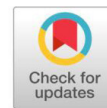


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Assessment of Genetic Variability in Turmeric (*Curcuma longa*) Germplasm

P. Hemalatha^{1*}, S. Geethanjali², V. Sivakumar³, M. Vijayabhama⁴, R. Ravi⁵ and K. Baranidharan⁶



¹Department of Agroforestry, Forest College and Research Institute, Tamil Nadu Agricultural University, Mettupalayam – 641 301, Coimbatore, Tamil Nadu, India

²Department of Plant Breeding and Genetics, CPBG, Tamil Nadu Agricultural University, Coimbatore - 641 003, Tamil Nadu, India

³Department of Fruit Science, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore - 641 003, Tamil Nadu, India

⁴Department of Physical Sciences and Information Technology, Tamil Nadu Agricultural University, Coimbatore - 641 003, Tamil Nadu, India

⁵Department of Forest Products and Wildlife, Forest College and Research Institute, Tamil Nadu Agricultural University, Coimbatore - 641 003, Tamil Nadu, India

⁶Department of Agroforestry, Forest College and Research Institute, Tamil Nadu Agricultural University, Coimbatore - 641 003, Tamil Nadu, India

Abstract

The present research work was conducted to assess the genetic variability present in elite turmeric germplasm comprising 50 genotypes. A total of nine morphometric traits including plant height, number of tillers, leaf growth parameters and rhizome yield attributes were recorded in these fifty genotypes. The genotypes exhibited a high degree of variation for all the characters studied. The magnitude of GCV and PCV were higher for the number of tillers, mother rhizome yield per plant, finger rhizome yield per plant and dry rhizome recovery percentage. Moderate to medium heritability estimates were recorded for leaf length, mother rhizome yield per plant, finger rhizome yield per plant, and dry rhizome recovery percentage and high heritability estimates were recorded for plant height, number of leaves, leaf breadth, number of tillers and total rhizome yield per plant. High heritability together with high genetic advance was registered for the number of tillers. Total rhizome yield per plant showed a significant positive correlation with finger rhizome yield per plant, mother rhizome yield per plant, leaf length and plant height. Among the various characters studied, mother rhizome yield per plant and finger rhizome yield per plant exhibited the highest positive direct effect on total rhizome yield per plant. Plant height, number of leaves, leaf length and leaf breadth exhibited a positive indirect effect on total rhizome yield via mother rhizome yield per plant and finger rhizome yield per plant.

Keywords: Turmeric, Germplasm, Genetic variability, Yield, Heritability, Correlation and Path Analysis.

Introduction

Turmeric (*Curcuma longa* L.) belonging to the family Zingiberaceae is a very important spice in India, which produces nearly the whole world's crop and consumes 80 per cent of the total production. Besides India, it is distributed in Cambodia, China, Indonesia, Madagascar, Malaysia, the Philippines and Vietnam [1]. India is the largest producer, consumer and traditional exporter of turmeric in the global

arena. India exports turmeric to over 100 countries throughout the world. Indian turmeric is regarded as the best in the world market because of its high curcumin content. Apart from its religious importance in India, this crop is being used as a culinary spice, in cosmetic preparations, as a food preservative, colouring agent and also for its pharmaceutical properties. The rhizomes of turmeric and its powder have been used extensively in the Indian systems of medicine (Ayurveda, Unani, and Siddha). In the recent past, its colouring principle "Curcumin" (chemically known as diferuloylmethane), has been established to have a wide spectrum of biological and pharmacological activities including antioxidant, anti-inflammatory, hypoglycemic, antimicrobial, antiviral and anti-cancerous properties [3].

Turmeric is a cross-pollinated crop and is vegetatively

*Corresponding Author: P. Hemalatha

E-mail Address: - hemalatha.p@tnau.ac.in

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propagated through underground rhizomes. Due to its triploid nature, artificial hybridization is difficult in this crop and genetic improvement relies basically on exploiting the existing variation present in the germplasm. Hence, the collection and characterization of turmeric germplasm for qualitative and quantitative traits is a prerequisite in turmeric breeding programmes. Yield is a highly complex trait influenced by both genotype and environment as well as G x E interactions. Understanding the level of phenotypic variability present in the germplasm and identifying the component traits that contribute to yield important for identifying promising accessions and utilising them in breeding programmes. Correlation, path analysis and multivariate techniques like principal component analysis can throw light on the effect and contribution of the independent variables towards yield and help the breeders to decide on the selection criteria for the genetic improvement of turmeric. However, only limited studies on assessing the genetic variability in turmeric are available, and the evaluation of the accessions is confined to different agro-climatic zones of the country as reported by [4] [10] [12] [14-16] [20-21] [24-25]. With this view, the present study was carried out to assess the extent of genetic variability and diversity available in elite germplasm of turmeric comprising 50 accessions.

