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ASSESSMENT OF GENE ACTION BY LINE X TESTER MATING DESIGN IN SESAME (*SESAMUM INDICUM* L.) ELITE GENOTYPES

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A B S T R A C T

Although sesame is self-pollinated, interest has recently been developed in producing hybrid varieties as a considerable amount of heterosis has been demonstrated in the crop. Successful yield improvement depends on the variability present among the different genotypes and in-depth understanding of the underlying gene action and genetic architecture of traits related to yield. Line x tester mating design was used to determine the combining ability and gene action of traits, and therefore an experiment involving nine females and five male parents was undertaken at the National Semi-Arid Resources Research Institute (NaSARRI) and Ngetta Zonal Agricultural Research and Development Institute (NgeZARDI), during 2013 growing seasons to assess the combining ability and gene action of various traits. Results showed that mean squares across locations had high significant difference for all the traits recorded indicating that locations had effect on those traits. Variances for the males were higher than the variances for the females for all the traits except capsule width suggesting greater variability among the males than the females. Combined general combining ability (GCA) across locations showed that GCA for the lines and testers were significantly positive for a few traits. Specific combining ability (SCA) was only positively significant for days to flowering, number of capsules on branches, number of capsules on main stem, total number of capsules and capsule length. Baker's ratio was high for most of the characters and medium for plant height, number of capsules on branches, number of capsules on main stem and capsule length. Coefficients of determination for narrow sense heritability (CD_{nsh}) were high for days to flowering, height of first branch and height of first capsule. Among the lines, Sesim 2, Ajimo A1-5, EM15-1-5, Ajimo A1-6//7029, Local 158//6022 and (Y-1//Local 158)-1-2-1 and among testers 4036-1-10-2 and SPS1438-1-6-4 were desirable for different traits.

Keywords: Coefficient of determination, combining ability, environment effect, gene effect, hybrid vigour.

INTRODUCTION

Sesame (*Sesamum indicum* L.) is normally called 'Simsim' in Eastern Africa and is a traditional and important oilseed crop in Uganda (Auckland, 1970). It is one of the ancient oilseed crops cultivated for its superior quality oil, hence it is regarded as 'queen of the oilseeds'' (Senthil Kumar and Ganesan., 2002). The Uganda national yield is reported to be about 600 kg/ha (FAOSTAT, 2009). Brigham (1985) reported average yields of 1,564 kg/ha in the USA. This disparity in yields is caused by various constraints including lack of improved varieties.

Although sesame is a self-pollinated crop, interest has recently been developed in producing hybrid varieties as a considerable amount of heterosis has been demonstrated in the crop (Krishnaswami *et al.*,1985). Hybrid crop production appears to promise a yield breakthrough in sesame like in other self-pollinated crops such as rice, barley, wheat and could make sesame more competitive and lead to wider cultivation and greater returns.

A successful yield improvement depends on the variability present among the different genotypes and in-depth understanding of the underlying gene action and genetic architecture of traits related to yield. Selection of parents based on their performance *per se* alone may not always be a sound procedure, since phenotypically superior genotypes may yield inferior hybrids and/or poor recombinants in the segregating

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generations (Banerjee and Kole, 2009; Vavdiya *et al*., 2014). It is very important to identify parents with high general combining ability (GCA) value for a trait to be improved (Yamanura *et al*., 2009) and high specific combining ability for hybrid development.

Information on gene action and combining ability helps in the choice of suitable parents for hybridization in developing superior F_1 hybrids so as to exploit hybrid vigour and building hybrid varieties. The choice of an appropriate breeding procedure for the improvement of productivity depends upon the nature and magnitude of genetic variation present in a population. A more precise estimate of general combining ability and specific combining ability is by line x tester mating design (Solanki and Singh, 2006).

The objectives of the present study were to assess the combining ability and the nature of gene action controlling the inheritance of seed yield and yield characters in selected sesame lines using line x tester mating design.

MATERIALS AND METHODS

From the previous breeding work that assembled and characterized the sesame germplasm, nine local female cultivars were selected and crossed to 5 introduced male testers (Table 1).

Table 1. Parents used as lines (females) and testers (males) and their characteristics.

