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Studies on character association and path analysis of yield with importent yield contributing traits in turmeric (*Curcuma longa* L.)

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Abstract
The present investigation was carried out in Randomized Block Design with three replications during 2016-17 and 2017-18 on two locations to study the variability, character association, and stability and adaptability for nineteen characters among twenty five genotypes across four environments. The study revealed that wide range of variation observed for all the traits among twenty five genotypes. Based on *per se* performance, the genotype NDH-98 produced maximum rhizome yield followed by NDH-1, NDH-74, NDH-16, NDH-11, NDH-15, NDH-79, NDH-68 and NDH-114 produced highest rhizome yield per hectare. PCV were higher than GCV for all the characters. High estimates of PCV as well as GCV was observed for plant height, plant girth, length of mother rhizome, width of mother rhizome, weight of mother rhizome, weight of primary rhizomes per plant, number of secondary rhizomes per plant, weight of secondary rhizomes per plant, number of tertiary rhizomes per plant and weight of tertiary rhizomes per plant in all four environments (E_1, E_2, E_3, E_4). The High heritability accompanied with high genetic advance as per cent of mean was estimated for plant height, weight of fresh rhizome per plant, width of mother rhizome, weight of mother rhizome, weight of primary rhizomes per plant, weight of secondary rhizomes per plant, number of tertiary rhizomes per plant, rhizome yield, dry matter and T.S.S. content in all four environments (E_1, E_2, E_3, E_4), this indicates that selection for these traits will be useful

Keywords: Turmeric (*Curcuma longa* L.), correlation coefficient, path coefficient

Introduction

The fascinating history of spices is a story of adventure exploration, congest and fierce naval rivalry. It was lure of these spices that brought many seafarers to the shore of India. India is known as 'land of spices', where all kinds of spices are grown (Pruthi, 1998). Turmeric, the golden spice of life, is one of the most essential spices used as important gradient in culinary all over the world. It is a multipurpose crop valued for its medicinal properties, coloring pigment and spicy flavour. According to Spices Board, Calicut, Kerala, mainly 52 spices are grown in India. *Curcuma longa* L. Syn. *C. domestica*, commonly known as turmeric, in Sanskrit 'Haridra' in Hindi 'Haldi' is one of the most important spices crop. It is a multipurpose crop valued for its medicinal properties, coloring pigment and spicy flavor. The genus *Curcuma* is considered to be a triploid with a somatic chromosome number of 63 (3n=3x=63) belonging to the family Zingiberaceae considered to have originated in the Indo-Malyan region (Purseglove, 1968) which comprises 40 genera and 400 tropical spices in the old world. Out of these three genera *viz. Curcuma* (Turmeric), *Elletaria* (Cardamom) and *Zingiber* (Ginger) have commercial importance as spices. Genus *Curcuma* has 40-50 species, which are found in tropical Asia.

Turmeric leaves are large, lanceolate or oblong with short or no petioles. Flowers are dense spike ending with a tuff of large colored tracts with two or more flowers arising from each tract. Calyx is a short cylindrical toothed tube and corolla comprising of board segment. Among the 40 species of Curcuma only two species *viz*. *Curcuma longa* L. and *C. aromatic* Salisb. Are commercially cultivated for the production of turmeric. The turmeric is cultivated in India, Ceylon, many east Indian Island, Fiji, Queensland, China, Formosa and Indo China region. The crop occupies an area of 233 lakh ha with an annual production of 1190 lakh tones and productivity of 5.1 MT per ha. It occupies 6 per cent of total area under spices in India (Anonymous, 2015). The crop occupies major share of the area in the state of

Tamil Nadu followed by Telangana, Andhra Pradesh, West Bengal and Karnataka.

Turmeric is valued globaly as a condiment, food dye, drugs and medicine. The rhizome contains yellow colouring component curcumin (3-9%), essential oil (5-9%) and oleoresin (3-13%). Curcumin is gaining more importance in food industries, preservatives and cosmetics. The ban of artificial colour has promoted the use of curcumin, anti-inflammatory, antiseptic, antimicrobial and antiproliferative activities.

It is used in canned beverages and baked products, dairy products, ice cream, yogurt, yellow cakes, orange juice, biscuits, popcorn color, sweets, cake icings, cereals, sauces and gelatins, etc. It is a significant ingredient in most commercial curry powders. Most turmeric that is used is in the form of rhizome powder, in some regions (especially in Maharashtra, Goa, Konkan and Kanara).

