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Per se performance of elite coconut genotypes and hybrids for economic quality traits and oil yield

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Abstract

The present study was conducted at Coconut Research Station, Aliyarnagar Tamil Nadu state of India. The experimental trees comprised of five tall coconut genotypes *viz.*, IC 610370, IC 610371, IC 610372, IC 610374 and IC 610379 West Coast Tall (Check), and the hybrids *viz.*, Chowghat Orange Dwarf x Aliyar 1 (COD x ALR1), Chowghat Orange Dwarf x West Coast Tall (COD x WCT), Aliyar 1 x Malayan Green Dwarf (ALR1 x MGD), Malayan Green Dwarf x Aliyar 1 (MGD x ALR), Kenthali Dwarf x Aliyar 1 (KTD x ALR1) and Veppankulam Hybrid Coconut VHC 2 (Check hybrid - released from Veppankulam Coconut Research Station, Tamil Nadu Agricultural University, Tamil Nadu, India). Coconut palms of uniform size were taken from the chosen genotypes and hybrids for recording the observation. All the coconut genotypes and hybrids showed variation in yield, nut characters, and quality traits. The results of the present study revealed that the genotype IC 610370 and the hybrid COD x WCT recorded maximum values for all the recorded traits. This was followed by the genotype IC 610371 and the hybrid COD x ALR1.

Keywords: Coconut, genotypes, hybrids, assessment of field performance, Nut characters, kernel characters, oil yieldass

Introduction

The coconut palm is known as the “Tree of Life”, “Tree of Heaven”, “Tree of Abundance” and “Kalpavriksha” because it offers all essentials for our life through its priceless products. Coconut crops has unique versatility because every part of the tree is used and it produces a wide range of valuable products, many of which contribute to health maintenance and improvement. In 92 nations throughout the world, coconut is mostly grown in Indonesia, the Philippines, India, Brazil, Sri Lanka, and other South Asian countries like Vietnam, Papua New Guinea, Thailand, Malaysia, Myanmar, Bangladesh, China, and East African countries like Kenya, Tanzania, and Mozambique. India owns a leading position in the world in coconut production and productivity. Coconut is cultivated in an area of 2082.11 thousand ha in more than 16 states of the country producing 23904.10 million nuts with an average productivity of 11481 nuts per ha. The four southern states of India, accounting for more than 92 percent of the total coconut production in the country include Kerala, Tamil Nadu, Karnataka and Andhra Pradesh.

Coconut is a monotypic species with two different botanical forms namely tall and dwarf types. The major source of coconut production comes from the tall coconut varieties, while the dwarf and hybrid varieties are meant especially for tender coconut and contribute about 10 percent of the total production. Nath et al. (2017) suggested that new genotypes are developed to increase coconut yield and their performance in specific regions and have to be evaluated. To develop new varieties, germplasm maintenance, assessment and conservation of coconuts should be considered, because, field gene banks are the only viable option for ex-situ conservation of coconut largely due to the recalcitrant nature of the coconut seed.

The genetic diversity of coconut germplasm offers criteria for the selection of coconut breeding materials and improvements in variety (He et al.,2014; Zhou and Cao). However, few studies have analyzed and identified the traits of coconut resources. To safeguard the genetic diversity of the coconut palms, collection, assessment and conservation have to be focused, mainly on exploiting the desirable characteristics by selecting the best genotype and by using it as one of the parents in the hybridization to exploit the hybrid vigor.(Nath et al.,2017). Germplasm resources are the basis of developing new varieties, breeding desirable hybrids, and serving as reservoirs for making innovations (Liu et al., 2011; Zhang et al., 2021). The identification and evaluation of germplasm traits can promote in-depth development and utilization of resources (Cao et al., 2013; Fan et al., 2015).

Coconut is mainly used for copra (70%) and culinary purposes (30%). Only 2% of the nuts are used as tender nuts. However, due to the high cost of cultivation and low price of the main coconut products, such as the nut and copra, a business venture could not be successful. As a functional plant, coconut has rich economic value (Udaya et al., 2020). For instance, coconuts have a wide range of nutritional elements, including high content of protein, fat, and carbohydrates, as well as vitamins and minerals (Zhang, 2011). The identification and analysis of various coconut type characteristics and traits serve as a foundation for selecting suitable types with desirable characteristics, which will facilitate the exploration and in-depth development of important coconut resources.

Value addition and product diversification remain the most viable but least explored areas as the coconut industry is concerned. The coconut growers who depend exclusively on coconut cultivation are mostly under-employed and expect a livelihood for their sustainable income for want of and hence wish to opt for coconut-based processing at the farm-household and community levels. Cost-effective and labor-intensive activities assume importance in such a situation (Sudha et al., 2021). Making diversified products is a highly beneficial and viable option for coconut growers to make the coconut industry lucrative through product diversification.

