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# PATH COEFFICIENT ANALYSIS FOR SEEDLING VIGOUR IN RADISH (*Raphanus sativus* L.) GENOTYPES

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**ABSTRACT:** The field study was conducted during 2010 and 2011 to assess the genetic variability, inter relationships and direct and indirect effects of component traits on seedling vigour in radish. High PCV values were obtained in FW (32.68%), SVI I (32.43%) and germination % (30.84%). Magnitude of heritability was highest for SVI II (92.00%) followed by germination (89.45%), 100 SW (84.90%), ASL (83.16%) and SVI I (79.27%). SVI II showed positive and highly significant association with germination %,ASL, seedling FW, DW, 100 SW and SVI I. Path analysis indicated positive direct effect of SVI I, shoot length and 100 seed weight on seedling vigour index II of different radish genotypes. The seedling vigour index I, shoot length, 100 seed weight and germination % exhibited strong positive correlation and positive or negative direct effects on seedling vigour index II emerged as important components contributing to seedling vigour. Therefore, selection primarily based on these traits may lead to identification and development of genotypes having better field emergence and seedling establishment.

***Keywords:*** *Radish, germination, heritability, path coefficient, vigour index.*

Seed is the single most important factor in successful, uniform and high yielding crop. Good seed quality ensures high seedling vigour, better crop establishment and more biomass. Seed vigor is the cumulative impact of complex genetic and eco physiological factors on the growth and development of endosperm and embryo (Sun *et al*, 16). "Seed vigour comprises those properties which determine the potential for rapid, uniform emergence and development of normal seedlings under a wide range of field conditions" (AOSA, 2). Quicker and uniform germination facilitates superior crop yields, whereas slow and non uniform germination due to low seed vigour decreases crop yields (Basra *et al,* 3). Seed vigour determines the ability of the plants to emerge through soil and grow vigourously under varied environmental conditions (TeKrony and Egli, 17). Seedling vigour is determined by various seed and physiological parameters like seed weight or size, germination, seedling dry weight and vigour indices (Awan *et al*, 4). The factors are of immense importance in case seed vigour is used as selection criterion in crop improvement (Evans and Bhatt, 6). Information on character association responsible for seedling vigour among these traits is very limited in radish. Since, radish is a short duration, quick growing crop and depending upon cultivars and season reach marketable maturity in 30-45 days after sowing. True estimation of seedling vigour and its association with contributing characters is very important to raise quick, vigorous and uniform crop stand. Therefore, a preliminary study was conducted to estimate the genetic variability, inter relationship and direct and indirect effects of component traits on seedling vigour in radish for selection of genotypes having superior establishment under field conditions.

## MATERIALS AND METHODS

The experiment was conducted at the Vegetable Research Farm, Punjab Agricultural University, Ludhiana during the winter season of 2010 and 2011. The experiment was laid out in a randomized block design replicated thrice. Planting material consisted of six genotypes of radish (*Raphanus sativus* L.) with three of them commercial cultivars (viz. Punjab Pasand, Punjab Safed and Pusa Chetki) and three advanced lines developed at PAU, Ludhiana (RL 2210, RL 9-1 and RL-25). 200 seeds of each genotype were sown on

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ridges in the first week of October each year. Between ridges and plant spacing were maintained at 45 cm and 7.5 cm, respectively. After one week of germination twenty randomly selected seedlings from each treatment were uprooted and washed carefully to remove soil particles. Data were recorded according to rules established by ISTA (8) on germination (%), seedling shoot length (cm), seedling root length (cm), seedling fresh weight (g), seedling dry weight (g), 100 seed weight (g) and seedling vigour indices I and II. The germination was calculated as per number of seedlings obtained after one week of sowing to the number of seeds sown. For determining seedling dry weight ten randomly selected normal seedlings were dried at 110°C for 17 hours and weighed. For 100 seed weight, 100 seeds were randomly selected from each genotype and weighed on electronic balance. Vigour indices were calculated using the formula given by Abdul-Baki and Anderson (1). The path analysis of direct and indirect effects for seedling vigour was calculated as suggested by Dewey and Lu (5).

