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LINE X TESTER ANALYSIS OF QUANTITATIVE TRAITS FOR SHORT DURATION AND HIGH YIELDING OF *BRASSICA RAPA* IN BANGLADESH

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Abstract

Three lines and nine testers are used for hybridization following Line × Tester mating design to get 27 hybrids. Evaluation of segregating generation was done to study combining ability effect and find out high yielding genotypes. Analysis of variance showed that mean squares due to replications, genotypes, lines, tester and interaction of line and tester were significant for all the studied traits except days to maturity and days to flowering in case of lines. It indicated that a large amount of variation present among the studied materials for these traits. Specific combining ability is considered an important criterion for evaluation of hybrid. From the result, the cross BS-14 × BC-4093 has shown the highest value of SCA in case of yield per plant. On the other hand, the parent BS-14 has the highest GCA effect among three lines in case of yield per plant. Besides, the tester BC-4093 has the highest GCA effect for yield per plant. Other side, considering days to maturity the cross BS-14 × SBC-2193 and the parent BS-17 has been exploited for future breeding by adopting proper strategies for short duration variety development. Besides, considering both traits (short duration and high yielding) the hybrid BS-15 × BS-9 could be selected for future use after large scale evaluation.

Keywords: Line × Tester analysis, Quantitative traits, GCA, SCA, *Brassica rapa.*

Introduction

The oilseed Brassicas rank third in the world in terms of oil output, and conventional and modern plant breeding techniques have led to a constant increase in their yield (Sabaghnia *et al.*, 2010). The quantitative characteristic of rapeseed seed production is mostly impacted by several environmental factors and it often has poor heritability. Any crop species' ability to use genetic variability is thought to be essential for gaining additional genetic improvements in seed production and other economically significant features (Wang *et al*., 2010). Crosses between and within *Brassica* species are useful methods for creating genetic differences and creating new varieties (Amiri *et al*., 2009). Mustard hybrids are developed through crossbreeding within the Brassicaceae family to improve traits such as yield, disease resistance, adaptability, and other desirable characteristics (Singh *et al*., 2022). Hybridization fosters genetic diversity, resulting in plants that are more

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resilient to pests and diseases, better suited to diverse environmental conditions, and exhibit enhanced vigor. A key objective of mustard hybridization is to increase crop yield (Ahmad *et al*., 2024). The general and specific combining ability effects (GCA and SCA) of rapeseed are significant markers of the inbred lines potential in hybrid combinations in the breeding programme for both hybrid and open pollinated varieties. Knowing how to combine genes is useful to learn about parent selection and the nature of the genes' functions, which can help to incorporate desirable traits and maximize economic outputs. Specific information and research on combining ability can be helpful when choosing breeding techniques and lines for hybrid combinations.

Besides, according to Varshney *et al.* (1986), seed yield in rapeseed is a complicated and highly changeable character that is linked to a variety of component characters. One of the main goals of rapeseed breeding is to increase yield. It is now understood that effective breeding techniques are required for yield improvement in order to introduce favorable genes into current commercial cultivars. For selecting suitable parents and crossings for yield and its related components in the breeding plan, combining ability is one of the effective approaches to distinguish between good and poor combiners (Kumar *et al*., 2022). To choose the best parents for hybridization, it is, therefore, necessary to evaluate interesting strains for their combining potential (Chaudhary *et al*., 2019). As a result, this experiment was conducted for the current Line x Tester analysis research. Here, the focus was on creating a short-lived and high-yielding rapeseed variety that will grow between Transplanted *Aman* and *Boro* rice to achieve sustained food security as well as early sowing variety which would be grown in first week of October.

