Genetic variability in biparental progenies of radish (*Raphanus sativus* L.)

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Abstract

Biparental progenies (BIP's) of inter-varietal cross Mino Early White x Pusa Himani (MEW x PH) of radish were developed in F_2 generation by utilizing North Carolina Design –I suggested by Comstock and Robinson (1948 and 1952). The analysis of variance indicated significant differences among the BIP's and F_3 progenies for different horticultural and quality parameters studied indicating the presence of good quantum of variability between BIP's and F_3 progenies. Biparental progenies when compared with F_3 progenies for their overall mean values revealed that former had greater means for most of the characters except leaf weight, leaf length and nitrate content. The biparental progenies resulted in creation of more genetic variability by breakage of both coupling and repulsion phase linkages that conceal the genetic variability in F_2. The phenotypic variability as revealed by the coefficient of variation (%) was greater in BIP progenies than F_3 progenies. The superior performance of biparental and F_3 generations revealed the breakage of undesirable linkages and plateau effect for bringing further improvement in radish.

Radish (*Raphanus sativus* L.) is an important quick growing, herbaceous root vegetable crop grown for its fresh edible roots throughout the world. It belongs to the family *Brassicaceae* and is probably a native of Europe and Asia. Its different preparations are useful in curing liver and gall bladder problems. Roots are also used for treating urinary complaints and piles (Hazra *et al*. 2013). Inspite of its economic importance, no major strive has so far been made for the improvement of its yield and quality traits. In allogamous crops like radish, the general breeding procedures have been to select desired segregants in the F_2 population, followed by mass selection or combined mass pedigree selection in the subsequent generations.

These methods do not allow growing and testing of large number of plants in F_2 and succeeding generations. These also do not permit repeated inter-crossing required for obtaining desired recombinants better in yield and quality traits. Therefore, conventional breeding methodology is inadequate to create maximum range of useful genetic variability required for switching genetic amelioration endeavour in any crop species for complex character like yield. Inter-mating of randomly selected F_2 plants may overcome these limitations to a considerable extent by accumulating favourable alleles and breaking undesirable linkages. This allows an additional cycle of recombination leading to transgressive segregants. The variability, thus, generated by breaking undesirable linkages can effectively be utilized in the subsequent generations. Biparental mating in early segregating generations would not only help in creating new rare recombinants, but also retain greater variability by breaking tight and unfavourable linkages for selection to be effective for a longer period. Keeping in view the above-mentioned facts, the present investigation based on biparental and F_3 progenies have been undertaken to obtain information on the genetic architecture of root yield and component traits in radish as suggested by Comstock and Robinson (1948 and 1952).

Materials and Methods

The present investigation was carried out at Vegetable Research Farm, CSKHPHV, Palampur (H.P.) in Randomized Block Design (RBD) with three replications for root yield, quality traits and yield contributing components. The experimental material was developed from an inter-varietal cross *viz*., Mino Early White x Pusa Himani (MEW x PH). The

parents were selected based on their genetically diverse origin involving Asiatic and European cultivars.

Biparental progenies were developed in F_2 generations of the inter-varietal cross MEW x PH using North Carolina Design -I as suggested by Comstock and Robinson (1948 and 1952). The biparental progenies were developed by designating four F_2 plants as male parents and crossing each of these to four plants selected as females. The plants used as males and females were chosen at random for the development of biparental progenies and no seed parent was used in more than one mating. The plants used in making the biparental progenies were also selfed. Thus, the family consisted of sixteen progenies (four in each male group). Twenty F_3 families were developed by selfing (4 males and 16 females). The experiment comprised three such sets or a total of 48 biparental progenies and 60 F_3 families. The data on BIP's and F_3 progenies were recorded for root yield, yield components and quality parameters (Table 1).

The method of analysis of variance followed was as proposed by Comstock and Robinson (1948 and 1952). The standard errors of s^2m and s^2f were calculated as per formulae proposed by Moll *et al.* (1960), whereas the standard errors of s^2_A and s^2_D were calculated by the method proposed by Panse and Sukhatme (1984). Expected gains from full-sib family selection were calculated as per procedure outlined by Robinson *et al.* (1949).

Results and Discussion

The analysis of variance indicated significant differences among the BIP's and F_3 progenies for different growth, yield and quality traits studied exhibiting the presence of good quantum of variability between BIP's and F_3 progenies.

Biparental progenies when compared with F_3 progenies for their overall mean values, in general, had greater means for most of the characters (except leaf weight, leaf length and nitrate content) which may be due to more heterozygosity in the former (biparental) progenies. The superior performance of biparental families seems to be primarily due to generation of more genetic variability by breakage of both coupling and repulsion phase linkages that conceal the genetic variability in F_2. The study confirms the findings of Dadlani *et al.* (1983), Lal *et al.* (1990) in cauliflower, Singh and Sharma (1983) in okra and Kumar (1997) in brinjal. Superior mean performance of BIP's over F_2 self's would generally be expected when major portion of total genetic variance is additive and additive x

additive type. In addition, even dominance and epistatic components could play some role towards increase in the mean of BIP's as compared to F_2 self's. These results corroborate with the findings of Kanwar and Korla (2002) and Kumar (1997) in brinjal.

