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Research Article

Studies on Physical and Bio-Chemical Traits Variation in Reddish-Brown and Brown Pulp Indian Date (*Tamarindus indica* L.) Genotypes

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ABSTRACT

Variability analysis was performed to investigate the physical, yield and bio-chemical attributes of twenty different tamarind genotypes. The experiment was conducted during the year 2018 and 2019 at the instructional-cum-research farm, department of horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar. The genotypes were evaluated for various traits with the major emphasis on pulp colour, pulp percentage, yield, yield efficiency, TSS content and acidity percentage. On the basis of pulp colour, genotypes were grouped accordingly into 2 categories which consist of 3 reddish-brown and 17 brown pulp genotypes. The highest variability among reddish-brown pulp genotypes were observed with respect to yield efficiency (1.86 kg/m^3 to 4.75 kg/m^3); ascorbic acid content (1.50 mg/100 g to 2.70 mg/100 g); vein per cent (2.57% to 4.33%); yield per plant (42 kg to 66 kg) and seeds per pod (5 to 7.67) etc. Similarly, in brown pulp genotypes highest variability were observed for yield efficiency (0.53 kg/m^3 to 5.81 kg/m^3) followed by yield per plant (9 kg to 85 kg); average seed weight (2.37 g to 6.67 g); average pulp weight (8.02 g to 17.45 g) and for number of seeds per pods (4.33 to 10) etc. The genotypes like RHRTG 10, RHRTG 11 and RHRTG 14 were reported suitable for table fruit purpose because of their lesser acidity and more of TSS content and pulp percentage. The result also revealed that among the brown genotypes, RHRTG 4, RHRHG 5 and RHRTG 20 can be used for culinary purpose because of their high titratable acidity percentage. Among reddish-brown genotypes, RHRTH 16 was reported for maximum titratable acidity percentage which can be utilized in confectionery for storage purpose and for giving natural colour to sweets. In this experiment an approach was used to assess the bearing habits of genotypes per unit of canopy volume *i.e.*, yield efficiency. Genotypes having high yield efficiency can be utilized in high density planting because of their lesser canopy volume and more yield per unit of canopy volume. The genotypes RHRTG 4 and RHRTG 15 were recorded superior for yield efficiency among brown pulp genotypes and RHRTG 16 among reddish-brown genotypes.

Keywords: Reddish-brown pulp tamarind genotypes; Yield; Yield efficiency; Pulp percentage; Quality parameters

INTRODUCTION

Tamarind (*Tamarindus indica* L.) is a hardy evergreen tropical tree which belongs to family 'Fabaceae' and is popularly known as 'date of India' which is derived from Arabic word "Tamar-ul-Hind". The fruit is commonly used as a spice because of its acidic nature but the sweet types from Thailand are now dominating the tamarind market as a table fruit [1].

The sweet tamarind has been attributed to a point mutation. Occasionally isolated branches on a tree may bear sweet fruits while others bear normal sour ones. Bud sports of these trees have been propagated vegetatively and form the basis for a range of recent cultivars. In case of sweet tamarind, the dried ripe fruit is generally eaten straight from the pod.

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The red tamarind is a rare mutant with scattered distribution. The fruit colour in unripe stage is red due to presence of anthocyanin the content of anthocyanin is high in red tamarind (180 mg/g to 360 mg/g of unripe fruit), while comparing with other anthocyannin rich fruits like grapes (80 mg/g-90 mg/g), cherry (70 mg/g-75 mg/g) and jamun (120 mg/g-130 mg/g). Red tamarind's anthocyanin also has rich antioxidant properties. Hence it will have wide scope for utilizing as potential bio-colorant in food processing, pharmaceutical, brewery and confectionery industries to replace the existing use of carcinogenic inorganic colorants [2].

