MORPHOLOGICAL EVALUATION OF CONSERVED COCONUT GERMPLASM IN MARDI JERANGAU

Sentoor Kumeran Govindasamy
Program Pembaikbakaan Tanaman Industri (IC1),
Pusat Penyelidikan Tanaman Industri (IC)
MARDI Bagan Datuk, Sungai Sumun, Perak
Email: sentoor@mardi.gov.my

Muhammad Azwan B Azmi
Program Pembaikbakaan Tanaman Industri (IC1),
Pusat Penyelidikan Tanaman Industri (IC)
MARDI Bagan Datuk, Sungai Sumun, Perak

ABSTRACT

Coconut is the fourth most important crop in Malaysia after oil palm, rice and rubber in the year 2017. Malaysian coconut industries highly dependable to coconut sourced from neighbouring countries mainly from Indonesia for raw material. There are many tall and dwarf coconut accessions present in the country. Germplasm collections from different geographical locations can be a great source of genetic material for crop improvements especially for perennials like coconut. In this study, coconut ecotypes originating from Malayan Tall and Malayan Dwarfs coconuts were collected from the east coast of the Malaysian peninsular and Bagan Datuk area in the west coast of the peninsular and were planted in MARDI Jerangau. Morphological characters of leaf, stem and flower were observed in this study to measure the genetic diversity among the ecotypes present in the ex situ conserved coconut germplasm. 11 accessions of tall and dwarf coconut were planted in MARDI Jerangau with three replications for morphological observations. The palms were 20 years of age. The soil type in MARDI Jerangau is sandy clay and all the palms are rain fed. All the data was analysed using SAS software for mean and ANOVA computation. Among 18 plant morphological observation studied, only stalk girth observation did not show any significant difference and leaflet width showed significant different at P=0.05 while the other 16 morphological characters showed significant differences at P=0.01 in all the 11 accessions studied. Eight accessions were observed to have normal type of flower morphology while 3 accessions had spicata type flower morphology. Three accessions exhibit brown-coloured fruits (Teladas, Seberang Tayor, Kerteh) while rest of the accessions except for MYD exhibit green fruiting colour. In this study, accessions showed diversified morphological observations increasing the genetic pool of coconut germplasm collections in Malaysia.

Keywords: coconut, germplasm, MARDI Jerangau, spicata

INTRODUCTION

Coconut is the fourth most important crop in Malaysia after oil palm, rice and rubber in the year 2017. Malaysian coconut industries highly dependable to coconut sourced from neighbouring countries mainly from Indonesia for raw material. Low availability of hybrids and good yielding inbred coconut seedlings often dampen the country's coconut productivity. There are many tall and dwarf coconut accessions present in the country. The indigenous Malayan Tall and Malayan Dwarf were planted in estates and small holders since pre independence period till now. Germplasm collections of these accessions were conserved in government and non-government coconut research establishment such as MARDI, Department of Agriculture and United Plantations (M) Bhd. Germplasm collections from different geographical locations can be a great source of genetic material for crop improvements especially for perennials like coconut (Perera *et al*, 2009). Nuts collected from *in-situ* locations when planted with proper coconut management systems in ex situ conserved germplasm location will yield its true nature of its morphology and its potential yield compared to plants in its original locations caused by improper care and management. The palm morphology observations latter can be utilized for characterizations and its yield observation hence used in breeding programmes or seedling productions for farmer's use.

The Malayan Tall (MT) consists of the normal and spicata type in Malaysia. It is a highly heterogenous type which exhibit large variation in fruit colour and size. The typical copra yield of MT is between 3 to 3.75 t of copra/ha/year (Vanialingam *et al*, 1980). There are mainly four local types of dwarfs in Malaysia, Malayan Yellow Dwarf (MYD), Malayan Red Dwarf (MRD), Malayan Green Dwarf (MGD) and Malayan Brown Dwarf (MBD). They are homozygous plant with distinct smaller fruits than tall types and mostly self-pollinating plants (Thomas *et al*, 2015). Due to farmers selection and breeding many different ecotypes may present in these long-cultivated MT and Malayan Dwarf varieties according to geographical conditions and may yield different morphological characters and yield of nuts (Samsudeen *et al*, 2015).

