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Study of genetic variability, heritability and genetic advance for yield and its contributing traits in Toria [*Brassica campestris* (L. ssp. Toria)]

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Abstract
The present study was conducted on twenty one F_1 crosses of Toria, developed by crossing 10 parents (7 lines and 3 testers) in line x tester fashion in completely randomized design with three replications at Himgiri Zee University, Dehradun under normal sown condition during *Rabi* 2020-21. The observations were recorded for 14 yield contributing traits. The statistical analysis for genetic variability was done using Windostat 9.2. The analysis of variance revealed significant difference among the crosses for different traits. The results indicated that high heritability values were observed for days to 50% flowering, number of primary branches per plant, number of secondary branches per plant, length of main shoot, siliqua on main shoot, siliqua length, plant height, number of siliqua per plant, number of seeds per siliqua, seed yield per plant, days to maturity and harvest index. High GCV and PCV values were observed for important yield contributing traits like number of primary branches, number of secondary branches, length of main shoot, siliqua on main shoot, number of siliqua per plant, seed yield per plant and harvest index. The results indicated that experimental material taken into consideration had sufficient amount of genetic variability which can be utilized further in crop improvement programme.

Keywords: Variability, GCV, PCV, GA and h^2

Introduction

Toria (*Brassica campestris*) belongs to family *Brassica*ceae which is one of the ten, economically most important plant families (Rich 2011) [19]. In the global context, oilseeds *Brassica* is the third most consumed vegetable oil, after palm and soybean. Jat *et al.* (2022) [25]. In India, oilseeds *Brassica* ranks third in domestic production and consumption after soybean and groundnut and has a contribution of 27% of the total edible oil obtained from various oilseeds. Rapeseed mustard is one of the important *rabi* oilseeds accounting for about one-fourth (24.6%) of the total nine major oilseeds production and 22 percent of the total arable area under oilseed production. The production of rapeseed-mustard in the country was 10.21 million tonnes with an acreage of 6.7 million hectare and productivity of 1524 kg/hectare in 2020-21 (Directorate of Economics & Statistics GOI. 2021).

The genus *Brassica* consist of six economically important cultivated species, of which B. *campestris, B. oleracea, B. nigra*, are elementary and diploid species with 2n=20, 18 and 16 chromosomes and *B. juncea, B. napus and B. carinata* being tetraploids with chromosome number 2n=36, 38 and 34 respectively. (NU 1935). Among these species, *Brassica juncea* (Indian mustard) and *B. campestris* are the two widely grown species in the Indian sub-continent. Toria has high oil content, high seed yield and early maturity of around 100 days as compared to130-150 days in Indian mustard. *B. campestris* synonym *B. rapa* is further classified into three ecotypes, *viz*., toria, brown sarson and yellow sarson. Toria is a short duration crop and finds its fitment under various cropping systems. It is grown as a catch crop in a north Indian states, in between two agricultural seasons of monsoon (*kharif*) and winter (*rabi*). In north eastern parts of India, it is grown as main *rabi* season crop. The crop Toria has potential to elevate farmer's income by increasing cropping intensity. The crop is mainly grown in tropical and subtropical areas and is preferred for its attributes like drought tolerance, quick growing habit and is grown in agro-climatic conditions with stress to rainfall, temperature and soil. Improved cultivars of toria with high yield, high oil content and having desirable oil quality possess a great potential in bringing a revolutionary changing in vegetable oil production and consumption scenario of the country.

