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MORPHOLOGICAL AND ANATOMICAL STUDIES IN *ARECA CATECHU* LINN. AND *A. TRIANDRA* ROXB.

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Morphological and anatomical variations within as well as between the species are useful for classificatory purposes and breeding desirable forms. Wide morphological variations exist in the cultivated species of *Areca catechu*. This species is also different from the allied *A. triandra* and a general description of these two species has been given by Blatter (1926). Inter-specific variations in *A. catechu* and *A. triandra* and intra-specific variations in the former are reported in this paper.

Materials and Methods

Four varieties of *A. catechu* representing four major arecanut growing tracts of South India, namely, South Kanara and Shimoga Districts of Mysore State, Palghat of Kerala State and Coimbatore of Madras State were selected for the study of intra-specific variation. Observation on *A. triandra* are based on palms maintained at the Museum Gardens, Trivandrum. Morphological characters were recorded in 30 to 50 middle-aged palms selected at random. The characters studied included a number of leaves on the crown, total number of nuts on the tree, average weight of nuts, and length and breadth of ripe nuts.

The epidermal leaf pattern in the varieties of *A. catechu* and *A. triandra* was studied from leaf samples collected from seedlings grown under uniform

TABLE 1 — MORPHOLOGICAL CHARACTERS OF *A. CATECHU* AND *A. TRIANDRA*

	A. CATECHU	*A. TRIANDRA*
Trunk	Single, straight, unbranched, cylindrical, height 12 to 30 m, circumference 50 cm, annulate	Multiple, 7 to 14 offsets at the base, straight, height 3 to 7 m, circumference 18 cm, annulate
Leaves	Pinnate, 7 to 12, 2 to 3 m long, leaf-sheath 86 × 41 cm, leaflets alternate, 40 to 70 pairs	Pinnate, 3 to 7, 1·5 to 2 m long, leaf-sheath 76 × 20 cm, leaflets subalternate, 16 to 20 pairs
Spadix	Infrafoliar, enclosed completely by a boat-shaped spathe, about 65 cm long, much branched with close-set spikes	Infrafoliar, enclosed completely by a boat-shaped spathe, about 30 cm long, branching limited to tertiary
Male flowers	15,000 to 48,000, 0·5 × 0·3 cm, lateral, uniseriate, alternate; perianth 3+3, outer whorl small, inner large, oblong, obtuse, rigid and striated; stamens 6, shortly stalked; pistillode tripartite to the base	9,000 to 12,800, 0·3 cm × 0·1 cm, unilateral in pairs; perianth 3+3, outer whorl minute, inner obtuse, oblong, apex oblique; stamens 3, filaments very short; pistillode simple, terete
Female flowers	0 to 1200, 1·2 × 0·8 cm, solitary or in groups of 2 or 3; perianth 3+3, acrescent, orbiculate, outer whorl cordate, rigid and fleshy, inner ovate; ovary ovoid globular with trifid sessile stigma	0 to 3680, 0·8 × 0·3 cm, solitary, unilateral on secondary peduncle, subtended by two staminate flowers; perianth 3+3, outer whorl smaller than the inner one, inner perianth lanceolate; ovary ovoid with unequally lobed trifid stigma
Fruit	Orange red or scarlet, 4-6 cm × 3-5 cm; kernel 2-4·5 cm × 2-4 cm, surface marked with reticulate veins; endosperm ruminate, opaque white, astringent	Deep orange red or scarlet, 2-3 cm × 0·8-1·5 cm; kernel 1·4 cm × 0·7 cm, surface marked with many parallel veins; endosperm horny, ruminate, less astringent

conditions following Clark's method (1960). Leaf samples were drawn from central portion of the middle leaflet of the third leaf from the base. The correlation between the number of stomata and number of epidermal cells was worked out for each variety. Stomatal Index (I) was arrived at using the formula

$$I = \frac{S}{S + E} \times 100$$

(Salisbury, 1928) where S = number of stomata and E = number of epidermal cells per unit area. Anatomical study of leaf and pericarp (fruit husk) was also undertaken in both the species. Formalin-acetic-alcohol was used for fixation, and free hand sections were stained with safranin and mounted in glycerine.

Morphological Studies

A comparative account of the morphology of *A. catechu* and *A. triandra* is presented in Table 1. It will be seen that *A. catechu* and *A. triandra* differ in a number of characters such as stature, suckering habit, disposition of male and female flowers, number of stamens, etc. (Figs. 1-4).