The presence of wide range of variability in any crop provides a better chance of selecting the desirable types. The genotypic variation in the population is due to genotypic differences among individuals for particular character. On the other hand, phenotypic character is the observable difference present in individual due to the effect of both genotype and environment. A variety having wide or good adaptability is one which consistently gives superior production over a wide range of environment. This combination of stability and performance is a very important. Stability is a common practice in trials involving varieties and breeding lines to grow a series of genotypes in a range of different environments.

Materials and Methods

The experimental material comprised of twenty five genotypes of turmeric maintained in All India Co-ordinated Research Project on Spices was taken for this investigation. These Narendra Haldi (NDH-8, NDH-10, NDH-11, NDH-16, NDH-40, NDH-68, NDH-74, NDH-79, NDH-98, NDH-114, NDH-115, NDH-116, NDH-128) genotypes were collected from Narendra Deva University of Agriculture and Technology, Narendra Nagar (Kumarganj), Faizabad, Uttar Pradesh.

The genotypes ACC-79, SLP-389/1 and ACC-48, IISR, Kozhikode, Calicut (Kerala), CSTH-9 from CCSHAU, Hisar (Haryana), PTS-12 and PTS-55 from Pottanigi, (Orissa), PIS-8, RAU, Dholi, (Bihar), TCP-64 and TCP-14 UKKV, Koch Bihar, (W. B.), CL-54 TNAU, Coimbtoor, (T. N.)

The check varieties were Pratibha [IISR, Kozhikode, Calicut (Kerala)] and NDH-1 (N. D. Univ. of Agri. & Tech. Faizabad, U. P.). The experiment was conducted in Randomized Block Design. The material used in the experiment comprised of twenty five selected germplasm lines of turmeric.

A random selection of five plants was made in each plot for recording the observations on different characters under study. The following observations were recorded during the course of experimentation. Observations on the following were recorded using the standard procedure: plant height (cm), number of tillers per clump, number of leaves per plant, plant girth (cm), weight of fresh rhizome per plant (g), length of mother rhizome (cm), width of mother rhizome (cm), weight of mother rhizome (g), number of primary rhizomes per plant, weight of primary rhizomes per plant (g), number of secondary rhizomes per plant, weight of secondary rhizomes per plant (g), number of tertiary rhizomes per plant, weight of tertiary rhizomes per plant, rhizome yield (q/ha), dry matter, curcumin, oleoresin and T.S.S. per cent.

The Phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) were calculated by the Burton and de Vane (1953). Heritability (Hanson *et al.* 1963) and Genetic advance in percent of mean (Johnson *et al*. 1955) [5].

Results and Discussion

The analysis of variance for twenty Five genotypes for all the nineteen characters were carried out in Randomized Block Design and the results of analysis of variance are presented in Table 1. The analysis of variance revealed that the highly significant differences were observed among the genotypes for all the characters in all four environments (E_1, E_2, E_3 and E_4). The variance due to replications was non-significant for all the characters in all four environments. The significant differences for traits in a particular environment indicated that the genotypes had remarkable variation for all the studied characters. Reddy *et al.* (1988) [10]; Indiresh *et al.* (1990) [3]; Datta *et al.* (2001) [1]; Panja *et al.* (2001); Velmurugan *et al.* (2008) [16] and Jan *et al.* (2012) [4]

