ESTIMATION OF HETEROSIS OF YIELD AND YIELD-RELATED TRAITS IN THE AFRICAN EGGPLANT (SOLANUM AETHIOPIUM) 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 F1 hybrids can either be used commercially or be exploited for selecting promising recombinants in advanced homoyzogous 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...
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            |
| NHGB/09/128| NHS 10-28 x NHS 10-22            |

MATERIALS AND METHODS

The research work was carried out at the Vegetable research field of National Horticultural Research Institute (NIHORT), Ibadan (latitude 7° 45'N and longitude 3° 54'E). Eight F₁ hybrids were developed from a biparental 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 experiment 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,

\[ MP = \frac{F_1 - M_P}{M_P} \times 100 \]

Where \( F_1 \) is the mean performance of the cross; \( M_P \) 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.

\[ BP = \frac{F_1 - B_P}{B_P} \times 100 \]

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 F₁ hybrids and heterosis: The F₁ 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  | 4.567 | 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 per 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 | 50.88d | 0.28b | 5.00e |
| NHGB/09/128 | 86.00d | 161.20d | 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 per 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 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 per 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  | NFPFT | FWTPFT | 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| 85.38bc| 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 | 4.98f   | 0.36a   | 38.52ab|

*DFL=days to 50 percent flowering; pltlt= plant height (cm); nlvs=number of leaves per plant; nfpft= number of fruits per cluster; fwtpl= fruit weight per plant; sdwtpl= 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  | STD  | NFCL  | NFPFT | FWTPFT | SDWTPLT | 100SDWT | UTFTWT |
|--------------------------|-------|-------|-------|------|------|-------|-------|--------|---------|---------|--------|
| 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; pltlt= plant height (cm); nlvs=number of leaves per 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.
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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