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Research Article

CORRELATION STUDIES OF QUANTITATIVE CHARACTERS IN RADISH (*Raphanus sativus* L.) IN GARO HILLS OF MEGHALAYA, INDIA

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Abstract- Fifteen germplasm lines of radish were collected from different parts of Meghalaya, India and were evaluated on the basis of 23 horticultural traits in a randomized block design with three replications at Krishi Vigyan Kendra, ICAR NEH, Sangsangiri, Tura, Meghalaya, India during winter season from October to January (2014-15). Correlation analysis was carried out to study the character association and contribution for ten quantitative characters, namely leaf length (cm), leaf width (cm), number of leaves, petiole length (cm), crown head diameter(cm), root length(cm), root diameter (cm), days to root harvest, root weight (g) and yield (t/ha) for the identification of appropriate selection indices. Phenotypic and Genotypic correlation coefficient analysis revealed that root weight, days to root harvest, number of leaves, root length leaf width, and root diameter had significant positive correlation, while petiole length, leaf length and crown head diameter had significant negative correlation with marketable yield.

Keywords- Radish germplasm lines, Character association, Character contribution, Correlation analysis, Yield components.

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Introduction

Radish (*Raphanus sativus* L.) is a quick growing and short duration root vegetable crop. It belongs to family cruciferae, originated in Europe and Asia (Thompson and Kelly, 1957) [13]. The radish is a diploid species, and has 18 chromosomes (2n=2x=18). Radish is an important root vegetable and grown world-wide. It occupies an important position among vegetable crops in India. The area under radish production in India was 186 thousand hectare and production was 2596 thousand metric tonnes (NHB database 2015-16) [6]. It is widely used as root vegetable; however, its immature young green pods are also used as a vegetable by a large population. Successful plant improvement programme needs diverse and broad base genetic resources. Process of cultivation and domestication, mutation and hybridization determines the diversity of cultivated plant species (Yamane *et al*., 2009 [14]; Heiser, 1988 [3]. Introduction of improved varieties and attempts at seed production utilizing such varieties as mother plants may lead to loss of the diversity of land races (Nisar & Ghafoor *et al*., 2011 [7]; Mumtaz *et al.,* 2010 [4]; Pervaiz *et al*., 2010 [10]. Short life cycle, male sterility and a multi-allelic incompatibility system makes the radish useful in molecular genetics research (Crisp, 1995) [2]. Adequate description of the diversity of radish should result in much greater emphasis on both conserving and exploiting this variation (Crisp, 1995) [2]. In plant breeding, correlation analysis provides information about the association of different characters with yield and helps in selection of appropriate traits for the improvement of yield. The correlation studies simply measure the associations between yield and other traits. Such information provides a realistic basis for allocation of appropriate weightage to various yield components. In radish, correlation coefficient analyses have been used by several researchers to measure the associations between yield and other traits and to clarify interrelationships between yield and other traits, respectively. In this study, an attempt was made to study the interrelationship among different characters and the direct and indirect effects of some important yield components on root yield in radish by adopting correlation coefficient analysis.

Materials and Methods

Field experiments for germplasm evaluation for various horticultural traits in radish germplasms was conducted in randomized block design with 3 replication during winter season, 2014-15 at Krishi Vigyan Kendra (KVK), ICAR, NEH, Sangsangiri, Tura, Meghalaya, India (25°31' N latitude and 90° 13'E longitude and 527 m above MSL). Fifteen germplasm accessions of radish were obtained from different parts of Meghalaya, India [Table-1]. The soil was well drained sandy loam having pH 5.82, organic carbon 0.93% and available N, P and K were 212.21 kg/ha, 20.34 kg/ha and 118.42 kg/ha respectively. The spacing between the rows was kept 20 cm while, within the row it was 10cm. Seed were sown in the row in line by broadcasting and after that 5 plants per germplasm were maintained. Recommended fertilizer dose and other cultural practices were followed throughout the crop season.

Data were recorded for 13 qualitative as well as 10 quantitative traits. Qualitative characters were recorded on both plant and root basis for early plant vigour, plant growth habit, leaf colour, leaf margin, leaf apex shape, leaf pubescence, petiole colour, crown head habit, crown head colour, root branching, root skin colour, root shape, and root tail. Quantitative characters like leaf length (cm), leaf width (cm), number of leaves per plant, petiole length (cm), crown head diameter (cm), root length (cm), root diameter (cm), root weight (g), days to root harvest and yield (t/ha) were also recorded. Trait selection and measurement techniques were based on NBPGR descriptors by taking average measurement of five plants. Root growth measurements were taken at the time of root harvest (marketable root stage). The mean for each trait over three replications was computed for each genotype and analyzed statistically as per randomized block design or RBD

described by Panse and Sukhatme, 1969 [9] using SPSS version 16 statistical package.

