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ASSESSMENT OF PHENOTYPIC AND GENOTYPIC VARIABILITY WITH CORRELATION AND PATH ANALYSIS IN DIVERSE GENOTYPES OF RADISH (*Raphanus sativus* L.)

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ABSTRACT

The present investigation entitled “Assessment of phenotypic and genotypic variability with correlation and path analysis in diverse genotypes of radish (*Raphanus sativus* L.)” was conducted during the *rabi* season of 2025-26 at the Agricultural Research Farm, School of Agriculture, Abhilashi University, Mandi (Himachal Pradesh). The experiment was laid out in a Randomized Block Design (RBD) with three replications comprising nine radish genotypes (eight test genotypes and one check variety, Japanese White). Observations were recorded on twelve quantitative traits, namely days to 50% germination, plant height, number of leaves per plant, crown diameter, root diameter, root length, days to marketable maturity, average root weight with leaves, average root weight without leaves, root yield per plot, root yield per hectare and total soluble solids (TSS). Analysis of variance revealed significant differences among the genotypes for all the characters studied, indicating the presence of substantial genetic variability. Among the genotypes, R-COH-6 exhibited superior performance for average root weight with leaves, root yield per plot and root yield per hectare, whereas R-COH-3 performed better for root length and also recorded high yield. R-COH-10 recorded the highest average root weight without leaves, while R-COH-1 exhibited the highest total soluble solids. The variability parameters indicated appreciable phenotypic and genotypic variation for most of the traits, suggesting good scope for effective selection. High heritability coupled with high genetic advance was observed for important yield-contributing traits, indicating the predominance of additive gene action and the effectiveness of selection in radish improvement.

Key words : Radish, Genetic variability, Heritability, Correlation, Genotypes.

Introduction

Radish (*Raphanus sativus* L.) is a diploid ($2n = 2x = 18$) root vegetable belonging to the family Brassicaceae and is widely cultivated in both tropical and temperate regions of the world. It is one of the oldest domesticated vegetable crops, believed to have originated in China and Korea. Radish is primarily grown for its fleshy edible roots, which are consumed as salad, cooked vegetable, garnish, or pickle, while its tender leaves and immature pods are also used as vegetables (Lu *et al.*, 2008). The crop is valued for its nutritional composition, being a good source of vitamin C, minerals, dietary fibre, carbohydrates and other health-promoting compounds. In India, radish

is cultivated extensively across several states and contributes significantly to vegetable production, including in Himachal Pradesh where it is an important winter-season crop. The success of any crop improvement programme depends on the availability of sufficient genetic variability. Estimation of phenotypic and genotypic variability provides valuable information regarding the extent of heritable variation present in a population. However, variability alone is insufficient for effective selection. Therefore, the estimation of heritability and genetic advance is essential to determine the proportion of variation that is genetically controlled and to predict the expected improvement through selection (Shivathanu

et al., 2014). High heritability coupled with high genetic advance generally indicates the predominance of additive gene action and enhances the efficiency of selection in breeding programmes. Root yield in radish is a complex quantitative trait influenced by several growth and yield-contributing characters. Understanding the association among these traits is important for identifying effective selection criteria. Correlation analysis measures the degree of association between traits, whereas path coefficient analysis partitions the correlation into direct and indirect effects, thereby identifying the traits that contribute most directly to yield. These statistical tools facilitate the selection of superior genotypes and improve the efficiency of breeding programmes aimed at developing high-yielding cultivars (Roopa *et al.*, 2018).

Materials and Methods

Experimental site

The present investigation was conducted during the *rabi* season of 2025-26 at the Agricultural Research Farm, School of Agriculture, Abhilashi University, Mandi, Himachal Pradesh, India, located in the mid-hill sub-humid agro-climatic zone.

Table 1 : Details of genotypes used in study.

