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CONTENTS

Selection parameters and heterosis for grain yield and yield contributing traits in yellow sarson (*Brassica rapa* var. yellow sarson)

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ABSTRACT: The present investigation was undertaken with an objective to assess the selection parameters and extent of heterosis in Yellow sarson (*Brassica rapa* var. yellow sarson). Forty F_1 along with 10 lines as female and 4 testers as males were included in experimental material for generating the information. Analysis of data showed presence of wide range of variability for various characters under study. The estimates of phenotypic coefficients of variability (PCV) were found higher than genotypic coefficient of variability (GCV) and environmental coefficient of variability (ECV). Maximum heritability was recorded for seed/siliqua (94.30%), followed by seed yield per plant (90.61%) and number of primary branches/plant (84.59%) along with high genetic advance for seed yield/plant (32.34%), seed/siliqua (29.12%) and number of primary branches/plant (21.70%). For days to maturity, NDYS-2018×NDYS-113 (-12.21**), NDYS-2018 × Pusa Gold (-11.62**) and B-9 × PPS-1(-8.65**) recorded highest better parent heterosis, relative heterosis and economic heterosis respectively. NDYS-115 × Pusa Gold (-15.69**, -15.85**) possessed highest estimates of heterobeltiosis and mid parent heterosis while NDYS-2018×NRCYS-05-01 (-9.65**) registered highest estimate of economic heterosis for plant height. For seed yield maximum heterobeltiosis and relative heterosis was observed in cross, Jhumka × NDYS-113 (52.36**, 65.34**) while NDYS-128 × PPS-1 (41.54**) was the best cross with respect to economic heterosis. The Cross, NDYS-128 × NDYS-113 (24.47**) expressed highest estimate of heterosis over better parent and maximum relative and economic heterosis was possessed by NDYS-132 × NDYS-113 (25.18**, 22.29**) respectively. For oil content cross, YS-166 × NDYS-113 (7.57**, 7.74**, 8.40**) showed highest estimates for all three types of heterosis.

Key words: Component of variance, heterosis, selection parameter, yellow sarson

Rapeseed-mustard group of crops are one of the most important oilseed crops grown in different ecological zones across the country. This crop is considered as major primary source of edible oil. Besides, it is used as leafy vegetables and condiments since long and also found rich in minerals and antioxidants. Among rapeseed-mustard, yellow sarson (*Brassica rapa* var. yellow sarson) is preferably cultivated for its higher oil quantity (~46-48%), better texture of oil and medium maturity (~ 105-115 days) as compared to Indian mustard (130-150 days) and high yield potential when compare with the toria. Autogamous nature of crop also imparts an ease of maintenance of parental lines as well as populations. Because of added advantages of mating system and oil (content as well as texture), it always fetches the attention of growers, miller as well as scientists and attempts were made for its improvement by several researchers since long back (Rakow, 1995 and Singh, 2003) still the desired improvement has not been achieved. Narrow genetic base, lack of genetic variability, susceptibility to different biotic and abiotic stresses, are the major bottlenecks in improvement of yellow sarson. The success of a breeding programme relies on the amount and type of genetic variation available with the crop gene pool. The extent of genetic variability in crop gene pool will provide raw material on which the efficient selection programme can be operative which will provide the potential donors/ pre breeding lines for improvement programme.

A desirable extent of improvement can also be achieved through formulation of an effective breeding programme which will be possible if all the genetic components were well taken care and thoroughly studied for different yield contributing traits (Lakra *et-al*., 2020; Priyanka *and Pandey*, 2021; Patel *et al.*, 2019 and Rauf & Rahim, 2018). For the selection to be more effective, understanding of variability parameters like phenotypic and genotypic coefficients of variation, heritability and genetic advance is must. Therefore, it is essential for a breeder to measure the total genetic variability available in germplasm on the basis of basic parameters viz; phenotypic coefficient of variation and genotypic coefficient of variation, heritability and genetic advance which help in deciding extent the improvement in component trait during selection. Saroj *et al.*, 2021 and Maurya *et al.*, 2018 reported the crucial role of basic information for an improvement programme. It is therefore imperative for breeder to know inheritance and regulation of the yield and associated agronomical characters to improve the yield potential of the crop effectively.