Oilseeds play a significant role in the agricultural economy of India. The country being global leading producer, account for nearly 7 percent of world's edible oil production and has a share of 14 percent of acreage. Despite being a leading producer of vegetable oils, the country needs to import to bridge the gap between domestic demand and supplies. India heavily depends on imports to meet its edible oil requirement and is the largest importer of vegetable oils in the world. Out of the total imported edible oils, palm oil accounts to 60% followed by soybean oil (25%) and sunflower (12%). Low and unstable yields of most oilseed crops and uncertainty in return to investment, resulting from prolonged cultivation of oilseeds in rainfed, high risk environment are the main factors in creating a huge demand-supply gap. (Snehi *et al.* 2020) [23]

Genotypic variability describes the differences among the genotypes, within and between the species. Various genetic parameters like analysis of variance, heritability and genetic advance, etc are used for accessing the level of genetic variability available in a genotype. The success of a crop improvement programme depends on the extent and nature of available genetic variability, heritable variation and genetic advance present within the breeding population. Greater the variability, more is the possibility of getting the desired plant genotypes. Selection of genotypes with high yield alone, may not be rewarding since yield is a complex character. Hybridization followed by selection in F_1 and further segregating generations is a common breeding approach in *Brassica* species. The parents having more genetic variability result into higher heterosis in F_1 progenies (Joshi and Dhawan 1966) [11] and further segregating generations. Appropriate selection of the parent is essential to enhance the genetic recombination for potential yield increase. The present study on toria was conducted to assess the genetic variability among the crosses of toria based on yield and yield contributing characters and to find out their suitability for further breeding programmes.

Materials and Methods

The experiment was conducted at Agriculture Research Farm, Himgiri Zee University, Dehradun during *Rabi* 2020-21. The experimental material comprised of 21 F_1's of Toria (*Brassica campestris* L. var. Toria) developed using 10 diversified parents in line x tester mating design. (Table-1) These crosses were planted in 3 replications in randomized block design. Each treatment was sown in plots of 3 rows, each of 3 m length. The row to row distance of 45 cm and plant to plant spacing of 15 cm was maintained by thinning. Recommended package of practice were followed to raise a healthy crop.

The observations was taken on 14 yield contributing traits *viz*. days to 50% flowering, number of primary branches per plant, number of secondary branches per plant, length of main shoot (cm), number of siliqua on main shoot, siliqua length (cm), plant height (cm), number of siliqua per plant, number of seeds per siliqua, 1000 seed weight (g), seed yield per plant (g), days to maturity, harvest index and oil content (%).

The standard statistical analysis was performed for computation of heritability, genotypic and phenotypic coefficient of variation and genetic advance. The analysis of variance for the design of experiment was carried out according to the procedure defined by Panse (1978) [17]. The significance of difference among treatments means were tested by 'F' test. Phenotypic, genotypic and environmental coefficients of variation were calculated according to Burton (1952) [4]. The expected genetic advance under selection for the different characters was estimated as suggested by Allard, (1960) [2]. Genetic advance as percent of mean for each character was estimated as defined by Johnson (1955) [12], Robinson and Comstock, (1949) [20]. Statistical software WINDOSTAT version 9.2 provided by INDOSTAT Services, Hyderabad, India was used for statistical data analysis.

Results and Discussion

Analysis of variance for yield and yield contributing traits

The analysis of variance was carried out for yield and its contributing traits in Randomized Block Design and the results are presented in the Table 2. The mean sum of square of the differences among the treatments was observed highly significant for all the characters understudy which indicated that sufficient genetic variability was present among the crosses for yield and yield contributing traits. The analysis of variance revealed significant difference among the genotypes which was further validated on the basis of genetic and statistical analysis of data. It revealed that mean squares due to crosses were found to be significant for all the characters. The findings of the present study were found similar with findings of Kumar *et al*. (2020) [14], Pandey *et al.* (2020) [16], Aktar *et al.* (2019) [1], and Raliya *et al*. (2018) [18].

