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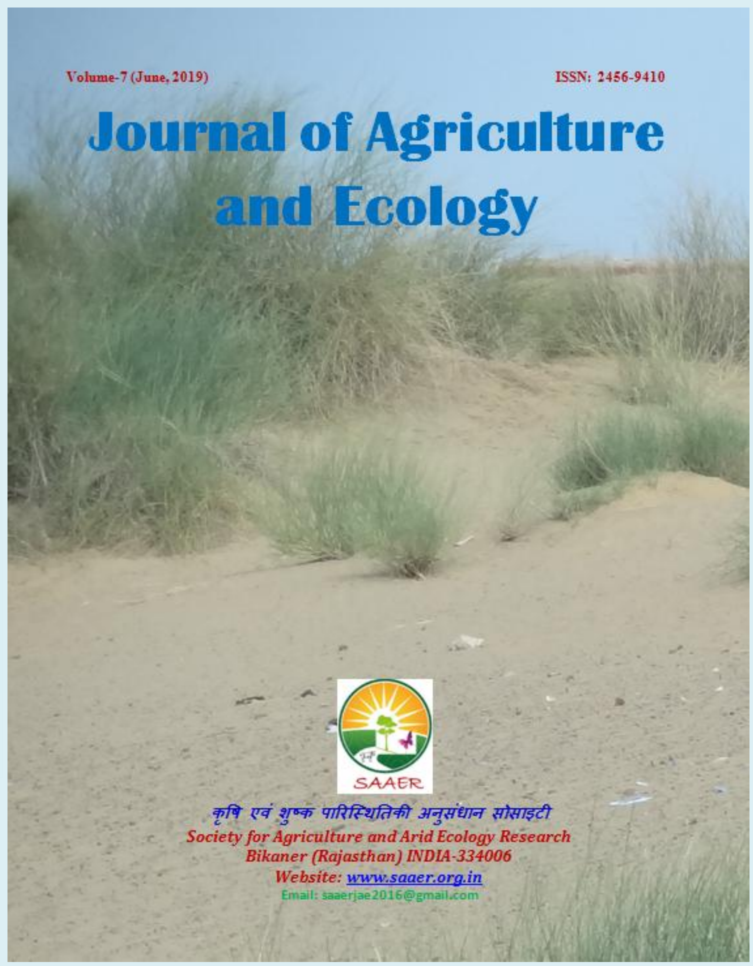

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Evaluation of turmeric (*Curcuma longa* L.) genotypes for yield and curcumin content

V Vinodhini, B Senthamizh Selvi, S Balakrishnan & R Suresh
Department of Spices and Plantation Crops, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore-641 003
**[1]Corresponding author's Email ID:*
Corresponding author: V Vinodhini, Email: vinodhinimani831995@gmail.com

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Abstract

Evaluation of genotypes for existing variability and to create variability among genotypes is a vital step, to start fresh crop improvement programme. Fifty five genotypes were evaluated under augmented design with two checks *viz*., BSR-2 and CO-2. The study revealed that significant difference exists for all the traits studied *i.e.* plant height, pseudostem girth, number of tillers, number of leaves, soluble protein, weight of mother rhizomes, weight of primary rhizomes, yield, curcumin content except for total chlorophyll content. The fresh rhizome yield was maximum in genotype CL-195 (798 g) followed by CL-74 (978 g). With respect to curcumin content, CL-78 (2.79 %) was identified as line with high curcumin content. Both the factors yield and quality (Curcumin content) gets optimized in the genotypes CL-49 and CL-22.

