BULLETIN No. 7

INTRA-SPECIFIC HYBRIDS IN COCONUTS

COCONUT RESEARCH INSTITUTE

April, 1956

COCONUT RESEARCH INSTITUTE (CEYLON)

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20/-

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1. PRELIMINARY REPORT ON CROSSES BETWEEN TYPICA AND NANA VARIETIES

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INTRA-SPECIFIC HYBRIDS IN COCONUTS

I. PRELIMINARY REPORT ON CROSSES BETWEEN TYPICA AND NANA VARIETIES

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INTRODUCTION

Considering that coconut palms (*Cocos nucifera* L) have been cultivated for over a century, the number of available improved strains is relatively small. This has been due to the lack of systematic and sustained breeding work, largely because of the longevity of the life cycle of the palm, difficulties involved in pollination and the absence of any known methods of vegetative propagation. Hitherto, the only method of breeding has been limited to mass selection ; collection of illegitimate seed from selected palms. The current practice is collection of seed-nuts from palms that conform to certain desirable agronomical characters and selection of seedlings before transplantation.

In an out-breeding species like the coconut palm and with a mixed stand composed of both desirable and undesirable types of palms, collection of open-pollinated seed is not a very efficient method unless the pollen parent is controlled. Evidence collected so far, indicates that there are no significant differences in the yield of the progenies, whether open-pollinated seed-nuts are taken from individual high-yielding palms or high-yielding blocks, but that there is a significant response due to selection of seedlings on a basis of early sprouting and vigour (Liyanage, 1953). Besides selection with or without controlling the pollen parent, there is scope for evolving improved strains by hybridisation of selected varieties that exhibit useful characters.

Narayana and John (1949) have listed five varieties of coconuts as follows : the tall type of palm that is commonly grown on a plantation scale has been classified as the variety *typica* and the early bearing dwarf palm as *nana*. Variety *Javanica* is said to

be a true breeding mutant from Java. Two other types have been given varietal status purely because of sex suppression ; *androgena*, the male coconut palm and *spicata*, the female type. There are a number of forms within each variety. These are essentially agricultural varieties and forms. Copeland (1941) has named fourteen types of coconuts found in the Philipine Islands, the two important types being San Ramon and Laguna. Both are tall in habit, the former with large nuts—3,270 nuts to a ton of copra—and the latter with small nuts—6,000 nuts to a ton of copra. The various varieties and forms have a number of characters that are useful for breeding purposes.

Two types of intra-specific hybrids have been described in literature. In the Fiji islands, Malayan dwarf has been crossed with Niu leka. Both parental types are early flowering and short in habit ; Niu leka is sometimes referred to as the Fijian dwarf, which as a group is said to be distinct with the inflorescences differing in many respects from those of the Malayan dwarfs (Marechal, 1928). In the hybrid, Niu leka characters predominate but there is considerable variation between the progenies. Some progenies are high-yielding and have been ' much sought after during the past years ' (Surridge, 1932 ; B.E.V.P., 1953).

A cross between the Indian ' tall ' palm and the dwarf has been described by John and Venkatanarayana (1943). The first generation palms exhibit hybrid vigour and combine the very desirable early flowering nature of the dwarf parent with the economic nut character of the ' tall ' parent.

A programme of hybridisation work was started in 1949 at the Coconut Research Institute (Ceylon), and initially the *typica* and *nana* varieties were chosen as the parent types. The main purpose in crossing these two varieties was to study the first generation progenies in relation to, (*a*) the expression of hybrid vigour, (*b*) the expression of the two useful characters of early flowering and short habit of the dwarf palm and (*c*) the general behaviour of the hybrid palms with a view to economic exploitation.

There are 30 first generation palms derived from crosses involving 9 *typica* and 6 *nana* palms. Seed-nuts were first put down in a nursery and eight-month old seedlings were selected on vigour and transplanted in the field in November, 1950, with a spacing of 28 × 28 feet.

DESCRIPTION OF PARENT PALMS

Typica Variety.—This is the variety of coconut palms grown on a plantation scale in Ceylon for the copra obtained from the endosperm of the nut. The palms thrive over a wide range of soil and climatic conditions and are very hardy being resistant to pests and diseases to a high degree. They remain economically productive for sixty to seventy years under favourable conditions and attain a height of about 40 to 60 feet.

