major targets for genetic engineering. A number of groups have reported successful gene insertion and expression in plants but until recently no one has succeeded in getting expression only in the seed tissues—the target tissues for oil seeds that need improvement in their storage products. However, a general report has just been published in *Biotechnology* by Netzer (7) describing successful insertion of the phaseolin gene (phaseolin is the major storage protein of bean seed) into a tobacco plant with this major expression in its seed. The report identifies the workers as J. D. Kemp and T. C. Hall of Agrigenetics in Madison, Wisconsin.

So far as the major components of oil seed tissue are concerned, proteins, fats and polysaccharides, the difficulty of genetic controlled changes in composition markedly increases from left to right. Proteins in seed tissues, however, are notoriously complex mixtures of many components. Expression of a gene for a new protein must therefore be at a very high level to become a major component. Major fatty-acid modifications could be attained by insertion of a gene coding for a new enzyme.

THE FUTURE

The next ten years will see the gradual introduction of oil seed varieties improved in yield and other properties dictated by complex groups of genes by exploitation of clonal selection and somaclonal variation. In addition, recombinant DNA techniques will provide plants improved in composition of the oil seed so that the products are better adapted to major end users of the protein, triglyceride and polysaccharide components. This will be supplemented by isolated enzyme-based systems that transform low cost bulk oils and polysaccharides to higher value specialized products. All these developments will tend to decrease processing costs of bulk raw materials and open up new opportunities in the oil and fat-based industries.

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Contribution of Biological Research to the Development of the Coconut Industry

WILLIAM G. PADOLINA, Ph.D., National Institutes of Biotechnology and Applied Microbiology, University of the Philippines at Los Baños, College, Laguna Philippines.

ABSTRACT

Current developments in coconut breeding, embryo and tissue culture, and the studies on the etiology of cadang-cadang disease are discussed. The present state of the art for each of these with specific reference to the Philippine situation is presented.

INTRODUCTION

This paper focuses on three areas of concern with regard to coconut as a commercial crop: breeding and conservation of germplasm, plant tissue culture studies, and the characterization of cadang-cadang disease. Selection of these topics was based mainly on their critical importance to coconut as well as the availability of literature for this review.

This is by no means a complete review, but it will attempt to present the state of the art, as well as highlight current efforts, especially in the Philippines.

COCONUT BREEDING

One of the best means to improve the coconut industry is by breeding improved varieties towards the following objectives (1,2,3):

- Increased production of nuts and copra at different levels of soil fertility,
- Improved quality of yield in terms of oil and protein content, and
- Stability of annual production through resistance to environmental stresses such as drought, strong wind and outbreak of pests and diseases.

In the Philippines, coconut breeding work has been done at various levels of activity in the Bureau of Plant Industry (BPI), University of the Philippines at Los Baños (UPLB), the Visayas State College of Agriculture (VISCA) and the Philippine Coconut Authority (PCA). In addition to these, there are a few private farms involved in the breeding effort.

As a guideline, it has been felt that any cultivar developed by national institutions must be directed toward the needs and capabilities of the average farmer and farm (2). These cultivars must be precocious and must give high yields under a wide range of environment and management levels.

The coconut breeding program being implemented in the Philippines includes three basic activities (2,3):

- Identification and collection of cultivars,
- Evaluation and selection of cultivars – hybridization and evaluation and selection of hybrids, and
- Seed production.

The identification and collection of cultivars is directed toward the establishment of a gene pool and the conservation of genetic resources. This effort was started as early as 1668 by Alzina. There are about 28 local cultivars in the collection of UPLB, VISCA and PCA (Table I), and 40 collections from foreign sources at BPI (Table II) and PCA (Table III). These collections can serve as the breeders' working collection and the conservationists' base collection. According to Santos (3), due to the high variability of the coconut, the seednuts collected to be used for the breeding program must come from as many palms to be planted. This is to ensure that large-scale seed production can be undertaken if promising hybrids are obtained.

There is now a continuing evaluation for these collections with regard to their vegetative and reproductive characters. Characteristics of these collections with particular reference to their copra is presented in Tables IV, V and VI. Further work is being undertaken to evaluate these local and foreign collections for the content and quality of their oil and protein.

