. aMP and BP=Mid-parent and better-parent heterosis. *=significant at 5% probability level.

Table 6(b). Estimates of Mid-parent (average) heterosis (%) for seed yield and related traits in eight crosses of African eggplant.

Hybrids	NFPLT		FRTWPLT		UTFTWT	
	MP	BP	MP	BP	MP	BP
NHS 10-71 x NHS 10-22	-40.28*	-59.83*	20.03*	-24.65*	123.66*	104.13*
NHS 10-71 x NHS 10-28	-8.66*	-24.66*	60.74*	19.89*	62.28*	7.11
NHS 10-83 x NHGB/09/128	-61.47*	-57.21*	30.99*	-12.21*	232.12*	113.24*
NHS 10-71 x NHS 10-40	-48.52*	-71.01*	-50.76*	-69.39*	-74.22*	-86.7*
NHS 10-83 x NHS 10-22	-40.56*	-64.34*	52.56*	-6.11*	146.82*	118.02*
NHS 10-71 x NHS10-55	-68.81*	-80.16*	-63.52*	-73.5*	-32.65*	-62.13*
NHS 10-71 x NHS 10-83	-71.66*	-77.63*	-49.43*	-51.9*	85.39*	51.35*
NHS 10-28 x NHS 10-22	-77.17*	-86.02*	-26.71*	-44.3*	8.89*	67.7*

Frtwplt= fruit weight per plant; utftwt=unit fruit weight per plant. aMP and BP=Mid-parent and better-parent heterosis. *=significant at 5% probability level.

DISCUSSION

The observed significance from the analysis of variance for the parental lines revealed that the lines possess sufficient genetic variability for improvement of the African eggplant. This result agrees with earlier workers who reported genetic variability evaluated among some garden egg and pepper accessions (Kubie, 2013; Suryal *et al.*, 2013).

A hybrid is said to exhibit heterosis or hybrid vigour if it shows superiority relative to its inbred parents with respect to traits of interest as a result of mixing the genetic contributions of its parents (Sharma *et al*., 2013; Wengui, 2003 and Reshnika *et al.*, 2015). Earliness is an important agronomic trait in crop improvement for the adaptation of crops to different agro-ecologies (Adeyanju and Ishiyaku, 2007). NHS10-71 x NHS10-55, NHS10-71 x NHS10-40 and NHS10-71 x NHS10-28 flowered twelve days, four days and one day earlier than the better parents respectively (Table 6). The result agrees with the report of Kumar *et al*., (2013). Negative but significant heterosis for height displayed by NHS10-71 x NHS10-55, NHS10-71 x NHS10-83 and NHS10-28 x NHS10-22 over the better parents showed improvement for moderate height. This result agrees with the result of Surya *et al*., (2013). Increase in fruit-bearing branches may lead to increase the yield of crops. Two hybrids showed negative but significant heterosis for a number of branches while the remaining six showed positive and significant heterosis over the better parents. This suggests that the hybrids with positive heterosis possess genes that can further be exploited for developing varieties with moderate height. Kumar *et al*., (2013) reported similar findings. In general, positive heterosis is good for yield (Shahjahan *et al*., 2016). In this study however, the hybrids showed significant negative better parent heterosis for a number of fruits per plant. This indicates that the lines used in this study were not genetically diverse enough to produce superior hybrids for fruit yield.

CONCLUSION

The availability of genetic variability for the yield-related traits suggests that the lines used in this study possess genetic variability on which selection to improve these traits can act. More accessions must be introduced to the breeding program in order to broaden the genetic base for fruit yield.

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