The presence of genetic variability encoded in breeding material plays a significant role in developing superior hybrids. Genetic diversity study helps to estimate the divergent parents for the hybridization program. High yielding varieties were developed by exploiting heterosis in many crops like rice, maize and sorghum. Heterosis is increment in the vigor, potential, resistance to disease and insect pests or climatic vigor of crosses as compared with corresponding parents (Shull, 1952; Jinks and Jones, 1958). Hybrid development has been successfully achieved in many Brassica species (Miller, 1999) but it is still awaited in yellow sarson. Expression and exploitation of heterosis in rapeseed- mustard is a viable tool to improve yield and other economic trait and break the yield plateauing**.** Dar *et al.*, 2012, Dutta, 2014 and Nair *et al.*, 2017 have reported appreciable level of heterosis in *B. rapa* (25 to 110%). The magnitude of heterosis provide a ground for evaluation of genetic diversity and a guide for a choice of desirable parents for developing superior F1 hybrids in order to exploit hybrid vigour and for building gene pools to be use in breeding programme. Estimation of heterobeltiosis may be useful in selecting true heterotic combination but these crosses can be of immense practical value if they show a high estimate of economic (standard) heterosis as well. It has also been reported that the maximum heterosis can be realized when more diverse parents with significant gene difference are mated. Categorization of germplasm in diverse gene pool is still not done in case of brassicas which is most demanding and fundamental prebreeding activity. It was also reviewed that in yellow sarson reports on these basic information were negligible therefore there is an urgent need to do thorough study on the basic parameters in order to have improvement in crop. In order to achieve above objective the present investigation was planned to study basic parameters of selection and extend of heterosis in yellow sarson.

MATERIALS AND METHODS

The study was conducted at N.E.B. Crop Research Center and Quality Breeding laboratory of department of Genetics and Plant Breeding., G.B.P.U.A. &T Pantnagar, U.S. Nagar, Uttarakhand The experimental material consisted of 40 F1's derived from the crosses generated by involving 10 advanced genotypes *viz.* NDYS-2018, NDYS-107, B-9 (Binoy), NDYS-115, Jhumka, YS-166, NDYS-132, NDYS-116, NDYS-128 and NRCYS-0502 used as lines to four advanced genotypes *viz.* Pant Pili Sarson-1 (PPS-1), NRCYS-0501, Pusa Gold and NYDS-113 as males. Line×Tester mating design was used to generate 40 F_1 crosses. The experimental materials comprised of 40 crosses and 14 parents, were planted in randomized complete block design with three replications. For each entry, rows length was kept 3 m with plant geometry of 30×10cm.In order to debar border effect, experimental plots were encircled by one row of B-9. Standard variety, Pant Pili Sarson-1 was treated as check in the experiments. Standard agronomic practices were followed to raise the good crop. Observations were recorded on randomly selected five competitive plants for important quantitative traits, *viz.,* days to maturity, plant height, siliquae on main shoot, length of main shoot, siliqua density on main shoot, siliqua length, seeds per siliqua, number of primary branches, 1000 seed weight, oil content and seed yield per plant.

Coefficients of Variation (C.V.)

