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INHERITANCE OF SOME QUANTITATIVE CHARACTERS IN *BRASSICA CAMPESTRIS* L.

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Abstract

The data collected for four quantitative characters have been analysed by biometrical techniques. Estimates of K1 indicated the presence of 1-2 effective factors, whereas those of K2 suggested the presence of 4-14 effective factors operating for the characters studied. Presence of overdominance and complete dominance was observed in heading-to-ripening and sowing-to-heading period respectively, whereas in the remaining characters no dominance was noted. Transgressive segregation was indicated in both directions for all the characters.

Introduction

A study of the inheritance of quantitative characters in mustard is of considerable interest with respect to breeding for commercial varieties, as most of the economic characters of the crop are quantitative in nature. Previous work was mostly concerned with the studies of qualitative characters except a few cases where quantitative characters were investigated using F_2 and backcross data. No publication is known, where data from F_2, F_3 and other progenies have been used to study the inheritance of quantitative characters of the crop. The present investigation was, therefore, undertaken to study the inheritance of some quantitative characters in *Brassica campestris* L. using the data of F_2 and F_3 progenies.

Materials and Methods

The following two varieties of *Brassica campestris* L. were chosen for the present study as they show well marked difference in various quantitative characters.

(a) Toria-7—Seed red, short sowing-to-heading and long heading-to-ripening period with short plant height at both heading and ripening time.

(b) Toria-TP - Seed white, long sowing-to-heading and short heading-to-ripening period with tall plant height at both heading and ripening time.

Crosses were made between the two varieties using Toria-TP as female parent. The F_2 and parental plants were grown. F_2 and fresh F_1 seeds were collected. Seeds of F_2 generation along with those of F_1 and parents were sown in three replications during 1967-68 winter. One replication comprised 16 rows (each

600 cm long) in a block of 450 cm × 600 cm size. Passage between blocks were 90 cm wide as was the border all round the field. Space between rows as well as between plants were 30 cm. The border rows on two sides of a block were sown with parental seeds and were treated as non-experimental, while of the remaining 14 rows, seeds of each of P_1, P_2 and F_1 were sown in two rows and F_2 seeds were sown in 8 rows. Two plants on two ends of each of these rows were treated as non-experimental. Thus there were 38 experimental plants for each of P_1, P_2 and F_1 progenies and 152 plants for F_2 generation in each block. Data were collected on an individual plant basis. Fresh crosses were made and F_1 and F_3 seeds were collected.

Two parents, F_1 and 150 F_3 lines selected at random from previous year's F_2 population were grown in three replications during 1968-69 winter. Five rows from each of parental and of F_1 progenies and one row for each of 150 F_3 lines were randomly assigned in each replication. Row size, space between plants and between rows and passage between blocks and round the field were the same as are stated above. Plants grown on border rows on two sides of each block and one plant from either end of all other rows were treated as non-experimental. Thus there were in each replication, 95 experimental plants for each of P_1, P_2 and F_1 progenies and 19 plants for each of 150 F_3 families for experimental purpose.

Data collected on individual plant basis for four quantitative characters, namely, date of heading, date of ripening, plant heights at heading and at ripening time were analysed following biometrical techniques of Mather (1949) and Mather and Vines (1952).

Experimental Results

The environmental variances ($\hat{E}_1$, $\hat{E}_2$ and $\hat{E}_3$) and the observed variances of F_2 and F_3 were calculated. These variances along with their expected values and the differences between the expected and the observed values are shown in Table 1. The mean of the variances of P_1, P_2 and F_1 grown with F_3 populations during 1968-69, provided the value for $\hat{E}_3$, while the mean of the variances of P_1, P_2 and F_1 grown with F_2 population in the previous year gave the value for $\hat{E}_1$. $\hat{E}_3$ divided by the harmonic mean number of plants per F_3 family provided the value for $\hat{E}_2$. The analysis was conducted by the inclusive-exclusive least square methods outlined by Mather (1949) and Mather and Vines (1952). In the inclusive analysis $\hat{D}$, $\hat{H}$, $\hat{E}_1$, $\hat{E}_2$ and $\hat{E}_3$ were estimated utilizing all seven equations, whereas in the exclusive analysis, estimation of $\hat{D}$, $\hat{H}$, $\hat{E}_1$ and $\hat{E}_2$ were made excluding $\bar{V}_{F3}$ and V_{E3}. The results are shown in Table 2.