Table-1 *Sources of different germplasm lines of Radish*

Sl. No.	Name of the varieties	Sources
1	Tura Selection-4	Sangsanggiri, Meghalaya
2	Garobadha Selection-1	Garobadha, Meghalaya
3	Garobadha Selection-2	Garobadha, Meghalaya
4	Shillong-1	Shillong, Meghalaya
5	Tura Selection-1	Sangsanggiri, Meghalaya
6	Tura Selection-2	Rongram Meghalaya
7	Tura Selection-5	Tura, Meghalaya
8	Tura Selection-6	Garobadha, Meghalaya
9	Tura Selection-3	Cherangri, Meghalaya
10	Tura Selection-7	Garobadha, Meghalaya
11	Tura Selection-8	Tura, Meghalaya
12	Tura Selection-9	Rongram, Meghalaya
13	Tura Selection-10	Garobadha, Meghalaya
14	Tura Selection-11	Tura, Meghalaya
15	Tura Selection-12	Tura, Meghalaya

Results and Discussion

Fifteen radish germplasm lines were evaluated on the basis of 23 horticultural traits. Mean values of 15 germplasm lines of radish for 10 main horticultural traits (quantitative) along with general mean and critical differences are presented in [Table-2 and 3]. Highly significant differences was observed for ten (10) quantitative characters namely leaf length**,** leaf width, number of leaves, petiole length, crown head diameter, root length, root diameter, days to root harvest, root weight and yield among the radish genotypes studied.

From the study it was found that the genotype Tura Selection-3 was having the highest leaf length (25.23 cm), whereas, genotype Tura Selection-7 was having the lowest leaf length (14.14 cm). The general mean was observed to be 20.16 cm. The genotype Tura Selection-3 was having the highest leaf width (8.3 cm) where as the genotype Tura Selection-6 was having the lowest leaf width (5.52 cm). The general mean was observed to be 6.32 cm. The genotype Tura Selection-4 was having the highest number of leaves (13.8) whereas; the genotype Tura Selection-6 was having the lowest number of leaves (5.16). The general mean was observed to be 7.98. The genotype Tura Selection-9 was found to have the highest petiole length (8.21 cm), whereas, the genotype Tura Selection-7 was found to have the lowest petiole length (2.77 cm). The general mean was observed to be 5.08. The genotype was found Garobadha selection-2 to have the highest crown head diameter (2.38 cm), whereas, the genotypes Garobadha Selection-1 and Tura Selection-8 were found to have the lowest crown head diameter (1.2 cm). The general mean was observed to be 1.53. The genotype Shillong-1 was having the highest root length (11.97 cm) whereas; the genotype Tura Selection-2 was having the lowest root length (5 cm). The general mean was observed to be 9.06. The genotypes Tura Selection-4, Tura Selection-7 and Tura Selection-8 were harvested earlier than other genotypes (35 days) and the genotypes Tura Selection-5, Tura Selection-10, Tura Selection-11 and Tura Selection-12 were harvested most lately. The general mean for days to root harvest was 40.66. The genotype Tura Selection-3 was having the highest root diameter (3.1 cm), whereas, the genotype Tura Selection-6 was having the lowest root diameter (1.4 cm). The general mean for root diameter was 2.29 cm. The genotype Tura Selection-7 was found to have the highest root weight (71.11 g), whereas, the genotype, Tura Selection-6 was found to have the lowest root weight (11.25 g). The general mean for root weight was 27.82 g. The highest yield was obtained from the genotype Tura Selection-7 (35.55 g) and the lowest yield was obtained from the genotype Tura Selection-6 (5.29 g). The general mean for root yield was 14.82 g. Observed data clearly indicated that there was a sufficient variability for each trait among genotypes selected for study. A similar result was also observed by Aynewa *et al.* (2013) [1] in participatory evaluation of malt barley and other agronomic traits in North Ethiopia.