The various morphological characters of the varieties studied are given in Table 2. This shows significant differences between the varieties in respect of mean number of nuts per palm and mean weight of nuts.

Anatomical Studies

The length and breadth of guard cells, length of stomatal pore, and length and breadth of epidermal cells are given in Table 3. These results indicate that the length of stomatal pore and length and breadth of epidermal cells are highly significant.

The mean number of stomata and epidermal cells per unit area, stomatal

TABLE 2 — MORPHOLOGICAL CHARACTERS OF VARIETIES

Name of variety	Mean No. of leaves per palm	Mean No. of nuts per palm	Mean weight of nuts gm	Mean length of nuts cm	Mean breadth of nuts cm
1. South Kanara	9·80	211·4	38·36	5·25	3·72
2. Shimoga	8·74	369·6	17·45	4·16	3·20
3. Palghat	8·48	162·6	29·57	5·50	3·48
4. Coimbatore	9·08	278·8	22·41	4·67	2·74
S.E. of mean	—	29·29	2·05	—	—
Critical difference (P = 0·05)	—	82·83	4·00	—	—

TABLE 3 — MEASUREMENTS OF STOMATA AND EPIDERMAL CELLS

Name of variety	Stomata			Epidermal cells	
	Guard cells		Stomatal pore		
	*Length μ	*Breadth μ	**Length μ	**Length μ	**Breadth μ
1. South Kanara	28·35	18·73	18·20	44·45	20·30
2. Shimoga	28·00	18·20	18·38	45·68	18·73
3. Palghat	28·18	19·78	20·48	52·15	18·73
4. Coimbatore	30·28	19·25	19·43	56·00	15·75
S.E. of mean	0·556	0·374	0·386	1·98	0·502
C.D. (P = 0·05)	1·57	1·057	1·091	5·60	2·74

*Significant at 5 per cent level of probability.
**Significant at 1 per cent level of probability.

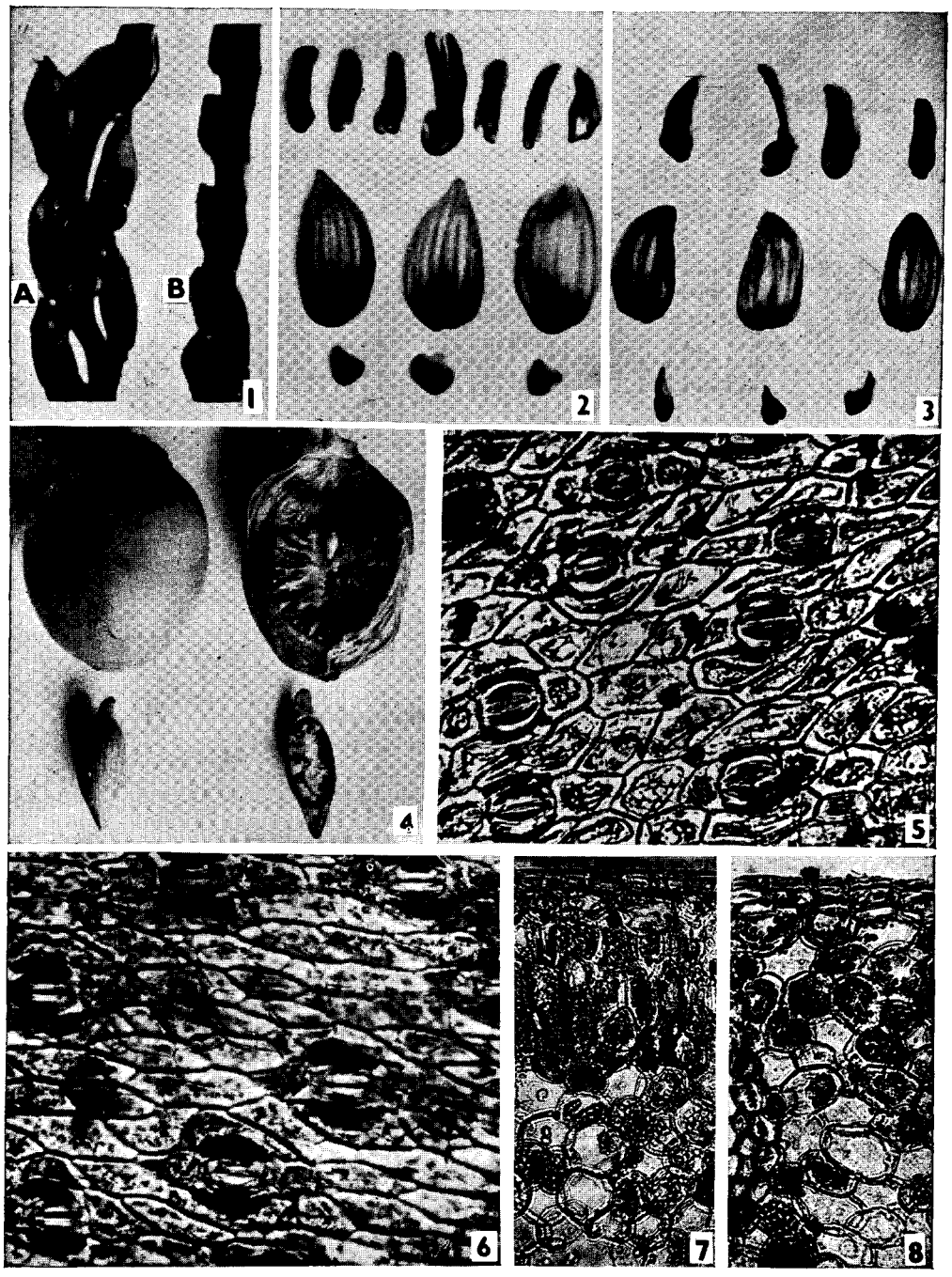
TABLE 4 — STOMATAL INDEX AND CORRELATION CO-EFFICIENT OF NUMBER OF STOMATA AND NUMBER OF EPIDERMAL CELLS

