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Evaluation of some elite turmeric genotypes in Terai region of West Bengal

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Abstract
An investigation was carried out in the year 2018-19 and 2019-20 in 22 elite turmeric genotypes in terai region of West Bengal for evaluation and characterization according to DUS descriptors. The genotypes were collected from different sources from West Bengal and different turmeric growing regions of the country. The characters were evaluated on the basis of DUS descriptors which were developed by IISR (Indian Institute of Spices Research). Randomized Block Design (RBD) was adopted as statistical method for evaluation of 22 genotypes along with DMRT test for finding the statistical results of the different characters. Qualitative characters like pseudostem habit, leaf deposition, leaf margin, rhizome habit and rhizome shape were also characterized in all the genotypes and grouped according to pattern of divisions of descriptors. TCP 191, LTS-1, TCP 111, TCP 246, TCP 190, TCP 120, TCP 90, TCP 235, TCP58, TCP 232 showed better result than local check variety TCP-2 (Suranjana) after the completion of the investigation. All the varieties excelled in production than national variety PRATIVA, so they can be recommended in this terai region of West Bengal.

Keywords: Characterization, evaluation, DUS descriptors, RBD, DMRT test, local check, national check, grouping

Introduction
Turmeric (*Curcuma longa* L.) is a plant of the Zingiberaceae family and comprises about 70 species (Smartt Simmonds 1992) [13]. It is a herbaceous plant belonging to the family Zingiberaceae, order Sacitaminae, considered to have originated in the Indo – Malayan region (Sasikumar, 2005) [12]. *Curcuma* belongs to the tribe Hedychieae. The ecology of the species varies so much that their habitat ranges from sea level (sandy coastal habitat) to high altitude such as above 2000 m in the Western Ghats and Himalayas in India. The species such as *C. longa*, *C. zedoaria*, *C. amada* and *C. 884ydroxyl* are found predominantly in plains. *C. angustifolia*, *C. neilgherrenis*, *C. kudagenesis*, *C. thalakaveriensis*, *C. pseudomontana* and *C. coriacea* etc. are confined to hills at 1000 – 2500 m altitude (Velayudhan *et al.*, 1999) [16]. The higher diversity is concentrated in India and Thailand (Hikmat UI Zaan *et al.*, 2011) [3]. While originated in South East Asia, India has the predominant position as the largest producer of turmeric in the world. Turmeric is commonly known as 'Golden spice', and considered to be triploid species (2n = 3x = 63; x = 21) as reported by Ramachandran, (1961) [11]. It is very shy in flowering requiring, needs specific climatic conditions for flowering and has pollen fertility less than 60% as reported by Nambiar, 1979 [8] and Nair *et al.*,2004 [9]. The uses of turmeric are dated back to 'Atharva Veda' of 1000 – 1500 BC, a holy treatise of the Hindus, as 'Haldi' or 'Haridrar' (AV/1/22/4) (Shah, 1997) [14]. However, the ancient Indian system of medicine, Ayurveda (Science of Life), of approximately 5000 years of antiquity mentions the medicinal uses of turmeric. Interestingly, there is no mention of turmeric in Bible or in the list of religious plants. The principle colouring components of turmeric rhizome is the curcumin (Cur-I) [1,7- bis (4- 884ydroxyl-3-methoxyphenyl)- 1,6-heptadiene-3,5-dione], while two pigments demethoxy curcumin (Cur-II) [1-(4-hydroxyphenyl)-7-(4-hydroxy-3-methoxyphenyl)-1,6- heptadiene-3,5 dione] and bis-demethoxy curcumin (Cur-III) [1,7-bis (4-hydroxyphenyl)-1,6- heptadiene-3,5-dione] are present in lesser extent (Jayprakasha *et al.*, 2002) [4]. The major components were alpha-turmerone (53.4%), beta-turmerone (18.1%) and aromatic – turmerone (6.2%) in fresh rhizome and aromatic-turmerone (9.6%), alpha-santalene (7.8%) and alpha turmerone (6.5%) in dry rhizome.
The significantly less amount of alpha- turmerone and beta-turmerone in dry rhizome could contribute to its low antioxidant activity as reported by Mittal *et al.* (2018) [6]. Curcumin has been found to be having antioxidant, anti-inflammatory, antiviral and antifungal properties