In present study many plus trees have been identified which were of seedling origin. There is need to develop the new variety of tamarind from the available local genotypes. Therefore, the present investigation was undertaken to study the variations in physical and qualitative characteristics with the objectives to study the tamarind genotypes for yield and sweet type quality parameters.

MATERIALS AND METHODS

The present investigation entitled "evaluation of tamarind genotypes for growth, yield and quality" was conducted during the flowering and fruiting season of 2018-2019. The twenty genotypes were evaluated for various physico-chemical characters. The investigation was carried out at the instructional-cum-research farm, department of horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar (MS), India [3]. The tamarind trees were observed carefully for various parameters *i.e.,* total number of pods along with other desirable fruit characters like big sized pod, small seed and attractive colour of measocarp, shape of pod and desirable taste of mesocarp. From the selected tree about twenty pods were randomly selected from all sides of plant at the time of their ripening stage. Fruit samples were packed in polyethylene bag and brought for further study in the laboratory of department of horticulture, post graduate institute, MPKV, Rahuri.

The physical parameters recorded during course of investigation were mature pod colour, mature pod shape, mature pod pulp colour, average pod weight (g), average pod length (cm), average pod breadth (cm), average shell weight (g), average pulp weight (g), average seed weight (g), average vein weight (g), number of seeds per pod, weight of 100 seeds (g), shell percentage (%), pulp percentage (%), vein percentage (%), seed percentage (%), yield per plant (kg) and yield efficiency (kg/m^3). The data on physical parameters were recorded as per standard procedures with the help of electronic equipment. Yield efficiency was computed by dividing the total yield obtained per plant with canopy volume of that plant [4].

RESULTS AND DISCUSSION

The genotypes were primarily evaluated for pulp colour and grouped accordingly into 2 categories which consist of 3 reddish-brown and 17 brown pulp genotypes.

Physical and bio-chemical characters of reddish-brown genotypes

The data presented in Table 1 indicate the variability among the genotypes for qualitative physical attributes. With respect to mature pod colour, out of three reddish-brown genotypes, two genotypes (RHRTG 1, RHRTG 16) were recorded for grey colour and one genotype (RHRTG 3) for brown colour pod. Similar findings were reported by Bhogave et al. where out of 26 genotypes, eight were recorded for light brown and eighteen for brown colour pod [5]. All the three reddish-brown genotypes (RHRTG 1, RHRTG 3 and RHRTG 16) were reported similar with regard to mature pod shape *i.e.,* moderately curved and pulp colour *i.e.,* reddish brown. Our results are in line with the finding of Nandini et al.

Data regarding quantitative physical attributes are presented in Table 2. The average weight and length of pod ranged from 17.90 g (RHRTG 16) to 22.53 g (RHRTG 1) and 11.15 cm (RHRTG 16) to 15.12 cm (RHRTG 1) respectively. RHRTG 1 was recorded superior for both of these characters. Our study is in close conformity with the findings of Mayavel et al. who has also reported variation in pod weight and pod length of tamarind in the range of 4.89 g to 13.94 g and 4.96 cm to 12.02 cm respectively.

Table 1: Qualitative physical characters of reddish-brown and brown pulp tamarind genotypes.

Sr. No	Genotype	Mature pod colour	Mature pod shape	Mature pod pulp colour
Reddish-brown pulp genotypes				
1.	RHRTG 1	Grey	Moderately curved	Reddish brown
2.	RHRTG 3	Brown	Moderately curved	Reddish brown
3.	RHRTG 16	Grey	Moderately curved	Reddish brown
Brown pulp genotypes				
4.	RHRTG 2	Grey	Moderately curved	Pale Brown
5.	RHRTG 4	Grey	Deeply curved	Brown

