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Studies on Biodiversity and Physico-chemical Properties of Carambola (*Averrhoa Carambola* L.) in Nagaland

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ABSTRACT

An experiment on the biodiversity and physicochemical properties of carambola (*Averrhoa carambola* was conducted in the Department of Horticulture, Nagaland University, SASRD, Medziphema Campus, Nagaland, India during February–April, 2021. 22 carambola genotypes were collected randomly from different locations (altitude 150–360 m MSL) of Dimapur district in Nagaland to identify the magnitude of variability and to study the plant morphological and biochemical properties of collected fruits. Ethnobotanical uses, medicinal and ayurvedic properties in different parts of carambola were documented by interrogation and questionaries from villagers during exploration. Majority of the genotypes were recorded to have spreading tree habit. The variation in fruit weight (84.66±38.72 g), fruit volume (66.32±33.33 cc), TSS (5.55±0.25° Brix), vitamin C content (26.57±6.77 mg 100 g^{-1}), titratable acidity (0.29±0.13%), total sugar (8.32±1.44%), reducing sugar (7.62±1.33%) and oxalic acid (1.22±0.30%) was noted in different genotypes. The desirable characters with high heritability coupled with high genetic advance as percent of mean were recorded in fruit weight (98.20% and 92.52%), reducing sugar (97.40% and 36.05%), titratable acidity (99.90% and 92.97%) and oxalic acid (99.70% and 53.79%). Genotype-2 and Genotype-21 were considered as homogenous and more similar with less coefficient value (0.68) followed by Genotypes-13 and Genotypes-15 (2.10). Less acidity (0.19–0.20%), high Vitamin-C (37.87 mg 100 g^{-1} pulp) and high reducing sugar (9.28–9.45%) were noticed in Genotype-10 and Genotype-16 that stands as most promising genotypes in respect of biochemical composition of fruits.

KEYWORDS: Carambola, fruit quality, genetic advance, heritability, variability

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1. INTRODUCTION

A wide range of edible local fruits are well found naturally or in the wild between humid tropical to temperate altitude of Nagaland and many of them are grown for consumption at home and to sell in local markets. Among the underutilized fruits, Carambola (*Averrhoa carambola* L.) also known as starfruit belongs to family Oxalidaceae. Carambola is a word which has been derived from Sanskrit word '*karmaranga*' meaning "food appetizer" (Chakraborty et al., 2012). The plant is extensively cultivated in south east Asia and Malaysia (Khoo et al., 2010, Morton, 2013). The carambola is a small, bushy and evergreen fruit tree which grows best on well-drained, deep clay-loams. It can tolerate a range of pH levels but 5.2–6.2 is preferred (Watson et al., 1988). It is also well adapted under varying tropical and sub-tropical conditions but prefers warm and moist condition (Galan-Sauco et al., 1993). It grows best at temperature between 21° and 32°C. Annual rainfall between 1800–2500 mm is found to be optimum for better growth and quality fruit production (Morton, 1987, Wahab Ngah et al., 1989). Carambola fruits can be either sweet or sour depending on the cultivar and the concentration of oxalic acid. The fruit has distinctive ridges running down its side and when it is cut horizontally gives a star shape hence, the fruit is also called star-fruit. The leaves of carambola are soft, medium size, green and that they are spirally arranged round the branch in an alternately (Chakraborty et al., 2012). The flowers are tiny pink-purple and bell shaped in clusters which develop into oblong, ovoid or ellipsoid shaped fruits with 4-6 but usually 5 angled edges (Dinesh and Nirujogi, 2013). The tree becomes ready for harvesting when the plant attains 3-4 years. Carambola fruit is non-climacteric and rich in reducing sugars, ascorbic acid, antioxident and minerals such as K, Ca, Mg, Fe, Zn and P (Bose et al., 2002, Carolino et al., 2005, Moresco et al., 2012, Sharma et al., 2013, Singh et al., 2014a, Pawar et al., 2014, Kanwar and Budhwar, 2018). The ethno-botanical benefits include the fruit being used to stimulate the appetite and fruit powder used as natural preservative (Mahapatra and Biswas, 2019). The fruit juice has also been known to counteract fever, lower high blood sugar, antiulcer, anti-inflammatory, hypoglycemic, hypocholesterolemia and high blood pressure and to treat diarrhea, vomiting, jaundice and dysentery (Chau et al., 2004a, Chau et al., 2004b, Shui and Leong, 2006, Wu et al., 2009, Cabrini et al., 2011, Dinesh and Nirujogi, 2013, Lakmal et al., 2021). The leaves are known to lower high blood sugar and high blood pressure, curing chicken pox and scabies (Singh et al., 2014b). The fruits rich in oxalic acid can give an adverse effect when consumed by uremic patients (Chang et al., 2000, Chang et al., 2002, Tse et al., 2003). In Nagaland, the fruits are consumed as fresh fruits, RTS juices, jam, wines, etc and the leaves are boiled or prepared as tea. Nagaland has a rich diversity of carambola having both sweet and sour types in varying sizes and quality. However, this fruit is still unexploited as they are grown in homestead garden or in the wild (Chadha, 2013). Besides, there is a lack of documentation of the biodiversity of genotypes found in Nagaland. Therefore, the present study was carried out for the documentation of morphological and physicochemical analysis of carambola in the district of Dimapur, Nagaland.