(Ammon and Wahl, 1991) [1] and exhibits free radical scavenging/ antioxidant property which act as a inhibitor for cyclooxygenase, 5-lipooxygenase and glutathione Stransferase (Jayprakash *et al*., 2006) [5]. Curcumin and its derivatives were found to be effective in the treatment of inflammatory disorder (Villagaes *et al*., 2008) [18], anorexia, cough, diabetic wounds (Mohamed *et al*., 2009) [6], tumors, hepatic disorder, cardiovascular disease, rheumatism, sinusitis, multiple sclerosis (Valsala and Peter, 2007) [19], antimicrobial activity and health problems (Morshed *et al*., 2011) [8].

Materials and methods

The present experimental investigation was carried out during the summer season 2018 – 2019 and 2019 – 2020 at the experimental field comes under the University farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch-Behar which is 26° 19′ 86″ N latitude, 89° 23′ 53″ E longitude with an altitude of 43 m above the mean sea level. Healthy finger and mother rhizomes of all genotypes with 20 gm each with well-developed buds were used as planting material after proper curing and sorting where 40 plants were sown in each replication. Specified operational practice where a fertilizer dose of N: P_2O_5: K_2O @ 120:60:60 (Kg/ha) were given in standard plot. The required amount of fertilizer were considered in terms of plot size and applied as Urea (46%N), SSP (16%P_2O_5) and MOP (60%K_2O). The total amount of Phosphorus and Potassium incorporated as basal dose and the nitrogen was applied in three equal doses, *i.e.* at 45, 75, 110 days. The 22 genotypes were collected from different turmeric growing states and districts of West Bengal and uniform plots of 3 m x 1 m size were made to accommodate all the treatments each having three replications (Tabe-1).

Table 1: List of source of 22 genotypes from different states in India

Sl. No.	Genotypes	Place of Origin	State	Sl. No.	Genotypes	Place of Origin	State
1.	TCP 191	Garubathan, Darjeeling	West Bengal	12.	IT 36	Raigarh	Chattirishgarh
2.	IT 23	Raigarh	Chattirishgarh	13.	TCP 11	Damdima Village, Jalpaiguri	West Bengal
3.	TCP 2	Bararangras Village, Coochbehar	West Bengal	14.	TCP 246	Nijamatapur, Goalpokhar	West Bengal
4.	IT 10	Raigarh	Chattirishgarh	15.	TCP 190	Local market Kalimpong –I, Darjeeling	West Bengal
5.	NDH 11	Kumargung	Uttar Pradesh	16.	TCP 120	Gairkata, Jalpaiguri	West Bengal
6.	RH 9/90	Dholi	Bihar	17.	TCP 90	Rajabhatkhawa Forest, Alipurduar	West Bengal
7.	LTS 1	Guntur	Andhra Pradesh	18.	TCP 235	Sonalagi part-I, Golakganj, Dhubri	Assam
8.	LTS 2	Guntur	Andhra Pradesh	19.	TCP 58	Dumdin, Jalpaiguri	West Bengal
9.	PRATIVA	IISR	Kerala	20.	TCP 32	RRS, UBKV, Darjeeling	West Bengal
10.	RH 80	Dholi	Bihar	21.	TCP 94	Damdima Village, Jalpaiguri	West Bengal
11.	NDH 128	Kumargung	Uttar Pradesh	22.	TCP 232	Khalisa,Gosanimari Coochbehar	West Bengal

Sowing was done in the first week of May in both trial (2018-19, 2019-20) with standard operational practices. Rhizome segments were bedded in raised beds at a depth of 4.5 cm with buds facing upwards at a spacing of 30 cm × 20 cm and covered with a thin layer of soil.

Result and discussion

Analysis of variance: The analysis of variance of 22 genotypes of turmeric was calculated where values were pooled over two cropping seasons and mean sum of squares of all the 10 DUS characters (Table 4). Mean sum of squares due to season (year) for all genotypes were found significant except i) number of leaves per plant (1.002) and ii) number of mother rhizome per plant (0.064) where it signifies role of seasons for all the characters except the two characters.