In this study, ecotypes originating from MT and Malayan Dwarfs were collected from the east coast of the Malaysian peninsular and Bagan Datuk area in the west coast of the peninsular. Morphological characters of leaf, stem and flower were observed in this study to measure the genetic diversity among the ecotypes present in the *ex-situ* conserved coconut germplasm.

MATERIALS AND METHODS

11 accessions of tall and dwarf coconut were planted in MARDI Jerangau with three replications for morphological observations. The palms were 20 years of age. The soil type in MARDI Jerangau is sandy clay and all the palms are rain fed. The ecotypes name, type, location of collection and source of collection is given in Table 1. All the palms had reached yield stability and free from pest and disease problems. However in this paper only the morphological characters are taken for observations. The palms have been managed under good agronomic practices with optimal fertilizer application. 24 morphological observations were made on all the palms in this study as suggested by Descriptors for coconut handbook. The stem observations were (1) Girth at 20 cm above soil level, (2) Girth at 1.5 m height, (3) stem height (metre), (4) bole type and (5) length of 10 leaf scars (cm). The leaf observations were (6) colour of petiole, (7) petiole length (cm), (8) petiole thickness (cm), (9) petiole width (cm), (10) rachis length (cm), (11) numbers of leaflets, (12) leaflet length (cm) and (13) leaflet width (cm). The 14th leaf was used for leaf data recording. The inflorescence observations were (15) inflorescence type (normal or spicata), (16) length of central axis (cm), (17) length of stalk (cm), (18) stalk girth (cm), (19) number of spikelets with female flowers, (20) number of spikelets without female flowers, (21) length of spikelets (cm) and (22) total number of spikelets. An additional observation of occurrence of stem bold and fruit colour were also recorded. All the data was analysed using SAS software for mean and ANOVA computation.

RESULTS AND DISCUSSIONS

There are three dwarf and eight tall types in MARDI Jerangau germplasm plot. Among the eight tall palms, three accessions exhibit spicata type inflorescence morphology while rest of the tall accessions have normal inflorescence morphology (Table 1). MYD is the only genotype with yellow petiole and yellow coloured fruit. The KBD and STBD have brown coloured fruit with yellowish green coloured petioles. The tall genotypes produced green coloured fruit with green coloured petioles. Bole in coconuts are usually found in tall types and some hybrids but rarely in dwarfs (Perera *et al*, 2016). In this study, all the MYD palms did not show any bole in their stem but KBD and STBD showed the presence of low bold in their stem (Table 1). Chan *et al* in 2006 suggested that some dwarf coconuts having dwarf characters can have bole and classified as intermediate type such as Niu Leka. Kamaral *et al* in 2016 also identified yellow dwarf coconut with root bole in Sri Lanka and classified it as semi tall yellow dwarf (SLYST). HMHP had a mix of low and high bole in their stems while the Bawang genotype had a mix of no bole (20%), low bole (50%) and high bole (30%). Gelugor and NB had 100% high bole while Teladas, NPP and ND had 100% low bole in their respective trunks. RTP also had a mixture of 53% of low bole palms and 46% of high bole palms as shown in Table 1.

Table 1: List of coconut genotypes and physical characters in MARDI Jerangau

No	Ecotype name	Variety type	Inflorescence type	Collection area	Source of collection	Petiole colour	Fruit colour	Bole occurrence (%)		
								0	3	7
1.	Malayan Yellow Dwarf (MYD)	Dwarf	Normal	Bagan Datuk	MARDI	Yellow	Yellow	100		
2.	Kerteh Brown Dwarf (KBD)	Dwarf	Normal	East Coast	Farmer's field	Yellowish Green	Brown		100	
3.	Seberang Tayor Brown Dwarf (STBD)	Dwarf	Normal	East Coast	Farmer's field	Yellowish Green	Brown		100	
4.	Hijau MHP (HMHP)	Tall	Normal	Bagan Datuk	MARDI	Green	Green		50	50
5.	Bawang	Tall	Normal	East Coast	Farmer's field	Green	Green	20	50	30
6.	Gelugor	Tall	Normal	East Coast	Farmer's field	Green	Green			100
7.	Ringan Telaga Papan (RTP)	Tall	Normal	East Coast	Farmer's field	Green	Green		53	46
8.	Teladas	Tall	Normal	East Coast	Farmer's field	Green	Green		100	
9.	Nipah Pasir Puteh (NPP)	Tall	spicata	East Coast	Farmer's field	Green	Green		100	
10.	Nipah Besut (NB)	Tall	spicata	East Coast	Farmer's field	Green	Green			100
11.	Nipah Dungun (ND)	Tall	spicata	East Coast	Farmer's field	Green	Green		100	