2. MATERIALS AND METHODS

A total of 22 genotypes of the fruit samples were collected randomly, *in situ*, from various locations of Dimapur district of Nagaland during February–April, 2021, Department of Horticulture, SASRD, Medziphema campus, Nagaland University, Nagaland, India. The experimental area was located at foot hill of Nagaland with an altitude of 305 m MSL with geographical location of 25°45'43'' N latitude and 93°53'04'' E and also represents sub-humid sub-tropical climate with moderate temperature prevailing 20°–35°C during summer and rarely below 8°C in winter, moderate to high rainfall (2000–2500 mm annum^{-1}). The soil pH was 5.5 with organic carbon (15 g kg^{-1}) and atmospheric humidity (75–85%). Uniform, ripe fruits were selected from each tree and brought to the laboratory for various physical and chemical analysis. The experiment was laid out in Randomized Block Design (RBD) replicated thrice. The information regarding the traditional or medicinal uses of the fruit was collected through interaction with the farmers/growers. The height of the tree was measured using a measuring tape tied to a long bamboo pole. The age of the tree was recorded through interaction with the individual farmer/grower. The weight of the carambola fruits was recorded by weighing in an electronic weighing balance. The volume of the fruits was measured by simple water displacement method. The TSS content of the carambola fruit juice was determined with the use of Hand Refractometer (Anonymous, 1984). The ascorbic acid content of the carambola fruits was estimated by using 2, 6-dicholorophenol dye by titrating as given by (Anonymous, 1984). The titratable acidity, total sugar and reducing sugar content of the fruit were estimated by using standard method of Anonymous (1984). The non-reducing sugar content of the fruit was estimated by subtracting reducing sugar from total sugar and multiplying it by 0.95. The oxalic acid content of the fruits was estimated by titrating the extract mixture against 0.05 N $KMnO_4$. The oxalic acid content of the fruit was estimated by taking 1 g of oven dried fruit material and transferred to 30 ml of 0.5 N H_2SO_4. It was boiled in a water bath for 15 minutes and the extract was then filtered. Equal volume of deionised water was added. Then 10 ml of filtered extract was taken and 40 ml 0.5 N H_2SO_4 was added. Final 50 ml of mixture was heated to 60° C and was titrated against 0.05 N $KMnO_4$.

