academicJournals

Vol. 10(11), pp. 1211-1223, 12 March, 2015
DOI: 10.5897/AJAR2013.8246
Article Number: 5768D2751402
ISSN 1991-637X

http://www.academicjournals.org/AJAR

African Journal of Agricultural Research

Full Length Research Paper

Collection and characterization of indigenous genotypes of Tikhur (*Curcuma angustifolia* Roxb.) under Bastar Plateau of Chhattisgarh

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Received 18 November, 2013; Accepted 17 December, 2014

The investigation was undertaken during the year of kharif seasons 2010-11 and 2011-12 at Shaheed Gundadhoor College of Agriculture and Research Station (IGKV) Kumhrawand, Jagdalpur, Bastar (C.G.) India. Twenty indigenous genotypes of Tikhur (*Curcuma angustifolia* Roxb.) collected from thirteen districts of Chhattisgarh viz., Bastar, Korba, Dhamtari, Rajnandgaon, Surguja, Jashpur, Korea, Bilaspur, Kondagaon, Narayanpur, Kanker, Dantewada and Bijapur during March to June 2010. The experiment was aimed at collection, characterization and evaluation of 20 indigenous genotypes of Tikhur. The mean and range are estimated during characterization of 20 genotypes. The highest tall plant (115.70 cm), leaf length (53.78 cm), leaf breadth (20.92 cm), basal diameter of sucker in two directions (3.08 cm), leaf sheath length (49.86 cm) and maximum breath of lamina (12.34 cm) was recorded in genotype IGDMT-10-1. Maximum number of leaves per plant 18.97 and number of suckers in a clone (5.10) was recorded in genotype IGKOT-10-1. Maximum petiole length 21.70 cm was recorded in genotype IGSJT-10-1. The flowering was observed only in 14 genotypes out of 20 and fruit setting was absent. Highest frequency of colour of coma bracts (78.57%) was observed for pink tint. The genotypes IGKNT-10-1 took less time (160 days) for maturity as compared among 20 genotypes. The highest rhizomes yield (30.32 t/ha) and highest starch recovery (16.57%) was recorded in genotype IGSJT-10-2. Tasteless, fine and white colour of starch was observed from all 20 genotypes. The highest protein content (0.945%) in starch recorded in genotype IGSJT-10-4. Characterization of genotypes provided the information on morphological agronomic and biochemical aspects of the material that is essential for gene bank management and conservation of the Tikhur (*Curcuma angustifolia* Roxb.).

Key words: Tikhur, *Curcuma angustifolia* Roxb., collection, characterization, rhizome yield, starch recovery.

INTRODUCTION

Tikhur (*Curcuma angustifolia*; family Zingiberaceae) is a rhizomatous herb also known as white turmeric or East Indian Arrowroot. Its cultivation has now been undertaken by the farmers of Bastar on a large area. Tikhur is

cultivated as medicinal crop in many parts of the state under moist deciduous mixed and *sal* forest of Madhya Pradesh, Chhattisgarh and Jharkhand. Tikhur is also found in central province, Bihar, Maharashtra and Southern part of India. In undivided Madhya Pradesh, it is widely distributed in Bastar, Balaghat, Chhindwara, Surguja, Bilaspur, Raipur and Mandla districts (Kirtikar and Basu, 1918). The total collection of Tikhur rhizome as a minor forest produce in Chhattisgarh is 1,90.00 tonnes. Bastar and Bilashpur divisions are the major potential area of the state for Tikhur (Anonymous, 2005). Two types of Tikhur are found in the Bastar division; one with creamy white flowers and another having light pink coloured flowers (Singh et al., 1999).

Tikhur rhizomes are used as appetizer reducing burning sensations and stomach pains, removal of stone from kidney, useful for ulcer patient (Sharma, 2003) and rhizome pulp is used for treatment of headache as well as it gives cooling effect (Nag et al., 2006). The starch of Tikhur is used for the preparation of many sweet meals and herbal dishes like *halwa, barfi, jalebi etc.* It is used specially during fast (*Vrata, Upwas*). Farmers also prepare herbal drink "*sarbat*" through Tikhur starch during summer due to its cooling effect (Singh and Palta, 2004). Rhizome pulp is used as a remedy for headache, joint pains, jaundice and leucoria (Hemadri and Rao*,* 1984), while essential oil of Tikhur rhizome is used against tape worm (Benerjee and Nigam, 1978).

In the past, Tikhur was occurring to a large extent throughout the *Sal forest* of Chhattisgarh. But at present the unscientific manner of harvesting and over exploitation have brought its occurrence to the restricted patches. No research work has been carried out on collection, characterization and conservation of Tikhur to screen superior genotypes assessing its genetic diversity and variation etc.

The farmers of Chhattisgarh who reside in the vicinity of the forest, collect naturally grown Tikhur rhizomes as a minor forest produce and some farmers grow it commercially in their kitchen garden and *badi* farming system. Farmers grew unidentified locally available genotypes of Tikhur for rhizome production and processing of rhizomes through traditional method for starch extraction. Farmers' effort yielded less starch due to unrefined extraction process. Very little information is available regarding this crop especially on collection and characterization of Tikhur genotypes under agro-climatic condition of Chhattisgarh. These kinds of work would ensure *ex-situ* conservation of medicinal plants, besides the economical up-scaling of farmers and the augmentation of supply of raw material to pharmaceutical industries. The importance of the crop for people of Chhattisgarh prompted this investigation.