Material And Methods

The current research investigation was carried out at the Thoppampalyam block of Agricultural Research Station, Tamil Nadu Agricultural University, Bhavanisagar, Erode district, Tamil Nadu during 2015-2019. The experimental site comes under the Western zone of Tamil Nadu which is located at 11° 29' N latitude and longitude of 77° 80' E at 256 m above MSL. The average yearly rainfall is 717 mm, the maximum temperature is 33.9 °C and the minimum temperature is 21.6 °C. The average wind velocity is 3.2 KMPH. The sunshine hours range from 3.7 to 7 per day with an average evaporation of 4.3 mm per day. Under this climatic condition, fifty elite turmeric germplasm collected from various parts of the country were evaluated for their yield performance and quality along with BSR 1 and 2 as check varieties. The research trial was carried out for five years to assess the performance of collected genotypes.

Each genotype was planted in a plot of 3 m × 2 m size of fine tilth. The seed rhizomes were sown in ridges adopting spacing of 45cm x 15cm and at a depth of 4cm in each plot. The experiment was laid

out in Randomized Block Design (RBD) with two replications. Recommended agronomic practices and plant protection measures were followed at timely intervals for the successful raising of the crop. Five competitive plants were randomly selected and tagged in each plot and observations on plant height, number of tillers, number of leaves, leaf length, leaf breadth, mother rhizome yield, finger rhizome yield, dry rhizome recovery and total rhizome yield per plants were recorded as per the standard descriptors.

The mean values were used for the analysis of variance (ANOVA) following the procedures as prescribed by [11]. The phenotypic and genotypic variances were calculated by using the respective mean sum of a square from the variance table [8]. The phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) was calculated as per the formula proposed by [2]. Heritability in the broad sense was estimated as per the formula suggested by [8] and expressed in percentage. The range of heritability was categorized as low (0-30 %), medium (31-60 %) and high (more than 60 %) as proposed by [6]. The genetic advance was calculated as per the formula as proposed by [6] and classified into high (more than 20 %), medium (10 - 20 %) and low (less than 10 %) as per procedure recommended by [6]. The mean data were subjected to correlation and path coefficient analysis using TNAUSTAT [9].

Results And Discussion

Variability, heritability and genetic advance in turmeric genotypes:

The presence of wide variability in the breeding materials is the basis for any crop improvement programme to enhance the probability of selection. In the present experiment, the mean squares of accessions for all the traits were signs indicating the presence of adequate variability among the accessions (Table 1). Such a high degree of variability for most of the quantitative traits in turmeric has been reported by [5] [12-13] [21] [25] which can be exploited in the breeding programmes.

The extent of variation as explained by mean, range, phenotypic and genotypic coefficient of variation, heritability and genetic advance are furnished in Table 2. The accessions exhibited wide variation for all the traits studied except for a number of leaves. Plant height ranged from 94.45 to 134.75cm. BS106 produced a maximum number of tillers. The mean

Table 1: Analysis of variance (ANOVA) showing the mean sum of squares for various traits in turmeric

Source d.f	Replications 1	Genotypes 39	Error 39
Plant height (PH)	10.11	117.14**	7.79
Number of leaves (NL)	0.28**	0.34**	0.03
Leaf length (LL)	95.44	44.97*	29.01
Leaf breadth (LB)	0.41	1.97**	0.12
Number of tillers (NT)	0.63*	3.27**	0.11
Mother rhizome yield per plant (MRYP)	42.19	1356.73**	488.84
Finger rhizome yield per plant (FRYP)	1833.61	14887.06**	6836.66
Dry rhizome recovery percentage (DRP)	0.046	4.27**	0.014
Total rhizome yield per plant (TRYP)	3444.00	23194.31**	8120.94

* and ** significant at 5% and 1% respectively

Table 2: Estimates of genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability (%), genetic advance for different traits in turmeric

