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Research Article

Breeding for an ideal plant type in yellow sarson (*Brassica rapa L.* yellow sarson)

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Abstract

Yield improvement has always been an important objective for plant breeders although seed yield is a complex trait influenced by several component characters. The present paper reports the efforts made to develop lines of yellow sarson with some established morpho-phisiological characters contributing to seed yield. A spontaneous erectophyle multilocular siliqua mutant was first used to transfer this trait into improved breeding lines. Both multilocular and bilocular siliqua types were comparable in seed yield but bilocular types recorded significantly higher number of siliqua per plant while tetralocular types recorded significantly larger number of seeds per siliqua. Erectophyle siliqua orientation was then established to be more productive than other posture like pendant or horizontal. A spontaneous basal branching mutant was then used to transfer this trait into the breeding lines and incorporated lines produced more number of siliqua per plant through increase in number of branches. A spontaneous apetalous mutant was isolated and this trait was transferred to the elite breeding lines. Among different groups waxy multilocular apetalous groups recorded significantly higher seed yield per plant. Thus the long term research efforts established the concept of achieving a high yielding ideotype in yellow sarson through incorporation of some morpho-physical traits following classical breeding.

Introduction

Augmentation of yield by changing the plant architecture using primary morphological components of seed yield such as number of siliqua per plant, number of seeds per siliqua and seed size has been advocated for long. Some morphological traits such as short and strong stock, erect leaf and pod posture, splitting leaf shape, dark green leaf colour, waxed leaf surface, big seed, large number of seed, apetalous flower and basal branches are of common interest in crop breeding for high grain yield in rapeseed. The present paper deals with a review of the work done on these aspects to breed a variety having desirable morphological traits producing higher yield.

Material and method

Experiment-1

The material used in the this experiment comprised of 17 bilocular and 17 multilocular true breeding lines sown in Randomized complete Block Design with three replications for two consecutive years to study the variability within and between the two siliqua types and the nature of seed yield and yield components among bilocular and multilocular siliqua types.

Experiment-2

A total of 30 advanced true breeding lines of yellow seeded rape classed into 3 orientation groups of each 10 (which correspond to upright, horizontal, and pendant) were line sown in RCB Design for two consecutive winters of 2000-2001 and 2001-02 to compare among 3 inclination groups as regards seed yield and its component.

Experiment-3

The material used in the present study represented three groups of true breeding recombinant lines, each groups comprised of 15 lines. The three groups i) basal branching ii) top branching and iii) non branching were sown in a Group Balanced Block Design with three replications to study the effect of branching type on seed yield and other yield attributes and their variability.

Experiment-4

The material in this experiment represented four groups of contrasting morphological traits (i) waxy petalous ii) waxy apetalous iii) nonwaxy petalous and iv) nonwaxy apetalous) each representing eight lines were sown in Group Balanced Block Design with three replications to

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study the effect of petalous and apetalous flowers and waxy and nonwaxy characters on seed yield and other yield attributes and variability.

Results and Discussion

Occurrence of 3-4 valved siliqua forms was quoted in *Flora indica* by Roxburgh (1832). Later Pathak and Singh (1949); Kamala and Rao (1984) and Salava *et al* (1996) studied the segregation pattern in *Brassica campestris* and confirmed monogenic control of the trait, bivalve being dominant over multivalve locule. Multilocular or multivalve siliqua bears more number of seeds than bilocular siliqua. Thurling (1974) suggested that component of yield appear to be attractive as alternative criteria of selection for higher yield as they are easy to measure and usually more heritable than yield itself. The tetralocular and bilocular groups (Table 1) were comparable in seed yield per plant. However, this comparable yield performance of the groups has been achieved in different ways. The most important attributes like number of siliqua per plant and number of seeds per siliqua differed significantly between the two groups. Bilocular group recorded significantly large number of siliqua per plant which was mainly contributed through more number of primary branches while tetralocular group although produced lower number of siliqua per plant due to lower number of primary branches produced significantly more number of seeds per siliqua. As seed weight of both the groups was comparable, the compensation for siliqua number was accomplished largely due to more number of seeds per siliqua in the tetralocular groups. In the pooled analysis over years, number of branches, number of siliqua per plant, 100 seed weight and seed yield per plant registered higher genotypic coefficient of variation than the corresponding value in the bilocular group. Tetralocular group recorded higher heritability for 100 seed weight and higher estimate of genetic advance in comparison to bilocular group. The tetralocular group recorded moderately high heritability and genetic advance for 100 seed weight indicating that selection for these traits would result in higher 100 seed weight.