Table 1 : *Observed and expected values for F_2 and F_3 statistics*

Statistics		Sowing-to-heading		Heading-to-ripening		Plant height at heading		Plant height at ripening	
		Inclusive	Exclusive	Inclusive	Exclusive	Inclusive	Exclusive	Inclusive	Exclusive
	Observed	41.5900	41.5900	58.8400	58.8400	72.6341	72.6341	113.9444	113.9444
$VF_2=\frac{1}{2}\hat{D}+\frac{1}{4}\hat{H}+\hat{E}_1$	Expected	39.6918	41.1624	57.2963	60.5485	73.3618	73.7216	112.2153	116.1936
	Deviation	1.8982	0.4276	1.5437	1.7085	0.7277	1.0875	1.7291	2.2492
	Observed	28.3000	28.3000	30.9704	30.9704	85.6369	85.6369	132.1168	132.1168
$V\bar{F}_3=\frac{1}{2}\hat{D}+1/16\hat{H}+\hat{E}_2$	Expected	27.7793	27.4355	32.9566	32.4237	93.0034	91.9062	137.5450	136.6118
	Deviation	0.5207	0.8645	1.9862	1.4533	7.3665	6.2693	5.4282	4.4950
	Observed	28.3798	28.3798	41.0306	41.0306	85.5954	85.5954	134.8758	134.8758
$W\bar{F}_3/F_2=\frac{1}{2}\hat{D}+1/8\hat{H}$	Expected	29.1522	29.6718	38.0416	38.8307	82.5348	82.3348	126.7280	128.1312
	Deviation	0.7724	1.2920	2.9890	2.1999	3.0606	3.2606	8 1478	6.7446
	Observed	15.7904		18.1824		35.9319		39.1470	
$\bar{V}F_3=\frac{1}{4}\hat{D}+1/8\hat{H}+\hat{E}_3$	Expected	19.0610		23.2212		37.8229		48.0150	
	Deviation	3.2706		5.0388		1.8910		8.8680	
	Observed	4.6701	4.6700	11.3166	11.3166	7.5184	7 5184	15.9004	15.9004
$V\hat{E}_1$	Expected	6.5628	5.0999	12.8363	10.5897	7.2691	6.4332	17.6210	13.6550
	Deviation	1.8928	0.4299	1.5197	0.7269	0.2493	1.0852	1.7260	2.2454
	Observed	0.0964	0.0964	0.1163	0.1163	0.1256	0.1256	0.1814	0.1814
$V\hat{E}_2$	Expected	0.6155	0.9590	−1.8758	−1.3430	2.2476	2.0482	−5.2499	−4.3157
	Deviation	0.5191	0.5191	1.7595	1.0067	2.1220	1.9226	5.0685	4.1343
	Observed	5.7700		6.0516		6.9202		9.6001	
$V\hat{E}_3$	Expected	2.4965		0.9912		5.0265		0.7179	
	Deviation	3.2735		5.0604		1.8937		8.8822	

Table 2 : *Values for* $\hat{D}$, $\hat{H}$, $\hat{E}_1$, $\hat{E}_2$, $\hat{E}_3$, $(\hat{H}/\hat{D})^{\frac{1}{2}}$, K_1, K_2 *and* $(K_2\hat{D})^{\frac{1}{2}}$

	Sowing-to-heading		Heading-to-ripening		Plant height at heading		Plant height at ripening	
	Inclusive	Exclusive	Inclusive	Exclusive	Inclusive	Exclusive	Inclusive	Exclusive
$\hat{D}$	50.3509 ± 12.1802	46.5624 ± 5.5265	63.2464 ± 18.9091	57.4205 ± 10.9613	196.9536 ± 17.1667	194.7622 ± 19.4582	317.7622 ± 37.7103	307.4475 ± 39.6874
$\hat{H}$	31.8145 ± 37.3029	51.1254 ± 17.6848	51.3473 ± 57.9102	81.0244 ± 35.0766	−131.5367 ± 59.5910	−120.3711 ± 54.9336	−257.0696 ± 115.4918	−204.7405 ± 100.0616
$\hat{E}_1$	6.5628 ± 3.5874	5.0999 ± 1.6579	12.8363 ± 5.5793	10.5897 ± 3.2885	7.2691 ± 5.7306	6.4332 ± 5.1501	17.6210 ± 11.1068	13.6500 ± 9.3809
$\hat{E}_2$	0.6155 ± 3.4161	0.9590 ± 1.6944	−1.8758 ± 5.3031	−1.3430 ± 3.0019	2.2476 ± 5.4573	2.0482 ± 4.7014	−5.2499 ± 10.5766	−4.3157 ± 8.3387
$\hat{E}_3$	2.4965 ± 2.9653		0.9912 ± 4.6034	.	5.0265 ± 4.7370		0.7179 9.1797	
$(\hat{H}/\hat{D})^{\frac{1}{2}}$	....	1.0478	....	1.1878	....	....	....	....
K_1	1.5317	1.6563	0.4594	0.5061	0.5921	0.6021	0.9210	0.9921
K_2	4.7565	5.6361	3.4070	4.1314	5.4502	5.7356	11.7439	13.8286
$(K_2\hat{D})^{\frac{1}{2}}$	15.4756	16.1998	14.6793	15.4022	32.7634	33.4237	61.0845	65.2041

The estimates of $\hat{D}$ was significant in all the characters without any significant change when estimated under exclusive analysis. The estimates of $\hat{H}$ were negative but significant for the character plant height both at heading and ripening time under both inclusive and exclusive analysis. The H values for the characters, sowing-to-heading and heading-to-ripening periods were, however, positive and significant when analysis was made excluding V_{F_3} statistics.