The mean performance of 21 F1 crosses has been listed in Table 3. The mean performance of different crosses for seed yield ranged from 7.97 g per plant (Bhawani x Uttara) to 17.32 g per plant (PT-303 x PT-507) with a general mean of 12.77 g per plant. The days to 50% flowering was lowest in the crosses PT-30 x G-14 and SDS-22x PT-507 (31 days) while it was highest in cross PT-30 x Uttara (39 days) with a general mean of 35 days. The mean value of primary branches per plant varied between 5.27 (PT-508 x Uttara) to 8.33 (PT-303 x PT-507) with a general mean of 6.58. The range of mean values for secondary branches per plant was observed between 6.27 in cross PT-508 x Uttara to 9.07 in cross PT-303 x PT-507 with a general mean of 7.38. The range of mean values for the trait length of main shoot ranged from value 42.07 cm to value 71.27 cm in cross Bhawani x Uttara and PT-30 x Uttara respectively with a general mean of 57.36 cm. The mean value of siliqua on main shoot was found between value 8.20 in cross PT-508 x PT-507 to 41.47 in cross SDS-22 x G-14 with a general mean of 24.71. The range of mean values for siliqua length was between value 4.07 cm to 4.38 cm in cross Bhhawani x PT-507 and cross PT-508 x Uttara respectively with a general mean of 4.72. The range of mean values for plant height was found between value 77.53 cm in cross Bhawani x PT-507 to 108.18 cm in cross PT-508 x G-14 with a general mean of 92.64 cm. The range of mean values for siliqua per plant was observd between 155.00 to 405.47 in cross PT-30 x G-14 and Bhawani x G-14 respectively with a general mean of 258.99. The range of mean values for seeds per siliqua was 10.45 to 15.26 in cross Tapeshwari x G-14 and PT-303 x PT-507 respectively with a general mean of 12.75. The mean value of 1000-seed weight was found between value 2.50 g in cross Tapeshwari x Uttara to 3.35 g in cross PHT-1 x Uttara with a general mean of 2.96 g. The mean value of days to maturity was observed between 93 days in crosses PT-303 x PT-507 and Bhawani x G-14 to 99 days in crosse Bhawani x Uttara and Bhawani x PT-507 with a general mean of 96 days. The harvest index was lowest in cross PT-508 x PT-507 (10.70%) while it was highest in cross PHT-1x G-14 (33.84%) with a general mean of 19.37%. The mean value of oil content varied between 39.15% (PHT-1 x G-14) to 44.51% (Bhawani x Uttara) with a general mean of 42.41%. Similar findings were observed by Singh *et al.* (2021) [22], and Roy *et al.* (2011) [21].

Success of any breeding programme depends upon the extent of variability present in the breeding population. The estimation of variability is of utmost importance in a crop for the identification of lines which can generate further variability so that artificial selection of desirable diverse genotypes can be done at a later stage. Selection becomes crucial since some of the very useful variations would go unutilized if not identified by the breeder during selection process.

Heritability, GCV, PCV and GA

The coefficient of variation at genotypic (GCV), phenotypic (PCV) level and genetic advance are presented in Table 4. Deshmukh *et al.* (1986) [6] classified PCV and GCV values as low (0-10%), moderate (10-20%) and high (20% and above) values. According to this classification, high GCV and PCV values were observed for the characters *viz*., number of siliqua on main shoot, number of siliqua per plant, seed yield per plant and harvest index whereas moderate GCV and PCV values were exhibited by the characters *viz*., number of primary branches per plant, number of secondary branches per plant, and length of main shoot and low for the characters *viz*., days to 5% flowering, siliqua length, days to maturity, and oil content. The GCV values for plant height, number of seed per siliqua, and 1000-seed weight were observed low whereas moderate PCV values were observed for these characters. The values of PCV for all the traits were higher than GCV values.

Robinson *et al.* (1949) [20] classified heritability values as high (>60%), moderate (30-60%) and values less than 30% low. Accordingly, the results of the present study indicated that high heritability values were observed in the characters *viz*., days to 50% flowering, number of primary branches per plant, number of secondary branches per plant, length of main shoot, siliqua on main shoot, siliqua length, plant height, number of siliqua per plant, seed yield per plant, days to maturity, and harvest index whereas low heritability were observed in number of seed per siliqua, 1000-seed weigh, and oil content. None of the character exhibited moderate heritability. High heritability values for these traits indicated that the variation observed was mainly under genetic control and was less influenced by the environment and the possibility of progress from selection.