Notes: no bole (0), low bole (3) and high bole (7)

Among 18 plant morphological observation studied, only stalk girth observation did not show any significant difference and leaflet width showed significant different at P=0.05 while the other 16 morphological characters showed significant differences at P=0.01 in all the 11 accessions studied (Table 2 and 3). However, in a study conducted by Singh *et al* (2021), indicated there is a significant difference among 13 local coconut genotypes in terms of stalk girth of coconut spadix. Pandin, D.S., (2017) also reported significant differences in stalk girth observation among three local coconut varieties in Indonesia's Lebak region. In MARDI Jerangau although there was a difference in stalk girth measurement when measured (Table 2), the difference is not significant statistically.

On average coconut palm produces 12 leaves per year and maintains a well-developed and functional leaf for a period of three years. In this study, MYD has the highest number of leaves (30.4) compared to tall types. This finding is also reported by Paramaguru *et al* in 2019 which recorded 29.78 numbers of leaves. Mohanalaksmi *et al* (2019) also observed among the genotypes studied, Malayan Yellow Dwarf exhibited high number of leaves per palm (34.68). The lowest number of leaves was recorded in STBD which is a dwarf type coconut. Usually, the tall types have higher number of leaves character compared to dwarfs. However, in this study, the MYD has unusually higher number of leaves. The average number of leaves in tall coconuts in a study in India showed a range of 31-33 leaves (Paramaguru *et al*, 2019). The tall types in this study showed an average of 27 leaves per plant which is less compared to tall palms in that evaluation.

Stem height in this study showed significant difference among the genotypes evaluated. MYD showed the lowest stem height (4.86 m) while RTP had the highest stem height at 10.76m. The tall palms showed much variation in their stem height from 8.36 m to 10.76 m. The dwarfs also showed varied observations in their respective stem height (4.86 m to 8.05 m). Dwarfs palms are usually much shorter in stature compared to tall palms.

Girth at 20 cm and 150 cm from the soil determines the presence of root bole in coconuts. Coconuts palms which have bole in the trunk usually had higher girth size at 20 cm from the soil and lower girth size at 150 cm from the soil. In palms without bole, the both girth size will be almost similar. The highest girth size at 20 cm from the soil was observed in RTP at 170.5 cm, NPP at 170.04 cm and HMHP at 161.81cm. The smallest girth at 20 cm from soil was recorded in NB (102.72 cm). The highest girth size at 150 cm from soil was recorded in MYD (130.43 cm) and lowest in NB (71.83 cm). In this study as in Table 1, genotypes identified as having bole had a difference of girth at 20cm and 150 cm from soil and the sole genotype which does not show bole occurrence was MYD. Table 1 showed a very small difference between the two girth size measurements at 20 cm and 1.5 m from the soil. The MYD in Jerangau also showed heavy type of trunk compared to normal dwarf palms.

Length of ten leave scars in coconut is important to coconut breeders as the shorter the length the leaves are closely compacted thus it is not a fast-growing accession. As the height of coconut after 20 years impose serious problem in harvesting, a slower growing palm would be a beneficial in coconut genetic conservations. In this study, all the dwarfs such as MYD, STBD and KBD had shorter ten leave scar length at 41.78 cm, 42.12 cm and 41.3 cm. This result is expected as dwarfs are slow growing genotypes compared to tall genotypes which in this study exhibit higher 10 scar length such as HMHP (57.34 cm), Bawang (59.87 cm) and Gelugor (58.45 cm) as presented in Table 2. RTP and Teladas are also slow growers compared to tall palms while spicata type genotypes also exhibit slow growth characters.