S. no.	Genotypes	Sources
1	R-COH-1	Dr. YSPCOHF, Neri, Hamirpur
2	R-COH-3	Dr. YSPCOHF, Neri, Hamirpur
3	R-COH-4	Dr. YSPCOHF, Neri, Hamirpur
4	R-COH-6	Dr. YSPCOHF, Neri, Hamirpur
5	R-COH-8	Dr. YSPCOHF, Neri, Hamirpur
6	R-COH-9	Dr. YSPCOHF, Neri, Hamirpur
7	R-COH-10	Dr. YSPCOHF, Neri, Hamirpur
8	R-COH-13	Dr. YSPCOHF, Neri, Hamirpur
9	Japanese White(check)	Dr. YSPCOHF, Neri, Hamirpur

Experimental design

The experiment was laid out in a Randomized Block Design (RBD) with three replications comprising nine genotypes including check variety.

Table 2 : Experiment details.

Location	Research Farm, Abhilashi University.
Experimental Design	Randomized Block Design (RBD)
Crop	Radish
Number of genotypes	8 (Cultivars) +1 (Check) =9
Number of replications	3

Spacing	30cm × 8cm
Net Plot size	1.5m × 1.0m
Number of plants per plot	50

Observations recorded

Growth and Yield parameters

The following observations were recorded to evaluate the growth, yield and quality performance of the crop: days to 50% germination, plant height (cm), number of leaves per plant, crown diameter (cm), root diameter (cm), root length (cm), days taken to marketable maturity, average root weight with leaves (g), average root weight without leaves (g), root yield per plot (kg), root yield per hectare (q) and total soluble solids (°Brix).

Disease studies

Under natural epiphytotic conditions, variation in *Alternaria* blight incidence and severity was observed among the evaluated genotypes, indicating differences in their response to disease. Disease incidence and severity were assessed using percentage disease incidence and the 0-5 disease rating scale, respectively. Such variability may be useful in identifying genotypes with comparatively better tolerance for incorporation into breeding programmes.

Statistical analysis

Analysis of variance (ANOVA) was performed according to the procedure described by Gomez and Gomez (1983) for Randomized Block Design. Phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability (broad sense), genetic advance and genetic gain were estimated following the methods of Burton and De Vane (1953), Allard (1960, 1969) and Johnson *et al.* (1955). Genotypic and phenotypic correlation coefficients were calculated according to Al-Jibouri *et al.* (1958), while path coefficient analysis was performed using the method proposed by Dewey and Lu (1959) to estimate the direct and indirect effects of different characters on root yield

Results and Discussion

Analysis of variance

The analysis of variance revealed highly significant differences among the nine radish genotypes for all twelve quantitative traits, namely days to 50% germination, plant height, number of leaves per plant, crown diameter, root diameter, root length, days to marketable maturity, average root weight with leaves, average root weight without leaves, root yield per plot, root yield per hectare and total soluble solids (TSS). The significant variation

Table 3 : ANOVA (Analysis of variance) for various traits of Radish.

S. no.	Traits	Mean Sum of Squares (MSS)		
		Replications	Treatments	Error
1	Days to 50% germination	0.25	11.30*	0.45
2	Plant height (cm)	26.94	30.31*	10.97
3	Number of leaves/plant	0.55	32.76*	0.35
4	Crown diameter (cm)	0.02	0.07*	0.03
5	Root diameter (cm)	0.01	0.45*	0.10
6	Root length (cm)	1.86	50.63*	1.66
7	Days taken to marketable maturity	18.60	61.68*	24.33
8	Average root weight with leaves (g)	79.20	10659.61*	106.26
9	Average root weight without leaves (g)	50.87	3166.52*	32.53
10	Root yield/plot (kg)	0.01	3.69*	0.11
11	Root yield/hectare (q)	367.99	51648.76*	959.81
12	TSS (°Brix)	0.05	2.16*	0.19

observed among the genotypes indicated the existence of considerable genetic variability, providing ample opportunity for effective selection and crop improvement. Similar findings have been reported by Sharma *et al.* (2009), Devi *et al.* (2010), Sharma *et al.* (2011) and Kumar *et al.* (2015).