TABLE I.

Some Collections of Local Coconut Cultivars in the Philippines, 1980 (2)

Cultivar	Where planted[a]	Origin
Late-bearing, small- to large-seeded		
Bago Oshiro	ZRC, ARC	Davao City
Baybay	ZRC	Leyte
Bunawan	DRC	Davao City
Laguna	ZRC, ARC, UPLB	Laguna
Macapuno	ARC, UPLB	Laguna
Purinkitan	DRC, UPLB	Leyte
San Ramon	DRC, ZRC, UPLB	Zamboanga City
Cuyamis	UPLB	Leyte
Pinata	UPLB	Laguna
Concepcion	UPLB	Iloilo
Balunbalunan	UPLB	Pangasinan
Tutupaen	UPLB	La Union
Lono	UPLB	La Union
Pag-asa	UPLB, ZRC (?)	Davao del Norte
Early-bearing, medium- to large-seeded		
Bilaka	UPLB	Lanao del Norte
Golden King	UPLB,DRC, ZRC, ARC	Davao del Norte
Silver Queen	UPLB, DRC, ZRC	Davao del Norte
Kinabalan	UPLB, ZRC	Davao del Sur
Magtuod	ZRC, ARC	Davao City
Marinduque	UPLB	Marinduque
Rabanue	UPLB, DRC, ZRC, ARC	Davao City
Rabara	UPLB, DRC, ZRC, ARC	Davao City
Makilala	UPLB, ZRC, ARC	North Cotobato
Marure (Spicata)	UPLB, VisCA	South Cotobato
Early-bearing, small-seeded		
Coconino	UPLB, VisCA	Laguna
Magnipod	UPLB, DRC	Laguna
Polipog	DRC, ZRC, ARC	Lanao del Norte
Mamareng	UPLB, BPI	Pangasinan

[a]UPLB = Univ. of the Philippines at Los Baños; DRC, ZRC, ARC = research centers of the Philippine Coconut Authority in Davao, Zamboanga and Albay; VisCA = Visayas State College of Agriculture; BPI = Bureau of Plant Industry in Quezon.

TABLE II.

Some Introduced Coconut Cultivars at BPI, Tiaong, Quezon and their Sources, 1980 (2)

Cultivar	Source
Karkar No. 2	PNG
Markham 2	PNG
M. Bangkok No. 2	Thailand
L. Bangkok No. 1	Thailand
Caledonia No. 7	New Caledonia
Nigeria No. 7	Nigeria
Tanganyika 97	Tanganyika
Niu Mata Kula 1	Tonga
Niu Kafa No. 2	Tonga
Niu Leka No. 2	Tonga
Bombay No. 1	India
Calcutta No. 1	India
Dau Tam Quang	Vietnam
Dua Dua 2	Vietnam
Dua Lun 4	Vietnam
Dua Bi 1	Vietnam
Dua Ta 5	Vietnam
Dua Lua	Vietnam
P 91C	Malaysia
P 123C	Malaysia
Var. A#2	Malaysia
Var. B#4	Malaysia
Var. E#3	Malaysia
Var. 21#5	Indonesia
Var. 72#5	Indonesia
Var. 105#1	Indonesia
Var. 107#1	Indonesia
Var. 109#3	Indonesia
Var. A#6	Sarawak, Malaysia
Var. B#2	Sarawak, Malaysia

TABLE III.

Introduced Cultivars at Philippine Coconut Authority Stations and their Sources, 1980 (2)

Cultivar	Stations		
	DRC	ZRC	ARC
Tall			
West African Tall	Ivory Coast	–	–
Ronnel	Solomon Island		
Markman	–	PNG	PNG
Kar-kar	–	PNG	PNG
Gazelle	–	PNG	PNG
Dwarf			
Aromatic	Thailand		
Yellow Malayan Dwarf	Ivory Coast		
Red Malayan Dwarf	Malaysia		
Brazilian Green	Ivory Coast	–	–
Red Cameron Dwarf	Ivory Coast	–	–
Sri Lanka	Sri Lanka	–	–

