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Variability, Heritability and Genetic Divergence in Yellow Sarson *(Brassica campestris.* var. Yellow Sarson) Genotypes under the Mid-hills of Sikkim

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Forty two genotypes of yellow sarson (*Brassica campestris* L. var. yellow sarson) were evaluated under organic conditions in the mid-hills of Sikkim in RBD during the *rabi* season of 2007 and 2008 for eight quantitative traits namely, plant height, number of primary branches, days to 50% flowering, days to maturity, number of siliqua/plant, length of siliqua, number of seeds/siliqua and seed yield/plant. High heritability with high genetic advance was observed for number of siliqua/plant, number of seeds/siliqua and seed yield/plant. The 42 genotypes were grouped into 9 clusters. The number of siliqua/plant contributed maximum towards genetic divergence. The performance and seed yield of seven genotypes *viz.,* Pusa Gold, NDYS 2018, SSY-1, *Ragini, Jhumka,* NDYS 9504 and GS-1 were found better.

Key Words: ***Brassica campestris,*** **Genetic divergence, Variability, Yellow sarson**

Introduction

Indian rapeseed (*Brassica rapa* L. Syn. *Brassica campestris* L.) is the second largest oilseed brassica grown mostly in the North-eastern parts of India, occupying an important position in rainfed agriculture. India stands first both in acreage and production of rapeseed and mustard in Asia. In India it covers an area of 5.92 mha, with production of 6.78 mt and yield of 1,145 kg/ha in 2011-12 (DRMR, 2013). Among the three ecotypes in this group, yellow sarson is the most important oilseed crop and is most favored in mountainous state of Sikkim. This crop is cultivated solely for obtaining edible oil, as almost all state population utilizes this oil as main edible oil, indicating its importance in the state. In Sikkim it is being cultivated during *rabi* season in low and mid-hills in about 5,80,000 ha area with an annual production and productivity of 4,55,000 tonnes and 784.48 kg/ha, respectively, in 2010-11 (FS&ADD, 2011).

For an organic state like Sikkim, it is imperative to identify rapeseed varieties which perform well under rainfed and low input conditions. Information on the nature and magnitude of variability present in the existing material and association among the various morphological characters is a pre-requisite for any breeding programme to be initiated by the local breeders for high yields. Knowledge on the extent of allelic variations which is expressed in terms of genetic divergence is helpful to identify lines having contrasting alleles and using them as parental lines to tailor the existing genotypes for improving the limiting traits to perform better under target environment. The quantitative characters are polygenic in nature, whose expression is influenced by the environment in which it is grown. The degree of influence of environment on the character decides the methodology to be improvised for improvement of character. This study was carried out with the objective to identify the yellow sarson genotypes suitable for cultivation under Sikkim organic conditions and also selection of the lines with desired characters for further utilization in breeding programmes for improvement of yield and its component traits in yellow sarson.

Materials and Methods

The experimental material for the present study consisted of 42 genotypes of yellow sarson, namely, Binoy, GS 1, IC374356, IC385666, IC385670, IC385678, IC385704, IC385705, IC385767, IC395576, IC398652, IC398654, Jhumka, NDYS 2, NDYS 2018, NDYS 9504, PROYS 2105, PROYS 9805, PS 66, Pusa Gold, PYS 2005, PYS 9804, Ragini, RS 1, Sikkim Sarson yellow 1 (SSY -1), SKYS 13, SKYS 17, YSB 2003, YSC 20, YSC 36, YSC 37, YSC 38, YSC 60, YSC 66, YSC 68, YSC 84, YSC 86, YSK 8501, YSP 842, YST 151, YSWB 952 and YSWB 955. These entries were evaluated in randomized block design with two replications during *rabi* 2007 and *rabi* 2008 at the experimental farm of ICAR Research Complex for NEH Region, Sikkim

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Centre, Tadong, Gangtok which represent the mid hills of Sikkim (1,350 m amsl). Each genotype was sown in 3 rows of 2 m length with spacing of 30 cm x 15 cm.