Phenotypic, genotypic and environmental coefficients of variation were calculated according to Burton (1952).

$$\text{P.C.V.} = \frac{\text{Phenotypic standard deviation}}{\text{Mean}} \times 100$$

$$\text{G.C.V.} = \frac{\text{Genotypic standard deviation}}{\text{Mean}} \times 100$$

$$\text{E.C.V.} = \frac{\text{Environmental standard deviation}}{\text{Mean}} \times 100$$

Heritability

The heritability in broad sense $h^2(b)$ was estimated for each character as the ratio of genotypic variance to phenotypic variance by the formula:

$$h^2(b) = (\sigma^2 g / \sigma^2 p) \times 100$$

Genetic Advance

The expected genetic advance under selection for the different characters was estimated as suggested by Allard (1960).

$$GA = h2 \times \sigma p_i \times K$$

Genetic advance as per cent of mean for each character was estimated as defined by Johnson, Robinson and Comstock (1955):

$$\text{G.A. (\% of mean)} = (GA/X_i) \times 100$$

Estimation of Heterosis

The heterosis was estimated, as deviation of F_1 mean from the better parent (BP), mid parental value (MP) and the standard variety (SV), according to method suggested by Hayes *et al.* (1955).

$$\text{Heterobeltiosis} = \frac{F1\text{-}BP}{BP} \times 100$$

$$\text{Relative heterosis} = \frac{F1\text{-}MP}{MP} \times 100$$

$$\text{Standard heterosis} = \frac{F1\text{-}SV}{SV} \times 100$$

The significance of heterosis was tested by 't' test as given below:

a) For heterobeltiosis and standard heterosis

$$\frac{F1 - BP}{\sqrt{2M\varepsilon/r}}$$

b) For relative heterosis

$$\frac{F1 - MP}{\sqrt{2M\varepsilon/r}}$$

RESULTS AND DISCUSSION

The experimental materials comprised of 40 crosses, 10 lines and 4 testers were evaluated in a randomized complete block design for 11 agro-morphological traits. Analysis of variance showed presence of significant amount of genetic variability in the experimental material.

Selection parameters for seed yield and component traits

Mean and Range: For days to maturity the range among parents was 96.67 to 116.00 days whereas in crosses days to maturity ranged from 95 to 113.67 days with a mean of 106.33 days. Plant height varied from 117.18 to 150.17 cm and 118.63 to 150.17 cm in parents and crosses respectively with a mean of 135.09cm. In case of length of main - raceme the mean value was 59.59 cm with a range of 50.33to 61.80cm in parents and 47.40 to 70.23cm in crosses. For siliquae on main raceme, the variation was from 35.00 to 48.47cm among parents and 34.33 to 49.87 in crosses and overall mean was 42.40. The mean value for siliqua density on main raceme was 0.72 with parental variation from 0.65-0.82 and variation among crosses was from 0.58 to 0.89. Primary branches per plant showed variation from 7.15 to 10.53 among parents and 7.33 to 11.63 in crosses. The average number of primary branches per plant was 8.92. For siliqua length, the estimates of overall mean, range in parents and range in crosses were 6.33cm, 5.30-6.90cm and 6.27-7.63cm respectively. Seeds per siliqua registered a mean of 33.06 with a parental range of 22.67-42.00 and crosses range of 22.67-41.33. In case of seed yield per plant, the overall mean was 9.42g with a parental range of 5.41-10.69g whereas the range among crosses was 6.80-12.01g. The test weight varied from 3.80-7.40g among the parent and 3.44-5.32g among crosses with overall mean of 4.36g. For oil content the mean value was 42.77% with a parental range of 40.90-43.73% and crosses range of 41.53-44.91%.

Coefficient of Variation: The estimate of PCV was found higher than GCV and ECV for all the 11 traits studied (Table 1). PCV ranged from 2.64% (oil content) to 17.32% (seed yield per plant). Moderate

PCV was observed for seed yield/plant (17.32%), seeds per siliqua (14.99%), number of primary branches/plant (12.45%), siliqua density on main raceme (11.34%) and siliquae on main raceme (10.90%). For rest of the traits the estimates of PCV were low. Maximum GCV was observed for seed yield per plant (16.49%) followed by seeds per siliqua (14.55%) and primary branches per plant (11.45%). A low GCV was noticed for rest of the traits. The above research findings were confirmed by the findings of Singh *et al.* (2017), Adhikari *et al.* (2018) and Snehi *et al.* (2019).

