Arunachalam, V., Chakrabarty, S. K.
and Vijayakumar, C.H. M.
Genetic Differentiation of Growth Parameters in
Brassica Species.
Journal of Oilseeds Research, 20 (2003):
109-112.

Oilseeds Res., 20 (1): 109-112 (2003)

Genetic differentiation of growth parameters in Brassica species

S.K. Chakrabarty[1] V. Arunachalam and C.H.M. Vijayakumar

Division of Genetics, Indian Agricultural Research Institute, New Delhi – 110 012

Received: July, 1998; Revised: December, 2002; Accepted: February, 2003

Abstract

Fourteen collections from the *Brassica* species, *B.Juncea*, *B. napus, B. carinata* and *B. campestris* showed substantial variability for growth parameters including vegetative (VPD) and reproductive phase (RPD) duration. In general, seed yield in all maturity groups was associated with growth parameters, particularly, VPD, RPD and flowering phase duration, for example, high yielders in the early maturity group and 60-75 days of VPD and 38-40 days of RPD. In contrast, those in the late maturity group had more than 100 days of VPD and relatively short, but varying RPD of 25-50 days. In the medium maturity group, high yields were often found to be associated with relatively long RPD. The yields of *B. napus* and *B. carinata* could be improved by shortening total crop duration and increasing RPD. Selection for optimal vegetative phase durations in the progeny of inter-specific hybrids could further improve the yields In *Brassica*.

Key words: Vegetative and reproductive phase duration, *Brassica*

Introduction

Developing pure lines from interspecific crosses is gaining importance in breeding for improved yields in Brassica. The species that are in common use are *B. juncea. B. napus. B. carinata* and *B. campestris*:. While *B. napus*: and *B, carinata* are relatively new, the other two species have long been cultivated in India. The amphidiploid *B. juncea*. ranks over the diploid, *B. campestris* in yield (Rai, 1989).Therefore, most of the B. campestris tract is now grown to *B. juncea*.

Interspecific hybridization is a common breeding technique to improve yields and based mostly on phenotypic divergence between parents. Concerted efforts are needed to understand major physiological differences between species vis-a-vis their realized yields in India. Such studies would identify novel criteria of selection of desired intra- and inter-specific variability. Potential biological efficiency (Tollenaar, 1983) is reportedly associated with increased absorption of incidental radiation and consequent Increase in photosynthate availability (Crosbie, 1982). Further, optimal partitioning of photo-assimilates has been a known requisite behind improved yields in crops. In a way, it is reflected in various traits in the vegetative and reproductive stages of plant growth.

Unlike cereals, *Brassica* plants, despite being morphologically determinate, lack a distinct demarcation of vegetative and reproductive phases making it difficult to evaluate their role in yield differences between and within species. We attempted therefore a study of those growth phases in various species of *Brassica* in relation to their yield variation.

Materials and methods

Fourteen high yielding collections viz., TN 3, YN 3, RNBL- 68 and Jap-nig of *B. juncea* (jn); ISN 706, 80 54, G 1286 and G 1237 of *B. napus* (np);p BCR 171 and *Carinata* 4B of B. cannata (cr) and Pusa Kalyani, KN 792, EC 223406 and EC 223048 of *B. campestris* (cm) were chosen for the study.

The others were collected from various sources and selected for phenotypic uniformity. The experiment was laid in a randomized block design with three replications at the Indian Agricultural Research Institute, New Delhi. Seeds were sown in plots of two rows of 5 m length with a spacing of 45 cm between rows and 15 cm between plants after thinning. Five plants were labeled at the seedling stage to record data. Days to first flowering (DFF), days to green pod stage (GPS, the stage when the pods became dark green and started constricting showing developing seeds inside) to be denoted as vegetative phase duration (VPO), days to last flowering (DLF) and days to maturity (DM) reckoned from the date of sowing are recorded for each labeled plant.

[1] **Senior Scientist, Seed Science & Technology, Indian Agricultural Research Institute, New Delhi – 110 012**

The labeled plants were harvested and seed yield (SY)/plant (g) was recorded. The growth parameters, reproductive phase duration (RPD) = [DM – GPS] and flowering phase duration (FPD) = (DLF-DFF) were computed. The following method was employed to rank the performance of collections/species based on the four traits. VPD, FPD, RPD and SY. The six possible mean differences between the four species were first tested by a t-test. Taking the desired direction of a trait also into account, a significant difference in the desired direction was given a score +1, and in the undesired direction a score -1 and non-significant differences a score zero. An aggregate score is the total of the scores received by the possible comparisons of each species with the rest. The aggregate scores were arranged in descending order to provide a final ranking of the species/collections.