Parents	Country of origin	Days to flowering	Days to maturity	Height at first capsule	Branching habit	Plant height	Capsule length	Hairiness of capsules
Females/Lines								
Sesim 1	Uganda	Greater 50 days	Greater 90 days	Middle	High (4-6 branches)	Tall	Medium (8 mm)	Absent
Sesim2	Uganda	Greater 50 days	Greater 90 days	High	high	Tall	Medium	Moderate
Ajimo A1-5	Uganda	Greater 50 days	Greater 90 days	Middle	high	Tall	Medium	Absent
Ajimo A1-6//7029	Cross between local and Thailand variety	Greater 50 days	Greater 90 days	Middle	high	Tall	Medium	Absent
Adong 4-4	Uganda	Greater 50 days	Greater 90 days	High	high	Medium tall	Medium	Absent
U1-7	Uganda	Greater 50 days	Greater 90 days	High	high	Medium tall	Medium	Absent
EM15-1-5	Uganda	Greater 50 days	Greater 90 days	High	high	Tall	Long (10 mm)	moderate
Local 158//6022	A cross between Ethiopian and Thailand line	Greater 45 and less than 50 days	Less than 90 days	middle	Medium (2 to 4 branches)	Medium tall	Medium	Denset
(Y-1//Local 158)-1-2-1	A cross b/w unknown origin and Ethiopian	Greater than 50 days	Greater than 90 days	High	High	Tall	Medium	Absent
Males/testers								
Local 158	Ethiopia	< 45 days	Less than 90 days	Middle	Medium	Medium tall	Medium	Present
SPS1438-1-6-4	China	< 35 days	Less than 85 days	Low	Low (None or 2 branches)	Medium tall	Long (10 mm)	absent
4036-1-10-2	China	< 35 days	Less than 85 days	Low	Medium (2 to 4 branches)	Medium tall	Long (10 mm)	Present

Renner 1-3-1-1	USA	<40 days	Less than 85 days	Middle	Medium	Medium tall	Short (7 mm)	Absent
7029-1-2	Thailand	< 35 days	Less than 85 days	Middle	2 to 4 branches	Medium tall	Medium	Absent

Line x tester mating design by Kempthorne (1957) to produce 45 F_1s was applied. The resulting 59 genotypes comprising 45 F_1s and the 14 parents were grown in a randomized complete block design with three replications during the second rains of 2013 at NaSARRI, Serere in eastern and Ngetta in northern Uganda. Each entry consisted of one row plot of 2 m long at a spacing of 30 x 10cm. Observations for eleven characters were recorded on five randomly selected plants of each genotype in each replication except for days to flowering and maturity which were on plot basis. The characters studied were: number of days to 50% flowering, number of primary branches per plant, height of first branch on the main stem, height of first capsule on the main stem, length of the capsule formation zone, number of capsules on the branches, number of capsules on the main stem, number of capsules per plant, plant height, capsule length, capsule width, 1000 seed weight, maturity, and seed yield per plant.

Statistical analysis: The statistical model by Kempthorne (1957) was used:

$Y_{ijkl} = \mu + a_l + b_{kl} + v_{ij} + (av)_{ijkl} + \varepsilon_{ijkl}$, where:

Y_{ijkl} is the observed value from each experimental unit (x_{ij}), μ is the population mean, a_l = location effect; b_{kl}= block or replication effect within each location; $v_{ij} = g_i + g_j + s_i$, where g_i = general combining ability (GCA) for the ith parental line; g_j = GCA effect of j^{th} tester; s_{ij} = specific combining ability (SCA) for the ij^{th} hybrid and $(av)_{ijl}$ = interaction effect between ij^{th} F_1 hybrid and l^{th} location; and ε_{ijkl} = residual effect.

The means of the characters for the different entries were subjected to L x T analysis and variance due to general combining ability (GCA) of parents and specific combining ability (SCA) of different cross combinations.