Characters	Mean	Max	Min	PCV %	GCV %	h ² %	Genetic advance (% mean)
Plant height (PH)	115.88 ± 1.97	134.75 (CL 199)	94.45 (BS 106)	6.82	6.38	87.53	12.30
Number of leaves (NL)	12.95 ± 0.11	14.00 (BS 9)	12.00 (BS 15)	3.32	3.07	85.83	5.86
Leaf length (LL)	46.36 ± 3.81	58.50 (BS3)	26.30 (BS 17)	13.12	6.09	21.58	5.83
Leaf breadth (LB)	14.51 ± 0.25	18.60 (BS 81)	12.10 (BS12)	7.06	6.63	88.11	12.82
Number of tillers (NT)	4.04 ± 0.24	6.70 (BS 106)	1.00 (BS4)	32.21	31.12	93.35	61.94
Mother rhizome yield per plant (MRYP)	101.43 ± 15.63	0.204 (BS 9)	0.059 (Kallipatti)	29.95	20.54	47.03	29.01
Finger rhizome yield per plant (FRYP)	406.39 ± 58.47	0.637 (Pradeepa)	0.208 (Kallipatti)	25.65	15.61	37.06	19.58
Dry rhizome recovery percentage (DRP)	510.31 ± 63.72	20.98 (Kallipatti)	15.40 (BS 120)	24.52	17.01	48.13	24.31
Total rhizome yield per plant (TRYP)	17.93 ± 0.09	0.824 (BS 9)	0.266 (Kallipatti)	8.17	8.14	94.32	16.71

leaf length and width of the accessions were 46.36 and 14.51cm respectively. Finger rhizome yield ranged from 0.208 to 0.637 kg per plant. The mother rhizome yield and total rhizome yield were highest in the accession BS9. The variations that are expressed at the phenotypic level is the total of the genotypic and environmental effect. The observations on the variability parameters revealed that PCV was higher than GCV for all the traits studied, indicating the additive nature of gene action. Similar results have been reported in turmeric [12] [24-25]. The magnitude of GCV and PCV were higher for a number of tillers and yield parameters *viz.*, mother rhizome yield per plant, finger rhizome yield per plant and dry rhizome

recovery percentage. However, wide variation between PCV and GCV values was also observed for these characters, which indicates the influence of environment on trait expression. In a study based on thirteen turmeric accessions, higher magnitudes of GCV and PCV for fresh rhizome yield and dry recovery percentage in turmeric were reported which is in line with the present findings [21].

In addition, to mean performance and variability, effective selection for superior genotypes from a base population also relies on the heritability estimates. The heritability estimates may be successfully utilized with better precision when studied in combination

Table3: Genotypic (above diagonal) and phenotypic (below diagonal) correlation coefficients among various traits in turmeric

Traits	PH	NL	LL	LB	NT	MRYP	FRYP	DRP	TRYP
PH	1.000	0.125	0.712	0.026	0.057	0.391	0.568	-0.237	0.498
NL	0.110	1.000	-0.027	0.198	0.081	0.455	0.157	-0.297	0.298
LL	0.288	0.004	1.000	0.345	0.069	0.575	0.522	0.061	0.575
LB	0.063	0.142	0.114	1.000	0.091	0.337	0.156	-0.100	0.208
NT	0.051	0.058	-0.016	0.086	1.000	-0.077	-0.245	0.164	-0.189
MRYP	0.289	0.294	0.204	0.237	-0.102	1.000	0.702	-0.189	0.951
FRYP	0.295	0.111	0.176	0.107	-0.096	0.376	1.000	-0.160	0.945
DRP	-0.222	-0.275	0.020	-0.101	0.158	-0.123	-0.102	1.000	-0.119
TRYP	0.311	0.212	0.205	0.145	-0.093	0.599	0.950	-0.086	1.000

PH- plant height (cm), NL- numbers of leaves per plant, LL- leaf length (cm),LB-leaf breadth (cm), NT- number per tillers per plant, MRYP- mother rhizome yield per plant (kg), FRYP- finger rhizome yield per plant (kg), DRP-dry recovery percentage (%) and TRYP-total rhizome yield per plant(kg).

