ORIGNAL ARTICLE

Selection Indices for Improved Traits in Rambutan (*Nephelium Lappaceum L.*)

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10.18805/ag.D-4887

Abstract

A study based on the characterization of natural variability of rambutan existing in the homesteads of entire Kerala state was taken up with the prime objective of comparing the Kerala collections of rambutan and rating it with the existing quality standards and popular varieties to develop selection criteria. The characterization of over 100 variable types of rambutan revealed that Kerala collections of rambutan are not only comparable with the prevailing standards/varieties but even excelled over them in most important fruit characters. Clustering of rambutan collections identified under different categories, namely as elite dessert types, export types and for industrial use confirmed the superiority of six collections over others. The lowest, mid, and highest values of these collections were taken for redefining the existing standards so as to categorize them as elite, super-elite, and an ideotype respectively. These selection criteria realized from the highest potential, can be certainly served as a directional principle to the fruit breeders, that what should be an ideotype, super-elite, and elite. And also to have a benchmark for each attribute to qualify to these standards.

Keywords: , Cluster analysis, Principal component analysis, Quality attributes, Sapindaceae, Variability.

Agricultural Science Digest (2019)

Introduction

Rambutan (*Nephelium lappaceum* L.), native to Indonesia and Malaysia is a crop of the warm, humid tropic and sub-tropical regions and is widely cultivated throughout South - East Asia. There exists great variability in rambutan because of natural cross-pollination and sexual propagation. Rambutan fruit is primarily valued as fresh fruit for dessert purpose. Fruits meant for export are preserved by canning in sugar syrup (Coronel, 1986). Several works have been carried out on the quality standardization of rambutan in order to define each class. Hiranpradit *et al.* (1992) set up quality standardization of two commercial varieties of Thai rambutan, namely rong-rien (RR) and See-chompoo (SC). They categorized the quality standardization of RR and SC into extra, class I, and class II. In case of RR, in the extra class the number of fruit specified per kilogram is <25, in Class I is 25-28, and in Class II it is <32, while in case of SC cultivar <28 includes extra class, 28–32 in Class I and <36 in Class II. Further, all classes should conform to a certain prescribed standard such as a) fresh appearance, clean and practically free from marked bruising, disease, and insect damage. b) shape, smell, and taste must be typical to the nature of the produce. c) general characteristics must be typical to the cultivar and d) the produce must be sufficiently developed and stay in satisfactory condition at the place of destination. For export, the fruits of rambutan should satisfy the following quality specifications: uniform red colour, free from lesions, pests and diseases, clean, weight above 30 g, spines no longer than 1 cm, thick firm aril with very poor adherence to seed, and total soluble solid content of 16 to 18° Brix (Landrigan *et al.*, 1996; Kader, 2001). The fundamental attributes of fruit quality from the consumer point of view are its visual aspects such as appearance, size, color, texture, firmness, and absence of defects, flavor, juiciness, poor attachment of aril to seed and nutrient content (Kader, 2001). According to Codex Standard (Codex Stan 246-2005), a size code of 1 is given for fruits weighing above 43g. The superior quality rambutan fruits are classified in the category 'extra', good quality fruits with some defects in Class I and fruits satisfying only minimum requirements in Class II (Codex Alimentarious, 2008). Even though these works set different classes for rambutan, based on the traits of paramount importance; a unified approach is required to form the benchmark for various groups and thereby to define an ideal type. In this context, the present study was taken up with the objectives of grouping the existing variability in rambutan types grown in Kerala, comparing the available types with the prevailing standards and cultivars and finalizing the basic standards, identifying the superior/elite types and giving selection criteria using a holistic approach.

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How to cite this article: Muhamed, S., Kurien, S. and Remzeena A (2019). Selection indices for improved traits in rambutan (*Nephelium lappaceum L.*). Agricultural Science Digest, 39(3): 200-204

Source of support: Nil.

Conflict of interest: None

Submitted: 09-02-2019 **Accepted:** 24-08-2019 **Published:** 04-10-2019

Materials and methods

The study was carried out at the major rambutan growing tracts of Kerala namely Pathanamthitta, Kottayam and Thrissur and a minor area in the plains of Idukki from December 2014 to April 2016. A total of 100 variable types of rambutan were located from these four districts. All the characters were recorded as per standard descriptors prescribed by IPGRI (2003).