The mean sum of squares of all the characters were found significant except i) number of leaves per plant(0.678) and ii) single clump wt (13881.95) indicates a large amount of variability was present among the characters except the two characters. However, significant mean sum of square of all the DUS characters due to Genotype x Year except rhizome length (1.048), Plot yield per year (2.434) and Projected yield (9.69) indicates characters performed differently in two crop growing seasons except the characters rhizome length, plot yield and projected yield of 22 genotypes taken for investigation.

Evaluation of Physiological and rhizome characters

No. of Leaves on main shoot: In the present investigation as per Duncan DMRT test RH 9/90,TCP 191,RH 80,TCP 235,TCP 32 and NDH 11 are non- significant and statistically at par with each other with the highest value TCP 58(8.93) in 2018-19. In 2019-20, as per Duncan DMRT test TCP 90,TCP 246,TCP 111,TCP 32,TCP 235, NDH 128,TCP 58,TCP 94,IT 23,LTS 1,TCP 2,LTS 2,TCP 191,IT 36,TCP 232 are non-significant and statistically at par with each other with the highest value TCP 120(9.8) (Table-3). Gupta *et. Al.* (2015)[2] reported genetic divergence while taking the number of leaves per plant in sixty five turmeric genotypes. Padmadevi *et. al.* (2012) [11], also discussed that the growth characters of turmeric is associated with respect to parameter, number of leaves.

Plant height: In the year 2018-2019, as per Duncan test TCP 58,TCP 232,TCP 120,TCP 111,TCP 246,TCP 90 are statistically at par with each other and differed non significantly with the highest value TCP 190 (166.34 cm). In the year 2019-2020, as per Duncan DMRT test TCP 32,TCP 235,TCP 90,TCP 232,IT 10,TCP 246,TCP 190,TCP 191,LTS 1,TCP 94,TCP 58,LTS 2 are statistically at par with each other and differed non significantly with the highest value TCP 120 (168.45cm) (Table-3).

Leaf lamina length: In the year 2018-2019, as per Duncan DMRT test IT 10, LTS 2,TCP 120,TCP 235,TCP 232 are statistically at par with each other and differed non significantly with the highest value Prativa (63.67 cm) (Table-3). In the year 2019-2020, as per Duncan DMRT test TCP 90, TCP 235, TCP 232, TCP 32, TCP 120, LTS 2, TCP 94, LTS 1 are statistically at par with each other and differed non significantly with the highest value IT 10 (72.91cm) (Table-3). Tomar *et al.*, (2005) [16] characterize leaf length character for investigation on character association and path analysis for yield components.

Leaf lamina width: In the year 2018-2019, as per Duncan DMRT test PRATIVA, LTS 1,IT 10 are statistically at par with each other and differed non significantly with the highest value NDH 11(17.05 cm) (Table-3). In the year 2019-2020, as per Duncan DMRT test RH 9/90,IT 23,LTS 1,NDH 11,TCP 90,TCP 246,TCP 232 are statistically at par with each other and differed non significantly with the highest value IT 36 (19.38 cm).

Number of mother rhizome: In the year 2018-2019, as per Duncan DMRT test TCP 246,TCP 120,PRATIVA, RH 80,TCP 235,TCP 58,TCP 191, TCP 94, NDH 11, LTS 1 are statistically at par with each other and differed non significantly with the highest value IT 36 (1.167) (Table-3). In the year 2019-2020, as per Duncan test TCP 90 and TCP 235 are statistically at par with each other.

Number of primary rhizome: In the year 2018-2019, as per Duncan DMRT test TCP 58,TCP 191,TCP 246,TCP 90, NDH 11, RH 9/90,IT 23,TCP 32,TCP 94,TCP 232,IT 10, LTS 2,TCP 120,LTS 1, RH 80,TCP 190,TCP 2, PRATIVA are statistically at par with each other and differed non significantly with the highest value TCP 235 (7.5) (Table-3). In the year 2019-2020, as per Duncan DMRT test TCP 120,TCP 246, RH 80,TCP 235,IT 23,LTS 1,TCP 232,NDH 128,TCP 32,LTS 2,TCP 191,IT 36,TCP 111,TCP 94,TCP 58,PRATIVAare statistically at par with each other and differed non significantly with the highest value TCP 90 (9.33).

