Arunachalam, V. and Amirthadevarathinam, A.
An Analysis of Character Association in Three Varietal Forms of Brassica Campestris L.
Genetica Agraria, 31 (1977): 171-180.

V. ARUNACHALAM and A. AMIRTHADEVARATHINAM

DIVISION OF GENETICS, INDIAN AGRICULTURAL RESEARCH INSTITUTE,
NEW DELHI 110012, INDIA

An analysisi of character association in three varietal forms of *Brassica campestris* L.

Estratto da « *Genetica Agraria* »
Vol. XXXI - Fasc. 1-2: pag. 171-180
1977

TIPOGRAFIA POPOLARE - PAVIA

Genet. Agr. 31: 171-180 (1977)

AN ANALYSIS OF CHARACTER ASSOCIATION IN THREE VARIETAL FORMS OF *BRASSICA CAMPESTRIS* L.

V. ARUNACHALAM and A. AMIRTHADEVARATHINAM
Division of Genetics, Indian Agricultural Research Institute, New Delhi 110012, India

Received: Sept. 9, 1976

INTRODUCTION

Rapeseed (*Brassica campestris* L.) is an important edible oil crop and includes in it three morphologically different varieties, brown sarson (BS), yellow sarson (YS) and toria (TR) with distinct genetic differences in flowering time, plant height, number of secondary branches and seeds per siliqua mainly caused by different pollinating systems and by variable degrees of self-incompatibility present in the varieties (SINGH, 1958; AMIRTHADEVARATHINAM *et al.*, 1976). Dhile YS and TR belong to strictly self-compatible and self-incompatible groups respectively, BS includes in it self-compatible, intermediate and self-incompatible forms. Seed yield in each of these varieties were reported to be associated with certain characters like total number of siliquae, number of primary branches, seeds per siliqua and seed weight (REDDI, 1961; RAMANUJAM *and* RAI, 1963; MAINI *et al.*, 1964; ZUBERI and AHMED, 1973; SRIVASTAVA and DAS, 1973).

Varying levels of association were reported among quantitative components of yield in the three forms, BS, YS and TR and they did not also show any stable pattern. Further, these associations were based on studies on one of these forms taken any one at a time. Since there appeared to be no apparent cryptic structural differences involved in the maintenance of these forms in nature (AMIRTHADEVARATHINAM *et al.*, 1976), it would be worthwhile to assess the differences, if any, in the nature and magnitude of association of the component characters with yield from a single experiment involving all the three forms, BS, YS and TR. The results of such a study are reported for the first time in this paper.

MATERIAL AND METHODS

33 entries, 11 each from BS, YS and TR possessing a wide range of variability for major characters related to yield, were raised in a completely randomised block design during the winter of 1971 at Indian Agricultural Research Institute, New Delhi. Each entry was grown in plots of 3 rows, each 3m long with a spacing of 75 cm between and 10 cm within rows. Observations on days to 50% flowering (X1), weight of seeds in a uniform volume of 100 cc (X2) and seed yield (X10) were recorded on plot basis. In addition, measurements on 5 random plants from each plot were taken on plant height (X3), length of main axis (X4), number of primary branches (X5), number of secondary branches (X6), number of siliquae on the main axis (X7), length of siliqua (X8) and number of seeds per siliqua (X9) at the time of harvest. Length of siliqua was based on measurements exclusive of the beak on 5 siliquae taken from each of those random plants. Seeds were counted on the same siliquae. Phenotypic correlation coefficients and their path coefficients (DEWEY and LU, 1959) were computed for each of the three forms.

RESULTS

Correlation: Positive and significant total correlation was observed between yield and seed weight in BS and YS. Yield was also found to be directly correlated with number of secondary branches which was by itself negatively correlated with flowering time in BS; on the other hand, yield was positively and significantly associated with flowering time in YS while no significant association between yield and any of its components was observed in TR.

TABLE 1.

Inter-correlations among yield and nine of its major components in B. campestris.