To find promising elite coconut genotypes and hybrids suitable for economic, quality traits, and oil yield, a study was conducted at the Coconut Research Station in Aliyarnagar, Tamil Nadu. It started with a methodical collection conservation and evaluation of coconut germplasm to identify the elite types based on yield and quality and to assess the suitability for value addition from the selected coconut types.

Materials and methods

The present study was conducted at Coconut Research Station, Aliyarnagar, Tamil Nadu during the years 2020, 2021, and 2022. The Coconut Research Station is located in the foothills of Western Ghats at the geographic coordinates of 10°N latitude and 77°E longitude, 20 km south of Pollachi at an elevation of 260 meters with an undulating topography. The tract receives a total rainfall of 802 mm in a year, of which nearly 300 mm is received during the southwest monsoon, 333 mm during northeast monsoon and 169 mm during summer.

The maximum and minimum temperatures during summer are 35°C and 22.1°C respectively. The maximum and minimum winter temperatures are 31.9°C and 16.8°C respectively. The soil type is sandy loam and noncalcareous with neutral pH, low nitrogen, medium P_2O_5 and high K_2O content.

The experimental trees comprised of five tall coconut genotypes *viz.*, IC 610370, IC 610371, IC 610372, IC 610374 and IC 610379 and West Coast Tall (Check) and the hybrids *viz.*, Chowghat Orange Dwarf x Aliyar 1 (COD x ALR1), Chowghat Orange Dwarf x West Coast Tall (COD x WCT), Aliyar 1 x Malayan Green Dwarf (ALR1 x MGD), Malayan Green Dwarf x Aliyar 1 (MGD x ALR), Kenthali Dwarf x Aliyar 1 (KTD x ALR1) and Veppankulam Hybrid Coconut VHC 2 (Check hybrid - released from Veppankulam Coconut Research Station, Tamil Nadu Agricultural University, Tamil Nadu, India) were used for evaluation. Coconut palms of uniform size were taken from the chosen genotypes and hybrids for recording the observation. The genotypes and hybrids are maintained in the field at a spacing of 7.5 x 7.5 m as an observational experimental trial with six palms per genotype/plot. The experiment was laid out in randomized block design (RBD) with four replications. The plantations were maintained under irrigated conditions following the standard package of practices as recommended by Tami Nadu Agricultural University.

Field assessment was done by recording observations on quantitative traits like palm height, palm girth, petiole length, leaf length, leaflet length, leaflet breadth, total number of leaves, annual leaf production, number of spikes per spathe, number of female flowers per spathe, nut yield per palm per year, fruit length, fruit breadth, tender water content, whole nut weight, de-husked nut weight, kernel thickness and copra outturn. The mean values were subjected to statistical analysis using TNAUSTAT (https://sites.google.com/site/tnaustat). and the significant values were derived using GRAPES, Kerala Agricultural University (https://www.kaugrapes.com/) based on R software. From the observed data on the assessment made repeatedly over the years, five best-performing genotypes and hybrid combinations were selected to study their nut yield, kernel and quality parameters on kernel-based products and oil yield to identify the best-performing types.

The observations were recorded in six palms per replication in each hybrid combination and the mean data was used for the statistical analysis. The nut yield per palm was recorded periodically at each harvest in a year and the data was pooled to get nut yield per palm per year.

Dehusked coconut

Dehusking was done by the traditional method and the weight of the dehusked individual nut as taken for five nuts and the average was expressed in grams.

Tender coconut water

Tender coconut water extracted from the coconuts harvested at the tender stage of 6-7 months after spathe opening by break opening the nut, measured and expressed in ml.

Matured coconut water

Matured coconut water extracted from the coconuts harvested at kernel extraction stage 10 months after spathe opening by break opening the nut, measured and expressed in ml.

Kernel

After the collection of matured water the white meat /kernel was taken out from the coconut shell, weighed, and expressed in grams.

Copra

Copra content per nut was recorded by the depiction of a random sample of six nuts per entry in each replication. Copra output per palm was calculated based on the copra content per nut in each treatment. The extracted kernel was dried in the sun for 7 days, weighed and expressed in gram.

Coconut milk

As per the procedures standardized by the Central Food Technological Research Institute (CFTRI), Mysore and the Coconut Development Board, Kochi, Kerala, the fresh matured coconut was taken and broken into two halves. Using a hand grater, the white flesh of the kernel was collected and weighed. An equal amount of water is added and blended till the coconut is ground well for a couple of minutes. The contents were poured in a bowl over a fine strainer. The shreds remained on the strainer and were pressed with a spoon to collect away all the milk. The collected milk was measured and expressed in ml.

Coconut cream

Collected coconut milk was poured into a big jar and set aside to separate the creamy part from the watery liquid part of the milk. After separation, the creamier part was scooped out and the watery liquid was discarded. To make it even thicker, the scooped cream was refrigerated and chilled overnight, taken out weighed and expressed in grams.