The estimates of phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) for nineteen characters of turmeric genotypes are presented in Table-2. The magnitudes of phenotypic coefficient of variation (PCV) was higher than the corresponding genotypic coefficient of variation (GCV) for all the traits. The high magnitude of genotypic coefficient of variation (GCV) along with phenotypic coefficients of variation (PCV) are recorded for plant height (PCV=28.86%, GCV=28.67%), number of tillers per plant (PCV=34.69%, GCV=21.40%), number of leaves per plant (PCV=24.73%, GCV=19.60%), plant girth (PCV=30.28%, GCV=27.35%), length of mother rhizome (PCV=30.58%, GCV=26.13%), width of mother rhizome (PCV=25.66%, GCV=24.44%), weight of mother rhizome (PCV=79.83%, GCV=79.38%), weigh of primary rhizomes per plant (PCV=21.67%, GCV=21.27%), number of secondary rhizomes per plant (PCV=28.81%, GCV=22.61%), weight of secondary rhizome per plant (PCV=27.28%, GCV=26.27%), number of tertiary rhizomes per plant (PCV=53.30%, GCV=46.66%), weight of tertiary rhizomes per plant (PCV=82.50%, GCV=80.55%), On the other hand weight of fresh rhizome per plant (PCV=16.04%, GCV=15.81%), rhizome yield (PCV=16.04%, GCV=15.81%), dry matter (PCV=17.42%, GCV=15.44%), curcumin (PCV=16.49%, GCV=12.81%), T.S.S. (PCV=18.02%, GCV=15.24%) showed moderate PCV along with GCV (Table-3). This indicated greater scope of obtaining high selection response for these two traits owing to presence of high genetic variability. The existence of high variability for plant height, number of tiller per clump, number of leave per plant, plant girth, weight of fresh rhizome, length of mother rhizome, width of mother rhizome, weight of mother rhizome, number of primary rhizomes per plant, weight of primary rhizomes per plant, number of secondary rhizomes per plant, weight of secondary rhizomes per plant, number of tertiary rhizomes per plant, weight of tertiary rhizomes per plant, rhizome yield, dry matter, curcumin and T.S.S. was in conformity with the findings of earlier workers [Mohanty *et al.* (1981); Mukhopadhyay *et al.* (1986); Subramanian (1986); Reddy *et al.* (1988) [10]; Rattan (1989); Indiresh *et al.* (1992); Pandey and Donbhal (1993); Singh (1993); Nirmal and Yamgar (1998); Chandra *et al.* (1998); Yadav and Singh (1996); Lynrah *et al.* (1998); Shanmugasundaran *et al.* (2000); Pandey *et al.* (2002); Singh *et al.* (2003); Yudhvir *et al.* (2003); Singh *et al.* (2008) [13];

Verma *et al.* (2014); Mishra *et al.* (2015) [6]; Gupta *et al.* (2016)] [2].

The low estimates of coefficients of variation at genotypic and phenotypic level was found for oleoresin (PCV=9.75%, GCV=7.60%) which suggested that selection directly based on these traits would not be much rewarding. The estimates of phenotypic coefficients of variation are slightly higher than genotypic coefficients of variation for all the nineteen characters, which indicates least influence of environmental effects.

Heritability in broad sense [$h^2{}_{(bs)\,\%}$] and genetic advanced in per cent of mean **($\overline{Ga}$ %)** for all the ten characters were estimated and findings are given in Table-4. The high estimates of heritability with high genetic advanced in per cent of mean (Pooled) was observed for plant height (h^2b%=98.70%, Ga%=58.68%), plant girth (h^2b%=81.60%, Ga%=50.90%), weight of fresh rhizome per plant (h^2b%=97.10%, Ga%=32.08%), width of mother rhizome (h^2b%=90.70%, Ga%=47.94%), weight of mother rhizome (h^2b%=98.90%, Ga%=162.59%), weight of primary rhizomes per plant (h^2b%=96.30%, Ga%=42.99%), weight of secondary rhizomes per plant (h^2b%=92.70%, Ga%=52.11%), weight of tertiary rhizomes per plant (h^2b%=95.30%, Ga%=162.00%), rhizome yield (h^2b%=97.10%, Ga%=32.09%). The character, mentioned above, having high values of heritability and high genetic advanced as per cent of mean emerged as ideal traits for improvement through selection because it has additive gene action. The traits dry matter (h^2b%= 78.50%, Ga%= 28.18%), curcumin (h^2b%= 60.40%, Ga%= 20.51%), oleoresin (h^2b%= 60.70%, Ga%= 12.21%) and T.S.S. (h^2b%= 71.50%, Ga%= 26.55%) showed moderate heritability and genetic advance values which suggested that the genotypes evaluated and/or segregating derived from them may provide response to selection for the characters exhibiting moderate heritability along with moderate genetic advanced owing to their moderate transmissibility and variability.

Number of leaves per plant (h^2b%= 62.80%, Ga%= 31.99%), length of mother rhizome (h^2b%= 73.10%, Ga%= 46.01%), number of secondary rhizomes per plant (h^2b%= 61.50%, Ga%= 36.53%) and number of tertiary rhizomes per plant (h^2b%=76.60%, Ga%= 84.14%) showed moderate heritability and high genetic advance as per cent of mean which show additive gene action in these characters the improvement are possible through selection.