		X1	X2	X3	X4	X5	X6	X7	X8	X9
	BS	0.15	0.66*	—0.28	—0.18	—0.11	0.71	—0.42	0.18	0.28
X10	YS	0.64*	0.88*	0.22	—0.25	0.13	—0.16	0.29	0.25	0.35
	TR	0.37	—0.23	—0.18	0.07	—0.11	—0.16	—0.02	0.03	—0.02
	BS		—0.38	0.45	0.21	0.05	—0.66*	0.15	0.10	—0.09
X1	YS		0.47	0.35	0.19	0.26	—0.10	0.01	0.50	0.01
	TR		0.06	—0.50	—0.40	0.10	—0.39	—0.54	—0.08	0.01
	BS			—0.46	0.68*	0.10	0.59	0.27	—0.01	0.11
X2	YS			0.31	—0.07	0.05	—0.13	0.35	0.13	0.11
	TR			0.01	—0.30	0.01	—0.28	—0.32	—0.19	—0.09
	BS				0.77*	0.51	—0.44	0.82*	—0.30	—0.06
X3	YS				0.74*	0.67*	0.16	0.74*	0.36	0.22
	TR				0.16	0.60	0.81*	0.54	0.30	—0.05
	BS					0.79*	—0.15	0.79*	—0.45	—0.09
X4	YS					0.59	0.20	0.68*	0.06	0.10
	TR					0.28	0.06	0.49	0.02	0.02
	BS						0.11	0.66*	0.04	0.46
X5	YS						—0.03	0.82	0.30	0.48
	TR						0.70*	0.03	0.31	0.09
	BS							0.25	0.20	0.35
X6	YS							—0.01	—0.03	—0.01
	TR							0.68*	0.17	—0.01
	BS								—0.29	—0.08
X7	YS								0.35	0.42
	TR								—0.13	0.04
	BS									0.65*
X8	YS									0.24
	TR									—0.01

* Significant at 5% level.

TABLE 2.

Path coefficients of the inter-correlations among yield and its components in *B. campestris*.

		X1	X2	X3	X4	X5	X6	X7	X8	X9	r
X1	BS	*0.52*	—0.12	—1.35	—0.26	—0.01	1.17	0.47	—0.12	—0.15	0.15
	YS	*—0.32*	0.65	—0.05	0.06	0.20	0.01	—0.02	0.01	0.10	0.64*
	TR	*—0.26*	0.01	0.12	—0.26	—0.08	—0.41	0.50	—0.01	0.01	—0.37
X2	BS	—0.20	*0.31*	1.38	—0.82	—0.01	—1.06	0.86	0.01	0.19	0.66*
	YS	—0.15	*1.41*	—0.08	—0.02	0.04	0.01	—0.39	0.04	0.02	0.88*
	TR	—0.02	*—0.02*	—0.02	—0.19	0.03	—0.29	0.30	—0.01	—0.01	—0.23
X3	BS	0.23	—0.15	*—3.01*	—0.93	—0.07	0.79	2.60	0.36	—0.10	—0.28
	YS	—0.13	0.44	*—0.24*	0.24	0.57	0.01	—0.84	0.12	0.05	0.22
	TR	0.13	0.01	*—0.27*	0.10	—0.49	0.85	—0.53	0.01	0.01	—0.18*
X4	BS	0.11	0.21	—2.32	*—1.21*	—0.11	0.27	2.51	0.52	—0.16	—0.18
	YS	—0.06	—0.10	—0.18	*0.33*	0.48	0.01	—0.77	0.02	0.02	—0.25
	TR	0.10	0.01	—0.06	*0.64*	—0.24	0.06	—0.46	0.01	0.01	0.07
X5	BS	0.03	0.03	—1.55	—0.95	*—0.14*	—0.19	1.91	—0.05	0.80	—0.11
	YS	—0.08	0.07	—0.16	0.19	*0.84*	0.01	—0.93	0.09	0.10	0.13
	TR	—0.03	0.01	—0.15	0.18	*—0.82*	0.72	—0.03	0.01	0.01	—0.11
X6	BS	—0.34	0.18	1.33	0.18	—0.01	*—1.78*	0.78	—0.23	0.60	0.71
	YS	0.03	—0.18	—0.04	0.06	—0.02	*—0.02*	0.01	—0.01	0.01	—0.16
	TR	0.10	0.01	—0.23	0.04	—0.57	*1.04*	—0.57	0.01	0.01	—0.16
X7	BS	0.08	0.08	—2.47	—0.96	—0.08	—0.44	*3.17*	0.34	—0.14	—0.42
	YS	0.01	0.49	—0.20	0.22	0.69	0.01	*—1.13*	0.11	0.09	0.29
	TR	0.14	0.01	—0.14	0.31	—0.05	0.63	*—0.94*	0.01	0.01	—0.02
X8	BS	0.05	0.01	0.92	0.54	—0.02	—0.35	—1.16	*—0.93*	1.12	0.18
	YS	—0.10	0.18	—0.09	0.02	0.25	0.01	0.32	*—0.39*	0.05	0.25
	TR	0.02	0.01	—0.08	0.01	—0.28	0.18	0.03	*0.13*	0.01	0.03
X9	BS	—0.05	0.03	0.18	0.11	—0.06	—0.63	—0.26	—0.76	*1.72*	0.28
	YS	0.01	0.16	—0.08	0.03	0.41	0.01	—0.47	0.08	*0.20*	0.35
	TR	0.01	0.01	0.01	0.01	—0.07	—0.02	—0.05	0.01	*0.07*	—0.02