Falconer and Mackay (1996) [7] classified genetic advance as percent of mean as low (0-10%), moderate (10-20%) and high (20% and above). Genetic advance as percent of mean (at 5% and 1%) were observed high for the characters *viz*., number of primary branches per plant, number of secondary branches per plant, length of main shoot, number of siliqua per plant, seed yield per plant, and harvest index whereas moderate values for genetic advance as per cent of mean were exhibited by days to 50% flowering and siliqua length but the characters 1000-seed weight, days to maturity, and oil content exhibited low values of genetic advance as per cent of mean. Heritability and genetic advance are important selection parameters. The estimate of genetic advance is more useful as a selection tool when coupled with heritability estimates **(**Johnson *et al*., 1955) [12]. In present study, high heritability coupled with high genetic advance were observed in number of primary branches per plant, number of secondary branches per plant, length of main shoot, siliqua on main receme, number of siliqua per plant, seed yield per plant and harvest index. The estimates of genetic advance help in understanding the type of gene action involved in the expression of various quantitative characters. High values of genetic advance are indicative of additive gene action whereas low values are indicative of non-additive gene action. The findings of present study on genetic variability parameters were observed similar with the findings of Bahadur *et al*. (2021) [3], Snehi *et al*. (2020) [23]. Chaurasiya *et al.* (2019) [5], Kayacetin *et al.* (2019) [13], Hassan *et al.* (2014) [26] and Yadava *et al.* (2011) [24].

The analysis of variance revealed significant difference among the genotypes which validated further on the basis of genetic and statistical analysis of the data. It revealed that mean squares due to treatments were found to be significant for all the characters. The wide range of mean performance was observed in different F1 crosses for different traits. The range of heritability, GCV, PCV and genetic advance as percent of mean was observed from low to high in different yield and yield contributing parameters. The traits which had desired value of genetic variability parameters and mean performance can be utilized in crop improvement programme. This study generally indicated that there was significant genetic variability among the F_1 crosses studied. Thus, there is an opportunity of direct selection of superior crosses for different yield contributing and yield contributing traits in crop improvement programme.

Table 1: List of 21 F_1 crosses obtained from mating of 7 lines and 3 testers of Toria. (*Brassica campestris*)

Lines (Female)	Testers (Male)		
	G-14	**PT-507**	**Uttara**
SDS-22	SDS-22 x G-14	SDS-22 x PT-507	SDS-22 x Uttara
PT-303	PT-303 x G-14	PT-303 x PT-507	PT-303 x Uttara
Tapeswari	Tapeswari x G-14	Tapeswari x PT-507	Tapeswari x Uttara
PT-508	PT-508 x G-14	PT-508 x PT-507	PT-508 x Uttara
PT-30	PT-30 x G-14	PT-30 x PT-507	PT-30 x Uttara
Bhawan	Bhawani x G-14	Bhawani x PT-507	Bhawani x Uttara
PHT-1	PHT-1 x G-14	PHT-1 x PT-507	PHT-1 x Uttara

Table 2: Analysis of variance for simple RBD with respect to different characters for F_1 's of Toria (*Brassica campestris*).

Sources of Variation	DF	Mean square						
		Days to 50% flowering	No. of primary branches per plant	No. of secondary branches per plant	Length of main shoot (cm)	No. of siliqua on main shoot	Siliqua length (cm)	Plant height (cm)
Replication	2	1.58	0.03	0.17	10.58	8.84	0.01	10.08
Treatment	30	19.57**	2.29**	1.92**	186.73**	198.94**	0.33**	221.31**
Error	60	1.98	0.07	0.12	9.35	14.11	0.05	21.74
C.D. 5%		2.30	0.43	0.57	4.99	6.14	0.39	7.61
C.D. 1%		3.06	0.53	0.76	6.64	8.16	0.52	10.13
C.V.		4.08	4.10	4.91	5.51	16.54	5.13	5.04
S. E.		0.81	0.15	0.21	1.77	2.17	0.14	2.69