The *typica* palms flower initially in six to eight years after planting, and thereafter inflorescences are produced successively at intervals varying between twenty-five to thirty days. Generally 14 inflorescences are produced in a year. Flowers are unisexual and monoecious (fig. 1) and are cross-fertilized by a timing mechanism ; the male phase precedes the female phase on the same inflorescence. The receptivity of a single female flower lasts about two days and that of the whole inflorescence not more than four to five days (Liyanage, 1949). Nuts are generally round and large, endosperm is thick, giving about 8 ozs. of copra per nut. Copra is of good quality, hard and crisp—with about 68 per cent oil (dry basis).

Altogether nine *typica* palms about fifty years old have been used in the crosses. They have been selected for their desirable vegetative characters, high yield, good size and weight of nut as specified by Peiris (1936).

Nana Variety.—Commonly known as the dwarf variety and thrives mostly on fertile soils with a good distribution of rainfall. The palms do not tolerate marginal or semi-marginal conditions and are very susceptible to drought, pests and diseases. Stems are narrow, short and delicate, and ultimately attain a height of about 20 feet. They do not remain productive for more than thirty years.

The palms flower initially in about three to three and a half years and exhibit periodicity in bearing—yield of nuts is low in alternate years. Flower structure is similar to the *typica* type, but the male and the female phases on the same inflorescence overlap and self-pollination is common. Nuts are small and oval, endosperm is thin with about 3 ozs. copra per nut. Copra is leathery and soft and is generally classified as low grade. Oil content 68 per cent (dry basis).

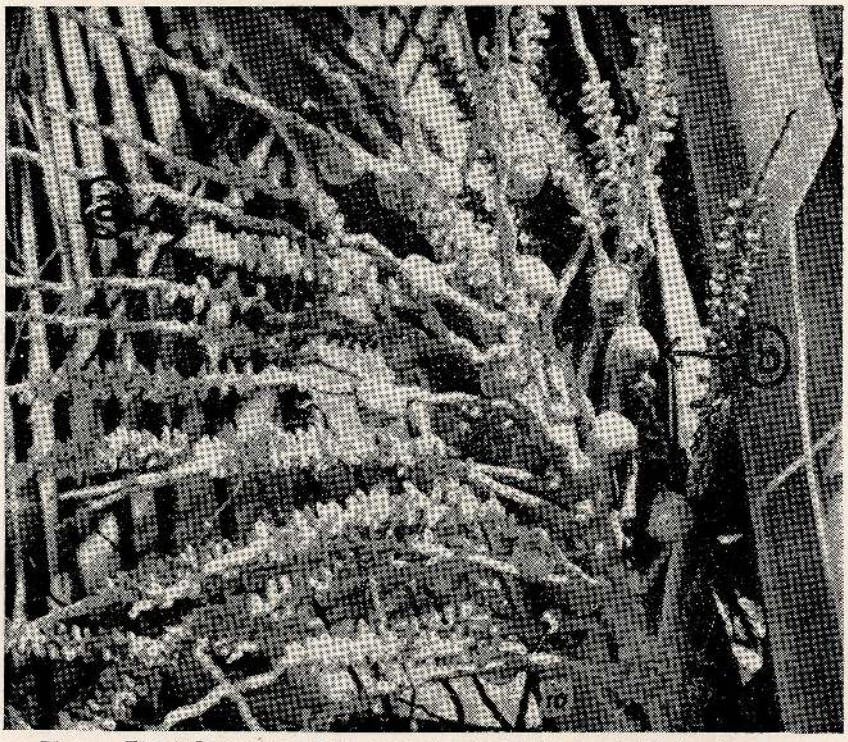

Fig. 1. The inflorescence of a coconut palm (*typica* variety) showing open male flowers (a) and unreceptive female flowers (b).

TECHNIQUE OF POLLINATION

The *typica* inflorescences were emasculated and bagged on the seventeenth day after the opening of the spathe and the female flowers were pollinated on two days, generally between the twenty-second and twenty-fourth days. The *nana* inflorescences were emasculated and bagged on the fifth day after the opening of the spathe and pollinations were done on three alternate days depending on receptivity of the female flowers. Pollinations were done with an insuffalator introduced into the bag through a narrow pouch without removing the bag (fig. 2). The bag was removed on the fourth day after the last date of receptivity. Nuts were ready for harvesting twelve months later.