Observations were recorded on five randomly selected plants in each replication and in each genotype for eight characters namely, plant height (cm), number of primary branches, days to 50% flowering, days to maturity, number of siliqua/plant, length of siliqua (cm), number of seeds/siliqua and yield/plant (g). The combined analysis of variance was performed as per the statistical procedures (Gomez and Gomez, 1984). The variance (GCV and PCV) were estimated following Burton and Devane (1953), heritability in broad sense by Hanson (1963) and genetic advance following Johnson (1955). Mahalanobis (1936) D^2 - statistic analysis was used for assessing genetic divergence among the test entries. The clustering of D^2 values was formed by using Tocher's method as described by Rao (1952) while the intra- and inter-cluster distance was calculated using formula given by Singh and Choudhary (1985). Statistical software INDOSTAT was used for analysis.

Results and Discussion

The yellow sarson genotypes expressed significant variation for all the eight quantitative traits studied as shown by combined analysis of variance (Table 1). Environment plays a major role in expression of quantitative characters and is highly influenced by G x E interaction. Our studies found non-significant variation in all the eight characters when combined variance was computed for two years which signifies that the lines performed consistent in both the years of testing with nil year x variety effect on the characters studied. The extent of genetic variation in characters studied suggests that selection can be exercised in the material either by identifying the suitable donors for traits or selecting the most diverse genotypes for obtaining heterotic progenies.

Ten genotypes *viz.*, *Jhumka* (147 cm), YSC 38 (148 cm), YSC 20 (150 cm), PROYS 2105 (150 cm), YSC 84 (154 cm), PROYS 9805 (156 cm), YST 151 (163 cm), YSK 8501 (165 cm), PS 66 (165 cm) and NDYS 2 (166 cm) were significantly taller than the general mean (135.02 cm). Genotype YSC 38 recorded maximum number of primary branches (9.50). Days to 50% flowering in the mid-hills of Sikkim was seen at 34^{th} day after sowing in IC374356, SKYS 17, RS 1, SSY 1 and YSWB 955 whereas, the flowering was delayed till 48^{th} day in genotypes like PROYS 9805 and PS 66. Days to maturity ranged from 143 days in IC374356 to 156 days in PS 66. The average days to maturity of 42 yellow sarson genotype tested in the mid-hills of Sikkim was 145.83 days. Wide variation in number of siliqua/plant was noticed among the entries with range between 77 in IC396852 to 352 in PYS 9804.

High siliqua number/plant was recorded in genotypes Pusa Gold (207), PROYS 9805 (207), IC374356 (210), YSC 68 (210), NDYS 9504 (223), YSC 60 (224), YSK 8501 (240), SSY (245), YSC 20 (247), PS 66 (249), YSC 66 (261), NDYS 2018 (262), YSC 36 (277), YSC 37 (280), SKYS 37 (280), YSWB 952 (312), GS 1 (316), YSC 38 (345) and PYS 9804 (352). Genotype RS 1 exhibited longest siliqua length (8.70 cm) higher than the general mean of 5.12 cm. The number of seeds/siliqua varied from 14 in genotype PYS 2005 to 40 in IC398652. Seven genotypes namely, YSC 20 (28 seeds/siliqua), IC385670 (31 seeds/siliqua), IC385678 (32 seeds/siliqua), IC385666 (35 seeds/siliqua), PS 66 (36 seeds/siliqua), IC385704 (38.50 seeds/siliqua) and IC398652 (40 seeds/siliqua) showed superiority in seeds/siliqua among test entries. Seed yield, an important

Table 1. Combined ANOVA over two years for eight quantitative traits in yellow sarson