***Heritability and Genetic advance**:* High estimates of heritability were observed in most of the traits. Highest heritability was observed in seed/siliqua (94.30%), followed by seed yield per plant (90.61%) and number of primary branches per plant (84.59%). Heritability broad sense coupled with genetic advance give an indication of improvement up on

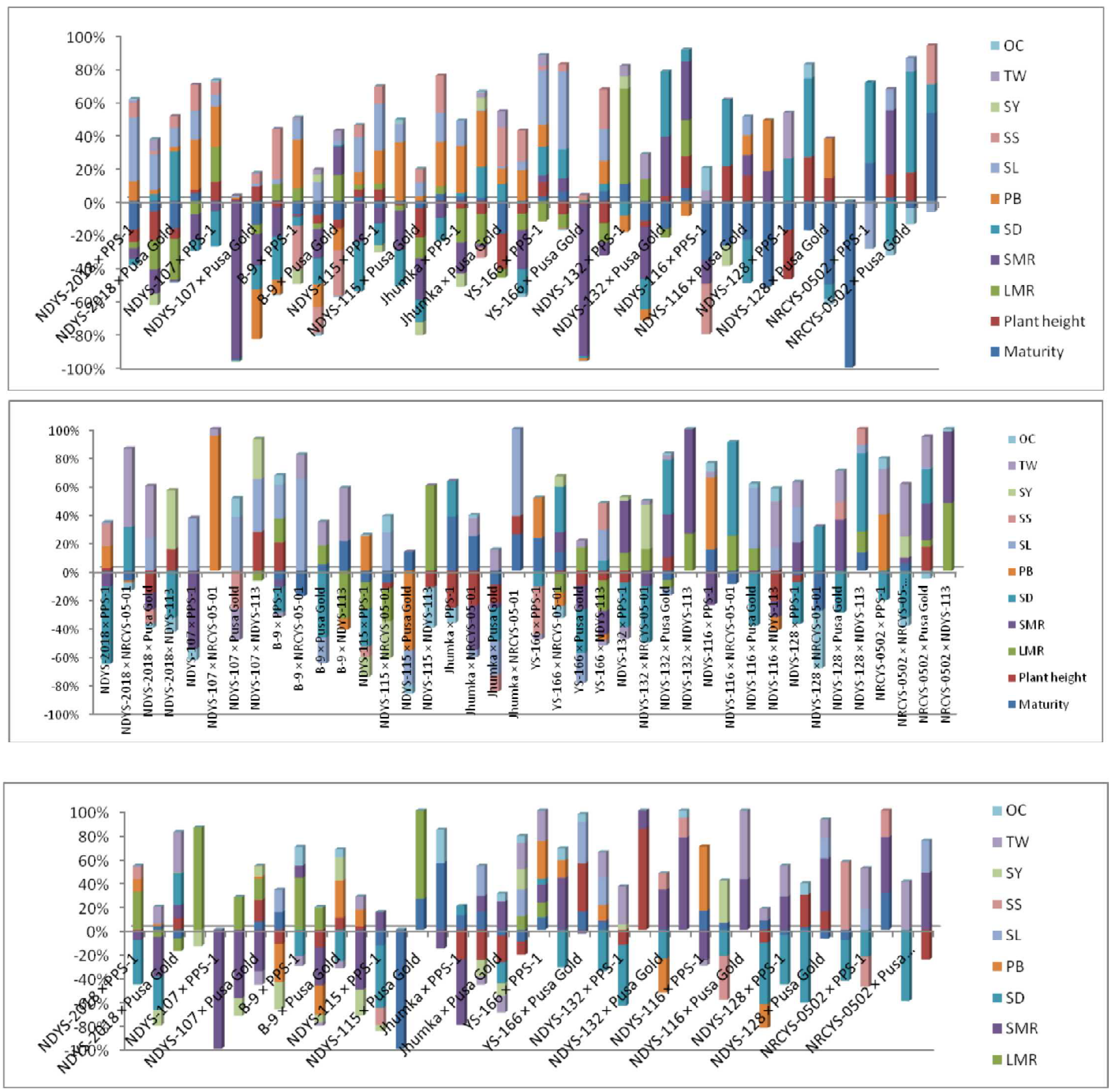

Fig 1: The estimates of relative heterosis (a), economic heterosis (b) and heterobeltosis (c) for 11 traits in yellow sarson

Table 1: Selection parameters for seed yield and component traits in yellow sarson

Characters	Grand mean	Range in parents	Range in crosses	PCV (%)	GCV (%)	ECV (%)	H^2_{bs} (%)	GA	GA as % of mean
Days to maturity	106.33	96.67-116.00	95.00-113.67	4.87	4.44	2.00	83.02	8.85	8.33
Plant height	135.09	117.18-150.17	118.63-150-17	6.88	6.12	3.14	79.13	15.16	11.22
Length of main raceme	59.59	50.33-61.80	47.40-70.23	9.63	8.80	3.92	83.45	9.87	16.56
Siliqua on main raceme	42.40	35.00-48.47	34.33-49.87	10.90	8.66	6.60	63.23	6.02	14.19
Siliqua density	0.72	0.65-0.82	0.58-0.89	11.34	8.41	7.60	55.00	0.09	12.80
Primary branches	8.92	7.15-10.53	7.33-11.63	12.45	11.45	4.89	84.59	1.94	21.70
Siliqua length	6.33	5.30-6.90	6.27-7.63	7.78	6.58	4.15	71.57	0.73	11.47
Seeds per siliqua	33.06	22.67-42.00	22.67-41.33	14.99	14.55	3.58	94.30	9.63	29.12
Seed yield	9.42	5.41-10.69	6.80-12.01	17.32	16.49	5.31	90.61	3.05	32.34
Test weight	4.36	3.80-4.70	3.44-5.32	9.42	8.29	4.47	77.47	0.66	15.03
