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CHARACTER ASSOCIATION IN SOME SELF-COMPATIBLE FORMS OF *BRASSICA CAMPESTRIS* VAR. BROWN *SARSON*

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The effect of natural and human selection for yield components and other factors influencing the fitness of a population is known to change the inter-relationship between characters related to those subjected to selection. Since a majority of these characters are polygenically inherited, a change in the gene frequencies controlling these characters could automatically result in a change of the first or second degree statistical parameters or both, of the populations. If there are any unfavourable relationships between the desired attributes under selection, genetic slippage could occur limiting genetic advance (Dickerson, 1955). Moreover, a change in the breeding system alone could substantially alter the genetic architecture of the resulting population. Such a change in the genetic structure could result in various degrees of divergence when human selection is superimposed on the altered breeding system. A study of these changes in the inter-relationships between the factors influencing yield in brown *sarson* was undertaken to examine the causes of the limited distribution of self-compatible forms and to compare the character association with those reported in self-incompatible types of brown *sarson* and self-compatible types of yellow *sarson* so as to understand the effect of a change in breeding system on characters influencing yield.

Materials and Methods

The material for this study consisted of 40 self-compatible forms of brown *sarson* cultivated in the Indo-Gangetic belt, studied over two seasons in a split-plot design with spacings as main treatment. The plot size was single row 10′ long with 18″ spacing between rows and 4″ or 6″ within rows.

Observations on six characters related to yield, namely, days to first flower, number of primary branches, number of fruit-bearing secondary branches, height at maturity, number of siliquae on main axis, and number of seeds per siliqua were taken on a random sample of 10 plants per plot.

Results

The correlation matrices for the phenotypic, genotypic, and error components between the six characters as well as the pooled genetic correlation matrix are presented in Table 1. The ANOVA for both the years revealed that the phenotypic, genotypic, and error variation was minimum for primary branches and maximum for height.

Table 1a. *Phenotypic total correlation matrix between six yield contributing characters in brown* sarson

A	B	C	D	E	F
—	0·0955	–0·1330	–0·0220	–0·0053	0·0016
0·2133	—	0·6730†	0·4244†	0·3018	0·2235
–0·1488	0·5744†	—	0·0378	0·1501	0·2330
0·5544†	0·4133†	0·0643	—	0·5928†	0·3690*
0·2986	0·2692	0·0577	0·7925†	—	0·2931
0·1304	0·1438	0·2924	0·1699	0·0053	—

Table 1b. *Genotypic total correlation matrix between six yield contributing characters in brown* sarson

A	B	C	D	E	F
—	0·2522	1·3200†	0·9380†	0·7838†	0·5937†
0·4899†	—	0·9581†	0·1722	–0·0386	0·1022
–0·1311	0·4719†	—	0·4132†	0·2851	–0·1947
0·1523	0·5204†	–0·0176	—	0·7909†	0·6287†
0·4350	0·3067	0·0062	0·8515†	—	0·2859
0·3732*	0·1279	0·3343*	0·2788	–0·0951	—

Table 1c. *Error total correlation matrix between six yield contributing characters in brown* sarson

A	B	C	D	E	F
—	–0·1329	–0·8580†	–0·3388†	–0·1782	–0·3038
–0·0289	—	0·6106†	0·4785†	0·3814*	0·2794
–0·1662	0·6549†	—	0·4983†	0·0986	0·5526†
0·2896	0·3868*	0·1575	—	0·5455†	0·3732*
0·1204	0·2371	0·3990*	0·6536†	—	0·1855
0·1035	0·1545	0·2822	–0·0058	0·1246	—

In a, b, and c : Above the diagonal—1962-63
Below the diagonal—1963-64
†Significant at 1 per cent. level.
*Significant at 5 per cent. level.

TABLE 1d. *Pooled genetic total correlation matrix between six yield contributing characters in brown* sarson

A	B	C	D	E	F
—	0·45	1·84	0·62	0·54	0·46
	—	0·55	0·51	0·28	0·12
		—	0·14	0·06	0·05
			—	0·85	0·32
				—	–0·04
					—

In Tables 1a-1d: A=Days to flower; B=No. of primary branches; C=No. of secondary branches; D=Height (cm.); E=No. of siliquae on main axis; and F=No. of seeds per siliqua

Positive and highly significant correlations at the phenotypic level were observed between number of primary branches and secondary branches, and height and number of siliquae on main axis in both the seasons. The correlation between flowering time and primary branches was low in both the seasons indicating very limited association between them. Similar was the case between days to flower and height, and days to flower and siliquae on main axis in 1962-63.