Source of variation	df	Plant height (cm)	No. of primary branches	Days to 50% flowering	Days to maturity	No. of siliqua/ plant	Length of siliqua (cm)	No. of seeds/ siliqua	Yield/ plant (gm)
Year	1	45.79*	9.27*	0.03	2.62	21.39*	38.41*	27.85*	17.16*
Replications within year	2	0.37	0.81	2.43	0.39	0.54	0.17	6.59*	0.12
Variety	41	181.06*	1.81*	4.63*	5.00*	1452.05*	4.20*	35.18*	15.54*
Year x Variety	41	0.13	0.03	0.03	0.01	0.06	0.10	0.09	0.05
Pooled error	82								

* refers to significant at 1% probability level

economic trait, ranged from 2.83g/plant to 9.67 g/plant with an overall mean of 5.80g/plant. Seven genotypes GS-1 (7.67g/plant), Jhumka (7.83g/plant), NDYS 9504 (7.83g/plant), Ragini (8.67g/plant), NDYS 2018 (9.33g/plant), SSY 1 (9.27g/plant) and Pusa Gold (9.67g/plant) performed consistently well during course of study (Table 2).

The estimates of environmental coefficient of variation (ECV%), genotypic coefficient of variation (GCV%), phenotypic coefficient of variation (PCV%) and expected genetic advance (GA) for eight yield related characters of 42 yellow sarson genotypes grown at the mid hills of Sikkim is presented in Table 3. The PCV value of all the characters (plant height, days to 50% flowering, days to maturity, number of siliqua/plant, length of siliqua, number of seeds/siliqua and yield/plant) except number of primary branches were greater in magnitude than the value of GCV or ECV for the corresponding characters which imply that the apparent variation seen for these characters in the above genotypes is not only due to genotypes but also due to the influence of environment. The extent of influence of these two determinants (environment and genotype) on the phenotype can be assessed from the magnitude of GCV and ECV. In the case of number of primary branches, the value of ECV was relatively higher (22.63%) than the GCV (8.46%) and PCV (18.10%) which indicates that the environment has played greater role in the expression of the trait and therefore, for the improvement of number of primary branches selection will not be effective at all.

For characters such as days to 50% flowering and siliqua length the magnitude of ECV was lesser than the value of PCV but greater than the value of GCV which is the sign of predominance role of environment on the expression of these trait than the influence of genotype. For traits such as plant height, days to maturity, number of siliqua/plant, number of seeds/siliqua and seed yield/plant, the difference between GCV and PCV was narrow. The narrow difference is suggestive of the fact that phenotypic variation was determined by and large by genotype with negligible influence of extraneous factors and therefore,

Table 2. The performance of selected high yielding genotype in the mid-hills of Sikkim

High yielding genotypes	Plant height (cm)	No. of primary branches	Days to 50% flowering	Days to maturity	No. of siliqua/plant	Length of siliqua (cm)	No. of seeds/ siliqua	Yield/ plant (g)
GS 1	130.00	8.00	39.00	153.00	316.00	3.80	18.00	7.67
Jhumka	147.00	8.50	43.00	146.00	168.00	4.90	16.00	7.83
NDYS 9504	137.00	7.00	44.00	148.00	223.00	4.70	18.00	7.83
Ragini	127.00	9.00	36.00	144.00	133.00	5.10	18.00	8.67
NDYS 2018	110.00	8.00	36.00	143.00	262.00	4.50	15.50	9.33
SSY-1	137.00	7.50	34.00	145.00	245.00	5.80	20.00	9.27
Pusa Gold	130.00	6.00	40.00	146.00	207.00	6.00	23.00	9.67
Minimum	95.00	4.00	34.00	141.00	77.00	3.20	14.00	2.83
Maximum	166.00	9.50	48.00	156.00	352.00	8.70	40.00	9.67
Mean	135.02	6.95	39.40	145.93	196.81	5.12	22.31	1.70
CD (5%)	10.99	NS	6.81	8.10	7.50	1.89	4.25	1.70
CV %.	1.83	22.62	8.54	2.92	1.97	18.43	9.89	14.69

Table 3. Estimates of variability and genetic parameters among 42 genotypes of yellow sarson evaluated at mid-hills of Sikkim

