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Indian Collections of Turmeric (*Curcuma longa* L.): Genetic Variability, Inheritance, Character Association and Performance

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Twenty seven genotypes of turmeric (*Curcuma longa* L.) were evaluated to estimate the variability and inheritance pattern, to suggest suitable breeding strategies and to identify productive genotypes. Highly significant mean squares for all the traits indicated large variation among genotypes. High genetic gain through selection is expected for shoot length, leaf area, rhizome yield and dry matter yield because of additive gene inheritance; while curcumin accumulation in rhizome could be improved by selecting the heterotic seedlings as it is governed by non-additive gene. Furthermore, leaf length and curcumin content could be the most effective and reliable selection indices, as indicated by correlation and path coefficients, in identifying the curcumin-rich productive genotypes. A variety of North East India 'Megha Turmeric-1' excelled for the traits of commercial importance (dry matter recovery and curcumin yield). Conclusively, the genotypes of North East India were superior to other parts of India for most of the economic traits and potentially useful for genetic enhancement as well as for varietal improvement of turmeric.

Key Words: Curcumin, Heritability, North East India (NEI), Turmeric (*Curcuma longa*), Variability, Yield

Introduction

Turmeric (*Curcuma longa* L.) is one of the most widely cultivated spice crops in North-eastern region of India because of agro-climatic suitability, rich genetic diversity and high curcumin content. India is the largest producer, consumer and exporter of turmeric accounting for about 80%, 90% and 60% share, respectively of the world's total (Anonymous, 2012). In India, turmeric is extensively cultivated in the states having high rainfall such as Andhra Pradesh, Tamil Nadu, Odisha, Karnataka, West Bengal, Gujarat, Maharashtra, Assam and Meghalaya. The distinctive yellow-orange curcuminoids (curcumin, demethoxycurcumin and bisdemethoxycurcumin) are important bioactive compounds that occur in the rhizomes. Among curcuminoids, curcumin is a major colour pigment whose concentration varies from 4.0–9.0% amongst genotypes. Turmeric possesses anti-inflammatory, hepatoprotective, antitumor, antiviral and anticancerous properties, and is also beneficial in treating gastrointestinal and respiratory disorders (Ammon and Wahl, 1991; Polasa *et al*., 1991; Anwarul *et al*., 2006). Recent data also suggest that curcumin and other antioxidant products from the dried rhizome may be useful in the treatment of some age-related degenerative processes (Miquel *et al*., 2002).

Indian states of the North East India (NEI) especially Mizoram, Meghalaya and Assam are endowed with a wide range of genetic variability in *C. longa* and other *Curcuma* species and with geo-climatic conditions of the region favouring higher accumulation of curcumin in rhizomes (Singh *et al*., 2013a; 2013c). The curcumin content is one of the major criteria for its export to the global markets. Alleppey turmeric, world's most outstanding and demanded grade, is the richest source of curcumin and it is extensively cultivated in Kerala. Turmeric is a cross-pollinated triploid species (2n = 3x = 63), very shy in flowering requiring, needs specific climatic conditions for flowering and has pollen fertility less than 60% (Nambiar, 1979; Nair *et al*., 2004). The aforementioned factors make its hybridization tedious and almost ineffective in most of the cases. Being propagated commercially by rhizomes and with flowering complexities, the genetic improvement programmes in turmeric are largely restricted to clonal selection and induced mutation. Moreover, limited viable seed setting in open-pollination and controlled crosses explore the possibility of recombination breeding through hybridization, and hence few varieties such as IISR Prabha and IISR Pratibha have been released through progeny selection of open-pollinated seedlings (Sasikumar *et al*., 1996).

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Considerable genetic variation for various traits of economic importance has been reported, especially among Indian collections excluding NEI (Babu *et al*., 1993; Sasikumar 2005). Those from this region have one of the best agro-climatic conditions for production of curcumin-rich turmeric, the potential for genetic improvement and production is still to be exploited. Therefore, the aim of the present study was to estimate the variance components, heritability, expected genetic advance and character association of important traits related to vegetative growth, rhizome yield and curcumin content, and its agronomic performance for various economic traits between and within Indian turmeric genotypes/ collections from a wide range of latitudes and longitudes. The findings pertaining to genetic variation and inheritance pattern would be helpful to the plant breeders in selecting the breeding approaches (clonal selection and/or hybridization), genotypes and traits more appropriately and efficiently.