Complex characteristics such as yield must be related to many individually distinguishable characteristics, which are regarded as yield components. All this yield components need not however, be expressed by changes in yield due to the varying degree of positive and negative associations between yield and its components and among components themselves. Therefore, selection of suitable characters should be done based on their association with yield. The phenotypic and genotypic correlation coefficients is presented in [Table-4]. From the observation it was found that root weight, number of leaves per plant and root length largely determine the yield and thus are considered as growth attributes. In the present study, the total yield showed highly significant and positive phenotypic correlation with root weight (0.94**) followed by days to root harvest (0.43**), number of leaves (0.40**), root length (0.19), leaf width (0.09) and root diameter (0.06). The character formed negative correlation with yield were petiole length (-0.46), leaf length (-0.34) and crown head diameter (-0.09). Root weight showed highest significant correlation with leaf width (0.66**), days to root harvest (0.54**), followed by number of leaves (0.43**), root length (0.25) and root diameter (0.11) and these results are in accordance with the findings [5]. For the character days to root harvest highest correlation coefficient was found with number of leaves (0.45**) and leaf length (0.38**). Highly significant and positive correlation (0.67**) was found between root diameter and between leaf width followed by crown head diameter (0.49**), number of leaves (0.49**) and leaf length (0.37**). Root length (0.06) positively correlated with root diameter. Rest other character *viz;* petiole length (-0.03) showed negative correlation coefficient with root diameter.

Root length showed positive and highly significance with leaf width (0.34**), followed by crown head diameter and number of leaves (0.16) and leaf length (-0.19) showed negative correlation coefficient with root length. Crown head diameter showed positive and highly significance with leaf width (0.38**) and number of leaves (0.37**). While, other characters leaf length (-0.11) and petiole length (-0.44) showed negative correlation coefficient with crown head diameter.

Table-2 *Mean table for different quantitative characters in Radish*

Treatment	Leaf length (cm)	Leaf width (cm)	No. of leaves	Petiole length (cm)	Crown head diameter (cm)
Tura Selection-4	18.04	6.8	13.8	2.98	2.27
Garobadha Selection-1	21.88	5.86	7.33	3.24	1.2
Garobadha Selection-2	17.89	6.51	12.75	3.02	2.38
Shillong-1	17.89	5.81	6.9	2.89	2.01
Tura Selection-1	18.24	6.62	11	3.63	1.25
Tura Selection-2	17.12	6.01	11.25	2.88	1.32
Tura Selection-5	25.05	6.44	8	7.59	1.29
Tura Selection-6	19.29	5.52	5.16	6.02	1.37
Tura Selection-3	25.23	8.3	11.33	4.94	2.08
Tura Selection-7	14.14	6.38	12	2.77	1.24
Tura Selection-8	24.4	6.16	12.83	7.68	1.2
Tura Selection-9	23.38	6.38	7.99	8.21	1.3
Tura Selection-10	19.11	5.56	8.33	6.59	1.52
Tura Selection-11	20.85	6.6	8.99	7.55	1.25
Tura Selection-12	19.9	5.94	9.16	6.26	1.29
Grand mean	20.16	6.32	9.78	5.08	1.53
C V	8.32	8.65	12.77	14.15	7.12
SEm	0.97	0.32	0.72	0.41	0.06
C D (1%)	3.78	1.23	2.82	1.62	0.25
C D (5%)	2.80	0.91	2.09	1.20	0.18

Petiole length showed positive and highly significance with leaf length (0.64**) and showed negative correlation coefficient with other characters *viz;* leaf width (-0.06) and number of leaves (-0.32). Number of leaves showed positive and highly significance with leaf width (0.48**) and negative correlation coefficient with leaf length (-0.13). Leaf width showed positive and high significance with leaf length (0.41**).

At genotypic level highly significant and positive correlation were obtained for association with yield were, root weight (0.98**), days to root harvest (0.64**) and number of leaves (0.48**). Root length ((0.22), root diameter (0.18) and leaf width (0.31) showed positive correlation with yield. Negative correlation were obtained for association with yield were, petiole length (-0.5), leaf length (-0.43) and crown head diameter (-0.1). For the character root weight, highly significant and positive

association was found with the character number of leaves (0.54**). Moderate significant and positive correlation was observed for the characters root length (0.30*) and days to root harvest (0.29*). Highly significant and positive correlation were obtained for association with days to root harvest were, crown head diameter (0.45**), root length (0.43**) and number of leaves (0.37**). With respect to yield comparatively large difference between the genotypic correlation coefficient and phenotypic correlation coefficient was recorded with average root diameter (rg= -0.00, rp=0.06), leaf width (rg=0.52, rp=0.48) and leaf length (rg=0.31, rp=0.41). while, rest other characters have shown little difference between the genotypic correlation coefficient and phenotypic correlation coefficient and was recoeded with yield (rg=0.98, rp=0.94), root weight (rg=0.16, rp=0.11), root length (rg=0.37, rp= 0.32), crown head diameter (rg=-0.45, rp=-0.44) and petiole length (rg=-0.34, rp=-0.32).