6.	RHRTG 5	Grey	Moderately curved	Brown
7.	RHRTG 6	Grey	Straight	Brown
8.	RHRTG 7	Grey	Moderately curved	Brown
9.	RHRTG 8	Brown	Moderately curved	Dark brown
10.	RHRTG 9	Grey	Moderately curved	Dark brown
11.	RHRTG 10	Brown	Moderately curved	Light Brown
12.	RHRTG 11	Brown	Moderately curved	Brown
13.	RHRTG 12	Brown	Moderately curved	Brown
14.	RHRTG 13	Grey	Straight	Pale brown
15.	RHRTG 14	Brown	Moderately curved	Brown
16.	RHRTG 15	Grey	Moderately curved	Brown
17.	RHRTG 17	Brown	Moderately curved	Brown
18.	RHRTG 18	Brown	Moderately curved	Brown
19.	RHRTG 19	Grey	Moderately curved	Brown
20.	RHRTG 20	Brown	Deeply curved	Brown

For pod breadth accessions ranged between 2.05 cm (RHRTG 16) to 2.38 (RHRTG 1) cm. The genotypes were found within the limit of general mean for this character [6]. The variation in pod breadth might be due to different genetical constitution of the individual genotypes. More or less similar kinds of variability in pod breadth in tamarind genotypes were observed by Bilcke et al.

The shell weight was recorded minimum in RHRTG 3 (4.19 g) and maximum in RHRTG 1 (5.62 g). The genotypes were found within the limit of general mean for all this characters also. Our study is in close conformity with the findings of who reported the shell weight in the range of 1.78 g (NTI-77) to 5.04 g (NTI-19). As is evident from the Table 2, pulp weight, seed weight and average vein weight ranged from 7.29 g (RHRTG 16) to 10.29 g (RHRTG 1); 4.15 (RHRTG 3) to 5.85 g (RHRTG 1) and 0.57 (RHRTG 16) to 0.80 g (RHRTG 3) respectively. The genotypes were reported within the limit of general mean for all these characters [7]. Our results are in the line with the findings of Challapilli and Benjamin and Seegobin. Seed test weight and number of seeds per pod ranged from 68.50 g (RHRTG 3) to 81.80 g (RHRTG 1) and 5.00 (RHRTG 3) to 7.67 (RHRTG 16) respectively [8]. The genotypes were reported within the limit of general mean for these characters. Our results are in the line with the findings of Divakara.

Table 2: Quantitative physical characters of reddish-brown pulp tamarind genotypes.

Sr. No	Genotype	Avg. pod wt. (g)	Avg. pod length (cm)	Avg. pod breadth (cm)	Avg. shell wt. (g)	Avg. pulp wt. (g)	Avg. seed wt. (g)	Avg. vein wt. (g)	No. of seeds per pod	Wt. of 100 seeds (g)	Shell%	Pulp%	Seed%	Vein%	Yield per plant (Kg)	Yield efficiency (Kg/m^3)
1	RHRTG 1	22.53	15.12	2.38	5.62	10.29	5.85	0.58	7.33	81.8	24.94	45.67	25.96	2.57	51	1.86
2	RHRTG 3	18.44	12.58	2.3	4.19	9.24	4.15	0.8	5	68.5	22.72	50.1	22.5	4.33	42	2.54
3	RHRTG 16	17.9	11.15	2.05	4.4	7.29	5.61	0.57	7.67	77.3	24.58	40.72	31.34	3.18	66	4.75

4	Range	17.9 to 22.53	11.15 to 15.12	2.05 to 2.38	4.19 to 5.62	7.29 to 10.29	4.15 to 5.85	0.57 to 0.8	5 to 7.67	68.5 to 81.8	22.72 to 24.94	40.72 to 50.10	22.50 to 31.34	2.57 to 4.33	42 to 66	1.86 to 4.75
5	Max.	22.53	15.12	2.38	5.62	10.29	5.85	0.8	7.67	81.8	24.94	50.1	31.34	4.33	66	4.75
6	Min.	17.9	11.15	2.05	4.19	7.29	4.15	0.57	5	68.5	22.72	40.72	22.5	2.57	42	1.86
7	Mean	19.62	12.95	2.24	4.74	8.94	5.2	0.65	6.67	75.87	24.08	45.5	26.6	3.36	53	3.05
8	S.D.	2.53	2.01	1.69	0.77	1.52	0.92	0.13	1.45	6.76	1.19	4.69	4.45	0.89	12.12	1.51
9	CV (%)	12.9	15.52	7.51	16.3	17.02	17.68	20	21.8	8.92	4.95	10.31	16.75	26.59	22.87	49.54