Materials and Methods

Field experiments were conducted at the Research Farm, ICAR-RC-NEH Region, Mizoram Centre, Kolasib, Mizoram during 2008–2009. The experimental material comprised 27 genetically diverse genotypes, including 11 released varieties and 16 germplasm collections (Table 1). These 27 genotypes were categorised into two groups i.e. (i) NEI collections: belonged to North East India and (ii) other parts of India (OPI) collections: belonged to other than North-eastern region of India. The growth parameters like shoot length, leaf length, leaf width, leaf area, shoot thickness near base and numbers of tillers/ plant were measured 120 days after planting. The observations pertaining to growth parameters were recorded on 15 randomly chosen plants in each plot. For measuring the leaf length, leaf width and leaf area, third leaf from top was selected. Days to maturity were counted at 50% neck-fall stage. Rhizome yield (q/ha) and dry matter content (%) were determined as per

Table 1. Details of basic experimental materials

S.No.	Genotype	Developing organization/ region of collection
	Released variety	
1	Megha Turmeric-1	ICAR-RC-NEH Region, Shillong, Meghalaya
2	Suranjana	UBKV, Pundibari, Cooch Behar, West Bengal
3	Narendra Haldi-1	NDUAT, Kumarganj, Faizabad, Uttar Pradesh
4	IISR Alleppy Supreme	IISR, Kozhikode, Calicut, Kerala
5	IISR Kedaram	
6	IISR Pratibha	
7	Duggirala Red	Dr YSRHU, Jagtial, Andhra Pradesh
8	BSR-2	TNAU, Coimbatore, Tamil Nadu
9	Rajendra Sonia	TCA, RAU, Dholi, Bihar
10	Rasmi	HARS, OUAT, Pottangi, Odisha
11	Roma	
	Germplasm	
12	Local-4	Barapani, Shillong, Meghalaya
13	Local-5	
14	Local-7	Silchar, Assam
15	Local-9	Dulte, Champhai, Mizoram
16	Local-10	Phaileng, Mamit, Mizoram
17	Local-11	Rotlang, Lunglei, Mizoram
18	IC0588788	Vengthar, Kolasib, Mizoram
19	IC0588789	
20	IC0588790	Kawnpuii, Kolasib, Mizoram
21	IC0588791	
22	IC0588792	Theiva, Saiha, Mizoram
23	IC0588793	
24	IC0588794	
25	IC0588795	
26	IC0588796	Siphir, Aizawl, Mizoram
27	IC0588797	

standard procedure (Bavappa, 1985). Curcumin content in turmeric powder was estimated by following the American Spice Trade Association method (ASTA, 1997). Finally, dry matter yield (q/ha) and curcumin yield (kg/ha) were calculated. The data were analysed statistically for analysis of variance (Singh and Chaudhary, 1977); variability, heritability and genetic advance (Burton and DeVane, 1953); correlation (Searle, 1961); and path coefficient (Dewey and Lu, 1959).

Results and Discussion

Highly significant mean squares for all the morphological and quality traits in 27 genotypes of turmeric (*Curcuma longa* L.) are presented in Table 2. It is clear from the data that there is natural variation among genotypes which can be improved by various breeding strategies. The extent of variability (Table 2) among genotypes was estimated in terms of range, coefficient of variation (CV), genotypic and phenotypic variance (σ^2g and σ^2p), and genotypic and phenotypic coefficient of variation (GCV and PCV). There was sufficient variation with respect to plant growth, maturity, yield and curcumin content. The magnitude of PCV was higher than the corresponding GCV for all the parameters which reflects the influence of environment on the expression of these traits. The respective PCV and GCV were higher for shoot length, leaf length, shoot thickness, leaf area, rhizome yield, dry matter yield and curcumin yield; whereas these were lower for leaf width, numbers of tillers/plant, days to maturity, dry matter content and curcumin content. The traits with high GCV possess a higher magnitude of variability and thus, present a better possibility of improvement through breeding approaches. Significant variations for various parameters were also reported by various workers (Babu *et al*., 1993; Manohar et al., 2004; Sasikumar, 2005; Pothitirat and Gritsanapan, 2006; Jan *et al*., 2011; 2012; Singh *et al*., 2013b,d; Rajyalakshmi *et al*., 2013).