RESULTS AND DISCUSSION

The results of the mean square across locations are presented in Table 2. The highly significant difference (P<0.001) for all the traits across locations except height to the first capsule and capsule length (P<0.01) were recorded suggesting that locations had effect on most of traits studied. Variances for the males were higher than the variances for females for all the traits except capsule width suggesting greater variability among males than females. Solanki and Gupta (2001) also observed that the variances due to males were greater than those due to females for most characters except for several capsules per plant, indicating a greater diversity in the males than in the females. Vavdiya *et al*. (2014) reported significant differences among mean squares due to lines, testers and line x testers for all characters but mean squares due to testers were larger than those due to lines for all the characters except days to 50% flowering, capsule length and 1000 seed weight. Significant difference among females was recorded only for capsule length (P<0.5) and capsule width (P<0.01) while significant difference among males was recorded for the height of first branch (P<0.001) and several capsules on the main stem (P<0.01). A number of the introductions which were used as males form capsules from the lower part of the main stem so eventually more capsules are formed on the main stem if the plant is tall. The female x male interaction was significant only for the height of first branch (P<0.5), the height of first capsule (P<0.01) and capsule width (P<0.01) suggesting the importance of these characters in making crosses for hybrid seed production.

The results of combined GCA and SCA variances and gene action for yield and its components for both Serere and Ngetta are presented in Table 3. GCA for lines was significant for most traits except for plant height, several capsules on branches, capsule width, length of capsule zone indicating that they possess wide variability for most of the traits. GCA for testers was significantly positive for most traits except plant height, several capsules on the main stem, capsule width and seed yield per plant suggesting that these testers also have wide variability in the traits they possess. These traits were therefore controlled by additive gene action (Yamanura *et al*. 2009). Zhang Ying Zhong (1999) reported that the GCA were significant for all the characters in females and six characters in the males and SCA was only positively significant for days to flowering, the number of capsules on branches, the number of capsules on mainstem, total number of capsules, capsule length and seed yield. Yamanura *et al*. (2009) reported SCA to be significant for all characters studied in sesame.

Table 2. Mean square variances combined across locations of NaSARRI and Ngetta.

Source	d.f	Height 1st branch	Height 1st capsule	Plant height	Branches per plant	Capsules on mainstem	Total capsules	Capsule length	Capsule width	Capsule length zone	Yield per plant
Location	1	1380.06***	214.63**	1895.35***	18.00***	2231.81***	8513.96***	0.11**	0.11***	1366.63***	719.19***
Female	8	64.56	58.14	61.42	0.35	17.68	81.55	0.081*	0.01**	61.86	4.82
Male	4	292.08***	398.72	106.92	0.83	26.21**	154.02	0.10	0.002	248.71	7.16
FxM	31	46.94*	43.3**	49.49	0.22	8.65	38.21	0.03	0.003**	59.95	1.16
LxF	8	47.65	29.25	20.39	0.46*	8.23	69.29	0.02	0.001	30.58	2.43
LxM	4	5.6	67.97**	48.54	0.34	1.05	36.29	0.02	0.005**	40.15	3.85
LxFxM	31	22.12	15.39	48.97	0.18	6.414	37.43	0.02	0.001	39.03	2.08
Total	87	64.48	52.87	71.5	0.48	34.66	147.43	0.03	0.004	72.76	10.59
error	85.5	28.31	19.86	34.58	0.20	4.87	25.89	0.01	0.002	31.23	1.77

*, **, *** Significant at 5%, 1% and 0.1% Probability level.

Significant negative SCA effect was recorded for the length of capsule zone implying that length of capsule zone is controlled by genes for reduced length of capsule zone under dominance gene action. Saravanan and Nadarajan (2003) using diallel method showed that variances due to general combining ability and specific combining ability were significant for all the characters studied and GCA variance was greater than the SCA variance for eight traits viz. plant height, number of primary branches per plant indicating the preponderance of additive gene action for these traits.

Baker's ratio was high for most of the characters but medium for plant height, number of capsules on branches, number of capsules on mainstem and capsule length suggesting that the parents contributed highly to the progenies (Baker, 1978). The coefficient of determination for broad sense heritability were high for most traits indicating that the genotypes contributed highly to the traits (Bernado, 2010). The coefficient of determination for narrow sense heritability were high for days to flowering, height of first branch and height of first capsule, suggesting that the environment had less control on these traits (Bernado, 2010).