The bio-chemical parameters of different genotypes are presented in Table 3. Very less of variation in TSS content was reported in reddish-brown genotypes ranging from 30.48 (RHRTG 16) to 32.10°B (RHRTG 3). More or less similar variations were reported by Joshi, et al. where they recorded the TSS of 31°Brix in local tamarind followed by 27°Brix and 26°Brix in Ajantha and Thailand type's tamarind varieties respectively. The acidity percentage was recorded minimum in the genotype RHRTG 3 (8.38%) and maximum in RHRTG 16 (11.18%). Our results are in the line with the findings of Tania, et al. The genotypes were recorded with in the limit of general mean for these characters [9].

Table 3: Bio-chemical characters of reddish brown pulp tamarind genotypes.

Sr. No.	Genotype	TSS (°Brix)	Acidity (%)	Total sugars (%)	Reducing sugars (%)	Non-reducing sugars (%)	Ascorbic acid (mg/100g)
1	RHRTG 1	32	9.7	21.4	15.54	5.56	2.1
2	RHRTG 3	32.1	8.38	21.16	15.96	4.94	1.5
3	RHRTG 16	30.48	11.18	18.2	13.28	4.67	2.7
4	Range	30.48 to 32.10	8.38 to 11.18	18.2 to 21.40	13.28 to 15.96	4.67 to 5.56	1.5 to 2.70
5	Max.	32.1	11.18	21.4	15.96	5.56	2.7
6	Min.	30.48	8.38	18.2	13.28	4.67	1.5
7	Mean	31.53	9.75	20.25	14.93	5.06	2.1
8	S.D.	0.91	1.4	1.78	1.44	0.45	0.6
9	CV (%)	2.87	14.36	8.8	9.65	9.02	28.57

The percentage of total sugars, reducing sugars and mg of ascorbic acid per 100 g varied from 18.20 (RHRTG 16) to 21.40 per cent (RHRTG 1) and 13.28 (RHRTG 16) to 15.96 per cent (RHRTG 3) and 1.50 (RHRTG 3) to 2.70 (RHRTG 16) mg per 100 g respectively among reddish-brown genotypes. The genotypes were recorded with in the limit of general mean for all these parameters also. These results confirmed variations in early findings of Shankaracharya. Shukla reported that ascorbic acid content of tamarind pulp ranging from 1.81 (IGTAM-8) to 4.05 mg/100 g (IGTAM-11). As per coefficient of variation highest variability among reddish-brown genotypes was observed for yield efficiency, followed by ascorbic acid, vein per cent, yield per plant, number of seeds per pod, average vein weight, average seed weight, average pulp weight, seed percentage, average shell weight, average pod length, titratable acidity, average pod weight, pulp percentage, reducing sugars, non-reducing sugars, weight of 100 seeds, total sugars, average pod breadth, shell percentage and TSS content [10].

With regard to shell weight, maximum value was recorded in the genotype RHRTG 6 followed by RHRTG 4 (5.87 g) and RHRTG 18 (5.72 g) and the minimum in genotype RHRTG 9 (3.65 g). Our study is in close conformity with the findings of Shivanandam who also obtained similar variations in shell weight among tamarind accessions between 2.94 g to 7.29 g. The weight of pulp which is expected to be more influenced by genetic control rather than environmental factors varied from 8.02 g to 17.45 g. The genotypes RHRTG 14 and RHRTG 18

(15.09 g) were reported superior for this character. More or less similar results were obtained by Divakara and Okello et al.