Table-3 *Mean table for different quantitative characters in Radish*

Treatment	Root length (cm)	Days to root harvest	Root diameter (cm)	Root weight (g)	Yield (T/ha)
Tura Selection-4	10.28	35	2.8	37.5	19.16
Garobadha Selection-1	6.85	40	2.01	28.7	21.18
Garobadha Selection-2	10.02	41	2.75	22.36	11.18
Shillong-1	11.97	36	2.42	30.82	14.20
Tura Selection-1	16	36	1.92	32.89	16.44
Tura Selection-2	5	43	2.1	24.72	12.37
Tura Selection-5	8.05	45	2.6	21.43	9
Tura Selection-6	8.22	44	1.4	11.25	5.29
Tura Selection-3	11.15	44	3.1	23.49	20.12
Tura Selection-7	10.5	35	2	71.11	35.55
Tura Selection-8	6.8	35	2.85	37.58	18.79
Tura Selection-9	8.35	41	2.15	22	11.3
Tura Selection-10	7.9	45	2.25	20.68	10.34
Tura Selection-11	6.55	45	2.61	18.75	10.36
Tura Selection-12	8.4	45	1.45	14.05	7.02
Grand mean	9.06	40.66	2.29	27.82	14.82
C V	17.86	22.31	9.84	20.58	12.84
SEm	0.94	0.33	0.30	3.33	1.06
C D (1%)	3.66	0.67	1.16	12.10	4.13
C D (5%)	2.71	0.35	0.86	9.63	3.06

Generally, positive and significant association of pairs of characters justified the possibility of correlated response to select. The negative and significant correlation prohibits the simultaneous improvement of those traits. For the non significant coefficient of correlation selection for different traits could be done separately and independently (Aynewa et al. 2015) [1]. From the perusal of the estimates of phenotypic and genotypic correlation coefficient [Table-3 and 4], in general, it was observed that estimates of genotypic correlation coefficients were in most cases higher than their corresponding phenotypic correlation coefficients. More significant genotypic association was observed between the different pairs of characters than the phenotypic correlation which means genetically, there is strong association between those characters, but the phenotypic value is lessened by the significant interaction of environment. The present findings are in consonance with the earlier findings of Muthukrishnan and Arumugam (1997) [5].

Table-4 *Genotypic and Phenotypic correlation coefficients among different characters of radish [1: Leaf length (cm), 2: Leaf width (cm), 3: No. of leaves, 4: Petiole length (cm), 5: Crown head diameter (cm), 6: Root length (cm), 7: Root diameter (cm), 8: Days to root harvest, 9: Root weight (g), 10: Yield (T/ha)]*

Chr.		1	2	3	4	5	6	7	8	9	10
1	G		0.31*	-0.21	0.71**	-0.15	-0.28	0.42**	-0.34	-0.51	-0.43
	P		0.41**	-0.13	0.64**	-0.11	-0.19	0.37**	0.38**	-0.31	-0.34
2	G			0.52**	-0.09	0.42**	0.37**	0.59**	0.22	0.10	0.09
	P			0.48**	-0.06	0.38**	0.34*	0.67**	0.21	0.66**	0.09
3	G				-0.34	0.34*	0.20	0.57**	0.37**	0.54**	0.48**
	P				-0.32	0.37**	0.16	0.49**	0.45**	0.43**	0.40**
4	G					-0.45	-0.42	0.05	0.01	-0.46	-0.50
	P					-0.44	-0.35	-0.01	0.017	-0.39	-0.46
5	G						0.37**	0.61**	0.45**	-0.06	-0.10
	P						0.32*	0.49**	-0.38	-0.04	-0.09
6	G							-0.01	0.43**	0.30*	0.22
	P							0.06	-0.38	0.25	0.19
7	G								0.14	0.16	0.12
	P								0.18	0.11	0.06
8	G									0.29*	0.64**
	P									0.54**	0.43**
9	G										0.98**
	P										0.94**

Conclusion

Yield is considered to be a complex, polygenic and highly variable character determined by cumulative effects of its component characters. Therefore, direct selection for yield may not be very effective and precise. Thus, it becomes necessary to find out the direction and degree of association between two characters at phenotypic and genotypic levels. In general, it was observed that estimates of genotypic correlation coefficients were in most cases higher than their corresponding phenotypic correlation coefficients. At both phenotypic and genotypic levels, the total yield showed highly significant and positive correlation with root weight, days to root harvest, number of leaves, root length, leaf width and root diameter. The characters formed negative correlation with yield were petiole length, leaf length and crown head diameter. Thus the analysis of interaction of different characters with yield will help to select the yield contributing characters in breeding process.

Conflict of Interest: None declared

Author Contributions Both the authors contributed equally for the research work.

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