Petiole length among the genotypes showed significant difference in them and Gelugor Tall had the highest petiole length at 141.71 cm while the shortest petiole was recorded in RTP at 116.17 cm. Gelugor tall also had the highest petiole width at 6.2 cm and the shortest petiole width was recorded in Teladas (3.84 cm). Petiole thickness was also observed in this study, RTP had the thickest petiole at 3.8 cm while thinnest petiole was recorded in KBD and MYD with the value of 2.42 cm and 2.45 cm respectively. It is observed RTP had a thick and short petiole among the genotypes. Petiole length showed significant negative correlation with nut yield in a study conducted F2 coconut populations in India (Namboothiri *et al*, 2007). Thus, having a shorter and thicker petiole promotes better support of coconut fruit bunch preventing the loss of coconut yield thru buckling. RTP is a good genotype for future breeding coconut programmes. RTP also exhibit high petiole width among the genotypes studied (6.06 cm).

Rachis length is an important character in coconut palms as longer rachis provides more leaf surface for photosynthesis process which gives more macronutrients for palms. It is generally noticed tall coconut genotypes have longer rachis compared to dwarf types. In this study, HMHP and Bawang showed high rachis length (425.36 cm and 433.55 cm) as shown in Table 2. MYD and STBD showed lowest rachis length as proposed for dwarf types (305.36 cm and 359.1 cm). Leaflet width and length also plays major role in plant photosynthesis process as it creates more surface area for light entrapment during its functional leaf period on the palm. NB had the highest leaflet width at 7.29 cm and Gelugor had the highest leaflet length (142.36 cm) as shown in Table 2. KBD (3.61 cm) and ND (3.64 cm) showed shortest leaflet width while MYD showed shortest leaflet length at 110.88 cm. This observation is similar to MYD leaflet length observation by Nath *et al* in 2017 in the region of Assam.

Table 2: Performance of 11 coconut genotypes for stems and leaf characters

Accession	Stem height (m)	Girth at 20 cm	Girth at 1.5 m	Length of 10 leaf scars (cm)	Numbers of leaflets	Petiole length (cm)	Petiole width (cm)	Petiole thickness (cm)	Rachis length (cm)	Leaflet width (cm)	Leaflet length (cm)
MYD	4.86 h	139.43 bc	130.38 a	41.78 c	30.4 a	127.23 abcd	4.79 cb	2.45 c	305.36 e	3.82 b	110.88 d
HMHP	9.38 cd	161.81 a	112.2 cb	57.34 ab	27.06 bcd	127.5 abcd	5.49 ab	3.71 ab	425.36 a	4.65 b	122.81 bc
Bawang	10.38 ab	118.66 de	81.87 ef	59.87 a	27.3 bcd	137.99 ab	5.8 a	3.22 abc	433.55 a	5.48 ab	123.37 bc
Gelugor	8.36 ef	127.91 cd	94.36 de	58.45 ab	26.7 cd	141.71 a	6.2 a	3.09 abc	390.94 b	4.23 b	142.36 a
RTP	10.76 a	170.5 a	118.17 abc	44.32 c	26.76 bcd	116.17 d	6.06 a	3.8 a	382.83 bc	4.56 b	120.41 bc
NPP	8.73 bc	170.04 a	115.03 bc	46.27 c	26 d	118.63 cd	3.87 d	2.78 c	318.8 e	3.82 b	118.83 cd

