Journal of Crop and Weed, 14(2): 61-64 (2018)

Multivariate techniques in evaluation of wax apple (*Syzygium javanicum* Miq.)

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Received : 29-09-2017 ; Revised : 07-08-2018 ; Accepted : 11-08-2018

ABSTRACT

The performance of six wax apple types under West Bengal condition was studied for leaf and fruit characters. Prominent variations were recorded in leaf size, fruit weight (24.35 - 77.63 cm), fruit length (3.10 - 7.27 cm), fruit diameter (3.63 - 5.50 cm) and chemical constituents like total soluble solids (4.47 - 8.73 0Brix) and total sugars (3.84 - 6.39%).ANOVA followed by Duncan's test and Multivariate data reduction techniques like principal component analysis (PCA) and cluster analysis were used for identifying the homogeneous group of varieties. Scatter diagram indicated that Type 1, 3 and 6 were promising for variables like fruit weight, fruit size, TSS, total sugars, reducing sugar and acidity. Dendrogram showed three clusters and members within cluster I (Type 4 and 5) and cluster II (Type 2, 3 and 6) were homogeneous in studied behaviour whereas cluster III comprised of single member. It is concluded that Type 1, 3 and 6 can be recommended for commercial cultivation in West Bengal.

Keywords: Fruit quality, genotypes, wax apple

Wax apple, a member of the Myrtaceae family, is botanically identified as *Syzygium javanicum* Miq. (Syn. *S. samarangense* Merr. and Perry, *Eugenia javanica* Lam.). The various vernacular names are Java apple, samarang rose apple, makopa, wax jamboo *etc*. This tropical fruit tree is indigenous to regions extending from Malaya to the Andaman and Nicobar Islands (Morton, 1987). Wax apple and water apple (*Syzygium aqueum* Alst.) are somewhat similar fruits of the genus *Syzygium* but the later has originated in south India and the fruits have uneven shape, being wider at the apex than base. On the other hand, wax apple fruits are nearly round or bell shaped or pear shaped with long neck. Wax apple fruits are usually eaten fresh mainly as a thirst quencher and in salads. Fruit has a cooling effect which makes it useful as a summer time fruit like cucumber. The greenish fruits are eaten raw with salt or may be cooked as a sauce. They are also stewed with true apples. Fruits have aromatic flesh, sweet taste and become crisp when ripe. The edible portion is about 80 per cent and water 90 per cent (Nakasone and Paull, 1998).

Wax apple is a newly introduced fruit crop in India mainly from Bangladesh and Thailand. Fruits have more demand than water apple due to attractiveness with remarkable variation. It has immense scope of commercial cultivation in West Bengal and in tropical and sub-tropical regions. There are no recommended standard or named varieties in the country. Hence, the present experiment was undertaken to study the performance and evaluation of differenttypes of wax apple with an objective to screen the suitable or desirable types.

MATERIALS AND METHODS

Six wax apple genotypes, growing in a farmer's orchard at Basirhat, North- 24 Parganas district of West Bengal were considered as experimental materials. These genotypes were probably carried out by the progressive local farmer/(s) from neighbouring border country Bangladesh for their own business interest. The experiment was undertaken during the year 2014-16 with five replicated plants of uniform age (5 years) and vigour. Fifteen matured leaves were taken from each replicated plant for taking observations like leaf size and petiole length. Sixty fruits at edible ripe stage from each type comprising three replications were collected randomly and immediately brought to the departmental laboratory for studying the physico-chemical characters. Leaf and fruit size were measured with the help of a slide calipers and weight of fruits with digital pan balance. The total soluble solids (TSS) content of the fruits was measured with the help of a refractometer which was calibrated in ^{0}Brix at 20 ^{0}C. Total sugars, reducing sugar and titratable acidity of fruits were determined by following the methods as described in AOAC. (1984). The ascorbic acid content of fruits was determined by 2,6-dichlorophenol indophenol dye titration method as described by Ranganna (2000). The data were analysed to compare mean results of six wax apple genotypes for all parameters by following one way ANOVA technique and Duncan test at 5% level of significance (Panse and Sukhatme, 1978) using SPSS version 24.