A total of 30 advance true breeding lines of yellow sarson classed into three orientation groups of ten each (which correspond to upright, horizontal and pendant) were sown in RCB design for two consecutive winters of 2000-01 and 2001-02. The significant excess as per seed yield and its attributes coming out by default in favour of upright plant type against horizontal and pendant, presumably may be attributed, linked to the siliqua angle, although passively (Table-2). As evident from the Table-2, upright siliqua types as a group performed better than pendant and horizontal groups. Longer main shoot and hence large pod bearing surface on it and more so the highest number of seed per siliqua makes upright form best yielder group of all the three plant types. Moreover, number of seeds per siliqua seems to play an important role in governing seed yield. All three types being multilocular, upright multilocular siliqua group proved to be the best among three siliqua angles or orientations. Upright collectively as a group significantly differed with respect to other two siliqua types for most of the seed yielding parameters (Shikari and Sinhamahapatra, 2004).

Seed yield in oilseed Brassica is a complex trait, which is influenced by several primary components and most often components like number of siliqua per plant, seeds per siliqua and seed size are considered most important. Among these three traits, siliqua per plant is reported to be much more variable than others. In most cases, relationships of these traits are not positive and therefore, improvement of these traits together is difficult. Further, all these traits are reported to be quantitative in nature and polygenically controlled and therefore, manipulation in the desired direction becomes very difficult. Among these three traits, number of seeds per siliqua in tetralocular form is inherited monogenically and therefore easy to manipulate. No reduction in 100 seed weight in tetralocular form in comparison to bilocular form indicates that compensation through reduction of seed weight was not affected which is advantageous for yield improvement. Grosse and Geisler (1988) reported that high number of seeds per siliqua and 100 seed weight could compensate low number of siliqua per meter square. However, incorporation of tetralocular form significantly reduced total number of siliqua per plant. This reduction is mainly affected through less number of siliqua on branches accomplished through less number of primary branches. The tetralocular form as a group, although having lower number of siliqua per plant achieved almost comparable seed yield to that of bilocular form. Further, improvement in seed yield in the tetralocular form appears to be achieved if more number of primary branches or more number of siliqua per branch could be incorporated. Enhancing main raceme length for more number of siliqua per plant could not be advocated as such because, plant type will lead to taller plant which will be proned to lodging as well as late in maturity. Introduction of genes for basal basal branching may improve the number of branches as well as number of siliqua per plant. Yadav (1988) reported that basal branching in *Brassica juncea* is controlled by two recessive genes. A spontaneous mutant in *Brasica rapa* was isolated having basal branching. This trait was transferred to the erect elite lines with basal branching. Three groups i) basal branching ii) top branching iii) non-branching, each comprising 15 randomly selected true breeding lines were tested in a Group Balanced Block Design with three replications in the year 2008. The mean values of basal branching, top branching and non-branching groups were presented in Table-3. Basal branching group recorded shortest plant height, larger number of primary branches and number of siliqua on branches, lowest number of siliqua on main raceme and comparable number of seeds per siliqua, 100 seed weight and seed yield per plant. It is evident that basal branching group produced higher number of branches and number of siliqua per plant and ranked first in seed yield per plant due to comparable number of seeds per siliqua and 100 seed weight. Therefore, selection of basal branching types with erect multilocular siliqua can compensate the reduction in total number of siliqua per plant and definitely improve seed yield as suggested by Vijoy Kumar *et al* (1997) for *Brassica juncea*. Non-branching group on the other hand, produced comparable number of seeds per siliqua and 100 seed weight but lowest number of siliqua per plant compelled to produce lowest seed yield per plant. It indicated the importance of number of siliqua on branches or total number of siliqua per plant as the main contributor to seed yield. Basal branching group recorded highest estimates of GCV and heritability for 100 seed weight and seed yield per plant and highest estimates of heritability for number of siliqua on branches and number of seeds per siliqua than other groups indicating the possibility for further improvement through selection.