Parameters	Plant height (cm)	No. of primary branches	Days to 50% flowering	Days to maturity	No. of siliqua/ plant	Length of siliqua (cm)	No. of seeds/ siliqua	Seed yield/ plant (g)
ECV %	1.83	22.63	8.55	2.92	1.97	18.43	9.90	14.70
GCV %	12.72	8.46	6.90	3.91	36.62	14.33	27.60	28.16
PCV %	12.79	18.10	9.17	4.42	36.64	19.37	28.48	30.02
h^2 (BS)	0.99	0.22	0.57	0.78	1.00	0.55	0.94	0.88
GA as % of Mean 5%	26.08	8.15	10.70	7.11	75.38	21.84	55.12	54.42

selection for such traits will be rewarding as also reported by Khan *et al.* (2006). Among the eight traits under study, greater magnitude of phenotypic variation was recorded for number of siliqua/plant (36.64%) followed by number of seeds/siliqua (28.48%). For improvement of these traits under mid-hill conditions the genotype donors PYS 98014 (352 siliqua/plant), IC398652 (40 seeds/siliqua) and Pusa Gold (9.67g/plant) could very well be utilized for improving number of siliqua/plant, seeds/siliqua and seeds yield/plant, respectively.

Heritability in broad sense was the highest for number of siliqua/plant followed by plant height, number of seeds/siliqua and yield/plant. Barring plant height, in the other traits mentioned above, the high heritability value was coupled with high genetic advance (50%). This situation most likely occurs if preponderance of additive gene action prevails as reported by Misra *et al.* (2007). Therefore, direct selection based on phenotypic observations may be effective for improvement of number of siliqua/plant, number of seeds/siliqua and seed yield/ plant.

The 42 yellow sarson genotypes were grouped in to 9 clusters in which three clusters (VI, VIII and IX) were solitary in nature (contain only one genotype in each cluster) while the other six were multi-genotype clusters. The distribution pattern of genotypes in various clusters reflected the considerable genetic variability present in the genotypes under study. Cluster I had maximum number of 10 genotypes followed by cluster II with seven genotypes. Cluster IV and V encompass six genotypes each while cluster III and VII consisted of five genotypes each. The constituent genotypes of each cluster are shown in Figure 1. Genotype YSC 37, NDYS 2108 and Binoy were divergent from other genotypes as each one of them represents a separate cluster.

The mean of each character in each cluster are presented in Table 4. Murty and Arunachalam (1966) have opined that hybridization programmes should be formulated in such a way that the parents belonging to different clusters with maximum divergence should be utilized to get desirable transgressive segregants. The genotypes from cluster VIII with highest yield/plant, moderate plant height, earliness for 50% flowering and maturity and cluster IX with shorter plant height, early maturity and genotypes in cluster III with highest number of siliqua/plant could be utilized in hybridization programme for getting desirable segregants and high heterotic response. The inter- and intra-cluster distances are shown in Table 5. The maximum inter-cluster distance (4166.6) was observed between cluster III and V, followed by cluster II and III (3174.53), cluster III and IX (2810.19), cluster V and VI (2656.48), cluster V and VIII (2291.88), and cluster V and VII (2149.79). The intra-cluster distance was the highest (159.44) in cluster VII and lowest (0.00) in cluster VI, VIII and IX. The genotypes grouped in a same cluster would display the lowest degree of divergence from one another, and therefore, crosses made between genotypes belonging to same cluster may not give heterotic progenies or transgressive segregants, as also reported by Singh *et al.* (2009). On the other hand, crosses between genotypes