3. RESULTS AND DISCUSSION

3.1. Ethno-botanical benefits

In Nagaland, the carambola fruits are mainly consumed as fresh fruits, ready to serve, jams, wines, pickles, etc. The village elders stated that the leaves are also boiled and prepared as tea which is also used to treat some disorders. Singh et al. (2014b) reported that the ripe carambola fruit pulp could be used against jaundice, bleeding piles as well as for washing utensils. The leaves of carambolas when crushed could be used to cure chicken pox, ring worm and scabies and the root extract could also be used as an antidote for poisoning. Thomas et al. (2008) also reported that ripe carambola fruits had digestible, tonic and strengthening properties and dried fruit was also used in fever as it has cooling and antiscorbutic properties. The leaves of carambola have also been known to be used as antipruritic, antipyretic and anthelmintic and also are helpful in scabies, various types of poisoning, pruritus, intermittent fevers and intestinal worms. Similarly, It is reported on star fruit from traditional uses to pharmacological activities for ailments of arthralgia, chronic headache, boils and pyodermas, colds, cough, epistaxis, spermatorrhea, fever, food poisoning, gastroenteritis, malaria, malarial splenomegaly, oliguria, postpartum edema, sore throat, subcalorism and traumatic injury. The boiled flowers are used as vermifuge in fever and malaria while the roots are used to treat arthralgia, chronic headache, etc. The seeds were also crushed and used for asthma and colic.

3.2. Plant and fruit morphological characters

During survey, it was found that carambola trees were small trunked medium sized tree and varied in between 7.50–26.00 ft height (Table 1). Kapoor (1990) reported that carambola trees were found to be 5–10 m of height, spreading 20–25 ft in diameter and 15 cm trunk size. The difference in the tree height might be due to soil fertility level as well as the nature of the particular genotype. The natures of the carambola tree canopy observed were upright, spreading and drooping. The age of the collected carambola genotypes ranged from 8.50–25.50 years. The oldest tree through interrogation and questionnaire with villagers was Genotype-7 (25.50 years) followed by Genotype-21 (24.50 years). Among the collected genotypes, the youngest tree was noticed by Genotype-6 with 8.50 years. The average age of the carambola genotypes was 17.50 years. The highest weight of fruits was recorded in Genotype-19 (174.33 g) followed by Genotype-9 (152.67 g). The lowest weight of the fruit was in Genotype-13 (29.67 g). The average fruit weight was 84.65 g. Similar results were also found by

Table 1: Plant and fruit morphological characters among different genotypes of carambola fruit

Accession no	Tree height (ft)	Tree habit	Age of plant	Fruit weight (g)	Fruit volume (cc)
Genotype-1	23.00	Spreading	23.50	40.67	48.00
Genotype-2	18.00	Upright	17.00	117.00	109.33
Genotype-3	12.00	Upright	18.50	89.33	91.00
Genotype-4	7.50	Spreading	22.00	116.33	112.33
Genotype-5	26.00	Upright	19.00	108.67	114.67
Genotype-6	23.00	Spreading	8.50	54.67	34.00
Genotype-7	10.00	Spreading	25.50	130.00	84.67
Genotype-8	25.00	Drooping	14.50	78.67	46.33
Genotype-9	20.00	Drooping	21.00	152.67	130.33
Genotype-10	15.00	Spreading	14.00	87.33	78.67
Genotype-11	24.00	Upright	18.00	109.33	84.00
Genotype-12	18.00	Upright	18.50	73.00	49.67
Genotype-13	23.00	Spreading	24.00	29.67	16.67
Genotype-14	13.00	Drooping	16.50	35.00	17.31
Genotype-15	15.00	Drooping	13.50	43.67	24.00
Genotype-16	22.00	Spreading	11.00	75.33	58.00
Genotype-17	14.00	Spreading	11.00	40.67	23.00
Genotype-18	8.50	Spreading	13.50	56.33	41.33
Genotype-19	15.00	Spreading	20.50	174.33	97.33
Genotype-20	14.00	Spreading	20.00	71.00	54.33
Genotype-21	20.00	Spreading	24.50	101.00	86.67
Genotype-22	9.00	Spreading	10.50	78.00	57.33
SEm±	-	-	-	5.10	4.07
CD (p=0.05)	-	-	-	14.56	11.64

