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Genetic variability, and genetic advance as percent of mean in turmeric (*Curcuma longa* L.)

Devraj Singh, DP Mishra, DK Dwibedi, Sharvan Kumar and Manjeet Kumar

Abstract
The present investigation entitled "Assessment of genetic variability, heritability and genetic advance in turmeric (*Curcuma longa* L.)" 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, divergence and stability and adaptability for twenty characters among thirty two genotypes across four environments. The study revealed that wide range of variation observed for all the traits among thirty two genotypes. Based on per se performance, the genotype NDH-98 produced maximum rhizome yield followed by RH-407, NDH-79, CL-34 and TCP-161 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, number of tillers per clump, number of leaves per plant, plant girth, 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, weight of tertiary rhizomes per plant and rhizome yield q/ha in all environments. The high heritability accompanied with high genetic advance was estimated for plant height, weight of fresh rhizome per plant, weight of mother rhizome, weight of primary rhizomes per plant, weight of secondary rhizome per plant, in all four environments (E1, E2, E3, E4).

Keywords: Turmeric, genetic variability, heritability, genetic advance

Introduction
India has been known as land of spices since very early period of recorded history. The history of Indian spices dates back to the beginning of human civilization.
Turmeric (*Curcuma longa* L.) is one of the most ancient and important spices crop belongs to family *Zingiberaceae.* It is ranked third among the spices crop of India next to chilli and black pepper. India is the largest producer and exporter of turmeric contributing 82 per cent of world production and 45 per cent in the export market. It occupies 6.6 per cent of total area under spices in India. The major items of exports are raw and dry rhizomes, turmeric powder, Curcumin and oleoresin. In our country the leading states of turmeric production are Andhra Pradesh, Orissa, Tamil Nadu, West Bengal, Assam, Bihar and Uttar Pradesh. Except India, Turmeric also cultivated some other countries extensively like Bangladesh, Jamaica, Sri Lanka, Taiwan, China, Burma, Indonesia, Fiji and Thailand.
It has anti cancer and anti viral activities and hence finds use in the drug industry and cosmetic industry. 'Kum-kum', popular with every house wife, is also a by-product of turmeric. It finds a place in offerings on religious and ceremonial occasions.
The rhizome contains yellow colouring component curcumin (3-9%), essential oil (5-6%) and oleoresin (6-13%). Curcumin is gaining more importance in food industries, pharmaceuticals, preservatives and cosmetics. The ban on artificial colour has prompted the use of curcumin as a food colorant. In pharmaceuticals it is valued for the anti cancerous, anti inflammatory, antiseptic, antimicrobial and anti- proliferative activities (Srimal, 1997) [15]. Turmeric being most important to growers, consumers and industries, there is pressing need to increase its productivity and quality to fulfil the increasing demands throughout nation and abroad. Genetic improvement may play a vital role in increasing production and productivity.
The magnitude of genetic variability forms the basis for crop improvement. The success of any breeding programme depends on the nature and amount of genetic variability available in the breeding material. Selection and hybridization approaches are easily followed in bringing about the quantitative improvement. In order to bring about desired improvement, it is essential to assess nature and magnitude of variability, heritability and genetic advance for various characters.

Material and Methods

The experimental material assimilates of 33 genotypes of Turmeric and 2 national checks was evaluated at two locations. These locations were Main Experiment Station (MES) of Vegetable Science, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya (U.P.) and Lal Bahadur Shastri Krishi Vigyan Kendra, Gopalgram, Gonda (U.P.) during 2016-17 and 2017-18. Geographically the experimental site falls under humid sub-tropical climate and is located in between 24.47º and 26.56º N latitude, and 82.12º and 83.58º E longitude at an altitude of 113 m above the mean sea level in the Gangetic Alluvial Plains of eastern Uttar Pradesh and the second location Lal Bahadur Shastri Krishi Vigayn Kendra, Gopalgram, Gonda (U.P.) India, which is situated on 27.12oN latitude and 82.85oE longitude having an elevation of 119 meter above the mean sea level.