Rhizome length: In the year 2018-19, as per Duncan DMRT test, PRATIVA, TCP 2, TCP 235, IT 10, IT 23 and rest of the genotypes were all found to be significantly differed with highest value IT 36 (11.29 cm) (Table-3). In the year 2019-20, as per Duncan DMRT test IT 36, LTS 2, TCP 2, LTS 1, TCP 58, PRATIVA, RH 80, TCP 90, TCP 32, TCP 235, TCP 232, TCP 246, TCP 111, IT 23 are statistically at par with each other and differed non significantly with the highest value IT 10 (9.38 cm).

Rhizome Internode pattern: In the year 2018-2019, as per Duncan DMRT test IT 23, TCP 235, RH 9/90, RH 80, TCP 2, TCP 246 are statistically at par with each other and differed non significantly with the highest value IT 36 (1.43) (Table-3). In the year 2019-2020, as per Duncan DMRT test TCP 58, TCP 235, TCP 90, PRATIVA, TCP 32, TCP94, NDH 11, IT 23, TCP 191, TCP 246, TCP 120, TCP 111, IT 10 are statistically at par with each other and significantly differed including with the highest value TCP 232 (1.18 cm). A.K. Gupta *et al.* (2015) [2] evaluated their turmeric genotypes taking internode pattern as one of the important characters.

Rhizome weight: In the year 2018-2019, as per Duncan DMRT test RH 80,TCP 2,TCP 246,TCP 232,IT 23, PRATIVA,TCP 111,RH 9/90,TCP 235,LTS 1,TCP 58,LTS 2,TCP 191 are statistically at par with each other and differed non significantly with the highest value TCP 90 (377.5 gm) (Table-3). In the year 2019-2020, as per Duncan DMRT test TCP 246,TCP 120,RH 80,TCP 235,LTS 1,TCP 2,IT 36,PRATIVA,TCP 232,IT 23,LTS 2,NDH 128,TCP 94,TCP 190,TCP 191,TCP 32,TCP 111,NDH 11are statistically at par with each other and differed non significantly with the highest value TCP 90 ((571.27 gm).

Projected Yield: In the year 2018-2019, as per Duncan DMRT test TCP 235,TCP 120,TCP 191,TCP 190 are statistically at par with each other and differed non significantly with the highest value TCP 246 (33.72 t/ha) (Table-3). In the year 2019-2020, as per Duncan DMRT test TCP 235,LTS 1,TCP 191,TCP 120,TCP 190 are statistically at par with each other and differed non significantly with the highest value TCP 246 (31.96 t/ha).

Table 2: Qualitative characters of twenty two turmeric genotypes

Genotype	Pseudo Stem Habit	Leaf Deposition	Leaf Margin	Rhizome Habit	Rhizome Shape
TCP 191	Open	Semi Erect	Even	Compact	Straight
IT 23	Close	Semi Erect	Wavy	Compact	Straight
TCP 2	Open	Horizontal	Even	Compact	Straight
IT 10	Open	Horizontal	Even	Compact	Straight
NDH 11	Open	Semi Erect	Wavy	Compact	Straight
RH 9/90	Open	Horizontal	Wavy	Compact	Straight
LTS 1	Open	Semi Erect	Even	Compact	Straight
LTS 2	Open	Horizontal	Wavy	Compact	Straight
PRATIVA	Open	Semi Erect	Even	Loose	Curved
RH 80	Open	Semi Erect	Even	Loose	Straight
NDH 128	Open	Erect	Wavy	Compact	Straight
IT 36	Open	Semi Erect	Even	Compact	Straight
TCP 111	Open	Semi Erect	Even	Loose	Straight
TCP 246	Open	Semi Erect	Even	Intermediate	Straight
TCP 190	Open	Horizontal	Even	Compact	Straight
TCP 120	Open	Semi Erect	Even	Intermediate	Curved
TCP 90	Close	Semi Erect	Wavy	Compact	Curved
TCP 235	Open	Horizontal	Even	Compact	Straight
TCP 58	Open	Horizontal	Even	Compact	Straight
TCP 32	Open	Semi Erect	Even	Compact	Straight
TCP 94	Open	Semi Erect	Even	Compact	Straight
TCP 232	Open	Semi Erect	Even	Compact	Straight