The traits number of tillers per clump (h^2b%= 38.10%, Ga%= 27.19%), number of primary rhizomes per plant (h^2b%= 36.10%, Ga%= 19.41%) showed low heritability and moderate genetic advance as per cent of mean.

Subramanian (1986) reported that width of mother rhizome had the highest percentage of heritability as well as high genetic advance. Geetha and Prabhakaran (1987) reported that the high heritability (in broad sense) and high genetic advance as per cent of mean for plant girth, plant height. Reddy *et al.* (1988) [10] reported that the high heritability (in broad sense) and high genetic advance as percent of mean for rhizome yield. Jalgoankar and Jamdagni (1989) observed the traits weight of mother rhizome, weight of primary rhizomes per plant and weight of secondary rhizomes per plant were showed high heritability and high genetic advance as per cent of mean in turmeric. Indiresh *et al.* (1990) [3] found high heritability (in broad sense) and high genetic advance as per cent of mean for the traits rhizome yield and weight of mother rhizome and alsa found moderate heritability in number of secondary rhizomes per plant.

Jaha *et al.* (2001) reported for weight of fresh rhizome and number of primary rhizomes per plant high variability and magnitude of heritability with appreciable genetic advance. Pandey *et al.* (2002) reported that weight of mother rhizome, weight of primary rhizomes per plant, weight of secondary rhizomes per plant show high genetic advance as per cent of mean as well as high heritability for these traits. Singh *et al.* (2003) and Yudhvir *et al.* (2003) suggested that superior genotypes may be obtained through selection based on the weight of mother, primary and secondary rhizome because these traits exhibited high magnitude of heritability and genetic gain. Rao *et al.* (2004) weight of the fresh rhizome had moderate to high heritability and genetic advance and suggested that in these improvement characters can be brought through simple plant selection programme. Datta *et al.* (2006) observed that high magnitude of heritability and genetic advance for most of the characters as well as the yield and its components indicating a great scope for selection in the existing germplasm. Singh *et al.* (2012) [13] observed the high heritability accompanied with a high genetic advance in per cent of mean for weight of mother rhizome and weight of fresh rhizome per plant. Mishra *et al.* (2015) estimate of broad sense heritability was high for plant height and genetic advance (GA) for fresh weight of rhizome. Gupta *et al.* (2016) [2] reported high heritability and high genetic advance for rhizome dry and fresh weight.

Table 4 1: Analysis of variance for different characters in environment-1 (MES, NDUA & T, 2016-17) and environment -2 (KVK, Gonda, 2016-17)

S. No.	Characters		Environment-1			Environment-2		
		S.V.	Replications	Treatments	Error	Replications	Treatments	Error
		D.F.	2	24	48	2	24	48
1.	Plant height (cm)		5.81	1769.84**	4.69	9	1621.90**	8.71
2.	Number of tillers per clump		0.03	1.05**	0.41	0.09	2.15**	0.19
3.	Number of leaves per plant		1.96	11.32**	1.39	3.61	14.06**	1.68
4.	Plant girth (cm)		0.02	14.22**	1.31	1.25	9.32**	0.71
5.	Weight of fresh rhizome per plant (g)		56.28	4347.85**	18.86	1.27	3924.93**	3.91
6.	Length of mother rhizome (cm)		0.45	12.73**	1.09	0.92	5.51**	0.58
7.	Width of mother rhizome (cm)		0.52	19.08**	0.41	0.03	16.92**	0.53
8.	Weight of mother rhizome (g)		0.21	1947.39**	1.81	5.85	1794.19**	2.10
9.	Number of primary rhizomes per plant		4.01	2.50*	1.40	0.48	1.84*	0.86
10.	Weight of primary rhizomes per plant (g)		4.93	2064.0**	24.0	10.60	1756.14**	8.72
11.	Number of secondary rhizomes per plant		0.65	10.71**	0.97	0.00	7.58**	1.38
12.	Weight of secondary rhizome per plant (g)		13.30	1477.89**	35.11	19.06	1222.90**	16.32
13.	Number of tertiary rhizomes per plant		0.81	10.24**	0.36	0.12	8.06**	0.23
14.	Weight of tertiary rhizome per plant (g)		0.44	53.76**	0.31	0.09	41.77**	0.34