Dominance was absent in all the characters but under exclusive analysis complete and overdominance were indicated in sowing-to-heading and heading-to-ripening period respectively.

The number of effective factors were calculated in two different ways and two kinds of information as to the number of effective factors were obtained. When the number of effective factors was estimated by dividing the square of half of the parental difference with $\hat{D}$, it was designated as K_1. On the other hand, it was termed as K_2, when it was determined by the formula, $H\bar{V}_{F_3}/(V_{V_{F_3}}-C)$, where $H\bar{V}_{F_3}$ is the heritable mean variance of F_3 families, $V_{V_{F_3}}$ is the variance of variances of F_3 families, and C is the correction factor for $V_{V_{F_3}}$ (obtained by dividing $2V^2\bar{F}_3$ by harmonic mean number of plants per F_3 family). The values obtained for K_1 and K_2 are shown in Table 2. The estimates K_1 indicated presence of 1-2 effective factors, whereas K_2 estimates suggested presence of 4-14 effective factors conditioning different characters investigated.

The effect of linkage was then tested. Since the test of linkage is a test of homogeneity of $\hat{D}$ and $\hat{H}$ over F_2 and F_3 least square estimates of $\hat{D}$, $\hat{H}$, $\hat{E}_1$ and $\hat{E}_2$ were determined with $\bar{V}_{F_3}$ and V_{E_3} excluded, taking into consideration the perfect fit of $\hat{D}$ and $\hat{H}$ for V_{F_2} and V_{F_3}. The comparison of mean square for linkage with the residual mean square indicated that linkage did not cause any statistically significant reduction in the sum of squares of deviations (Table 3).

Table 3 : *Test for linkage*

	Item	S.S.	D.F.	M.S.	t
Sowing-to-heading	Linkage	26.8342	1	26.8342	3.0411
	Residual	2.9015	1	2.9015	(not sig.)
Heading-to-ripening	Linkage	60.2502	1	60.2502	2.2974
	Residual	11.4144	1	11.4144	(not sig.)
Plant height at heading	Linkage	19.8942	1	19.8942	0.5961
	Residual	55.9923	1	55.9923	(not sig.)
Plant height at ripening	Linkage	192.1390	1	192.1390	1.4382
	Residual	92.8878	1	92.8878	(not sig.)

Discussion

Dominance and additivity played an important role in the inheritance of sowing-to-heading and heading-to-ripening period, whereas only additivity was identified to play significant role in the remaining two characters. That additivity is involved in the inheritance of sowing-to-heading period in *Brassica campestris* was previously reported (Joarder and Eunus 1970). Significant negative H value was estimated for plant height at heading and at ripening time may be due to genotype environmental interaction (Hill 1966)

Information derived from $(K_2\hat{D})^{\frac{1}{2}}$ for possible selective advance indicated that transgressive segregation on either direction is expected in all the characters. Similar expectation of transgressive segregation was reported by Joarder and Eunus (1970) in the segregating progenies.

Comparative study of the estimates of K_1 and K_2 as to the number of effective factors conditioning the characters under investigation provides information regarding the sequence of arrangement of genes with plus and minus effects within the two parents. In case plus and minus genes are not isodirectionally distributed within parents, K_1 is underestimated, while K_2 value remains unaffected (Mather 1949, Cooke and Mather 1962). The estimates of K_2 being always more than those of K_1 in all the characters indicated that at least some genes were non-isodirectionally distributed in the parents. Joarder and Eunus (1970) reported only one gene group (K_1) in the same crop and thought that low estimation of K_1 was due to non-isodirectional distribution of polygenes. K_2 estimates indicated the presence of 4-14 effective factors to control the characters studied. The presence of 3-19 and 1-6 effective factors were reported to condition the plant height and earliness respectively in *Brassica juncea* (Joarder and Eunus 1968).

Dominance relationship as measured by $(\hat{H}/\hat{D})^{\frac{1}{2}}$ shows overdominance and complete dominance in the characters heading-to-ripening and sowing-to-heading period respectively and no dominance was observed in the remaining two characters. Overdominance was not expressed in F_1 and F_2 data. This was probably due to the fact that $\hat{H}$ value were derived from sum of squares of plus and minus h values, while under direct observation of F_1 and F_2 plants, only average effects were expressed after some of the plus and minus values had cancelled each other (Eunus 1964, Joarder and Eunus 1969). Indication of non-isodirectional distribution of genes with plus and minus effects as stated above gives support to this inference. No dominance and partial dominance were reported respectively in the cross Toria-7 × Toria-BP and Toria-7 × Toria-TP by Joarder and Eunus (1970) for sowing-to-heading period.

Test of linkage could not detect its presence in any of the characters studied. From this, however, it cannot be said that there was no linkage, as the test fails to detect the presence of either weak or very strong linkage (Mather 1949. Eunus 1964).

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