Gordon et al. (2013) who observed that the average fruit weight of carambola ranged from 82.30–166.20 g. The difference in the findings of the genotypes may be due to the different growing conditions of the fruit trees as well as the size of the fruits. There was a significant variation in the volume of the fruits (17.31 cc–130.33 cc). The average fruit volume was recorded as 66.32 cc. Geonaga (2007) also noticed a wide variation in fruit length (10.9–12.8 cm) and diameter (6–7.2 cm) in different carambola genotypes. Similar observation was reported by Narain et al. (2001) who found the average weight of ripe carambola fruits with 60.38±19.56 g which is in consonance with the present study.

3.3. Bio-chemical characters of carambola fruits

Under the study, it was observed that the highest TSS content was in Genotype-20 (6.03° Brix) followed by

Genotype-18 (5.93° Brix) and the lowest TSS content was noticed in Genotype-6 (5.12° Brix) in Table 2. These present results was found to be consistent to the results observed by Sharma et al. (2013) who recorded the total soluble solids of *Averrhoa carambola* was 5°Brix in Manipur area. Wide variation in TSS content in fruits of carambola was documented as average TSS 6° Brix and Geonaga (2007) as 8–9.8% TSS. The vitamin-C content in fruits showed a significant and wide range of variation from 13.76–37.87 mg 100 g^{-1} and the average mean was found to be 26.57 mg 100 g^{-1}. The carambola genotypes developed through selection from Thailand and Malaysia were very sweet in taste and had TSS ranging from 8-15° Brix (Ray, 2002). Pawar et al. (2014) in carambola found the variation in vitamin-C content in the fruits from 15.6–32.8 mg 100 g^{-1}. The carambola genotype with the highest titratable acidity was in Genotype-4 and Genotype-11 with 0.58% followed by Genotype-2, Genotype-3 and Genotype-21 with 0.45%. The lowest titratable acidity was observed in Genotype-1 and Genotype-8 with 0.13%. The titratable acidity ranged from 0.13–0.58% and the average was 0.29%. Thomas et al. (2008) observed the variation in titratable acidity in different stages of carambola fruits ranged from 0.67% in young, 0.23% half ripe and 0.40% in full ripe stage. The variation among the different genotypes of carambola may be due to abiotic factors and genetic constitution. The average total sugar was recorded as 8.32±1.44%. The highest total sugar was observed in Genotype-15 (10.61%) followed by Genotype-14 (10%) and Genotype-13 (9.81%) and the lowest was observed in Genotype-17 (6.05%). Pawar

Table 2: Study on bio-chemical composition of fruits in different genotypes of carambola