In *Brassica rapa* L., mutants with apetalous flower were reported, the apetalous trait being controlled by one recessive gene (Singh, 1961a,b; Cours and Williams, 1977). The apetalous lines (originally isolated as a spontaneous mutant from the variety B-9) reported in the present study were derived after hybridization with petalous lines. Fray *et al* (1996) analyzed the transmission of solar radiation within the crop canopies of oilseed rape which is decreased both by the plant's yellow petals during flowering and by the horizontal posture of the pods once they are formed. Mendham *et al* (1991) suggested that most leaves senesced soon after flowering commenced and green pods and stem become the major source of photosynthesis and even increased number of pods, agronomic potential was compromised by the increased reflectivity by petals. Breeding for genotypes with reduced petal size or without petals was suggested for more efficient light distribution within the canopy thereby activating basal branching and greater efficiency of lower leaves, stem as well as pods (Buzza, 1983). Besides, apetalous traits were found to resist infection of *Sclerotonia selerotionium* disease (Thomson *et al*., 1994) and mustard aphid-*Lipaphis erysimi* (Naveen *et al*., 1996). As apetalous trait is very simple to transfer, this trait was transferred to the elite breeding lines with waxy or non-waxy, bilocular or multilocular erect siliqua and basal branching lines. Eight true breeding lines each of waxy petalous, waxy apetalous, non-waxy petalous and non-waxy apetalous groups were tested in a Group Balanced Block Design with three replications to study the effect of petals and waxiness on seed yield. The mean values, genotypic coefficients of variation and heritability estimates of four groups were presented in Table-4. Seed yield of waxy apetalous and non-waxy apetalous groups were significantly higher than the waxy petalous and non-waxy petalous groups. Higher seed yield of waxy apetalous and non-waxy apetalous groups than the petalous groups was achieved through the important yield attributes like higher number of siliqua on branches resulting from higher number of branches per plant. More number of primary branches was mainly achieved through basal branching as both the apetalous group recorded lower height of first fruiting branch than the petalous groups. Hundred seed weight of the apetalous groups was significantly higher than the petalous groups. Mendham *et al* (1981) suggested that apetalous flowers have the potential to reduce pod and seed abortion by improving the transmission of radiation in the developing pods at the base of each raceme. Greater number of seeds per siliqua was not recorded in the present study as selection for only multilocular siliqua was not practiced in any of the groups. Therefore, if apetalous groups were comprised of only multilocular siliqua, number of seeds per siliqua and consequently seed yield might have been improved further. Higher estimates of genotypic coefficient of variation and heritability were recorded for number of primary branches, height up to first fruiting branch, seeds per siliqua and seed yield per plant among the apetalous types indicating further improvement of these traits through selection.

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Table 1 Pooled mean and variability estimates different characters

Parameter	Siliqua type	Plant height (cm)	Number of branches	Number of siliqua per plant	Seeds per siliqua	100 seed weight (g)	Seed yield per plant (g)
Mean	Tetralocular	105.92	2.43	39.73	32.44	0.31	3.04
	Bilocular	104.02	5.08	65.12	23.03	0.32	3.11
CD at 5 % level		8.37	0.80	4.31	3.25	0.05	0.63
GCV	Tetralocular	4.63	29.60	15.05	3.38	9.66	8.29
	Bilocular	3.44	11.87	17.35	9.27	2.71	6.59
	All strains	3.84	40.64	29.99	20.14	7.11	7.40
h^2 (broad sense)	Tetralocular	0.16	0.28	0.34	0.11	0.72	0.09
	Bilocular	0.29	0.28	0.41	0.40	0.14	0.09
	All strains	0.15	0.60	0.65	0.79	0.52	0.08
GA (as % of mean)	Tetralocular	3.75	32.51	17.99	2.37	16.13	5.26
	Bilocular	3.85	17.85	23.02	1.15	3.12	4.18
	All strains	3.10	66.42	49.78	36.35	9.67	4.56

Table 2 Pooled mean values of different traits of the three siliqua inclination groups.