Oil content	42.77	40.90-43.73	41.53-44.91	2.64	2.36	1.18	80.09	1.86	4.36

PCV: Phenotypic Coefficient of Variation, GCV: Genotypic Coefficient of Variation, ECV: Environment Coefficient of Variation, h2 : Heritabilty, GA: Genetic Advance

selection. High heritability with high genetic advance was observed in seed yield/plant (32.34%), seed per siliqua (29.12%) and number of primary branches/plant (21.70%). Moderate genetic advance coupled with high heritability was expressed in length of main raceme (16.56%), test weight (15.03%), siliquae on main raceme (14.19%), siliqua density (12.80%), siliqua length (11.47%) and plant height (11.22%). High heritability with low genetic advance was found for days to maturity (8.33%) and oil content (4.36%) which was also reported by Meena *et al.* (2015), Snehi *et al.* (2019) and Adhikari *et al.* (2018). Upon revisiting the results, it was found that heritability broad sense was found high but the genetic gain or improvement was high, moderate or low. In such situation up on selection gain with variable level is expected. Therefore, the breeding strategy for improvement of trait must be based on the estimates of heritability and genetic gain. The simple selection procedure will be quite fruitful for those traits where high heritability with high genetic advance was recorded whereas for rest of the traits maintenance and exploitation of heterozygosity either by recurrent selection or development of hybrid would be a better to harness maximum gains.