The best period for collection of pollen was from the third to the eighth day after the opening of an inflorescence. During other times very little pollen was available. The spikelets were cut

above the female flowers preferably in the evenings and were dipped in test tubes containing water, mounted on a stand and left in an inclined position over black cartridge paper. The spikelets were completely covered with a box to prevent contamination with wind-borne pollen. Pollen grains were collected 6 to 12 hours later in vials, plugged with cotton wool and stored in a desiccator with 43.4 per cent sulphuric acid at room temperature (30°C approx.). Pollen grains remain viable for only two days under atmospheric conditions, but it is necessary to be able to keep them for twelve to fifteen days for pollinations. It was found that about 50 per cent of the pollen grains remained viable even on the fifteenth day with storage as described above (Liyanage, 1954).

RESULTS

F_1 Progenies of Typica (female) × Nana (male)

Vegetative Characters.—Measurements of vegetative characters recorded in November, 1954, i.e. at the end of the fourth year are given in Table I. The measurements of the respective parents at that age are not available, instead, for comparative purposes those of parental types of identical age grown under the same environmental conditions are presented.

TABLE I

Mean leaf number and girth of stem per palm.

	Typica	F_1 *of typica* × *nana*	*Nana*
Number of leaves produced during the fourth year	11.7 ± 2.21	15.8 ± 0.83	13.4 ± 1.49
Girth of stem in feet measured 6 inches above ground	4.8 ± 0.50	5.4 ± 0.25	2.8 ± 0.35

Leaf production was highest in the F_1 progenies and the differences with either of the parental types were significant at the 5 per cent level. This extra velocity of leaf production may be due to hybrid vigour.

The stems of *typica* palms are broad, being nearly twice the girth of *nana* palms, and those of the F_1 progenies are like the former parent (figs. 4, 5, 6). The differences in girth of stem between

the F_1 and *nana* are highly significant (P = 0.01) but that between the F_1 and *typica* are not significant. Thus in the early stages of growth, the F_1 palms combine the higher rate of leaf production character of the *nana* variety and the broad stem formation character of the *typica*. If these characters are retained in subsequent growth they will be of considerable economic importance.

Fig. 2. 'Pollinator' at work on the crown of a coconut palm. Note pollen being introduced into the bag with an insuffalator (A).

Breeding System.—As previously stated the *typica* palms are largely cross-fertilised with a timing mechanism. The male phase precedes the female phase on the same inflorescence, and when the next inflorescence opens the receptivity of the female flowers of the previous inflorescence is over. The only exception to this rule is that certain young and vigorously growing palms throw out inflorescences more frequently during certain seasons than more mature palms ; hence interspadix pollination is possible. In the *nana* variety the male and the female phases of the same

inflorescence overlap so that considerable in-breeding can occur. In the F_1 progenies of *typica* × *nana*, the out-breeding system of the former parent is completely dominant ; the female flowers are receptive only a day or two after the male flowers have fallen. However, due to the extra vigour of these progenies in leaf production (Table 1), inflorescences are produced at shorter intervals—one every twenty-three days—so that selfing can occur due to over-lapping of the female phase of the older open inflorescence with the male phase of the younger inflorescence.

The duration of the various floral phases are illustrated in figure 3. In the preparation of this figure, averages have been considered from 60 inflorescences taken from five palms within each category.