Coconut flour

Coconut pulp left after extracting coconut milk was oven-dried at 50°C for 45 minutes until the coconut pulp was completely dried. Then it was removed from the oven and let to cool for a few minutes. After cooling it was blended in a food processor for 1-2 minutes until the pulp became a fine powder. The powder was weighed and expressed in grams.

Desiccated coconut

Only the white part of the kernel was used for making desiccated coconut after peeling out the brown outer part. It was grated, and heated over a pan kept in low flame for 10-15 minutes without browning. Sauted till stickiness and moisture were completely removed. Then after cooling the desiccated coconut was weighed and expressed in gram.

Virgin coconut oil

The milk was poured into a large, heavy-based pan and heated at low, consistent temperatures. The milk became crumbly in texture and solidified, the oil separated from the solids was allowed to cool down and the pure oil was strained, measured and expressed in ml.

Coconut oil

The well-dried copra was cut into small pieces, and fed in the oil press expeller and the oil was collected measured and expressed in ml.

Results and Discussion

The results of the study conducted on nut and yield characters are presented in Table 1 and the coconut water content, kernel traits, kernel products and oil characters are presented in Table 2. Nut characters in coconut are more important and are evaluated based on the nut as well as the husk materials. Within the nut, the kernel weight, kernel thicknesses, and copra content are more important. The characteristics of the husk should be taken into account since they are employed in the coir industry, and coco peat should be used as a medium for high-value horticultural crops because it is in high demand both locally and internationally. The study results showed that the desirable and better performance of the genotype IC 610370 was observed for the number of bunches per palm per year (12.875), number of nuts per palm per year (123.86), whole nut weight (1939.82 g) and dehusked nut weight (774.87 g). From Table 2 it is evident that the same genotype IC 610370 performed well for the parameters *viz.*, tender coconut water (339.33 ml) and coconut water (219.03 ml), kernel yield (332.32 g), copra yield (176.005 g), coconut milk (450.09 ml), coconut cream (166.81 g), coconut flour (282.83 g), desiccated coconut (262.82 g), virgin coconut oil (27.17 ml) and coconut oil (74.21 ml).

The next genotype performed better was IC 610372 for number of bunches per palm per year (12.26), number of nuts per palm per year (101.68), IC 610379 for whole nut weight (1674.09 g), IC 610371 for dehusked nut weight (743.26 g). The same genotype also performed better for parameters *viz.*, tender coconut water (331.35 ml) and coconut water (212.93 ml), kernel yield (320.56 g), copra yield (152.93 g), coconut milk (434.67 ml), coconut cream (160.71 g), coconut flour (273.84 g), desiccated coconut (254.24 g), virgin coconut oil (21.62 ml) and coconut oil (71.18 ml).

Among the hybrids, performance excellence was recorded by the cross combination COD x WCT for number of bunches per palm per year (13.67), number of nuts per palm per year (136.82), whole nut weight (2056.095 g) and dehusked nut weight (712.81 g). From Table 2 it is evident that the same hybrid had favorable values for the traits *viz.*, tender coconut

Table 1. Nut and yield characters of coconut genotypes and hybrids

Treatments	Genotypes and hybrids	No. of bunches/ palm/year	No. of nuts/ palm /year	Whole nut weight (g)	Dehusked coconut weight (g)
T1	IC 610370	12.88[b]	123.86[bc]	1939.82[b]	774.87[a]
T2	IC 610371	10.02[h]	79.87[g]	1549.29[d]	743.26[b]
T3	IC 610372	12.26[cd]	101.68[e]	1198.26[g]	651.68[de]
T4	IC 610374	11.75[ef]	91.84[f]	1484.77[ef]	664.92[de]
T5	IC 610379	11.64[f]	100.32[e]	1674.09[c]	637.15[ef]
T6	West Coast Tall (Check)	10.85[g]	73.39[h]	1116.75[h]	602.0[g]
T7	COD x ALR hybrid	12.33[cd]	126.17[b]	1676.04[c]	706.75[c]
T8	COD x WCT hybrid	13.67[a]	136.82[a]	2056.09[a]	712.81[c]
T9	ALR x MGD hybrid	12.54[bcd]	119.26[cd]	1662.92[c]	640.20[ef]
T10	MGD x ALR hybrid	10.26[h]	125.08[b]	1438.78[f]	700.70[c]
T11	KTD x ALR hybrid	12.16[de]	121.21[bc]	1536.34[de]	668.68[d]
T12	VHC 2 hybrid (Check)	12.73[bc]	114.80[d]	1637.64[c]	618.89[fg]
Mean		**11.92**	**109.53**	**1637.64**	**618.89**
S.Ed		**0.34**	**1.92**	**10.45**	**3.07**
CD (P=0.05)		*1.05*	*5.82*	*31.37*	*9.23*