Estimation of heterosis

High estimates of specific combining ability effects suggested exploitation of heterosis. The heterosis was calculated over mid parent value, over better parent and over standard variety. Heterosis over better parent for days to maturity and plant height was estimated over early maturing and short height parent of the hybrids. Hence crosses with negative heterosis were considered as desirable. Manifestation of heterosis was found in both positive and negative directions. The results of heterosis are given in the Table 2 and represented as in graph (Fig 1A, B&C). The density distribution graph showed that most of crosses were better than the average

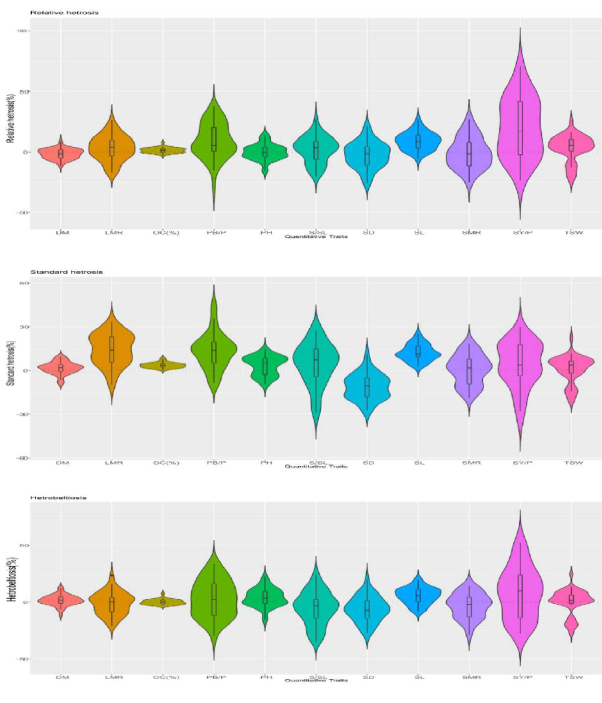

fig 2: Density distribution of mid-parent (a), standard parent (b) and best-parent (c) heterosis for seed yield and compenent traits. dashed lines represented corresponding parental values. average heterosis and standard deviation are shownin black dots and bars respectively.

Table 2: Summary of relative heterosis, economic heterosis and heterobeltiosis for 11 traits in yellow sarson