Table 3. Combined GCA, SCA variances and gene effects for yield and its components at NaSARRI and Ngetta.

	D.F	Days to flower	Days to maturity	Plant height	Height 1st branch	Height 1st capsule	Branches per plant	Capsules on branches	capsules on mainstem	Total capsules	Capsule length	Capsule width	Length of capsule zone	Yield per plant
(GCA) Line	8	1.17***	0.21**	0.48	9.46***	8.93**	0.05*	4.13	3.52***	21.53***	0.013***	0.00	-12.70	5.30***
(GCA) Tester	4	3.06***	0.15**	10.45	14.34***	31.42***	0.08**	5.73*	0.41	13.76***	0.003**	0.00	4.58**	0.05
SCA	32	0.76**	-0.01	11.41	2.99	3.36	-0.02	14.24*	5.61*	23.52*	0.02***	0.00	-40.78*	0.01**
BR		0.85	1	0.49	0.89	0.92	1	0.41	0.41	0.60	0.490	0.67	1	
CDBSH		0.87	0.47	0.41	0.61	0.72	0.37	0.53	0.60	0.59	0.722	0.07	0.12	
CDNSH		0.74	0.47	0.20	0.54	0.66	0.37	0.22	0.14	0.36	0.354	0.05	0.12	

*, **, *** Significant at 5%, 1% and 0.1% Probability level.

The results of combined general combining ability effects are presented in Table 4. Among the lines (females), positive significant effect for days to flowering was recorded in Sesim 2, Ajimo A1-5 and Em15-1-5 indicating that they had genes for late flowering. For reducing days to flowering, negative significant GCA effect (P<0.01) were recorded in Ajimo A1-6//7029 and Local 158//6022 suggesting that they have genes for early flowering. Significant positive effect for days to maturity was recorded only in Ajimo A1-5 which also recorded significant positive effect for days to flowering. Significant negative effect for days to maturity was recorded in (Y-1//Local158)-1-2-1 so that in order to reduce the time of maturity in the progeny, this genotype could be used as a female parent. Significant negative effect for height of first branch was recorded in Local 158//6022 suggesting that this genotype would be desirable as capsules would also be set lower on the stem and possibly more capsules set on the main stem if the plant height is maintained. Local 158//6022 and U1-7 recorded highly significant and significant positive effect respectively for number of capsules on branches, number of capsules on main stem and total number of capsules per plant indicating that this parent can be used to increase the number of capsules on the branches, number of capsules on the main stem and the overall total number of capsules per plant thus increasing seed yield per plant (Thangavelu and Sridharan (1998).

Table 4. Estimates of combined GCA effects for NaSARRI and Ngetta for various characters in sesame