MATERIALS AND METHODS

This research was conducted at Shaheed Gundadhoor College of Agriculture and Research Station (IGKV), Kumhrawand, Jagdalpur, Bastar, Chhattisgarh during *Kharif* seasons of 2010-11 and 2011-12. Twenty indigenous genotypes of Tikhur (*Curcuma angustifolia* Roxb.) collected (IGBT-10-1, IGKOT-10-1,IGDMT-10-1, IGDMT-10-2, IGMOT-10-1, IGSJT-10-1,IGJT-10-1,IGSJT-10-2, IGSJT-10-3, IGKT-10-1, IGSJT-10-4, IGBLT-10-1, IGBT-10-2, IGBT-10-3 (Local), IGNT-10-1, IGBT-10-4, IGBLT-10-2, IGKNT-10-1, IGDNT-10-1 and IGBJT-10-1) from thirteen districts of Chhattisgarh viz., Bastar, Korba, Dhamtari, Rajnandgaon, Surguja, Jashpur, Korea, Bilaspur, Kondagaon, Narayanpur, Kanker, Dantewada and Bijapur during March 2010 to June 2010. The passport data of collected Tikhur germplasm are given in Table 1. The collected rhizomes of the indigenous Tikhur genotypes was planted in Experimental Research Farm, AICRP Palm Experimental Field, Jagdalpur, Bastar, Chhattisgarh, during the period from June 2010 to November 2010 and June 2011 to November 2011. Characterization of Tikhur genotypes was done as per NBPGR descriptor.

The genotypes were grown randomly in single replication/block in a total of 20 plots of 3.0 m × 3.0 m each containing 75 plants per plot and spacing was 60 × 20 cm. The crop was grown under rainfed conditions. All the observations were taken from sprouting of rhizomes and up to maturity of crop for characterization. The mean and range are estimated during characterization of 20 genotypes of Tikhur.

RESULTS AND DISCUSSION

The results of characterization and grouping of genotypes for different morphological characters based on characterization data as per NBPGR descriptor are presented in Tables 2 to 6. Fifty-seven characters of twenty genotypes of Tikhur were studied and characterized during 2010-2011 and 2011-2012 and grouped under the following categories for interpretation of results. Findings are discussed here with pooled data of two years.

Leaf sucker and plant characters

The sprout colour was categorized into four groups with highest frequency observed in redish purple (35%). Leaf disposition pattern was categorized into three groups and highest frequency (50%) was observed as erect. Ventral leaf colour were categorized into two groups with dark green having the highest frequency (75%). Carpal leaf colour was categorized into two groups with highest frequency (70%) observed for light green. Spatial arrangement of veins on leaves were categorized into two groups and close arrangement of veins on leaves had the highest frequency (55%). Prominence of leaf venation was categorized into two groups with prominent

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Table 1. Collection details of indigenous genotypes of Tikhur (*Curcuma angustifolia* Roxb.).

S/No.	Collection No. and Name	Collected by	Place of collection	Location of collection	Status of plant (Cultivated/Wild)	Collected material
1.	IGBT-10-1	Shri Deo Shankar & Shri Gundhar Bhardwaj	Village: Bhatagura, Jagdalpur, Bastar (C. G.)	N 19° 39.963' E 81° 13.197' H 507 m	Cultivated (Collected from *Badi*)	Rhizomes
2.	IGKOT-10-1	Shri Deo Shankar & Shri D. P. Singh Tanwar	Shri Deepak Tanwar, Village: Rampur, Tahs-Katghora, Dist.- Korba (C. G.)	N 23° 01.432' E 82° 21.610' H 434 m	Cultivated (Collected from *Badi*)	Rhizomes
3.	IGDMT-10-1	Shri Deo Shankar & Shri Asharam Netam	Shri Asharam Netam, Village: Dugali, Block: Nagari, Dist.- Dhamtari (C. G.)	N 20° 29.477' E 81° 52.166' H 445 m	Cultivated (Collected from *Badi*)	Rhizomes
4.	IGDMT-10-2	Shri Deo Shankar & Shri J. L. Nag	Shri Lokeshwar Bhandari, Village: Mashulkhoi, Block: Nagari, Dist.- Dhamtari (C. G.)	N 20° 25.959' E 81° 43.228' H 459 m	Wild addible (Collected from *Forest*)	Rhizomes
5.	IGMOT-10-1	Shri Deo Shankar & Bhubaneswar Prasad Purame	Village: Mohla, Block: Mohla, District: Rajnandgaon (C. G.)	N 20° 29.477' E 81° 52.166' H 445 m	Wild addible (Collected from *Forest*)	Rhizomes
6.	IGSJT-10-1	Shri Deo Shankar	Shri Shiv Charan Singh,Village: Damodarpur, Block: Shankargarh, Tahs: Kusami (Samri), District: Surguja (C. G.)	N 21° 05.12' E 81° 02.21' H 432 m	Cultivated (Collected from *Badi*)	Rhizomes
7.	IGJT-10-1	Shri Kawatch Bhagat & Shri Deo Shankar	Village: Bagicha, District: Jaspur (C. G.)	N 21° 58.359' E 83° 01.64' H 621 m	Cultivated (Collected from *Orchard*)	Rhizomes
8.	IGSJT-10-2	Shri Deo Shankar & Shri Khora Ram	Shri Khora Ram, Village: Kamari, Block: Shankargarh, Tahs: Kusami (Samri), District: Surguja (C. G.)	N 23° 17.497' E 83° 37.190' H 680 m	Cultivated (Collected from *Badi*)	Rhizomes
9.	IGSJT-10-3	Shri Deo Shankar & Shri Iswar Prasad	Shri Iswar Prasad, Village: Kamari, Block: Shankargarh, Tahs: Kusami (Samri), District: Surguja (C. G.)	N 23° 17.469' E 83° 37.068' H 686 m	Cultivated (Collected from *Badi*)	Rhizomes

Table 1. Contd.