Table 4: Path coefficient analysis showing direct and indirect effects of various traits total rhizome yield per plant

Traits	PH	NL	LL	LB	NT	MRYP	FRYP	DRP	TRYP
PH	0.065	-0.011	-0.105	-0.001	0.000	0.282	0.291	-0.023	0.498**
NL	0.008	-0.087	0.004	-0.008	-0.001	0.328	0.081	-0.028	0.298*
LL	0.046	0.002	-0.148	-0.013	-0.001	0.415	0.267	0.006	0.575**
LB	0.002	-0.017	-0.051	-0.039	-0.001	0.243	0.080	-0.010	0.208*
NT	0.004	-0.007	-0.010	-0.004	-0.007	-0.055	-0.126	0.016	-0.189
MRYP	0.025	-0.039	-0.085	-0.013	0.001	0.721	0.360	-0.018	0.951**
FRYP	0.037	-0.014	-0.077	-0.006	0.002	0.506	0.512	-0.015	0.945**
DRP	-0.015	0.026	-0.009	0.004	-0.001	-0.136	-0.082	0.095	-0.119

Residual Value = 0.2714

PH- plant height (cm), NL- numbers of leaves per plant, LL- leaf length (cm),LB-leaf breadth (cm), NT- number per tillers per plant, MRYP- mother rhizome yield per plant (kg), FRYP- finger rhizome yield per plant (kg), DRP-dry recovery percentage (%) and TRYP-total rhizome yield per plant(kg).

with genetic advances [2] [22]. Heritability and genetic advance when considered together were more beneficial for predicting the significant effect of selecting the best genotypes rather than considering them individually [6].

In the present study, the broad sense heritability estimates were moderate for leaf length (21.58%), mother rhizome yield per plant (47.03%), finger rhizome yield per plant (37.06%), and dry rhizome recovery percentage (48.13%) and high for plant height (87.53%), number of leaves (85.83%), leaf

breadth (88.11%), number of tillers (93.35%) and total rhizome yield per plant (94.32%). High heritability coupled with high genetic advance was observed for a number of tillers. High heritability for growth and yield attributes in turmeric has also been reported by [12] [21] [25]. High heritability coupled with high genetic advance has been reported for leaf parameters and yield parameters such as rhizome yield and dry recovery percentage [18] [21]. Such traits exhibiting high heritability estimates and high genetic advance are amenable to being improved through simple phenotypic selection.

Correlation

The genotypic correlation and phenotypic correlation of growth and yield attributes with total rhizome yield per plant are presented in Table 3. The correlation study revealed that total rhizome yield per plant was positively and significantly associated with finger rhizome yield per plant, mother rhizome yield per plant, leaf length and plant height at both genotypic and phenotypic levels. Total rhizome yield per plant also exhibited a positive correlation with a number of leaves per plant and leaf breadth. An increase in plant height, number of leaves, leaf length and breadth contributed towards an increase in mother rhizome yield per plant. Hence, exercising direct selection for these traits would improve mother rhizome yield. Positive correlation of plant height, number of tillers, mother rhizome weight and mother rhizome yield with total rhizome yield have been reported by several workers in turmeric [7] [12] [17] [19] [21] [23] [25].

Path coefficient analysis

Path coefficient analysis was carried out to partition the genotypic correlations into direct and indirect effects by taking total rhizome yield per plant as a dependent variable and the rest of the quantitative traits as independent variables (Table 4). Among the various traits studied, mother rhizome yield per plant (0.721) and finger rhizome yield per plant (0.512) exhibited the highest positive direct effect on total rhizome yield per plant thereby favouring the selection of these traits for yield improvement in turmeric. Plant height, number of leaves, leaf length and leaf breadth exhibited a positive indirect effect on total rhizome yield *via* mother rhizome yield per plant and finger rhizome yield per plant. Similar findings have been reported [17] [24] [25]. The residual effect was also low, indicating that most of the yield contributing traits have been considered to explain their relationship with yield. Our results suggest that all the yield attributing traits influencing total rhizome yield either directly or indirectly should be given due importance while practising selection for yield improvement in turmeric.

Conclusion

Yield in turmeric is influenced both by genetic and environmental variation. The presence of a high degree of variation among the genotypes for the various traits studied opens up the opportunity for exercising selection in this germplasm for desirable

yield attributes. Exercising the selection of correlated traits exhibiting moderate to high heritability can be useful to improve the economic yield of turmeric. The present study indicates that total rhizome yield in turmeric can be improved by selecting for mother rhizome yield and finger rhizome yield directly. Phenotypic selection for increased plant height, with more number of leaves, which are larger, can indirectly help to improve the total rhizome yield in turmeric.

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