Materials and Methods

Parent materials of the experiment consisted of three lines and nine testers. Here, BS-14, BS-15, and BS-17 were used as lines. Besides, BS-4093, BS-12, BS-9, Din-2, SBC-2193, SBC-6823, SBC-8693, Tori-7 and a wild type were used as testers. All of the lines and testers are short duration varieties and inbred lines, respectively. All the lines and testers were sown and crossed followed by Line × Tester method during *rabi* season 2021-22. Three lines, nine tester and their resultant F_1 crosses (27) were evaluated in a RCB (Randomized complete block) design with three replications during the *rabi* season of 2022-23 at Oilseed Research Centre of Bangladesh Agricultural Research Institute in Gazipur. It is located at a latitude of 23°99′N and a longitude of 90°41′E. Annual precipitation averages around 1,898 and 1,895 mm, indicating a subtropical monsoon climate (Khaldun *et al.*, 2022.). Plot size was 4 rows 3 m long. Row to row distance was 30 cm and plant to plant distance was 5 cm. Fertilizers were applied @ 120: 80: 60: 40: 4: 1 kg/ha of N: P: K: S: Zn and Boron from Urea, TSP, MOP, Gypsum, Zinc sulphate, and Boric acid, respectively (FRG, 2018). Half of the urea and all other fertilizers were applied during final land preparation. The rest of the urea was applied at the flower initiation stage. All intercultural operations were done timely to raise a good crop. Ten plants were chosen randomly from every plot for recording data on days to flowering, days to maturity, plant height (cm), number of branches per plant, number of siliquae per plant and yield per plant (g). For statistical analysis, mean values were used. The line × tester analysis was done followed by Kempthorne (1957).

Results and Discussion

Analysis of variance showed that mean squares due to replications, genotypes, lines, tester and interaction of line and tester were significant for all the studied traits except for days to maturity and days to flowering for lines. It indicated that a large amount of variation is present among the studied materials for these traits (Table 1) (Amiruzaman *et al*., 2008). The mean squares due to lines were of larger magnitude than those of testers for some traits such as the number of branches per plant and yield per plant. On the other hand, the mean squares due to testers were of larger magnitude than those of lines for other traits indicating greater diversity present among the testers. The majority of the studied traits have lower mean squares value of interaction between line and tester than genotypes meaning that greater uniformity or homogeneity is present among the crosses than their parents. The variance component due to lines was higher than testers for the traits number of branches per plant meaning that greater diversity present among this trait. Specific combining ability is considered an important criterion for the evaluation of hybrid (Datta *et al*., 2021). Combining ability is a useful tool for selecting appropriate parental lines for a hybridization programme and for differentiating between good and poor combiners. Additionally, it offers details on particular promising combination to take advantage of heterosis (Kaur *et al*., 2020). From the result we found that, the cross BS-14 × BC-4093 had the highest value (11.08) of SCA followed by BS-15 × BS-9 (9.52) and BS-14 × SBC -6823 (8.38) in case of yield per plant (Table 2). For plant height, the cross BS-15 × SBC-2193 had the highest value (17.40) of SCA followed by BS-17 × Tori-7 (10.68). Besides, the trait number of branches per plant showed the highest value (3.71) from the crosses BS-14 × BS-12 followed by BS-15 × SBC-2193 (2.02). The estimates of the specific combining ability effect for the number of siliquae per plant, the cross BS-14 × SBC-6823 had the highest value (273.84) followed by the cross BS-15 × BS-9 (185.25). In case of days to first flowering, the combination BS-17 × BS-12 showed the highest value (1.81) followed by the cross BS-14 × SBC-6823 (1.54) meaning they need more time to mature than others. The cross BS-14 × Tori-7 had the highest negative value of SCA for days to first flowering. It means the crosses flowered earlier than all others. The maximum (4.07) significant positive SCA effect was found from the combination BS-14 × BS-12 followed by the hybrid BS-

14 × Tori-7 (2.35). The highest negative value (6.19) of SCA was recorded from the combination BS-14 × SBC-2193 followed by BS-14 × Wild for days to maturity meaning that both require less time to mature than others. The mean performance of all crosses for all the studied characters was presented in Table 3. The plant height average value was 97.14 cm and the character number of branches per plant was 7.24 with the average value for number of siliqua per plant was 282.81. The mean value for yield per plant (YPP) was 76.37 g and the average value for days to first flowering of the plant was 35.15 with the days to maturity value was 91.59.

On the other hand, the studied parents with high GCA values (strong GCA effects) could be used to further varietal improvement of the population depending on desirable traits (Datta *et al*., 2021). In case of yield per plant, the parent BS-14 has the highest GCA effect (0.92) and this parent could be used for the development of hybrid. The higher value of SCA and dominance effect indicated that the hybrids may be used for better yield (Ali *et al*., 2014).

