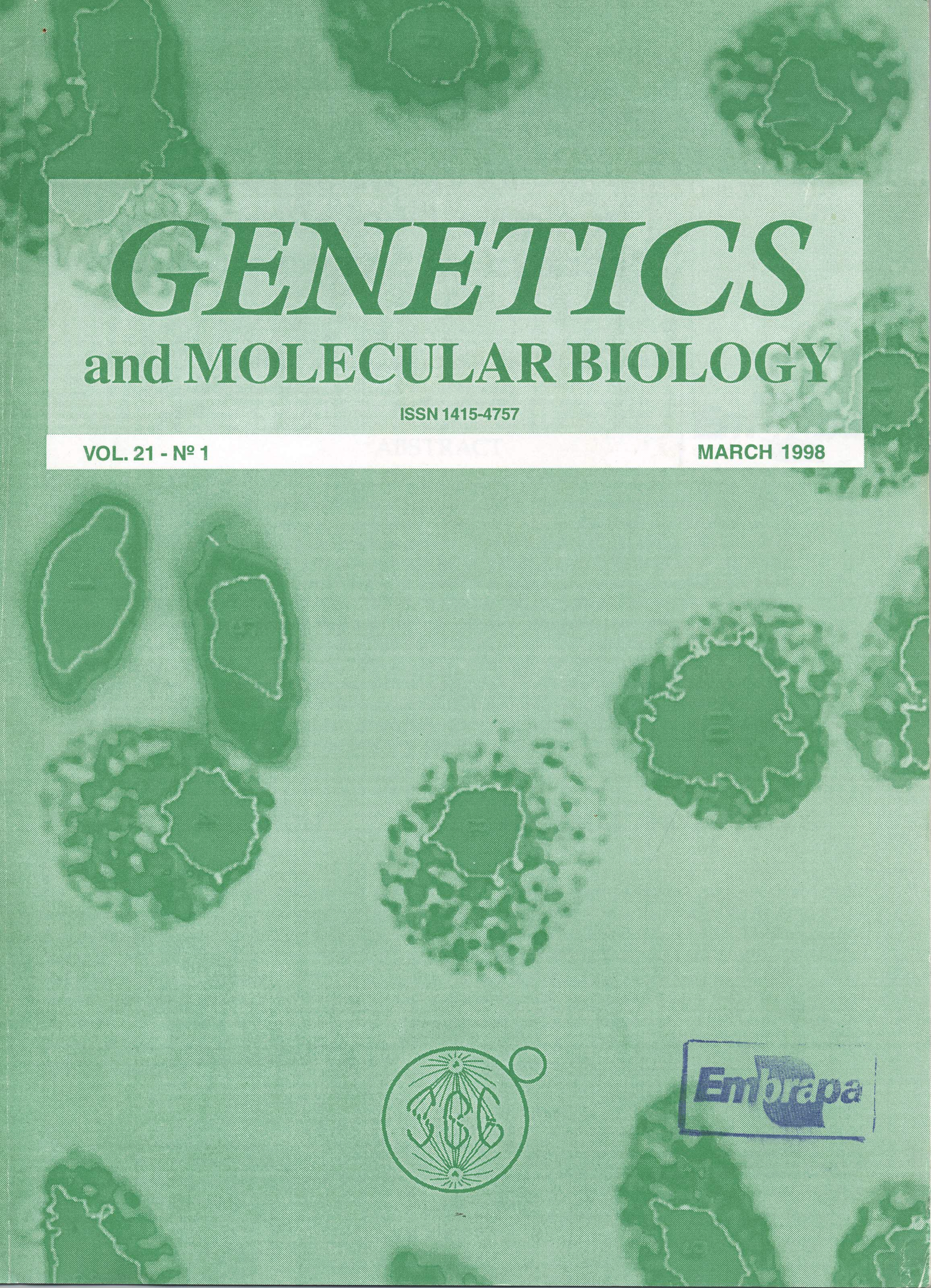

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Expression of heterosis for productive traits in F1 eggplant (*Solanum melongena* L.) hybrids*