The comparison of biparental and F_3 progenies for root yield per plant revealed that the mean of BIP's (395.2 g) was significantly higher than F_3 progenies (319.3g) in cross Mino Early White x Pusa Himani (MEW x PH). Significantly higher mean values were also observed in case BIP's for root yield per plot, root weight, root diameter, root: top ratio, days taken to maturity and dry matter content. The 't' ratio for leaf weight was negative and significant in cross Mino Early White x Pusa Himani. This suggests that it could be possible to isolate early transgressive segregants.

As regards the range in mean values for the various characters (Table 1), it was observed that the lower value of the range was less in F_3 progenies compared to BIP's and the higher value was high in BIP's as compared to F_3 progenies in most of the cases. Obviously, the proportion of desirable variants increased in the BIP's, which was also accompanied by an increase in the mean performance as stated earlier. Similar results were also reported by Singh and Sharma (1983) in okra, Dadlani *et al.* (1983) and Kumar (1997) in brinjal and Kanwar and Korla (2002) in cauliflower.

The phenotypic variability as revealed by the coefficient of variation (%), was greater in BIP progenies than F_3 progenies for most of the characters. This may be due to the breakage of both coupling and repulsion phase linkage in BIP's. The superiority of BIP's progenies over F_3 progenies with respect to coefficient of variation has also been reported by Singh and Sharma (1983) in okra. However, exceptions were noted in cross for root yield per plot, root length and root: top ratio where the coefficient of variation was higher in F_3 progenies than BIPs. These results substantiated the findings of Dadlani *et al.* (1983) who had also reported superiority of F_3 progenies over BIP's with respect to coefficient of variation in cauliflower.

The BIP's M_2 x F_8, M_1 x F_{17}, M_1 x F_{18}, M_1 x F_{20}, M_2 x F_{24}, M_3 x F_{42} and M_4 x F_{48} resulted in high mean values for root yield, quality traits and yield contributing components. The outstanding cross combinations were M_1 x F_{18}, M_2 x F_8 and M_1 x $F_{17.}$ These combinations manifested increase in root yield to the extent of 72.74, 60.91, 60.24%, 126.47, 110.95, 110.03% and 34.21, 25.02, 24.50% over the respective parents *viz.*, Mino Early White (MEW), Pusa Himani (PH) and the F_1 produced from them. The increase in

Table 1: Range, mean, standard deviation and coefficient of variation for different traits in biparental (BIP,s) and F$_3$ progenies in cross Mino Early White x Pusa Himani (MEW x PH)

Trait	Range@	Mean		Standard Deviation		Coefficient of variation		§t-ratio
		BIP	F$_3$	BIP	F$_3$	BIP	F$_3$	
Root yield (kg/plot$)	2.7-5.5	3.6	3.2	0.6	0.7	22.0	25.1	3.3**
Root weight (g)	170.6-395.2	234.6	216.5	30.1	38.2	24.9	22.4	2.6*
Root length (cm)	19.5-30.6	24.2	22.6	2.3	2.0	42.8	30.1	4.0**
Root girth (cm)	10.8-16.9	14.7	13.5	1.5	1.9	13.0	16.3	4.8**
Root diameter (cm)	3.2-5.1	3.7	3.6	0.4	0.5	13.4	16.1	0.2
Leaf weight (g)	55.4-75.1	65.1	70.1	11.1	10.7	29.8	24.5	-2.3*
Root : top ratio	2.8-4.3	3.6	3.2	0.6	0.7	21.2	26.7	2.9**
Days taken to maturity	50.4-64.5	59.9	57.9	5.9	4.3	11.9	8.8	2.1*
Leaf length (cm)	20.5-35.2	26.1	27.6	5.3	3.7	22.7	25.6	-1.7
Number of leaves	11.6-25.8	16.2	15.3	5.7	3.8	40.8	29.7	0.9
Total soluble solids (%)	5.5-8.1	7.3	7.11	0.6	0.73	11.0	12.52	1.6
Dry matter (%)	4.5-8.1	7.4	6.49	0.7	1.29	21.3	23.49	4.1**
Ascorbic acid (mg/100g)	14.5-22.0	19.7	19.11	2.0	1.77	12.2	10.90	1.8
Nitrate content (mg/100g)	170.1-216.6	189.3	195.07	20.4	17.19	12.4	9.20	-1.5

@ The range has been calculated on progeny mean basis and the figures rounded up to the nearest whole number.
§ t-ratio has been computed for the comparison of biparental (BIP, s) and F$_3$ progenies.
* Significant at P<0.05. ** Significant at P<0.01. $ 0.75 m^2

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root yield by them was 43.56, 33.73, 33.18% and 24.87, 16.32, 15.84% over F_2 and F_3 generations, respectively.

On comparing the coefficient of variation for various characters, it was observed that comparatively high quantum of phenotypic variability was observed in case of root yield per plot, root weight, root length, leaf weight, root: top ratio and number of leaves. The limited variability for most of the characters, in parents probably resulted in narrow coefficient of variation in BIP's and F_3 progenies. In spite of this narrower variability, the increase in root yield in top 5% BIP's was remarkable as found in the plant breeding comparisons. Top 5% BIP's were superior to their corresponding top 5% F_3 progenies, original parents, F_1's and F_2's progenies. Thus, the BIP's assume importance in the improvement of radish by breaking the plateau effect, which has resulted due to fixation of genes and as such transgressive segregants are feasible in radish through biparental mating which could be utilized for the development of high yielding and quality cultivars of radish.

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