Mean performance of genotypes

Days to 50% germination

Days to 50% germination indicates earliness and uniformity of seed germination, which is an important trait for assessing seed quality. Genotypes observed for this trait showed significant differences. The values for this trait in the present study ranged from 7.02 to 13.05 days and the mean was 10.80. The mean performance of different genotypes for days to 50% germination presented in Table 4. The mean performance of different genotype revealed that the genotype Japanese White (check) was earliest to germinate and took (7.02) days to attain 50% germination. The maximum days to 50% germination was recorded in genotype R-COH-9 with (13.05) days. Based on mean performance, the genotype R-COH-6 (8.67) days showed relatively better performance and can be considered as promising genotype for days to 50% germination. Nagar (2016) also reported similar findings for days to 50% germination in radish.

Plant height (cm)

Plant height influences plant growth, canopy development and ultimately affects yield and other yield contributing characters. In the present study, plant height ranged from 51.11 to 59.87 cm, with a mean value 55.25 cm, as presented in Table 4. The mean performance of different genotypes revealed that the genotype R-COH-

8 (59.87 cm) has maximum height, which was statistically at par with R-COH-10 (54.87 cm), R-COH-6 (56.73 cm), R-COH-4 (56.72 cm), R-COH-3 (57.60 cm) and R-COH-13 (57.27 cm). However, the lowest plant height was recorded in Japanese White (51.11 cm). Ola *et al.* (2018) and Singh *et al.* (2019) also reported significant differences in the performance of genotypes for plant height in the respective studies.

Number of leaves/plant

Number of leaves per plant is an important growth trait that shows the vegetative growth and health of plant. Highest number of leaves per plant may enhance photosynthesis, efficiency and assimilate production, thereby, contributing to great root biomass accumulates and yield. The trait value ranged from 6.93 to 17.07 with a mean value of 12.45 as presented in Table 4. The maximum number of leaves per plant was recorded in R-COH-3 (17.07), while minimum was observed in R-COH-9 (6.93). The genotype R-COH-1 (15.53) was found to be promising due to its better performance for important horticultural traits and yield contributing characters. These findings were in accordance to those observed by Mallikarjunarao *et al.* (2015), Ola *et al.* (2018) and Singh *et al.* (2019)

Crown diameter (cm)

Crown diameter parameter indicates the vegetative vigour and spread of the plant. A large crown diameter generally reflects better plant growth and development. In the present study, crown diameter ranged from 1.57 to 1.99 cm with a mean value of 1.79 cm as presented in Table 4. The maximum crown diameter was recorded in R-COH-1 (1.99 cm), which was statistically at par with R-COH-3 (1.97 cm), R-COH-4 (1.71 cm), R-COH-8

Table 4 : Mean performance of different horticultural traits of radish.

Genotypes	Days to 50 per cent germination	Plant height (cm)	Number of leaves/plant	Crown diameter (cm)	Root diameter (cm)	Root length (cm)	Days taken to marketable maturity	Average root weight with leaves (g)	Average root weight without leaves (g)	Root yield/plot (kg)	Root yield/hectare (g)	TSS (°Brix)
R-COH-1	11.67	51.80	15.53	1.99	3.36	18.10	56.67	105.40	65.73	3.12	281.04	5.90
R-COH-3	11.19	57.60	17.07	1.97	4.04	22.09	52.00	164.40	125.60	4.27	438.40	4.83
R-COH-4	11.00	56.72	9.73	1.71	3.76	19.23	50.00	102.13	66.67	3.15	272.00	3.03
R-COH-6	8.67	56.73	14.33	1.57	4.21	18.30	46.33	221.20	126.56	5.47	588.80	4.63
R-COH-8	10.00	59.87	9.60	1.72	3.21	16.83	49.00	73.33	53.84	2.14	269.60	4.97
R-COH-9	13.05	51.33	6.93	1.73	4.27	7.53	56.00	135.40	89.53	2.23	188.00	5.83
R-COH-10	12.33	54.87	10.93	1.91	3.55	18.67	58.67	157.40	130.47	4.27	419.20	5.37
R-COH-13	12.33	57.27	14.00	1.65	3.36	20.57	57.86	71.53	52.80	2.45	190.40	5.30
Japanese White (check)	7.02	51.11	13.97	1.86	3.84	18.26	49.00	193.02	92.81	3.21	283.60	4.97
Mean	10.80	55.25	12.45	1.79	3.73	17.72	52.84	126.51	87.88	3.37	325.67	4.98
Min	7.02	51.11	6.93	1.57	3.21	7.53	46.33	71.53	52.80	2.14	188.00	3.03
Max	13.05	59.87	17.07	1.99	4.27	22.09	58.67	221.20	130.47	5.47	588.80	5.90
SE(m)±	0.39	1.91	0.34	0.10	0.18	0.74	2.85	5.95	3.29	0.19	17.89	0.25
CD (P=0.05)	1.16	5.73	1.02	0.30	0.55	2.23	8.54	17.84	9.87	0.56	53.63	0.75