10.	IGKT-10-1	Shri Deo Shankar & Shri R. K. Patre	Shri Mohit Rajwade, Village: Kailaspur, Block: Sonhat, Tahs: Sonhat, District: Korea (C. G.)	N 23° 26.698' E 82° 28.844' H 761 m	Wild addible (Collected from *Forest*)	Rhizomes
11.	IGSJT-10-4	Shri Ramphal Singh & Shri Deo Shankar	Shri Ramphal Singh, Village: Sukhari, Block: Lakhanpur, Tahs: Ambikapur, District: Surguja (C.G.)	N 23° 05.982' E 83° 02.933' H 624 m	Cultivated (Collected from *Mango Orchard*)	Rhizomes
12.	IGBLT-10-1	Shri Prahlad Singh Kusaro & Shri Deo Shankar	Village: Mohli, Tahs: Kota, District: Bilaspur (C. G.)		Wild addible (Collected from *Forest*)	Rhizomes
13.	IGBT-10-2	Shri Gundhar Bhardwaj and Shri Mangal Bagde	Shri Mangal Bagde, Village: Makdi, Tahs: Kondagaon, District: Bastar (C. G.)	N 19° 59.655' E 81° 36.362' H 632 m	Wild (Collected from *Forest*)	Rhizomes
14.	IGBT-10-3 (Local)	Shri Gundhar Bhardwaj and Shri Mangal Bagde	Shri Gundhar Bhardwaj, Village: Dharmaur, Block: Tokapal, Tahs: Jagdalpur, District: Bastar (C. G.)	N 19° 13.696' E 81° 98.116' H 677 m	Cultivated (Collected from *Badi*)	Rhizomes
15.	IGNT-10-1	Shri Gundhar Bhardwaj and Shri Pawan Kunwar	Village: Narayanpur, District: Narayanpur (C. G.)	N 19° 40.864' E 81° 14.572' H 507 m	Wild addible (Collected from *Bunds of pond*)	Rhizomes
16.	IGBT-10-4	Shri Gundhar Bhardwaj and Shri Bhubaneswar Majhi	Village: Machkot, Tahs: Jagdalpur, District: Bastar (C. G.)	N 19° 02.789' E 81° 57.041' H 559 m	Wild (Collected from *Forest*)	Rhizomes
17.	IGBLT-10-2	Shri Bodhram Paikra & Shri Deo Shankar	Village: Banabel, Block: Belgahana, District: Bilaspur (C. G.)		Cultivated (Collected from *Badi*)	Rhizomes
18.	IGKNT-10-1	Shri M. R. Netam and Shri Deo Shankar	Village: Narharpur, Block: Narharpur, District: Kanker (C. G.)	N 20° 26.213' E 81° 43.429' H 698 m	Cultivated (Collected from *Badi*)	Rhizomes
19.	IGDNT-10-1	Shri M. K. Druv and Shri Mahadev Netam	Village: Binjam, Block: Geedam, District: Dantewada (C. G.)	N 18° 59.106' E 81° 05.707' H 512 m	Wild addible (Collected from *Forest*)	Rhizomes
20.	IGBJT-10-1	Shri Tankeshwar Nag, RAEO, Bhairamgarh	Shri Balram Kashyap, Village: Nelusnar, Block: Bhairamgarh, District: Bijapur (C. G.)	N 19° 39.963' E 81° 13.197' H 507 m	Wild addible (Collected from *Forest*)	Rhizomes

Table 2. Morphological characterization of indigenous genotypes of Tikhur (*Curcuma angustifolia Roxb*) as per NBPGR descriptor.

S/No.	A. Leaf, sucker and plant characters							
	Collection No. and Name	**Sprout Colour**	**Leaf disposition pattern (Ho./SE./E.)**	**Ventral leaf Colour (G./D. G.)**	**Dorsal leaf Colour (Gr./D.Gr.)**	**Spatial arrangement of veins on leaves (Cl./D.)**	**Prominence of leaf venation (Less Pro./Pro.)**	**Plicate of leaves (L/M/H)**
1.	IGBT-10-1	Reddish Purple	Erect	Green	Green	Distant	Less Prominent	Medium
2.	IGKOT-10-1	Reddish Purple	Semi erect	Green	Light Green	Distant	Less Prominent	High
3.	IGDMT-10-1	Blackish Purple	Semi erect	Dark Green	Green	Close	Prominent	Low
4.	IGDMT-10-2	Dark Purple	Semi erect	Dark Green	Green	Distant	Prominent	Low
5.	IGMOT-10-1	Reddish Purple	Semi erect	Green	Light Green	Distant	Less Prominent	Medium
6.	IGSJT-10-1	Dark Purple	Erect	Green	Light Green	Close	Prominent	Medium
7.	IGJT-10-1	Blackish Purple	Semi erect	Green	Light Green	Close	Prominent	Medium
8.	IGSJT-10-2	Light Purple	Erect	Green	Light Green	Close	Prominent	Medium
9.	IGSJT-10-3	Reddish Purple	Erect	Green	Light Green	Close	Prominent	Medium
10.	IGKT-10-1	Reddish Purple	Erect	Green	Light Green	Close	Less Prominent	Medium
11.	IGSJT-10-4	Dark Purple	Erect	Dark Green	Green	Close	Prominent	Medium
12.	IGBLT-10-1	Blackish Purple	Horizontal	Green	Light Green	Distant	Less Prominent	High
13.	IGBT-10-2	Dark Purple	Erect	Green	Light Green	Distant	Less Prominent	Medium
14.	IGBT-10-3	Reddish Purple	Erect	Green	Light Green	Distant	Less Prominent	Medium
15.	IGNT-10-1	Light Purple	Semi erect	Dark Green	Green	Distant	Prominent	Low
16.	IGBT-10-4	Reddish Purple	Semi erect	Dark Green	Green	Close	Prominent	Medium
17.	IGBLT-10-2	Dark Purple	Horizontal	Green	Light Green	Close	Less Prominent	High
18.	IGKNT-10-1	Dark Purple	Semi erect	Green	Light Green	Distant	Prominent	Low
19.	IGDNT-10-1	Light Purple	Erect	Green	Light Green	Close	Prominent	Medium
20.	IGBJT-10-1	Light Purple	Erect	Green	Light Green	Close	Prominent	Medium