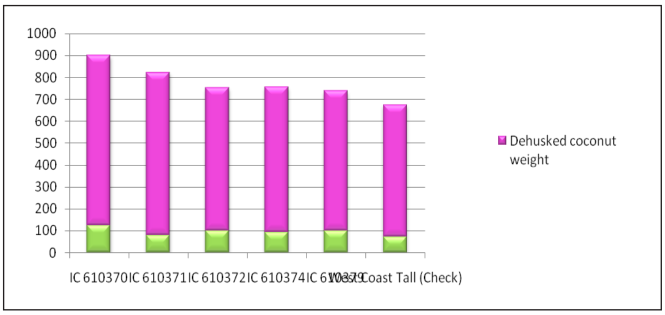


Figure 1. Nut yield and dehusked coconut weight of genotypes

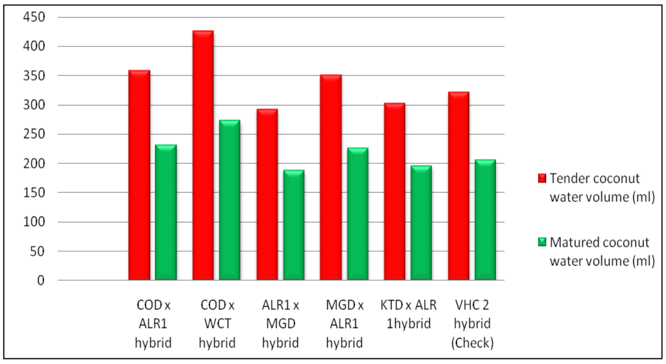


Figure 2. Tender coconut water and matured coconut water yield of hybrids

water (425.67 ml) and coconut water (272.75 ml), kernel weight (411.84 g), copra yield (165.62 g), coconut milk 557.72 ml), coconut cream (211.31 g), coconut flour (351.09 g), desiccated coconut (326.42 g), virgin coconut oil (27.5217 ml) and coconut oil (75.08 ml).

This was followed by the hybrid COD x ALR 1 which had higher values for the number of bunches per palm per year (12.33), number of nuts per palm per year (126.17), whole nut weight (1676.04 g) and dehusked nut weight (706.75 g), tender coconut water (359.00 ml) and coconut water (231.44 ml), kernel weight (349.75 g), copra yield (161.87 g), coconut milk (473.79 ml), coconut cream (175.76 g), coconut flour (297.99 g), desiccated coconut (277.19 g), virgin coconut oil (24.27 ml) and coconut oil (71.75 ml). The nut yield and dehusked nut weight of genotypes (Figure 1), tender coconut water and coconut water yield of hybrids (Figure 2), coconut flour and desiccated coconut yield of hybrids (Figure 3), virgin coconut oil and coconut oil yield of genotypes (Figure 4) are presented in the form of figures. The dehusked nut and the products developed out of the genotypes and hybrids are depicted in Plate 1-12.

The maximum number of bunches per palm per annum in WCT was reported by Potty et al., (1980) on comparison of coconut varieties for number of bunches per palm. The tall genotypes namely, Laccadive micro, Andaman Ordinary, Laccadive Ordinary and Philippines Ordinary recorded the

Table 2. Performance of coconut genotypes and hybrids for coconut kernel, kernel-based products and oil

Treat-ments	Geno-types and hybrids	Tender coconut water volume (ml)	Matured coconut water volume (ml)	Kernel weight (g)	Single copra weight (g)	Single coconut milk yield (ml)	Single coconut cream weight (g)	Single coconut flour weight (g)	Desicca-ted coconut weight (g)	Virgin coconut oil volume (ml)	Coconut oil volume (ml)
T1	IC 610370	339.33^{cd}	219.03^{cd}	332.32^{cd}	176.06^{a}	450.09^{cd}	166.81^{cd}	282.83^{cd}	262.82^{c}	27.13^{a}	74.21^{a}
T2	IC 610371	331.35^{de}	212.93^{de}	320.56^{de}	152.93^{c}	434.67^{de}	160.705^{de}	273.84^{de}	254.24^{cd}	21.62^{d}	71.18^{bc}
T3	IC 610372	261.00^{g}	168.00^{g}	256.195^{g}	121.27^{g}	345.35^{g}	127.59^{g}	222.82^{g}	201.72^{gh}	17.34^{f}	61.29^{g}
T4	IC 610374	267.07^{g}	172.00^{g}	261.37^{g}	131.19^{f}	354.39^{g}	130.71^{g}	222.43^{g}	206.81^{g}	17.57^{f}	60.18^{g}
T5	IC 610379	257.27^{g}	165.05^{g}	250.985^{g}	150.38^{c}	338.78^{g}	126.055^{g}	212.52^{g}	195.76^{h}	16.85^{f}	69.74^{cd}
T6	West Coast Tall (Check)	236.00^{h}	152.00^{h}	230.88^{h}	140.81^{de}	311.99^{h}	115.82^{h}	196.81^{h}	184.25^{i}	15.96^{g}	64.93^{ef}
T7	COD x ALR1 hybrid	359.00^{b}	231.44^{b}	349.745^{b}	161.87^{b}	473.78^{b}	175.755^{b}	297.99^{b}	277.19^{b}	24.27^{b}	71.75^{abc}
T8	COD x WCT hybrid	425.67^{a}	272.75^{a}	411.835^{a}	165.62^{b}	557.72^{a}	211.31^{a}	351.09^{a}	326.42^{a}	27.52^{a}	73.08^{ab}
T9	ALR1 x MGD hybrid	292.15^{f}	188.20^{f}	285.13^{f}	138.07^{e}	386.96^{f}	143.25^{f}	242.77^{f}	227.19^{ef}	19.41^{e}	64.08^{f}
T10	MGD x ALR1 hybrid	350.18^{bc}	225.69^{bc}	342.44^{bc}	156.17^{c}	461.97^{bc}	171.22^{bc}	291.64^{bc}	247.97^{d}	23.05^{c}	70.39^{bc}
T11	KTD x ALR1 hybrid	303.00^{f}	195.56^{f}	296.77^{f}	144.71^{d}	401.10^{f}	148.4^{f}	252.91^{f}	219.72^{f}	20.14^{e}	67.18^{de}
T12	VHC 2 hybrid (Check)	320.88^{e}	206.00^{e}	312.83^{e}	143.08^{de}	422.57^{e}	156.68^{e}	266.98^{e}	232.59^{e}	21.03^{d}	65.93^{ef}
Mean		**311.91**	**200.72**	**304.25**	**148.51**	**411.61**	**152.86**	**259.55**	**236.39**	**20.99**	**67.83**
S.Ed		3.27	2.51	3.92	1.63	4.48	2.09	2.74	2.42	0.43	0.53
CD (P=0.05)		*9.84*	*7.58*	*11.84*	*4.92*	*13.51*	*6.33*	*8.26*	*7.35*	*1.32*	*1.65*