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Table 1: Leaf and fruit size of different wax apple genotypes

Type No.	Leaf length (cm)	Leaf width (cm)	Petiole length (cm)	Fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)
1	19.88 ^{ab}	7.47 ^{b}	0.57^{a}	77.63 ^{a}	5.95 ^{b}	5.50 ^{a}
2	19.69 ^{ab}	9.52 ^{a}	0.43^{a}	47.32 ^{c}	7.01 ^{a}	3.63 ^{c}
3	18.48 ^{b}	7.31 ^{b}	0.50^{a}	64.47 ^{b}	7.27 ^{a}	4.36 ^{b}
4	21.76 ^{ab}	7.57 ^{b}	0.47^{a}	24.35 ^{d}	3.10 ^{c}	4.04 ^{bc}
5	23.53 ^{a}	10.50 ^{a}	0.60^{a}	26.62 ^{d}	3.46 ^{c}	4.04 ^{bc}
6	19.59 ^{ab}	9.45 ^{a}	0.47^{a}	54.57 ^{bc}	5.71 ^{b}	4.27 ^{b}
LSD (0.05)	**NS**	**1.63**	**NS**	**10.39**	**0.54**	**0.53**

Note: Similar alphabets containing data are statistically at par. Means bearing different alphabets have significant difference ($P \leq 0.05$)

Table 2: Fruit quality of different wax apple genotypes

Type No.	TSS (^{0}Brix)	Reducing sugar (%)	Total sugars (%)	Acidity (%)	Ascorbic acid (mg 100^{-1} g)
1	7.27 ^{ab}	5.13 ^{a}	5.72 ^{ab}	0.15 ^{a}	37.6 ^{ab}
2	4.93 ^{bc}	3.38 ^{b}	3.84 ^{c}	0.07 ^{b}	61.1 ^{ab}
3	5.33 ^{bc}	3.96 ^{ab}	4.27 ^{bc}	0.13 ^{a}	51.7 ^{ab}
4	7.33 ^{ab}	3.80 ^{ab}	4.33 ^{bc}	0.13 ^{a}	61.1 ^{ab}
5	4.47 ^{c}	2.96 ^{b}	4.39 ^{bc}	0.12 ^{ab}	65.8 ^{b}
6	8.73 ^{a}	4.37 ^{ab}	6.39 ^{a}	0.12 ^{ab}	56.4 ^{a}
LSD (0.05)	**2.60**	**NS**	**1.57**	**NS**	**NS**

Table 3: Component matrix and other PCA results

Traits	Component			
	1	**2**	**3**	**4**
Leaf length	-0.62	0.77	-0.02	0.02
Leaf width	-0.67	0.09	0.13	0.73
Petiole length	0.12	0.76	-0.56	0.30
Fruit weight	0.87	-0.34	-0.25	0.25
Fruit length	0.43	-0.83	-0.27	0.25
Fruit diameter	0.89	0.37	-0.23	0.06
TSS	0.59	0.16	0.79	-0.05
Reducing sugar	0.98	0.05	0.17	-0.01
Total sugar	0.67	0.27	0.51	0.45
Acidity	0.68	0.64	-0.11	-0.26
Ascorbic acid	-0.96	0.00	0.23	-0.01
Eigen values	**5.71**	**2.62**	**1.49**	**1.02**
% of Variance	**51.88**	**23.86**	**13.57**	**9.24**
Cumulative %	**51.88**	**75.74**	**89.31**	**98.55**

Multivariate data reduction techniques like principal component analysis (PCA) and cluster analysis were used for identifying the homogeneous groups of varieties. Principal component analysis, a factor extraction method was used to form uncorrelated linear combinations of the observed variables (Dhillon and Goldstein, 1984). It helped to identify relatively homogeneous varieties based on orthogonal components as expressed by component matrix and scatter diagram of the regression factor scores. Scatter diagram was drawn only for first two components to diagnose the homogeneous group of varieties.