In the present investigation, five qualitative characters have been chosen for characterization of 22 turmeric genotypes and these characters have been specified in DUS guidelines. Genotype namely IT 23 only shows close type of pseudo stem habit and the rest of genotypes are of open type. TCP 2, IT 10, RH 9/90, LTS 2, TCP 190, TCP 235, TCP 258 exhibited horizontal leaf deposition, NDH 128 showed erect leaf deposition and rest of the genotypes appeared to be semi erect

leaf deposition type. While observing the character leaf margin IT 23, NDH 11, RH 9/90, LTS 2, NDH 128 and TCP 90 found to be exhibit wavy leaf margin and the rest of genotypes expressed to have even type of leaf margin. In investigating the character rhizome habit Prativa, RH 80 and TCP 111 showed loose type where as two genotypes namely TCP 246 and TCP 120 found to have intermediate type and the remaining 17 genotypes are compact. Only three genotypes Prativa, TCP 120, TCP 235 had curved rhizome while all other 19 genotypes are straight in rhizome habit. According to DUS descriptors characterization of all the genotypes were evaluated and grouped in individual descriptors according to the pattern of different groups (Table 5).

Table 3: Evaluation of different quantitative characters of 22 genotypes

Sl. No	Genotype	No. of Leaves on Main Shoot			Plant Height			Leaf Lamina Length		
		2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
1	TCP 191	8.67	8.27	8.47	139.51	158.73	149.12	54.98	64.09	59.53
2	IT 23	8.13	8.43	8.28	129.39	150.7	140.05	45.46	63.27	54.36
3	TCP 2	8.07	8.33	8.20	134.78	141.31	138.05	45.64	60.09	52.86
4	IT 10	7.87	7.93	7.90	141.64	162.43	152.04	63.59	72.91	68.25
5	NDH11	8.4	7.27	7.83	128.4	140.11	134.25	53.67	62.36	58.01
6	RH 9/90	8.73	6.47	7.60	123.32	149.99	136.66	48.89	65.51	57.2
7	LTS 1	7.67	8.40	8.03	132.66	158.55	145.6	52.33	67.96	60.15
8	LTS 2	7.87	8.27	8.07	128.71	154.33	141.52	61.52	68.57	65.05
9	PRATIVA	8.13	7.87	8.00	126.83	138.75	132.79	63.67	61.58	62.62
10	RH 80	8.47	8.07	8.27	125.58	122.82	124.20	46.49	56.68	51.59
11	NDH 128	7.93	8.73	8.33	132.11	141.47	136.79	49.3	63.56	56.43
12	IT 36	8.27	8.2	8.23	125.42	143.83	134.63	49.97	61.45	55.71
13	TCP 111	8.07	8.87	8.47	151.11	153.11	152.11	52.65	61.73	57.19
14	TCP 246	8	9.07	8.53	150.55	161.58	156.07	51.77	66.65	59.21
15	TCP 190	8.07	8.07	8.07	166.34	159.55	162.95	55.25	65.55	60.4
16	TCP 120	7.8	9.8	8.8	152.11	168.45	160.28	58.52	68.82	63.67
17	TCP 90	8.33	9.53	8.93	150.36	164.09	157.22	50.32	72.05	61.18
18	TCP 235	8.4	8.8	8.60	146.78	166.24	156.51	57.82	70.19	64.01
19	TCP 58	8.93	8.67	8.80	158.34	157.05	157.69	50.39	63.34	56.86
20	TCP 32	8.4	8.8	8.06	146.44	166.94	156.69	53.65	69.5	61.57
21	TCP 94	8.27	8.53	8.40	148.67	157.29	152.98	49.25	68.04	58.65
22	TCP 232	8.2	8.13	8.17	157.44	162.58	160.01	55.76	70.17	62.97
Mean		8.21	8.38	8.29	140.74	153.63	147.18	53.22	65.63	59.42
SEM±		0.18	0.494		2.77	4.26		2.47	1.76	
C.D.		0.51	1.41		7.91	12.17		7.055	5.033	
C.V.		3.8	10.21		3.41	4.81		8.045	4.65	