Siliqua group	**Plant height (cm)**	**Number of Branches**	**Number of siliqua per plant**	**Seeds per siliqua**	**100 seed weight (g)**	**Seed yield per plant (g)**
Pendant	87.23	6.11	49.33	27.54	0.38	5.22
Horizontal	101.50	5.27	56.80	28.21	0.36	5.84
Upright	124.70	5.88	77.59	31.37	0.27	6.73
CD at 5 %	9.36	0.73	5.84	2.98	0.04	0.76

Table 3 Mean values and variability estimates for different characters in different groups of branching habit

Group	Plant Height (cm)			Number of branches			Number of siliqua on main raceme			Number of siliqua on branches			Number of seeds per siliqua			100 seed weight (g)			Seed yield per plan (g)t		
	Mean	GCV	h^2	Mean	GCV	h^2	Mean	GCV	h^2	Mean	GCV	h^2	Mean	GCV	h^2	Mean	GCV	h^2	Mean	GCV	h^2
Basal Branching	86.13	10.00	0.73	5.59	18.22	0.52	18.17	11.13	0.55	23.89	38.79	0.96	30.94	20.56	0.86	0.26	32.28	0.96	2.20	47.91	0.94
Non Branching	97.37	8.00	0.82	1.28	22.28	0.34	22.70	12.83	0.60	1.92	55.62	0.47	30.83	13.32	0.84	0.26	16.10	0.94	1.83	20.77	0.74
Top Branching	102.84	7.39	0.87	4.03	39.39	0.89	23.09	14.20	0.78	10.05	43.35	0.81	27.68	23.53	0.85	0.28	12.71	0.87	2.18	39.41	0.81
CD at 5 % Level	6.55	-	-	1.11	-	-	3.24	-	-	2.87	-	-	3.56	-	-	0.02	-	-	0.50	-	-

Table 4 Mean values and variability estimates for different characters of four groups of yellow sarson

Parameter	Group	Plant Height (cm)	Height up to 1st fruiting branch (cm)	Number of Branches	Number of siliqua per plant	Seeds per siliqua	100 seed weight (g)	Seed yield per plant (g)
Mean	WP	106.32	28.87	5.36	54.79	22.01	0.29	2.99
	WAP	111.45	21.44	6.56	72.96	24.11	0.32	4.84
	NWP	100.42	31.03	4.95	55.60	23.96	0.29	3.12
	NWAP	116.80	19.69	8.00	75.17	24.25	0.32	4.98
CD at 5 %		4.79	1.90	0.93	8.60	4.94	0.02	0.64
GCV	WP	1.66	5.31	11.15	6.55	19.14	0.69	16.58
	WAP	5.51	14.11	11.31	12.41	17.21	5.10	19.42
	NWP	3.37	8.07	26.39	17.59	25.13	1.16	15.54
	NWAP	2.73	17.87	14.06	3.87	16.39	4.19	9.66
h^2(broad sense)	WP	0.58	0.81	0.75	0.51	0.92	0.20	0.77
	WAP	0.87	0.76	0.57	0.88	0.95	0.47	0.87
	NWP	0.71	0.86	0.85	0.90	0.50	0.22	0.83
	NWAP	0.48	0.96	0.95	0.17	0.96	0.63	0.54
GA(% of mean)	WP	2.61	9.86	20.02	9.64	37.86	0.65	30.00
	WAP	10.60	25.38	17.74	24.00	34.69	7.25	37.40
	NWP	5.87	15.47	50.19	34.55	36.95	1.14	29.18
	NWAP	3.91	36.18	28.26	3.30	33.17	6.88	14.71