The experiment was conducted in Randomized block design with three replication. The spacing dimensions row to row 30cm and plant to plants 20cm and plot size of each plots was 3.0 x 1.0 m^2. The observations were recorded from five randomly selected plants from each replication to each plots. Observations on the following parameters 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), Weight of mother rhizome (g), Length of mother rhizome (cm), Width of mother rhizome (cm), Number of primary rhizomes per plant, Weight of primary rhizomes per plant (g), Number of secondary rhizomes per plant, Weight of secondary rhizome per plant (g), Number of tertiary rhizomes per plant, Weight of tertiary rhizome per plant (g), Rhizome yield (q/ha), Dry matter (%), Curcumin (%), Oleoresin (%), Essential Oil (%), TSS (%).Phenotypic variance was calculated by adding genotypic variance and environmental variance, which was suggested by Burton and de Vane (1953) [1]. Heritability in broad sense calculated according to Hanson *et al.*, (1956) [4], and Genetic advance according to Johnson *et al*., (1955) [5].

Result and Discussion

The high estimates of phenotypic variation were observed for plant height (30.11%), number of tillers per clump (25.35%), number of leaves per plant (20.26%), plant girth (22.62%), weight of mother rhizome (79.36), weight of primary rhizomes per plant (28.29%), number of secondary rhizomes per plant (27.89), weight of secondary rhizomes per plant (45.61), number of tertiary rhizomes per plant (36.05), weight of tertiary rhizomes per plant (56.52) and rhizome yield q/ha (44.04). The medium estimates of phenotypic variation were observed for weight of fresh rhizome (18.40%), length of mother rhizome (16.85%), width of mother rhizome (19.08), number of primary rhizome per plant (18.18%), dry matter (16.66%), curcumin (11.31%) and TSS (19.78%) and the low estimates of phenotypic variation were observed for oleoresin (4.42%) and essential oil (6.61%).

The high estimates of genotypic variation were observed for plant height (30.11), plant girth (20.87), weight of mother rhizome (79.10), weight of primary rhizomes per plant (28.01%), number of secondary rhizomes per plant (27.14), weight of secondary rhizomes per plant (45.33), number of tertiary rhizomes per plant (33.60), weight of tertiary rhizomes per plant (54.86).The medium estimates of genotypic variation were observed for number of tillers per clump (16.58%), number of leaves per plant (17.68%), weight of fresh rhizome per plant (17.42%), length of mother rhizome (16.21%), width of mother rhizome (18.39%), number of primary rhizome per plant (15.08%), rhizome yield q/ha (17.58%), dry matter (15.22%) and TSS (19.15%).The low estimates of genotypic variation were observed for curcumin (7.64%), oleoresin (3.55%) and essential oil (4.59%). The similar results were also reported by Yudhvir *et al*. (2003) [19], Sinkar *et al*. (2005) [14], Singh *et al.* (2007) [8], Singh *et al*. (2008) [9], Singh *et al*. (2012), Prajapati *et al.* (2014) [6] and Verma *et al.* (2014) [17], Gupta *et al.* (2016) [2].

The pooled High estimates of heritability (>80%) were observed for plant height (98.39%), plant girth (85.08%), weight of fresh rhizomes per plant (89.61%), length of mother rhizome (92.60%), width of mother rhizome (92.88%), weight of mother rhizome (99.34%), weight of primary rhizomes per plant (98.05%), number of secondary rhizome (94.73%), weight of secondary rhizomes per plant (98.75%), number of tertiary rhizomes per plant (86.82), weight of tertiary rhizome (94.24%), dry matter (83.44%) and TSS (93.69%). Whereas, number of leaves per plant (76.19), number of primary rhizome per plant (68.80%) and oleoresin (64.37%) showed moderate estimates (50-80%) of heritability and number of tillers per clump (42.79%), rhizome yield (15.94%), curcumin (45.64%) and essential oil (48.29%) showed low estimate (<50) of heritability per cent in broad sense in all four environments (E1, E2, E3, E4)