Name of species/variety	No. of stomata/unit area	No. of epidermal cells/unit area	Stomatal index	Correlation co-efficient
Areca catechu				
1. South Kanara	104·20	832·3	11·13	0·9474**
2. Shimoga	58·35	748·6	7·23	0·9148**
3. Palghat	49·95	701·4	6·65	0·6472**
4. Coimbatore	35·85	658·4	5·16	0·6683**
Areca triandra	50·80	591·3	7·91	—

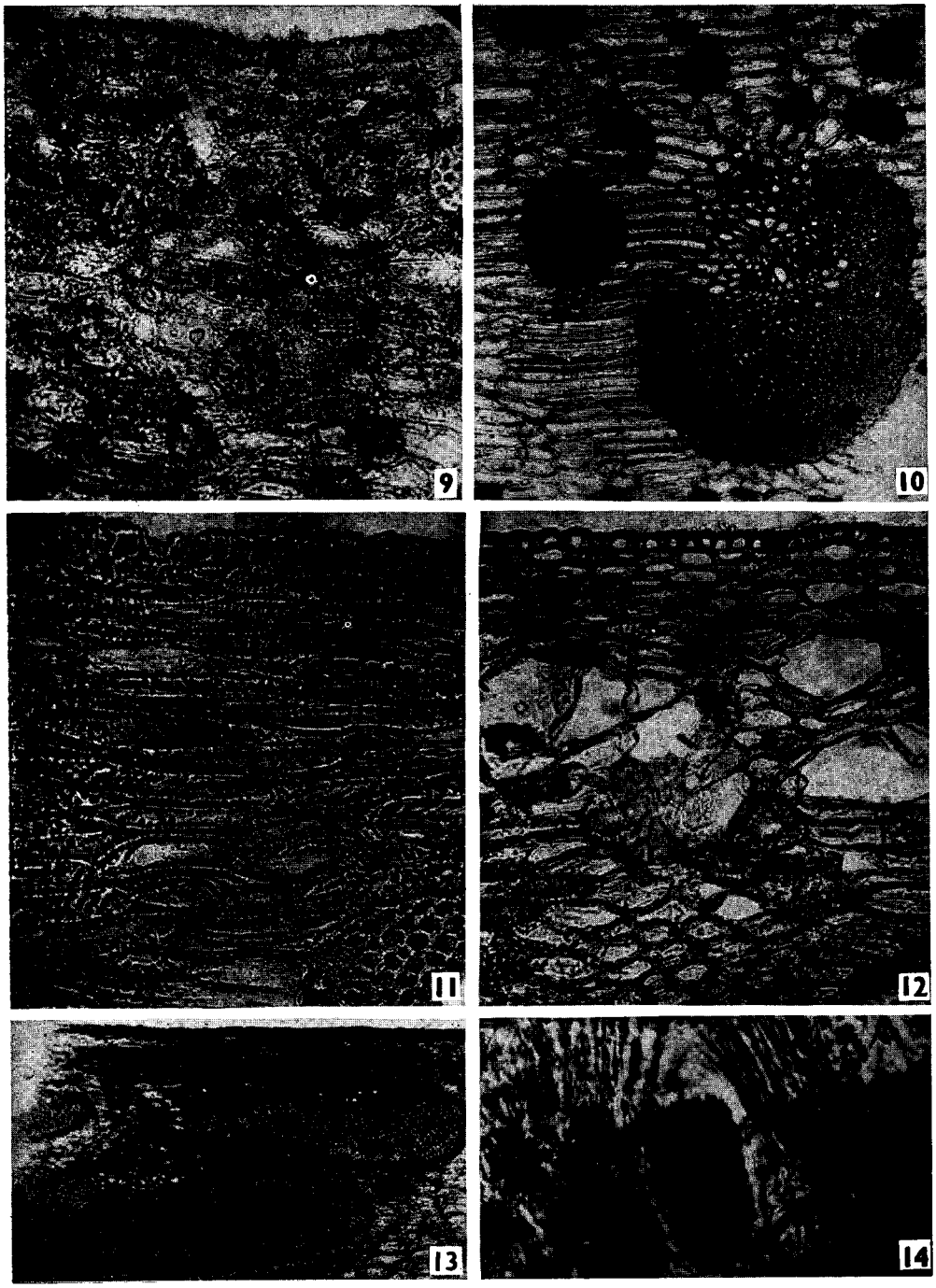
**Significant at 1 per cent level of probability.