(1.72 cm), R-COH-9 (1.73 cm), R-COH-10 (1.91 cm) and Japanese White (1.86 cm), while the minimum crown diameter was observed in R-COH-6 (1.57 cm). These findings were in line to those obtained by Mallikarjunarao *et al.* (2015), Roopa *et al.* (2018) and Singh *et al.* (2019) in radish.

Root diameter (cm)

Root diameter in radish affects the size and quality of the root. A higher root diameter generally indicates better root development and marketable yield. The values of root diameter in various genotypes of radish ranged from 3.21 to 4.27 cm and the mean was 3.73 cm in Table 4. The maximum root diameter was recorded in R-COH-9 (4.27 cm), which was statistically at par with R-COH-3 (4.04 cm), R-COH-4 (3.76 cm), R-COH-6 (4.21 cm) and Japanese White (3.84 cm). While, the least root diameter was seen in genotype R-COH-8 (3.21 cm) among all the genotypes under study. These findings for root diameter were in confirmation to those recorded by Mallikarjunarao *et al.* (2015), Roopa *et al.* (2018) and Singh *et al.* (2019) in radish.

Root length (cm)

Root length is an important trait that shows the growth and development of radish roots. Longer roots generally contributes to better yield and market quality. The data recorded on root length showed wide range from 7.53 to 22.09 cm and the mean was 17.72 cm in Table 4. The maximum root length was recorded in R-COH-3 (22.09 cm) statistically at par with R-COH-13 (20.57 cm). The minimum root length was recorded in R-COH-9 (7.53 cm) These findings were in line to those obtained by Mallikarjunarao *et al.* (2015), Roopa *et al.* (2018) and Singh *et al.* (2019) in radish.

Days taken to marketable maturity

Days taken to marketable maturity refers to the number of days from sowing to the stage when roots become ready for harvesting and marketing. It is an important

Table 5 : Estimates of phenotypic and genotypic coefficients of variation, heritability and genetic advances for various characters in radish.

S. no.	Parameters	Coefficient of variability		Heritability (%)	Genetic gain (%)	GAM (%)
		Genotypic	Phenotypic			
1	Days to 50% germination	17.67	18.68	78.92	3.69	34.21
2	Plant height (cm)	4.60	7.55	37.02	3.18	5.76
3	Number of leaves/plant	26.39	26.82	86.87	6.66	53.51
4	Crown diameter (cm)	6.19	11.34	29.77	0.13	6.96
5	Root diameter (cm)	9.21	12.49	54.39	0.52	14.00
6	Root length (cm)	22.80	23.93	80.78	7.93	44.75
7	Days taken to marketable maturity	6.68	11.48	33.86	4.23	8.01
8	Average root weight with leaves (g)	46.88	47.58	87.07	120.38	95.15
9	Average root weight without leaves (g)	36.78	37.35	86.98	65.57	74.61
10	Root yield/plot (kg)	32.43	33.82	81.93	2.16	64.04
11	Root yield/hectare (q)	39.91	41.03	84.63	260.48	79.98
12	TSS (°Brix)	16.30	18.46	67.95	1.48	29.65

trait for determining crops earliness and productivity. The trait under study ranged from 46.33 to 58.67 days and the mean was 52.84 days in Table 4. The minimum days taken to marketable maturity was recorded in genotype R-COH-6 (46.33) days which is statistically at par with R-COH-8 (49.00) days, R-COH-4 (50.00) days, Japanese White (49.00) days and R-COH-3 (52.00) days. The maximum days taken to marketable maturity was recorded in R-COH-10 (58.67) days. These results were in accordance to those obtained by Dongarwar *et al.* (2017).