	Days to flower	Days to maturity	Plant height	Height 1st branch	Height 1st capsule	Branches per plant	Capsules on branches	Capsules on mainstem	Total capsules	Capsule length	Capsule width	Capsule length zone	Yield per plant
Lines													
Sesim 1	-0.18	-0.63	3.68	-1.52	-0.55	0.12	-1.32	0.91	-0.78	-0.01	-0.01	3.89	-0.07
Sesim 2	0.82*	0.11	-0.80	-0.12	-0.21	0.06	-0.76	-0.62	-2.24	-0.02	0.03	-0.64	-0.56
Ajimo A1-5	0.89*	0.63*	1.16	0.93	5.19**	0.10	1.34	-1.29	-1.38	0.04	-0.01	-3.51	-0.63
Ajimo A1-6//7029	-1.65***	-0.17	-2.26	-0.12	-2.09	-0.41	-1.98	-0.89	-2.11	0.26***	0.03	-0.65	1.10
EM15-1-5	1.22**	0.29	2.82	2.07	-0.27	-0.30	-0.81	1.84	1.24	0.02	0.00	2.96	-0.32
U1-7	0.63	0.55	0.48	-1.12	-1.08	-0.14	2.08	2.31*	3.96	0.12	0.00	2.22	-0.44
Adong 4-4	-0.18	0.39	-2.84	-1.12	-1.88	-0.28	-4.38*	-1.22	-6.31*	-0.17***	-0.03	-0.11	-1.00
Local 158//6022	-1.96***	-0.43	-3.86	-6.42**	-4.82*	0.35	7.16**	4.59***	14.16***	-0.06	-0.03	0.97	0.90
(Y-1//Local 158) -1-2-1	0.02	-0.83**	0.46	6.15***	4.72*	0.59**	0.08	-2.35**	-3.71	-0.09	0.00	-4.91	-0.44
S.E	0.39	0.29	2.55	1.84	1.85	0.22	2.06	1.12	2.83	0.05	0.02	2.65	1.56
Testers													
Local 158	1.37***	0.43	3.57	6.67***	8.21***	0.31	2.83	-0.78	2.69	-0.01	-0.01	-4.5*	-0.46
SPS1438-1-6-4	-2.97***	-0.57**	-4.13*	-4.88***	-8.08***	-0.53***	-4.79**	-0.27	-7.24***	0.01	-0.02	4.11*	-0.41
4036-1-10-2	1.10***	0.49*	2.94	-1.14	-0.97	-0.05	0.40	1.84*	3.44	0.05	0.02	3.96*	0.92
Renner 1-3-1-1	0.77**	-0.08	-3.87*	-0.17	-0.60	0.22	0.71	-0.34	0.47	-0.11**	-0.01	-3.82	0.04
7029-1-2	-0.12	-0.23	1.90	0.27	2.36	0.08	1.16	-0.53	0.95	0.05	0.03	-0.23	-0.09
S.E	0.29	0.21	1.90	1.37	1.38	0.16	1.53	0.83	2.11	0.03	0.01	1.98	-

Local 158//6022 and U1-7 recorded highly significant and significant positive effect respectively for number of capsules on branches, number of capsules on main stem and total number of capsules per plant indicating that this parent can be used to increase the number of capsules on the branches, number of capsules on the main stem and the overall total number of capsules per plant thus increasing seed yield per plant (Thangavelu and Sridharan (1998).

For capsule length highly positive significant effect was recorded in Ajimo A1-6//7029. The increase in capsule length could possibly result in more seeds per capsule and therefore indirectly would influence seed yield per plant (Uzo *et al*. (1985).

Among the testers (males) which were introduced genotypes, highly significant positive effects were recorded in Local 158, 4036-1-10-2 and Renner 1-3-1-1 for days to flowering suggesting that they possessed genes for late flowering. The highly significant negative effect for flowering was recorded only in SPS1438-1-6-4 suggesting that the genotype possessed genes for early flowering. For days to maturity, only 4036-1-10-2 recorded positive significant effect (P<0.05) while SPS1438-1-6-4 contributed highly negative significant effect for days to maturity. Highly positive significant GCA effect was recorded in Local 158 and highly negative significant effect was recorded in SPS1438-1-6-4 for height of first branch and height of first capsule. SPS1438-1-6-4 would then be a desirable parent as source for reducing height of first branch and height of first capsule on the main stem.

The number of capsules on the main stem, only 4036-1-10-2 had high significant positive effect indicating that this genotype could be used for increasing the number of capsules on the mainstem in the progeny.

SPS1438-1-6-4 and 4036-1-10-2 had high positive significant effect for length of capsule zone and so these genotypes would then be desirable parents or testers for increasing the length of the capsule zone. None of the parents had good GCA for all the traits studied. Similar results were also reported by Vavdiya *et al*. (2014).

The results of combined SCA effects are presented in Table 5. Significant negative effect was recorded in Ajimo A1-6//7029 x local 158 for days to flowering thus reducing time of flowering and positive significant effect in Local158//6022 x SPS1438-1-6-4 thus increasing time for flowering. Significant negative effect (P<0.05) was recorded in U1-7 x Renner 1-3-1-1 for days to maturity thus reducing time for maturity and significant high negative effect (P<0.01) was recorded in EM15-1-5 x Renner 1-3-1-1 for height of first branch thus reducing height to first placement of capsule. Positive significant effect was recorded in Adong 4-4 x Local 158 for height of first capsule. Since climate change is causing erratic drought, negative significant effect by reducing days to flowering and maturity would be desirable but since days to flowering is positively correlated to yield (Okello-Anyanga, 1996), positive significant effect would be desirable. When SCA effects are significant, it indicates that these traits were controlled by dominance genes in these crosses.