→

FIGS. 1-8 — 1A, B. Arrangement of male flowers on filament of inflorescence. A. *Areca catechu*, alternate arrangement. × 4. B. *A. triandra*, unilateral arrangement in pairs. × 4. Fig. 2. *A. catechu*, male flower. × 6. Fig. 3. *A. triandra*, male flower. × 8. Fig. 4. *A. catechu* (top row) and *A. triandra* (bottom row), entire and longitudinal section of nut. × 3/5. Fig. 5. *A. triandra*, stomata and epidermal cells. × 280. Fig. 6. *A. catechu* (" Coimbatore variety "), stomata and epidermal cells. × 350. Fig. 7, 8. Transections of leaf. Fig. 7. *A. catechu*. × 225. Fig. 8. *A. triandra*. × 225.



FIGS. 1-8



FIGS. 9-14 — Figs. 9-11. *Areca catechu*, pericarp. Fig. 9. Exocarp. × 230. Fig. 10. Mesocarp. × 87. Fig. 11. Endocarp. × 230. Figs. 12-14. *A. triandra*, pericarp. Fig. 12. Exocarp. × 225. Fig. 13. Endocarp. × 87. Fig. 14. Raphides. × 450.

Index and correlation co-efficients of the number of stomata and number of epidermal cells of the four varieties of *A. catechu* and that of *A. triandra* are presented in Table 4.

The number of stomata per unit area is greater in the " South Kanara " variety than in others, and in this respect *A. catechu* varieties are distinct from *A. triandra* (Figs. 5, 6).

The correlation between the number of stomata and number of epidermal cells in each variety is also significant. The strength of association of the two characters is about the same in " South Kanara " and " Shimoga " varieties as well as in the " Palghat " and " Coimbatore " varieties.

In *A. catechu* the epidermis on the adaxial and abaxial sides of the lamina is covered by a thin layer of cuticle. On the adaxial side there is an indistinct hypodermal layer. Two or 3 rows of palisade cells and 7 or 8 rows of spongy parenchyma form the ground tissue (Fig. 7). Histologically *A. triandra* leaf is different in that the cuticle is thicker, hypodermal layer is absent, and ground tissue consists of only spongy parenchyma (Fig. 8). The stomatal chambers, in this species, are both large in size and number as compared to *A. catechu*. The parenchyma also shows a higher concentration of chlorophyll.

The thickness of pericarp (fruit husk) in these species varies very widely. In *A. catechu* the mean thickness is 5·2 mm while in *A. triandra* it is only 0·68 mm. In a mature fruit of *A. catechu* three zones of more or less distinct morphology — exocarp, mesocarp and endocarp—can be distinguished while in *A. triandra* only exocarp and endocarp are distinct.