Average root weight with leaves (g)

The higher average root weight with leaves is desirable trait in case of radish as it directly contributes to the higher yields and helps the farmer to increase income. Radish is generally solid in the market with leaves and these leaves are very nutritious hence, they often used to make vegetable. Average root weight with leaves ranged from 50.40 g to 221.20 g and the mean weight was 126.51 g in Table 4. The highest root weight with leaves was recorded in R-COH-6 (221.20 g). The genotype Japanese White was found to be promising due to its better performance for important horticultural traits and yield contributing characters. The minimum average root weight with leaves was recorded in R-COH-9 (50.40 g). Semba *et al.* (2019), Dongarwar *et al.* (2017) and Ola *et al.* (2018) conducted similar studies in radish.

Average root weight without leaves (g)

Average root weight without leaves directly reflects the edible root yield of the radish. The values observed by nine genotypes ranges from 49.62 to 130.47 g with the mean value of 87.88 g in Table 4. The maximum root

weight without leaves was recorded in R-COH-10 (130.47 g) statistically at par with R-COH-6 (126.56 g) and R-COH-3 (125.60 g). The minimum average root weight without leaves was recorded in R-COH-9 (49.62 g). These results were in confirmation to those obtained by Semba *et al.* (2019), Dongarwar *et al.* (2017) and Roopa *et al.* (2018) in radish.

Root yield/plot (kg)

Higher yield is the principal objective in all the crop improvement programmes and thus the root yield per plot is a very important horticultural trait as it directly influences the root yield of radish produced in a unit area. The value for this trait in present study ranges from 2.14 kg to 5.47 kg and the mean was 3.37 kg in Table 4. Maximum root yield per plot was recorded in R-COH-6 (5.47 kg). Based on mean performance, the genotype R-COH-3 (4.27 kg) and R-COH-10 (4.27 kg) showed relatively better performance and can be considered as promising genotype for root yield per plot. Minimum root yield per plot was recorded in genotype R-COH-8 (2.14 kg). These findings for root yield per plot (kg) were similar to those reported by Singh *et al.* (2019), Roopa *et al.* (2018) and Ola *et al.* (2018).

Root yield/hectare (q)

Root yield per hectare is an important yield trait that indicates the total production of roots obtained from a unit area of land. It reflects the combined effect of growth, root development and adaptability of different genotypes under given environmental conditions. The root yield per hectare of selected genotypes ranges from 188.00 to 588.80 q and the mean root yield per hectare is 325.67 q. The maximum root yield per hectare was recorded in R-

Table 6 : Phenotypic correlation coefficients among various traits in radish.

Traits	Days to 50 % germination	Plant height (cm)	Number of leaves/plant	Crown diameter (cm)	Root diameter (cm)	Root length (cm)	Days taken to marketable maturity	Average root weight with leaves (g)	Average root weight without leaves (g)	Root yield/plot (kg)	TSS (°Brix)	Root yield per hectare (q)
Days to 50 % germination	1.00	0.15	-0.29	0.17	-0.12	-0.24	0.51*	-0.66*	-0.35	-0.33	0.29	-0.33
Plant height (cm)		1.00	0.05	0.04	-0.12	0.33	-0.36	-0.10	0.14	0.01	-0.36	0.22
Number of leaves/plant			1.00	0.27	-0.02	0.72*	-0.04	0.56*	0.41*	0.49*	0.08	0.44*
Crown diameter (cm)				1.00	-0.10	0.06	0.13	0.05	0.12	-0.07	0.16	0.01
Root diameter (cm)					1.00	-0.29	-0.31	0.31	0.22	0.43*	-0.12	0.30
Root length (cm)						1.00	-0.12	0.45*	0.45*	0.41*	-0.33	0.37
Days taken to marketable maturity							1.00	-0.31	-0.22	-0.20	0.38*	-0.30
Average root weight with leaves (g)								1.00	0.82*	0.85*	-0.20	0.81*
Average root weight without leaves (g)									1.00	0.84*	-0.10	0.88*
Root yield/plot (kg)										1.00	-0.20	0.91*
TSS(°Brix)											1.00	-0.15

*Significant at 5% level of significance

Table 7 : Genotypic correlation coefficients among various traits in radish.