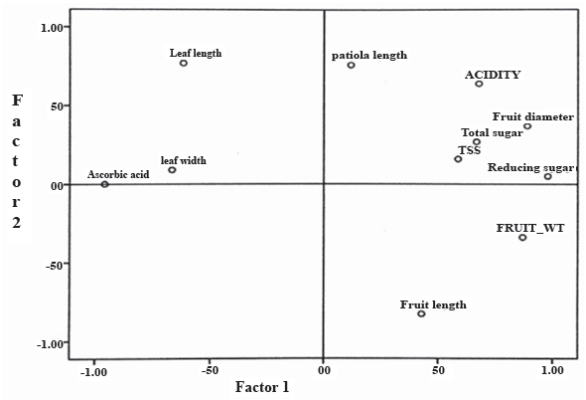

Fig. 1: Scatter diagram of regression factor scores under first two principal components showing position of different wax apple genotypes

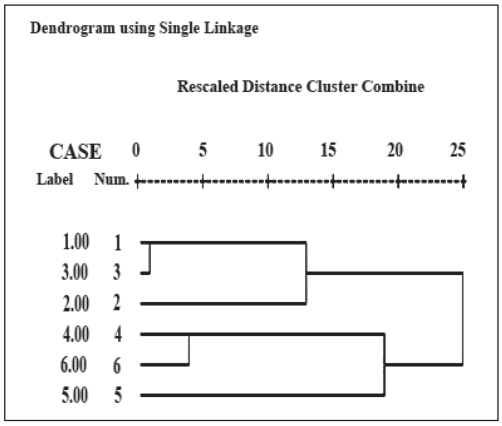

Fig. 2: Hierarchical cluster analysis based upon proximity matrix as Pearson's Correlation matrix

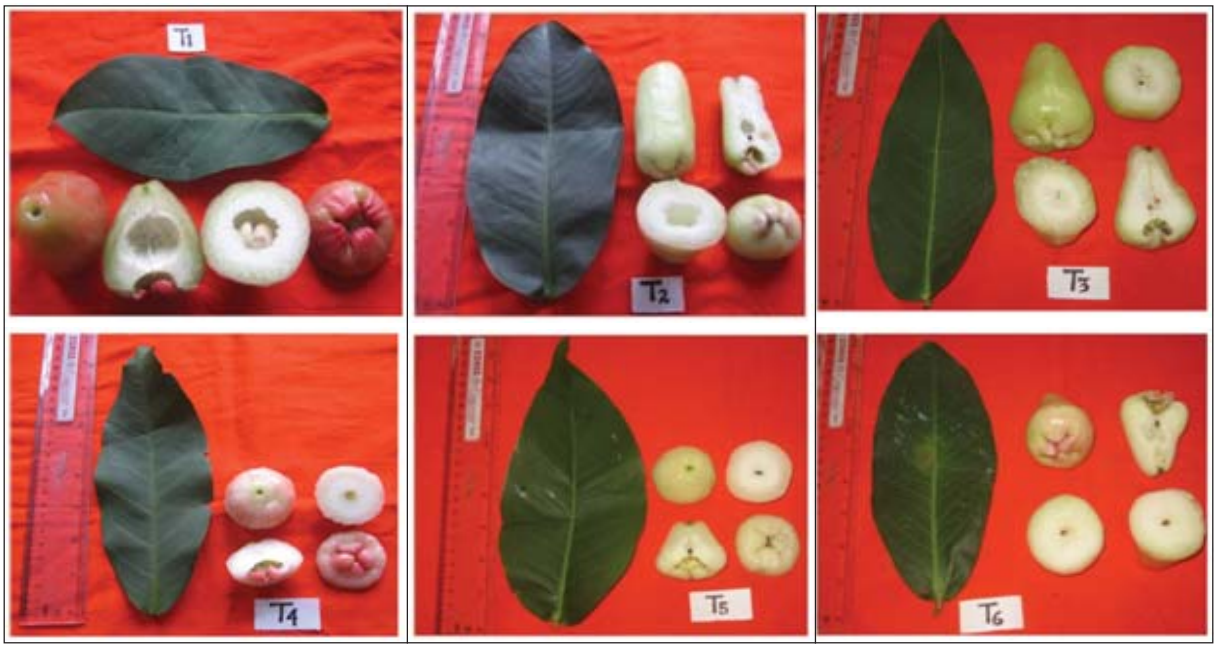

Fig. 2: Different types of wax apples

Hierarchical cluster analysis procedure was attempted to identify relatively homogeneous groups of varieties based on studied characteristics using an algorithm that starts with each case (or variable) in a separate cluster and combines clusters until only one is left. Distance or similarity measures following Pearson's Correlation matrix technique were generated by the proximities procedure as input of this analysis. Dendrogram resulted by this analysis was drawn for better understanding of homogeneous varieties.

