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Original Article

Genetic Control and Heterosis of Quantitative Traits in Several Local Eggplant Genotypes

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Abstract

The present study was performed to assess the nature of gene action governing inheritance of agronomic traits in eggplant genotypes and extent of mid parent heterosis (MPH) and better parent heterosis (BPH) in six eggplant hybrids generated from four superior and optimally divergent genotypes of eggplant namely 'Yalo', 'Uyo', 'K3' and 'Iyoyo' selected from the germplasm and were crossed in 4×4 half diallel mating design. The six hybrids were found to show a significant (p< 0.05) positive MPH in yield traits and the highest was obtained in the hybrid 'Yalo' × 'K3' for number of fruits per plant (158.90%) and 'K3' × 'Iyoyo' for fruit yield per plant (63.14%) and fruit yield per hectare (62.20 %). The hybrid combinations 'Yalo' × 'K3' and 'K3' × 'Iyoyo' had significant positive BPH for the number of fruits per plant, 104.08% and 42.43%, respectively. For fruit yield per plant, the hybrid combination 'Yalo' × 'K3' (7.93%), 'Uyo' × 'K3' (8.48%) and 'K3' × 'Iyoyo' (12.26%) had significant positive BPH. However, the hybrid 'K3' × 'Iyoyo' (11.51%) showed significant positive BPH in fruit yield per hectare. Dominance and dominance × dominance gene effect were found to be positively higher in magnitude in all crosses for number of fruits per plant, fruit yield per plant and fruit yield per hectare. The prevalence of dominance and dominance × dominance gene effect in the yield traits indicate heterosis breeding as the best breeding method to improve the productivity of eggplant.

Keywords: diallel, eggplant, gene effect, heterosis, hybrid vigor

Introduction

Eggplant is an important vegetable crop of the tropical and subtropical regions of the world and has originated in India (Daunay *et al.*, 2001). It belongs to the family Solanaceae and it is grown extensively in all parts of the world. Eggplant fruits have high nutritive value and high market demand (Chinedu *et al.*, 2011). Therefore, its cultivation is most lucrative and remunerative (Kumar *et al.*, 2012). The productivity of eggplant is low in Nigeria as compared to the other eggplant growing countries, owing to use of low yielding cultivars grown for local preference (Nalini, 2007). The present production, however, is not proportionate to the country's demand. Therefore, the crop deserves a deep deliberation for improvement. However, for the development of effective heterosis breeding programme in eggplant, one need to have the information about genetic architecture. Being that eggplant exhibits a huge genetic diversity for various traits which offers much scope for improvement through heterosis breeding the required goals of increasing productivity in the quickest possible time (Kumar *et al.*, 2012).

Based on its rising demand especially of traits of consumers' preference, it is necessary to develop high yielding and high quality cultivars/hybrids of this crop. The gene actions among traits are the basis for initiating the effective breeding programme (Prasad *et al.*, 2010). Plant breeders and geneticists often use diallel mating designs to obtain genetic information for an interest trait from a fixed or randomly chosen set of parental lines (Karami and Talebi, 2013; Prohens *et al.*, 2017). The estimation of additive and non-additive gene action through this technique could be useful in determining the possibility of commercial exploitation of heterosis and isolation of pure lines among the progenies of the good hybrids (Stuber, 1994). However, only few reports are available pertaining to the extent of hybrid vigour in eggplant yield. Hence, the present study was taken up with the following objectives (i) to generate information on genetic architecture of quantitative traits and (ii) to estimate the magnitude of heterosis in the hybrids of eggplant.

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Materials and Methods

The experiment was conducted at the Teaching and Research Field of Department of Crop Science, University of Nigeria, Nsukka, Nigeria. Nsukka (latitude 6°51'E, and longitude 7°29'N of 475 m above sea level), area characterized by lowland humid condition with bimodal annual rainfall distribution that ranges from 1,155mm to 1,955mm, a mean annual temperature of 29 °C to 31 °C and relative humidity that ranges from 69% to 79% (Uguru *et al*., 2011).

The research was done from April, 2014 to July, 2015. Four superior and optimally divergent genotypes of eggplant namely 'Yalo', 'Uyo', 'K3' and 'Iyoyo' selected from the germplasm were crossed in half diallel mating design to generate six (6) single crosses during 2014 (April-July) planting season. Part of the seeds of parents and the F_1 were planted during August-December, 2014 to produce their F_2 and were cross to their respective parents to generate their backcross (BCP). The parents, F_1, F_2, BCP_1 and BCP_2 of each cross were evaluated in a randomized complete block design (RCBD) with three replicates during April-July, 2015.