Sesim 1 x SPS 1438-1-6-4 had significant positive effect (p<0.05) for plant height. Improvement of F1 in plant height is desirable as it is correlated to yield and yield components (Bakheit and Madhya, 1988; Alvaran., 1993). Local158//6022 x SPS1438-1-6-4 had positive significant (P<0.05) for number of branches per plant. More number of branches produce more capsules that positively correlate to yield (Thangavelu and Sridharan, 1988, Okello-Anyanga, 1996). For number of capsules on branches, U1-7 x 7029-1-2 had high positive significant effect (P<0.01) and positive significant effect (P<0.05) was recorded in Sesim 1 x SPS1438-1-6-4 and Ajimo A1-6//7029 x Renner 1-3-1-1. The number of capsules on main stem showed significant positive effects (P<0.05) in Sesim 1 x SPS1438-1-6-4, EM15-1-5 x Renner 1-3-1-1 while significant (P<0.05) negative effect was recorded in Local158//6022 x SPS1438-1-6-4. Higher number of capsules contributes to improved seed yield. Significant positive effects for capsule length were recorded in Sesim 2 x 7029-1-2, Ajimo A1-6//7029 x Renner 1-3-1-1, U1-7 x SPS1438-1-6-4. Significant positive (P<0.05) effect for length of capsule zone was recorded in Sesim 1 x SPS1438-1-6-4, EM15-1-5 x Renner 1-3-1-1 while negative significant effect (P<0.01) was recorded in Local158//6022 x SPS1438-1-6-4 indicating that the latter is desirable as it starts forming capsules from near the ground and thus more capsules are formed on the main stem.

Ajimo A1-6//7029 x Renner 1-3-1-1 and EM15-1-5 x Renner 1-3-1-1 had positive significant effect for two traits compared to other crosses that had either one or no significant desirable effect for SCA. These two crosses therefore would be desirable for developing hybrid seed since they had more significant SCA effects compared to the other crosses.

Table 5. Estimates of combined SCA effects for yield and yield components at NaSARRI and Ngetta.

	Cross	Days flower	Days maturity	Height 1st branch	Height 1st capsule	Plant height	Branches per plant	Capsules on branches	Capsules on mainstem	Total capsules	Capsule length	Capsule width	Capsule length zone	Yield per plant
1	Sesim 1 x Local 158	0.80	-0.49	1.95	1.11	-5.23	0.43	-6.23	-3.03	-8.10	0.00	-0.03	-5.32	1.10
2	Sesim 1 x SPS1438-1-6-4	-1.20	1.18	-3.83	-0.94	13.17*	0.27	10.39*	5.79*	11.8	0.19	0.05	12.06*	1.15
3	Sesim 1 x 4036-1-10-2	-0.28	-0.88	0.42	-3.05	-4.90	-0.21	-4.14	-2.32	-6.51	0.08	0.04	-4.13	-1.46
4	Sesim 1 x Renner 1-3-1-1	0.40	0.69	0.12	3.58	4.51	-0.15	3.21	3.19	7.8	-0.02	0.00	2.32	0.33
5	Sesim 1 x 7029-1-2	0.29	-0.49	1.34	-0.71	-7.55	-0.34	-3.23	-3.62	-5.02	-0.25*	-0.07	-4.94	-1.12
6	Sesim 2 x Local 158	0.80	0.43	-2.78	-5.56	-0.45	-0.17	-0.46	1.50	1.37	-0.12	-0.04	5.22	-0.39
7	Sesim 2 x SPS1438-1-6-4	-0.86	-0.24	0.77	1.40	6.25	-0.33	-0.70	1.65	1.97	0.10	0.01	5.93	0.12
8	Sesim 2 x 4036-1-10-2	-0.28	-0.30	1.35	3.62	-4.42	0.19	-3.37	-4.79	-10.38	-0.21	-0.03	-9.26	-0.09
9	Sesim 2 x Renner 1-3-1-1	1.40	-0.06	4.05	1.92	-2.31	-0.08	-2.68	-0.61	-3.07	-0.02	0.03	-2.15	0.34
10	Sesim 2 x 7029-1-2	-1.05	0.16	-3.39	-1.38	0.93	0.40	7.21	3.25	10.11	0.25*	0.03	0.26	0.04
11	Ajimo A1-5 x Local 158	0.06	0.91	-1.83	0.38	8.29	0.45	8.44	3.83	8.83	0.09	0.01	7.75	0.80
12	Ajimo A1-5 x SPS1438-1-6-4	-0.60	-0.76	1.97	-0.33	-8.31	-0.50	-5.30	-2.01	-7.24	-0.03	-0.01	-8.54	-0.24
13	Ajimo A1-5 x 4036-1-10-2	-0.34	-0.15	1.64	0.55	1.62	-0.18	-2.14	0.55	0.43	-0.07	-0.05	2.61	0.72

