THE PHILOSOPHY AND STRATEGIES IN COCONUT VARIETAL DEVELOPMENT AND SEED PRODUCTION AT UPLB

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Introduction

The coconut industry plays an important role in the Philippine economy. More than 2.28 million hectares or 21 percent of the total cropland is devoted to coconut, supporting about 1/3 of the population. The industry accounts for about 20 per cent of the country's external earnings and supplies almost 70 per cent of the coconut products traded in the world market.

Coconut productivity in the Philippines is quite satisfactory compared to that of many other countries. However, many of the palms have already reached the senescent stage, hence they need to be replanted. The Philippine government, like others in Asia and the West Indies, has actually launched a replanting program to start in 1980 with the objective of replacing all the present palms within a period of 40 years. This program calls for the massive production of planting materials suitable to the wide range of climatic, edaphic and biotic environments in the country. At this stage, we are still testing a number of materials and strategies.

Previous works and present outlook

1. The coconut farm The present coconut farm in the country averages about 4 hectares and more than 73 per cent of the farms are less than 5 hectares. Coconut is partially intercropped to annuals or perennials, but does not get the benefits of modern inputs like fertilizer, pesticides, irrigation, regular cleaning and tillage. It is tended by a farmer with about 4 years of schooling who usually does other jobs to augment his income from an average production of 1.43 tons of copra per hectare annually. **

Most of the planting materials in the farm are obtained from the neighborhood, usually for free, in exchange for goodwill or other farm products. Seldom, if at all, does the farmer pay in cash for seeds. This is the general custom.

2. Genetic diversity in coconut The Philippines is fortunate in having a large pool of indigenous cultivars of coconut found all over the country. As early as 1668, Alzina mentioned several forms and as of 1918, Wester reported more than 100 varieties, including the widely known 'San Ramon' and 'Laguna' which need only 3.0 to 3.5 and 4 to 5 nuts, respectively, to produce a kilogram of dried meat or copra (David, 1953). An attempt was made (Carlos, 1963) to classify these genetic variabilities into functional groups following partly the systems advanced by John and Narayana (1949) in India and Liyanage (1958) in Sri Lanka. Three varieties, namely *Typica, Javanica* and *Nana* with 11, 1, and 2 forms, respectively, were recognized. Recently, however, more varieties and forms were discovered, including at least ten forms of the *Javanica* variety, two forms of the *Nana,* several of the *Typica,* and three forms of another variety, the *Spicata,* locally known as *Marure* (Anon. 1975). Of special interest to coconut breeders is another variability which bears up to 1,232 instead of 12 to 30 buttons or female flowers per bunch, of which 300 may develop into mature nuts (Carlos & Cuevas, 1976).

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** Based on palms in bearing age only. The national average for 1976 was 1.1 tons, including non-bearing palms.

This resembles the Laccadive Micro of India (John & Narayan, 1949). Named 'Pag-Asa', all the seedlings from a palm surrounded by *Typica* palms produced plenty of buttons.

The *Typica* variety is late-bearing, tall, small to large seeded, and generally cross-pollinating; *Javanica* is early to medium-late, dwarf, small to large seeded, and generally self-pollinating; *Spicata* is like *Javanica* except that it is generally cross-pollinating and it has only 1 or 2 rachillae which bear the male flowers, *Nana* is also like the *Javanica* except that it has small nuts.

3. Heritability of characters Varietal development in a crop like coconut involves so much time, efforts, and resources that an understanding of character heritabilities of the palm will contribute greatly to the direction of activities towards attainment of much needed results without much delay. Fortunately, some data have been evolved in this respect which serve as general guidelines in the activities of the UPLB. They are as follows:

Character	Source	
	Liyanage & Sakai (1961)	IRHO (1966)
Total copra	0.67	0.41*
Earliness to flowering	0.33	–
Number of nuts	0.48	0.29*
Number of bunches	–	0.13*
Copra/nut	0.95	0.72**

* significant; ** highly significant

It is very clear from the data that copra per nut and total copra produced per tree are inherited heavily by the progenies, although number of nuts and number of bunches, which are components of total copra production may also be used to advantage. In this connection, number of leaves have also been found to be highly correlated with number of bunches (Liyanage & Abeywardena, 1958) and productivity of the palm (Fremond et. al, 1966). This is a character which is discerned both in the field and nursery.