leaf venation having the highest frequency (60%). Plicate of leaves was categorized into three groups with medium plicate having the highest frequency (65%). The highest tall plant (115.70 cm), maximum leaf length 53.78 cm, leaf breadth 20.92 cm, highest basal diameter of sucker in two directions (3.08 cm), maximum leaf breadth (20.92 cm) and breath of lamina (12.34 cm) was recorded in genotype IGDMT-10-1 (Figure 1). Number of suckers in a clone (5.10) was recorded maximum in genotype IGKOT-10-1. Maximum petiole length was recorded as 21.70 cm in genotype IGSJT-10-1. Maximum number of leaves per plant 18.97 was recorded in genotype IGKOT-10-1. The much variability were observed in collected genotypes for leaf suckers and plant characters like plant height, sprout colour, ventral leaf colour, spatial arrangement of veins etc. and it might be due to genetic makeup of plant genotype which express their own characters. This was also reported by Latha et al. (1994), Naidu et al. (2000), Srivastava and Singh (2003) in turmeric.

Flower characters

Flowering was observed only in 14 genotypes out of 20. Months of flowering were classified into three groups and highest frequency was observed for June month of flowering (85.71%). Colour of coma bracts were categorized into three groups and highest frequency 78.57% was observed for

Table 3. Morphological characterization of indigenous genotypes of Tikhur (*Curcuma angustifolia Roxb*) as per NBPGR descriptor.

S/No.	A. Leaf, sucker and plant characters										
	Collection No. and Name	Plant ht. up to the tip of leaves	No. of suckers in a clone	Length of petiole (cm)	Length of leaf (cm)	Breadth of leaf (cm)	Basal diam. of sucker in two direct.	Leaf sheath length LP (cm)	Breadth of lamina (cm)	No. of leaves per plant	Length of mother plant (cm)
1.	IGBT-10-1	95.57	3.37	11.69	35.99	14.05	2.33	35.49	6.58	13.67	101.24
2.	IGKOT-10-1	86.35	5.10	10.77	39.59	15.74	2.55	40.95	6.72	18.97	133.24
3.	IGDMT-10-1	118.75	1.84	14.65	53.78	20.92	3.08	49.86	12.34	9.83	152.21
4.	IGDMT-10-2	107.00	1.87	13.81	43.89	13.92	1.94	27.19	7.03	9.30	105.03
5.	IGMOT-10-1	98.60	1.80	14.36	38.07	15.18	2.47	44.93	7.53	8.17	127.53
6.	IGSJT-10-1	108.62	2.90	21.85	38.29	14.48	1.88	34.63	12.30	10.17	132.01
7.	IGJT-10-1	77.69	2.80	20.69	34.70	14.82	2.33	40.09	7.05	8.70	136.61
8.	IGSJT-10-2	79.10	2.33	22.80	36.83	16.97	2.23	38.85	8.11	8.13	135.33
9.	IGSJT-10-3	66.85	1.97	14.51	32.00	17.55	2.20	36.51	12.04	8.04	121.85
10.	IGKT-10-1	86.73	2.00	16.68	39.98	13.59	1.80	36.90	6.81	9.07	114.65
11.	IGSJT-10-4	88.42	1.90	18.55	39.09	16.18	1.80	45.68	11.96	9.50	138.95
12.	IGBLT-10-1	74.14	2.60	11.20	27.28	16.49	2.50	35.29	10.73	9.17	117.90
13.	IGBT-10-2	76.39	2.37	17.01	32.89	15.90	1.77	45.70	11.90	8.37	141.66
14.	IGBT-10-3	66.45	3.37	19.02	29.85	17.29	2.30	44.13	12.17	11.10	140.18
15.	IGNT-10-1	102.94	1.97	9.41	39.48	18.21	2.58	45.11	10.94	9.17	141.83
16.	IGBT-10-4	99.75	3.13	13.15	44.07	14.56	2.27	40.17	8.48	12.40	135.01
17.	IGBLT-10-2	73.00	2.53	10.03	35.75	15.71	2.54	38.08	8.17	10.54	124.82
18.	IGKNT-10-1	77.59	2.30	14.93	36.77	18.61	2.16	44.78	12.45	10.67	140.41
19.	IGDNT-10-1	84.59	1.93	14.14	39.60	12.55	1.45	33.86	8.55	12.00	107.96
20.	IGBJT-10-1	77.14	1.97	16.67	32.75	13.22	1.79	34.45	8.48	9.43	116.66

pink tint colour (Figure 2). Flower bracts colour was categorized into two groups and light green colour had the highest frequency 85.71%. Shape of coma bracts observed ovate in all the 14 flowered genotypes. Flower bracts were categorized into two groups and lanceolate flower bract had the highest frequency 92.85%.