15.	Rhizome yield (q/ha)	81.27	6259.87**	27.14	2.28	5653.09**	5.61
16.	Dry matter (%)	3.10	33.38**	1.02	0.22	35.55**	0.71
17.	Curcumin (%)	0.01	1.76**	0.06	0.11	1.79**	0.17
18.	Oleoresin (%)	0.11	2.71**	0.19	0.06	4.52**	0.10
19.	TSS (%)	0.14	9.43**	0.05	0.04	4.77**	0.10

*; **Significant at 5% and 1% probability levels, respectively against error

Table 4 2: Analysis of variance for different characters in environment-3 (MES, NDUA&T, 2017-18) and environment-4 (KVK, Gonda, 2017-18)

S. No.	Characters		Environment-3			Environment-4		
		S.V.	Replications	Treatments	Error	Replications	Treatments	Error
		D.F.	2	24	48	2	24	48
1.	Plant height (cm)		5.81	1769.84**	4.69	4.2	1675.92**	6.75
2.	Number of tillers per clump		0.03	1.05**	0.41	0.62	1.45**	0.16
3.	Number of leaves per plant		1.96	11.32**	1.39	5.16	13.76**	1.70
4.	Plant girth (cm)		0.02	14.22**	1.31	0.56	11.62**	0.58
5.	Weight of fresh rhizome per plant (g)		56.28	4347.85**	18.86	54.96	3920.60**	47.38
6.	Length of mother rhizome (cm)		0.45	12.73**	1.09	0.32	7.11**	0.54
7.	Width of mother rhizome (cm)		0.52	19.08**	0.41	0.36	19.02**	0.46
8.	Weight of mother rhizome (g)		0.21	1947.39**	1.81	9.15	1910.93**	3.86
9.	Number of primary rhizomes per plant		4.01	2.50*	1.40	1.48	2.26**	0.92
10.	Weight of primary rhizomes per plant (g)		4.93	2064.0**	24.0	52.81	1732.16**	19.27
11.	Number of secondary rhizomes per plant		0.65	10.71**	0.97	1.45	8.19**	1.34
12.	Weight of secondary rhizome per plant (g)		13.30	1477.89**	35.11	18.34	1187.92**	32.44
13.	Number of tertiary rhizomes per plant		0.81	10.24**	0.36	0.24	8.03**	0.24
14.	Weight of tertiary rhizome per plant (g)		0.44	53.76**	0.31	0.02	30.50**	0.41
15.	Rhizome yield (q/ha)		81.27	6259.87**	27.14	95.43	5637.82**	66.94
16.	Dry matter (%)		3.10	33.38**	1.02	1.09	42.85**	1.61
17.	Curcumin (%)		0.01	1.76**	0.06	0.06	1.15**	0.07
18.	Oleoresin (%)		0.11	2.71**	0.19	0.06	2.96**	0.09
19.	TSS (%)		0.14	9.43**	0.05	0.18	4.83**	0.06

*; ** Significant at 5% and 1% probability levels, respectively against error

Table 2: Range, mean, coefficient of variation, heritability and genetic advance for different characters in different environments (E), E_1 (MES, 2016-17), E_2 (KVK Gonda, 2016-17), E_3 (MES, 2017-18) and E_4 (KVK Gonda, 2017-18)

