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Variability, character association and path coefficient analysis in rat tail radish

D. Jamatia, R.A. Kaushik*, K.D. Ameta and R.B. Dubey
Rajasthan College of Agriculture, Maharan Pratap University of Agriculture & Technology, Udaipur 313 001, Rajasthan

ABSTRACT

Twenty rat tail radish genotypes were evaluated in randomised block design with three replications. Genetic variability, heritability, correlation and path analysis for 15 traits were estimated. The highest genotypic and phenotypic coefficients of variation were observed for yield per plant and number of flowers per plant in comparison to other characters, indicating the presence of high amount of genetic variability for these characters. High heritability estimates coupled with high genetic advance as per cent of mean were also recorded for pod yield per plant and number of flowers per plant. Secondary branches per plant had positive and significant correlations with number of clusters per plant, number of flowers per plant and yield per plant at both genotypic and phenotypic levels. The path coefficient analysis revealed that the number of flowers per plant (14) had highest positive direct effect on pod yield per plant followed by number of seeds per pod (2.92) and secondary branches per plant (2.39). Therefore, greater emphasis should be given on these characters while selecting for higher yield and related traits. The genotypes MPRT-16, MPRT-17, MPRT-12 and MPRT-14 were found superior in terms of high mean values of pod yield per plant. These genotypes may further be utilized in breeding programme aimed at improving pod yield per plant in rat tail radish.

Key words: Rat tail radish, variability, character association, path coefficient analysis.

INTRODUCTION

The rat tail radish or mougri (*Raphanus sativus* var. *caudatus*) belongs to the Cruciferae family, which is very similar to common radish, but does not possess the characteristics fleshy root. This radish comes in the group of edible-podded radish. Thus, *mougri* or rat tailed is grown for its long slender pods, which are eaten as a raw as salad or cooked as a vegetable. The rat tail radish is considered as underutilized vegetable and its cultivation is limited to some isolated locations only. There is no standard known variety of this crop, but it is one of the potential vegetable crops. To make this crop more productive and resistant to diseases and insect pests, breeder have to launch an intensive breeding programme for releasing array of variability. Development of high yielding cultivar requires knowledge of existing genetic variation and also the extent of association among yield contributing characters. The variability is combined estimate of genetic and environmental causes. Correlation and path analysis will establish the extent of association between yield and its component and also bring out the relative importance of their direct and indirect effects and thus, give a clear understanding of their association with yield. Assessment of variation made on truly diverse germplasm provides an idea about the extent of genetic variation. Greater the genetic variability better the chances of improvement of the crop.

Keeping this in view, the present investigation was made to explore the genetic variability, by determining the magnitude of genetic coefficient of variation, heritability estimates and expected genetic advance of different biometric traits, their correlation and effects in a group of 20 rat tail radish genotypes.

MATERIALS AND METHODS

Twenty genotypes of rat tail radish were evaluated in randomised block design with three replications at Hi-Tech Horticulture Farm, Department of Horticulture Farm, Rajasthan College of Agriculture, Udaipur. In each replication genotypes were sown in a plot of 2.25 m × 2 m size accommodating three rows of 2.25 m length spaced 75 cm apart with an intra-row spacing of 50 cm maintained. All the recommended package of practices was followed to raise a good crop. Five competitive plants were marked in each plot per replication and observations were recorded on these plants. Observations were recorded on these plants for plant height (cm), number of secondary branches per plant, flowers per plant, leaves per plant, clusters per plant, pods per cluster, days to first flowering, seeds per pod, length (cm), diameter (mm) and weight (g) of pod, pod yield per plant, TSS (%) of pod and dry matter content (%), the data were recorded on whole plot basis.

*Corresponding author's E-mail: kaushik_ra@yahoo.co.in

Analysis of variance was done by method suggested by Panse and Sukhatme (10). The phenotypic and genotypic coefficient of variation (Burton, 5), heritability (broad sense) and genetic advance were computed. The path coefficient analysis was obtained by following the method of Wright (15).