4. Performance of hybrids As early as 1923, chance hybrids of coconut between the dwarf and the tall have been observed in India (Personal Com.). Hybrids between the 'Coconino' (*Nana*) and the 'Laguna' (*Typica*) produced in the Philippines by about 1955 (Zuniega, 1973) and 1966 (Romero, 1966) are productive. Earlier, Ceylon also started hybridization (Liyanage, 1956). However, all of the above efforts were not pursued vigorously. Work started in 1966 in the Ivory Coast was more massive and persistent, producing as of 1973 nine year old hybrids between the 'West African Tall' and the 'Yellow Dwarf' which yielded 4.6 tons of copra per hectare per year with heavy manuring (6 kg. fertilizer per tree/year) and artificial irrigation. Unfortunately, these and other hybrids produced by the IRHO in West Africa are susceptible to 2 diseases which can kill up to 61 per cent of the seedlings in the nursery and 63 per cent of field plantings within 3 years from transplanting (Renard *et. al.*, 1976).

5. Varietal development objectives Most coconut producing countries today especially those in Asia, are looking forward to taking advantage of the known heterosis in the palm. Jamaica and Florida (USA) are particularly engaged in developing a variety resistant to lethal yellowing, a serious disease caused by mycoplasma. In Asia, the target is more for early-bearing and high-yielding types. Cadang-cadang disease resistance is another significant breeding objective for the Philippines while a type against the *Sexava* insect may be another goal for Indonesia. Root wilt disease resistance is a significant part of the work in India. In Sri Lanka, tolerance to dry conditions is also sought.

6. Objectives of This Paper This article was prepared to present the philosphy and general strategies of the coconut varietal development and seed production program at the University of the Philippines in Los Banos and to discuss some of the results obtained so far.

Varietal development

Underlying Philosophy

The basic guideline of the breeding program at the university envisions the development of a variety(ies) that is productive under an intermediate level of technology in a wide range of environment and easily available to the average farmer under a system of responsible partnership.

1. Productivity vs level of technology The average coconut farmer in the Philippines can hardly afford to buy modern inputs like fertilizer, pesticides and the like even for the annual crops that he plants under the palms. It is far more difficult to convince him to apply the same inputs to coconut which responds to these technologies within a period of two to three years. Besides, there are data which show that high yields in some hybrids go hand-in-hand with high inputs. Against this background, therefore, a fairly good yielding material under low to intermediate level of technology is the need of the times.

2. Wide adaptability to environments The principle of coconut adaptability had been aptly elaborated by Fremond, *et. al* (1966) with their experiences in the Ivory Coast, thus:

> "It is a fairly general rule that introductions do not perform in their new home as well as the strains long established there. Yield from strains from Mozambique or Polynesia planted at Port Bouet are on the average lower than those local materials while their susceptibility to the *Oryctes* beetle and to fungi is greater... The palms of West Africa may fail to survive in the very moist climate of some places (Cambodia, Thailand etc.)... This is an important principle to consider".

Even local cultivars in the Philippines show variations in their performances under different environments in the country. Some which were planted in the university campus in 1963 failed to produce nuts as satisfactorily as the palms from which they were obtained. Also, some show higher tolerance to drought than others which perform better during the rainy months.

In view of the wealth of coconut germplasm available in the country, the breeding program at the university makes full use of locally available cultivars, to be supplemented only if found necessary later, with desirable foreign cultivars.

3. Availability and acceptability Any improved material in coconut must be appreciated by and within the reach of the average farmer. The 'Laguna'/'Coconino' hybrids produced by the Bureau of Plant Industry and the university in earlier years take 5 nuts/kilogram of copra, which is rather small to the Filipino farmer who currently produces the same amount only from 3 to 4.5 nuts. The same problem holds with the well-publicized 'West African Tall'/ 'Yellow Dwarf' hybrid.

The planting materials must be reasonably cheap so that the farmer can avail of them. Otherwise, the materials may just be for the few large plantations. Furthermore, the choice of planting materials must be left to the farmer himself. After all, he too recognizes what is good and wishes the best for himself, his family, and his community.

General Procedures

1. Gene bank establishment Basic to the approach by the university is the collection of germplasm in the country. A seven-hectare lot was planted to more than 50 cultivars in 1963 and further increased in 1973. To date, a pool of about 65 cultivars is available in about 25 hectares of lots, including a ten hectare area planted to two promising forms of the *Javanica* variety. The Philippines, through the efforts of the university and the Philippine Council for

Agriculture and Resource Research (PCARR), has been chosen as the regional site for the base collections of coconut in Southern Asia by the International Board on Genetic Resources. A proposal to this effort had been made by the university.