Heritable variation among genotypes could be anticipated by calculating the estimates of heritability and genetic advance as percentage of mean. The magnitude of heritability (Table 3) varied from 62.7–92.9% (moderate to high). High heritability (> 80%) was estimated for

Table 2. Mean squares for morphological and quality traits in turmeric genotypes

Source of variation	d.f.	Mean square											
		Shoot length	Leaf length	Leaf width	Shoot thickness	Leaf area	No. of tillers/ plant	Days to maturity	Rhizome yield	Dry matter content	Dry matter yield	Curcumin content	Curcumin yield
Replication	2	26.8	4.67	0.24	3.08	788	0.012	19.3	1382	3.93	50.0	0.010	2231
Genotype	26	1071.2**	218.68**	8.09**	37.88**	130043**	1.858**	464.9**	14017**	40.61**	741.9**	1.091**	43452**
Error	52	26.7	7.85	1.34	2.32	4456	0.266	46.8	912	2.18	56.6	0.049	2241

*,** Significant at $P < 0.05$ and $P < 0.01$, respectively.

Table 3. Estimates of variance, heritability and genetic advance for economic and quality traits in genotypes of turmeric

Parameter	Range	CV (%)	σ^2g	σ^2p	GCV (%)	PCV (%)	h^2 (%)	GA	GA as %age of mean
Shoot length (cm)	53.6-135.2	6.06	348.1	374.9	21.9	22.7	92.9	37.0	43.4
Leaf length (cm)	28.1-68.2	6.65	70.3	78.1	19.9	21.0	90.0	16.4	38.9
Leaf width (cm)	8.9-17.5	9.05	2.3	3.6	11.7	14.8	62.7	2.4	19.1
Shoot thickness (mm)	10.3-26.2	9.15	11.9	14.2	20.7	22.6	83.6	6.5	39.0
Leaf area (cm^2/leaf)	190-1146	13.20	41863	46318	40.5	42.6	90.4	400.7	79.2
No. of tillers/plant	2.4-6.8	11.87	0.5	0.8	16.8	20.5	66.6	1.2	28.2
Days to maturity	180-228	3.30	139.4	186.2	5.7	6.6	74.8	21.0	10.1
Rhizome yield (q/ha)	158-500	9.94	4368.3	5280.1	21.8	23.9	82.7	123.8	40.8
Dry matter content (%)	10.0-27.5	7.01	12.8	15.0	17.0	18.4	85.5	6.8	32.4
Dry matter yield (q/ha)	26.0-93.7	11.85	228.4	285.0	23.8	26.6	80.1	27.9	43.9
Curcumin content (%)	5.01-7.51	3.60	0.3	0.4	9.6	10.3	87.7	1.1	18.6
Curcumin yield (kg/ha)	151.0-646.2	12.04	13737.2	15977.9	29.8	32.2	86.0	223.9	57.0

CV: Coefficient of variation (%) σ^2g: Genotypic variance σ^2p: Phenotypic variance
GCV: Genotypic coefficient of variation PCV: Phenotypic coefficient of variation h^2: Heritability GA: Genetic advance

shoot length (92.9%), leaf length (90.0%), shoot thickness (83.6%), leaf area (90.4%), rhizome yield (82.7%), dry matter content (85.5%), dry matter yield (80.1%), curcumin content (87.7%) and curcumin yield (86.0%). A high heritability for a trait indicates that a large portion of phenotypic variance is contributed through genotypic variance and therefore, a reliable selection could be made for these traits. However, moderate heritability (50–80%) indicates considerable influence of environment on the expression of leaf width, numbers of tillers/plant and days to maturity. High heritability for plant height and leaf width as well as moderate to low heritability for yield have been reported by Babu *et al*. (1993).