RESULTS AND DISCUSSION

Analysis of variance indicated significant differences among genotypes for all the characters indicating a good deal of variability in the material used (Table 1). The range of variation was high for number of flowers per plant (414.67- 2188.33) followed by clusters per plant (15.67-64.00) (Table 2). The maximum number of secondary branches per plant, clusters per plant, flowers per plant and pod yield per plant per picking was observed in genotype MPRT-16. The genotypes MPRT-16, MPRT-17, MPRT-12 and MPRT-14 were found superior in terms of high mean values of pod yield per plant per pickings.

A better idea can be gained by comparing the relative amount of coefficient of phenotypic and genotypic variance for the actual strength of variability. The estimates of phenotypic coefficient of variation estimates was generally higher than genotypic coefficient of variation for all the traits studied indicating positive effect of environment on character expression. Among all the characters studied, high genotypic and phenotypic coefficients of variation were observed for yield per plant and number of flowers per plant in comparison of other characters, indicating the presence of high amount of genetic variability for these characters and selection for these characters would be effective because the response to selection is directly proportional to the variability present in the experimental population. Moderate GCV and high PCV was observed for number of clusters per plant and pod weight. Moderate genotypic coefficient of variation and phenotypic coefficient of variation were observed for the secondary branches per plant, number of pods per cluster, pod length and TSS.

The high genetic coefficient of variation for pod yield per plant was also reported by Ali *et al.* (2), Kalia and Shakuntala (8), Basavarajappa and Gowda (4) and Singh (13). With the help of PCV and GCV alone it is not possible to determine the amount of variation which is heritable. The heritability along with genetic advance is more meaningful and helps in predicting the resultant effect of selection on phenotypic expression. Heritability indicates the effectiveness with which selection for genotypes can be done on the basis of its phenotypic variation in the experimental population. The heritability estimates were quite high for the characters, *viz.*, pod yield per plant and number of pods per cluster. These findings are in agreement with the results obtained by Ali *et al.* (2) and Meena *et al.* (9). Singh (13) also reported high heritability for seed yield per plant and yield related characteristics. Moderate heritability was obtained for pod length, TSS, secondary branches per plant, days to flower,

Table 1. Analysis of variance for different characters in rat tail radish.

Trait	Replication (2)	Genotype (19)	Error (38)
Days to first flowering	14.61	64.43**	10.44
Plant height (cm)	654.61*	299.41*	147.30
Secondary branches per plant	19.36**	7.66**	1.187
No. of leaves per plant	738.15**	135.94*	65.69
No. of clusters per plant	710.61**	400.10**	126.50
No. of flowers per plant	437248.12**	528670.73**	7.643
No. of pods per cluster	84.33**	82.56**	6.157
No. of seeds per pod	2.33	5.68*	2.672
Pod length (cm)	19.47	65.84**	7.748
Pod dia. (mm)	4.51**	1.22*	0.616
Av. pod weight (g)	1.81	2.42*	1.052
Days to harvest	67.51	88.67**	35.220
Yield per plant (kg)	0.02**	0.03**	0.002
TSS (%)	1.83**	1.89**	0.220
DM (%)	1.13*	1.84**	0.309

*, **Significant at 5 and 1% levels of significance respectively; Figures in parenthesis are degree of freedom.

Table 2. Mean performance of rat tail radish genotypes for different traits.