2. **Variety trials** Selected forms of the *Typica, Javanica* and *Nana* varieties are currently being tested in replicated lots in at least 3 locations in the country representing dry, wet, and intermediate rainfall patterns. This is being done for the following reasons:

1) To test their adaptability to varying regional, soils, climate and pests;
2) To study their cultural requirements under these environments;
3) To demonstrate which cultivar and culture are best for the areas;

3. **Hybridization and selection** Hybridizations involving *Javanica/Javanica, Typica/Javanica, Typica/Nana,* and *Javanica/Nana* constitute the bulk of the crossing program for specific and general combining ability test. Other crosses like *Typica/Typica, Typica//Typica/Nana,* and *Javanica//Typica/Nana* are also programmed after the primary crosses are accomplished. Hybrids produced in each of these crosses will likewise be tested outside the university in the areas where the field trials for the parental lines are conducted.

4. **Other studies** Basic studies aimed at developing finer techniques in breeding and seed production, including pollen physiology, storage, and dispersal; floral biology of the various dwarf populations, flower abscission and fruit set of parental palms; sampling studies for the different populations; establishment of genetic markers; and nutrition of the different populations are also being conducted with the assistance of our graduate and undergraduate students.

Seed production

Types of Seed to be Produced

As mentioned earlier, precocity and high-yield are the primary targets of the government. Yet, materials included in the initial phase of the field trials by the university consist of promising established forms of the early bearing, medium to large seeded varieties. This is aimed at finding out if any of these stable forms or varieties may already be acceptable to the community. Seednuts from these palms which may be shared with the neighboring farmers, by virtue of their demonstrated merits, will at least be as good as the palms producing them. Worthwhile hybrids, which may subsequently be developed at the university could also be produced with these varieties in trial fields. Good and cheap planting materials adapted to the same physical environments may then be produced by the locality and be made available to small farmers in the surrounding communities.

This strategy fits well into the government policy of self-reliance and suits the Filipino farmer's temperament and tradition. Large private and corporate farms produce the seednuts/seedlings in the Ivory Coast and Malaysia but government agencies are in charge of seednut production in India, Sri Lanka, and Jamaica.

System of Seed Production

Where seedlings of established varieties are used, all the seednuts from such palms may be gathered for planting without any human interference, if the lot is reasonably isolated from other coconut varieties. These writers are not aware of such a seedgarden elsewhere.

The same pure population of mother palms as above may be emasculated for artificial pollination to produce hybrids. Several types of hybrids may be produced with these mother palms by just changing the types of pollen used. The university has at least four areas of such palms. one such area is a 10 hectare lot inside a 4000 hectares of forest.

Other commercial seedgardens for coconut so far are such that male and female parental palms are interplanted at varying ratios. All sorts of combinations ranging from 1:1 to 1:8 were observed in the Ivory Coast (Personal Obs; 1973) and 1:9 in Sri Lanka (Per. Obs., 1977).

Seednuts are gathered from the mother palms which were emasculated at flower opening to insure hybridization. The type of hybrid produced in this system of seednut production is fixed to the progeny of the interplanted parent palms.

Other systems of hybrid seed production do not lend themselves to large scale seednut production due to the cost involved, although, they fit well in breeding and genetics studies.

Some results

Varieties of Coconut

1. Typica There are 25 cultivars of the tall coconuts in the Gene Bank of the university, all of which are of native origin and now in their 14 years of growth (Table 1). They are all late-bearing and cross-pollinating, bearing small to large fruits. Several others are found in the country-side. 'Laguna' and 'San Ramon' dominate all others in terms of extensiveness in cultivation. They produce a kilogram of copra for every 4.5 and 3.0 nuts. Balingasa (1976) reported six others, three of which (Baybay, Bago-Oshiro, Tagnanan) appear better in terms of copra per nut but inferior in terms of copra per hectare when compared to the 'Laguna' (Table 2). Earlier, the 'Laguna' variety produced 4.7 tons of copra with 3 kg. of fertilizer/tree/year.

Table 1. Cultivars of tall coconuts at the UPLB Gene Bank, 1977.