Fruit setting was absent in all the 14 genotypes which bears maximum peduncle length 15.20 cm and was recorded in genotype IGJT-10-1. The maximum spike with 13.6 cm was recorded in genotype IGBT-10-4. Maximum flower bract length 8.0 cm was recorded in genotype IGSJT-10-3. Maximum flower bract width 4.7 cm was recorded in genotype IGSJT-10-3. Maximum coma bract length 5.0 cm was recorded in genotype IGBT-10-4; maximum coma bract width 4.7 cm length was also recorded, and maximum flower tip was recorded as 27.4 cm in genotype IGSJT-10-3 as reported by Pant et al. (1998) in gladiolus.

The variation in flower characters might be due to genetic makeup of plant genotype which expresses their own character.

Rhizome characters

Number of mother rhizome per plant (2.63) was recorded highest in entry IGBT-10-2, as was also reported by Dutta et al. (2001) in turmeric. The maximum length of mother rhizome (6.11 cm) was observed in genotype IGNT-10-1. The maximum thickness of mother rhizome 3.82 cm was recorded in genotype IGDMT-10-1. Maximum number of primary finger rhizomes per plant (10.42) was recorded in genotype IGKOT-10-1. Maximum length of primary fingers (9.63 cm) was

Table 4. Morphological characterization of indigenous genotypes of Tikhur (*Curcuma angustifolia Roxb*) as per NBPGR descriptor.

S/No.	B. flower characters														
	Collection No. and Name	Months of flowering	Colour of Coma bracts (W/WG/LG/ LP tint/ P.tint)	Flower bracts colour (W/WG/ LG/LP tint/ P.tint)	Shape of coma bracts (Ov/Ob/ Elpt./lan./oblan./ linear)	Flower bract (Ov./ Lan.)	Fruit setting (Ab/ Pr)	Length of peduncle (cm)	Length of inflorescence (cm)	Width of spike (cm)	Flower bract length (cm)	Flower bract width (cm)	Coma bract length (cm)	Coma bract width (cm)	Length of flower up to tip (cm)
1.	IGBT-10-1	June	Pink tint	Light green	Ovate	Lanceolate	Absent	7.0	10.2	4.0	5.0	3.0	3.6	3.2	16.62
2.	IGKOT-10-1	June	Pink tint	Light green	Ovate	Lanceolate	Absent	7.5	13.4	8.5	4.4	3.4	4.0	3.7	21.0
3.	IGDMT-10-1	June	Light pink tint	Light green	Ovate	Lanceolate	Absent	5.6	10.6	7.2	5.1	3.3	4.0	3.6	15.5
4.	IGDMT-10-2	Sept.	Creamy white pink tint	Whitish green	Ovate	Lanceolate	Absent	6.2	11.2	8.1	6.1	3.5	4.1	3.7	17.2
5.	IGMOT-10-1	June	Pink tint	Light green	Ovate	Lanceolate	Absent	5.6	15.8	11.7	5.7	3.6	4.3	4.2	21.2
6.	IGSJT-10-1	June	Pink tint	Light green	Ovate	Lanceolate	Absent	7.2	15.9	7.9	6.5	3.7	4.3	4.1	20.6
7.	IGJT-10-1	June	Pink tint	Light green	Ovate	Lanceolate	Absent	15.2	14.3	9.0	6.2	3.8	3.2	3.8	23.3
8.	IGSJT-10-2	June	Pink tint	Light green	Ovate	Ovate	Absent	14.5	13.9	8.4	5.8	3.5	3.4	3.5	19.8
9.	IGSJT-10-3	June	Pink tint	Light green	Ovate	Lanceolate	Absent	8.5	14.6	9.1	8.0	4.7	4.3	4.6	27.4
10.	IGKT-10-1	June	Pink tint	Light green	Ovate	Lanceolate	Absent	5.5	12.1	8.0	5.3	3.4	3.6	4.3	17.6
11.	IGSJT-10-4	June	Pink tint	Light green	Ovate	Lanceolate	Absent	3.8	16.9	7.0	7.6	4.2	3.4	4.2	16.5
12.	IGBLT-10-1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13.	IGBT-10-2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14.	IGBT-10-3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15.	IGNT-10-1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16.	IGBT-10-4	June	Pink tint	Light green	Ovate	Lanceolate	Absent	9.2	13.6	13.6	5.5	3.2	5.0	4.7	27.3
17.	IGBLT-10-2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18.	IGKNT-10-1	Oct.	Creamy white pink tint	Whitish green	Ovate	Lanceolate	Absent	13.5	12.6	7.90	6.9	3.9	3.8	3.8	22.6
19.	IGDNT-10-1	June	Pink tint	Light green	Ovate	Lanceolate	Absent	9.3	16.2	10.2	4.8	3.6	4.4	4.4	25.6
20.	IGBJT-10-1	-	-	-	-	-	-	-	-	-	-	-	-	-	-

recorded in genotype IGSJT-10-2. Maximum thickness of primary fingers (2.15 cm) was recorded in genotype IGBT-10-1. Maximum number of secondary finger rhizome per plant (10.90) was recorded in genotype IGSJT-10-3. Maximum length of secondary finger rhizome (6.14 cm) was recorded in genotype IGBT-10-3. The maximum thickness of secondary finger rhizomes (1.95 cm) and length of tertiary finger rhizomes (4.90 cm) was recorded in genotype IGDMT-10-2. Maximum number of tertiary finger rhizomes (7.0) was recorded in genotype IGBT-10-3. Similar findings

Table 5. Morphological characterization of indigenous genotypes of Tikhur (*Curcuma angustifolia Roxb*) as per NBPGR descriptor.