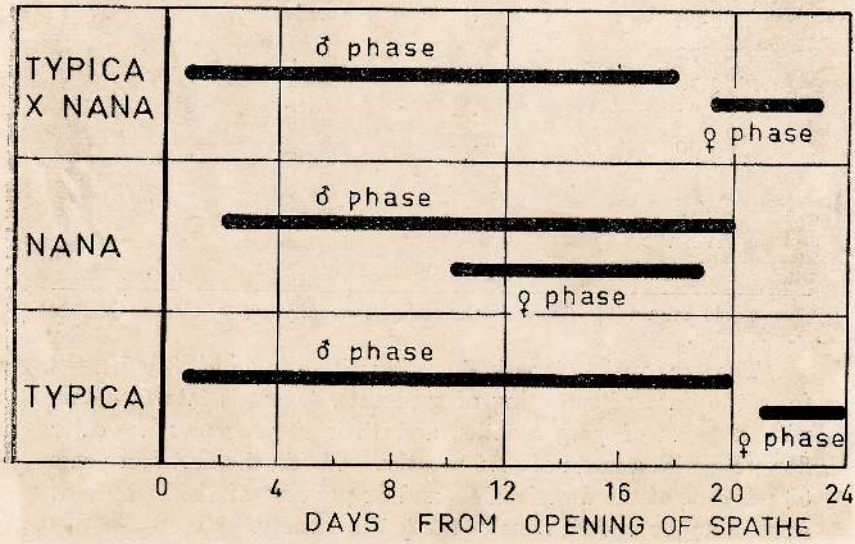

Fig. 3. The duration of male (♂) and female (♀) phases in *typica*, *nana* and *typica* × *nana* palms.

Bearing Age.—The two parental types differ widely in this aspect : *typica* is late-flowering and *nana* is early-flowering. The frequency distribution of the flowering age of these two varieties and of their hybrids is given in Table 2. The flowering-age has been calculated as the period from the date of sprouting of seed-nut to the date of emergence of the first inflorescence. Since most of the *typica* palms grown with the hybrids are not in flower yet, the data relating to these palms have been taken from an adjacent block with the same soil conditions, but planted earlier.

TABLE II

Frequency distribution of flowering-age of palms.

Flowering age (months)	*Frequency Distribution*		
	Nana variety	*Typica variety*	*F_1 of Typica × Nana**
31-36	10	—	—
37-42	4	—	1
43-48	1	—	13
49-54	1	1	4
55-60	1	—	3
61-66	—	3	1
67-72	—	3	—
73-78	—	1	—
79-84	—	5	—
85-90	—	3	—
Total	17	16	22
Average (months)	38.0	74.3	48.6

* One palm not in flower at the end of the 5th year.

The *nana* variety is early flowering with a mean of 38.0 months from the date of sprouting of seed-nuts, *typica* is late flowering with a mean of 74.3 months, and their F_1 progenies are early flowering with a mean of 48.6 months. Within the first four years 88 per cent of the dwarf palms and 61 per cent of the F_1 hybrids were in flower against none of the *typica* variety.

One serious disadvantage with the dwarf palm grown under Ceylon conditions is that there is a periodicity in flower production ; after 10 to 12 inflorescences have been formed, the palms generally rest for about six months. In the *typica* palms generally there is no such resting period. Fortunately, in the hybrid palms flower initiation has been regular so far, without the resting period associated with the dwarf parent.

Yield of Nuts.—Nuts were ripe and ready for harvesting approximately eleven months after the fertilization of female flowers. Most of the palms flowered in the latter half of 1954 and not more than 4 to 6 bunches were harvested the following year. Consequently,

it is premature to consider the yield of nuts and copra at this stage. However, some useful data have been collected regarding size and weight of nuts and the quality of copra of the first generation palms of *typica* × *nana* and they are presented below.

Mean weight per husked nut	..	1.62 lb.
Number of nuts required per ton of copra	..	4,320
Percentage of Nos. 2 and 3 copra	..	8.3
Mean oil per cent (dry basis)	..	67.1

The above data have been collected from 448 nuts harvested in 1955. In the *typica* palms grown under estate conditions the mean husked-nut weight is 1.5 lb. (approx.) with an out-turn of about 4,600 nuts to a ton of copra.

Dwarf nuts being much smaller require about 8,000 to 11,500 nuts to a ton of copra depending on environment. Dwarfs generally have 20 to 25 per cent low grade copra due to the presence of many leathery halves ; in *typica* copra it is not more than 7.5 per cent. Thus the initial harvests gathered from the hybrid palms compare very favourably with the *typica* palms, with regard to size and weight of nut and quantity and quality of copra. In fact, the nuts of the hybrid palms show an increase in size and weight over *typica*, but as pointed out earlier, it is too early yet to offer any conclusions.

F_1 Progenies of Nana (female) × Typica (male)

Although a number of reciprocal crosses were made, i.e. with the *nana* variety as the female parent, only 7 F_1 progenies are now available, as a severe drought was experienced at the station where the crosses were made and the development of female flowers was arrested. Further, some of the progenies turned out to be purely of the female parent type ; their vegetative characters and breeding system were similar to the dwarf palms. It appears that some contamination of pollen may have occurred at the time of pollination. Consequently, these palms have been rejected from the present analysis. The remaining 7 palms are similar to the hybrids of *typica* × *nana* in vigour, stem and leaf formation, breeding system and size and weight of nut (figs. 6 and 7). The flowering period was eight months more with an average of 56.0 months from date of sprouting of seed-nut, against 48.3 months for the reciprocal cross.

