*Indian J. Genet.*, 70(2): 197-200 (2010)

*Short Communication*

# Environmental sensitivity of parents and their crosses for combining ability and rank correlation in *Brassica rapa* L. var. Yellow Sarson

**A. K. Singh, A. K. Mall*[1], Ram Bhajan and O. N. Singh[1]**

Department of Genetics and Plant Breeding, N.D. University of Agril. and Tech., Kumarganj, Faizabad 224 229
[1]Crop Improvement Division, Central Rice Research Institute, Cuttack 753 006

(Received: November 2009; Revised: March 2010; Accepted: April 2010)



*Brassica rapa* L. var. yellow *sarson* occupies major area in Bihar, West Bengal, Eastern Uttar Pradesh and North Eastern States. Despite several changes in the rapeseed mustard sector, such as development of improved varieties, region specific production technology, India is not yet self sufficient in edible oil production [1]. The yellow *sarson* being autogamous in nature has an edge over out-breeding toria types under adverse weather situations such as foggy and cloudy conditions. However, varieties good in *per se* performance may not necessarily produce desirable progenies when used in hybridization. Knowledge about combining ability is important in selecting suitable parents for hybridization, proper understanding of underlying inheritance of quantitative traits and also in identifying the promising crosses for further use in breeding programme. However, environmental effect greatly influences the combining ability estimates.

Twenty seven $F_1$'s derived using line (9) x tester (3) mating design along with parents were grown during dry season of 2003-04 at the Genetics & Plant Breeding Farm ($E_1$) of Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad and Crop Research Station ($E_2$), Masodha, Faizabad (U. P.) in a randomized complete block design with three replications. In both experiments each entry was grown in three rows of three meter length. The spacing between row to row and plant to plant was 30 and 15 cm, respectively. The experimental area was fertilized at the rate of 60: 30: 30 kg NPK $ha^{-1}$ with three irrigations. Plant height (PH), length of main raceme (LMR), number of primary branches per plant (PB/P), number of siliquae on main raceme (SMR), number of siliquae per plant (S/P), number of seeds per siliqua (S/S), 1000-seed weight (TW), seed yield per plant (SY/P) and oil content (OC) were recorded on 10 plants taken from each replication randomly. Data were recorded for days to 50 per cent flowering (DFF) and days to maturity (DM) on plot basis. The mean values of all these 11 traits were used for combining ability analysis as suggested by Kempthorne [2]. The degree of dominance and heritability in narrow sense ($h^2n$) were calculated using the formula given by Kempthorne and Curnow [3]. The spearman's rank correlation coefficient ($r_s$) was calculated according to Spearman [4].

Pooled analysis of variance for combining ability reflected significant difference with locations, testers and lines for all the traits except OC for females and DM for males (Table 1). The females x males and females x locations interactions were significant for all the traits except TW while, testers x locations interaction were significant for all the traits except for DFF, LMR and TW only. This indicated that combining ability of males and females was considerably influenced by locations. The significant differences observed with (females x males) x locations for all the traits except TW and SY/P, suggested that performance of hybrids with respect to component traits was considerably influenced by

*Corresponding author's e-mail: ashutoshkumarmall@gmail.com
Published by Indian Society of Genetics & Plant Breeding, F2, First Floor, NASC Complex, PB#11312, IARI, New Delhi 110 012
Online management by indianjournals.com

environments. These results are in confirmation with the earlier finding [5, 6].

*Estimates of component of variance, degree of dominance and heritability in narrow sense*