Residual path: BS: negligible; YS: Medium; TR: High.

Quantities in italics represent direct effects;
* Significant at 5% per cent level; r = Correlation coefficient with yield.

Among the other major yield components, seed weight was found to be positively associated with length of main axis in BS. Plant height showed significant and positive association with length of main axis in BS and YS, with number of primary branches in YS (the association being moderately high and positive in BS and TR also), number of secondary branches in TR and number of siliquae on the main axis in BS and YS. Length of main axis was found to be significantly associated with number of primary branches in BS and number of siliquae on the main axis in BS and YS. Number of primary branches was correlated with number of secondary branches in TR and with number of siliquae on the main axis in BS and YS. Number of secondary branches was also found to be associated with number of siliquae on the main axis in TR and length of siliqua had shown positive and significant association with number of seeds per siliqua in BS. It would be evident from the above, that the relationships between the components varied with the varieties.

Path Analysis: An analysis of the path coefficients showed that the characters — number of seeds per siliqua in BS, YS and TR in addition to days to flowering, seed weight and number of siliquae on the main axis in BS- seed weight, length of main axis and number of primary branches in YS- and length of main axis, number of secondary branches and length of siliqua in TR exerted direct influence in general, on the association of component characters with yield. However, not all direct effects could bring about positive and significant association with yield. While the positive direct effect of seed weight resulted in such association in BS and YS, that of flowering time could only result in positive but non-significant association in BS. On the other hand, negative direct effect of flowering time could not effect any certain change in the positive and significant association with yield in YS or the non-significant association in TR; neither its negative indirect effects could influence the positive and significant association of seed weight with yield in BS and YS, or that of secondary branches with yield in BS.

The indirect effect of number of siliquae on the main axis was pronounced in the association of seed weight with yield in all the three forms BS, YS and TR, in addition to those of flowering time and of number of secondary branches. Flowering time- number of primary and secondary branches, seed weight and number of seeds per siliqua- plant height and length of siliqua- and length of main axis were the four component combinations which exerted indirect influences in that order on the associations with yield.

DISCUSSION

This study does not support the commonly held belief that number of secondary branches is highly correlated with yield and hence breeders should lay emphasis on improving this character among all the yield components to enrich yield. However, conflicting reports are available regarding the relationships of yield with number of primary and secondary branches. For example, a negative correlation between yield and number of primary branches and between primary branches and secondary branches was noted by NATHAWAT *et al.,* 1969 and significant and high positive correlation was found between yield and number of secondary branches as well as plant height by REDDI (1961) in BS. These observed associations did not appear to be influenced by the degree of self-incompatibility in BS (RAJAN, 1970).

From our study and from the available reports on correlations, it would be difficult to postulate any fixed correlations in the desirable or undesirable directions for the yield components in any of the three varieties considered. Despite this, a qualified statement to the effect that number of pods, seeds per pod and seed weight would influence yield (OLSSON, 1960) could be made. It would therefore be difficult to expect simultaneous improvement in yield when selection was made for a few yield components in *Brassica campestris* group. It would be imperative, therefore, to study the character association more carefully in intra- and inter-varietal crosses over selected environments and to devise suitable breeding procedures to break the undesirable associations. It may not be out of place to mention in this regard that disruptive selection for flowering time alone could bring about a high correlated response in all the yield components in BS (MURTY *et al.*, 1972).