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ABSTRACT

This study was carried out to obtain estimates of heterosis in crosses between seven eggplant cultivars (Embu = E; Santa Genebra = SG; Viserba = V; Aubergine de Barbentane = AB; Florida Market 10 = FM; Black Beauty = BB, and Melitino = M) and two breeding lines (B-14-07 = B1 and B-31-06 = B2). The F1 hybrids used were: E x FM; E x BB; E x M; E x B1; E x B2; SG x FM; SG x BB; SG x M; SG x B1; SG x B2; V x FM; V x B1; V x B2; AB x FM; AB x M; AB x B1; AB x B2 and M x FM. Cultivars, lines and hybrids were evaluated at the ESAL experimental field in Lavras, MG, from February to October 1992. A randomized complete block design with three replications was used. Significant heterosis relative to the parental means was detected for all traits studied. Their values ranged from +41.23% to +113.31% for total fruit yield, from -11.45% to +26.17% for average fruit weight, and from +27.98% to +141.81% for early production. Heterosis relative to the superior parent ranged from +13.89% to +92.51% for total fruit yield. Hybrid pairs: SG x FM and AB x B1, V x FM and AB x FM, E x M and AB x B1 were the most heterotic relative to the parental mean for total fruit production, mean fruit weight and early production, respectively. The hybrids displaying highest heterosis relative to the superior parent for total yield were AB x B1 and SG x FM.

INTRODUCTION

The eggplant (*Solanum melongena* L.) is a solanaceae native to the tropical regions of the Far East. The high degree of heterosis in eggplants has been reported in several studies, in the Brazilian and world-wide literature (Monteiro, 1975; Noda, 1980; Dixit *et al.*, 1982; Singh and Kalda, 1989; Chadha *et al.*, 1990; Sousa, 1993). Most authors recommend the commercial use of eggplant hybrids because of heterosis for fruit yield traits (Monteiro, 1975).

MATERIAL AND METHODS

Seven open pollinated cultivars (Embu = E, Santa Genebra = SG, Viserba = V, Aubergine de Barbentane = AB, Florida Market 10 = FM, Black Beauty = BB and Melitino = M), two breeding lines (B-14-07 = B1 and B-31-06 = B2), 18 experimental hybrids obtained from the cultivars (E x FM; E x BB; E x M; E x B1; E x B2; SG x FM; SG x BB; SG x M; SG x B1, SG x B2; V x FM; V x B1; V x B2; AB x FM; AB x M; AB x B1; AB x B2 and M x FM) and two commercial hybrids (F-100 and F-1000) were used as experimental materials (Table I).

Among the open pollinated cultivars and lines, only those which could be used for seed production, that is, those that did not produce excessively large fruit when mature and/or were good seed producers, were used as the female parent. Seeds from three of the 20 experimental hybrids obtained did not germinate.

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Table I - Description of the eggplant parentals.

Parental	Origin	Average plant height (cm)	Fruit shape	Fruit color	Fruit size (cm)	Fruit diameter (cm)	Calix color
Embu	Brazil (São Paulo)	77.0	Oval	Shiny dark purple	17.0	6.0	Pale green
Santa Genebra	Brazil (IAC/Campinas, SP)	70.0	Elongated oval	Shiny pale wine	18.0	6.5	Green
Viserba	USA	96.0	Long	Shiny dark purple	20.0	6.0	Pale green
Aubergine de Barbentane	France	87.0	Fairly long	Shiny dark purple	22.0	7.0	Green with purple marks
Florida Market 10	USA	85.0	Oval	Shiny fairly dark purple	18.0	6.0	Green
Black Beauty	USA	67.0	Oval/round	Pale purple	14.0	7.0	Green
Melitino	Italy	75.0	Long	Shiny dark purple	21.0	6.5	Green
Line B-14-07	Brazil (Dr. H. Ikuta, ESALQ/USP)	86.0	Oval/round	Pale wine	15.0	5.5	Green
Line B-13-06	Brazil (Dr. H. Ikuta, ESALQ/USP)	77.0	Elongatel oval	Very dark purple	18.0	8.0	Green

The seven cultivars, two lines, 18 F1 hybrids and two commercial hybrids were tested in a randomized complete block design with three replications at the experimental field of the ESAL campus, Lavras, MG, from February to October 1992. Each experimental plot consisted of 10 plants and was spaced at 1.20 x 0.50 m. Growing conditions were maintained similar to those normally used for a commercial eggplant crop. Fourteen harvests were carried out, at seven day intervals, during a three and a half month period.

The assessed traits were:

a. Total yield, expressed in kg/ha;
b. Early yield (1st to 4th harvest), expressed in kg/ha;
c. First class fruit production, expressed in kg/ha;
d. Average weight per fruit, expressed in g/fruit;
e. Average weight of early fruit, expressed in g/fruit.