Accession no.	TSS (°Brix)	Vitamin C (mg 100 g^{-1})	Titratable acidity (%)	Total Sugar (%)	Reducing Sugar (%)	Non-Reducing sugar (%)	Oxalic acid (%)
Genotype-1	5.64	24.08	0.13	9.45	8.52	0.88	1.42
Genotype-2	5.44	29.24	0.45	8.90	8.00	0.86	1.51
Genotype-3	5.34	22.36	0.45	9.45	9.12	0.31	1.64
Genotype-4	5.24	13.76	0.58	9.63	9.20	0.41	0.90
Genotype-5	5.74	20.64	0.26	8.00	7.54	0.48	1.84
Genotype-6	5.12	23.36	0.26	7.22	6.84	0.36	1.28
Genotype-7	5.51	20.64	0.19	7.60	7.22	0.36	1.04
Genotype-8	5.41	27.52	0.13	6.50	6.23	0.29	0.96
Genotype-9	5.57	25.80	0.19	9.40	8.97	0.41	1.07
Genotype-10	5.47	37.87	0.19	9.81	9.45	0.34	1.43
Genotype-11	5.17	24.08	0.58	8.39	7.65	0.70	1.34
Genotype-12	5.27	36.12	0.32	7.53	6.84	0.66	1.62
Genotype-13	5.87	15.48	0.26	9.81	8.67	1.08	0.88
Genotype-14	5.27	22.36	0.20	10.00	7.32	2.55	1.21
Genotype-15	5.67	24.08	0.26	10.61	9.10	1.09	0.95
Genotype-16	5.57	20.64	0.20	9.60	9.28	0.30	0.87
Genotype-17	5.62	36.12	0.26	6.05	5.90	0.14	0.76
Genotype-18	5.93	36.12	0.26	6.12	5.00	1.06	1.10
Genotype-19	5.82	30.96	0.38	6.30	5.30	0.95	1.09
Genotype-20	6.03	32.68	0.26	6.50	6.34	0.15	1.54
Genotype-21	5.57	28.02	0.45	8.30	7.80	0.48	1.39
Genotype-22	5.77	32.68	0.20	7.90	7.48	0.46	0.91
Mean	5.55±0.25	26.57±6.77	0.29±0.13	8.32±1.44	7.62±1.33	0.65±0.52	1.22±0.30
SEm±	0.085	0.286	0.004	0.111	0.219	0.055	0.017
CD (*p*=0.05)	0.242	0.813	0.013	0.316	0.624	0.156	0.050

et al. (2014) recorded the range of total sugars in between 7.13–13.36% which was in consonance with the findings in the present study. Higher total sugar content (10.85) was reported in ripen fruit of carambola (Neog and Mohan, 1991). Joseph and Mendonca (1989) also noticed that sweet type fruits had higher sugar content (14 g 100 g^{-1}) as compared with sour types (6.25 g 100 g^{-1}). The genotype of carambola with the highest reducing sugar content was observed in Genotype-10 (9.45%) followed by Genotype-16 (9.28%) while the lowest was observed in Genotype-18 (5.0%). The average reducing sugar content of the collected genotypes was found to be 7.62%. There was a significant variation in non-reducing sugar content (0.14–2.55%) in different genotypes of carambola. The average content of non-reducing sugar was 0.69%. Shrisat and Thakor (2014) also reported that non reducing sugar content of carambola juice of ripe fruit was 2.04% which are both in the range of the current findings. Das and Bal (2010) also reported that non-reducing sugar content of carambola ranged from 2.25–2.36%. The oxalic acid content in the different genotypes ranged from 0.76–1.84% and the mean of oxalic acid was found to be 1.22%. There was significant variation in oxalic acid content in fruit. The oxalic acid content was highest in Genotype-5 (1.84%) followed by Genotype-3 (1.64%) while the lowest oxalic content was observed in Genotype-17 (0.76%). However, Murillo et al. (2016) reported the oxalic acid content in the fruit with 0.10% in *Averrhoa carambola* juice. The variation in the different genotype might be influenced by the abiotic factors as well as the genetic makeup of the genotypes.

3.4. Coefficient of variation, heritability and genetic advance

Significantly very high estimates of GCV (45.32%) and PCV (45.73%) were recorded while moderate ECV (10.59%) was recorded in fruit weight (Table 3). The similar trend in GCV (54.44%) and PCV (53.81%) was also found in fruit volume. The high estimate of genetic covariance (GCV) was found in titratable acidity (45.16%) and non-reducing sugar (79.12%). Significantly high estimates of GCV (26.15%) and PCV (26.19%) was recorded while low ECV (2.44%) was estimated in oxalic acid. The desirable characters with high heritability coupled with high genetic advance as percent of mean were recorded in fruit weight (98.20% and 92.52%) and reducing sugar (97.40% and 36.05%), titratable acidity (99.90% and 92.97%) and oxalic acid (99.70% and 53.79%). These characters are effective for further crop improvement.