DISCUSSION

General.—The main economic products of the coconut palm are oil, desiccated coconut and fibre. According to world trade, oil is the primary consideration and therefore any breeding programme should aim at getting the maximum quantity of oil from a unit area without altering the output of the other subsidiary products. Since oil is extracted from copra, the quantity of oil per unit area depends on two factors, viz., the oil-content of copra and the yield of copra. Both these factors vary considerably between varieties of palms ; the second factor varies even within forms of a particular variety. Therefore, the yield of oil could be increased by breeding nuts having higher oil content or by increasing the yield of copra per unit area. The latter aspect has been the main theme in the present work as both the parent types have the same oil content—68 per cent (approx.) on a dry basis.

It is premature yet to come to conclusions based on the present material, on the possibilities of economic exploitation of the hybrid palms between the Ceylon *typica* and *nana* varieties as the palms are still too young and their ultimate yield potentialities are not known.

However, their performance in vegetative growth during the first five years has been very satisfactory and compares favourably with the *typica* form with the added advantages of extra vigour and early flowering.

There was an expression in hybrid vigour in vegetative growth during the fourth year (Table 1). Rate of leaf production was significantly higher than in either of the parental types, and this will be an important economic factor if it is maintained in subsequent growth, for in each axil of the leaf there is an inflorescence and consequently more nuts are likely to be harvested yearly.

The F_1 progenies are early flowering like the dwarf palm (Table 2). Within the first four years after planting, 74 per cent of the hybrids were in flower against none from *typica*. The variations in flowering-age between families are indicated in Table 3 and some of these variations, other than those due to environment, may be due to the fact that the flowering-age of *typica* palms used in the original crosses was not known and may have been variable.

TABLE III

Average time taken for initial flowering from date of sprouting of seed-nuts

Cross	No. of F_1 palms	Average flowering-period (months)	Range (months)
Typica × Nana			
139 × 2646	4	47.0	45.4 to 57.2
218 × 1713	5	45.6	42.6 to 47.5
273 × 2646	1	44.9	
360 × 1713	5	50.3	43.8 to 50.2
360 × 1712	5	47.7	45.6 to 50.8

The hybrids do not show two of the marked defects of the dwarf parental type, viz. susceptibility to pests and diseases and periodicity in flower production. Tammers (1955) has recorded that the F_1 progenies between tall and dwarf forms of coconut palms are very homogeneous and do not exhibit the undesirable weakness of the dwarf variety. 'In the isle of Halmaheeira (Indonesia), an estate of dwarfs lost nearly all its pure dwarf types after the first year of production, but the hybrids of which there were a great many proved to be as vigorous as the ordinary coconut'.

Judging by the nuts collected from the F_1 palms during their first year of bearing the yield potentialities of the palms are promising. Confirmatory evidence is available from work done in India. According to John and Venkatanarayana (1943) 'The hybrid progenies (Tall × Dwarf) gave definitely higher initial setting percentage and produced more nuts. These were like the nuts of the tall variety in size, thickness of kernel, quality and out-turn of copra'.

Natural Hybrids.—Natural hybrids of *nana* (female) × *typica* (male) occur in nature. A number of these natural hybrids exist in a ten acre dwarf palm plantation opened in 1939. They can be easily picked out in the field from the dwarf palms due to their extra vigour in growth and the mode of the breeding system. Further they are taller than the dwarfs and the internodal length is intermediate between those of the *typica* and dwarf forms. Their mean yield during the twelfth to fifteenth year after transplantation was 68 nuts per palm per year.

Unlike in the progenies of controlled crosses, there is considerable variation between palms with regard to yield. The dwarf female parent has not been selected and the unknown pollen parent may have been any palm from a mixed stand of *typica* palms in the neighbourhood.

No doubt, a large percentage of variations between these natural hybrids have been due to the variations in parental material. Although these variations may be reduced in controlled crossings by judicious selection of parents, yet some degree of variation is always likely to occur in the F_1 progenies as the *typica* palms are heterogeneous. The performance of these fairly mature natural hybrids indicates that there are possibilities for the economic exploitation of first generation hybrids between *typica* and *nana* palms.