## RESULTS AND DISCUSSION

Mean performance of genotypes (Table 1) showed significant existence of variation for various parameters except average seed ling root length (Singh *et al.,* 15). Highest germination was recorded in Punjab Pasand (93.67%) and lowest in Punjab Safed (71.67%) after one week of sowing. Seedling shoot length (ASL) was maximum for Punjab Pasand (13 cm) followed by RL-2210(12.3 cm) which was statistically at par and was least in RL-25 (8.6 cm). ARL (seedling root length) was non significant among all the genotypes. Punjab Pasand also exhibited significantly high values for FW (fresh weight, 9.8 g), seed vigour index I (SVI 1, 1218.37), seed vigour index 2 (SVI 2, 61.16) and 100 seed weight (1.06 g). RL-22 was statistically at par with Punjab Pasand in FW, DW, vigour index 2 and 100 seed weight. RL-25 recorded lowest values for DW (0.41), seedling vigour index 1 (661.3), seedling vigour index 2 (31.55) and 100 seed weight (0.88). Variability among the characters can well be measured by the range and genotypic coefficient of variation. In most of the traits difference between phenotypic (PCV) and genotypic coefficients of variation (GCV) was not too high indicating less impact of environmental fluctuations (Rahman *et al.,* 13). High GCV and PCV values suggest that direct selection of these traits can be more beneficial. Phenotypic coefficients of variations were highest in FW (32.68%), followed by SVI I (32.43%), germination (30.84%), SVI II (27.04 %) and it was least for 100 SW (7.97%).

High magnitude of heritability was observed for all the traits except for SRL (28.87%). Heritability estimates were highest for SVI 2 (92.00%) followed by germination (89.45%), 100 SW (84.90%), SSL (83.16%), FW (80.62%) and SVI 1(79.22%), depicting that selection for these characters can be effective for improving seedling vigour in radish (Saeidi, 14). High heritability and PCV values for FW, SVI I, SVI II and final germination % show dominant effect of genes and thus bear significant effect on determining genetic variability among radish genotypes (Malik *et al.,* 11).

Seed vigour is of utmost importance in early crop establishment and growth. Correlation coefficient (Table 2) for seedling vigour index II showed significantly high and positive correlation with germination, shoot length, fresh and dry weight, 100 seed weight and vigour index I. Genotypes showing better vigour and shoot length would lead to better field performance. (Kamoshita *et al.,* 9). Further genotypic correlation coefficients were generally higher than phenotypic correlation coefficients implying strong association between two characters at genotypic level. From 100 seed weight, results also showed that bolder the seed higher the vigour index (Willenborg, 18). Germination exhibited significant and positive correlation with all the traits except root length, indicating dependence upon these traits on final seedling number (Munir *et al.,* 12). However, root length showed significantly negative correlation

**Table 1: Means, range, phenotypic and genotypic coefficients (PCV and GCV) of variation, heritability and genetic advance of various seedling characters in different genotypes of radish.**

| Genotype | Germ. (%) | ASL (cm) | ARL (cm) | FW (g) | DW (g) | 100 SW (g) | SVI I | SVI II |
|---|---|---|---|---|---|---|---|---|
| Punjab Pasand | 93.67 | 13.00 | 5.57 | 9.80 | 0.65 | 1.06 | 1218.37 | 61.16 |
| RL 9-1 | 73.67 | 9.40 | 5.30 | 6.29 | 0.45 | 0.90 | 694.77 | 33.27 |
| Pusa Chetki | 73.00 | 11.30 | 4.93 | 8.35 | 0.57 | 0.96 | 825.40 | 41.77 |
| RL 2210 | 79.67 | 12.30 | 4.67 | 9.78 | 0.69 | 1.03 | 980.80 | 54.85 |
| PP x AR | 77.00 | 8.60 | 4.93 | 5.49 | 0.41 | 0.88 | 661.73 | 31.55 |
| Punjab Safed | 71.67 | 9.33 | 5.87 | 4.55 | 0.45 | 0.92 | 669.30 | 32.03 |
| C.D.(P=0.05) | 4.99 | 1.42 | NS | 1.92 | 0.15 | 3.10 | 117.06 | 11.40 |
| Mean | 78.11 | 10.65 | 5.21 | 7.37 | 0.49 | 0.95 | 841.72 | 42.43 |
| Range | 73.67-91.67 | 8.6-13 | 4.66-5.86 | 4.55-9.8 | 0.41-0.69 | 0.87-1.06 | 661.73-1 218.36 | 31.54-61. 16 |
| PCV | 30.84 | 17.91 | 11.92 | 32.68 | 25.69 | 7.97 | 32.43 | 27.04 |
| GCV | 29.25 | 16.33 | 6.41 | 29.34 | 19.97 | 7.34 | 28.87 | 25.94 |
| $h^2$ % | 89.45 | 83.16 | 28.87 | 80.62 | 60.42 | 84.90 | 79.22 | 92.00 |

Germination—Germ. Average Shoot Length—ASL, Average Root Length—ARL, Fresh Weight—FW, Dry Weight—DW, 100 Seed Weight—100 SW, Seed Vigour Index I—SVI I, Seed Vigour Index II—SVI II, Phenotypic coefficient of variation (PCV), Genotypic coefficient of variation (GCV), Heritability in broad sense ($h^2$)