Table 3: Analysis of mean, range, variance, coefficient of variation, heritability and genetic advance as % of mean in different characters of carambola

Characters	Grand mean	SEm±	Range Min-Max	GCV (%)	PCV (%)	ECV (%)	Heritability (%)	Genetic Advance (%)
Fruit weight (g)	84.68	5.18	29.67–174.33	45.32	45.73	10.59	98.20	92.52
Fruit volume (cc)	65.33	4.08	17.31–130.33	54.44	53.81	10.81	98.70	109.35
Fruit length (cm)	7.69	0.26	4.63–12.27	30.68	30.86	5.75	98.80	62.84
Fruit width (cm)	5.17	0.19	5.17–7.17	18.44	18.81	6.45	96.10	37.34
TSS(°Brix)	5.52	0.09	5.12–6.03	3.20	3.56	2.68	81.10	5.94
Titratable acidity (%)	0.29	0.004	0.128–0.576	45.16	45.18	2.62	99.90	92.97
Vitamin C (mg 100 g^{-1})	26.57	0.29	13.76–37.87	25.42	25.45	1.86	99.80	52.33
Total sugar (%)	8.34	0.11	6.05–10.61	17.17	17.22	2.31	99.40	35.27
Reducing sugar (%)	7.59	0.22	5–9.45	17.74	17.98	5.07	97.40	36.05
Non-reducing sugar (%)	0.69	0.05	0.14–2.55	79.12	79.52	13.74	99.00	162.17
Oxalic acid (%)	1.24	0.02	0.76–1.84	26.15	26.19	2.44	99.70	53.79

3.5. Cluster analysis

The 22 accessions were classified into five major clusters (Table 4). Cluster-I comprised of five accessions- Genotype-2, Genotype-3, Genotype-4, Genotype-11 and Genotype-21. The fruits in the first cluster had comparatively high fruit weight (89.33–117 g) with high acidity (0.45–0.58%) and reducing sugar (7.80–9.20%) as compared to the other genotypes. TSS of the genotypes also ranged from 5.17–5.57° Brix. Cluster-II consisted of three accessions- Genotype-5, Genotype-7 and Genotype-9. The accessions in the second cluster had high fruit weight (108.67–152.67 g) and reducing sugar (7.22–8.97%). The vitamin C content in this group ranged from 20.64–25.80 mg 100 g^{-1} and titratable acidity ranged from 0.19–0.26%. Cluster-III comprised of four accessions-Genotype-6, Genotype-8, Genotype-10 and Genotype-12. The fruit

Table 4: Clustering and distribution of different genotypes of carambola

Cluster	Genotypes/ Accessions	Traits
I	Genotype-2, Genotype-21, Genotype-11, Genotype-3 and Genotype-4	Fruit weight: 89.33–117g TSS:5.17–5.57°Brix TTA:0.45–0.58% Reducing sugar: 7.80–9.20%
II	Genotype-7, Genotype-9 and Genotype-5	Fruit weight: 108.67–152.67g Vitamin C: 20.64–25.80 mg 100 g-1 TTA: 0.19–0.26% Reducing sugar:7.22–8.97%
III	Genotype-6, Genotype-8, Genotype-10 and Genotype-12	Fruit weight: 54.67–87.33g Fruit length: 5.20–8.30 cm TSS: 5.12–5.47°Brix Vitamin C: 23.36–37.87 mg 100 g-1
IV	Genotype-13, Genotype-15, Genotype-16, Genotypen-1 and Genotype-14	Total sugar: 9.60–10.66 % Reducing sugar: 7.32–9.28% Oxalic acid: 0.87–1.42%
V	Genotype-17, Genotype-22. Genotype-18, Genotype-20 and Genotype 19	Vitamin-C: 30.96–36.12 mg 100 g-1 Total sugar:6.05–7.90 % Reducing sugar: 5.90–7.48 % Oxalic acid: 0.76–1.39 %