Planting was done at a spacing of 70 × 50 cm and inorganic compound fertilizer, N:P:K (20:10:10) was applied at the rate of 300 kg per hectare at two weeks after transplanting. Weeding was done manually on the field as when due.

Data were collected on the following parameters: plant height (cm), number of leaves, number of branches, stem girth (cm), days to 50% and 100% flowering, number fruits per plant, fruit yield per plant (kg), fruit yield per hectare (tonnes) and fruit circumference (cm) and diameter (cm).

The performance of the F_1's and their parents were used to determined heterosis according to Allard (1960) as follows:

Heterosis over the mid parent (%) = $(F_1\text{-}BP) / BP \times 100/1$

Heterosis over better parent (%) = $(F_1\text{-}BP) / BP \times 100/1$

Where MP is mean of mid parent and is obtained by $P_1+P_2 / 2$, P_1 and P_2 are both parents.

BP is mean of better parent; and F_1 is mean of F_1's.

Test of significance was also done as described by Kumar *et al*. (2011).

$$CD = \sqrt{(2me/r)} \times t$$

Where CD = Critical Difference; t = t tabulated at 5% probability; r = number replications; *me* = error mean square; 2 = a constant.

The estimates of the various gene effects of the metric traits were obtained using generational mean data from the parental, F_1's, F_2's and backcrosses (BCP_1's and BCP_2's) according to the relationship giving by Hayman (1958) model as explained by Singh and Chaudhary (1985) as follows:

$$m = F_2$$

$$a = B_1 - B_2$$

$$d = F_1 - 4F_2 - \left(\frac{1}{2}\right)P_1 - \left(\frac{1}{2}\right)P_2 + 2B_1 + 2B_2$$

$$aa = 2B1 + 2B2 - 4F2$$

$$ad = B_1 - \left(\frac{1}{2}\right)P_1 - B_2 + \left(\frac{1}{2}\right)P_2$$

$$dd = P_1 + P_2 + 2F_1 + 4F_2 - 4B_1 - 4B_2$$

Test of significant was done based on the relationship as describe by Gamble (1962).

t value of effect = (gene effect) / √(variance of gene effect)

Where m = mean of F2, a = additive gene effect, d = dominance gene effect, aa = additive × additive gene effects, ad = additive × dominance gene effects, dd = dominance × dominance gene effects, B_1 = Mean of backcross to Parent 1, B_2 = Mean of backcross to Parent 2, P_1 = Mean of Parent 1, P_2 = Mean of Parent 2, F_1 = Mean of first filial generation, F_2 = Mean of second filial generation.

Results

The results presented in Table 1 show the expression of heterosis of F_1 over mid parent (MPH) on the agronomic traits of eggplant genotypes. The results revealed that the cross 'Yalo' × 'Uyo' had a positive significant ($p < 0.05$) MPH in most of the traits such as number of fruits per plant (66.40%), fruit yield per plant (7.26%) and fruit yield per hectare (7.32%). 'Yalo' × 'K3' showed a positive significant MPH in most of the traits, such as number of fruits per plant (158.90%), fruit yield per plant (31.11%) and fruit yield per hectare (30.66%). The hybrid 'Yalo' × 'Iyoyo' showed a positive significant MPH in number of fruits per plant, fruit yield per plant and fruit yield per hectare of 102.28%, 21.57% and 18.01%, respectively.

The cross 'Uyo' × 'K3' showed positive significant MPH in number of fruits per plant (19.40 %), fruit yield per plant (21.05%) and fruit yield per hectare (20.37%). The results obtained in a cross combination 'Uyo' × 'Iyoyo' showed positive significant MPH in number of fruits per plant (33.85%), fruit yield per plant (29.03%) and fruit yield per hectare (29.58%). Hybrid 'K3' × 'Iyoyo' showed a positive significant MPH in number of fruits per plant, fruit yield per plant and fruit yield per hectare of 126.81%, 63.14% and 62.20%, respectively.