Table 4. Cluster mean of different characters in yellow sarson genotypes

Cluster	Plant height (cm)	No. of primary branches	Days to 50% flowering	Days to maturity	No. of siliqua/ plant	Length of siliqua (cm)	No. of seeds/ siliqua	Seed yield/ plant (g)
Cluster I	130.70	6.60	38.10	119.70	203.30	5.28	21.55	5.77
Cluster II	139.86	6.50	38.71	121.14	128.00	5.53	21.14	4.95
Cluster III	139.21	8.50	38.60	120.80	324.80	4.80	19.20	6.69
Cluster IV	156.40	7.20	42.60	124.40	179.60	4.78	19.30	5.87
Cluster V	112.50	5.92	41.66	121.17	101.17	4.70	31.75	5.56
Cluster VI	128.00	6.00	37.00	118.00	280.00	5.60	19.00	6.50
Cluster VII	149.83	7.67	39.67	125.67	253.17	5.08	22.67	5.66
Cluster VIII	110.00	8.50	36.00	118.00	262.00	4.50	15.50	9.33
Cluster IX	95.00	6.00	36.00	114.39	147.00	5.20	22.00	5.00
CV%	15.50	14.81	5.97	2.84	36.37	7.57	20.88	21.59

Table 5. Mahalanobis Euclidean² cluster distances between and within cluster

Cluster	I	II	III	IV	V	VI	VII	VIII	IX
I	101.38	562.03	1262.30	287.75	991.65	524.18	367.62	469.94	513.60
II		70.53	3174.53	326.04	296.46	1948.43	1347.77	1780.12	471.82
III			104.34	1897.60	4166.60	219.55	563.15	474.27	2810.19
IV				115.01	925.57	1087.40	576.00	1116.97	841.01
V					121.11	2656.48	2149.79	2291.88	333.04
VI						0.00	240.88	95.47	1552.54
VII							159.44	419.69	1456.90
VIII								0.00	1160.38
IX									0.00

Diagonal values refers to intra-cluster distance and upper diagonal values refers to inter-cluster distance