The genotypic correlations were larger in magnitude than the corresponding phenotypic correlations in ten cases out of fifteen in 1962-63 and in nine cases in 1963-64 indicating the existence of a strong positive inherent relationship between the characters, namely, flowering time and primary branches, flowering time and siliquae on main axis, flowering time and seeds per siliqua, height and siliquae on main axis and height and seeds per siliqua. The correlation between flowering time and secondary branches was abnormal in 1962-63, because of a high positive genetic covariance and high negative error covariance. However, in 1963-64 the corresponding genetic correlation was low and negative.

DISCUSSION

The present study revealed considerable genetic variability for each of the characters influencing fitness. A comparison of the coefficients of variability for each of the characters revealed that all the characters were more variable than primary branches and in some cases, flowering time.

Considerable influence of environment, as revealed by the proportion of environmental variance to phenotypic variability, was found in days to flower, primary branches, height, and siliquae on main axis and to some extent secondary branches in both the years. Such a situation would automatically result in limited genetic advance for these characters. The estimates of heritability, reported by Reddy (1961), 85·76, 41·30, 67·16, 40·73, and 29·05 respectively were probably gross over-estimates except that of secondary branches, since his data were based on one year only. It could also be argued that self-compatible forms could not be compared to self-incompatible forms. If that argument is valid, the self-compatible types should show a higher heritability, which was not borne out by the data. Such a high environmental variability would limit response to selection, since inter-environmental genetic slippage would be considerable between generations (Dickerson, 1955).

In this study (*see* Table 1), the number of primary branches was found to be highly and positively correlated with secondary branches and height, and positively correlated with flowering time, siliqua number, and number of seeds per siliqua in both the seasons. Since the extent of variation for primary branching was limited (3·4–8·0 as compared to 7 to 14 primary branches in self-incompatible types), the extent of correlated response possible under selection for primary branches would be limited as compared to self-incompatible types.

The number of secondary branches had little association with days to first flower from sowing. Similarly, there was negligible association of secondary branches with height, number of siliquae on main axis, and number of seeds per siliqua. However, the significant association in other types of *sarson*, particularly for secondary branching and flowering time indicates need for caution in selection.

The correlation between the number of seeds per siliqua and other characters was found to be positive and non-significant in both the years, except with height in 1962-63. Therefore, the supposed association of seed number with maturity is not confirmed. The extent of variability for other characters would permit the isolation of different plant types with high seed number. The relation of seeds per siliqua with seed-size is worth investigating. Thus, yield in self-compatible types can be improved by changes in many facets which were hitherto considered not possible.

The considerable variation in the genetic correlation between flowering time, height, primary branches and secondary branches with other characters might lead to possible changes in the relative magnitude of the components of genetic variation over seasons, as was observed by Nei and Syakudo (1957) in rice. This was expected since adverse cold weather and frost could delay the flowering in *sarson* upto a fortnight. Primary branching and secondary branching are also equally susceptible to changes in environment. The absence of stability of genetic correlation between some characters in two seasons would necessitate preservation of residual genetic variability for these characters within the populations.

The general assumption regarding high correlation between height and flowering time was not borne out by the phenotypic correlations in both the years. However, the genotypic correlations revealed the positive association between them which was also varying with the seasons. Such changes in the association could be due to the closing or opening of some metabolic pathways depending on the environments.

An examination of the reported correlation between some characters in self-incompatible brown *sarson* (Reddy, 1961) and yellow *sarson* (Ramanujam and Rai, 1963) with those observed in the self-compatible types in this study is interesting (Table 2).

TABLE 2

Comparison of correlation between some characters in self-incompatible brown and yellow sarson *with self-compatible brown* sarson

Correlation between	Phenotypic correlation			Genetic correlation		
	Brown sarson		Yellow sarson	Brown sarson		Yellow sarson
	SC	SI	SC	SC	SI	SC
B×C	0·5744†	0·5590†	0·5973†	0·4719†	0·5880†	0·5627†
B×D	0·4133†	0·3640†	—	0·5204†	0·3490†	—
B×F	0·1438	0·0390	0·0742	0·1279	0·0010	0·0357
C×D	0·0643	-0·0420	—	-0·0176	-0·1110	—
C×F	0·2924	-0·2910*	-0·3907†	0·3343*	0·1910	-0·3096†
D×F	0·1699	-0·0380	—	0·2788	-0·0440	—

B = No. of primary branches
C = No. of secondary branches
D = Height (cm.)
F = No. of seeds per siliqua
SC = Self-compatible
SI = Self-incompatible
* = Significant at 5% level
† = Significant at 1% level

The phenotypic correlations in self-incompatible brown *sarson* and self-compatible brown *sarson* were similar for primary branches × secondary branches, height × seeds per siliqua, secondary branches × height, and height × seeds per siliqua. However, there was considerable difference in respect of secondary branches × seed per siliqua; this was similar in magnitude in both the types but opposite in direction. In self-compatible types, association between height and number of siliquae on main axis, and number of siliquae on main axis and seeds per siliqua were negligible. Thus, improvement in yield by simultaneously increasing capsules on main axis and seeds per siliqua could be possible in self-compatible types.