S. No.	Characters	E	Range		General mean Se ±	Genotypic coefficient of variation (GCV %)	Phenotypic coefficient of variation (PCV %)	Heritability [$h^2_{(bs)}$%] in broad sense	Genetic advance	Genetic advance in per cent of mean ($\overline{Ga}$ %)
			Lowest	Highest						
1.	Plant height (cm)	E_1	41.37	129.17	85.9	28.24	28.35	99.21	49.77	57.94
		E_2	39.60	123.8	82.38	28.15	28.38	98.41	47.39	57.53
		E_3	45.10	138.97	84.62	29.80	29.88	99.43	51.79	61.21
		E_4	40.60	127.10	82.44	28.61	28.78	98.80	48.30	58.60
2.	Number of tillers per clump	E_1	1.67	4.00	2.45	18.83	32.23	34.13	0.56	22.66
		E_2	1.33	4.67	2.32	28.15	28.38	77.30	47.39	57.53
		E_3	1.33	4.33	2.71	23.72	30.57	60.20	1.03	37.90
		E_4	1.33	4.33	2.07	31.70	37.04	73.30	1.16	55.90
3.	Number of leaves per plant	E_1	7.00	14.67	9.68	18.79	22.40	70.41	3.15	32.49
		E_2	4.67	14.00	8.19	24.81	29.44	71.00	3.53	43.07
		E_3	7.67	15.00	10.41	16.03	19.78	65.6	2.79	26.75
		E_4	5.67	14.00	8.32	24.10	28.75	70.30	3.46	41.62
4.	Plant girth (cm)	E_1	5.23	12.83	7.67	27.07	30.91	76.70	3.74	48.83
		E_2	4.73	10.67	6.69	25.32	28.27	80.30	3.13	46.73
		E_3	5.50	13.47	7.78	27.93	30.61	83.30	4.08	52.50
		E_4	4.87	12.07	6.75	28.44	30.60	86.40	3.67	54.46
5.	Weight of fresh rhizome per plant (g)	E_1	165.30	301.43	234.26	16.22	16.32	98.70	77.75	33.19
		E_2	161.53	299.20	227.17	15.91	15.94	99.70	74.36	32.74
		E_3	168.33	301.93	234.38	15.58	15.65	99.10	74.88	31.95
		E_4	158.17	296.43	225.14	15.96	16.25	96.50	72.70	32.29
6.	Length of mother rhizome (cm)	E_1	3.80	14.43	6.27	31.44	35.57	78.10	3.59	57.25
		E_2	3.80	9.50	5.51	23.27	27.04	74.00	2.27	41.24
		E_3	3.67	13.93	6.81	27.32	28.57	91.40	3.67	53.82
		E_4	3.57	10.43	5.63	26.30	29.36	80.20	2.73	48.53
7.	Width of mother rhizome (cm)	E_1	6.07	16.50	10.17	24.53	25.33	93.80	4.98	48.94
		E_2	6.40	15.50	9.35	25.01	26.19	91.20	4.60	49.20
		E_3	5.30	17.33	10.67	23.50	24.50	92.00	4.95	46.43
		E_4	6.23	16.27	9.63	25.83	26.79	93.10	4.95	51.35
8.	Weight of mother rhizome (g)	E_1	6.5	134.37	32.89	77.44	77.55	99.70	52.39	159.30
		E_2	9.70	132.90	29.61	82.56	82.70	99.70	50.26	169.77
		E_3	6.33	137.63	34.04	75.44	75.57	99.60	52.80	155.12
		E_4	9.50	135.47	30.02	83.90	84.25	99.40	51.78	172.51
9.	Number of primary rhizomes per plant	E_1	4.00	7.33	5.15	11.77	25.84	20.70	0.57	11.04
		E_2	2.33	6.00	3.84	14.90	28.32	27.7	0.62	16.15

		E_3	4.00	7.33	5.31	11.02	23.36	22.20	0.57	10.70
		E_4	3.00	6.67	4.24	15.76	27.62	32.60	0.79	18.53
10.	Weight of primary rhizomes per plant (g)	E_1	65.13	162.87	118.60	21.99	22.37	96.6	52.80	44.52
		E_2	68.83	162.20	116.05	20.80	20.95	98.50	49.35	42.52
		E_3	66.23	164.83	117.71	21.94	22.10	98.60	52.83	44.89
		E_4	67.37	161.90	114.76	20.82	21.17	96.70	48.41	42.19
11.	Number of secondary rhizomes per plant	E_1	4.67	10.67	7.99	22.56	25.71	76.90	3.26	40.75
		E_2	3.33	9.33	6.20	23.20	29.93	60.10	2.30	37.10
		E_3	5.00	12.00	8.47	24.63	28.18	76.40	3.75	44.34
		E_4	2.33	8.33	5.95	25.40	32.01	63.00	2.47	41.51
12.	Weight of secondary rhizome per plant (g)	E_1	49.73	123.40	79.19	27.69	28.69	93.20	43.61	55.07
		E_2	37.60	111.77	76.06	26.37	26.90	96.10	40.50	53.25
		E_3	48.10	111.23	77.81	26.24	26.42	98.60	41.77	53.68
		E_4	44.80	110.17	75.74	25.91	26.98	92.20	38.83	51.26
13.	Number of tertiary rhizomes per plant	E_1	1.00	8.33	3.99	45.51	47.93	90.20	3.55	89.03
		E_2	1.00	7.33	2.80	57.69	60.15	92.00	3.19	113.98
		E_3	1.00	7.33	3.56	42.95	45.73	88.20	2.96	83.08
		E_4	1.00	7.67	2.64	61.01	63.81	91.40	3.17	120.17
14.	Weight of tertiary rhizome per plant (g)	E_1	0.90	20.23	4.87	86.755	87.51	98.30	8.62	11.05
		E_2	0.90	18.20	4.71	78.87	79.83	97.60	7.56	160.53
		E_3	0.90	20.03	4.74	87.39	87.96	98.70	8.47	178.83
		E_4	1.50	14.77	4.48	70.78	72.20	96.10	6.40	142.93
15.	Rhizome yield (q/ha)	E_1	198.37	361.73	281.11	16.21	16.32	98.70	93.29	33.19
		E_2	193.80	359.10	272.60	15.92	15.94	99.70	89.25	32.74
		E_3	202.00	362.33	281.27	15.58	15.65	99.1	89.87	31.95
		E_4	189.80	355.73	269.96	15.96	16.25	96.50	87.21	32.31