All the 100 collections of rambutan had diverse characters with the relatively lesser quantum of similarity. Had all the 100 collections been taken for comparative evaluation, the dimensionality of the problem would have drastically narrowed down the major findings. Hence it was decided to reduce the dimensionality for better analysis and interpretation of the results by grouping the collections in to three major categories namely a) elite selections b) selections for export types and c) selections of promising types for processing/industrial use based on a criteria developed through the measurable and most desirable characteristics as described below.

Selection for elite types

All the collections were scored based on the most desirable characteristics namely fruit weight, aril taste, aril texture, aril juiciness, attachment of aril to seed, TSS, aril to fruit ratio and seed to fruit ratio. The maximum of point tally that a collection could achieve with regard to this criteria was thus 21. In relation to this, the scores of individual collections were judged, and those collection who ranked within the highest 1/3rd group were carried forward for further study. The rest of the 2/3rd collections possessing scores in the range 4-13were filtered in a step by step manner according to the frequency of the collections such that a representative sample of two collections each were selected from a particular score using the most relevant characters namely TSS and adherence of aril to seed. Thus the two collections, each possessing highest score in case of TSS and aril attachment were also taken for further study. In the event of tie having occurred in the above-said traits, the next important criteria (aril to fruit ratio) was taken as the rationale for selection.

Selection for export trade

With respect to export trade selections, all the collections were scored based on the the quality specifications of export rambutan viz., weight above 30 g, poor adherence of aril to seed, and a minimum total soluble solid content of 16 to 18° Brix (Landrigan *et al.*, 1996; Kader, 2001). Those collections which satisfied all the export specifications were further carried forward in the study. Seven collections which satisfied all the criteria except free seed aril which fell in the category of medium were also taken for further analysis. An exception to this thump rule was made in Col.052 which was distinctly superior with respect to fruit weight and poor adherence but only had a TSS of 15.5° brix against the base value of 16° brix.

Selection for industrial use

Rambutan collections holding promise for industrial use were filtered by assigning scores based on the processing attributes, namely aril weight, juiciness, adherence to seed, TSS, titrable acidity, and total sugar content. The maximum of point tally that a collection could thus achieve with regard to this criteria was 16. In relation to this, the scores of individual collections were judged and those collections which had a score 10 or above were carried forward for further study. The rest of the collections possessing scores below 10 were filtered in a step by step manner according to the frequency of the collections such that a representative sample of two collections were selected from a particular score using the most relevant characters namely aril weight and TSS as juicy types that had already found its place in the first category. Thus two collections, each possessing highest score in aril weight and TSS were also carried further in the study.

Clustering was carried out for each category of collections using principal components based on score plot by using the software Minitab 17.

Results and discussion

The comparative studies of rambutan collections of Kerala with the existing standards and popular varieties in the world revealed that the Kerala selections possess improved traits which are not only comparable with the best-known cultivars in the world but even exhibit superiority over them (Table1).

Clustering of elite selections of rambutan

Clustering of elite selections of rambutan (37 collections) based on the first two principal components yielded ten major distinct clusters (Figure 1). The score plot indicated that cluster I (Col.061), II (Col.020 and Col.018) and III (Col.042, Col.072, Col.033, Col.028, Col.073, Col.055, Col.027, Col.023, Col.086, Col.022, Col.021, and Col.019) positioned at the first quadrant (+ve side of PCI and + ve side of PC2) were exhibited their superiority over other clusters. Hence they can be categorized as excellent types. Col.052 (61.5 g) and Col.053 (45 g) located in the fourth quadrant and fell under the category 1 of the Codex Alimentarious (2008) with a significant character of free seed aril and hence could be considered as superior among the elite selections. A critical evaluation revealed the importance of the first three groups as they were found to be superior in almost all the improved traits.

Clustering of rambutan collections of export quality

The score plot (Figure 2) constructed based on PCI and PC2 for the clustering of rambutan collections of export quality (20 collections) revealed that clusters I (Col.074, Col.068, Col.034, Col.069) and cluster II (Col.063 and Col.53) possessed the best export attributes compared to all other clusters. In addition, clusters VI (Col.027), VII (Col.022, Col.023 and Col.055), and VIII (Col.021) which exhibited preferred qualities such as fruit weight above 43 g and compare favourably with the superior category suggested by Codex Alimentarious (2008)

Table 1: Comparative studies of rambutan collections of Kerala with the prevailing standards and cultivars