The average seed weight ranged from 2.37 g to 6.67 g. maximum seed weight was recorded in the genotypes RHRTG 6 followed by RHRTG 4 (6.43 g) and RHRTG 13 (5.73 g).

The pulp percentage ranged from 37.12% to 62.16%. The genotype RHRTG 14, RHRTG 10 (60.58%) and RHRTG 11 (59.57%) were recorded superior for pulp per cent. More or less similar results were obtained by Challapilli. Maximum seed percentage was recorded in the genotype RHRTG 4 (29.04%) followed by RHRTG 2 (24.86%), RHRTG 6 (24.36%) and RHRTG 9 (24.29%) and minimum in RHRTG 10 (12.32%), RHRTG 11 (13.84%) and RHRTG 18 (14.56%). Prabhushankar et al. evaluated 15 tamarind clones and reported the 11.42 per cent seed weight in Urigam and 35.13 per cent in P-13.

Yield is the principal objective for breeding but at the same time very complex phenomenon influenced by various biotic and a-biotic factors. Yield of the selected genotypes varied from 9 to 85 kg/plant. The genotypes RHRTG 4 followed by RHRTG 12 (75 kg), RHRTG 14 (72 kg), RHRTG 11 (70 kg) and RHRTG 15 (68 kg) were recorded superior for yield character. A wide variation in yield pattern was reported by Agasimani et al. Yield efficiency ranged from 0.53 kg/m^3 to 5.81 kg/m^3. The genotypes RHRTG 4 and RHRTG 15 (5.09 kg/m^3) were found superior for this character than rest of genotypes [11].

Data with regard to bio-chemical traits of brown pulp tamarind genotypes are presented in Table 4. In case of sweet tamarind TSS, acidity and pulp per cent are the major attribute which primarily decides the palatability of this crop as table fruit. During selection of superior genotypes for table fruit purpose breeder should focus more on these traits. Among 17 brown pulp genotypes, TSS content varied from 28.68°B to 34.80°B. The genotypes RHRTG 6 (34.80°B) followed by RHRTG 14 (33.00°B) and RHRTG 10 (32.76°B) were found superior than rest of genotypes. More or less similar kinds of variability were also observed by Osorio et al. The variation in TSS may be due to different genetical constitution of the individual genotypes. Fruit growing in arid region with limited water tended to more accumulation of dry matter and lower moisture may result in higher TSS in fruits [12].

Table 4: Bio-chemical characters of brown pulp tamarind genotypes.

Sr. No.	Genotype	TSS (°Brix)	Acidity (%)	Total sugars (%)	Reducing sugars (%)	Non-reducing sugars (%)	Ascorbic acid (mg/100 g)
1	RHRTG 2	31.73	8.08	20.82	15.1	5.43	1.98
2	RHRTG 4	30.03	9.75	19.59	14.94	4.41	3.54
3	RHRTG 5	31.17	9.3	20.94	15.6	5.07	1.88
4	RHRTG 6	34.8	8.68	25.79	19.65	5.83	2.14
5	RHRTG 7	32.27	8.35	22.19	16.65	5.26	2.4
6	RHRTG 8	30.3	8.33	19	14.03	4.72	1.95
7	RHRTG 9	30.5	8.16	20.53	15.9	4.39	2.13
8	RHRTG 10	32.76	8.1	23.09	18.92	3.96	1.8
9	RHRTG 11	30.13	8.38	19.83	14.79	4.78	1.95
10	RHRTG 12	30.6	8.95	18.76	13.53	4.96	1.58
11	RHRTG 13	29.73	8.55	17.1	12.6	4.27	2.25
12	RHRTG 14	33	8.49	23.4	16.43	6.62	1.35
13	RHRTG 15	28.68	8.25	19.6	14.31	5.02	1.95
14	RHRTG 17	31.5	8.43	21.29	16.73	4.33	2.4
15	RHRTG 18	29.37	8.13	18.64	13.39	4.98	1.8
16	RHRTG 19	31.93	8.19	22.65	15.44	6.84	1.82
17	RHRTG 20	30.84	9.85	20.87	14.59	5.96	1.95