Genotype	Days to 1st flowering	Plant height (cm)	Secondary branches per plant	No. of leaves per plant	No. of clusters per plant	Flowers/ plant	Pods/ cluster	seeds/ pod	Pod length (cm)	Pod dia. (mm)	Pod wt. (g)	Days to harvest	*Yield/plant/ picking (kg)	TSS (%)	DM (%)
MPRT- 1	48.67	115.67	9.33	51.67	30.33	758.33	25.33	12.67	24.53	8.36	4.88	81.00	0.16	5.30	8.29
MPRT- 2	46.67	128.00	12.50	67.67	34.67	1209.00	37.83	12.20	25.10	8.85	5.37	78.00	0.27	6.10	8.77
MPRT- 3	50.00	126.17	11.83	63.67	25.67	597.00	24.37	10.28	19.70	7.13	3.67	81.00	0.19	5.93	9.47
MPRT- 4	57.00	110.67	11.40	55.67	26.00	780.00	30.33	8.83	19.33	7.45	3.72	80.00	0.29	5.83	9.83
MPRT- 5	51.33	118.33	12.07	61.00	32.67	716.33	25.67	10.61	26.83	7.92	4.98	78.00	0.23	6.43	9.86
MPRT- 6	47.00	122.33	10.57	69.00	32.33	910.00	32.67	8.00	10.17	9.68	2.75	82.67	0.17	6.10	8.42
MPRT- 7	53.00	130.00	12.20	68.33	25.00	893.33	38.83	11.83	24.30	8.21	5.00	78.33	0.23	5.33	8.49
MPRT- 8	48.00	138.00	13.01	63.67	43.33	1038.00	28.33	10.11	22.32	8.32	3.44	81.00	0.22	5.13	7.54
MPRT- 9	47.33	144.50	12.30	58.67	35.00	758.33	25.17	9.55	22.40	8.52	4.05	74.67	0.16	4.27	8.03
MPRT- 10	44.33	127.17	12.80	69.33	37.67	1000.00	29.67	9.22	20.67	8.70	3.56	72.67	0.20	5.87	8.27
MPRT- 11	54.00	131.33	13.17	65.00	24.00	761.67	33.33	8.77	12.97	7.08	2.53	84.67	0.08	6.00	7.58
MPRT- 12	44.33	139.50	14.67	64.67	42.00	1695.67	40.67	10.72	25.97	8.88	4.00	68.67	0.34	6.13	9.13
MPRT- 13	42.67	142.00	10.98	64.00	43.33	1258.33	35.50	11.43	22.40	7.95	4.74	66.33	0.22	5.87	8.01
MPRT- 14	47.00	141.50	11.73	78.00	35.67	1330.00	38.00	10.37	23.12	7.94	4.20	74.67	0.30	5.97	8.14
MPRT- 15	46.33	130.17	10.33	74.33	26.33	667.67	25.23	10.00	25.92	8.86	4.72	77.00	0.17	5.57	7.75
MPRT- 16	43.33	123.33	15.70	74.00	64.00	2188.33	34.17	10.03	22.75	8.17	4.46	69.33	0.52	7.13	9.25
MPRT- 17	45.33	125.00	13.27	69.00	58.00	1523.33	25.83	10.83	21.90	8.43	3.95	75.67	0.45	6.43	9.87
MPRT- 18	61.00	108.50	9.50	58.33	15.67	414.67	26.33	7.67	11.43	7.45	2.22	88.00	0.14	8.27	9.04
MPRT- 19	48.33	127.17	11.20	57.33	27.00	856.67	31.67	10.83	19.70	7.93	4.50	81.00	0.27	5.57	8.26
MPRT- 20	48.67	128.33	10.43	59.67	28.67	937.67	33.00	12.22	21.93	8.29	5.35	79.67	0.24	5.73	7.50
GM	48.72	127.88	11.95	64.65	34.37	1014.72	31.10	10.31	21.17	8.21	4.10	77.62	0.24	5.95	8.57
CD (5%)	5.34	20.06	1.80	13.40	18.59	456.95	4.10	2.70	4.60	1.30	1.70	9.81	0.08	0.78	0.92
CV (%)	6.63	9.49	9.12	12.54	32.73	27.25	7.98	15.86	13.15	9.57	24.99	7.65	19.20	7.97	6.47

*Average of ten pickings

dry matter content, number of flowers per plant and plant height, whereas, low estimates were recorded for number of cluster per plant, days to harvest, pod weight, number of seeds per pod, number of leaves per plant, plant height, pod diameter (Table 3).