Traits	Days to 50 % germination	Plant height (cm)	Number of leaves/plant	Crown diameter (cm)	Root diameter (cm)	Root length (cm)	Days taken to marketable maturity	Average root weight with leaves (g)	Average root weight without leaves (g)	Root yield/plot (kg)	TSS (°Brix)	Root yield per hectare (q)
Days to 50% germination	1.00	-0.08	-0.31	0.13	-0.17	-0.28	0.84*	-0.68*	-0.35	-0.30	0.32	-0.38
Plant height (cm)		1.00	0.06	-1.02*	-0.50*	0.64*	-0.23	-0.03	0.34	0.19	-0.56*	0.31
Number of leaves/plant			1.00	0.52*	-0.07	0.76*	-0.13	0.57*	0.42*	0.51*	0.09	0.44*
Crown diameter (cm)				1.00	-0.29	0.38	0.80*	0.19	0.35	0.14	0.54*	-0.05
Root diameter (cm)					1.00	-0.43*	-0.34	0.46*	0.30	0.48*	-0.13	0.46*
Root length (cm)						1.00	-0.17	0.47*	0.45*	0.44*	-0.42*	0.40*
Days taken to marketable maturity							1.00	-0.67*	-0.38	-0.42*	0.81*	-0.56*
Average root weight with leaves (g)								1.00	0.84*	0.89*	-0.20	0.85*
Average root weight without leaves (g)									1.00	0.87*	-0.12	0.92*
Root yield/plot (kg)										1.00	-0.21	0.99*
TSS(°Brix)											1.00	-0.21

*Significant at 5% level of significance

Table 8 : Estimates of direct and indirect effect of different traits on root yield per hectare at genotypic level in radish varieties.

Traits	Days to 50% germination	Plant height (cm)	Number of leaves/plant	Crown diameter (cm)	Root diameter (cm)	Root length (cm)	Days taken to marketable maturity	Average root weight with leaves (g)	Average root weight without leaves (g)	Root yield/plot (kg)	TSS (°Brix)	Root yield per hectare (q)
Days to 50% germination	-0.13	0.01	0.04	-0.02	0.02	0.04	-0.15	0.09	0.05	0.04	-0.04	-0.37
Plant height (cm)	-0.00	0.05	0.00	-0.05	-0.03	0.03	-0.01	-0.00	0.02	0.01	-0.03	0.31
Number of leaves/plant	-0.17	0.03	0.55	0.28	-0.04	0.42	-0.07	0.32	0.23	0.28	0.05	0.44*
Crown diameter (cm)	0.01	-0.07	0.03	0.07	-0.02	0.03	0.05	0.01	0.02	0.01	0.04	-0.05
Root diameter (cm)	0.06	0.17	0.03	0.10	-0.34	0.15	0.12	-0.16	-0.10	-0.16	0.05	0.46*
Root length (cm)	0.23	-0.53	-0.62	-0.31	0.35	-0.83	0.14	-0.38	-0.38	-0.36	0.35	0.40*
Days taken to marketable maturity	-0.28	0.06	0.03	-0.20	0.08	0.04	-0.25	0.16	0.09	0.10	-0.20	-0.56*
Average root weight with leaves (g)	0.57	0.02	-0.48	-0.16	-0.39	-0.39	0.56	-0.84	-0.71	-0.75	0.17	0.85*
Average root weight without leaves (g)	-0.19	0.18	0.22	0.19	0.16	0.24	-0.20	0.45	0.54	0.47	-0.07	0.92*
Root yield/plot (kg)	-0.38	0.25	0.66	0.18	0.62	0.56	-0.54	0.85	0.82	0.79	-0.28	0.99*
TSS(°Brix)	-0.08	0.14	-0.02	-0.14	0.03	0.11	-0.21	0.05	0.03	0.05	-0.25	-0.21