Results and Discussion

There were distinct maturity differences between B. juncea and B. campestris on the one hand (140-145days) and B. napus and B. carinata on the other (160-170 days) (Table 1). On the contrary, the mean reproductive phase spanned about 60 days (40-43 % of the total maturity) in the former compared to about 50 days (30-32% of the total maturity) in the latter. But, this distinct difference was masked in seed yield, The results were, however, supported by the relatively shorter vegetative phase in jn and cm compared to np and cr. Associated differences in flowering phase were not distinct.

The variation between and within species for growth parameters and seed yield was significant. Such significant variation was observed in all the species except *B. napus* (which had significant variation for seed yield only). However, the variation within *B. Carinata* based on only two collections, must be considered with caution. Genetic variances for growth parameters and seed yield were the lowest in *B. napus* (Table 2), moderate in *B. juncea* and *B. Carinata* and highest. in *B. campestris*. Low variance for vegetative phase duration was found accompanied by high variance for reproductive phase duration and vice-versa (Table 3). Taking into account the estimates of error variances, it would seem that heritability for the growth parameters, VPD. FPD and RPD was, in general, much lower in *B. napus* and *B. Carinata* than in *B. juncea* and *B. campestlis*.

The substantial intra-specific variability for the three parameters and SY (Table 3) made it possible to rank the collections in each species on a joint evaluation across them. RNBL 68, of 'jn', BO 54 of 'np', both *Carinata* 4B and BCR 171 of 'cr' and EC 223406 of 'cm' were ranked at the top. Likewise *B. carinata*, *B. campestris, B. juncea* and *B. napus* were ranked in that order (Table 4, details not shown). While the affinity of the cultivated species (in India) 'cm' and 'jn' was upheld, 'cr' appeared to have highest breeding potential than 'np' for the growth parameters. The collections were classified into short, medium and long maturity groups based on observed maturity of varieties in 8rassica growing tracts in India. While, *B. campestris* and *B. juncea* collections were assigned into early or medium maturity groups, *B. carinata* and *B. napus* (except one collection in each) were classified in long duration groups (Table 3). Though, generalization on the basis of collections tested is risky, it would appear that cultivated species in India have undergone intense selection for early maturity. Though, clear-cut differences were not visible for seed yield of the three maturity groups, high yield range appeared more frequently in medium than in other maturity groups. The highest yield of 44.3 g/plant of *B. carinata* collection BCR 171 was found in long maturity group and the lowest of 9.1 g/plant of *B. campestris*, collection KN 792 in short maturity group.

In general, high yielders, like YN 3 and EC 223406 in the short duration group were about 60-75 days of VPD and 38-40 days of RPD. Those in the medium duration group had 80-90 days of RPD and those in late maturity group had more than 100 days of VPD with relatively short and widely varying RPD (25-50 days).

In C_3 and C_4 crops, distinguishing features like rate of photosynthesis, rate and duration of grain development would suggest intra-specific and inter-specific differences for growth parameters such as those studied here. Differences in the rate of dry matter accumulation were earlier reported in *Brassica* species. For instance, 85% of the total dry matter was accumulated after anthesis in *B. campestris* compared to 50% of *B. napus* (Thurling 1974a). Thus, defining VPD and RPD in *Brassica* and discovering their relationships with seed yield in various species is a gainful exercise. Though, VPD and FPD overlap, it was found feasible to define a green pod stage and RPD. It was further observed that longer RPD was an advantage in realizing high yields in medium duration *B. campestris* and *B juncea* (Table 4). In Indian conditions *B. carinata* and *B. napus* are late maturing and their relatively high yields resulted from long VPD and short RPD. Such results were also reported in West Australian conditions (Thurling, 1974b; Thurling and Das, 1979).

The following results of this study are novel for breeding improved productivity: (a) four species of *Brassica* had fairly distinct differences in VPD. FPD and RPD; (b) at least, in medium duration collections, high yields were associated with relatively long RPD; (c) high yields in species like *B. carinata* and *B napus,* yet to be cultivated in large scale in India, were still characterized by long VPD. Since genetic variation for VPD, RPD and FPD was substantial in those species (Table 2), it should theoretically be possible to improve yields of these species keeping total duration unchanged but by increasing RPD at the cost of VPD. One must be cautious about the threshold for VPD, reduction below which could affect LAI, LAD and photosynthesis; (d) In the context of Increasing *Brassica* area grown to *B. napus* and *B. carinata,* results of this study are gainful pointers to study yield increases as a function of VPD, FPD and RPD and employing strategies like direct selection or recombination breeding (e) even in the sample of the collections of four species studied here, substantial variability was observed.