The path analysis showed again that the direct role of secondary branches on yield was not crucial thereby stressing the need to analyse the main role of secondary branches in addition to its interacting role with number of primary branches, siliquae per plant and seeds per siliqua in yield improvement. The negative direct effects of plant height on yield in BS, YS and TR would relegate it to a lower order of merit in breeding. However, plant height was observed to exert large direct and indirect effects in rice (SIVASUBRAMANIAM and MADHAVA MENON, 1973) and ragi (MAHUDESWARAN and MURUGESAN, 1973). Among characters influencing indirectly the associations with yield, flowering time was important as was also observed in rice (CHANG and TAGUMPAY, 1970) and in red gram (VEERASAMY *et al.*, 1975).

Further, no distinct patterns of association could be observed in the three forms to clearly delineate them with respect to a set of major components of yield. A study on 150 inter-varietal crosses among BS, YS and TR (AMRITHADEVARATHINAM *et al.*, 1976) confirmed the possibility that differentiation among the three forms in nature was weak and long history of human selection for a set of yield components including flowering time, maturity and plant height, aided by the variable degree of self-incompatibility could explain the existing morphological differences in BS, YS and TR. The possibility of bringing a constellation of genes influencing yield to coherent action by inter-crossing BS, YS and TR should therefore be given its due merit by plant breeders.

The observation by OLSSON (1960) that increase in oil content was possible without decrease in seed yield, as supported by evidence in white mustard, should be examined and given its due importance in view of reports to the contrary (RAMANUJAM and SUSHIL KUMAR, 1963 in Vetiver and JOSHI, 1965 in Coriander). While seed weight was negatively correlated with oil content, seed yield was observed to be considerably influenced by number of pods, seeds per pod and seed weight. Hence the association of oil content with those yield components should be studied in detail, to explore the possibility of improving oil content and seed yield simultaneously by turning these associations to advantage. The amount of success one would achieve in this direction cannot be predicted however, since epistatic gene action is usually found associated with oil content and yield (HANSON and WEBER, 1962).

ACKNOWLEDGEMENT

The authors wish to thank Dr. B. R. Murty, Indian Agricultural Research Institute, New Delhi for initiating this study.

REFERENCES

Amirthadevarathinam A., Arunachalam V. and Murty B. R., 1976 - A quantitative evaluation of inter-varietal hybrids of *Brassica campestris* L. *Theor. Appl. Genet.*, *48*: 1-8.

Chang T. T. and Tagumpay O., 1970 - Genetic association between agronomic traits in a cross between rice varieties of contrasting plant types. *Euphytica, 19*: 356-363.

Dewey D. R. and Lu K. H., 1959 - A correlation and path coefficient analysis of components of crested wheat grass population. *Agron. J.*, *15*: 515-518.

Hanson W. D. and Weber C. R., 1962 - Analysis of genetic variability from generation of plant progeny lines in soybeans. *Crop. Sci.*, *2*: 63-67.

Joshi B. S., 1965 - Analysis of factors affecting yield and their significance for the improvement of *Coriandrum sativum* L. Ph. D. Thesis, Indian Agricultural Research Institute, New Delhi.

Mahudeswaran and Murugesan M., 1975 - Correlation and path analysis in *Eleusine coracana* Gaertn. *Madras Agric.*, *60*: 1287-1291.

Maini N. S., Dhillon B. S. and Bhander D. S., 1964 - Breeding potentialities of the genetic stock of toria (*Brassica campestris*). *Indian Oilseeds J.*, *8*: 62-67.

Murty B. R., Arunachalam V., Doloi P. C. and Ram J., 1972 - Effects of disruptive selection for flowering time in *Brassica campestris* var. brown sarson. *Heredity*, *28*: 287-295.

Nathawat K. S., Joshi P., Bagrecha L. R. and Bhargava P. D., 1969 - Influence of soil drought on the relation between yield and yield components in *Brassica campestris* L. var. sarson. *Indian J. Agric. Sci.*, *39*: 397-399.