18	Range	28.68 to 34.80	8.08 to 9.85	17.1 to 25.79	12.6 to 19.65	3.96 to 6.84	1.35 to 3.54
19	Max.	34.8	9.85	25.79	19.65	6.84	3.54
20	Min.	28.68	8.08	17.1	12.6	3.96	1.35
21	GM	31.14	8.59	20.83	15.45	5.11	2.05
22	S.D.	1.51	0.55	2.12	1.85	0.81	0.46
23	CV (%)	4.86	6.48	10.2	11.98	15.93	22.74

Titratable acidity percentage is also one of the most important criteria, which also determine the quality of pods. Acidity percentage was found in the range of 8.08 to 9.85 percent. The minimum value of titratable acidity was recorded in RHRTG 2 (8.08 percent) and maximum in RHRTG 20 (9.85%), RHRTG 4 (9.75%) and RHRTG 5 (9.30%). More or less similar results were reported by Pooja et al. This is a fact in many fruits that, when TSS is increasing acidity is definitely decreased [13]. The variation among genotypes for acidity might be due to higher TSS and genetic makeup of plant (Figure 1).

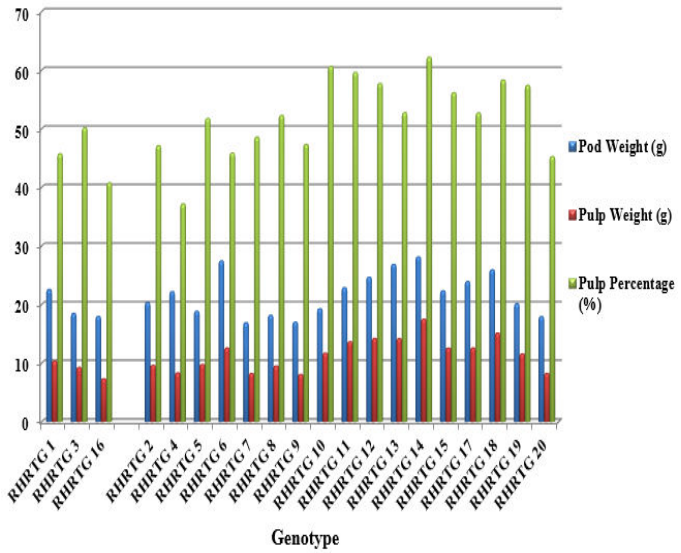

Figure 1: Variation in genotypes with respect to pod weight, pulp weight and pulp percentage.

In all 17 brown genotypes studied the genotype RHRTG 14 (Figure 2) was reported superior for all prime character like pulp weight, pulp percentage (Figure 1), yield and TSS content. The all brown pulp genotypes were reported in medium acidic range as per DUS grouping (*i.e.*, 8% to 10%). But titratable acidity of some genotypes was recorded just slight above than sweet type range (*i.e.*, below 8%).

Figure 2: Genotype RHRTG 14 having maximum pulp weight and pulp percentage.

CONCLUSION

Therefore, few genotypes like RHRTG 10, RHRTG 11 and RHRTG 14 were reported suitable for table fruit purpose because of their lessor acidity percentage and more of pulp percentage and TSS content. For culinary purpose genotypes like RHRTG 4, RHRHG 5 and RHRTG 20 were reported suitable because of their high titratable acidity percentage. Among reddish-brown genotypes, RHRTH 16 was reported for high titratable acidity percentage which can be utilized for storage purpose in confectionary. It is suggested that these promising types which are showing superior characteristics should be considered for further studies for the improvement of local elite types of tamarind by following standard breeding methods.

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