Table 1. Mean squares of analysis of variance and components of variance for parents and crosses

SOV	df	PH	NOBP	NOSP	YPP	DF	DM
R	1	46.89**	3.46**	257.85**	2.75**	46.29**	46.30**
G	26	185.88**	6.22**	54165.99**	68.54**	3.12*	13.70**
L	2	160.62**	15.84**	49983.74**	91.21**	3.35 ns	0.68ns
T	8	194.47**	5.77**	74774.09**	83.51**	3.87*	12.50**
L × T	16	184.75**	5.24**	44384.72**	58.22**	2.72*	15.93**
E	26	3.23	0.11**	32.36	0.09	1.25	1.99
σ^2_L		0	0.59	311.05	1.83	0.03	0
σ^2_T		1.62	0.09	5064.89	4.21	0.19	0
$\sigma^2_{L\times T}$		90.75	2.56	22176.17	29.07	0.73	6.97
$h^2_{B\ (\%)}$		99.55	99.52	99.98	99.98	40.68	96.55
$h^2_{N\ (\%)}$		00	10.52	12.01	54	12.26	0

Legend: '**' significant at 1% level and '*' significant at 0.5% level, SOV: Source of variation, df: degrees of freedom, R; Replication, G: Genotypes, L: Line, T: Tester, E: Error, $\sigma^2_{L:}$ Genotypic variance of line, σ^2_T: Genotypic variance of tester, $\sigma^2_{L\times T}$: Genotypic variance of line × tester, h^2_B: Heritability in broad sense, h^2_N: Heritability in narrow sense, PH: Plant height, NOBP: Number of branches per plant, NOSP: number of siliquae per plant, YPP: Yield per plant, DF: Days to first flowering, DM: Days to maturity

Table 2. General combining ability effects (GCA) of parents and specific combining ability (SCA) effects on crosses

LINE and TESTER	PH	NOB	NOSP	YPP	DF	DM
BC-4093	-0.42	-0.42	1.33	1.32	1.06	00
BS-12	0.07	0.07	0.12	0.12	8.32	00
BS-9	-0.26	-0.26	1.11	1.11	-2.53	00
Din-2	0.24	0.24	0.00	0.00	1.70	00
SBC-2193	-1.26	-1.26	-1.31	-1.30	-0.47	00
SBC-6823	0.07	0.07	0.03	0.03	-2.53	00
SBC-8693	-0.76	-0.76	-0.90	-0.90	2.25	00
Tori-7	1.24	1.24	1.32	1.32	4.40	00
Wild	1.07	1.07	-1.71	-1.71	-12.18	00
BS-14	0.20	-0.56	-59.84	0.92	0.02	0.2
BS-15	-0.02	1.08	39.49	-0.3	-0.09	-0.02
BS-17	-0.19	- 0.52	20.35	-0.62	0.06	-0.19
Crosses						
BS-14× BC-4093	-0.29	0.7	-126.36	11.08**	0.54	1.50
BS-14 × BS-12	5.13	3.71	-30.16	2.30	-0.46	4.07**
BS-14 × BS-9	8.31	-0.24	-13.23	-1.49	0.37	1.07
BS-14 × Din-2	2.38	-0.54	-96.56	-5.87	0.37	1.93
BS-14 × SBC-2193	-19.25	-1.54	-27.43	-7.25	0.37	-6.19
BS-14 × SBC -6823	9.61	-1.9	273.84	8.38**	1.54	1.50
BS-14 × SBC -8693	-1.72	-0.4	113.04	3.03	0.37	-0.20
BS-14 × Tori-7	-4.32	-0.24	-114.36	6.1	-2.13	2.35
BS-14 × Wild	0.14	0.45	21.24	-1.66	-0.96	-4.48
BS-15× BC-4093	-1.83	-0.55	26.51	-3.57	-0.85	1.07
BS-15 × BS-12	-4.59	-3.11	-133.49	-2.27	-1.35	-1.91
BS-15 × BS-9	-4.73	-0.28	185.25	9.52**	0.48	0.22
BS-15 × Din-2	-4.46	-0.08	150.51	6.03*	0.48	0.65
BS-15 × SBC-2193	17.4	2.02	44.55	-2.94	-0.02	-0.20
BS-15 × SBC -6823	5.27	1.55	-155.79	-4.08	-0.35	-0.20
BS-15 × SBC -8693	-4.61	0.2	-130.69	-3.14	-0.02	1.93
BS-15 × Tori-7	-6.36	1.12	-23.09	3.93	1.48	1.50
BS-15 × Wild	3.92	-0.86	36.21	-8.23	0.15	-3.20
BS-17× BC-4093	2.12	-0.15	99.85	1.64	0.31	-1.06
BS-17 × BS-12	-0.54	-0.6	163.65	0.84	1.81	-3.20
BS-17 × BS-9	-3.58	0.52	-172.02	-0.34	-0.85	-0.20
BS-17 × Din-2	2.08	0.62	-53.95	-0.13	-0.85	1.08
BS-17 × SBC-2193	1.85	-0.48	-17.12	1.18	-0.35	1.08
BS-17 × SBC -6823	-14.88	0.35	-118.05	-4.06	-1.19	-0.63
BS-17 × SBC -8693	6.33	0.2	17.65	-6.12	-0.35	-1.06
BS-17× Tori-7	10.68	-0.88	137.45	-0.95	0.65	1.08
BS-17 × Wild	-4.06	0.41	-57.45	-1.92	0.81	1.50