14	Ajimo A1-5 x Renner 1-3-1-1	0.33	0.42	-4.67	1.85	0.43	0.54	4.56	-2.61	0.73	0.09	0.01	-1.28	-0.61
15	Ajimo A1-5 x 7029-1-2	0.55	-0.43	2.89	-2.45	-2.03	-0.31	-5.55	0.25	-2.75	-0.07	0.04	-0.54	-0.66
16	Ajimo A1-6//7029 x Local 158	-3.08**	-0.62	-3.78	-5.36	-3.59	-0.37	-3.24	0.10	-3.77	-0.20	-0.00	0.22	-0.94
17	Ajimo A1-6//7029 x SPS1438-1-6-4	0.61	-0.29	-0.90	-2.73	0.11	-0.20	-0.28	1.69	1.84	-0.32**	-0.06	2.59	0.13
18	Ajimo A1-6//7029 x 4036-1-10-2	1.19	-0.12	3.02	2.15	-4.35	0.32	-1.47	-2.19	-4.18	0.11	0.00	-8.26	-0.87
19	Ajimo A1-6//7029 x Renner 1-3-1-1	0.19	0.22	-0.62	1.79	8.15	0.38	9.22*	1.66	11.46	0.34**	-0.01	5.86	1.56
20	Ajimo A1-6//7029 x 7029-1-2	1.09	0.70	2.28	4.15	-0.31	-0.14	-4.23	-1.15	-5.35	0.07	0.06	-0.41	0.12
21	Adong 4-4 x Local 158	1.46	0.15	0.89	9.78*	4.69	0.49	4.83	-1.90	3.10	0.17	-0.00	-2.32	-0.05
22	Adong 4-4 x SPS1438-1-6-4	-0.20	-0.51	-3.57	-2.26	3.39	-0.33	-2.88	3.25	2.36	0.05	0.08	6.73	0.97
23	Adong 4-4 x 4036-1-10-2	0.73	0.42	3.35	3.95	0.02	-0.15	-2.41	-1.86	-5.64	0.04	0.00	-2.13	-0.61
24	Adong 4-4 x Renner 1-3-1-1	-0.94	0.45	3.72	-6.09	-7.47	-0.42	-3.05	-1.67	-5.67	-0.06	-0.04	-7.02	0.18
25	Adong 4-4 x 7029-1-2	-1.05	-0.52	-4.39	-5.38	-0.63	0.40	3.50	2.18	5.85	-0.19	-0.04	4.73	-0.49
26	U1-7 x Local 158	0.65	-0.00	-2.11	-2.36	-5.03	0.03	3.04	-2.10	0.84	-0.13	-0.00	-1.98	-0.86
27	U1-7 x SPS1438-1-6-4	-1.34	0.33	-0.90	-4.74	5.37	-0.13	-5.68	3.06	0.43	0.29*	0.08	9.73	-1.39