The fruits classified as first class corresponded to the official commercial classification, classes Extra AA and Extra A. Heterosis relative to the parental mean (Ht = 100) and relative to the superior parent (Hb = 100), named heterobeltiosis, were calculated for the experimental hybrids. In the analyses of variance (ANOVA) the F test was used at the 5% or 1% levels of probability. The trait means were compared by the Tukey test at the 5% level of probability.

RESULTS AND DISCUSSION

The treatment square means, evaluated by the F test, were significant at the 1% probability level for all the assessed traits. All hybrids showed positive heterosis and heterobeltiosis for total yield (Table II). The hybrids displaying high heterosis also had high heterobeltiosis (Table II). Pal and Singh (1946), Odland and Noll (1948), Ikuta (1961) and Monteiro (1975) also found significant heterosis results for this trait. The heterosis magnitude indicates that the use of F1 hybrid plants improves this characteristic. The values obtained for the yield characteristics in the hybrids depended on the parents involved in the crosses, but all the yield characteristics had some type of genetic gain in the hybrids, compared to the parents.

The heterosis and heterobeltiosis for hybrid early yield were also positive (Table II). Among the hybrids, Embu x Melitino, Embu x B-14-07 and Aubergine de Barbentane x B-14-07 were superior. Cultivars Embu and B-14-07 were parentals in those hybrids. The magnitude of the heterosis depended on the genotypes used. The use of F1 hybrids in eggplants provided a quick and practical way of obtaining greater early yields.

Table II - Total yield (kg/ha), early yield (kg/ha) and first class fruit yield means, heterosis (Ht) and heterobeltiosis (Hb) in eggplants.

Treatments	Total yield			Early yield			First class fruit yield		
	Means (kg/ha)	Heterosis		Means (kg/ha)	Heterosis		Means (kg/ha)	Heterosis	
		Ht (%)	Hb (%)		Ht (%)	Hb (%)		Ht (%)	Hb (%)
E	43431 fgh	-	-	5586 ef	-	-	10225 fgh	-	-
SG	36870 gh	-	-	9270 cdef	-	-	5664 fgh	-	-
V	47815 efgh	-	-	12036 abcdef	-	-	7108 fgh	-	-
AB	36898 gh	-	-	8097 def	-	-	5345 gh	-	-
FM	49068 efgh	-	-	10089 bcdef	-	-	26048 bcdef	-	-
BB	57182 defgh	-	-	13281 abcde	-	-	11036 fgh	-	-
M	57946 cdefgh	-	-	9717 bcdef	-	-	19717 efgh	-	-
B1	30142 h	-	-	4036 f	-	-	2189 h	-	-
B2	60160 bcdefg	-	-	8745 cdef	-	-	20300 efgh	-	-
F1 (E x FM)	83866 abcd	81.33	70.92	10814 abcdef	37.98	7.19	45165 ab	149.03	73.39
F1 (E x BB)	86971 abc	72.88	52.10	15853 abcd	68.05	19.37	46758 ab	339.93	323.76
F1 (E x M)	89743 a	77.05	54.87	18025 ab	141.81	93.35	48234 a	222.18	144.63
F1 (E x B1)	65924 abcdefg	79.20	51.79	9717 bcdef	11.96	73.94	21723 defgh	249.97	112.44
F1 (E x B2)	89293 ab	72.40	48.43	13692 abcde	91.08	56.57	44331 abc	190.45	118.38
F1 (SG x FM)	91657 a	113.31	86.80	19128 a	97.62	89.59	44909 ab	183.23	72.41
F1 (SG x BB)	87582 ab	86.24	53.16	19459 a	72.58	46.52	34873 abcde	317.63	215.98
F1 (SG x M)	72346 abcdef	52.60	24.85	15161 abcd	63.10	62.63	18050 efgh	42.23	-8.5
F1 (SG x B1)	63979 abcdefg	90.95	73.52	13134 abcde	97.41	41.68	12450 fgh	217.08	119.81
F1 (SG x B2)	68518 abcdef	41.23	13.89	14167 abcde	57.29	52.83	20778 efgh	60.05	2.35
F1 (V x FM)	76860 abcde	58.67	56.64	14159 abcde	27.98	17.63	34809 abcde	109.97	33.63
F1 (V x B1)	57490 defgh	47.49	20.23	12200 abcdef	51.81	1.36	8678 fgh	86.67	22.08
F1 (V x B2)	69337 abcdef	28.43	15.26	14981 abcd	44.18	24.46	21312 efgh	55.51	4.98
F1 (AB x FM)	87891 ab	14.48	79.12	13272 abcde	45.96	31.55	36876 abcde	134.93	41.57
F1 (AB x M)	89166 ab	88.03	53.88	17274 abc	97.64	84.65	20159 efgh	60.87	2.24
F1 (AB x B1)	71032 abcdef	111.91	92.51	13664 abcde	125.23	68.75	17198 efgh	356.56	221.78
F1 (AB x B2)	85993 abcd	77.20	42.94	14575 abcd	73.08	66.68	24142 cdefg	88.28	18.92
Hybrid F-100	81582 abcd	-	-	13142 abcde	-	-	42081 abcd	-	-
Hybrid F-1000	72615 abcdef	-	-	11314 abcdef	-	-	21000 efgh	-	-
F1 (M x FM)	82160 abcd	53.55	41.79	13814 abcde	42.33	36.92	43673 abc	90.86	67.67
DMS Tukey 5%	29210			8730.3			20693		