The highest and lowest gca variance ($\sigma^2 g$) was noted for siliquae on main raceme (6.64) and OC (0.02) in $E_1$. The highest $\sigma^2 g$ was exhibited by S/P (49.54) and lowest for DM (0.03) in $E_2$. The PH under both the environments was found with highest sca variance ($\sigma^2 s$) (154.35 in $E_1$ and 94.17 in $E_2$), while it was lowest for DF (0.05 in $E_1$ and -5.10 in $E_2$). All the traits except S/P and SY/P had higher $\sigma^2 s$ than $\sigma^2 g$ under both the environments (Table 2), indicating pre ponderance of non-additive type of gene action in the inheritance of these traits. The results of average degree of dominance further, confirmed these observations. The results were in agreement with the earlier findings [6, 7] and indicated depletion of additive variance for OC among yellow *sarson* strains [8]. High estimates of heritability in narrow sense were recorded for S/S (58.28 per cent in $E_1$ and 48.56 per cent in $E_2$) followed by SMR (38.90%) in $E_1$ and TW (47.92%) in $E_2$. Low estimates of heritability $h^2 n$ were recorded for LMR, PH and DFF under both the environments.

**Estimates of general and specific combining ability effects**

The parent NDYS-9802 was a good general combiner for earliness of maturity as revealed by significant negative GCA effects. Similarly, NDYS-120 possessed favorable genetic architecture for imparting early flowering. The parents *viz*., NDYS-128 (0.24** in $E_1$ and $E_2$), NDYS-139(0.25** in $E_1$ and 0.26** in $E_2$), NDYS-2 (0.71** in $E_1$ and 0.70** in $E_2$) and NDYS-921 (0.13** in $E_1$ and 0.14** in $E_2$) displayed greater potentiality as good general combiners for SY/P in both the environments. These parents also showed desirable GCA effects for two or more component traits [6]. The parent NDYS-921 was the only parent that emerged as high GCA parent, simultaneously for both the end-products namely SY/P and OC in both the environments. It was observed that GCA effect of the parents were not associated with their *per se* performance for majority of the traits as revealed by non-significant rank correlations. Thus, it can be inferred that choice of parent for breeding to improve yield and its contributing traits should be based on the estimates of GCA effects as well as on their *per se* performance. These results were not in agreement with certain previous reports where a positive association between GCA estimate and *per se* performance of parents was observed [8, 9].

**Table 1.** ANOVA for combining ability (Pooled analysis) over two locations in yellow *sarson*

| Sources of variation | d.f. | DFF | DM | PH(cm) | LMR(cm) | PB/P | SMR | S/P | S/S | TW(g) | SY/P(g) | OC (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Locations | 1 | 445.00** | 410.89** | 916.92** | 8.47** | 185.43* | 8.45** | 10.25** | 20.58** | 22.95** | 258.35** | 9.72** |
| Replications/ locations | 4 | 0.14 | 0.68 | 129.67** | 21.47** | 1.24 | 6.52** | 14.58** | 2.42 | 0.13 | 0.70 | 0.33 |
| Lines | 8 | 7.53** | 6.33** | 1010.88** | 105.49** | 6.16** | 387.03** | 233.65** | 349.50** | 3.30** | 11.21** | 0.30 |
| Testers | 2 | 1.37** | 1.34 | 337.70** | 80.09** | 17.20** | 69.58** | 7.91** | 31.65* | 1.22** | 0.24** | 0.66 |
| Lines x Testers | 16 | 1.65* | 4.77** | 584.57** | 78.40** | 5.65** | 74.83** | 54.08** | 26.32** | 0.66 | 0.33** | 0.60** |
| Lines x locations | 8 | 5.45** | 8.19** | 95.84** | 56.18** | 7.35** | 17.50** | 615.52** | 7.63** | 0.55 | 0.69* | 0.92** |
| Testers x locations | 2 | 0.16 | 8.80** | 508.73** | 0.90 | 10.78** | 32.52** | 32.42** | 41.18** | 0.19 | 0.90* | 1.15** |
| (Lines x Testers) x locations | 16 | 1.60** | 4.19* | 157.48** | 30.38** | 4.46** | 12.68** | 37.92** | 16.41** | 0.55 | 0.29 | 0.60** |
| Error | 104 | 0.61 | 1.65 | 39.49 | 6.35 | 0.81 | 5.22 | 31.19 | 2.00 | 0.72 | 0.14 | 0.29 |

*, ** Significant at 5% and 1% probability levels, respectively.