28	U1-7 x 4036-1-10-2	0.29	0.51	1.69	3.15	2.90	0.06	-0.88	0.61	0.42	-0.09	0.00	0.87	-0.31
29	U1-7 x Renner 1-3-1-1	0.59	-1.49*	4.38	3.45	-8.59	-0.22	-8.19	-4.54	-13.93*	-0.16	-0.04	-12.68*	-1.64
30	U1-7 x 7029-1-2	-0.19	0.66	-3.06	0.49	5.35	0.26	11.71**	2.98	12.24	0.08	-0.04	4.06	1.43
31	EM15-1-5 x Local 158	0.73	0.25	8.03*	4.50	-2.67	0.19	-2.41	-1.96	-3.45	0.14	0.06	-0.39	0.16
32	EM15-1-5 x SPS1438-1-6-4	0.07	-0.07	-0.42	-2.54	-10.97	0.03	-1.79	-4.81	-8.52	-0.21	-0.06	-9.01	-1.77
33	EM15-1-5 x 4036-1-10-2	0.33	0.52	-3.90	-2.95	0.96	0.42	6.88	3.06	11.23	0.17	-0.02	1.49	0.76
34	EM15-1-5 x Renner 1-3-1-1	-0.34	0.05	-11.47**	-6.02	5.07	-0.39	3.38	5.26*	9.44	-0.09	0.03	14.25*	1.32
35	EM15-1-5 x 7029-1-2	-0.78	-0.76	7.75	7.02	7.61	-0.25	-6.07	-1.55	-8.70	-0.02	-0.01	1.66	-0.49
36	Local 158//6022 x SPS1438-1-6-4	2.92**	0.30	5.40	7.34	-9.99	1.05*	-2.42	-5.22*	-6.11	-0.07	-0.09*	-16.68**	-1.51
37	Local 158//6022 x 4036-1-10-2	-1.50	-0.42	-3.00	-6.77	1.24	-0.44	6.05	4.00	7.88	-0.14	0.00	8.13	1.09
38	Local 158//6022 x Renner 1-3-1-1	-0.82	0.15	-2.31	-0.80	4.46	-0.05	-1.92	1.52	1.19	0.02	0.06	4.57	-0.04
39	Local 158//6022 x 7029-1-2	-0.60	-0.04	-0.09	0.24	4.29	-0.56	-1.71	-0.30	-2.96	0.19	0.03	3.98	0.46
40	(Y-1//Local 158)-1-2-1 x Local158	-1.41	-0.63	-0.38	-2.49	3.99	-1.04*	-3.96	3.56	1.17	0.05	-0.00	4.82	0.18
41	(Y-1//Local 158)-1-2-1 x SPS1438-1-6-4	0.60	0.05	1.50	4.80	0.99	0.14	8.66	-3.28	3.44	0.00	0.01	-2.80	-0.23

42	(Y-1//Local 158)-1-2-1 x 4036-1-10-2	-0.14	0.32	-4.58	-0.65	6.92	-0.01	1.47	2.94	6.76	0.13	0.04	10.67	0.76
43	(Y-1//Local 158)-1-2-1 x Renner 1-3-1-1	-0.8-	-0.44	6.79	0.32	-4.27	0.38	-4.54	-1.20	-7.94	-0.11	-0.04	-3.88	-1.43
44	(Y-1//Local 158)-1-2-1 x 7029-1-2	-0.14	0.32	-3.33	-1.98	-7.63	0.53	-1.63	-2.02	-3.42	-0.07	-0.01	-8.81	0.73
	SE	0.87	0.64	4.12	4.14	5.69	0.48	4.62	2.50	6.33	0.11	0.04	5.93	1.33

CONCLUSION

Genetic differences occurred between the local lines and the introduced testers in some traits while in some traits, there were no differences. Both additive and dominance gene effects played a role in gene action of the different traits.

Among the lines therefore, Sesim 2, Ajimo A1-5 and EM15-1-5 were late flowering while Ajimo A1-6//7029 and Local 158//6022 were early flowering. (Y-1//Local 158)-1-2-1 was early maturing. For capsule traits, Local 158//6022 was desirable for number of capsules on branches, mainstem and total number of capsules per plant while Ajimo A1-6//7029 had longer capsule length. Among the testers (males), Local 158, 4036-1-10-2 and Renner 1-3-1-1 were late flowering while SPS1438-1-6-4 was early flowering. For capsule traits, 4036-1-10-2 was desirable for number of capsules on main stem while both 4036-1-10-2 and SPS1438-1-6-4 were desirable for increased length of capsule zone.

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