The expression of heterosis of F_1 over better parent (BPH) presented in Table 2 revealed that the cross combination 'Yalo' × 'Uyo' had a positive BPH for number of fruits per plant (18.28%). Non-significant positive BPH was obtained in fruit yield per hectare (7.68%) from hybrid combination 'Yalo' × 'K3'). However, significant positive BPH of 104.08% was obtained in number of fruits per plant and fruit yield per plant (7.93%).'Yalo' × 'Iyoyo' showed non-significant BPH in number of fruits per plant (16.06 %). 'Uyo' × 'K3' cross showed positive BPH in in number of fruits per plant (3.36%) and fruit yield per hectare (7.89%). Also significant positive BPH of 8.49% was obtained in fruit yield per plant. 'K3' × 'Iyoyo' showed significant positive BPH in number of fruits per plant (42.42%), fruit yield per plant (12.26%) and fruit yield per hectare (11.51%).

The results presented in Table 3 shows various gene effects in the inheritance of agronomic traits in eggplant. The cross 'Yalo' × 'K3' showed that dominance ×

dominance effect had the highest positive magnitude of 45.70 in number of fruits per plant. The positive and highest dominance gene effect was found for number of fruits per plant (79.75) in cross 'Yalo' × 'Iyoyo' showed that to be in magnitude. For fruits yield per plant (1.76) and fruit yield per hectare (48.66) dominance × dominance gene effect had the highest positive values.

In the cross 'Uyo' × 'Iyoyo', the highest positive magnitude of dominance gene action was in number of fruits per plant (191.50), fruit yield per plant (0.86) and fruit yield per hectare (24.43). 'K3' × 'Iyoyo' cross showed that dominance gene action had the highest positive magnitude in number of fruits per plant (85.4), fruit yield per plant (2.42) and fruit yield per hectare (64.23).

Discussion

Heterosis shows the degree by which the means of the F_1 exceeds its better parent or the mid parent. The magnitude of heterosis depends on the accumulation of favourable dominant alleles in the F_1 (Amaefula *et al.*, 2014). High positive mid and better parent heterosis observed in most of the agronomic traits of eggplant in the crosses suggests that all the crosses performed better than their parents in those traits. The negative MPH and BPH obtained in days to flowering was a desirable result indicating that the crosses are good materials for developing early maturing hybrids.

Cross combinations 'Yalo' × 'K3', 'Uyo' × 'K3' and 'K3' × 'Iyoyo' showed positive BPH in number of fruits per plant, fruit yield per plant and fruit yield per hectare. The result is in conformity with the findings of (Kumar *et al.*, 2012; AL-Hubaity and Teli, 2013) who found positive mid parent, better parent and standard heterosis in the above mention traits in eggplant.

However, Amaefula *et al.* (2014) observed negative BPH in number of fruit per plant in tomato which is a contradictory report. Fruits circumference and diameter showed a negative BPH in the crosses. This could attribute to either wide diversity among the parents or the dominating gene effect of small fruit circumference and diameter over the large fruit circumference and diameter. Similar findings have also been reported by (AL-Hubaity and Teli, 2013).

Gene action is important in determining breeding methodology used to develop cultivar type (hybrid, pure line, synthetic, etc.). Dominance and dominance × dominance gene effect showed high positive effect when compare to others gene effect in number of fruits per plant, fruits yield per plant and fruits yield per hectare in all the crosses indicating that these attributes are governed mainly by dominance gene action and could be exploited through heterosis breeding.

The result is in agreement with the findings of Chaudhary and Malhotra (2000), Panda *et al.* (2005), Prasad *et al.* (2010) who observed that number of fruits and fruit yield is governed by dominance gene effect in eggplant. However, the results contradict the findings of Mistry *et al.,* (2016) who observed a significant additive gene effect in number of fruit per in some cross and early selection for improvement of this trait in eggplant.

Table 1. Estimates of heterosis (%) in F_1 over the mid parents (MP) for 11 agronomic traits of eggplant genotypes