Sl. No	Genotype	Leaf Lamina Width			No.of Mother Rhizome			No. of Primary Rhizome		
		2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
1	TCP 191	14.55	15.89	15.22	1.17	1.27	1.22	7.17	7.47	7.32
2	IT 23	13.99	18.04	16.02	1	1.2	1.1	6.5	8.13	7.32
3	TCP 2	13.1	16.09	14.6	1	1.2	1.1	5.5	5.47	5.48
4	IT 10	15.75	17.07	16.41	1	1.07	1.03	6.17	6.27	6.22
5	NDH11	17.05	17.67	17.36	1.17	1	1.08	6.83	6.93	6.88
6	RH 9/90	13.25	18.28	15.76	1	1	1	6.67	6.6	6.63
7	LTS 1	15.88	17.87	16.88	1.17	1.13	1.15	6	8.07	7.03
8	LTS 2	14.11	17.14	15.62	1	1.2	1.1	6.17	7.53	6.85
9	PRATIVA	16.08	14.97	15.53	1.5	1.4	1.45	5.5	7.2	6.35
10	RH 80	12.92	15.64	14.28	1.33	1.13	1.23	4.33	8.27	6.3
11	NDH 128	13.44	16.99	15.22	1.67	1.33	1.5	5	7.8	6.4
12	IT 36	13.23	19.38	16.31	1.17	1.13	1.15	5.83	7.47	6.65
13	TCP 111	13.11	16.27	14.69	1	1.07	1.03	5.17	7.27	6.22
14	TCP 246	12.45	17.4	14.92	1.5	1.2	1.35	7.17	8.33	7.75
15	TCP 190	13.55	16.94	15.25	1	1.2	1.1	5.67	6.33	6
16	TCP 120	14.11	17.16	15.64	1.5	1.4	1.45	6	8.33	7.17
17	TCP 90	12.11	17.62	14.87	1	1.87	1.43	7.17	9.33	8.25
18	TCP 235	13.67	16.9	15.29	1.33	1.47	1.4	7.5	8.27	7.88
19	TCP 58	12.89	16.02	14.46	1.33	1.1	1.22	7.33	7.2	7.27
20	TCP 32	14.00	16.71	15.35	1	1.13	1.07	6.5	7.67	7.08
21	TCP 94	14.00	15.62	14.81	1.17	1.07	1.12	6.33	7.27	6.8
22	TCP 232	14.44	17.32	15.88	1	1.4	1.2	6.17	7.87	7.02
Mean		13.98	16.95	15.46	1.18	1.22	1.20	6.21	7.50	6.85
SEM±		0.46	0.62		0.133	0.14		0.61	0.63	
C.D.		1.33	1.78		0.37	0.41		1.74	1.8	
C.V.		5.78	6.38		19.48	20.76		17.054	14.57	

Sl. No	Genotype	Plot Yield			Projected Yield		
		2019	2020	Pooled	2019	2020	Pooled
1	TCP 191	14.6	13.03	13.81	29.5291	26.35	27.94
2	IT 23	8.58	6.67	7.63	17.3641	13.49	15.43
3	TCP 2	12.01	9.91	10.96	24.29	20.04	22.17
4	IT 10	11.6	9.93	10.77	23.47	20.09	21.78
5	NDH11	10.78	9.29	10.03	21.81	18.79	20.30
6	RH 9/90	7.54	6.17	6.85	15.25	12.48	13.87
7	LTS 1	11.97	13.38	12.68	24.22	27.07	25.64
8	LTS 2	8.51	9.79	9.15	17.22	19.8	18.51
9	PRATIVA	8.46	6.67	7.56	17.11	13.49	15.30
10	RH 80	8.2	7.62	7.91	16.58	15.42	16.00
11	NDH 128	9.15	7.68	8.41	18.52	15.53	17.02
12	IT 36	7.71	8.77	8.24	15.6	17.74	16.67
13	TCP 111	12.73	11.23	11.98	25.76	22.73	24.24
14	TCP 246	16.67	15.8	16.23	33.72	31.96	32.84
15	TCP 190	14.27	12.04	13.15	28.86	24.35	26.61
16	TCP 120	15.87	12.84	14.35	32.1	25.97	29.03
17	TCP 90	12.43	10.37	11.4	25.15	20.98	23.07
18	TCP 235	15.9	14.49	15.19	32.17	29.3	30.73
19	TCP 58	13.67	10.36	12.01	27.65	20.95	24.30
20	TCP 32	12.13	10.31	11.22	24.55	20.86	22.70
21	TCP 94	13.2	10.08	11.64	26.7	20.39	23.54
22	TCP 232	13.07	11.00	12.04	26.43	22.26	24.35
Mean		11.77	10.33	11.05	23.82	20.91	22.36
SEM±		0.87	1.24		1.77	2.51	
C.D.		2.49	3.54		5.05	7.17	
C.V.		12.88	20.82		12.88	20.82	