High heritability accompanied with high genetic advance was estimated for plant height, weight of fresh rhizome per plant, weight of mother rhizome, weight of primary rhizomes per plant, weight of secondary rhizome per plant, in all four environments (E1, E2, E3, E4).While, plant girth, length of mother rhizome, width of mother rhizome, number secondary rhizomes per plant, number of tertiary rhizomes per plant, weight of tertiary rhizome per plant, dry matter and TSS showed high heritability along with low genetic advance respectively. However, low heritability and high genetic advance was analysed for number of tillers per clump, rhizome yield, Curcumin and essential oil and medium heritability and low genetic advance was observed in number of leaves per plant, number of primary rhizomes per plant and oleoresin in four environment pooled analysis. Similar findings were reported by Yudhvir *et al*. (2003) [19] and Singh *et al*. (2012).

Table 1: Range, mean, GCV, PCV, heritability, genetic advance and genetic advance as per cent of mean for different characters in four environments (E1, E2, E3, E4) (MES, NDUAT and K.V.K, Gonda) over the year 2016-17 and 2017-18

S. No.	Characters	Range		General mean	Genotypic coefficient of variation	Phenotypic coefficient of variation	Heritability (%) in broad sense	Genetic advance	Genetic advance in per cent of mean
		Highest	Lowest						
1.	Plant height (cm)	132.85	43.53	81.75	30.11	30.35	98.39	50.30	61.53
2.	Number of tillers per clump	3.82	1.87	2.35	16.58	25.35	42.79	52.55	22.34
3.	Number of leaves per plant	14.38	6.71	8.72	17.68	20.26	76.19	2.77	31.80
4.	Plant girth (cm)	10.95	5.32	7.06	20.87	22.62	85.08	2.80	39.65

5.	Weight of fresh rhizome per plant (g)	238.55	120.80	150.11	17.42	18.40	89.61	51.00	33.97
6.	Length of mother rhizome (cm)	14.07	7.06	8.22	16.21	16.85	92.60	2.64	32.15
7.	Width of mother rhizome (cm)	18.07	7.82	10.46	18.39	19.08	92.88	3.82	36.51
8	Weight of mother rhizome (cm)	141.20	15.87	32.31	79.10	79.36	99.34	52.48	162.40
9	Number of primary rhizomes per plant	6.05	3.17	4.70	15.08	18.18	68.80	1.21	25.77
10.	Weight of primary rhizomes per plant (g)	108.95	37.52	68.75	28.01	28.29	98.05	39.28	57.14
11.	Number of secondary rhizomes per plant	10.60	4.20	6.62	27.14	27.89	94.73	3.60	54.43
12.	Weight of secondary rhizome per plant (g)	148.62	23.35	63.97	45.33	45.61	98.75	59.36	92.79
13.	Number of tertiary rhizomes per plant	9.52	1.67	5.89	33.60	36.05	86.82	3.80	64.50
14.	Weight of tertiary rhizome per plant (g)	24.17	2.00	10.33	54.86	56.52	94.24	11.33	109.72
15.	Rhizome yield (q/ha)	427.70	201.33	255.41	17.58	44.04	15.94	36.94	14.46
16.	Dry matter (%)	24.17	2.00	21.01	15.22	16.66	83.44	6.01	28.64
17.	Curcumin (%)	32.17	18.18	4.06	7.64	11.31	45.64	43.23	10.64
18.	Oleoresin (%)	4.61	3.08	11.17	3.55	4.42	64.37	0.65	5.86
19.	Essential Oil	11.93	10.12	6.02	4.59	6.61	48.29	39.63	6.58
20.	TSS	12.48	6.45	8.73	19.15	19.78	93.69	3.33	38.19

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