RESULTS AND DISCUSSION

It is evident from the data cited in the table 1 and 2 that there was wide range of variations in eleven characters among six wax apple genotypes. The range of variation remained 18.48 to 23.53 cm in leaf length, 7.31 to 10.50 cm in leaf width and 0.43 to 0.60 cm in petiole length but ANOVA (F-test) resulted in inconsistent and insignificant variation of leaf length and petiole length among different types. However, Duncan's test resulted insignificant variation of leaf length but failed to establish the variation of petiole length. Leaf size and petiole length were found maximum in Type 5. Prominent and significant variation was found in fruit weight (24.35-77.63 g), fruit length (3.10-7.27 cm) and fruit diameter (3.63-5.50 cm). Type 1 and 3 had higher fruit weight and fruit diameter but the fruit length was

more in Type 2 and 3 (Table 1). It is evident from Table 2 that chemical constituents of fruits ranged widely in respect to TSS (4.47- 8.73 ^{0}Brix), reducing sugar (2.96-5.13 %), total sugars (3.84-6.39 %), acidity (0.07-0.15 %) and ascorbic acid (37.6-65.8 mg 100^{-1} ml juice) similar to the earlier findings (Xue and Zhou, 2002; Rosnah *et al*., 2012; Mohammad *et al*., 2015). Morton, (1987) also obtained total sugars content of the fruits in the higher side (6.56 %). ANOVA (F test) failed to establish the difference among the genotypes in respect of reducing sugar, acidity and ascorbic acid content of fruits. However, 'Duncan's Multiple Range Test' revealed high reducing sugar content of fruit significantly in Type 1 than Type 2 and 5 and significantly higher fruit acidity in Type 1 than Type 2. Significantly higher ascorbic acid content of fruit was estimated in Type 5 than Type 1. Type 6 contained maximum TSS (8.73 ^{0}Brix) and total sugars in fruits followed by Type 1 and 4. But the reducing sugar (5.13 %) and acidity (0.15 %) in fruit were found maximum in Type 1. Least fruit acidity was estimated in Type 2 (0.07 %). It is peculiar thatType 2 and 5 contained higher amount of ascorbic acid in fruits (61.1 mg and 65.8 mg 100^{-1} g of pulp, respectively) although its content of other chemical constituents like TSS, sugars and acidity were very less.

Principal component analysis based upon correlation matrix resulted in 4 components with reference to eigen values of more than 1. A cumulative variance of 98.55 per cent could be explained from principal component analysis. However, component 1 alone explained 51.88 per cent of total variance. Fruit weight, fruit length, fruit diameter, TSS, reducing sugar, total sugar, acidity were highly and positively loaded in component 1 but the ascorbic acid was highly and negatively loaded (Table 3).

Factor 2 explained another 23.86 per cent of total variance and positively loaded with all the variables except fruit length and fruit weight which were negatively loaded. However leaf width, reducing sugar and ascorbic acid were almost zero loadings in this factor. Factor 3 and factor 4 explained 13.57 and 9.24 per cent of total variance respectively. Highly and positively loaded variables were TSS and total sugar in factor 3 and leaf width and total sugars in factor 4. However, petiole length was highly and negatively loaded in factor 3.Regression factor scores were displayed at the scatter diagram for first two factors only possessing higher variance (Fig.1). It is clear from the figure that Type 1, 3 and 6 were promising for variables like fruit weight, fruit size, TSS, total sugars, reducing sugar, acidity but poor in leaf size and ascorbic acid. This figure further explained that Type 1, 4 and 5 were having more leaf length, petiole length, fruit diameter, acidity, total sugars but comparatively poor in fruit length and fruit weight.

Single linkage clustering or nearest neighborhood technique of clustering when used on proximity matrix as Pearson's correlation matrix, a total of three clusters were formed where allowed distance coefficient was 0.986 (Fig. 2). The dendrogram showed that members within cluster I (Type 4 and 5) and cluster II (Type 2, 3 and 6) are homogeneous or similar in studied behaviour where as cluster III comprised of single member, *i.e*. Type 1.

Hence, from the present investigation, it may be inferred that wide variation exists in the traits under study among the assembled genotypes of wax apple Type 1, 3 and 6 can be recommended for commercial cultivation in West Bengal, based on the obtained results.

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