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Introduction

Turmeric (*Curcuma longa* L.), a rhizomatous perennial crop, is a certified source of the natural dye curcumin besides its long use in traditional, medicinal and cosmetics sections (Ravindran et al. 2007). Multiline usage of the wonder herb has brought about huge demand and need for identification of genotypes which greatly satisfies the specific requirements *viz*., high essential oil content, high curcumin content, high yield *i.e*. biomass for curry powder preparation. The genus *Curcuma* was reported to be originated from South East Asia. India, Myanmar and Thailand possess the greatest diversity (Nair 2013). The major shortcomings in turmeric cultivation are non-availability of requisite high yielding genotype, poor curcumin and essential oil content in the ruling cultivars, loss due to disease and pests during cultivation and storage and slow multiplication rate. Turmeric being triploid, has no chance of sexual propagation. The variability among the

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species is poor, but the variability, once created by natural selection and spontaneous mutation is conserved across generations. Hence, survey, collection and evaluation of turmeric germplasm is a great way for successful crop improvement programme. Wide variability among cultivars and collections for growth, yield and quality parameters were reported by Bahadur et al. 2016 and Gupta et al. 2016. Growth and yield analysis would help in understanding the physiology and agronomy of the crop and pave a new insight into the variability in a population and is an essential base work for every breeding programme.

Material and Methods

The field experiments were laid at Horticultural College and Research Institute, TNAU, Coimbatore during 2017- 18, following augmented design with 2 checks *viz.*, BSR 2 and CO 2. A set of 55 genotypes were chosen as experimenting material and planted at spacing of 45 x 15 cm. The detail of the genotypes and place of collection is presented in Table-1. The observations for growth parameters were recorded at 180 days after planting (DAP). The leaf soluble protein content was estimated using Lowry's method (Lowry et al. 1951) and the total chlorophyll content was accessed using SPAD meter at 180 days after planting (DAP). The senescence of the above ground parts marks the maturity of the crop and the leaf sheaths were cut to ground level one week before harvest. The harvested rhizomes (25 % mother rhizome and 75 % finger rhizomes) were cured, powdered and the curcumin content was analysed (ASTA 1968).

Table 1. List of turmeric genotypes taken for study and their geographical origin

S. No.	Genotypes	Geographical origin	Vernacular names
1	CL 2	Bhavanisagar, Erode	Erode local
2	CL 15	Bhavanisagar, Erode	5303 -2 -1
3	CL 22	Bhavanisagar, Erode	Armoor
4	CL 35	Bhavanisagar, Erode	Erode local
5	CL 41	Bhavanisagar, Erode	Erode local
6	CL 42	Bhavanisagar, Erode	Erode local
7	CL 43	Bhavanisagar, Erode	Erode local
8	CL 49	Bhavanisagar, Erode	Erode local
9	CL 52	Bhavanisagar, Erode	Erode local
10	CL 74	Bhavanisagar, Erode	Gundur
11	CL 75	Bhavanisagar, Erode	Dindigam
12	CL 78	Bhavanisagar, Erode	Wynad
13	CL 88	Bhavanisagar, Erode	Kahin-Assam
14	CL 89	Bhavanisagar, Erode	Erode local Akhai
15	CL 100	Kattumaraballi, Erode	Erode local
16	CL 114	Bhavanisagar, Erode	Mydukar
17	CL 120	Vellanikkara, Thrissur	Alleppey
18	CL 121	Vellanikkara, Thrissur	Alleppey
19	CL 122	Vellanikkara, Thrissur	VK 5
20	CL 130	Vellanikkara, Thrissur	Sudarsana
21	CL 131	Vellanikkara, Thrissur	Suguna

22	CL 132	Vellanikkara, Thrissur	Swarna
23	CL 133	Vellanikkara, Thrissur	Roma
24	CL 134	Pottangi	Kalimpong
25	CL 135	Pottangi	Sikkim local
26	CL 144	Salem	Salem local
27	CL 146	Alleppey	Alleppey
28	CL 147	Pottangi	PTS 43
29	CL 148	Pottangi	PTS 12
30	CL 149	Pottangi	PTS 38
31	CL 151	Pottangi	Acc 360
32	CL 152	Pottangi	ACC 361
33	CL 156	Pollachi, Coimbatore	PTS 2
34	CL 158	Mangalapura, Erode	Erode local
35	CL 169	Alathupalayam, Erode	Erode local
36	CL 172	Erode	PTS 8
37	CL 173	Malayampalayam, Erode	Erode local
38	CL 174	Vellatamparapu, Erode	Erode local
39	CL 175	Vellatamparapu, Erode	Erode local
40	CL 184	Kodumudi, Erode	Erode local
41	CL 189	Bhavanisagar, Erode	CO 1
42	CL 192	Rasipuram, Salem	Salem local
43	CL 194	Pottangi	PTS-2
44	CL 195	Pottangi	Rajendra sonia
45	CL 198	Pottangi	PTS 55
46	CL 199	Pottangi	PTS 15
47	CL 200	Pottangi	PTS 17
48	CL 201	Pottangi	Sonali
49	CL 209	Erode	Erode local
50	CL 213	Erode	Erode local
51	CL 255	Erode	Erode local
52	CL 260	Erode	Erode local
53	CL 262	Erode	Erode local
54	CL 263	Erode	Erode local
55	CL 269	Erode	Erode local