No	Trait	Relative heterosis			Economic heterosis			Heterobeltiosis		
		Cross (no.)	Range	Best crosses	Cross (no.)	Range	Best crosses	Cross (no.)	Range	Best crosses
1	DM	16	-11.62 To 8.79	NDYS-2018 × PUSA GOLD, NDYS-128 × PUSA GOLD, B-9 × PUSA GOLD	4	-8.65 to 9.29	B-9 × PPS-1, B-9 × NRCYS-05-01, B-9 × PUSA GOLD	4	-11.49 to 12.21	NDYS-2018 × PUSA GOLD, NDYS-107 × PUSA GOLD, NDYS-116 × PUSA GOLD
2	PH	11	-15.85 To 13.71	NDYS-115×PUSA GOLD NDYS-2018 × NRCYS-05-01NRCYS-05-02 × NDYS-113	4	-9.65 to 14.37	NDYS-2018×NRCYS-05-01 NDYS-115×PUSA GOLD NDYS128×PPS-1	3	-15.69 to 22.46	NDYS-115 × PUSA GOLD NDYS-2018 × NRCYS-05-01 NDYS-2018 × NDYS-113
3	LMR	22	-17.2 to 26.03	NDYS-107 × PPS-1, NDYS-116 × PPS-1, NDYS-128 × NRCYS-05-01	27	9.94 to 33.44	NDYS-128×PUSA GOLD, NDYS-128 × NRCYS-05-01, NRCYS-05-02 × NRCYS-05-01	8	-21.02 to 23.28	NDYS-107 × PPS-1, NDYS-107 × PPS-1, NDYS-128 × NRCYS-05-01
4	SMR	10	-25.41 to 26.93	NDYS-128 × NRCYS-05-01, NDYS-128 × NDYS-113 NDYS-128 × PUSA GOLD	6	-18.59 to 18.26	NDYS-128×NRCYS-05-01, NDYS-116 × NRCYS-05-01, NDYS-128 × NDYS-113	5	- 29.17 to 14.43	NDYS-128 × NRCYS-05-01, NDYS-128 × NDYS-113 NDYS-116 × NRCYS-05-01
5	SD	4	-26.25 to 20.41	NDYS-2018 × PUSA GOLD JHUMKA × NRCYS-05-01 AND NDYS-128 × NDYS-113	1	-27.50 to 11.25	JHUMKA × NRCYS-05-01 (11.25*)	2	-27.50 to 20.00	NDYS-2018 × PUSA GOLD JHUMKA × NRCYS-05-01
6	PB	19	-30.19 to 33.53	NDYS-115×NRCYS-05-01 JHUMKA × NRCYS-05-01 NDYS128 × PPS-1	27	-35.32 to 21.50	NRCYS-05-02 × PUSA GOLD NDYS-115 × NRCYS-05-01 NDYS-107 × PPS-1	5	-30.39 to 33.72	NDYS-115 × NRCYS-05-01 JHUMKA × NRCYS-05-01 NDYS-2018 × NDYS-113
7	SL	26	-6.22 to 26.90	NDYS-132 × NDYS-113, NDYS-132 × NRCYS-05-01 NDYS-132 × PPS-1	31	25.08 to 8.69	NDYS-2018 × NRCYS-05-01 YS-166 × NRCYS-05-01 NDYS-116 × NRCYS-05-01	16	-8.26 to 19.50	NDYS-132 × NDYS-113 NDYS 2018 × NRCYS-05-01 YS-166 × NRCYS-05-01
8	SS	17	-20.47 to 27.09	NDYS-107 × NDYS-113 NDYS-115×NDYS-113NDYS-2018 × NDYS-113	21	-29.16 to 27.09	NDYS-107 × NDYS-113 YS-166 × PUSA GOLD NRCYS-05-02 × PUSA GOLD	9	-35.19 to 24.49	NDYS-107 × NDYS-113 NDYS-132 × PPS-1 JHUMKA × NDYS-113
9	SY	23	-22.44 to 70.99	NDYS-128 × NDYS-113 JHUMKA × NDYS-113 YS-166 × NDYS-113	18	-35.46 to 41.54	NDYS-128 × PPS-1 YS-166 × PUSA GOLD YS-166 × NDYS-113	9	-27.81 to 52.36	JHUMKA × NDYS-113 (52.36**), NDYS-116 × PUSA GOLD (49.33**), NDYS-128 × NDYS-113
10	TW	18	-24.64 to 25.18	NDYS-132 × NDYS-113 NRCYS-05-02 × NDYS-113 NDYS-2018 × NDYS-113	10	-20.92 to 22.29	NDYS-132 × NDYS-113 NDYS-128 × NRCYS-05-01 NDYS-128 × NDYS-113	9	-28.03 to 24.47	NDYS-128 × NDYS-113 NDYS-132 × NDYS-113 NDYS-128 × NRCYS-05-01
11	OC	17	1.69 To 7.74	YS-166 × NDYS-113 NDYS-132 × PPS-1 B-9 × NDYS-113	30	2.39 to 8.40	YS-166 × NDYS - 113 NDYS - 107 × PUSA GOLD NDYS-132 × NRCYS-05-01	8	-3.32 to 7.57	YS-166 × NDYS-113, NDYS-132× PPS-1 B-9 × NDYS-113