Cultivar	Relative Maturity	Pollination habit	Nut size
San Ramon A	late	cross	large
San Ramon B	late	cross	large
San Ramon C	late	cross	large
San Ramon D	late	cross	large
San Ramon E	late	cross	large
Laguna	late	cross	medium
Limbajon	late	cross	medium
Pula	late	cross	small
Malapon	late	cross	medium
Lupisan	late	cross	large
Makapuno	late	cross	medium
Lupisan	late	cross	large
Makapuno	late	cross	medium
Luno A	late	cross	medium
Luno B	late	cross	medium
Lupog	late	cross	medium
Cuyamis	late	cross	medium
Purikit	late	cross	large
Plicata	late	cross	medium
Lakihan	late	cross	medium
Mestisa	late	cross	medium
Bulao	late	cross	medium
Agta	late	cross	medium
Sangol	late	cross	large
Blanquera	late	cross	medium
Pañgos	late	cross	medium
Negransa	late	cross	small

Source: Carlos, J.T., 1963

Table 2. Some other tall coconut cultivars in the Philippines with their economic characters.

Cultivar	Copra (gm)/nut	Copra (kg.)/palm/yr.	Copra (ton.)/ha.
Bago-Oshiro	213	22.5	3.23
Baybay	288	20.4	2.92
Tagnanan	304	27.4	3.95
Zamboanga	213	14.1	2.02
Bunawan	–	–	–
Laguna	–	31.0	4.43

Source: PCA Annual Report, 1975–1976.

Table 3. Comparative copra content of commercial varieties of coconut in some countries.

Country	Nuts/ton of copra
India	6800
Ivory Coast	6200
Fiji	6000
Papua New Guinea	5500
Sri Lanka	5000
Thailand	5000
Indonesia	4700
Western Samoa	4500
Philippines	4500

Source: Group Report, Philippine Delegation to the International Workshop on Coconut Research and Development. December 26–30, 1976. Kasaragod, India.

Table 4. Forms of the Javanica variety of coconut in the Philippines.

Cultivar	Nut size
Tambolilid *	medium
Conception Green Dwarf *	large
Lanao Green Dwarf *	medium
Marinduque Green Dwarf *	medium
Rabanuel Green Dwarf *	medium
Rabara Green Dwarf *	medium
Golden King/Orange Dwarf *	medium-small
Zamboanga Green Dwarf	medium
Linkuranay	medium-small
Marure A, B, C	medium
Pascual Green Dwarf *	medium
Java Dwarf *	medium-small
JKY *	medium-small
Silver Queen/Yellow Dwarf *	medium-small
Lanipao Green Dwarf	medium-small
Dajili *	medium-small

* Included in the UPLB Gene Bank

Table 5. Nut characters of some selected cultivars of coconut in the Philippines.

Cultivar	Nut volume, cc	Nut/kg copra
Typica variety		
San Ramon (SR)	4688	2.98
Laguna (La)	3600	4.50
Javanica variety		
Rabanuel GD (RL)	2770	4.18
Rabara GD (RA)	3643	4.56
Lanao GD (LG)	2415	4.26
Pascual GD (PG)	3057	3.50
Marinduque GD (MG)	3520	3.77
Java GD (JD)	1308	5.99
Golden King (OD)	1584	5.23
Silver Queen (YD)	1560	6.55
Nana variety		
Coconino (CN)	1110	9.98

The commercial 'Laguna' cultivar compares favorably well with commercial cultivars of other countries. Table 3 shows the national averages in terms of nuts per ton of copra of some coconut producing countries of the world.

2. **Javanica** Eighteen small-to-large seeded, early-bearing cultivars are known in the country (Table 4). Twelve of these are found at the university. It may be noted that while most have medium-sized fruits, some take less fruits to produce a kilogram of copra than the commercial 'Laguna' cultivar, indicating more meat per nut (Table 5). This character is highly heritable.

3. **Nana** Five cultivars of the small-seeded, prolific, and early-bearing variety *Nana* are found in the country. These include 'Coconino', 'Mangipod', 'Mamareng', 'Red Dwarf', and 'Garing'. At present, only the first two are found in the university collection. The rest will be collected soon.

It takes about ten nuts to produce a kilogram of copra from 'Coconino' and 'Mamareng'.

Currently, cultivars of the *Nana* variety are used commercially as ornamentals and as source of fresh nuts for refreshments.

4. **Hybrids** Coconut breeding activities in the Philippines were sporadic. Hybridization started late at the university and the first few ones were concentrated on the delicacy cultivar called 'Macapuno' rather than on the commercial cultivar. The first attempt to produce Tall x Dwarf hybrids was initiated in 1960 to 1968. An interesting cross produced was 'Laguna/Coconino' with the resulting few palms performing as follows after 7 years:

bunches produced/tree/years ---------- 14
number of nuts/bunch ---------- 20
copra per nut, gm. ---------- 200
nuts per kilo of copra ---------- 5

This group of hybrids is comparable to those produced in Sri Lanka, India, and West Africa in terms of nut size and copra per nut but is better in terms of bunch and nut production, and therefore, yield per tree or per hectare. However, the nuts are small compared to the commercial variety and the palms are growing under highly favorable conditions. It is clear,

however, that 56 kg of copra/tree/year or 8.4 to 10 tons per hectare is attainable.* This and several other crosses have been and will still be produced in greater number for field trials in at least 3 environments (Table 6).