Olsson G., 1960 - Some relations between number of seeds per pod, seed size and oil content and the effects of selection for these characters in *Brassica* and *Sinapis*. *Hereditas*, *46*: 29-70.

Ramanujam S. and Sushil Kumar, 1963 - Correlation studies in two populations of *Vetiveria*. *Indian J. Genet.*, *23*: 82-89.

Ramanujam S. and Rai B., 1963 - Analysis of yield components in *Brassica campestris* var. yellow sarson. *Indian J. Genet.*, *23*: 312-319.

Rajan S. S., 1970 - The relationships between the mating systems and genetic correlation among yield determining characters in *Brassica campestris* L. International Conf. on oil rape, Paris. Plant Breeding Abstracts 3241.

Reddi G. P., 1961 - Studies on variability and the inter-relationships of yield determining characters in *Brassica campestris* var. brown sarson. Assoc. I.A.R.I. Thesis, New Delhi.

Singh D., 1958 - Improvement of rape and mustard. In Rape and Mustard, I.C.O.C., Hyderabad, India.

Sivasubramaniam and Madhava Menon P., 1973 - Path analysis of yield components in rice. *Madras Agric. J.*, *60*: 1217-1221.

Srivastava L. S. and Das K., 1973 - Genetic parameters, correlation coefficients and discriminant function in *Brassica campestris* L. var. sarson Prain. *Indian J. Agric. Sci.*, *43*: 312-315.

VEERASWAMY R., RATHINASWAMY R. and MURUGESAN M., 1975 - Path analysis in red gram (*Cayanus cajan* L.). *Madras Agric. J.*, *62*: 166-168.

ZUBERI M. I. and AHMED S. V., 1973 - Genetic study of yield and some of its components in *Brassica campestris* L. var. toria. *Crop Sci.*, *13*: 13-15.

SUMMARY

In a study of three varieties — brown sarson (BS), yellow sarson (YS) and toria (TR) — of *Brassica campestris* L., it was found that seed yield was significantly and positively associated with seed weight per unit volume and number of secondary branches in BS, and with seed weight and days to 50% flowering in YS. Path analysis showed that number of seeds per siliqua made substantial positive and direct contribution to the total correlation with seed yield in all the three varieties, in addition to days to 50% flowering, seed weight and number of siliquae on the main axis in BS, seeds weight, length of main axis and number of primary branches in YS, and length of main axis and number of secondary branches in TR. The inter-relationships were variable and could not support the view that strong differentiation had occurred among BS, YS and TR in nature. An earlier study of 150 inter-crosses among the three varietal forms tended to confirm that they differed mainly due to long and intense human selection for flowering time, maturity and height, aided by the varying degrees of self-incompatibility found in them. The implications of this study in breeding for seed yield and oil content are discussed.

RIASSUNTO

Analisi dell'associazione dei caratteri in tre tipi di Brassica campestris L.

In uno studio su tre varietà di *Brassica campestris* L. (BS), (YS) e (TR) è stato trovato che la produzione di seme era significativamente e positivamente correlata con il peso dei semi per unità di volume e il numero di rami secondari in BS, e con peso dei semi e numero di giorni corrispondenti al 50% di fioritura in YS. L'analisi dei path coefficients mostrava che il numero di semi per baccello fornisce un contributo sostanziale, positivo e diretto alla correlazione totale con la produzione di seme in tutte e tre le varietà, in aggiunta al numero di giorni corrispondenti al 50% di fioritura, al peso dei semi e al numero di baccelli sull'asse principale in BS; al peso dei semi, alla lunghezza dell'asse principale e al numero di rami primari in YS; e alla lunghezza dell'asse principale e al numero di rami secondari in TR. Le relazioni reciproche erano variabili e potrebbero non essere in accordo con la tesi che in natura forti differenziazioni esistevano

tra il tipo BS, il YS e il TR. Uno studio più recente su 150 incroci tra i tre tipi varietali tendeva a confermare che essi differiscono soprattutto a cause della lunga ed intensa opera di selezione, operata per la data di fioritura, di maturazione e per l'altezza, favorita dal variare del grado di autoincompatibilità trovato in questi tre tipi di *Brassica campestris*.

Vengono discusse le conseguenze che questa ricerca può avere per il miglioramento della produzione in seme e del contenuto in olio.