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Genetic variability of selected morphological traits in turmeric (*Curcuma longa* L.)

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Abstract
Analysis of variance carried for 14 characters in 63 genotypes received highly significant differences among genotypes for all the characters and revealed the presence of high genetic variability, heritability with low to high genetic advance per cent mean. The characters like the number of mother rhizome, the girth of primary fingers, Length of secondary fingers, curcumin and oleoresin content were recorded for high genetic advance over per cent of mean coupled with high heritability. The genotypes giving high values for these parameters indicated that plant selection based on these parameters may be given more emphasis and hence, better selection for further crop improvement. Thus, the result demonstrated existence of variability among collected genotypes from the southern districts of Karnataka for yield and quality attributing traits in turmeric, which indicates potential for crop improvement.

Keywords: Turmeric, genotypic, phenotypic, heritability and genetic advance

Introduction
Turmeric (*Curcuma longa* L.) is an important sacred and ancient spice of India popularly known as Indian saffron. It is a major rhizomatous spice produced and exported from India. It is a herbaceous perennial, native to tropical South-East Asia, belonging to the family Zingiberaceae, under the order Scitaminae. Turmeric is cross-pollinated triploid species (2n = 3x = 63), which can be vegetatively propagated using its underground rhizomes (Sasikumar, 2005). It is widely used as a spice and condiment in the preparation of pickles and curries and as a colouring agent in textile, food and confectionery industries. In Ayurvedic medicine, turmeric is primarily used as a treatment for anti-inflammatory, hepatoprotective, antitumor, antiviral, wound healing and anti-cancerous properties and is also beneficial in treating gastrointestinal and respiratory disorders. Curcumin and curcuminoids (6%) be some of the most promising compounds for Alzheimer's disease therapies (Shiyou *et al*., 2011) [15]. In India, turmeric is being cultivated in an area of 2,96,181 hectares with an annual production of 11,78,750 tonnes (dry) which accounts for nearly 70 per cent of the world turmeric production (Anon., 2019a) [1]. India is exporting 1,37,650 tonnes of processed turmeric and earning a foreign exchange of Rs.1,28,691 lakhs (Anon., 2019b) [2]. India exporting to countries *viz*., UK, USA, Iran, Japan, UAE, Saudi Arabia, the Netherlands, South Africa and Singapore in different forms such as whole dry rhizome, turmeric powder, oleoresin, curcumin, essential oil and curry powder.

Turmeric is grown in specific niche regions and it has a crop duration of 8-9 months. It is grown both as a sole and mixed crop, especially with coconut. All over the regions, there are custodian farmers who have a legacy of keeping the landraces of turmeric over decades and indeed the source of seed material to fellow farmers. They grow this crop as a matter of tradition in those regions. Many landraces are therefore existing all over the regions where this crop is being cultivated. The landraces are known by the names of the villages or sometimes by the family names of the custodian farmers. There is an urgent need to establish the characters in the existing landraces are delineating from the commercial varieties or share the commonality.

Owing to the functional sterility, no sexually derived seeds are formed in this crop hence, rhizomes are the sole source of planting material. The rhizomes formed in clusters underground are separated and used as planting material. Over a period accumulated somatic mutations have contributed to the present day heterogeneity and heterozygous noticed among the landraces, rendering them to the population of genotypes.

This is contributing to the unevenness in the crop and production.

In this paper, we attempted to elucidated diversity in native genetic resources and their similarity to commercially grown/ released varieties of the southern region of Karnataka.

Material and Methods

The experimental material comprised of 63 genotypes with check varieties -Prabha, Prathibha and Salem as checks and they were collected from potentially turmeric growing areas of southern districts *viz*., Chamarajanagar, Mysore, Mandya and Shivamogga from the farmer's field. The experiment was laid out in Augmented Block Design.

About 30-40g weight healthy mother rhizome of different genotypes were line planted during May 2018-19 and 2019-20 during *kharif* season with a spacing of 30 x 30 cm between row to row and plant to plant spacing was maintained. All the agronomic package of practices was adapted to grow a healthy crop. Observations were recorded for plant height, number of leaves, leaf area, leaf area index, petiole length, number of tillers, dry weight of aerial parts and rhizomes, dry matter production, number of mother rhizomes and fingers, fresh and dry weight of mother rhizomes and fingers, length and girth of mother rhizomes and fingers, crop duration, the fresh yield of rhizomes, cured rhizome yield, curcumin and oleoresin content. The analysis of variance for testing the variation among genotypes was carried out as per the method suggested by Federer (1956) [4]. The phenotypic and genotypic coefficient of variation was calculated as per methods given by Burton and Devane (1953) [3]. Subsequently, heritability and genetic advance as per cent mean were calculated by according to Weber and Moorthy (1952) [17]; Johnson *et al*. (1955) respectively.