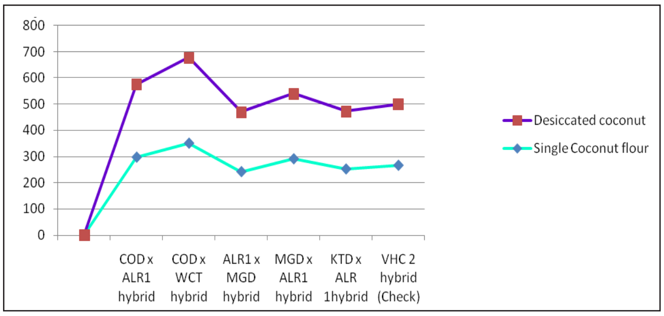


Figure 3. Single coconut flour weight and desiccated coconut weight of hybruds

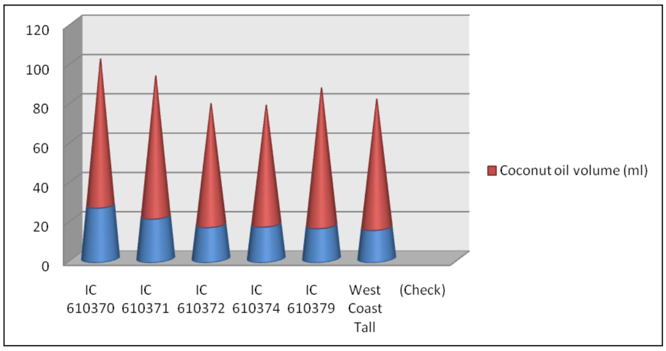


Figure 4. Virgin coconut oil and coconut oil yield of genotypes

maximum number of nuts per bunch. These genotypes also showed maximum values for nut yield. Ninan et al., (1961) and Patil et al., (1993) also recorded a maximum number of nuts per bunch with high yield in Laccadive Ordinary. In the selection program, due emphasis should be given to this character as it leads to an increase in the production of the number of nuts per palm (Abeywardena and Mathew, 1980).

Ramanathan et al., (1992) and Patil et al., (1993) reported that the genotypes having maximum value for dehusked nut weight also showed maximum value for kernel weight and shell weight. They reported that this character was desirable and directly related to the copra content of a nut.

The maximum number of nut yields may be due to the increased production of inflorescence per palm per year and the number of functional leaves per year which might have contributed to higher photosynthetic accumulation towards the reproductive phase. Higher copra content might be due to the higher yield and higher kernel weight. Jayabose et al.,