S/ No.	C. Rhizome characters												
	Collection No. and Name	No. of Mother rhizomes per plant	Length of Mother rhizome (cm)	Thickness of Mother rhizome	No. of Primary fingers	Length of prim. fingers (cm)	Thickness of prim. fingers (cm)	No. of second. finger rhizome per plant	Length of sec. fingers (cm)	Thickness of Sec. fingers (cm)	No. of tertiary fingers	Length of tertiary finger (cm)	Thickness of tertiary fingers (mm)
1.	IGBT-10-1	1.40	5.42	3.48	6.77	7.92	1.86	6.94	4.62	1.83	4	1.15	4.60
2.	IGKOT-10-1	1.77	5.02	3.13	10.24	7.73	1.54	8.34	4.36	1.77	5	1.10	4.45
3.	IGDMT-10-1	1.54	5.07	3.83	6.37	7.79	1.81	10.70	4.96	1.61	6	1.25	4.05
4.	IGDMT-10-2	1.44	3.95	2.98	6.70	5.41	1.66	9.97	5.10	1.95	6	1.32	4.90
5.	IGMOT-10-1	2.07	4.05	3.14	8.17	7.43	1.87	9.20	4.65	1.80	6	1.20	4.52
6.	IGSJT-10-1	1.57	3.96	3.59	8.74	9.23	2.01	10.40	5.93	1.28	6	1.45	3.22
7.	IGJT-10-1	1.30	4.53	3.62	6.40	7.49	1.91	9.20	5.10	1.25	6	1.30	3.15
8.	IGSJT-10-2	2.13	4.29	3.19	10.87	9.63	2.29	8.77	5.79	1.21	5	1.50	3.02
9.	IGSJT-10-3	1.40	4.76	3.59	8.30	8.50	1.87	10.90	5.83	1.09	5	1.45	2.75
10.	IGKT-10-1	1.34	3.84	3.27	7.20	8.17	1.82	10.84	6.04	1.60	6	1.50	3.98
11.	IGSJT-10-4	1.90	4.56	3.26	8.97	8.49	1.89	8.04	4.36	1.03	5	1.12	2.55
12.	IGBLT-10-1	1.87	4.32	2.77	5.57	8.23	1.77	9.03	5.22	1.01	6	1.30	2.52
13.	IGBT-10-2	2.63	4.51	3.05	8.23	7.47	1.70	10.54	5.44	1.05	6	1.38	2.65
14.	IGBT-10-3	1.40	4.87	2.83	8.40	9.25	1.58	11.04	6.14	1.10	7	1.52	2.76
15.	IGNT-10-1	1.74	6.11	3.08	6.73	6.84	1.76	6.03	3.17	1.82	4	0.80	4.66
16.	IGBT-10-4	3.13	4.76	3.53	6.83	8.42	2.15	9.74	5.00	1.21	6	1.25	3.04
17.	IGBLT-10-2	1.60	4.24	2.86	5.90	7.32	1.52	6.27	4.67	0.99	4	1.18	2.50
18.	IGKNT-10-1	1.44	5.27	3.60	6.34	7.13	2.01	7.17	5.01	1.44	5	1.26	3.62
19.	IGDNT-10-1	1.34	4.48	3.54	6.17	7.13	1.71	5.14	4.65	1.14	3	1.20	2.82
20.	IGBJT-10-1	1.34	4.18	2.86	5.97	7.44	1.46	8.50	5.31	0.99	5	1.30	2.46

were given by Pathania et al. (1988), Sinkar et al. (2005) and Chaudhary et al. (2006) in turmeric.

Rhizome, rhizome flesh and starch characters

All the 20 genotypes had stipitate or stalked rhizomes. The stipitate tubers help the plant in strong extra starch and water for regeneration immediately after the summer. The stipitate tubers vary in size shape and colour reported by Vimala and Nambisan (2010). Genotype IGKOT-10-1 had maximum length of stipitate rhizomes (5.27 cm). Maximum thickness of stipitate rhizome (2.74 cm) was recorded in genotype IGSJT-10-1. For leaf spot disease observation, genotypes were categorized into two groups, absence and presence of disease. The highest frequency was observed (70%) for absence of leaf spot disease. Fresh colour of rhizomes genotypes were categorized in three groups and cream fresh colour had the highest frequency (80%) which is the valuable character for the classification of the species (Figure 1). The highest rhizome yield (30.32 t/ha) was recorded in genotype IGSJT-10-2 and also recorded by Vimala and Nambison (2010) in *Curcuma malabarica*. For organoleptic taste of rhizomes, genotypes were classified into three groups and highest frequency was observed for mild bitter test (45%). For the shape of mother

Table 6. Morphological characterization of indigenous genotypes of Tikhur (*Curcuma angustifolia Roxb*) as per NBPGR descriptor.