Heritability estimates singly do not able to provide reliable information about the gene action governing the expression of a particular trait present in the population. Johanson *et al.* (7) had given statement that the heritability estimates along with genetic advance were more useful than heritability estimates alone in predicting the response to selection. In the present investigation, genetic advance as per cent of mean was also estimated in order to determine the relative merits of different characters or traits that can be further utilized as a selection parameter in plant breeding programme. High heritability estimates coupled with high genetic advance as per cent of mean were recorded for pod yield per plant and number of flowers per plant. These results are confirmed by the findings of Ali *et al.* (2), Kalia and Shakuntala (8), and Singh (13). High heritability with moderate genetic advance was recorded for number of clusters per plant and pod length. Similar results were reported by Acharya and Patti (1). Singh *et al.* (14) found higher heritability along with high genetic advance for plant height. High heritability with high genetic advance as percent of mean was observed for yield per plant and number of flowers per plant. The potential productivity of any crop is basically valued in terms of yield per unit area. Its improvement by direct selection is generally difficult because yield is governed by complex polygenic character largely influenced by its various component characters as well as by the environment. Hence, it becomes essential to estimate association of yield per plant with yield contributing characters and among themselves. The knowledge of magnitude and direction of correlation is used for judging how improvement in one character will cause simultaneous change in the other characters.

Data presented in Table 4 indicated that plant height had positive and significant correlations with number of pod per cluster, whereas, TSS (rg - 0.51*) showed negative and significant correlation both at genotypic level only. These results were supported by Acharya and Patti (1), Aytac *et al*. (3) and Sadat *et al.* (11). Secondary branches per plant had positive and significant correlations with number of clusters per plant, number of flowers per plant and yield per plant at both levels. Number of leaves per plant had positive and significant correlation with number of clusters per plant, number of flowers per plant, number of pods per cluster, pod diameter, and yield per plant at genotypic level only. Number of clusters per plant showed positive and significant correlations with number of flowers per plant at both levels while it was negative and significant with days to harvest. Number of flowers per plant showed positive and significant correlations with yield per plant and pods per cluster at both levels and genotypic level, respectively.

Table 3. Estimates of genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability (h^2), genetic advance (GA) and genetic gain (GG) for different traits in rat tail radish.

Trait	GCV (%)	PCV (%)	h^2 (%)	GA	GG (%)
Days to first flower	8.71	10.95	63.28	6.95	14.27
Plant height (cm)	5.57	11.00	25.60	7.42	5.80
Secondary branches per plant	12.30	15.31	64.54	2.43	20.35
No. of leaves per plant	7.49	14.60	26.28	5.11	7.90
No. of clusters per plant	27.79	42.94	41.88	12.73	37.04
No. of flowers per plant	38.26	46.97	66.36	651.52	64.21
No. of pods per cluster	16.23	18.08	80.53	9.33	30.00
No. of seeds per pod	9.73	18.60	27.35	1.08	10.48
Pod length (cm)	20.79	24.59	71.42	7.66	36.19
Pod dia. (mm)	5.49	11.03	24.78	0.46	5.63
Pod weight (g)	16.50	29.95	30.35	0.77	18.73
Days to harvest	5.44	9.38	33.60	5.04	6.49
Yield per plant (kg)	40.77	45.07	81.86	0.19	75.99
TSS (%)	12.54	14.86	71.20	1.30	21.79
DM (%)	8.35	10.57	62.47	1.17	13.60

Table 4. Genotypic and phenotypic correlation coefficient between different characters in rat tail radish.