Plate-1 Dehusked coconut

Plate-2 Tender coconut water

Plate-3 Matured coconut water

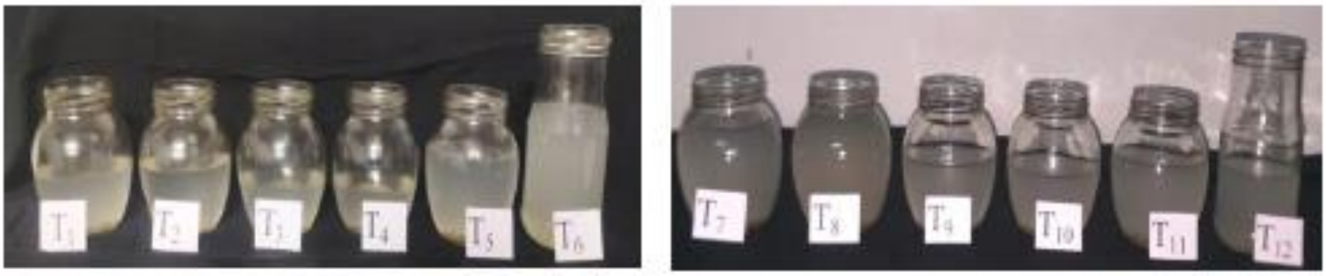
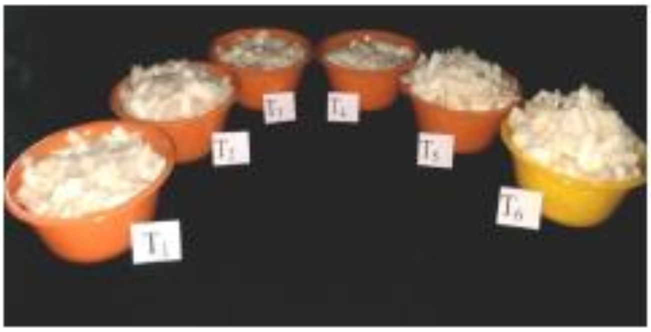


Plate-4 Peeled Kernel (White meat)

Plate-5 Chopped Kernel



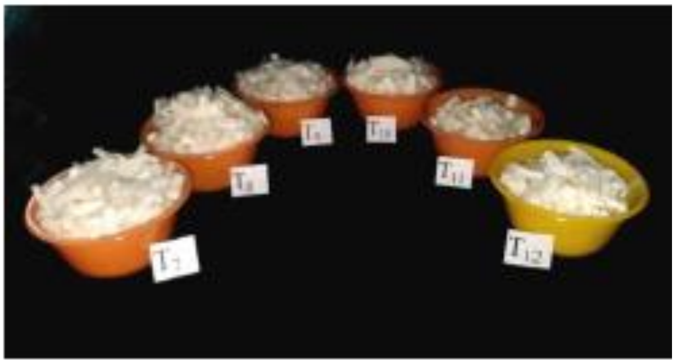
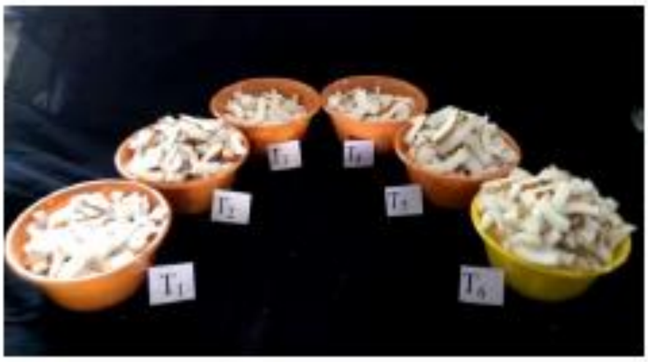