Quality standards/cultivars	*Quality attributes*	*References*	*Kerala collections*	
Export specifications	Extra class (fruit weight > 30g)	(Landrigen *et al.*, 1996; Kader, 2001)	Fruit weight ≥ 30g: 38 collections	Ten collections
	TSS ≥ 16° Brix		TSS ≥ 16° Brix: 84 collections	
	Freestone aril		19 collections	
Codex Standard	Category I (fruit weight > 43g)	(Codex Alimentarious, 2008)	Fruit weight > 43g : 8 collections	
Thailand varieties				
Rong-rien	Extra class (fruit weight ≥ 40g)	(Hiranpradit *et al.*, 1992)	Fruit weight ≥ 40g: 14 collections	
See-chompoo	Extra class (fruit weight ≥ 35g)		Fruit weight ≥ 35g: 20 collections	
Thailand hybrid (IE 20)	Maximum fruit weight- 3g	(Aifaa *et al.*, 2013)	Fruit weight > 43g : 8 collections	
Mexican selections	Maximum fruit weight -35g	(Arenas *et al.*, 2010)	Fruit weight ≥ 35g: 20 collections	
IIHR, Bangalore Selections				
Arka Coorg Arun	Fruit weight: 45 g, Aril percentage: 42%, TSS: 17.5° Brix		Fruit weight ≥ 45g: 6 collections	
Arka Coorg Patib	Fruit weight: 30 g, Aril percentage: 30% TSS: 18.5° Brix	(Kumar *et al.*, 2016)	Aril percentage ≥ 42% : 15 collections TSS ≥ 20° Brix : 48 collections	

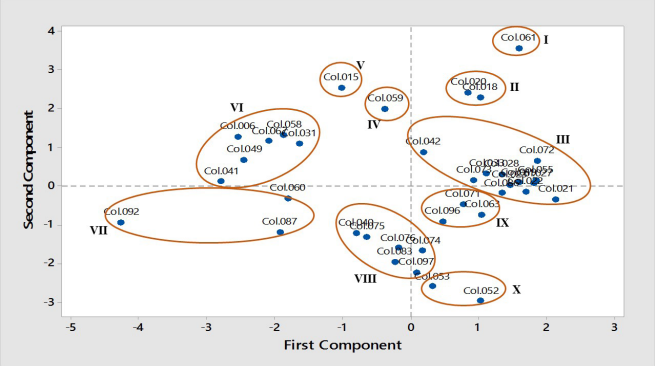

Fig. 1: Score plot based on the first two principal components of elite selections of rambutan

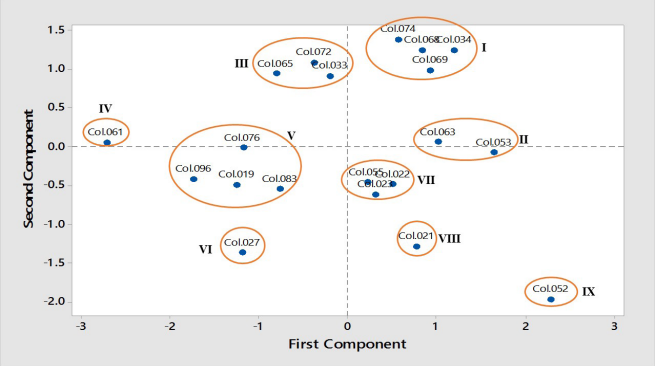

Fig. 2: Score plot based on the first two principal components of rambutan selections of export quality

with better TSS of above 20° Brix and free seed aril were also taken or could be classed as superior export types. Cluster IV (Col.061) satisfied all the export attributes with the highest TSS of 27.5° Brix except the adherence of aril which was found to be medium and Cluster IX containing only Col.052 showed its superiority over other collections with a distinctive fruit weight of 61.5 g and free seed aril but lagged behind other clusters with regard to TSS (15.5° Brix). This was slightly short of the basic requirement of 16° Brix. Hence, the farmer who wants to grow export quality rambutan can select from a wide array of collections made available from the study.

Clustering of rambutan collections having promise for processing attributes

With regard to processing attributes rambutan collections were grouped to ten clusters(Figure 3), clusters I (Col.061), II (Col.098), III (Col.042) and IV (Col.018, Col.096, Col.084, Col.086 and Col.028) exhibited the best values compared to other clusters as indicated by their position in the score plot (first quadrant). Besides these, clusters VIII (Col.052) and X (Col.019, Col.021, Col.023, Col.027, Col.033, Col.055, Col.072, and Col.073) also possessed favorable processing attributes and hence could be categorized as superior among the selections of processing/industrial use. Thus, again the study presents another distinct group of improved selections that favorably combines all the important traits and meets the requirement of the processing industry.