Legend: '**' significant at 1% level and '*' significant at 0.5% level, PH: Plant height, NOBP: Number of branches per plant, NOSP: number of siliquae per plant, YPP: Yield per plant, DF: Days to first flowering, DM: Days to maturity

Table 3. Mean performance of the crosses for different studied characters

Crosses	PH	NOBP	NOSP	YPP	DF	DM
BS-14 X BC-4093	13	6.2	91.6	143	34	92
BS-14 X BS-12	118.34	10.67	41	93	34	95
BS-14 X BS-9	11.1	6.6	330.6	80	35	94
BS-14 X Din-2	109.6	6	187.4	50	35	94
BS-14 X SBC-2193	82	4.4	155.2	38	35	84
BS-14 X SBC-6823	110.6	3.2	614.4	123	38	93
BS-14 X SBC-8693	105.5	6.75	318	90	34	90
BS-14 X Tori-7	106.6	8.2	71.2	118	35	95
BS-14 X Wild	92.34	7.34	26.4	65	35	85
BS-15 X SBC-4093	110	7	346	63	34	92
BS-15 X BS-12	100	5	300	62	34	92
BS-15 X BS-9	12.6	8.2	636.2	129	34	92
BS-15 X Din-2	107	8.2	537.6	107	34	92
BS-15 X BC-2193	127.4	10	326.8	54	34	92
BS-15 X SBC-6823	113	8.6	283.8	54	35	93
BS-15 X SBC-8693	109.8	10	177.2	53	35	94
BS-15 X Tori-7	108.6	11.2	263.4	100	38	95
BS-15 X Wild	100	7.5	140	22	35	88
BS-17 X SBC-4093	110.2	5.6	397.4	88	35	90
BS-17 X BS-12	117.4	6.8	318	78	38	88
BS-17 X BS-9	100.6	7.6	242.4	76	35	90
BS-17 X Din-2	112.4	7.4	310.4	72	35	94
BS-17 X BC-2193	108.6	5.8	245.2	70	35	94
BS-17 X SBC-6823	91	6	301	52	35	90
BS-17 X SBC-8693	118	7.8	305.6	38	35	90
BS-17 X Tori-7	124	8	409.2	74	38	94
BS-17 X Wild	103	5.4	260	70	35	91
Mean	97.14	7.24	282.81	76.37	35.15	91.59

Legend: '**' significant at 1% level and '*' significant at 0.5% level, PH: Plant height, NOBP: Number of branches per plant, NOSP: number of siliquae per plant, YPP: Yield per plant, DF: Days to first flowering, DM: Days to maturity

Conclusion

Considering yield potentiality, the cross BS-14 × BC-4093 and the parent BS-14 were selected as the best hybrid and the best parent, respectively. Other side, considering days to maturity the cross BS-14 × SBC-2193 showed the lowest value of SCA among all other crosses and the parent BS-17 has shown the lowest GCA effect among all lines and testers. Besides, considering both traits (short duration and high yielding) the hybrid BS-15 × BS-9 could be selected for future use after a large-scale evaluation.

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