Crosses	PH	NB	NL	SG	D50F	D100F	FC	FD	NF	FY/P	FY/H
'Yalo' × Uyo'	16.49	33.58	13.41	4.59	-6.59	-6.58	-5.07	-2.92	66.40	7.26	7.32
'Yalo' × K3'	5.94	14.75	16.00	22.79	-15.21	-11.58	-7.80	-11.85	158.90	31.11	30.66
'Yalo' × Iyoyo'	13.87	29.03	25.34	13.70	3.90	-7.01	-28.64	-27.29	102.28	21.57	18.01
'Uyo' × K3'	8.96	26.17	26.63	13.83	-2.79	-4.90	6.42	6.03	19.40	21.05	20.37
'Uyo' × Iyoyo'	6.81	2.14	7.98	0.28	-11.49	-8.49	-8.26	-5.59	33.85	29.03	29.58
'K3' × Iyoyo'	15.38	23.58	24.30	6.20	18.29	0.00	-11.72	-14.79	126.81	63.14	62.20
SE	3.35	4.00	24.80	0.21	1.63	1.43	0.65	0.46	10.93	0.18	5.06
CD ($p < 0.05$)	10.06	6.94	43.25	0.35	2.83	2.48	1.14	0.79	18.95	0.3	8.78

D50F= Days to 50% flowering, D100F= Days to 100% flowering, FC= Fruit circumference (cm), FD= Fruit diameter (cm), NB= Number of branches per plant, NF= Number of fruits per plant, NL=Number leaves per plant, PH= Plant height (cm), SG= Stem girth (cm), FY/P=Fruits per plant (kg), FY/H=Fruits yield per hectare (tone/ha), SE= Standard error, CD=Critical differences

Table 2. Estimates of heterosis (%) in F_1 over the better parents (BP) for 11 agronomic traits of eggplant genotypes

Crosses	PH	NB	NL	SG	D50F	D100F	FC	FD	NF	FY/P	FY/H
'Yalo' ×'Uyo'	13.99	23.66	13.35	1.88	-8.96	-7.98	-22.16	-24.09	18.28	-18.9	-18.76
'Yalo' × 'K3'	2.06	3.67	5.73	15.54	-20.5	-13.74	-19.92	-22.65	104.08	7.93	7.68
'Yalo' × 'Iyoyo'	13.60	-48.16	-7.44	-2.99	-15.38	-11.32	-53.89	-54.95	16.06	-24.39	-26.57
'Uyo' × 'K3'	7.25	21.58	15.36	9.85	-5.43	-5.88	-4.68	-7.29	3.36	8.49	7.89
'Uyo' × 'Iyoyo'	4.76	-31.51	-20.23	-16.24	-21.65	-13.98	-31.15	-31.63	-9.66	-4.76	-4.56
'K3' × 'Iyoyo'	11.41	-18.35	-13.45	-13.79	10.03	-6.85	-38.35	-43.16	42.43	12.26	11.51
SE	3.35	4.00	24.80	0.21	1.63	1.43	0.65	0.46	10.93	0.18	5.06
CD ($p < 0.05$)	10.06	6.94	43.25	0.35	2.83	2.48	1.14	0.79	18.95	0.30	8.78

D50F= Days to 50% flowering, D100F= Days to 100% flowering, FC= Fruit circumference (cm), FD= Fruit diameter (cm), NB= Number of branches per plant, NF= Number of fruits per plant, NL= Number leaves per plant, PH= Plant height (cm), SG= Stem girth (cm), FY/P=Fruits per plant (kg), FY/H=Fruits yield per hectare (tone/ha),), SE= Standard error, CD=Critical differences