**Table 2.** Estimates of components of variance, degree of dominance, heritability ($h^2n$) and per cent contributions of lines, testers and lines x testers for 11 characters and rank correlation in yellow *sarson*

| S.N. | Charac-ters | Environ-ment | *gca* variance ($\sigma^2 g$) | *sca* variance ($\sigma^2 s$) | Average degree of domin-nance $(\sigma^2 s/2\sigma^2)^{1/2}$ | Predic-tability ratio | Herita-bility ($h^2n$) $2\sigma^2/2\sigma^2+\sigma^2 s$ | Per cent contributions Lines (F) | Testers (M) | Lines x testers | Rank correlation *Per se* perfor-mance of | SCA and heterosis over BP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | DFF | $E_1$ | 0.03 | 0.05 | 1.31 | 0.54 | 6.15 | 57.21 | 1.50 | 41.30 | 0.60** | 0.80** |
| | | $E_2$ | 0.19 | -5.10 | @ | @ | 3.00 | 67.79 | 2.01 | 30.20 | 0.65** | 0.82** |
| 2. | DM | $E_1$ | 0.16 | 1.37 | 2.98 | 0.18 | 7.53 | 40.11 | 8.34 | 51.55 | 0.51** | 0.57** |
| | | $E_2$ | 0.03 | 0.33 | 3.21 | 0.16 | 3.49 | 45.30 | 4.27 | 50.43 | 0.71** | 0.79** |
| 3. | PH (cm) | $E_1$ | 3.19 | 154.35 | 6.96 | 0.04 | 2.83 | 22.23 | 12.53 | 65.24 | 0.76** | 0.74** |
| | | $E_2$ | 10.19 | 94.17 | 3.04 | 0.18 | 8.35 | 52.49 | 2.97 | 44.54 | 0.57** | 0.60** |
| 4. | LMR | $E_1$ | 0.25 | 18.27 | 8.55 | 0.03 | 1.76 | 42.20 | 3.88 | 53.93 | 0.70** | 0.25 |
| | | $E_2$ | 0.45 | 13.46 | 5.50 | 0.06 | 4.84 | 37.90 | 6.84 | 55.27 | 0.72** | 0.67** |
| 5. | PB/P | $E_1$ | 0.32 | 1.93 | 2.47 | 0.25 | 21.75 | 13.15 | 26.04 | 60.81 | 0.80** | 0.70** |
| | | $E_2$ | 0.27 | 0.97 | 1.88 | 0.36 | 21.13 | 52.83 | 8.47 | 38.70 | 0.69** | 0.64** |
| 6. | SMR | $E_1$ | 6.64 | 16.26 | 1.57 | 0.45 | 38.90 | 67.60 | 5.16 | 27.24 | 0.45** | 0.72** |
| | | $E_2$ | 3.69 | 10.96 | 1.73 | 0.40 | 15.96 | 59.89 | 3.94 | 36.17 | 0.41** | 0.86** |
| 7. | S/P | $E_1$ | 6.51 | 4.23 | 0.81 | 0.76 | 19.31 | 73.70 | 0.23 | 26.06 | 0.52** | 0.79** |
| | | $E_2$ | 49.54 | 11.53 | 16.90 | 2.73 | 20.62 | 37.00 | 4.97 | 58.03 | 0.27 | 0.93** |
| 8. | S/S | $E_1$ | 5.39 | 5.65 | 1.02 | 0.66 | 58.28 | 74.38 | 8.11 | 17.51 | 0.52** | 0.94** |
| | | $E_2$ | 4.18 | 7.43 | 1.33 | 0.53 | 48.56 | 80.29 | 0.25 | 19.47 | 0.22** | 0.95** |
| 9. | TW (g) | $E_1$ | 0.00 | 0.31 | 8.78 | 0.03 | 2.28 | 6.19 | 84.89 | 8.92 | 0.79** | 0.66** |
| | | $E_2$ | 0.08 | 0.04 | 0.74 | 0.78 | 47.92 | 3.69 | 80.26 | 16.05 | 0.47** | 0.81** |
| 10. | SY/P (g) | $E_1$ | 0.46 | 0.05 | 0.11 | 3.27 | 26.59 | 29.15 | 11.10 | 58.86 | 0.23 | 0.89** |
| | | $E_2$ | 0.45 | 0.02 | 0.07 | 3.68 | 22.87 | 6.63 | 84.74 | 8.63 | 0.40** | 0.58** |
| 11. | OC (%) | $E_1$ | 0.002 | 0.27 | 0.05 | 0.15 | 6.05 | 55.67 | 2.63 | 41.70 | 0.51** | 0.63** |
| | | $E_2$ | 0.05 | 0.23 | 0.08 | 0.39 | 14.60 | 28.04 | 17.53 | 54.42 | 0.12 | 0.78** |