Seed Production.—One of the main difficulties associated with coconut breeding is the absence of any methods of vegetative propagation. In the multiplication of *typica* × *nana* hybrids, seeds have to be derived by hand-pollination which is rather a laborious and expensive process. Further, it may not be possible to meet the entire demand, if large quantities of seed-nuts are required.

A feasible approach to the problem is to have mixed plantings of *typica* and *nana* palms, preferably with an isolation barrier round the entire block to keep out pollen from coconut palms in the neighbourhood. If *typica* (female) × *nana* (male) hybrids are required, the inflorescences of the *typica* palms should be emasculated as soon as the spathes open so that their female flowers would be pollinated only with dwarf pollen, and *vice versa* if hybrids of the reciprocal cross are required.

One advantage of having the *nana* variety as the female parent is that the hybrid seedlings can be easily picked out in the nursery due to their extra vigour relative to the dwarf seedlings, whereas if the *typica* palm is used as female parent, it is not possible to pick out the hybrid seedlings as there are no noticeable differences in vigour between them and the *typica* seedlings.

It may be possible to use male-sterile *typica* palms in the mixed plantations so that the laborious work of emasculation could be eliminated altogether. In natural populations there are two types of male-sterile coconut palms. In one type, the inflorescence is

unbranched and the female flowers are borne on the central axis—this type has been classified as the variety *spicata* (Jacob, 1941). In the other type, the inflorescence is branched, but the spikelets are relatively short and the female flowers are carried on them. Work is in progress in crossing the latter type of male-sterile palm with the *nana* variety.

SUMMARY

This is the first of a series of interim statements on long-range research on breeding in progress at the Institute. The performance of hybrids between *typica* and *nana* varieties of coconut palms during the first five years of growth is described.

The first generation palms have shown hybrid vigour with respect to leaf-production and formation of stem. They are early flowering and do not exhibit periodicity in flower production as does the *nana* parent. The cross-fertilization mechanism of the *typica* parent is completely dominant.

Generally the *typica* characters predominate in the hybrid. Nuts are large and heavy and copra is of good quality.

ACKNOWLEDGEMENTS

My thanks are due to Mr. F. C. Cooke, Director, Coconut Research Institute for encouragement given during various stages of this work, Mr. W. R. N. Nathanael, Chemist, for analysis of oil content of copra and Mr. R. W. Senaratne, Senior Field Assistant for assistance in recording the palms.

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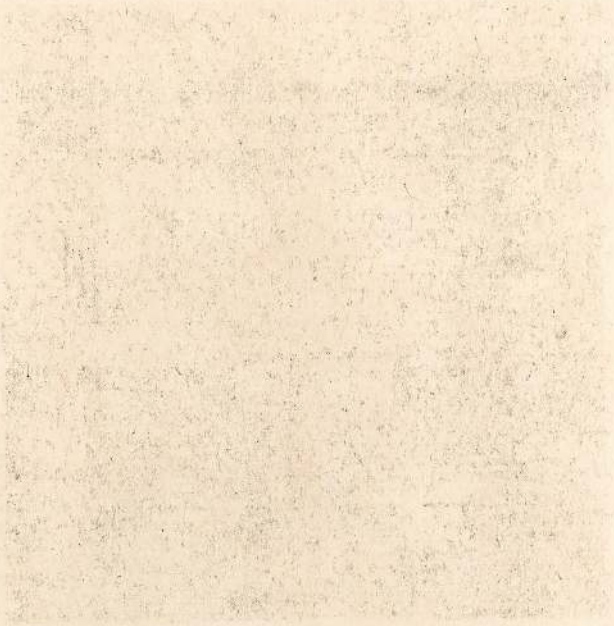
Fig. 4. (× 1/27). A *typica* (tall) variety palm, $4\frac{1}{2}$ years old.

Fig. 5. (× 1/24). A *nana* (dwarf) variety palm, $4\frac{1}{2}$ years old.

Fig. 6. (× 1/27). A first generation palm of *typica* × *nana*, $4\frac{1}{2}$ years old.

Fig. 7. (× 1/27). A first generation palm of *nana* × *typica*, $4\frac{1}{2}$ years old.



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