Table 6. Crosses in the current coconut hybridization program of the UPLB, 1977.

Typica/Javanica		Javanica/Javanica*		Typica or Javanica/Nana	
Male	Female	Male	Female	Male	Female
SR	LG	LG	LG	SR	CN
La	RL	RL	RL	La	
Lu	RA	RA	RA	Lu	
Pu	PG	PG	PG	LG	
	JD	JD	JD	RL	
	OD	OD	OD	PG	
	YD	YD	YD		

* No selfing is made.

The WAT x YD hybrid from West Africa yielded 4.6 tons of copra per hectare/year at about the same age in 1972. Those palms received 6 kilograms each of fertilizer annually and were irrigated artificially.

Abstract

The philosophy and general approaches to coconut breeding and seed production at the University of the Philippines at Los Baños are presented and discussed in relation to their perceived relevance to the present and immediate needs of the average farmer and industry. Some of the results are presented, with reasonable indications of developing and producing locally adaptive and high-yielding varieties and hybrids.

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* Based on 156 and 180 palms per hectare planted at 8 m apart in square and triangular system, respectively.

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Discussion

J. Soria, Costa Rica:

1. You mentioned that among the objectives in your coconut breeding program you wanted to develop varieties adapted to intermediate technology. How do you evaluate varieties for intermediate technology?

2. Are you evaluating your coconut varieties for competition of nutrients, water and light for the different cropping systems that you described in your presentation?

Answer:

1. We are testing our materials with about 0, 1 and 2 kilograms of fertiliser per tree annually at the bearing age, depending upon the environment and soil conditions. We do not apply more than 2 kg. as farmers cannot afford higher levels. Irrigation is not supplied and insect pests and diseases are not being controlled regularly.

2 We are not yet investigating this problem now. We would like to understand changes in soil chemistry and microbiology as well as investigate micro-climate and ecological parameters in relation to pest occurrence.

J. T. Rao, India: What are you doing about wilt disease? Is there any resistant germplasm?

Answer: It is possible that that there is some genetic resistance or tolerance to root wilt disease in India. Cultivars could be collected at the international level for such purpose.

J. T. Rao, India: The breeding objectives seem to be concentrated on evolving dwarf early maturing varieties. However, in the hybrids the number of nuts seems to be low. Do you think you can concentrate on higher kernel nut ratio, thereby increasing kernel production per unit area?

Answer: The objective is to produce early-bearing and productive materials based on copra production per tree or per unit area. The hybrids have relatively good nut production per bunch and bunch per tree. However, they have relatively low kernel/nut ratio. This is because the parents were mainly of the *Typica* and *Nana* varieties which are extremes as far as that character is concerned. Our subsequent crosses involve more of the *Javanica* variety which does not show a reduction in meat/nut ratio because, like the *Typica,* the pollen source, it bears medium to large nuts.

M. Iizuka, Japan. How do you protect your plants from the effects of lethal yellow which is due to a type of Mycoplasma, when you introduce germ plasm from the Caribbean?

Did you ever introduce pollen grains for making crosses in your breeding system?

Answer: At the University of the Philippines we are not introducing germplasm, nut or pollen from the Caribbean because we have a good indication that there is a wide base of genetic variability in the country. Also the introduction of foreign materials might be accompanied with the outbreak of diseases.

K. Sakai, Japan: Why don't you improve first economic characters by mass-selection within variety so as to make crossing experiments within these varieties rather than undertake hybridisation work in coconut varieties which are heterogeneous and heterozygous?

Answer: The tall variety is heterogeneous but not the dwarf one. Within the tall there are distinct populations or forms which are relatively constant in morphology. These are being used in hybridisation with homogeneous dwarf varieties. The hybrids seem to be doing better than commercial varieties in terms of copra production per tree. The evaluation aspects of our general strategy include both population (mass) and individual palm selection. The need for the simultaneous conduct of evaluation and hybridisation stems from the availability of germplasms already in the bearing stage in the station and from pressing demand for early-bearing and high-yielding palms.