There are active hybridization programs at UPLB and PCA. Hybridization has been used to improve general performance through the effects of hybrid vigor and by developing a new plant type. Two approaches are currently being used by coconut breeders. Some breeders favor using parents with narrow genetic bases while others prefer materials with broad genetic bases. The nut component characters of selected local hybrids and that of Yellow Malayan Dwarf (YMD) by West African Tall (WAT) is presented in Table VII. Early results showed higher nut yield of the YMD x WAT hybrids over the local hybrids (3). However, because of smaller nuts of the YMD x WAT hybrids, it failed to register a wide margin in total copra yield over the local hybrids. An ongoing evaluation program is being undertaken to monitor earlier precocity in flowering and nut yield; number of leaves, nuts and bunches; fruit composition; and total copra yield. This evaluation program must be sustained in order to acquire good information for future efforts in coconut breeding.

Seed production must follow once a reasonable evaluation of the materials (varieties or hybrids) shows good potential for large scale production. There is a private coconut seed-garden in the Philippines to serve the national coconut replanting program. Other seedgardens are said to exist in Malaysia, Indonesia, India, Ivory Coast and Costa Rica. It is also important to note that a seed certification board must be established to ensure the quality of planting materials. This is especially important for seed-propagated perennial crops like the coconut because of the long maturity times involved.

COCONUT EMBRYO AND TISSUE CULTURE

The IBPGR (1982), in putting the coconut as a priority crop for the development of in vitro techniques for propagation and in vitro storage, recognized the limitations faced in conventional methods for genetic improvement of coconut. Seednuts are genetically variable, do not breed true-to-type and take 3-7 years to flower. Due to the existence of

TABLE IV.

Some Other Tall Coconut Cultivars in the Philippines with their Economic Characters (2,4)

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

TABLE V

Nut Character of Some Selected Cultivars of Coconut in the Philippines (2)

Cultivar	Nut volume (CC)	Nuts/kg copra
Typica variety		
San Ramon (SR)	4688	2.98
Laguna (La)	3600	4.50
Javanica variety		
Rabanuel GD (RL)	2770	4.18
Lanao GD (LG)	2415	4.26
Rabara GD (Ra)	3643	4.56
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		
Coconiño (CN)	1110	9.98

TABLE VI.

Copra Conversion Rates of Commercial Coconut Varieties in Some Countries (2,5)

Country	Nuts/ton of copra	Copra/nut (gm)
India	6800	147
Ivory Coast (West African Tall)	6200	162
Fiji	6000	167
Papua New Guinea	5500	182
Sri Lanka	5000	200
Thailand	5000	200
Indonesia	4700	212
Western Samoa	4500	222
Philippines: Laguna	4500	222
San Ramon	3500	286

TABLE VII.

Nut Component Characters of YMD x WAT and 3 local hybrids (3)

Entry[a]	Whole nut	Nut component (gm) Husk	Shell	Water	Meat	FQV	Copra (ton) per nut	ha
CAT x LAG	1067.2	311.9	184.4	219.0	351.8	.41	209.2	1.09
CAT x BAO	1116.5	310.8	187.8	231.9	386.0	.44	232.6	.76
CAT x TAG	1165.6	314.7	199.2	254.2	397.6	.44	233.3	1.05
YMD x WAT	826.2	299.4	131.2	126.4	261.7	.38	169.2	1.23

[a]BAO: Bajo Oshiro; CAT: Catigan: LAG: Laguna; YMD: Yellow Malayan Dwarf; WAT: West African Tall

only one growing point, it is not possible to propagate the coconut by conventional vegetative methods. Furthermore, the bulk and weight of the seednuts make them expensive to transport by air.

These problems provide a challenge to the rapidly advancing field of plant tissue culture as this technique has been applied in the clonal propagation of economically important crops. A review of tissue culture of coconut by Pannetier and Buffard-Morel (6) is in press.