Means followed by the same letters did not differ significantly by the Tukey test (Probability = 5%).
E = Embu; SG = Santa Genebra; V = Viserba; AB = Aubergine de Barbentane; FM = Florida Market 10; BB = Black Beauty; M = Melitino; B1 = B-14-07; B2 = B-31-06.

Under Brazilian conditions, early yield is not a limiting trait. However, it may be useful in the Southern region when planting is carried out soon after winter. In the temperate regions, the best prices are normally paid at the beginning of the production season, which makes early cultivars more valuable.

For first class fruit yield, heterosis values were all positive and displayed a wide range, of over 300% (Table II). On the other hand, the Santa Genebra x Melitino hybrid displayed a negative heterobeltiosis value. All the other hybrids showed positive values. The large magnitudes for this trait showed, in general, the great superiority of the F1 hybrids, compared to the open pollinated cultivars, for obtaining good quality fruit. Monteiro (1975) and Noda (1980) also reached this conclusion.

First class fruit yield is a production characteristic which allows phenotypic selection of superior genotypes, in a screening process. However, since it does not take into account the yield of slightly inferior but still commercially viable fruits, this criterium cannot be used as the only selection method.

Fruit characteristics are very important in eggplant breeding, as quality in vegetables is as much or more important than quantity (Paterniani, 1974). The assessment criteria for quality values are more efficient than those which merely quantify production (Noda, 1980). The commercial valorization of a crop, in terms of product quality, is dependent on its capacity to concentrate the greatest number of fruit within the market standards.

Positive heterosis for weight of early fruit was detected for the majority of hybrids, with highest positive scores for hybrids Embu x Melitino, Embu x Florida Market 10 and Embu x Black Beauty. On the other hand, the heterobeltiosis values were mostly negative, though the hybrid Embu x Melitino was positive and outstanding (Table III). Following the same

Table III - Average fruit weight (g), average early fruit weight (g), heterosis (Ht) and heterobeltiosis (Hb) in eggplants.