Sl. No	Genotype	Rhizome Length			Rhizome Internode Pattern			Rhizome Weight		
		2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
1	TCP 191	8.18	7.26	7.72	0.84	1.01	0.92	271.33	381.00	326.17
2	IT 23	8.61	7.38	8.00	1.22	1.02	1.12	323.0	429.07	376.03
3	TCP 2	8.82	8.41	8.62	1.01	1.12	1.07	346.17	458.00	402.08
4	IT 10	8.62	9.38	9.00	0.91	0.99	0.95	266.0	337.07	301.53
5	NDH11	7.62	6.78	7.20	0.85	1.02	0.93	259.33	339.80	299.57
6	RH 9/90	8.13	6.66	7.40	1.06	1.10	1.08	314.67	331.47	323.07
7	LTS 1	8.01	8.27	8.14	0.99	1.12	1.05	303.0	480.40	391.70
8	LTS 2	7.79	8.58	8.19	0.83	1.15	0.99	283.17	427.20	355.18
9	PRATIVA	9.74	7.77	8.75	0.99	1.02	1.01	322.5	436.17	379.33
10	RH 80	8.53	7.72	8.13	1.03	1.10	1.07	375.67	503.27	439.47
11	NDH 128	7.76	7.32	7.54	0.94	1.04	0.99	266.17	411.07	338.62
12	IT 36	11.29	9.03	10.16	1.43	1.10	1.27	251.33	548.30	399.82
13	TCP 111	7.08	7.40	7.24	0.88	1.00	0.94	319.33	345.20	332.27
14	TCP 246	8.11	7.50	7.81	1.01	1.01	1.01	343.17	512.04	427.60
15	TCP 190	7.94	7.31	7.63	0.98	0.86	0.92	240.0	394.47	317.23
16	TCP 120	7.32	7.27	7.29	0.92	1.00	0.96	251.5	508.93	380.22
17	TCP 90	7.17	7.67	7.42	0.81	1.03	0.92	377.5	571.27	474.38
18	TCP 235	8.74	7.56	8.15	1.07	1.05	1.06	311.67	499.07	405.37
19	TCP 58	7.66	7.82	7.74	0.97	1.06	1.01	293.17	336.37	314.77
20	TCP 32	7.79	7.57	7.68	0.93	1.02	0.98	256.33	377.20	316.77
21	TCP 94	7.68	7.27	7.48	0.94	1.02	0.98	233.67	405.07	319.37
22	TCP 232	7.09	7.53	7.31	0.89	1.18	1.04	331.67	434.13	382.9
Mean		8.16	7.70	7.93	0.97	1.046	1.00	297.31	426.05	361.68
SEM±		0.36	0.59		0.069	0.06		31.86	67.22	
C.D.		1.03	1.69		0.19	0.18		90.93	191.84	
C.V.		7.65	13.32		12.22	10.98		18.56	27.32	

Table 4: Analysis of variance of physiological and rhizome characters of turmeric