Trait		Days to 1st flower	Plant height (cm)	Secondary branches/ plant	No. of leaves per plant	No. of clusters per plant	No. of flowers/ plant	No. of pods/ cluster	seeds/ pod	Pod length (cm)	Pod dia (mm)	Pod weight (g)	Days to harvest	Yield/ plant (kg)	TSS (%)	DM (%)
Days to first flower	G	1	-0.23	-0.45*	-0.63**	-0.82**	-0.71**	-0.28	-0.61**	-0.51*	-0.88**	-0.58**	0.89**	-0.52*	0.34	0.31
	P	1	-0.38	-0.34	-0.34	-0.63**	-0.60**	-0.17	-0.24	-0.42	-0.38	-0.28	0.68**	-0.31	0.27	0.06
Plant height (cm)	G		1	0.17	0.21	-0.34	-0.01	0.68**	0.12	0.16	-0.05	-0.06	-0.33	-0.31	-0.51*	-1.00
	P		1	0.14	0.26	0.19	0.19	0.17	0.00	0.14	0.15	0.07	-0.37	-0.22	-0.25	-0.35
Secondary branches per plant	G			1	0.55*	0.84**	0.82**	0.39	0.00	0.30	0.06	-0.08	-0.74**	0.68**	0.10	0.31
	P			1	0.35	0.55*	0.66**	0.33	-0.03	0.21	0.03	0.05	-0.34	0.55*	-0.00	0.18
No. of leaves per plant	G				1	0.46*	0.64**	0.55*	-0.44*	0.06	0.46*	-0.33	-0.45*	0.50*	0.22	-0.20
	P				1	0.39	0.42	0.24	0.08	0.18	0.23	0.21	-0.36	0.26	0.12	0.02
No. of clusters per plant	G					1	0.90**	0.26	0.23	0.35	0.39	0.27	-0.80**	1.03	0.11	0.29
	P					1	0.88**	0.03	0.17	0.35	0.28	0.14	-0.63**	0.56*	0.01	0.14
No. of flowers per plant	G						1	0.62**	0.29	0.33	0.37	0.30	-0.86**	0.97**	0.23	0.20
	P						1	0.42	0.21	0.35	0.24	0.19	-0.63**	0.69**	0.10	0.16
No. of pods per cluster	G							1	0.31	0.11	0.32	0.23	-0.57**	0.29	0.04	-0.21
	P							1	0.21	0.11	0.08	0.02	-0.22	0.28	0.04	0.07
No. of seeds per pod	G								1	1.01	0.21	1.42	-0.48*	0.28	-0.53*	-0.17
	P								1	0.54*	0.08	0.56**	-0.23	0.20	-0.23	-0.06
Pod length (cm)	G									1	0.36	1.10	-0.67**	0.43	-0.42	0.08
	P									1	0.07	0.61**	-0.54*	0.28	-0.31	0.09
Pod dia (mm)	G										1	0.00	-0.57**	0.22	-0.39	-0.19
	P										1	0.34	-0.14	0.08	-0.11	-0.18
Pod weight (g)	G											1	-0.72**	0.42	-0.60**	-0.05
	P											1	-0.26	0.20	-0.13	-0.01
Days to harvest	G												1	-0.77**	0.17	-0.06
	P												1	-0.36	0.13	-0.09
Yield per plant (kg)	G													1	0.31	0.57**
	P													1	0.22	0.43
TSS (%)	G														1	0.60**
	P														1	0.33
DM (%)	G															1
	P															1

*, **Significant at 5 and 1% levels, respectively; G, P indicates genotypic and phenotypic correlations, respectively.

Results indicated that these attributes were mainly influencing the yield of rat tail radish. Similar results exhibiting highly significant and positive correlation between yield of rat tail radish and other traits as obtained in the present investigation were reported by Basavarajappa and Gowda (4). These findings indicated that selection for improvement of one character, if successful, will result in the decline in the other characters. Yield per plant showed positive and significant correlation with dry matter content at genotypic level only. Similar results exhibiting highly significant and positive correlations between yield per plot were reported by Basavarajappa and Gowda (4). Thus, the present study supports the earlier findings that selection for plant height, secondary branches per plant, number of leaves per plant, number of flowers per plant, pod yield per plant, pod length and pod weight may bring about simultaneous improvement in pod yield.

Path coefficient analysis was carried out by taking pod yield per plant as dependent variable to partition the correlation coefficients into direct and indirect effects in order to determine the contribution of different characters towards the pod yield per plant. Direct and indirect effects of various characters on pod yield per plant indicated that there is an agreement between direction and magnitude of direct effect of various characters and correlation with pod yield per plant. Thus, a significant improvement in pod yield per plant can be expected through selection in the component traits with high positive direct effects (Table 5). The highest positive direct effect on pod yield per plant was recorded for number of flowers per plant (14.00) followed by number of seeds per pod (2.92), secondary branches per plant (2.39), Days to harvest (1.54) and DM (0.67). Similar results have been reported by Dhatt and Garg (6), Aytac *et al*. (3), and Sharma *et al.* (12). Number of flowers per plant, showed positive and highly significant correlation with pod yield per plant (r = 0.97**) due to its positive direct and indirect effect of days to first flower (2.21), plant height (0.01), number of secondary branches per plant (1.95), number of seeds per pod (0.85) and dry matter (0.13). Number of secondary branches per plant exhibited highly significant and positive correlations with pod yield per plant (r = 0.68**) due to its positive direct and indirect effect of number of flowers per plant (11.54),days to first flower (1.41) and seeds per pod (0.01).