@, not calculated due to negative sign of $\sigma^2_g$; $E_1$: GPB Farm, Kumarganj; $E_2$: CRS, Masodha



Recombination breeding through multiple crosses involving high GCA parents such as NDYS-2 both for SY/P and OC simultaneously, NDYS-128, NDYS-139, and NDYS-921 for seed yield and NDYS-123 and NDYS-921 for OC combining high SCA effects will also be rewarding approach for amelioration of SY/P and OC in yellow *sarson*. From this study, it is suggested that both additive and non additive gene actions are important in controlling various traits in yellow *sarson*. The best combiners were NDYS-128, NDYS-139, NDYS-2 and NDYS-921 and could be utilized in future breeding programmes.

The ranking of hybrids on the basis of *per se* performance was found to be positively correlated to the SCA effect as indicated by the significant rank correlation value for DFF, DM, PH, LMR, PB/P, SMR and TW. For SY/P and OC, the rank correlation estimates were positive in both the cases but emerged significant only in one environment. A perusal of SCA estimates showed that five crosses for SY/P while, two crosses for SY/P and OC (Table 3), displayed desirable SCA effect in both the environments. It was observed that desirable SCA effects for yield of these cross where accompanied by desirable SCA value for one or more of component traits [8]. A noteworthy observation was that all the promising crosses for SY/P and oil content identified on the basis of SCA values combined one good GCA parent and the other with low/average GCA as elsewhere has been reported [6, 10]. It is thus,

**Table 3.** Estimates of specific combining ability (*sca*) effects of promising crosses for yield and their respective characters in yellow *sarson*

| SN | Crosses | Environ-ment | DF | DM | PH (cm) | LMR (cm) | PB/P | SMR | S/P | S/S | TW (g) | SY (g) | OC (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | NDYS-9 x NDYS-2 | $E_1$ | -0.32 | 0.02 | 10.98* | 0.92 | -2.40** | 2.84* | 3.78** | -1.42 | -0.79** | 1.95** | -1.28** |
| | | $E_2$ | 0.81 | 0.43 | 9.34 | -1.58 | -0.29 | 4.70** | 17.87** | 0.43 | 0.02 | 1.94** | -1.27** |
| 2. | NDYS-128 x NDYS-2 | $E_1$ | -0.42 | -0.86 | -0.59 | -3.02 | -0.61 | -2.85* | 1.36 | 1.39 | 0.17 | 0.44* | 0.40 |
| | | $E_2$ | -0.76 | 0.73 | -11.43 | -0.08 | -0.68 | -1.51 | -1.48 | -0.02 | -0.07 | 0.45* | 0.45 |
| 3. | NDYS-139 x NDYS-2 | $E_1$ | 0.06 | 1.17** | 17.31** | 9.74** | -0.38 | 5.64** | 0.36 | -0.63 | -0.40** | 0.94** | -0.20 |
| | | $E_2$ | 1.03* | -0.05 | 8.35 | 2.21 | -0.84 | 5.06** | 7.12** | 0.03 | -0.41* | 0.94** | -0.41 |
| 4. | NDYS-141 x NDYS-2 | $E_1$ | 0.36 | -0.31 | -16.73** | -6.73** | 0.99** | -2.79* | -1.71 | -0.75 | 0.23* | 1.67** | 0.30 |
| | | $E_2$ | -0.28 | -0.68 | 3.09 | -2.13 | 1.52* | -3.55** | 17.69** | -0.01 | 0.48* | 1.66** | 0.32 |
| 5. | NDYS-9 x NDYS-921 | $E_1$ | 0.07 | 0.14 | 8.43 | 0.85 | -1.20** | 0.81 | 5.54** | 1.89* | -0.23* | 0.98** | 0.76* |
| | | $E_2$ | -0.72 | 0.54 | 10.93 | 1.74 | 0.70 | 1.78 | 19.16** | 1.03 | 0.16 | 0.98** | 0.66 |
| 6. | NDYS-123 x NDYS-2 | $E_1$ | -0.99** | -1.09 | -1.18 | 0.48 | -0.83* | -1.50 | -1.26 | -0.31 | 0.65** | 1.33** | 0.78* |
| | | $E_2$ | -0.70 | -0.01 | -4.06 | -3.06* | -0.87 | -2.92** | 18.46** | 0.36 | -0.14 | 1.37** | 0.79* |
| 7. | NDYS-123 x NDYS-921 | $E_1$ | -0.11 | 1.25** | -3.23 | -0.18 | 0.31 | 0.22 | 6.22** | -0.15 | -0.56** | 0.86** | 1.27** |
| | | $E_2$ | 1.35** | 0.77 | 3.55 | 2.56* | -0.32 | 0.61 | -4.77** | 0.30 | -0.11 | 0.86** | 1.28** |