Plate-6 Chopped Copra



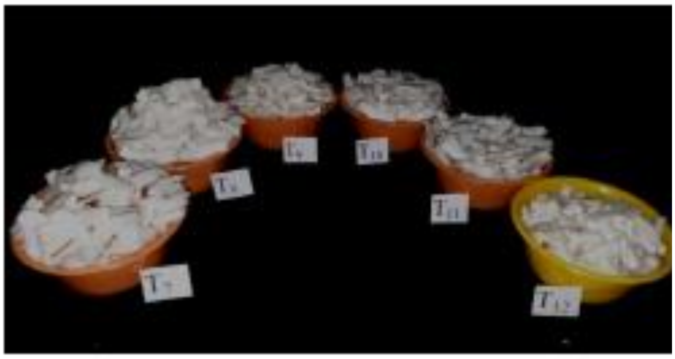


Plate-7 Coconut milk

Plate-8 Coconut cream

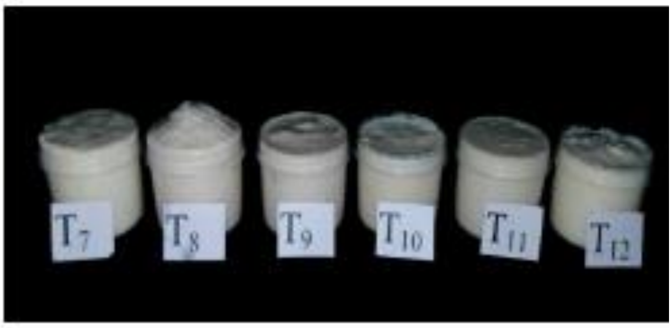


Plate-9 Coconut flour

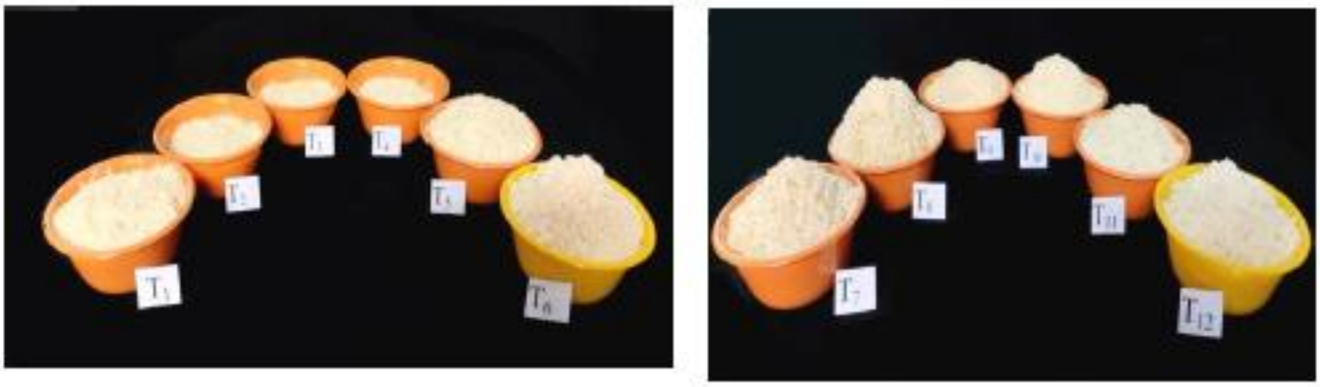


Plate-10 Desiccated coconut

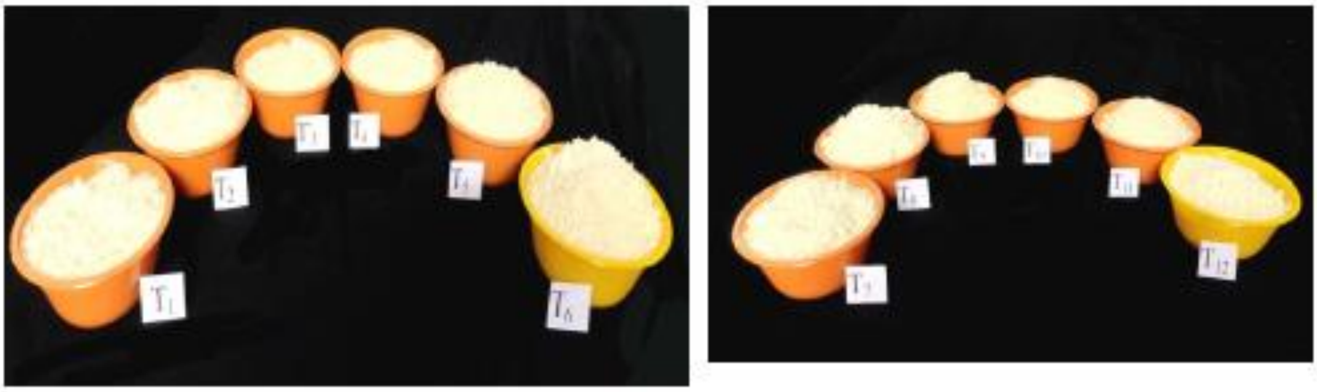


Plate-11 Virgin coconut oil

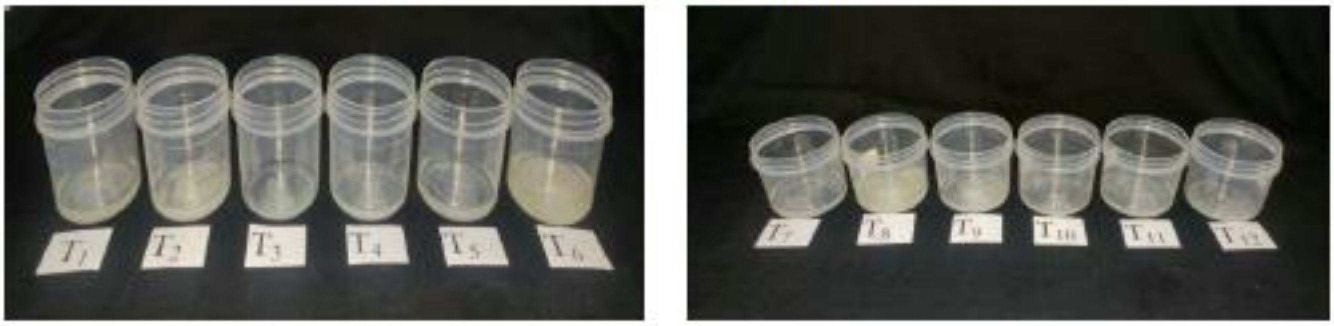
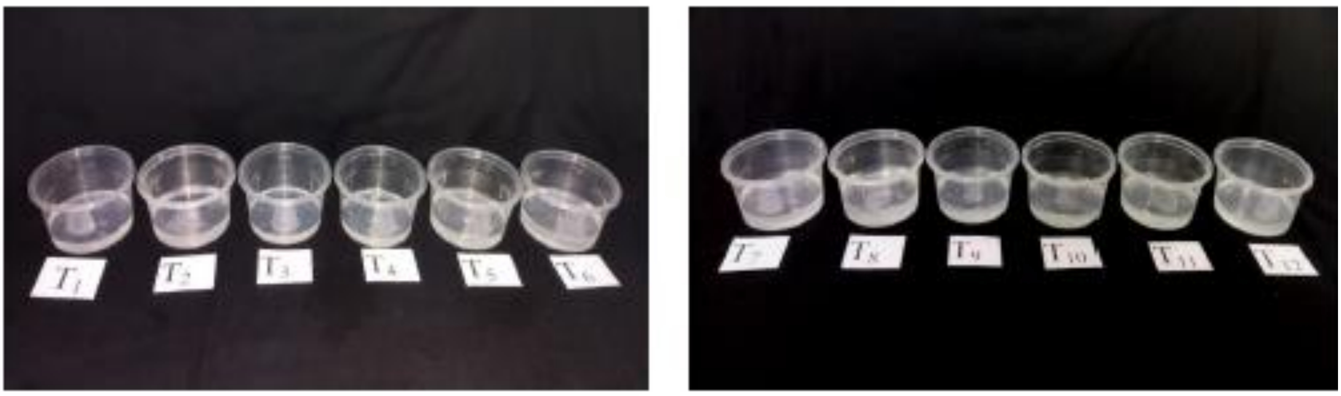


Plate-12 Coconut oil



(2008) reported that among ten coconut tall cultivars, Cochin China Tall (CCT) showed a high kernel weight followed by Philippines Ordinary Tall (PHOT) and the results agreed with Jerard (2002); Suchitra (2014); Ramanandam et al., (2017), and Tripura et al., (2018).

A wide range of variation is reported for oil and copra content in different countries as it depends upon the stage of maturity and place of origin etc (Suchithra and Paramaguru, 2019).

As shown by the yield data, the coconut hybrids provided higher nut yields compared to other genotypes, which may be attributed to the higher yield potential of the hybrids due to their hybrid vigor. Indian coconut cultivar populations show tremendous diversity as they have been cultivated for many years. It is well known that a cultivar's performance on a site is a function of its genotype and environment. Therefore, performance varies under different agroclimatic conditions.

Bai and George (2002) reported that the total nut production per se cannot be considered an important criterion in breeding programs, and the partitioning of total dry matter (TDM) towards the economic yield in terms of copra content serves as a basic selection parameter in assessing the production potential of the palms. Geethanjali et al., (2014) also reported that a balanced weightage should be given for the traits, *viz.*, number of nuts and copra content in the selection criteria for elite coconut palms, since these traits are important yardsticks in determining the yield performance of coconut genotypes.