Results and Discussion

PCV was higher than GCV for all the characters studied. Among traits, yield components *viz*., number of mother rhizomes, length of mother rhizomes and secondary fingers, girth of primary fingers and quality traits like curcumin and oleoresin content showed very narrow differences between phenotypic and genotypic co-efficient of variation indicating less influence of environment in the expression of these characters during both years of study (Table 1). The magnitude of variance, as such does not reveal the relative amount of variability as ascertained through the co-efficient of variation. Thus, selection for these characters would be more effective. Plant height and crop duration were recorded low GCV and PCV, low to moderate GCV and PCV were found in the number of leaves per clump, tillers per clump and curing percentage indicating selection would be less effective. Similar results were reported by Prajapati *et al*. (2014) [10], Rajyalakshmi *et al*. (2013) [11], Luiram *et al*. (2018) [7] and Paw *et al*. (2020). The other characters such as leaf area, leaf area index, petiole length, number of secondary fingers, length and girth of mother rhizomes and primary fingers showed moderate GCV and PCV indicating more sensitivity of these characters to environmental factors. Hence, response to selection would be poor (Salimath *et al*., 2017) [13], (Jayshree *et al*., 2009) [5] and (Luiram *et al*., 2018) [7]. Traits like the number of mother rhizomes and primary fingers, length and girth of secondary fingers, a fresh yield of rhizomes, cured rhizome yield, curcumin and oleoresin content were recorded high PCV and GCV with moderate difference indicating that selection would be very effective by these characters. Similar results have also been reported by Sinker *et al*. (2005) [16], Prajapati *et al*. (2014) [10], Salimath *et al*. (2017) [13] and Luiram *et al*. (2018) [7].

Heritability value indicates the heritable properties of variation. Burton and Devane (1952) had suggested that genotypic co-efficient of variation together with heritability estimates would give the best picture of the amount of progress to be expected by selection. In the present study, heritability ranged from 62.52 (Crop duration) to 97.71 (Number of mother rhizome) during 2018-19 whereas, during 2019-20 it ranges from 71.73 (Tillers per clump) to 96.71 (Curcumin). High heritability was noticed for all characters but among that, the number of mother rhizomes, the girth of primary fingers, length of secondary fingers, curcumin and oleoresin content showed very high heritability. Similarly, high heritability estimates were reported by Rao *et al*. (2000) [12], Salimath *et al*. (2017) [13], Luiram *et al*. (2018) [7] and Maurya *et al*. (2018) [8], indicated that these characters are less influenced by environmental factors and are under the control of additive gene effect and improvement for such characters through simple selection would be rewarding.

Heritability estimates along with genetic gain (genetic advance as per cent of mean) are more useful than heritability alone in predicting the resultant effect for selecting the best individuals (Johnson *et al.*, 1955). Genetic advance is the measure of improvement that can achieved by practicing selection in a population. High heritability with low genetic advance indicates the importance of non-additive gene action, while high heritability with high genetic advance indicates the additive gene effects.

In the present study, high genetic advance over per cent of mean coupled with high heritability was observed for the characters like number of mother rhizome, girth of primary fingers, length of secondary fingers, curcumin and oleoresin content. These characters were under additive gene effect and could be improved by simple selection procedure. Traits such as plant height, tillers per clump, number leaves per clump, crop duration and curing percentage have shown high heritability coupled with moderate genetic advance over mean and only one trait crop duration shows lowest GAM which indicate the presence of certain degree of non additive gene effects.

Conclusions

The study indicated that sufficient variability is present among the collected genotypes from the southern districts of Karnataka for yield and quality attributing traits in turmeric. These varieties can be utilized for further improvement or further manipulation of genetic resource through breeding as genotypes in this region good sources of many desirable traits. Since turmeric as rhizomatous crop, the selection would more effective when selection based on traits with high GCV, PCV, High heritability and genetic advance percent mean will beneficial for further crop improvement.