NB	9.79 bc	102.72 e	71.83 f	43 c	28.5 bc	121.3 cd	4.41 cd	2.86 c	365 cd	7.29 a	128.2 b
ND	8.96 de	165.48 a	120.82 ab	48.64 bc	28.6 ab	133.4 abc	4.18 cd	2.48 c	380.4 bcd	3.64 b	16.48 bc
Teladas	9.35 cd	125.75 cd	96.85 d	43.6 c	27.75 bcd	131.35 abc	3.84 d	2.47 c	390.75 b	3.95 b	122.25 bc
STBD	6 g	159.49 ab	104.57 cd	42.12 c	21.6 e	128.68 abcd	4.08 cd	2.9 bc	359.1 d	3.73 b	120.92 bc
KBD	8.05 f	121.8 cde	95.1 de	41.3 c	26.5 d	124.25 bcd	3.85 d	2.42 c	391.25 b	3.61 b	123.9 cb
Mean	8.71	143.48	105.67	50.51	27.29	128.97	5.31	3.14	381.35	4.55	123.79
LSD	0.71	20.53	14.25	9.92	1.85	15.03	0.81	0.82	22.06	2.21	8.67

Note: significant statistical differences among accessions were observed for all the traits.

NPP had the highest length of central axis in coconut flower at 45.27 cm while MYD had the shortest central axis length at 25.96 cm as shown in Table 3. NPP being a spicata genotype possess a longer spadix structure thus giving higher value of length of central axis. However, among the normal flower morphology, HMHP and KBD had the longest length of central axis. Length of stalk was the highest in HMHP genotype (58.58 cm) and lowest was observed in Gelugor (36.28 cm). A study by Nath *et al* in 2017 showed length of central axis as 42.8 cm in MYD planted in Indian ecotype compared to MYD in MARDI Jerangau at 39.41 cm. The stalk lengths were recorded higher than length of central axis in this study among all the genotypes as shown in Table 3.

Stalk girth value in this study did not show any significant difference among the genotypes. The range of observed stalk girth was between 10.16 cm to 12.88 cm with an average mean of 11.14 cm. Number of spikelets with and without female flowers or buttons are traits that determine the yield of coconuts as higher numbers of spikelets with female flowers promotes more fruiting vice versa the higher number of spikelets without female flowers will induce less fruiting in coconuts. The coconut fruit developments are much affected by abortion of nuts during its early stage of maturation. In this study, both of the said traits were significantly different among the genotypes (Table 3). All the spicata type showed higher values of number of spikelet with female flower. Spicata type flower has more female buttons with little male flowers (Perera *et al*, 2008). Compared to normal type flowers, it is well documented fact that spicata type has more buttons than the latter. The buttons in spicata were attached to smaller spikelets in the spadix. Thus in this study, NP, NB and ND have the highest value of number of spikelets with female flowers and the lowest value of spikelets without female flowers as shown in Table 3. NB also had the highest total number of spikelets among the genotypes in MARDI Jerangau. RTP (21.6) and KBD (23.0) had the highest value of number of spikelets with female flowers while STBD inflorescence had the highest spikelets without female flowers at 33.7. HMHP had the longest spikelet length at 44.9 cm while the spicata types NB, NP and ND had the shortest length of spikelets. Tall palms usually will have longer spikelets as it has to bear large sized fruits compared to dwarf which bears smaller fruits. Spicata type flowers even though had many buttons compared to normal type flowers will bear very few fruits due to its lack of male flowers for higher percentage pollination success and short spikelets that don't hold large fruits causing early abortion of fruits.

Table 3: Performance of 11 coconut genotypes for floral characters

Accession	**Length of central axis (cm)**	**Length of stalk (cm)**	**Stalk girth (cm)**	**Number of spikelets with female flowers**	**Number of spikelets without female flowers**	**Total number of spikelet**	**Length of spikelets (cm)**
MYD	25.96 c	39.41 d	11.47 ab	7.3 g	30.3 ab	37.6 e	32.83 c
HMHP	44.49 ab	58.58 a	12.88 a	19.36 cde	24.4 cd	43.7 d	44.9 a
Bawang	26.98 c	41.69 cd	10.16 b	18.16 def	23.33 d	41.23 de	43.47 ab
Gelugor	29.72 c	36.28 d	11.1 ab	16.76 ef	26.06 cd	42.36 d	41.53 ab
RTP	27.44 c	41.86 cd	10.91 ab	21.66 cd	16.8 e	38.46 e	44.27 ab
NPP	45.27 a	51.38 ab	10.45 ab	42.5 b	7.49 f	50.1 c	3.96 d
NB	39.79 b	50.05 b	10.91 ab	51.8 a	6.5 f	58.3 a	4.25 d
ND	39.9 b	48.84 bc	10.3 ab	43.2 b	7.6 f	50.8 bc	4.16 d
Teladas	41.05 ab	51.7 ab	10.55 ab	12.25 f	28.25 bc	40.75 de	42 ab
STBD	44.43 ab	51.53 ab	10.85 ab	15 f	33.7 a	47.7 c	36.46 c
KBD	43.3 ab	50.7 b	9.77 ab	23 c	31 ab	54.25 b	40.95 b
Mean	33.52	45.17	11.14	20.51	22.7	42.98	36.31
LSD	4.99	7.52	ns	3.74	3.9	3.85	3.84