weight in this group ranged from 54.67–87.33 g, the fruit length ranged from 5.20–8.30 cm and the total soluble solids ranged from 5.12–5.47° Brix. High vitamin-C content (23.36–37.87 mg 100 g^{-1}) was also recorded in this group. Cluster-IV consisted of five accessions- Genotype-1, Genotype-13, Genotype-14, Genotype-15 and Genotype-16. The accessions in the fourth cluster had high total sugar (9.60–10.66%) and reducing sugar (7.32–9.28%) as compared to other genotypes. The oxalic acid content also ranged from 0.87–1.42% and vitamin-C content ranged from 15.48–24.08 mg 100 g^{-1}. Cluster-V comprised of five accessions- Genotype-17, Genotype-18, Genotype-19, Genotype-20 and Genotype-22. The accessions in this group had high vitamin C content (30.96–36.12 mg 100 g^{-1}). The total sugar ranged from 6.05–7.90%, reducing sugar content was ranged from 5.90–7.98% and oxalic acid content also ranged from 0.76–1.39%. Similar cluster analysis was done by Hafiz et al. (2012) in the hierarchical cluster analysis of genetic diversity of starfruit based on six fruit quality traits. The cluster analysis of the selected characters in *Averrhoa* sp. germplasm showed wide variability for all characters that were studied however noted that there is need to evaluate on sensory taste parameter.

3.6. *Agglomeration co-efficient*

The agglomeration schedule followed the proximity matrix in the output (Table 4 and 5). Each row in the schedule displayed a stage at which two cases were combined to form a cluster and displayed the similarity. Genotype-2 and Genotype-21 was considered as homogenous and more similar showing the less coefficient value (0.68) which was followed by Genotypes-13 and Genotypes-15 (2.10) and Genotype-7 and Genotype-9 (4.25). It indicated that Genotype-2 and Genotype-21 showed more similarity in vitamin C (29.24 mg 100 g^{-1} and 28.02 mg 100 g^{-1} respectively) and titratable acidity for both genotypes was 0.45%. Both genotypes also had quite high fruit weight (117 g and 101 g). In Genotype-13 and Genotype-15, the traits like total sugar, reducing sugar and oxalic acid was recorded to be very similar (9.81% and 10.61% respectively for total

Table 5: Analysis of agglomeration schedule in different carambola genotypes

Stage	Cluster Combined		Coefficients
	Cluster 1 (Genotypes)	Cluster 2 (Genotypes)	
1	2	21	0.68
2	13	15	2.10
3	7	9	4.25
4	2	11	6.49
5	6	8	8.82
6	2	3	11.33
7	17	22	14.05
8	13	16	16.99
9	1	13	20.29
10	18	20	23.71
11	10	12	28.16
12	17	18	33.24
13	5	7	39.13
14	2	4	46.21
15	6	10	54.64
16	17	19	63.72
17	5	6	73.22
18	1	14	85.59
19	2	5	102.72
20	1	2	131.54
21	1	17	168.00

sugar, 8.67% and 9.10% respectively for reducing sugar and 0.88% and 0.95% respectively for oxalic acid). Genotype-7 and Genotype-9 was also showed the most similarity in fruit weight (130.00 g and 152.67 g respectively), Vitamin C (20.64 mg 100 g^{-1} and 25.80 mg 100 g^{-1} respectively) and titratable acidity (both 0.19%). Consecutively, there was a large progressive difference between the coefficient of two genotypes by increasing the heterogeneity and too dissimilarity.

4. CONCLUSION

The great variability existed with regard to many desirable characters among different genotypes of carambola in respect of fruit size and weight, attractive deep yellow fruit colour, high vitamin C, high total and reducing sugar, lower titratable acidity and oxalic acid content. The most promising genotypes based on desirable attributes might stand in selection for further crop improvement.

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