Sources of Variation		Mean sum of squares										
	df	PLMS	PH	LLL	LLW	NMR	NFR	RL	RIP	S Rwt	PLY	PRY
Year	1	1.002	5476.18***	5089.008**	290.964**	0.064	54.992***	7.194*	0.159**	546874.648***	68.270***	279.447***
Rep	2	0.537	50.97	23.1125	0.577	0.106	3.035	0.912	0.025	6368.264	1.355	5.541
Genotype	21	0.678	738.703***	100.727***	3.682***	0.146**	2.714**	2.973***	0.039***	13881.95	41.088***	168.140***
GEN X year	21	1.09**	137.600***	36.673**	4.0774***	0.102*	1.487	1.048	0.0326**	5360.214	2.434	9.969
Error	84	0.416	38.848	13.8338	0.913	0.059	1.159	0.722	0.014	8300.705	3.469	14.193
Total	131											

*, **, *** signifies 0.1%, 0.05%and 0.01% level of significance respectively

PLMS- Number of leaves per plant, PH- Plant Height, LLL- Leaf Lamina length, LLW- Leaf Lamina Width; NMR- Number of month rhizome per plant; NPR- Number of primary Rhizome per plant; RL- Rhizome length; RIP- Rhizome Inter node Pattern; S Rwt- Single rhizome weight; Ply- Yield/plot, ProY – Projected Yield.

Table 5: Characterization of turmeric genotypes according to DUS descriptors

Character	Narrow(<10cm)	Medium(10-15cm)	Broad(>15cm)
Plant number of leaves	TCP 191; IT 23; TCP 2; IT 10; NDH 11; RH9/90; LTS 1; LTS 2; PRATIVA; RH 80; NDH 128; IT 36; TCP 11; TCP 246; TCP 190; TCP 120; TCP 90; TCP 235; TCP 58; TCP 32; TCP 94; TCP 232		
Plant Height	TCP 191; IT 23; TCP 2; IT 10; NDH 11; RH9/90; LTS 1; LTS 2; PRATIVA; RH 80; NDH 128; IT 36; TCP 11; TCP 246; TCP 190; TCP 120; TCP 90; TCP 235; TCP 58; TCP 32; TCP 94; TCP 232		
Character	Short (<30cm)	Medium (30-40cm)	Long (>40cm)
Leaf Lamina Length			TCP 191;IT 23;TCP 2;IT 10;NDH 11;RH9/90;LTS 1;LTS 2;PRATIVA;RH 80;NDH 128;IT 36;TCP 11;TCP 246;TCP 190;TCP 120;TCP 90;TCP 235;TCP 58;TCP 32;TCP 94;TCP 232
Character	Narrow(<10cm)	Medium(10-15cm)	Broad(>15cm)
Leaf Lamina Width		TCP 2;RH 80;TCP 11;TCP 246;TCP 90; TCP 58;TCP 94	TCP 191;IT 23;IT 10;NDH 11;RH9/90;LTS 1;LTS 2;PRATIVA;NDH 128;IT 36;TCP 190;TCP 120;TCP 90;TCP 235;TCP 32;TCP 232
Character	One	Two – Three	More than three
No.of Mother Rhizome	TCP 191;IT 23;TCP 2;IT 10;NDH 11;RH9/90;LTS 1;LTS 2;RH 80;IT 36;TCP 11;TCP 246;TCP 190;TCP 235;TCP 58;TCP 32;TCP 94;TCP 232	PRATIVA;NDH 128;TCP 120;TCP 90	
Character	Short (<5cm)	Medium (5-10cm)	Long (>10cm)
Rhizome Length		TCP 191;IT 23;TCP 2;IT 10;NDH 11;RH9/90;LTS 1;LTS 2;PRATIVA;RH 80;NDH 128;TCP 11;TCP 246;TCP 190;TCP 120;TCP 90;TCP 235;TCP 58;TCP 32;TCP 94;TCP 232	IT 36
Character	Close (< 1)	Distant (>1)	
Rhizome Internode Pattern	TCP 191;IT 10;NDH 11;LTS 2;NDH 128;TCP 11;TCP 190;TCP 120;TCP 90;TCP 32;TCP 94		

Conclusion

Characterization and grouping of all the genotypes was successfully done according to DUS Descriptors in Vegetative and rhizome characters after evaluation of different characters. TCP 191, LTS-1, TCP 111, TCP 246, TCP 190, TCP 120,TCP 90, TCP 235, TCP 58, TCP 232 showed better result than local check variety TCP-2. All the varieties excelled in production than national variety PRATIVA, so they can be recommended in this terai region of West Bengal.

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