In the present study, the residual effect was 0.2306, which suggested that there might be few more component traits responsible to influence the pod yield per plant than those studied. For the improvement of yield, emphasis should be made on all yield contributing characters which are influencing it directly or indirectly.

Table 5. Direct and indirect effect of different traits on pod yield/ plant (kg) in rat tail radish.

Trait	Days to 1st flower	Plant height (cm)	Secondary br/ plant	No. of leaves/ plant	No. of clusters/ plant	No. of flowers/ plant	No. of pods / cluster	No. of seeds / pod	Pod length (cm)	Pod dia. (mm)	Pod wt (g)	Days to harvest	TSS (%)	DM (%)	Correlation with pod (r) yield /plant
Days to 1st flower	**-3.13**	0.18	-1.07	0.51	9.78	-9.88	1.49	-1.78	1.52	0.16	0.45	1.37	-0.33	0.20	-0.52*
Plant height (cm)	0.73	**-0.78**	0.40	-0.17	4.11	-0.16	-3.68	0.35	-0.47	0.01	0.05	-0.51	0.48	-0.67	-0.31
Secondary branches /plant	1.41	-0.13	**2.39**	-0.44	-10.02	11.44	-2.11	0.01	-0.89	-0.01	0.06	-1.14	-0.09	0.21	0.68**
No. of leaves /plant	1.98	-0.16	1.31	**-0.80**	-5.47	8.97	-2.96	-1.30	-0.19	-0.08	0.25	-0.70	-0.21	-0.13	0.50*
No. of clusters/plant	2.56	0.27	2.00	-0.37	**-11.95**	12.54	-1.41	0.67	-1.04	-0.07	-0.20	-1.22	-0.10	0.19	1.03
No. of flowers/plant	2.21	0.01	1.95	-0.51	-10.70	**14.00**	-3.36	0.85	-0.97	-0.07	-0.23	-1.32	-0.22	0.13	0.97**
No. of pods/cluster	0.86	-0.53	0.93	-0.44	-3.11	8.70	**-5.41**	0.90	-0.32	-0.06	-0.18	-0.88	-0.04	-0.14	0.29
No. of seeds/pod	1.91	-0.09	0.00	0.36	-2.75	4.07	-1.66	**2.92**	-3.01	-0.04	-1.08	-0.74	0.50	-0.11	0.28
Pod length (cm)	1.60	-0.12	0.71	-0.05	-4.17	4.56	-0.58	2.95	**-2.98**	-0.06	-0.84	-1.03	0.40	0.05	0.43
Pod dia. (mm)	2.76	0.04	0.15	-0.37	-4.60	5.25	-1.73	0.61	-1.07	**-0.18**	-0.00	-0.88	0.37	-0.13	0.22
Pod weight (g)	1.83	0.05	-0.20	0.26	-3.19	4.20	-1.27	4.15	-3.29	-0.00	**-0.76**	-1.10	0.57	-0.04	0.42
Days to harvest	-2.79	0.26	-1.77	0.36	9.52	-12.01	3.09	-1.41	1.99	0.10	0.55	**1.54**	-0.16	-0.04	-0.77**
TSS (%)	-1.08	0.39	0.23	-0.17	-1.27	3.26	-0.24	-1.54	1.25	0.07	0.46	0.26	**-0.95**	0.40	0.31
DM (%)	-0.96	0.78	0.75	0.16	-3.45	2.78	1.16	-0.50	-0.23	0.03	0.04	-0.09	-0.57	**0.67**	0.57**

**Significant at 1% levels; G, P indicates genotypic and phenotypic correlations, respectively; Residual = 0.2306; Bold figures in main diagonal indicate direct effects.

In the light above findings, it may be concluded that improvement in the characters like number of flowers per plant, number of secondary branches per plant, number of clusters per plant number of pods per cluster, average pod weight and pod length and days to first flower will help in improving the pod yield in rat tail radish both directly and indirectly. Therefore, these characters should be considered for yield improvement in rat tail radish breeding programme.

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