High nut yield, high copra content and high oil content have all been important factors in choosing genotypes for use as parents in hybridization programs or for direct use as varieties. For coconut-based enterprises to remain viable, copra output is a critical yield quality. Regardless of the size of the nuts, handling, counting, husking, cracking, or shelling costs account for about 80% of the manufacturing costs (Ranasinghe, 1997). Geethanjali et al. (2014) reported that because more nuts are required to give the requisite amount of copra or oil, a genotype with a high nut yield but small size and low copra content per nut may not be economically viable. The production cost goes up as a result.

Coconut water can quickly replenish the water and minerals lost by the human body due to its detoxifying and electrolyte-balancing properties hence considered a natural injection (Zhang, 2011). The processing and utilization of coconuts in various forms are highly valued. At present it is well known that the level of coconut processing and value addition is relatively enhanced, with coconut juice, coconut milk, coconut flower juice, coconut wine, coconut flour, virgin coconut oil and other processed products and by-products preferred and trusted by an increasing number of consumers (Xia et al., 2007; Zhang, 2011). Maravilla (1975) and Maravilla and Magat (1993) highlighted several factors such as the age of palms, climate, phenotypic yield group and mineral nutrition of palms are major contributing characters to various yield levels of coconut products.

Conclusion

The results of the present study revealed that the genotype IC 610370 and the cross-combination COD x WCT recorded maximum values for all the recorded traits. Followed by the genotype IC 610371 and the hybrid COD x ALR1 showed better performance for the recorded traits.

The yield of coconut products depends on the potential of the genotypes on nutrient uptake, transport, assimilation, storage, remobilization and synthesis of storage compounds. Hence the genotypes IC 610370 and IC 610371 and the hybrids COD x WCT and COD x ALR1 recorded maximum values for the observed traits, they could be given priority to promote them for variety release and commercial cultivation.

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