Table 1: Estimates of range, mean and genetic parameters for growth, yield and quality traits in turmeric genotypes

Sl. No.	Characters	Range		Mean	GCV (%)	PCV (%)	h BS (%)	GA	GAM (%)
		Min	Max						
1	Plant height (cm)	61.53	90.25	81.65	6.06	6.82	78.80	9.06	11.09
2	Leaf area/clump (dm^2)	92.00	206.34	148.19	14.15	15.55	82.75	37.75	26.55
3	Leaf area index/clump	10.22	22.93	15.80	14.08	15.56	81.99	4.16	26.31
4	Number of leaves/clump	16.25	26.34	20.29	9.48	10.43	82.61	3.61	17.77
5	Petiole length (cm)	8.10	17.45	13.11	11.11	12.64	77.26	2.64	20.14
6	Tillers per clump	2.50	4.60	3.71	9.04	10.89	68.90	0.57	15.47
7	NMR	1.02	3.78	2.04	32.88	33.27	97.71	1.37	67.06
8	NPR	4.33	13.67	8.77	26.59	28.94	84.39	4.42	50.39
9	NSR	7.56	18.27	14.43	18.36	19.06	92.81	5.27	36.49
10	GMR (cm)	7.21	14.66	10.61	17.62	19.57	81.09	3.47	32.74
11	GPR (cm)	3.89	8.68	6.34	17.62	19.49	81.70	2.08	32.85
12	GSR (cm)	1.57	6.54	3.69	32.18	33.92	90.02	2.32	62.99
13	LMR (cm)	2.66	9.86	6.51	18.34	19.44	89.04	2.32	35.70
14	LPR (cm)	5.01	9.34	7.31	16.65	17.78	87.66	2.35	32.16
15	LSR (cm)	2.13	7.86	5.30	31.13	31.91	95.16	3.32	62.64
16	Crop duration	234.13	272.00	261.74	2.35	2.97	62.52	10.02	3.83
17	Fresh yield (t ha^{-1})	7.88	46.52	27.98	31.82	35.82	78.91	12.23	58.31
18	Cured yield (t ha^{-1})	1.70	11.83	4.53	38.33	40.79	88.32	3.37	74.32
19	Curing percentage	14.00	25.42	21.97	8.98	10.06	79.69	3.63	16.54

Table 2: Estimates of range, mean and genetic parameters for growth, yield and quality traits in turmeric genotypes

Sl. No.	Characters	Range		Mean	GCV (%)	PCV (%)	h BS (%)	GA	GAM (%)
		Min	Max						
1	Plant height (cm)	67.23	98.32	83.78	6.42	7.11	81.46	10.01	11.95
2	Leaf area/clump (dm^2)	113.63	232.03	172.66	15.43	16.46	87.88	47.83	29.85
3	Leaf area index/clump	12.63	25.78	17.81	15.38	16.46	87.34	5.28	29.66
4	Number of leaves/clump	16.52	26.00	21.46	9.93	10.75	85.36	4.06	18.93
5	Petiole length (cm)	8.67	20.00	13.64	12.73	13.99	82.85	3.26	23.91
6	Tillers per clump	2.75	4.80	3.75	9.55	11.28	71.73	0.63	16.69
7	NMR	2.01	4.68	4.12	24.75	24.87	98.99	2.09	50.80
8	NPR	5.36	14.07	11.28	21.65	23.98	81.52	4.55	40.32
9	NSR	10.35	19.65	17.51	14.91	15.96	87.25	5.03	28.73
10	GMR (cm)	7.32	14.65	11.19	17.14	18.65	84.39	3.63	32.48
11	GPR (cm)	4.68	8.50	6.83	16.93	17.64	92.15	2.29	33.53
12	GSR (cm)	2.10	6.35	3.88	27.96	29.78	88.13	2.10	54.14
13	LMR (cm)	3.79	10.17	6.93	17.49	18.51	89.32	2.36	34.10
14	LPR (cm)	4.98	9.37	7.49	15.14	16.33	86.04	2.17	28.98
15	LSR (cm)	2.36	7.53	5.98	26.46	27.18	94.76	3.18	53.14
16	Crop duration	240.00	268.00	254.32	3.16	3.68	74.11	14.29	5.62
17	Fresh yield (t ha^{-1})	7.94	52.02	29.37	30.94	33.79	83.80	14.82	58.42
18	Cured yield (t ha^{-1})	1.39	13.59	7.55	37.22	40.6	84.07	3.21	70.41
19	Curing percentage	14.50	26.12	22.54	8.73	10.03	75.87	3.54	15.69
20	Curcumin (%)	1.88	6.33	4.36	23.46	23.86	96.71	2.07	47.6
21	Oleoresin (%)	3.27	14.35	9.27	26.1	27.07	92.95	4.81	51.91

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