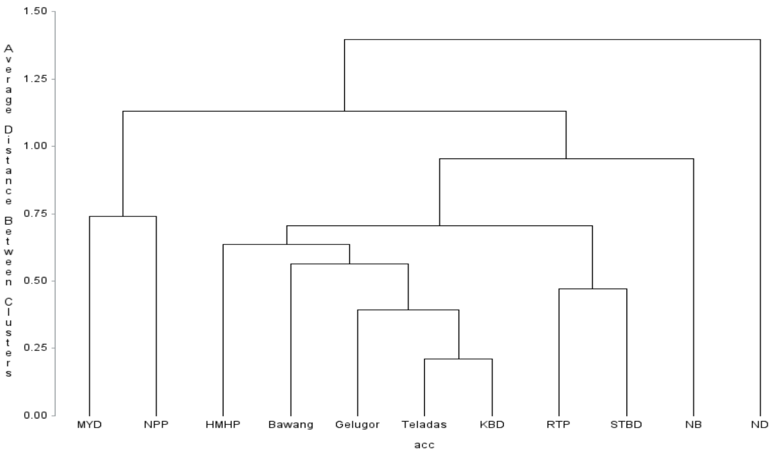
Note: significant statistical differences among accessions were observed for all the traits except for stalk girth which is not significant.

Cluster analysis

18 variables observed in this study using 11 genotypes were analyzed in SAS for Unweighted Paired Group Method Arithmetic Average (UPGMA) for cluster analysis to show similar grouping of genotypes and shown in Figure 1. The dendrogram showed five different grouping or cluster of genotypes in MARDI Jerangau. The first group consist of sole genotype ND, the second group consist of NB, the third grouping consist of RTP and STBD, fourth grouping of HMHP, Bawang, Gelugor, Teladas and KBD while the fifth group consist of MYD and NPP. Similarity in phenotypic traits studied in these genotypes clustered the genotypes in same groups and shows the diversification and genetic distance among them. ND, NB and NPP which even though were spicata

type coconut showed many different phenotypic traits and were genetically were different among them. RTP and STBD were clustered together as many traits were similar while all the tall types were clustered together. KBD being a dwarf was also clustered together with tall which might indicate it has some tall palm phenotypic traits induced by environment interaction. MYD is separated together with NPP showing greater genetic distance between them and tall genotypes. In coconut hybridization programmes, to induce better heterosis effect in hybrid planting material, crossing are done between parental genotypes with increased genetic distance between them (Sarkar *et al*, 2012). In MARDI Jerangau germplasm the genotypes of MYD can be hybridize with RTP or Bawang to produce Dwarf x Tall hybrid seedlings in terms of better vegetative traits.

Fig. 1: Dendrogram using average linkage between the conserved genotypes at MARDI Jerangau



CONCLUSION

Coconut shows many different vegetative and yield trait in their genotypes. Apart from genetics, interaction between environment and human selection had given way to a well-diversified species. To harvest the genetic diversity of coconut for mankind usage, studies are done to understand better the sole species of Arecaceae which is *Cocos nucifera* (coconut). In this study, 11 genotypes of coconut were evaluated for its vegetative morphology diversification in MARDI Jerangau. Among the eighteen stem, leaf and floral observation done, only stalk girth did not show any significant difference between genotypes. There is great diversification present in the morphological characters and cluster analysis showed that the 11 genotypes can clustered in to 5 different groups. This promotes for better conservation and utilization of different coconut genotypes in breeding and production of coconut seedlings.