Results and discussion

Significant variations for the traits, plant height, number of leaves, number of tillers, soluble protein content, yield and curcumin content were observed among the 55 genotypes (Table 2). The 2 checks CO-2 and BSR-2 employed in field design help to rule out the environmental influence and also considered as scale to choose superior performing genotypes in the population. Yield being a complex polygenic trait, evaluating the genotypes considering yield attributing traits will be promising, rather than evaluating the yield directly.

Plant height: The variations for plant height among the genotypes varied in the range of 46.00 to 136.76 cm. The tallest among the genotypes was CL- 22 (136.76 cm) which was at par with with CL-49 (133.02 cm) (Table 2). The increased interpretation of light would favours higher photosynthetic rate and yield (Duncan, 1971). Hence, plant height is an influential trait in determining the final yield (Narayanpur et al. 2003; Ravindran et al. 2007). A total of eleven genotypes recorded significantly higher values for plant height over the better check CO-2 (99.51 cm) and fifteen genotypes showed significantly lower values than the check BSR-2 (91.87 cm). The variation in this prime morphological trait is of great importance in crop improvement. Pseudostem girth: The pseudostem girth varied in the range of 4.88 cm to 9.56 cm among the genotypes (Table 2). The highest pseudostem girth was valued in the genotype CL-88 (9.56 cm) followed by 189 (9.06 cm), CL-42 (8.80 cm), CL-43 (8.48 cm), CL-22 (8.30 cm). Mamatha (2016) reported that pseudostem girth has high direct effect on rhizome yield. Hence greater pseudostem girth supports better source sink relationship hence ultimately higher yield. Number of tillers: Maximum number of tillers was observed in the genotype CL-133 (8.60) which was at par with CL-132 (8.40 per plant) and ten genotypes recorded a more number of tillers than the superior check CO- 2 (5.32) (Table 2). High number of tillers may contribute to high yield, if soil and environment provides adequate nutrition to the developing tillers. In case of fragile soil or presence of any factors that hinders nutrient acquisition, the assimilated metabolites in the main shoot gets translocated to tillers to supports its growth. Hence genotypes with optimum tillers are of appreciable value (El Fatih et al. 2014). Number of tillers per plant was least in the genotype CL-201 (1.40).