*, **: Significant at 5% and 1% probability levels, respectively.



obvious that these crosses may be expected to produce desirable transgressive sergeants', if additive genetic system operating in good combining parent and epistatic effects in the other parent act in the same direction. The stable crosses *viz*., NDYS-9802 x NDYS-2, NDYS-9 x NDYS-2, NDYS-128 x NDYS-2, NDYS-139 x NDYS-2, NDYS-141 x NDYS-2 and NDYS-9 x NDYS-921 could be used for exploitation of heterosis for seed yield and NDYS-123 x NDYS-2 and NDYS-123 x NDYS-921 for commercial traits *viz*., seed yield and oil content in $F_1$ generation.

## References

1. **Moza M. K.** 2006. New developments in rapeseed mustard. Current Sci., **90**: 1174-1175.
2. **Kempthorne O.** 1957. An Introduction of Genetic Statistics. John Wiley and Sons Inc., New York.
3. **Kempthorne O. and Curnow R. N.** 1961. The partial diallel cross. Biometrics, **17**: 229-250.
4. **Spearman C.** 1904. Rank correlation **In**: Statistical Methods by Snedecor G. W. 1946, Iowa State College Press, Ames Iowa, U.S.A.
5. **Singh P. K., Ram Bhajan and Kumar K.** 2000. Combining ability analysis using genetic male sterility in yellow *sarson* (*Brassica rapa* L.). Cruciferae Newsletter. Nr., **22**: 43-44.
6. **Tripathi A. K., Ram Bhajan and Kumar K.** 2005. Combining ability analysis for seed yield and its components over environments in Indian colza (*Brassica rapa* var. yellow *sarson*). Indian J. Genet., **65**: 137-138.
7. **Yadav I. S. ans Yadava T. P.** 1996. Genetic analysis and combining ability for seed yield and yield components in toria (*Brassica compestris* L. var. *toria*). J. Oilseeds Res., **13**: 84-87.
8. **Singh Y. and Sachan J. N.** 2003. Combining ability analysis for seed yield, and its components in Indian mustard [*Brassica juncea* (L.) Czern & Coss.]. Indian J. Genet., **63**: 83-84.
9. **Katiyar R. K., Chamola R. and Chopra V. L.** 2000. Heterosis and combining ability in Indian mustard [*Brassica juncea* (L.) Czern & Coss]. Indian J. Genet., **60**: 557-559.
10. **Singh P. K., Ram Bhajan and Kumar K.** 2003. Heterosis in male sterility based hybrids in yellow *sarson* (*Brassica rapa* L. var. yellow *sarson*). New Botanist, **30**: 93-97.