* Significant at 5% level of probability, ** Significant at 1% level of probability

Sources of Variation	DF	Mean square						
		No. of siliqua per plant	No. of seeds per siliqua	1000 seed weight (g)	Seed yield per plant (g)	Days to maturity	Harvest Index	Oil content (%)
Replication	2	870.03	0.12	0.01	24.89	2.69	64.41	8.97
Treatment	30	11795.83**	5.52**	0.17**	26.71**	10.74**	99.96**	6.06**
Error	60	1306.12	2.61	0.08	1.19	1.76	5.72	2.74
C.D. 5%		59.02	2.63	0.45	1.78	2.17	3.90	2.70
C.D. 1%		78.50	3.51	0.60	2.36	2.88	5.19	3.59
C.V.		14.20	12.54	9.51	8.69	1.38	12.93	3.90
S. E.		20.86	0.93	0.16	0.63	0.77	1.38	0.95

* Significant at 5% level of probability, ** Significant at 1% level of probability

Table 3: Mean performance of yield and its contributing traits in 21 F_1 crosses of Toria (*Brassica campestris*)

S. No.	F_1 Cross	Days to 50% Flowering	No. of primary branches per plant	No. of secondary branches per plant	Length of main shoot (cm)	No. of siliqua on main shoot	Siliqua length (cm)	Plant Height (cm)	No. of Siliqua per plant	No. of Seeds per Siliqua	1000 seed weight (g)	Seed yield per plant (g)	Days to maturity	Harvest Index	Oil content (%)
1	SDS-22 x Uttara	34	6.27	7.13	63.40	31.66	4.92	93.27	255.87	14.11	3.05	16.42	95	28.30	43.67
2	SDS-22 x PT-507	31	7.13	7.87	55.73	32.60	4.72	98.67	208.93	13.07	3.27	9.60	97	12.76	41.55
3	SDS-22 x G-14	34	6.27	7.27	61.40	41.47	4.20	93.33	278.40	12.31	2.70	14.42	97	19.19	42.49
4	PT-303 x Uttara	32	7.53	8.00	48.87	20.32	4.76	88.60	264.07	14.72	3.15	13.76	95	16.86	43.01
5	PT-303 x PT-507	38	8.33	9.07	58.13	18.27	5.10	95.47	355.49	15.26	2.94	17.32	93	29.88	40.12
6	PT-303 x G-14	38	6.60	7.47	64.87	30.80	5.22	98.50	271.13	14.07	3.04	16.96	96	25.53	41.48
7	Tapeswari x Uttara	32	5.60	6.47	47.27	21.54	4.29	86.30	283.73	10.63	2.50	12.77	94	24.07	44.08
8	Tapeswari x PT-507	36	6.53	7.47	54.93	18.87	5.34	88.33	234.87	12.23	3.14	10.77	99	13.33	42.60
9	Tapeswari x G-14	37	6.67	7.40	54.27	23.00	5.01	87.23	229.73	10.45	2.84	11.79	98	17.10	44.28
10	PT-508 x Uttara	36	5.27	6.27	63.03	19.60	4.38	96.07	190.27	15.12	2.74	13.49	94	19.59	39.92
11	PT-508 x PT-507	35	5.60	6.33	49.87	8.20	4.91	90.40	204.60	10.63	2.84	9.32	97	10.70	39.68
12	PT-508 x G-14	32	7.47	8.33	62.67	23.00	4.82	108.18	327.00	12.02	2.55	12.60	97	12.43	41.66
13	PT-30 x Uttara	39	6.53	7.07	71.27	34.80	5.38	99.00	205.93	12.09	3.24	10.36	97	14.52	42.15
14	PT-30 x PT-507	38	8.20	8.87	68.54	39.80	4.40	104.80	307.53	14.27	2.66	14.24	97	25.19	43.15
15	PT-30 x G-14	31	5.87	6.87	62.40	30.20	4.72	95.27	155.00	11.25	3.23	13.25	99	15.60	43.25
16	Bhawani x Uttara	36	6.47	7.13	42.07	15.00	4.25	79.27	198.07	11.77	3.24	7.97	99	16.93	44.51
17	Bhawani x PT-507	34	5.67	6.53	48.60	18.50	4.07	77.53	188.13	11.28	3.11	7.09	99	14.41	43.02
18	Bhawani x G-14	34	7.60	8.40	58.03	25.40	5.14	97.00	405.47	14.49	2.82	15.76	93	22.48	43.75
19	PHT-1 x Uttara	36	6.13	6.87	61.07	14.60	4.50	89.40	253.67	11.90	3.35	12.40	97	15.63	43.67
20	PHT-1 x PT-507	36	6.60	7.60	59.93	24.00	4.61	101.10	336.33	13.76	3.14	15.79	95	18.56	43.47
21	PHT-1 x G-14	32	6.00	6.73	48.40	27.31	4.51	77.89	284.57	12.38	2.61	12.12	96	33.84	39.15
Mean		34.52	6.39	7.22	55.46	22.71	4.71	92.58	254.36	12.88	2.93	12.54	96.09	18.50	42.37
C.V.		4.08	4.10	4.91	5.51	16.55	5.13	5.04	14.21	12.54	9.51	8.69	1.38	12.93	3.91
S.E.		0.81	0.15	0.20	1.77	2.17	0.14	2.69	20.87	0.93	0.16	0.63	0.77	1.38	0.96
C.D. 5%		2.30	0.43	0.58	4.99	6.14	0.39	7.62	59.03	2.64	0.45	1.78	2.17	3.91	2.70
C.D. 1%		3.06	0.57	0.77	6.64	8.16	0.53	10.13	78.50	3.51	0.61	2.37	2.88	5.20	3.59
Min		30.00	5.07	5.93	38.40	8.20	4.07	76.33	116.73	10.45	2.50	6.88	93.00	10.67	39.15
Max		39.00	8.33	9.07	71.27	41.47	5.38	108.67	405.47	15.26	3.35	17.32	99.00	33.84	44.51