Number of leaves and leaf area: The maximum number of leaves was observed in the genotype CL-78 (10.80), which was at par with CL-49 (10.20), CL-74 (9.80), CL-88 (10.40), CL-147 (9.80) Twelve number of genotypes registered more number of leaves than the superior check CO 2 (9.12) (Table 2). With respect to leaf area, the maximum leaf area was calculated in the genotype CL-22 (666.51 cm^2), followed by CL-74 (547.38 cm^2). Nineteen genotypes were had significantly superior values over the check BSR-2 (387.14 cm^2) for leaf area. In general, the genotypes, which have the highest leaf area, produces significantly better yield, than most of the genotypes. The genotypes CL-74, CL-22 has maximum leaf area and produces rationally high yield (793 g/ plant) and (692.00 g/plant), respectively. The genotype CL-78 has the maximum number of leaves and registered highest curcumin content (2.79 %). The turmeric's active compound curcumin is actively synthesized in earlier 3 to 4 leaves. The total $^{14}CO_2$ assimilated by plant's, the first, second, third, and fourth leaves fixed 31, 23, 21, and 9 % of carbon in roots (4 %), rhizome (6 %), oil (0.01 %), and curcumin (4.6 %) of the fresh weight of rhizome (Dixit and Srivastava, 2000). The youngest developing leaf assimilated maximum $^{14}CO_2$ into metabolites and essential oil. In the rhizome, curcumin constituted the major metabolite. The incorporation of $^{14}CO_2$ into metabolites and oil declined as the leaves matured. Thus, curcumin content of a genotype depends on crops early stage, its leaf area and life span of the leaf. Hence, variation for leaf number and leaf area is of great scope in breeding for quality trait. Variations for total chlorophyll and protein content: The SPAD values for total chlorophyll content did not vary significantly among the genotypes at 180 DAP (Table 2). There exist significant variations in leaf soluble protein content among the genotypes in the range of 10.90 and 41.81 mg g^{-1} (Table 2). The genotype CL-255 recorded the highest soluble protein content (41.81 mgg^{-1}) and was on par with the genotypes CL-41 (41.74 mg g^{-1}), CL-42 (41.10 mgg^{-1}), CL-74 (35.97 mg g^{-1}), CL-52 (35.74 mg g^{-1}), and CL-120 (32.94 mg g^{-1}). Around 40 % of total soluble protein constitutes RuBisCo, key enzyme in carbon fixation. Higher values for soluble protein indicates high RuBisCo activity, ultimately, high carbon fixation and productivity (Parry et al. 2012).

Table 2. Mean values of yield, yield attributing traits and curcumin content of studied turmeric genotypes

Genotypes	Plant height (cm)	Pseudo stem girth (cm)	No. of tillers per plant	No of leaves per plant	Petiole length (cm)	Leaf area (cm^2)	Soluble protein (mg/g)	Total chlorophyll content (SPAD units)	Weight of mother rhizomes (g)	Weight of secondary rhizomes (g)	Yield/plant (g)	Curcumin content (%)
CL 2	112.44	7.32	4.80	7.20	27.38	503.19	12.35	22.60	103.00	217.00	410.00	2.54
CL 15	111.46	6.82	5.80	7.80	32.94	403.81	23.68	25.00	48.00	147.00	252.00	2.06
CL 22	136.76	8.30	3.20	3.20	33.26	666.51	18.26	20.70	226.00	385.00	692.00	2.55
CL 35	104.56	7.80	4.80	4.80	23.52	462.69	19.68	27.10	78.00	123.00	214.00	2.13
CL 41	101.94	6.98	4.60	8.20	20.86	432.16	41.74	28.20	192.00	139.00	366.00	2.52
CL 42	112.22	8.80	3.40	8.80	23.50	528.74	41.10	29.20	117.00	103.00	269.00	2.33
CL 43	107.40	8.48	5.00	8.80	24.20	469.30	23.74	22.90	128.00	216.00	401.00	2.09
CL 49	133.02	8.24	4.20	10.20	31.64	528.33	23.74	23.00	147.00	226.00	453.00	2.55
CL 52	101.10	7.70	3.80	8.00	22.30	492.99	35.74	24.00	94.00	225.00	347.00	2.24
CL 74	111.78	7.82	3.80	9.80	34.44	547.38	35.97	28.20	400.00	326.00	793.00	2.21
CL 75	74.50	5.50	2.00	7.00	13.80	386.16	24.65	29.10	45.00	53.00	207.00	2.59
CL 78	123.92	7.50	4.00	10.80	25.08	486.86	23.35	23.20	72.00	258.00	401.00	2.79
CL 88	119.16	9.56	4.20	10.40	23.86	526.68	29.10	38.90	150.00	390.00	624.00	1.79
CL 89	106.90	7.38	5.80	9.40	23.24	426.22	23.16	29.70	145.00	119.00	372.00	1.75
CL 100	88.80	6.24	4.80	8.20	21.04	348.63	19.39	25.00	33.00	71.00	127.00	1.58
CL 114	86.72	6.40	4.80	8.40	20.90	354.77	28.26	25.80	99.00	120.00	258.00	1.77
CL 120	81.38	5.82	3.80	7.20	18.66	373.49	32.94	26.40	87.00	30.00	117.00	1.52
CL 121	69.68	5.68	4.40	7.40	17.64	303.03	30.45	33.00	98.00	109.00	230.00	1.63
CL 122	74.48	5.44	3.40	7.80	15.94	270.52	26.48	28.40	98.00	160.00	311.00	1.38
CL 130	75.88	6.96	3.60	8.20	17.80	306.26	30.23	30.80	53.00	86.00	162.00	2.02
CL 131	91.36	7.30	3.80	8.80	19.02	384.69	11.03	34.50	60.00	46.00	117.00	2.01
CL 132	88.72	6.72	8.40	4.00	20.94	391.86	16.61	29.30	80.00	181.00	312.00	2.01
CL 133	80.80	6.88	8.60	5.20	20.74	370.75	14.81	29.90	100.00	179.00	323.00	1.75
CL 134	102.82	6.36	7.60	4.40	17.58	357.01	16.00	25.20	81.00	200.00	350.00	1.74
CL 135	99.68	7.04	5.00	9.60	19.78	375.63	17.90	31.60	107.00	185.00	366.00	1.97
CL 144	101.76	6.68	4.20	9.20	20.94	398.72	15.90	24.80	52.00	121.00	215.00	2.01
CL 146	103.64	7.28	5.20	9.00	21.56	412.98	17.52	29.30	30.00	248.00	371.00	1.98
CL 147	130.64	5.72	3.80	9.80	27.50	400.57	14.52	26.60	150.00	198.00	411.00	1.70