values of their respective parents (Fig 2 A, B& C) which reflected that sufficient amount of heterosis was found among the crosses and this heterosis can further utilized either in hybrid development programme or as F1 in specific cross combination. From the results, it was noticed that the cross combinations having desirable heterosis were less as the crop suffers with the narrow genetic base and very less exploitation of diverse gene pool. For days to maturity, NDYS-2018×NDYS-113 (-12.21**) showed maximum hereobeltiosis. NDYS-2018 × Pusa Gold (-11.62**) showed highest relative heterosis and B-9 × PPS-1(-8.65**) expressed maximum standard heterosis. NDYS-115 × Pusa Gold (-15.69**, -15.85**) recorded highest estimates of better parent heterosis and relative heterosis while NDYS-2018×NRCYS-05-01 (-9.65**) was the best cross with respect to standard heterosis for plant height. Singh and Mishra (2001), Dar *et al.* (2012) and Meena *et al.* (2014) reported significant level of heterosis for days to maturity and plant height in negative (desired) direction. In case of length of main raceme, maximum heterobeltiosis and relative heterosis was observed in NDYS-107 × PPS-1 (23.28**, 26.03**) respectively while the best cross for standard heterosis was NDYS-128×Pusa Gold (33.44**). For Siliquae on main raceme, cross NDYS-128×NRCYS-05-01 (26.93**, 18.26** and 14.43**) showed highest estimate for all three types of heterosis. Maximum relative heterosis and heterobeltiosis was recorded in NDYS-115×NRCYS-05-01 (33.53**, 33.72**) while NRCYS-05-02 × Pusa bold (21.50**) expressed highest estimate of standard heterosis for primary branches per plant. Maximum improvement for siliqua length over better parent and mid parent was observed in cross NDYS-132 × NDYS-113 (19.50**, 26.90**) whereas over standard check variety heterosis was found in cross NDYS-2018 × NRCYS-05-01 (25.08**). NDYS-107 × NDYS-113(24.49**, 27.09**, 27.09**) expressed highest estimates of all three types of heterosis for number of seeds per siliqua. Significant level of heterosis in desired direction for different yield component traits has already been reported by Singh *et al.* (2001), Verma *et al.* (2009) and Gautam *et al.* (2010) in yellow sarson, Parmar *et al.* (2011) and Meena *et al.* (2014) in Indian mustard and Dar *et al.* (2012) in brown sarson. Both heterobeltiosis and relative heterosis was observed maximum in cross Jhumka × NDYS-113 (52.36**, 65.34**) for seed yield and maximum standard heterosis was registered in NDYS-128 × PPS-1 (41.54**). In case of test weight maximum heterobeltiosis was recorded in NDYS-128 × NDYS-113 (24.47**) and highest estimates of relative and economic heterosis was registered in NDYS-132 × NDYS-113 (25.18**, 22.29**) respectively. The cross YS-166 × NDYS-113 (7.57**, 7.74**, 8.40**) showed highest estimates of all three types of heterosis for oil content. Significant heterosis for seed yield and oil content was also found in the research finding of Bhatt *et al.* (2005), Aher *et al.* (2009), Dar *et al.* (2012), Rameeh (2012), Meena *et al.* (2014), Meena *et al.* (2015), Nair *et al.* (2017), Adhikari *et al.* (2017), Shrimali *et al.* (2018), Tomar *et al.* (2018), Snehi *et al.* (2019) and Mahanta & Barua (2020).

CONCLUSION

From the research finding and discussion from the above study the preponderance of non-additive genetic action was found crucial for most of the characters which suggested appreciable advantages of creating and maintaining heterozygosity or restoring it at the end of the breeding programme. Relevant multiple selection parameters showed great assistance in identifying potential parents and crosses. NDYS-2018×Pusa Gold for days to maturity, NDYS-115×Pusa Gold for plant height, NDYS-2018×NRCYS 05-01 for main raceme length and siliquae on main raceme and NDYS-128 × NDYS-113 for seed yield were identified as best crosses. NDYS-2018, Jhumka, Pusa Gold and NRCYS 05-01were observed to be potential donor that were involved in most the crosses that showed significant heterosis. Such identified parents can serve as potential donor for trait specific improvement programme. Highly heterotic cross combination can be selected and involved in heterosis breeding to achieve maximum improvement through development of hybrids.

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