S/No.	Collection No. and Name	D. Rhizome, rhizome flesh and starch characters														
		Presence of stipitate or stalked rhizome (P/A)*	Length of stipitate rhizomes (cm)	Thickness of stipitate rhizomes (cm)	Leaf spot disease (P/A)*	Fresh colour of rhizomes (C/PY/YC/)*	Organoleptic taste of rhizomes (MB/VB/W/B/SA)	Shape of mother rhizome (Sp/Ob)*	Aroma of rhizomes (Aro/SA/HA/NA)*	Days to maturity	Rhizome yield (t/ha.)	Starch recovery (%)	Organoleptic taste of starch	Colour of starch	Nature of starch (granular / fine/ sticky)	Protein content (%) in starch
1.	IGBT-10-1	P	4.47	2.46	P	C	MB	Sp	SA	170	14.46	13.90	Tasteless	White	Fine	0.855
2.	IGKOT-10-1	P	5.27	2.01	A	C	VB	Sp	HA	171	13.57	12.99	Tasteless	White	Fine	0.915
3.	IGDMT-10-1	P	3.80	2.31	A	P Y	W	Ob	NA	174	16.82	12.17	Tasteless	White	Fine	0.78
4.	IGDMT-10-2	P	3.13	1.68	A	PY	W	Ob	NA	174	13.37	9.46	Tasteless	White	Fine	0.86
5.	IGMOT-10-1	P	5.20	2.34	P	C	MB	Sp	SA	169	15.09	13.08	Tasteless	White	Fine	0.815
6.	IGSJT-10-1	P	4.07	2.74	A	C	MB	Sp	SA	160	21.52	13.88	Tasteless	White	Fine	0.57
7.	IGJT-10-1	P	2.93	1.91	A	C	W	Sp	NA	167	21.18	12.81	Tasteless	White	Fine	0.69
8.	IGSJT-10-2	P	4.27	1.84	P	C	MB	Sp	SA	166	30.32	16.57	Tasteless	White	Fine	0.785
9.	IGSJT-10-3	P	4.00	2.69	A	C	B	Sp	Aro	167	20.24	11.87	Tasteless	White	Fine	0.76
10.	IGKT-10-1	P	3.60	1.41	P	C	MB	Sp	SA	168	17.87	13.72	Tasteless	White	Fine	0.41
11.	IGSJT-10-4	P	2.73	1.74	A	C	B	Sp	Aro	166	19.25	15.45	Tasteless	White	Fine	0.945
12.	IGBLT-10-1	P	5.13	1.81	A	C	VB	Sp	HA	166	17.46	15.52	Tasteless	White	Fine	0.645
13.	IGBT-10-2	P	4.80	1.44	A	C	MB	Sp	SA	167	19.73	12.34	Tasteless	White	Fine	0.685
14.	IGBT-10-3	P	3.93	1.69	A	C	MB	Sp	SA	161	20.12	11.23	Tasteless	White	Fine	0.755
15.	IGNT-10-1	P	2.53	1.89	A	Y C	W	Ob	HA	169	12.37	10.05	Tasteless	White	Fine	0.845
16.	IGBT-10-4	P	3.13	2.31	P	C	M B	Sp	SA	172	16.56	15.80	Tasteless	White	Fine	0.765
17.	IGBLT-10-2	P	4.93	1.36	P	C	VB	Sp	HA	171	8.11	13.60	Tasteless	White	Fine	0.695
18.	IGKNT-10-1	P	2.87	2.36	A	P Y	SA	Ob	HA	177	10.17	12.66	Tasteless	White	Fine	0.91
19.	IGDNT-10-1	P	2.20	1.49	A	C	MB	Sp	SA	170	12.20	10.84	Tasteless	White	Fine	0.68
20.	IGBJT-10-1	P	2.93	1.32	A	C	B	Sp	Aro	168	14.12	11.87	Tasteless	White	Fine	0.865

*P=Present, A=Absent, C=Cream, PY=Pale Yellow, YC=Yellowish Cream, MB=Mild Bitter, VB=Very Bitter, W=Watery, B=Bitter, SA=Slighty Acrid, Sp=Spherical, O=Oblong, Aro=Aromatic, SA=Slightly Aromatic, HA=Highly Aromatic, NA=Non Aromatic.

rhizome, genotypes were categorized into two groups and spherical shape had the highest frequency (80%). The root stock is the mother rhizome while its branches were divided into primary secondary and tertiary rhizomes. The root stock bears both sessile and stipitate tubers. It was also observed that the root stocks vary in shape from spherical to slightly conical; hemispherical and cylindrical was also reported by Vimala and Nambisan (2010) in starchy *curcuma species*. For aroma of rhizomes, genotypes were categorized into four groups and highest aromatic had the highest frequency (45%). The genotype IGKNT-10-1 took less time (160 days) for maturity among 20 genotypes. The highest rhizomes yield (30.32 t/ha) and starch recovery (16.57%) were recorded in genotype IGSJT-10-2; the findings correlate with that of Vimala (2002). Organoleptic tastes of extracted starch from all 20 genotypes were observed tasteless. Only white colour of starch was observed for all 20 genotypes (Figure 3). Nature of starch for all the 20 genotypes was fine. The highest protein content (0.945%) in starch was recorded in genotype IGSJT-10-4.