The efficacy of genetic gain and gene action responsible for a particular trait could be revealed by the estimates of genetic advance. Heritability values along with genetic advance as percentage of mean are better tools in predicting gain under selection than either of them alone. Genetic advance as percentage of mean ranged from 10.1–79.2% (Table 3). Its magnitude was high (> 40%) for shoot length, leaf area, rhizome yield, dry matter yield and curcumin yield; moderate (30 – 40%) for leaf length, shoot thickness and dry matter content; and low (< 30%) for leaf width, number of tillers/plant, days to maturity and curcumin content. In the present study, a high heritability accompanied with high genetic advance for shoot length, leaf area, rhizome yield, dry matter yield and curcumin yield clearly suggest the role of additive gene action, and hence a high genetic gain is expected from selection for these traits; while non-additive gene action was responsible for curcumin as revealed by low genetic advance along with high heritability which could be enhanced by heterosis breeding. Heritability and genetic advance were observed to be high for rhizome yield and number of tillers/plant (Rajyalakshmi *et al*., 2013). According to Manohar *et al*. (2004) there was moderate to high heritability and genetic advance for cured yield, fresh weight of the mother rhizome and number of secondary finger rhizomes. High heritability coupled with moderate genetic advance for leaf length, shoot thickness and dry matter content indicate the involvement of both additive and non-additive gene action.

Correlation coefficient measures the degree and direction of relationship between various characters, and determines the component characters on which selection can be made efficiently. The coefficient of genotypic correlation was higher in magnitude than its related phenotypic correlation (Table 4) which indicates that the apparent association of two traits is not only because of genetic architecture but also due to influence of environmental interactions. The meager the difference, the lesser is the environmental impact. The significant positive correlation of shoot length, leaf length and shoot thickness along with rhizome yield, dry matter content and curcumin content (0.689, 0.710 and 0.676; 0.550, 0.562 and 0.432; and 0.557, 0.555 and 0.427, respectively) indicates that plant vigour influences the yield, recovery (dry matter) and quality (curcumin content) of turmeric very significantly. However, days to maturity had positive association with dry matter content which indicated that selection for short duration cultivars would adversely affect the dry matter recovery of turmeric. Rhizome yield and curcumin content had a strong positive correlation; meaning improving either of these traits will take care of the other simultaneously.

Correlation coefficients indicate only the general association between any two traits without tracing any possible cause of such association. Hence, the path coefficient analysis at genotypic level (Table 5) was done to partition the correlation coefficient into direct and indirect effects by taking rhizome yield as a dependent variable. Here, only directly measured traits (leaving deduced parameters such as dry matter yield and curcumin yield) were taken into consideration to avoid masking effects by deduced parameters. Most of the traits, except days to 50% maturity and dry matter content, were influenced by positive indirect effects of leaf length. However, positive direct effects on rhizome yield were high for leaf length (2.070) and curcumin content (0.617) which is higher or fairly close to its significant correlation coefficients indicating that a direct selection based on leaf length and curcumin content would be the most effective and reliable tool to identify productive and curcumin-rich genotypes of turmeric.

With respect to range and mean performance of 27 genotypes (also categorized into two groups as per their source of collection i.e. NEI collection and OPI collection), there was a variation within and between category(ies) for various traits in general (Table 6). The NEI collections were significantly superior to OPI collections with respect to shoot length, leaf length, shoot thickness, leaf area, rhizome yield, dry matter yield, curcumin content and curcumin yield with their respective values being 40.4%, 33.0%, 91.8%, 23.3%, 33.3%, 34.0%, 13.5% and 52.4% (Table 6). This is attributable

Table 4. Correlation coefficients for economic and quality traits in genotypes of turmeric

Economic traits		Shoot length	Leaf length	Leaf width	Shoot thickness	Leaf area	No. of tillers/ plant	Days to maturity	Rhizome yield	Dry matter content	Dry matter yield	Curcumin content	Curcumin yield
Shoot length	g	–	0.991**	0.758**	0.563**	0.969**	0.191	–0.388*	0.689**	–0.043	0.550**	0.557**	0.600**
	p	–	0.954**	0.600**	0.550**	0.911**	0.206	–0.322	0.606**	–0.024	0.497**	0.499**	0.552**
Leaf length	g		–	0.813**	0.677**	0.980**	0.252	–0.369	0.710**	–0.037	0.562**	0.555**	0.610**
	p		–	0.718**	0.620**	0.962**	0.268	–0.321	0.609**	–0.010	0.502**	0.525**	0.567**
Leaf width	g			–	0.904**	0.828**	0.256	–0.176	0.618**	0.056	0.525**	0.328	0.512**
	p			–	0.683**	0.794**	0.254	–0.139	0.460*	0.080	0.419*	0.258	0.419*
Shoot thickness	g				–	0.750**	0.229	–0.334	0.676**	–0.156	0.432*	0.427*	0.473*
	p				–	0.671**	0.200	–0.253	0.585**	–0.105	0.409*	0.347	0.442*
Leaf area	g					–	0.157	–0.467*	0.716**	–0.091	0.520**	0.534**	0.571**
	p					–	0.173	–0.403*	0.609**	–0.053	0.464*	0.499**	0.529**
No. of tillers/ plant	g						–	0.536**	0.487*	0.253	0.562**	0.360	0.552**
	p						–	0.374	0.383*	0.166	0.430*	0.276	0.437*
Days to maturity	g							–	–0.122	0.657**	0.348	–0.240	0.192
	p							–	–0.115	0.545**	0.266	–0.158	0.161
Rhizome yield	g								–	–0.158	0.753**	0.757**	0.839**
	p								–	–0.160	0.754**	0.615**	0.813**
Dry matter content	g									–	0.524**	–0.134	0.347
	p									–	0.511**	–0.115	0.359
Dry matter yield	g										–	0.557**	0.952**
	p										–	0.457*	0.948**
Curcumin content	g											–	0.781**
	p											–	0.710**
Curcumin yield	g												–
	p												–