In *A. catechu* the exocarp consists of the epidermis covered by a cuticle, and parenchymatous cells intermixed with stray collenchyma and separate strands (about 9 per unit area) of thin fibers (Fig. 9). The upper 10 to 12 layers of parenchyma contain chloroplasts. The mesocarp, which is a continuation of exocarp is characterized by more or less parallel rows of parenchymatous cells with numerous lignified fibers. Large fibers, about 4 per unit area, occur both as separate strands and as sheaths or bundle caps associated with vascular bundles (Fig. 10). The endocarp consists of highly pitted and elongated parenchymatous cells covered by a thick-walled inner epidermis. The cuticle is also thick (Fig. 11).

The epidermis of the exocarp in *A. triandra* is covered with a thick cuticle. Collenchymatous cells, singly or in groups of 3 or 4, are distributed in the parenchymatous tissue. Two rows of remarkably large-sized cells containing raphides were also observed (Figs. 12, 14). The upper layers of parenchyma are devoid of chloroplasts unlike in *A. catechu*. The endocarp consists of a thick-walled endodermis, a few layers of elongated, sparsely pitted parenchymatous cells, and two rows of vascular bundles associated with fibers. The fibers are broad as compared to those of *A. catechu* (Fig. 13). The parenchymatous cells adjoining the vascular bundles contain chloroplasts.

Summary and Conclusion

There are significant morphological and anatomical differences in *Areca catechu* varieties. As a single character concerning yield, the number of nuts per palm is an important attribute. The number of nuts per palm produced by different varieties differs significantly. Marked difference was also observed in the mean weight of nuts. The number of nuts per palm and mean weight are significantly different between the varieties and can be used as criteria for their identification. Similar quantitative character differences have been used for distinguishing ecotypes of different crop plants. Gregor (1946) reported that in sea-plantain seed size and reproduction potential show specific ecotypic variability. The studies by Anderson (1949) in maize, Bocher (1949) in *Prunella vulgaris* and Harberd (1957) in *Festuca ovina* have yielded similar results.

The varieties of *A. catechu* can also be identified by the number of stomata per unit area. The correlation between the number of stomata and number of epidermal cells per unit area is significant.

and the strength of association is about the same in the " South Kanara " and " Shimoga " varieties on the one hand, and " Palghat " and " Coimbatore " varieties on the other. The stomatal index (number of cells transformed into stomata for every 100 epidermal cells) shows a similar trend, " South Kanara " and " Shimoga " varieties giving higher values than the rest. It may be pointed out that the South Kanara and Shimoga tracts have a higher rainfall. The similarity in the association of the number of stomata and epidermal cells appears to be a physiological adaptation. Extensive studies by Salisbury (1928) on the Woodland Flora of England and Hirano (1931) on *Citrus* also show that climatic factors influence stomatal frequency.

Regarding the size of stomata and epidermal cells, the former does not show any specific variation. The length of stomatal pore and length and breadth of epidermal cells show a uniform variation (*cf.* strength of association between the number of stomata and number of epidermal cells). The decrease in the number of cells per unit area from " South Kanara " to " Coimbatore " variety can be explained by an increase in cell length and the consequent increase in cell size. Investigations concerning morphological differentiation of ecotypes involving a study of one or two separate characters that show geographic regularities of distribution, their inter-relationship through statistical methods, and an intensive study of morphological and physiological characteristics of a relatively small series of samples of the species population (Stebbins, 1950) strongly support the varietal distinctness of the population of *A. catechu* and the possibility of their identification through morphological and anatomical characters. Evidences from cytological studies of these varieties (Bavappa & Raman, 1965) also confirm this contention.

From a study of the differences between ecotypes, both in the wild as well as garden cultures, Turesson (1922, 1925) concluded that each ecotype is a product of selection by its environment. Gregor (1939) has pointed out that the value of ecotypes to the breeder is more likely to lie in their usefulness as a source of material for the production of bred strains than as a direct supply of commercial seed. In the light of these observations there appears to exist considerable scope for synthesizing new strains of *A. catechu* combining characters such as larger number and heavier weight of nuts.

The presence of a thicker cuticle in *A. triandra* is interesting. This relatively hard layer is considered to be effective against infection by parasites (Priestley, 1943). The relative resistance of *A. triandra* against infestation by mites, which is a very serious pest of *A. catechu*, seemes to be due to the presence of thicker cuticle.

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