The relative magnitudes of genetic correlations in self-compatible and self-incompatible brown *sarson* revealed a parallel situation to the differences in corresponding phenotypic correlations in five out of the possible six cases. The association between secondary branches and seeds per siliqua was positive in both the types with a change in the sign for self-incompatible types as compared to its phenotypic correlation. Thus, the differences in associatoin at phenotypic level were more due to inter-environmental correlation than due to differences in genetic association.

The over-all picture of genotypic and phenotypic correlation indicated that a substantial change had taken place in the genetic architecture of the self-compatible types as compared to the self-incompatible types. However, the inter-relationship between primary branches, secondary branches and height were parallel although not identical in both the breeding systems.

A comparative study of the relationship between the self-compatible brown *sarson* and yellow *sarson* would be worthwhile to see if the self-compatibility observed in the latter was associated with a similar constellation of characters. The differences in the phenotypic and genetic correlation in self-compatible brown *sarson* and yellow *sarson* were similar to those observed between self-compatible and self-incompatible types for all the three comparable associations, namely, primary branches × secondary branches, primary branches × seeds per siliquae, and secondary branches × seed per siliqua. Out of the three, only the first association was similar in both self-compatible brown *sarson* and yellow *sarson.*

In spite of the self-compatibility in both self-compatible brown *sarson* and yellow *sarson*, the associations between the characters studied were quite different. Therefore, a change in the breeding structure of the population alone might not be responsible for the differences between yellow *sarson* and self-compatible brown *sarson* while it might be true for the differences between self-compatible and self-incompatible brown *sarson.* Natural selection and differences in initial composition of the population from which self-compatible brown *sarson* and yellow *sarson* might have arisen could be responsible for the observed differences in the character association. Yellow *sarson* has been subjected to similar natural and human selection for adaptation to the agro-climatic conditions in the same areas as self-incompatible brown *sarson.* Moreover, yellow *sarson* is grown either in a pure or mixed crop, as compared to self-compatible brown *sarson*, which is invariably grown as a mixed crop. Therefore, under selection in different environments and more so under human cultivation, differences between self-compatible brown *sarson* and yellow *sarson* are to be expected as observed. If the hypothesis by Rajan (1958) that self-compatibility in yellow *sarson* is of a primary nature is correct, the secondary type of self-compatibility arising from a pre-existing self-incompatibility of brown *sarson* could be another cause for differences in the genetic architecture and consequently character association between self-compatible brown *sarson* and yellow *sarson.*

In addition to out-crossing in self-compatible population, there is yet another mechanism by which variability is maintained even in inbreeders. Manning (1955) observed a significant amount of heterozygosity even after seven generations of selfing in cotton. Selection advantage of certain heterozygotes for some loci and amphidiploidy and interaction of non-allelic genes could be responsible for a similar situation in self-compatible brown *sarson* as well. It is also possible that heterozygosity would be important and, therefore, necessary in maintaining gene combinations together, particularly of those that are linked or physiologically related. Inversions and other recombination-suppressor mechanisms suggested by Rajan (1958) could maintain co-adapted gene complexes developed over long periods of selection.

Although the investigation has brought to light the nature of divergence, the factors influencing this divergence and the consequences of a change in the breeding system, substantial information is yet to be obtained on some more aspects such as changes in the first and second degree statistics of these characters under diverse environments and the causes for the varying degree of self-incompatibility in this crop.

SUMMARY

A collection of 40 self-compatible types of *Brassica campestris* var. brown *sarson* cultivated in the Indo-Gangetic belt, was studied over two seasons for six characters related to fitness; their associations were found out and compared with the reported phenotypic and genetic associations in self-incompatible brown *sarson* and yellow *sarson.*

Positive and significant phenotypic correlations were observed between primary branches and each of the other characters studied except days to flower. The relative magnitudes of phenotypic correlations and genotypic correlations indicated the existence of strong inherent relationship between a majority of these characters. The large environmental correlations for secondary branches with primary branches, height with primary branches, and siliquae on main axis with height were found to be possible causes for limiting the simultaneous improvement of these characters.

The persistence of considerable variability in the self-compatible types could be related with the changing agro-ecological conditions under which they are grown, entomophilous nature of the crop and the strong genetic associations between some of the characters.

The behaviour of self-incompatible brown *sarson* and self-compatible yellow *sarson* are compared with that of self-compatible brown *sarson.*

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