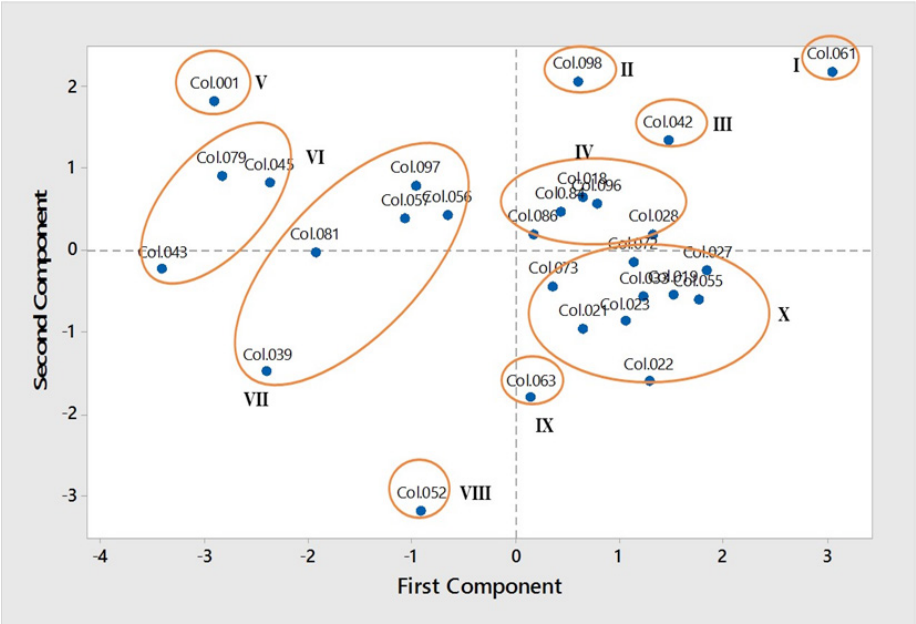

Fig. 3: Score plot based on the first two principal components of rambutan collections having promise for processing attributes

Like in the case of litchi, which is commercially exploited for juice production rambutan is another crop of the same family which has tremendous potential for commercial exploitation. One of the limitations in this direction is the lack of suitable varieties that serves the basic purpose of juiciness or high juice recovery. The study has thus opened out another challenging area worth future studies.

From the above clustering of each category of rambutan selections, an attempt was made to classify a 'supergroup' that can be grouped as elite and fulfills the requirements of an export class and also satisfies the needs of processing industry. Six collections (Col.021, Col.022, Col.023, Col.052, Col.055, and Col.061) was in full conformity to the requirements of all the three categories and hence can be outrightly recommended as elite for commercial cultivation, for export purpose and for industrial use.

These six-collection possessing most optimal properties with respect to the major fruit characters; fruit weight, aril weight, percentage aril, percentage seed, juiciness, total soluble solids, total sugar, and acidity were selected towards developing selection criteria for rambutan. The important characteristics ranged from 32.23–61.5g, 12–21g, 34–44%, 5–9%, 32.07–88.33%, 15.5°–27.5° Brix, 13.57–18.41% and 0.51–0.83% in the order of fruit weight, aril weight, percentage aril, percentage seed, juiciness, total soluble solids, total sugar and acidity respectively. A tree possessing all the above optimal values for each of the trait may be hypothesized as having all the highest values and can be called as an 'ideotype'. The highest values in the six selections obtained in the study were thus fixed as those possessing a fruit weight of 61.5g; aril weight of 21g; percentage aril of 44%; percentage seed of 5%; juiciness of 88.33%; TSS of 27.5° Brix; total sugar of 18.41% and an acidity of 0.51%. A tree possessing above mid values for each of the trait such as fruit weight of-46.865g; aril weight of -16.5g; percentage aril of-39; percentage seed of 7 ; juiciness of -60.2% ; TSS-21.5° Brix; total sugar-15.99% and acidity-0.67% can be labeled as 'super-elite.' Further, the trees possessing the base or lowest values for all the important attributes such as fruit weight of- 32.23g; aril weight- 12g; percentage aril-34; percentage seed- 9; juiciness- 32.07%; TSS- 15.5° Brix; total sugar- 13.57%; acidity of -0.83% could be labelled as 'elite'. Thus we are giving a directional principle to the breeders to fix a basic criteria for selection to obtain a plant possessing characters almost near to an ideotype, equal to or above in case of super-elite and an elite type which could qualify for further very intended purpose which in turn will help to achieve the desired production level and quality in rambutan.

Acknowledgments

This research was funded by Kerala Agricultural University. The facilities, help, and advice of KAU faculty and the award of KAU Junior Research Fellowship to the first author are sincerely acknowledged.

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