*,** Significant at $P < 0.05$ and $P < 0.01$, respectively; g: genotypic level; p: phenotypic level

Table 5. Genotypic path coefficients for various traits of turmeric showing the direct and indirect effects on fresh rhizome yield

Parameter	Shoot length	Leaf length	Leaf width	Shoot thickness	No. of tillers/ plant	Days to maturity	Dry matter content	Curcumin content	'r' value with rhizome yield
Shoot length	**-1.660**	2.051	0.282	-0.160	-0.019	-0.165	0.017	0.344	0.689**
Leaf length	-1.644	**2.070**	0.302	-0.193	-0.025	-0.156	0.014	0.343	0.710**
Leaf width	-1.258	1.681	**0.372**	-0.257	-0.026	-0.074	-0.023	0.203	0.618**
Shoot thickness	-0.933	1.399	0.336	**-0.285**	-0.023	-0.141	0.060	0.263	0.676**
No. of tillers/plant	-0.317	0.523	0.096	-0.066	**-0.100**	0.228	-0.099	0.222	0.487*
Days to maturity	0.643	-0.762	-0.065	0.095	-0.054	**0.425**	-0.256	-0.148	-0.122
Dry matter content	0.071	-0.075	0.022	0.044	-0.026	0.280	**-0.389**	-0.083	-0.157
Curcumin content	-0.924	1.149	0.122	-0.122	-0.036	-0.102	0.052	**0.617**	0.757**

Residual effect = 0.457; The Bold values indicate direct effect, while others indicate indirect effect.
*,** Significant at $P < 0.05$ and $P < 0.01$, respectively.

to the NEI having favourable climatic conditions (mild temperature and high rainfall) for turmeric cultivation. However, with respect to leaf width, numbers of tillers/ plant, days to maturity and dry matter content there was no significant difference between the two groups. Pothitirat and Gristsanapan (2006) have reported lower content of curcuminoids under cooler and drier climate.

The dried turmeric rhizomes are mostly processed into powder and oleoresin (40–55% curcuminoid and 15–20% volatile oil). Considering the economic importance and commercial value, dry matter yield (factor of dry matter content and rhizome yield) and curcumin yield (factor of curcumin content and rhizome yield) were calculated to find out the actual quantity of

Table 6. Category-wise mean performance and range of turmeric genotype for various economic traits