Table 1 Mean, range and CV growth parameters and yield in species of Brassica

Species		VPD	FPD	RPD	SY
B. juncea	Mean	86.8	57.5	57.3	26.4
	Range	75.7-96.0	41.0-73.0	51.7-60.3	16.6-30.9
	Coefficient variation	13.3	25.6	17.8	27.3
B.napus	Mean	110.3	49.9	46.7	20.5
	Range	108.7-110.0	46.7-54.7	43.3-50.3	13.8-26.7
	Coefficient variation	4.8	12.9	11.7	32.1
B. carinata	Mean	116.7	42.2	50.3	31.4
	Range	111.3-122.0	25.3-49.0	39.0-64.3	18.4-44.3
	Coefficient variation	7.1	23.4	28.9	47.6
B. campestris	Mean	75.0	50.7	62.7	16.8
	Range	63.0-92.0	38.7-57.0	52.7-72.0	9.1-35.4
	Coefficient variation	21.4	21.0	17.5	70.4

Table 2 Estimates of genetic variance for three growth parameters and yield in species of *Brassica*

Species	VPD	FPD	RPD	SY
B. Juncea	200.3	541.1	100.8	130.2
B. napus	@	10.6	13.0	131.5
B. carinata	30.4	57.3	296.8	330.9
B. Campestris	599.5	174.9	161.6	461.9

@ Negative estimate

Table 3 Mean values of three growth parameters and yield in 14 *Brassica* collections in three maturity groups

Collections	Species	DM	VPD	FPD	RPD	SY
			Short Duration (<135 days)			
KN	cm	124.7	63.0a	61.7ab	50.7a	9.1a
EC 223406	cm	135.0	63.0a	72.0b	38.7a	12.6a
YN 3	jn	128.0	75.7a	52.3a	41.0a	16.6
Mean		129.2	67.2	62.0	43.5	12.8
			Medium Duration (136-155 days)			
Pusa Kalyani	cm	144.7	92.0a	52.7	57.0a	10.1a
EC 223406	cm	146.3	82.0a	64.3ab	55.7a	35.4cd
TN 3	jn	147.7	96.0a	51.7a	52.3a	27.1c
RNBL 68N	jn	150.0	85.0a	65.0b	73.0ab	30.8c
Jap-nig	jn	151.0	90.7a	60.3ab	63.7a	30.9c
Bo 54	np	154.0	108.7ab	44.0a	54.7a	26.7c
Car 4B	cr	150.3	111.3b	39.0a	49.0a	18.4b
Mean		149.1	95.1	53.8	57.9	25.6
			Long Duration (>155 days)			
ISN 706	np	159.0	110.0a	49.0a	46.7b	15.5a
G 1286	np	157.3	114.0a	43.3a	46.7b	13.8a
G 1237	np	159.0	108.7a	50.3a	51.7b	25.9b
BCR 171	cr	186.3	122.0a	64.3b	25.3a	44.3c
Mean		164.4	113.7	51.7	42.6	24.9
CD=(P=0.05)			14.96	14.26	17.44	6.99

cm: *B campestris; jn=B.juncea; np=B. napus; cr=B.carinata*

within columns means followed by the same letter are not significantly different; DM= days to maturity

Table 4 Test differences in man values of three growth parameters and yield among four species of *Brassica*

Comparison	VPD	FPD	RPD	SY
Jn-np	**-23.5***	**6.5**	**10.7***	**5.9***
Jn-cr	-29.8*	20.3*	5.7	- 5.0*
Jn-cm	11.8*	7.0	-5.3	9.6*
Np-cr	-6.3	13.8	-5.0	-10.9*
Np-cm	35.3*	0.4	-16.0	3.7
Cr-cm	41.7*	-13.4*	-11.0*	14.6

* Significant at P = 0.05

References

Crosbie. T .M. 1982. Changes in physiological traits associated with long-term breeding efforts to improve grain yield of maize. In: HD. Loden and D. Vilkinson (eds) Proc. 37th Annual *Corn and Sorghum international Research Conference,* Chicago. IL 5-9 Dec. American Seed Trade Association, Washington D.C., pp.206-223.

Rai, B. 1989. Brassicas. In: V.L Chopra (ed). Plant Breeding - Theory and Practice. Oxford and IBH Publishing Company Pvt. Limited, pp.159-170.

Thurling, N. 1974a. Morpho-physiological determinant of yield in rapeseed (*Brassica campestris* and *Brassica napus*). I. Growth and morphological characters.. *Australian Journal of Agricultural Research*, 25: 697-710

Thurling, N. 1974b. Morpho-physiological determinants of yield in rapeseed (*Brassica campestris* and *Brassica napus*) II. Yield components. *Australian Journal of Agricultural Research*, 25 : 711-721.

Thurling, N. and Vijendra Das, LD. 1979. Genetic control of the pre-anthesis development of spring rape (*Brassica napus* L.).. I. Diallel analysis of variation in the field. *Australian Journal of Agricultural Research.* 30: 251-259.

Tollenaar, M. 1983. Potential vegetative productivity in Canola. Canadian journal of Plant Science, 63 :. 1-10.