**Table 2: Genotypic (G) and phenotypic (P) correlations among different seedling characters in radish.**

| Character | | Germ | ASL | ARL | FW | DW | 100 SW | SVI 1 | SVI II |
|---|---|---|---|---|---|---|---|---|---|
| Germ. | G | 1.000 | 0.738** | 0.261 | 0.710** | 1.703** | 0.805** | 0.879** | 0.908** |
| | P | 1.000 | 0.662** | -0.060 | 0.604* | 0.491 | 0.697** | 0.941** | 0.789** |
| ASL | G | | 1.000 | -0.278 | 0.918** | 0.910** | 0.805** | 0.829** | 0.892** |
| | P | | 1.000 | -0.055 | 0.900** | 0.886** | 0.795** | 0.769** | 0.835** |
| ARL | G | | | 1.000 | -0.731** | -0.708** | -0.089 | -0.335 | -0.010 |
| | P | | | 1.000 | -0.152 | 0.005 | -0.023 | 0.003 | -0.045 |
| FW | G | | | | 1.000 | 0.892** | 0.915** | 0.905** | 0.747** |
| | P | | | | 1.000 | 0.815** | 0.811** | 0.849** | 0.841** |
| DW | G | | | | | 1.000 | 0.809** | 0.879** | 0.908** |
| | P | | | | | 1.000 | 0.697** | 0.754** | 0.881** |
| 100 SW | G | | | | | | 1.000 | 0.895** | 0.924** |
| | P | | | | | | 1.000 | 0.867** | 0.905** |
| SVI 1 | G | | | | | | | 1.000 | 0.910** |
| | P | | | | | | | 1.000 | 0.898** |

*P=0.05, **P=0.01

Germination— Germ., Average Shoot Length—ASL, Average Root Length—ARL, Fresh Weight—FW, Dry Weight—DW, 100 Seed Weight—100 SW, Seed Vigour Index I—SVI I, Seed Vigour Index II—SVI II

**Table 3: Direct and indirect effects of component traits on seed vigour in radish.**

| Trait | | Direct effect | Germ. | ASL | ARL | SFW | SDW | 100 SW | SVI I | Correlation |
|---|---|---|---|---|---|---|---|---|---|---|
| Germ. | G | 0.035 | | 0.539 | -0.001 | -0.015 | -0.594 | -0.070 | 0.921 | 0.815** |
| ASL | G | 0.730 | 0.026 | | 0.001 | -0.020 | -0.753 | 0.095 | 0.812 | 0.891** |
| ARL | G | -0.003 | 0.009 | -0.203 | | 0.015 | 0.598 | 0.008 | -0.414 | -0.010 |
| FW | G | -0.021 | 0.025 | 0.716 | 0.002 | | -0.704 | -0.103 | 0.932 | 0.847** |
| DW | G | -0.844 | 0.025 | 0.755 | 0.002 | -0.033 | | 0.076 | 0.927 | 0.908** |
| 100 SW | G | 0.100 | 0.031 | 0.727 | 0.001 | -0.020 | -0.808 | | 0.896 | 0.927** |
| SVI I | G | 0.918 | 0.028 | 0.730 | 0.001 | -0.020 | -0.842 | 0.095 | | 0.910** |

ASL- Average shoot length, ARL- Average root length, FW- Seedling fresh weight, DW- Seedling dry weight, Germ.-Germination,SVI I-Seed vigour index I,SW-Seed weight, SVI II-Seed vigour index II.

with fresh weight and dry weight. The correlation matrix of component seedling traits showed that improving germination, seedling length, fresh weight and 100 seed weight would improve the seed vigour index and thereby better field establishment (Lafond and Baker, 10).

Correlation estimates give broader indication of interrelationship between component traits which could be misleading due to mutual cancellation of effects of component characters. But path coefficient analysis provides for partitioning of relationships into specific direct and indirect effects depicting the relative influence of each of the causal factors in determining the seedling vigour (Guler *et al.,* 7). Path coefficient analysis taking seedling vigour index II as dependent variable revealed that seedling vigour index I, shoot length and 100 seed weight exhibited strong positive direct effect with SVI II with minor positive contribution from germination %. Correlation and path analysis indicated major positive relationship and contribution of SVI I, ASL and 100 SW, thereby implying that these could be exploited for selection of genotypes with high seedling vigour (Singh *et al,* 15). DW though having significant positive correlation had significant negative direct effect on seedling vigour. FW exerted small negative direct effect but great indirect effect via DW and 100 SW on seedling vigour.

The results from the present study indicated high heritability for germination %, ASL, 100 SW FW, DW and SVI I. These characters also exhibited positive or negative direct effect on seedling vigour index II. Therefore, emphasis should be laid these component traits while selecting genotypes with high seedling vigour index for crop improvement.

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