Treatments	Average fruit weight			Average early fruit weight		
	Means (g)	Heterosis		Means (g)	Heterosis	
		Ht (%)	Hb (%)		Ht (%)	Hb (%)
E	198.67 defgh	-	-	171.66 fghij	-	-
SG	131.57 jkl	-	-	147.10 ijk	-	-
V	92.23 l	-	-	100.94 k	-	-
AB	128.28 kl	-	-	141.52 jk	-	-
FM	232.10 abcd	-	-	237.12 abcde	-	-
BB	255.08 ab	-	-	284.80 a	-	-
M	213.25 bcdefg	-	-	202.26 cdefghij	-	-
B1	211.32 bcdefg	-	-	213.16 cdefgh	-	-
B2	243.78 abc	-	-	228.76 abcdef	-	-
F_1 (E x FM)	244.37 abc	13.46	5.29	249.43 abc	22.04	5.19
F_1 (E x BB)	268.10 a	18.17	5.10	276.99 ab	21.36	-2.74
F_1 (E x M)	237.66 abcd	15.39	11.45	230.11 abcdef	23.08	13.77
F_1 (E x B1)	240.14 abcd	17.13	13.62	226.75 abcdefg	17.85	6.37
F_1 (E x B2)	244.13 abc	10.35	0.14	239.02 abcd	19.38	4.48
F_1 (SG x FM)	220.48 bcdef	21.25	-5.01	223.93 abcdefg	16.56	-5.56
F_1 (SG x BB)	222.43 bcde	15.06	-12.80	229.19 abcdef	6.13	-19.53
F_1 (SG x M)	174.92 ghij	1.45	-17.98	183.11 defghij	4.82	-9.47
F_1 (SG x B1)	176.70 fghi	3.05	-16.40	174.37 efghij	-3.20	-18.20
F_1 (SG x B2)	166.18 hijk	-11.45	-31.83	184.35 defghij	-1.91	-19.41
F_1 (V x FM)	204.61 cdefgh	26.17	-11.85	200.12 cdefghij	18.39	-15.60
F_1 (V x B1)	147.23 ijk	-3.00	-30.34	164.08 ghijk	4.48	-23.03
F_1 (V x B2)	151.27 ijk	-9.96	-37.95	159.02 hijk	-3.54	-30.49
F_1 (AB x FM)	220.03 bcdef	22.11	-5.20	213.83 bcdefgh	12.95	-9.82
F_1 (AB x M)	200.43 cdefgh	17.37	-6.01	204.45 cdefghij	18.94	1.08
F_1 (AB x B1)	183.42 efghi	8.01	-13.22	189.13 cdefghij	6.65	-11.27
F_1 (AB x B2)	183.79 efghi	-1.20	-24.61	173.25 fghij	-6.42	-24.27
Hybrid F-100	218.87 bcdefg	-	-	209.40 cdefghi	-	-
Hybrid F-1000	203.55 cdefgh	-	-	222.72 abcdefg	-	-
F_1 (M x FM)	249.47 ab	12.03	7.48	222.87 abcdefg	1.45	-6.01
DMS Tukey 5%	44.83			63.173		

Means followed by the same letters did not differ significantly by the Tukey test (Probability = 5%).
For abbreviations see Table II.

tendency of the early assessment, the mean fruit weight had positive heterosis for the majority of the hybrids. Hybrids Viserba x Florida Market 10, Albergine de Barbentane x Florida Market 10 and Santa Genebra x Florida Market 10 were the most heterotic. Heterobeltiosis values were mostly negative. The highest positive values were displayed by the hybrids Embu x B-14-07 and Embu x Melitino (Table III). The mean fruit weight, independent of the heterosis and heterobeltiosis values found, showed small difference from the established standard in the market (commercial F-100 hybrid).

When the yield characteristics are used as assessment criteria, it is desirable that the heterosis and heterobeltiosis levels, shown in the hybrid combinations, be as high as possible. Mean fruit weight and mean weight of early fruit are exceptions since very high heterosis and/or heterobeltiosis values may lead to fruit much heavier than those established by the market.

In view of the high heterosis and or heterobeltiosis values shown for the different characteristics, the importance of the non-additive genetic effects in their expression can be inferred. Thus, it is presumed that the establishment of a population with a wide genetic base, using recurrent selection methods for increasing combining ability along with reciprocal recurrent selection, will lead to future new lines which result in hybrids superior to those studied.

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RESUMO

Este trabalho visou obter estimativas da heterose em cruzamentos entre sete cultivares de berinjela (Embu = E, Santa Genebra = SG, Viserba = V, Aubergine de Barbentane = AB, Florida Market 10 = FM, Black Beauty = BB e Melitino = M) e duas linhagens (B-14-07 = B1 e B-31-06 = B2). Os híbridos F_1 utilizados foram: E x FM; E x BB; E x M; E x B1; E x B2; SG x FM; SG x BB; SG x M; SG x B1; SG x B2; V x FM; V x B1; V x B2; AB x FM; AB x M; AB x B1; AB x B2 e M x FM. O trabalho foi conduzido no campus da ESAL em Lavras-MG, de fevereiro a outubro de 1992. O delineamento empregado foi o de blocos casualizados completos com três repetições. Em relação às médias dos pais, houve heterose significativa para os caracteres estudados, variando de +41,23% a +113,31% para produção total de frutos; de -11,45% a +26,17% para peso médio de fruto; e de +27,98% a +141,81% para produção precoce. A heterose em relação ao pai mais produtivo variou entre +13,89% e +92,51% para produção total de frutos. Destacaram-se entre os mais heteróticos, relativamente às médias dos pais, os híbridos SG x FM e AB x B1, para produção total de frutos; V x FM e AB x FM, para peso médio de frutos; E x M e AB x B1, para produção precoce. Em relação ao pai superior, os híbridos com maior heterose para produção total foram AB x B1 e SG x FM.

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