Table 4: Genetic variability parameters for different yield and its contributing traits in F_1 crosses of Toria. (*Brassica campestris*)

Parameters	Days to 50% Flowering	No. of primary branches per plant	No. of secondary branches per plant	Length of main shoot (cm)	No. of siliqua on main shoot	Siliqua length (cm)	Plant Height (cm)	No. of siliqua per plant	No. of seeds per siliqua	1000 seed weight (g)	Seed yield per plant (g)	Days to maturity	Harvest Index	Oil content (%)
GCV	7.01	13.48	10.70	13.86	34.56	6.44	8.81	23.24	7.64	5.91	23.27	1.80	30.30	2.48
PCV	8.11	14.09	11.77	14.92	38.32	8.23	10.14	27.24	14.69	11.20	24.84	2.27	32.95	4.63
h^2 (Broad Sense)	0.74	0.91	0.82	0.86	0.81	0.61	0.75	0.72	0.27	0.27	0.88	0.62	0.84	0.28
h^2 (Broad Sense) %	74	91	82	86	81	61	75	72	27	27	88	62	84	28
Genetic Advancement 5%	4.30	1.70	1.44	14.71	14.58	0.48	14.58	103.93	1.06	0.18	5.63	2.82	10.62	1.16
Genetic Advancement 1%	5.53	2.18	1.85	18.86	18.69	0.63	18.69	133.20	1.35	0.24	7.21	3.62	13.61	1.49
Gen.Adv as % of Mean 5%	12.50	26.56	20.04	26.53	64.22	10.38	15.75	40.86	8.19	6.42	44.90	2.94	57.41	2.75
Gen.Adv as % of Mean 1%	16.01	34.04	25.68	34.01	82.30	13.30	20.19	52.36	10.50	8.24	57.55	3.77	73.58	3.52

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