Particular		Shoot length (cm)	Leaf length (cm)	Leaf width (cm)	Leaf area (cm^2/leaf)	Shoot thickness (cm)	No. of tillers/ plant	Days to maturity	Rhizome yield (q/ ha)	Dry matter content (%)	Dry matter yield (q/ ha)	Curcumin content (%)	Curcumin yield (kg/ ha)
All collections	Range	53.6–135.2	28.1–68.2	8.9–17.5	190.3–1145.8	10.3–26.2	2.4–6.8	180.0–228.0	158.3–500.0	10.0–27.5	26.0–93.7	5.01–7.51	151.0–646.2
	Mean	85.4	42.1	12.8	505.7	16.6	4.3	207.5	303.6	21.1	63.5	6.12	393.1
OPI collections	Range	53.6–83.3	28.1–43.4	8.9–15.0	190.3–488.3	10.4–17.9	2.8–6.1	190.0–228.0	158.3–369.0	10.0–27.5	26.0–88.2	5.01–6.17	151.0–540.8
	Mean	68.0	34.9	12.1	320.5	14.5	4.4	213.7	251.0	20.8	52.3	5.64	295.5
NEI collections	Range	65.3–135.2	34.2–68.2	9.1–17.5	339.4–1145.8	10.3–26.2	2.4–6.8	180.0–228.0	216.7–500.0	16.3–27.5	48.7–93.7	5.25–7.51	284.7–646.2
	Mean	95.5	46.4	13.2	614.6	17.9	4.3	203.8	334.6	21.2	70.1	6.40	450.4
Advantage of NEI collections over OPI collections (%)		40.4	33.0	9.3	91.8	23.3	-0.5	-4.6	33.3	1.8	34.0	13.5	52.4

economic produce. The present study clearly revealed the genetic potential of NEI collections over OPI collections which have 34.0–52.4% yield advantages of economic produce i.e. dry rhizome and curcumin yield (Table 6). Dry matter recovery and curcumin yield among various genotypes ranged from 29.5–89.4 q/ha and 172–620 kg/ha, respectively (Table 7). The best performing top 10 genotypes (Megha Turmeric-1, Local-4, Local-5, Local-7, Local-9, Local-11, IC0588791, IC0588795, IC0588796 and IC0588797) belong to NEI for both the

Table 7. Mean performance (in descending order) of genotypes for dry matter yield and curcumin yield

Dry matter yield		Curcumin yield	
Genotype	Quantity (q/ha)	Genotype	Quantity (kg/ha)
Megha Turmeric-1	89.4	Megha Turmeric-1	620
Local-9	87.2	IC0588797	578
Local-11	84.0	IC0588796	552
IC0588797	78.8	Local-4	524
IC0588795	76.5	Local-5	513
Local-4	76.1	IC058879	504
Local-5	75.1	Local-11	500
IC0588796	74.9	Local-9	491
IC0588791	71.2	IC0588795	459
Local-7	70.8	Local-7	455
IISR Pratibha	69.1	IISR Alleppy Supreme	408
IC0588788	67.5	IISR Pratibha	401
IISR Alleppy Supreme	67.3	IC0588788	389
Roma	66.2	Local-10	387
IISR Kedaram	64.8	Roma	382
Rasmi	60.8	IISR Kedaram	366
Local-10	60.8	IC0588793	357
IC0588793	58.5	IC0588789	353
IC0588794	58.4	IC0588794	350
IC0588789	57.0	Rasmi	329
IC0588792	54.4	IC0588792	328
Duggirala Red	51.0	IC0588790	298
IC0588790	50.5	Duggirala Red	272
Suranjana	47.3	Suranjana	256
BSR-2	36.5	BSR-2	190
Rajendra Sonia	30.2	Rajendra Sonia	179
Narendra Haldi-1	29.5	Narendra Haldi-1	172

traits of commercial importance (dry matter recovery and curcumin yield). Furthermore, 'Megha Turmeric-1' had excelled with respect to all the aforementioned traits; while other two varieties such as 'IISR Alleppy Supreme' and 'IISR Pratibha' were better among OPI collections. Singh *et al*. (2013b) reported that the varieties such as 'Megha Turmeric-1', 'IISR Pratibha', 'Duggirala' and 'Roma' performed better under different planting dates at Kolasib, Mizoram. Recently, in a 'genotype × environment' trial (11 cultivars including 1 from NEI, 10 environments for fresh yield, and 5 environments for curing per cent, curcumin and dry yield) across India; three cultivars ('Megha Turmeric-1', 'IISR Kedaram' and 'IISR Prathiba') were recommended as preferred genetic source for stability in breeding for high dry yield and curcumin content (Anandaraj *et al*., 2014).

Conclusion

Two economic parameters namely leaf length and curcumin content could be the most effective and reliable tools for identifying productive and curcumin rich genotypes and to realize maximum genetic gain in turmeric breeding. The best performing top 10 genotypes belong to NEI ('Megha Turmeric-1' ranked first) for both traits of commercial importance (dry matter recovery and curcumin yield). Therefore, the NEI genotypes should be given importance in the programmes of genetic enhancement and varietal improvement of turmeric.

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