References

1. Datta S, Chatterjee R, Chattopadhyay PK. Turmeric propagated from mother rhizome-its morphological and yield characters. Environment and Ecology. 2001; 19(1):114-117.
2. Gupta AK, Mishra R, Lal RK. Genetic variability and character interrelationship among indigenous germplasm of turmeric (*Curcuma longa*). Journal of Herbs, Spices & Medicinal Plants. 2016; 22(2):190-201.
3. Indiresh KM, Uthaiah BC, Herle PS, Rao KB. Morphological, rhizome and yield characters of different turmeric varieties in coastal Karnataka. Mysore J Agric. Sci. 1990; 24(4):484-490.
4. Jan HU, Rabbani MA, Shinwari ZK. Estimation of genetic variability in turmeric *(Curcuma longa* L.). Germplasm using agro morphological traits. J Bot. 2012; 44(1):231-238.
5. Johnson HW, Robinson HF, Comstock RE. Estimates of genetic and environmental variability in soyabean. Agron. J 1955; 47:314-318.
6. Mishra R, Gupta AK, Lal RK, Banergee NJT. Genetic variability, analysis of genetic parameters, characters association and contribution of agronomical traits in turmeric (*Curcuma longa*). Ind. Crops and Products. 2015; 76:204-208
7. Panj B, De DK, Basak S, Chattopadhyay SB. Correlation and path analysis in turmeric (*Curcuma longa* L.). J Spices and Aromatic Crops. 2002; 11(11):70-73.
8. Panse VG, Sukhatme PV. Statistical Methods for Agricultural Workers, ICAR, Pub. New Delhi, 1984.
9. Prajapati KN, Patel MA, Patel JR, Joshi NR, Patel AD, Patel JR. Genetic variability, character association and path coefficient analysis in turmeric (*Curcuma longa* L.). Electronic Journal of Plant Breeding. 2014; 5(1):131-137.
10. Reddy ML, Rao AM, Reddy KA. Studies on the performance of turmeric cultures in northern Telangana zones of Andhra Pradesh. Proceedings of National Seminar on Chillies, Ginger and Turmeric, Hyderabad, 1988, 97-99.
11. Singh AP, Pandey VP, Rahman SMA, Pervez R. Genetic variability and character association in turmeric (*Curcuma longa* L.). Trends in Biosci. 2012; 5(1):11-13.
12. Singh B, Kumar M, Kumar D, Pal MK. A study on character Association, variability, heritability and genetic advance in turmeric (*Curcuma longa* L.). Third National Symposium on Recent Trends and Future Prospects in Agriculture, 2007, 87.
13. Singh B, Kumar M, Kumar D, Pal MK. A study on character association, variability, heritability and genetic advance in turmeric (*Curcuma longa* L.). Adv. Plant Sci. 2008; 21(2):641-643.
14. Sinkar PV, Haldankar PM, Khandekar RG, Ranpise SA, Joshi GD, Mahale BB. Preliminary evaluation of turmeric (*Curcuma longa* L.) varieties at Konkan region of Maharashtra. J of Spices and Aromatic Crops. 2005; 14(1):28-33.
15. Srimal RC. Turmeric: a brief review of medicinal properties. Fitoterapia. 1997; 68(6):483-493.
16. Velmurugan M, Chezhiyan N, Jawaharlal M. Correlation and path analysis in turmeric (*Curcuma longa* L.). International J Agric. Sci. 2008; 4(1):103-106.