COH-6 (588.80 q). The genotype R-COH-3 (438.40 q) was found to be the most promising for root yield per hectare. The minimum root yield per hectare was recorded in genotype R-COH-9 (188.00 q). The findings for root yield per hectare were similar to those reported by Singh *et al.* (2019).

TSS (°Brix)

Total soluble solids indicate the amount of dissolved sugars and substances present in radish roots, which influence taste and quality. It is an important quality parameter used to assess sweetness and consumer acceptability in vegetable crops. The values of the genotypes for the character total soluble solids ranged from 3.03-5.90°B and the mean was 4.98 °B in Table 4. The maximum TSS was recorded in R-COH-1 (5.90 °B) statistically at par with R-COH-9 (5.83 °B), R-COH-10 (5.37 °B) and R-COH-13 (5.30 °B). The minimum TSS was recorded in R-COH-4 (3.03 °B). Similar values for the trait total soluble solid were also recorded by Kumar *et al.* (2012), Mallikarjunarao *et al.* (2015) and Ola *et al.* (2015) in case of radish.

Parameter of variability

The estimates of phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability (broad sense), genetic advance (GA) and genetic gain (GG) were computed for all the twelve quantitative traits to assess the extent of genetic variability among the radish genotypes. Significant differences observed among the genotypes indicated the presence of considerable genetic variability for all the characters studied.

The magnitude of PCV was slightly higher than the corresponding GCV for all the traits, indicating the influence of environmental factors on the expression of these characters. However, the narrow differences between PCV and GCV for most of the traits suggested that environmental influence was relatively low and that phenotypic performance could be used as a reliable criterion for selection. Similar observations have been reported by Sivathanu *et al.* (2014), Roopa *et al.* (2018), Mashkey *et al.* (2021) and Thakur *et al.* (2023). High heritability coupled with high genetic advance was observed for the important yield and yield-contributing characters, indicating the predominance of additive gene action. These traits are expected to respond effectively to direct selection and can therefore be utilized successfully in radish improvement programmes. Moderate heritability and genetic advance observed for some traits suggested the influence of both additive and non-additive gene effects as well as environmental factors

on their expression. Overall, the variability parameters indicated the existence of sufficient genetic diversity among the evaluated radish genotypes, providing ample scope for selecting superior genotypes for higher yield and associated horticultural traits under the agro-climatic conditions of Himachal Pradesh.

Correlation analysis

The correlation analysis indicated that root yield exhibited positive associations with several yield-contributing characters. Traits such as root weight, root diameter, root length and plant vigour showed favourable relationships with root yield, suggesting that improvement in these traits could simultaneously enhance yield. Similar associations have been reported by Roopa *et al.* (2018), Ola *et al.* (2018), Esho *et al.* (2022) and Thakur *et al.* (2023), emphasizing the importance of these traits as reliable selection criteria in radish breeding programmes.

Path Coefficient analysis

Path coefficient analysis revealed that major yield-contributing characters exerted positive direct effects on root yield, demonstrating that these traits contribute independently to yield improvement. Root weight and other associated growth parameters emerged as the most important selection indices due to their substantial direct contribution towards yield. These results indicate that simultaneous selection for these characters would be effective in developing high-yielding radish genotypes. Similar findings have been reported by Nagar *et al.* (2016), Naseeruddin *et al.* (2018), Kamal *et al.* (2022) and Esho *et al.* (2022).

Conclusion

In conclusion, effective improvement in radish can be achieved through selection based on root yield per plot, average root weight without leaves and number of leaves per plant. The genotype R-COH-6 may be recommended for cultivation as well as utilization in future breeding programmes aimed at developing high-yielding and superior quality radish varieties.

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