Table 3. Estimates of gene effects for 11 agronomic traits in eggplant

Crosses	Traits	*m*	*a*	*d*	*aa*	*ad*	*dd*
'Yalo' ×' K3'	PH	70.66	5.00	18.81	14.48	7.78	-10.53
	NB	19.99	-1.00	-6.17	-8.64	-2.97	9.26
	NL	89.00	1.20	42.55	28.8	-7.15	-42.30
	SG	5.11	0.62	-2.26	-3.24*	0.32	5.19*
	D100F	29.33	3.33	-2.82	0.02	4.16	7.69
	D50F	20.67	3.67*	4.33	8.66	3.34	-9.36
	FC	19.89	3.90*	1.12	2.12	0.74	-1.50
	FD	9.54	1.31	0.77	1.00	-0.15	0.89
	NF	23.00	-13.50**	11.15	-13.40	-9.35**	45.70**
	FY/P	1.18	0.11	1.98	2.40	-0.18	-2.44
	FY/H	33.62	2.95	68.80**	56.62**	-5.29	-70.16**
'Yalo' × 'Iyoyo'	PH	72.00	-0.62	38.15**	27.88	-0.45	-41.20
	NB	40.00	-9.60	8.69	-0.80	4.39	-4.51
	NL	163.40	-31.60	-100.60	-137.60	20.1	279.60*
	SG	3.98	0.20	-0.93	-1.40	-0.39	1.54
	D50F	26.00	2.00	-5.82	-5.32	-1.5	-4.36
	D100F	36.00	1.67	-14.82	-12.66	0.17	0.32
	FC	11.80	8.20**	1.71	5.36	-0.31	-3.06
	FD	5.53	3.00**	-0.30	1.58	-1.43**	6.38**
	NF	48.00	-41.20**	79.75	34.30	-8.55	4.10
	FY/P	0.89	0.40*	-0.18	-0.40	-0.22	1.76
	FY/H	25.43	11.53*	-6.33	-11.62	-5.99	48.66*
'Uyo' × 'Iyoyo'	PH	85.11	-1.11	-6.63	-11.54	-2.52	-18.95
	NB	29.00	-16.23**	27.09	26.42	-0.84	-14.78
	NL	126.10	-57.20**	180.85*	169.20*	-5.55	-235.3
	SG	4.31	0.15	-1.09	-1.10	-0.56	-0.83
	D50F	25.00	-2.33	-5.85	-3.34	-5.17	-10.99
	D100F	36.67	-2.67	-16.67	-17.34	-4.67	14.66
	FC	9.00	3.52**	4.33	5.20	0.02	-6.02
	FD	4.17	1.86*	2.52	2.78	0.02	1.71
	NF	44.90	-60.60**	191.50**	174.00**	-35.70*	-285.80**
	FY/P	0.74	0.18	0.86	0.68	-0.04	-1.48
	FY/H	21.24	5.24	24.43	19.24	-1.10	-42.02
'K3' × 'Iyoyo'	PH	82.89	12.89	-8.76	-20.02	10.28	24.14
	NB	41.22	-24.56*	9.93	2.68	-8.59	-32.74
	NL	191.80	-4.10	-72.35	-105.80	55.95*	61.90
	SG	4.10	0.83	-1.07	-1.3.00	-0.04	1.47
	D50F	26.00	-2.34	-9.5	-14.00	-4.51	17.66
	D100F	37.33	1.67	-24.66	-24.66	-0.67	26.67
	FC	9.86	5.35**	1.89	3.34	0.00	0.42
	FD	4.72	2.40**	0.30	1.18	-0.57	0.81
	NF	90.30	-53.20*	85.40	24.4	-24.70	-95.60
	FY/P	0.76	0.56	2.42	1.16	0.23	-0.15
	FY/H	21.62	7.14	64.23*	51.24*	-2.33	-79.35*

*,**= significant at (p=0.05) and (P=0.05) respectively, D50F= Days to 50% flowering, D100F= Days to 100% flowering, FC= Fruit circumference (cm), FD= Fruit diameter (cm), NB= Number of branches per plant, NF= Number of fruits per plant, NL= Number leaves per plant, PH= Plant height (cm), SG= Stem girth (cm), FY/P=Fruits per plant (kg), FY/H=Fruits yield per hectare (tonnes/ha), m= F_2 mean, a= additive gene effect, d=dominance gene effect, aa= additive x additive gene effect, ad= additive x dominance gene effect, dd= dominance x dominance gene effect

High positive additive gene effect was obtained in fruit circumference and diameter in all crosses indicating that these attributes can be fixed for possible selection of promising genotypes at the early generation. This result is in accordance with Prasad *et al*. (2010) who observed that additive gene had the highest positive value when compare with other gene effect in length and breadth of fruits in eggplant but this result is not in support of the findings of Mistry *et al.* (2016) that found positive and significant dominance gene effect for fruit length and fruit girth in eggplant. High magnitude of dominance and dominance × dominance gene effect in yield traits indicate heterosis breeding as the best breeding method to improve the productivity of this crop.

Conclusions

A better parent heterosis (BPH) which can be important to eggplant breeders, was obtained in 'Yalo' × 'K3' and 'Uyo' × 'K3' genotypes for fruit yield. Dominance and dominance × dominance gene effect was found to be positive and higher in magnitude in all crosses for number of fruits per plant, fruit yield per plant and fruit yield per hectare indicating hybrid breeding is the best breeding method to improve the productivity of this crop. Additive and additive × additive gene effect was positive and high in magnitude for some growth trait studied. The results indicated that for the improvement of these growth traits such as plant height, number branches and number of leaves, selection breeding method is a more appropriate method to adopt in eggplant genotypes.

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