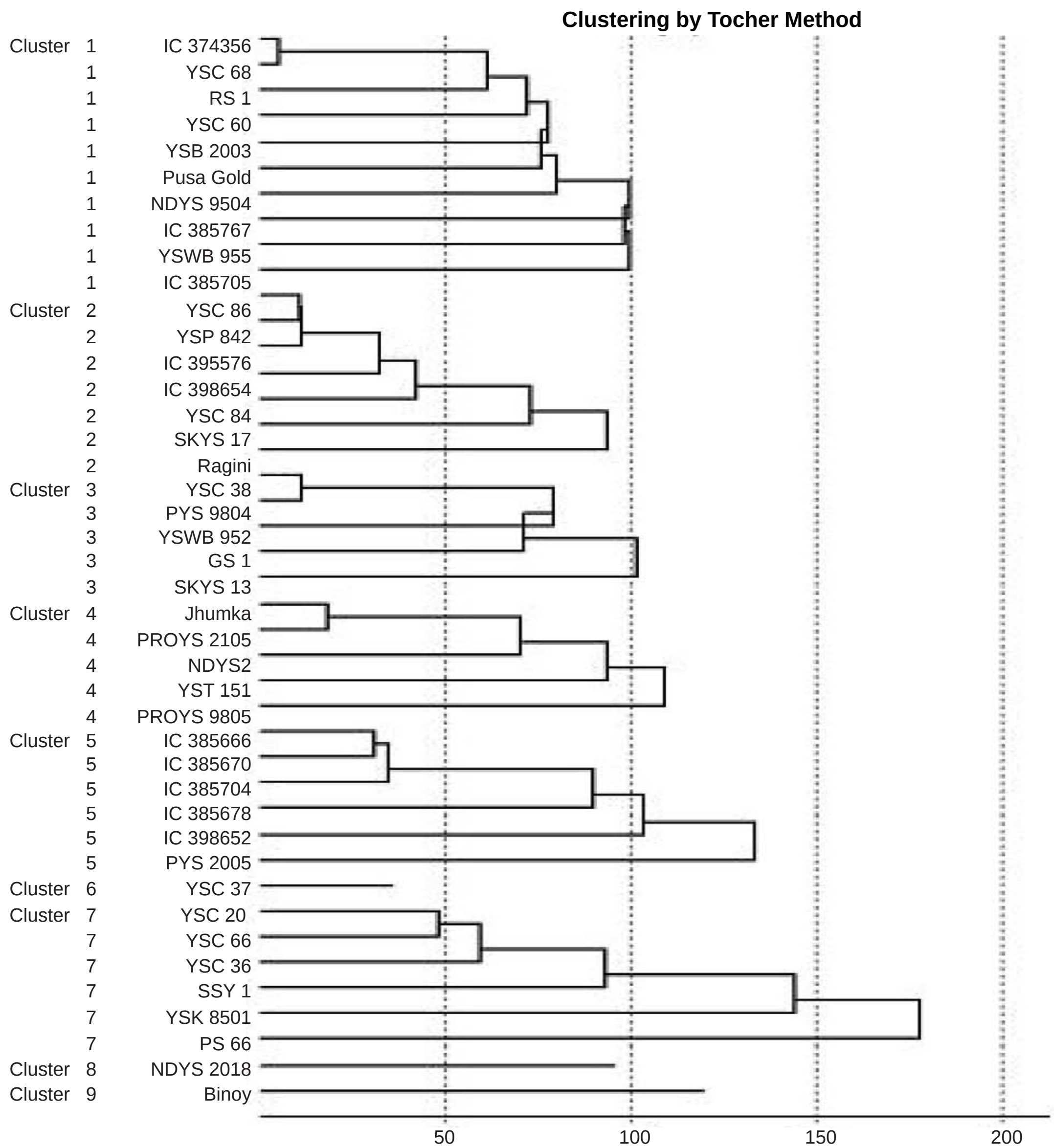

Fig. 1. Clustering of yellow sarson genotypes (Wards' dendrogram) based on Tocher method

belonging to distant clusters like cluster III (SKYS 13, GS 1, YSC 38, YSWB 952 and PYS 9804) and V (IC385666, IC385670, IC385678, IC385704, IC398652 and PYS 2005), cluster III and cluster II (IC395576, IC398654, SKYS 17, YSC 86, RAGINI, YSC 84 and YSP 842) and cluster V with cluster VI (YSC 37), VI (YSC 20, YSC 66, YSC 36, YSK 8501 and PS 66), VIII (NDYS 2108) would result in heterotic progenies and sometime transgressive segregants as reported by Aunwinithul *et al*. (2004).

The contribution of individual characters towards divergence was assessed by ranking d_1 $(=Y_i^j - Y_i^k)$ values. In the present study, the number of siliqua/plant has contributed maximum towards divergence followed by plant height (Table 6). At inter-cluster level the number of siliqua/plant followed by seed yield/plant was the contributor towards divergence. Irrespective of the procedure applied, the number of siliqua/plant is the potential contributor of genetic divergence in yellow sarson. Earlier reports by Singh *et al.* (2009), Somu (2001) and Shalini (1998) also emphasized the contribution of number of siliqua/plant towards genetic divergence.

Our study reports siliqua/plant as the character which contributed maximum to the divergence of the yellow sarson genotypes under mid-hill conditions. This character is directly associated with yield, so scientific acumen can be exercised in selection of these economic characters in yellow sarson. Based on our studies genotypes Pusa Gold, NDYS 2018, SSY-1, Ragini, Jhumka, NDYS 9504 and GS-1 showed superiority in terms of yield and other component traits and can be promoted for cultivation in organic and mid-hill conditions.

Table 6. Contribution of characters towards divergence in 42 yellow sarson genotypes

Characters	Number of times ranked first	Percent contribution
Plant height	162	16.84
Number of primary branches	0	0.00
Days to 50% flowering	0	0.00
Days to maturity	2	0.00
Number of siliqua/plant	661	78.86
Length of siliqua	4	0.46
Number of seeds/siliqua	17	2.32
Seed yield/plant	12	1.51

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