CL 148	67.36	4.88	3.20	7.20	14.72	241.48	15.45	31.40	66.00	103.00	208.00	1.85
CL 149	72.76	5.26	3.00	7.80	15.18	258.17	10.90	33.10	30.00	54.00	90.00	1.77
CL 151	71.98	5.32	3.60	7.80	16.74	296.40	14.13	24.50	64.00	146.00	249.00	1.59
CL 152	105.72	8.16	4.80	9.20	27.52	422.32	14.13	28.10	83.00	168.00	353.00	2.45
CL 156	105.92	7.82	4.00	9.20	27.14	332.74	17.03	30.90	67.00	106.00	202.00	1.57
CL 158	82.90	6.50	4.50	8.00	16.75	276.24	14.94	29.60	79.00	117.00	236.00	1.51
CL 169	91.16	7.22	4.40	8.60	17.84	316.56	18.58	29.60	88.00	69.00	180.00	1.59
CL 172	88.96	7.84	4.20	8.40	20.22	391.12	21.65	22.70	81.00	146.00	293.00	1.69
CL 173	82.98	7.72	4.20	7.80	18.62	338.95	20.84	33.30	106.00	146.00	280.00	1.99
CL 174	77.36	6.72	3.80	7.80	17.36	283.44	21.71	29.70	75.00	80.00	132.00	2.11
CL 175	73.16	6.50	5.00	8.00	14.54	321.74	16.45	21.60	64.00	107.00	196.00	2.27
CL 184	109.66	7.86	4.80	9.60	21.50	439.85	15.39	25.50	90.00	165.00	288.00	2.27
CL 189	119.07	9.06	4.60	9.60	30.26	492.30	13.10	29.20	131.00	250.00	470.00	1.83
CL 192	111.54	8.10	5.00	9.40	23.72	404.14	15.90	30.30	100.00	206.00	375.00	2.26
CL 194	118.90	7.76	5.00	9.00	26.72	459.03	18.97	25.40	153.00	400.00	620.00	1.98
CL 195	103.30	8.12	6.20	8.60	24.96	431.92	22.39	23.40	127.00	473.00	798.00	1.93
CL 198	99.62	6.96	4.60	8.80	20.10	406.99	18.48	32.20	82.00	254.00	395.00	1.77
CL 199	111.54	7.98	6.40	9.40	27.00	435.59	21.06	26.30	111.00	122.00	266.00	2.30
CL 200	106.34	7.60	5.00	9.40	24.32	397.97	16.74	30.50	136.00	260.00	495.00	2.13
CL 201	46.00	8.20	1.40	6.20	7.40	186.29	18.42	26.90	102.00	232.00	370.00	2.09
CL 209	108.40	7.80	3.40	8.60	20.38	516.71	21.87	31.50	120.00	242.00	413.00	1.89
CL 213	92.56	8.04	3.20	8.40	21.62	359.01	21.42	31.90	102.00	139.00	289.00	1.61
CL 255	90.18	8.72	5.20	8.60	18.90	408.04	41.81	33.00	129.00	174.00	338.00	2.26
CL 260	108.38	7.82	7.80	9.40	24.14	400.70	18.77	35.90	120.00	189.00	383.00	2.33
CL 262	104.94	7.88	8.00	9.40	21.72	443.48	20.45	28.20	97.00	293.00	516.00	1.91
CL 263	89.88	7.10	7.20	8.60	18.10	338.61	19.16	30.30	94.00	183.00	312.00	2.16
CL 269	71.10	7.24	4.60	7.20	33.22	163.30	19.23	29.10	21.00	51.00	214.00	2.30
BSR 2	91.87	6.89	2.34	5.47	19.84	387.14	22.94	28.07	140.47	191.84	317.10	2.12
CO 2	99.51	6.90	5.32	9.12	20.00	191.54	16.10	26.19	137.10	223.66	338.82	2.35
Range	46.00-136.76	4.88-9.56	1.40-8.60	3.20-10.80	7.40-34.44	163.30-666.51	5.00-10.50	20.70-38.90	21-400	30-473	48.55-101.95	1.38-2.79
SEd	2.86	0.88	0.23	0.50	1.88	17.39	41.81	6.61	13.97	22.74	798.00	0.04
CD (0.05)	6.01	1.84	0.48	1.05	3.95	36.51	20.90	13.88	29.34	47.75	334.59	0.09