Conclusion

The genotype IGDMT-10-1 was observed for tall

(1) Plant and rhizome characters of genotype IGKOT-10-1

(2) Plant and rhizome characters of genotype IGDMT-10-1

(3) Plant and rhizome characters of genotype IGSJT-10-1

(4) Plant and rhizome characters of genotype IGSJT-10-2

Figure 1. Specific characteristics of Tikhur (*Curcuma angustifolia* Roxb.) genotypes.

plant, maximum leaf length, leaf breadth, basal diameter of sucker in two directions, leaf sheath length and maximum breath of lamina. Genotype IGKOT-10-1 was observed for maximum number of leaves per plant and number of suckers in a clone. Maximum petiole length was recorded in genotype IGSJT-10-1. The flowering was observed only in 14 genotypes out of 20 and fruit setting was absent. Highest frequency of colour of coma bracts

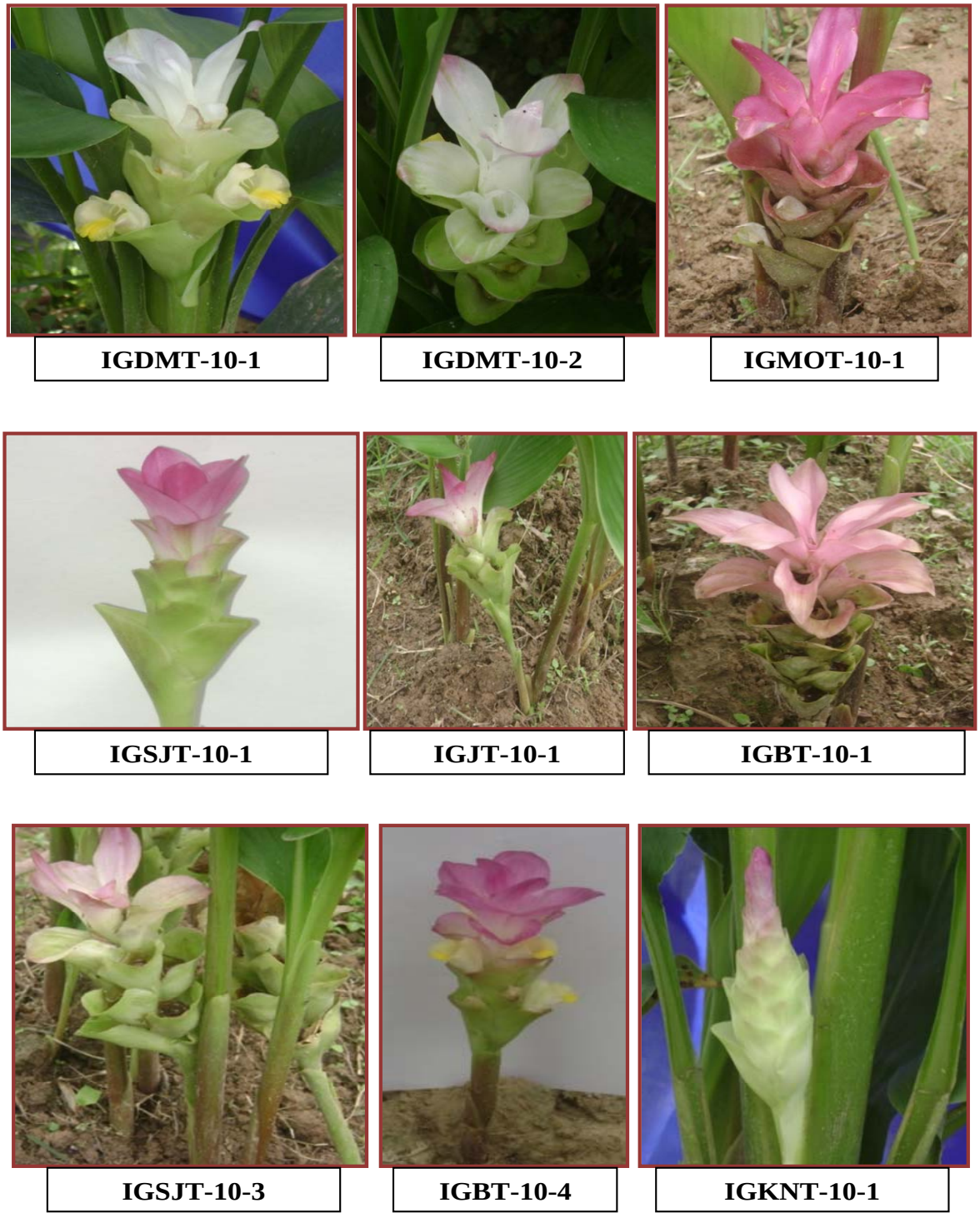

Figure 2. Flower characters of Tikhur genotypes.

was observed for pink tint. The genotypes IGKNT-10-1 was observed for early maturity as compared among 20 genotypes. The highest rhizomes yield (30.32 t/ha) and highest starch recovery (16.57%) was recorded in genotype IGSJT-10-2. Tastless, fine and white colour of starch was observed from all 20 genotypes. The highest protein content (0.945%) in starch was recorded in genotype IGSJT-10-4. Characterization of indigenous genotypes or germplasm of Tikhur (*Curcuma angustifolia* Roxb.) is very important for their evaluation, effective

Figure 3. Starch characters of Tikhur (*Curcuma angustifolia* Roxb.) genotypes (T_1-T_{20}).

management and subsequent utilization. The main objective behind evaluation is to isolate the potential donors for their effective utilization in subsequent breeding programme, such as for transferring the desirable trait in only standard variety, to make the genotype ideal.

Conflict of Interest

The authors have not declared any conflict of interests.

ACKNOWLEDGEMENT

The authors express their sincere gratitude to Dr. S. K. Patil, former Director of Research and present Vice Chancellor, IGKV, Raipur for the facilities provided and encouragement for undertaking this programme. They are also grateful to Shri J. L. Nag, SMS, KVK, Bhatapara (C. G.), Shri R. K. Sori, Ranger, State Forest Departmen. (C. G.) and farmers for their help and cooperation during collection of Tikhur germplasm.

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