REFERENCES

1. Perera, S. A. C. N., Ekanayake, G. K., & Attanayake, R. B. (2009). Characterization of conserved coconut germplasm in Sri Lanka with morphological descriptors. *CORD*, *25*(1), 46-53.
2. Vanialingam, T., Khoo, K. T., & Chew, P. S. (1980). Performance of Malayan Dwarf x Tall coconut hybrids in Peninsular Malaysia. *Performance of Malayan Dwarf x Tall coconut hybrids in Peninsular Malaysia.*, 532-542.
3. Thomas, R. J., Rajesh, M. K., Jacob, P. M., Jose, M., & Nair, R. V. (2015). Studies on genetic uniformity of Chowghat Green Dwarf and Malayan Green Dwarf varieties of coconut using molecular and morphometric methods. Journal of Plantation Crops, 43(2): 89-96
4. Samsudeen, K., Thamban, C., Niral, V., Jerard, B. A., Rajesh, M. K., Manjula, C., & Karun, A. (2013). In situ approach for rapid characterization to aid on farm conservation of coconut germplasm-A case study of two ecotypes from West coast of India. Journal of Plantation Crops, 41(3): 357-363
5. International Board for Plant Genetic Resources. (1992). *Descriptors for Coconut, Cocos Nucifera L*. Bioversity International.
6. P. Paramaguru, M. S. (2019). Studies on performance of certain indigenous and exotic coconut genotypes [Cocos nucifera L.]. *Electronic Journal of Plant Breeding*, *10*(2), 899-921. http://www.ejplantbreeding.org/index.php/EJPB/article/view/2843
7. Mohanalakshmi, M., & Arunkumar, K. (2019). Performance of coconut genotypes for yield and nut quality under Coimbatore conditions. *Journal of Pharmacognosy and Phytochemistry*, *8*(2), 2384-2387.
8. Perera, L., Baudouin, L., & Mackay, I. (2016). SSR markers indicate a common origin of self-pollinating dwarf coconut in South-East Asia under domestication. *Scientia Horticulturae*, *211*, 255-262.
9. Chan, E., & Elevitch, C. R. (2006). Cocos nucifera (coconut). *Species profiles for Pacific Island agroforestry*, *2*, 1-27.
10. Kamaral, L. C. J., Perera, S. A. C. N., & Dassanayaka, P. N. (2016). Sri Lanka Yellow Semi Tall; a new addition to the coconut (*Cocos nucifera* L.) classification in Sri Lanka. COCOS. 2 0 1 6 : 22: 4 9 -5 5
11. Singh, L. S., Das, A., Niral, V., & Acharya, G. C. (2020). Study on flowering behavior of some local coconut (Cocos nucifera L.) genotypes under assam condition. *INDIAN JOURNAL OF PLANT GENETIC RESOURCES*, *33*(2), 217-223.
12. PANDIN, D. S. (2017). Inbreeding depression on morphological markers in Mapanget Tall coconut line No. 32. *Buletin Palma*, (36), 30-39.
13. Namboothiri, C. G. N., Niral, V., & Parthasarathy, V. A. (2007). Correlation and path coefficient analysis in the F2 populations in coconut. Indian Journal of Horticulture, 64(4), 450-453.

14. Nath, J. C., Deka, K. K., Saud, B. K., & Maheswarappa, H. P. (2017). Performance of coconut hybrid MYD× WCT in the Brahmaputra valley region of Assam. Indian J. Hort. 74(2), June 2017: 173-177
15. Perera, P. I. P., Wickremasinghe, I. P., & Fernando, W. M. U. (2008). Morphological, cytogenetic and genotypic differences between spicata and ordinary tall coconut (Cocos nucifera L.). *Journal of the National Science Foundation of Sri Lanka*, *36*(1), 103-108.
16. Sarkar, M. D., Choudhury, S., Islam, N., & Islam, M. N. (2012). Morphometric characterization of coconut germplasm conserved at Bari. *International Journal of Sustainable Agriculture*, *4*(3), 52-56.