Variations for weight of mother and primary rhizomes: The mother and primary rhizomes offer diverse usage of turmeric. The mother rhizomes are chiefly used for cosmetic purposes and dye extraction, while primary rhizomes are used for curry powder preparation besides it is employed as propagating material. The weight of mother rhizome varied in the range of 21.00 – 400.00 g/plant (Table 2). The genotypes CL-74 and CL-269 recorded the maximum and minimum values for weight of mother rhizomes. Three genotypes (CL-22, CL-41, CL-74) performed better than the check BSR-2 (140.47 g). The weight of primary rhizomes varied in the range from 30.00 to 473.00 g (Table 2). The genotype CL-195 recorded the maximum weight of primary rhizome 473.00 g. six genotypes (CL-22, CL-74, CL-88, CL-194, CL-195, CL- 262) showed better values for weight of primary rhizomes than the check CO-2 (223.66 g).

Variation for the trait yield and curcumin content: Significant variation for fresh rhizome yield per plant was recorded among the evaluated genotypes in the range of 90.00 to 798.00 g (Table 2). The highest fresh rhizome yield per plant was recorded in the genotype CL 195 (798 g) followed CL 74 (793.00 g). Over 10 genotypes CL-74, CL-22, CL-49, CL-74, CL-88, CL-189, CL-194, CL-195, CL-200, CL-262 registered better values than both the check CO-2 (338.82 g). The highest and lowest curcumin content was perceived in the genotype CL-78 (2.79 %) and the lowest curcumin content (1.38 %) (Table 2). A total of seven genotypes CL-78 (2.79 %), CL-75 (2.59 %), CL-49 (2.55 %), CL-22 (2.55 %), CL-2 (2.54 %), CL-41 (2.52 %) and CL-152 (2.45 %)) showed better values for curcumin content than the check CO 2 (2.35 %). The curcumin content has been reported to vary depending upon soil organic carbon, available nitrogen and manganese and agroclimate condition (Geethanjali et al. 2016). Hence from the study, it is concluded significant variations exists among the genotypes for all the traits except total chlorophyll content at 180 DAP. The genotype CL-78 is identified as line with high curcumin content. The economic traits both yield and quality (curcumin) gets optimized in the genotype CL-22 and CL-74.

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