The successful application of coconut embryo culture to overcome the nongermination of the sport coconut (macapuno) has encouraged the work on other coconut varieties (7). Initially cultured in liquid medium, the embryo is transferred to a succession of solid media within a period of

8 months, after which it is transferred to nonsterile potted soil (8). After a period of recovery and adjustment, which lasts up to 16 months after transfer to potted soil, the seedling is ready for field planting. Controlled pollination of in vitro propagated plants gave 100% yield of macapuno nuts (9). Similar growth responses were observed for other coconut cultivars using the technique developed for macapuno (10). However, further research is necessary to improve the efficiency of embryo culture for purposes of germplasm exchange and in vitro conservation of germplasm (11).

Vegetative propagation by tissue culture using leaf tissues and the developing coconut inflorescence has shown some interesting results (6,11). The use of leaf tissues for callus formation has led to organized structures with the characteristics of somatic embryos but which did not develop into plantlets. Another approach is the use of immature inflorescence tissue and its induction to vegetative development to obtain plantlets. Earlier reports (12) claimed that flower primordia could be manipulated to form shoot-like structures. De Guzman and Del Rosario (13) were able to obtain development of shoot and some true leaves from individual floral meristems. In some cultures more than one vegetative shoot was produced from a single floral meristem. Subsequent studies to obtain vegetative development from inflorescent tissues have resulted only in the enlargement and expansion of the floral meristems. Furthermore, the nodular callus growth was observed. This is significant because each nodule is a potential site for organization towards plantlet formation. Histological studies of this callus revealed the presence of *meristemoids* which differentiate into embryoid-like structure and vascular tissues (11). Nodular tissues that form upon addition of 2,4-D to the culture medium of coconut embryo have also shown shoot-like primordia forms. This is a subject of further study (11). Much of the encouragement in the development of tissue culture for the vegetative propagation of coconut comes from the success in the production of plantlets from callus on other palm species (14). It is probably a matter of time before similar success will be obtained for the coconut.

Pollen-derived embryos were obtained from anthers. The development of the microspore-derived embryos started with the symmetrical nitotic division of pollen nucleus leading to formation of globular, heart-shaped and torpedo embryos, but no plantlet formation was observed (15).

ETIOLOGY OF THE CADANG-CADANG DISEASE

Cadang-cadang, a blight disease considered serious because it kills vast areas of coconut, was first reported in 1931 in a plantation in San Miguel Island, in the Bicol Region of the Philippines. The disease has since been reported in other places in the Philippines.

Bigornia (16) made a critical review on the various theories proposed for the causative agent of this disease. Among these theories, two have been studied in great detail: the physiogenic and the viroid nature of the disease.

Indications that the disease is physiogenic in nature have been pursued by Velasco et al. (17,18,19). They have pointed out that the severity of the disease varies widely in a few contiguous areas. In one experiment, they observed that applying ammonium phosphate fertilizer to the affected trees alleviated the disease while application of ammonium nitrate aggravated the disease. These seem to indicate that there could be some detrimental factors in the soil. It was also reported that in their analysis of the soil, they found that the rare earths and thallium were present in appreciable amount in the soil of affected groves. Further studies, however, did not confirm the presence of thallium.

As early as 1937, Ocfemia (20) proposed that the disease is caused by a virus, but evidence for the presence of a virus in diseased trees has not been convincing (21). Since no virus-like particles could be associated with the disease, Randles et al. (22,23) have provided evidence that viroids may be the cause of the disease. The cadang-cadang RNA (ccRNA) was proven to have properties similar to those of the potato spindle tuber viroid (PSTV) (22). They have reported that the ccRNA was successfully transmitted mechanically to young coconut seedling with a latent period between 1.5 and 2.0 years. Likewise, ccRNA was detected in young palm fronds before leafspot symptoms appear. In order to demonstrate the exact nature and pathogenicity of the ccRNA, pure isolates were prepared for the determination of structure and infectivity (24). This work confirmed previous observations that structurally ccRNA's belong to the viroid group of pathogens. Final proof of the viroid etiology relied on the demonstration of the infectivity of the pure isolates of the viroid as shown by the recovery of the diagnostic ccRNA's from the test plants and the reproduction of the disease symptoms in the infected plants (25).

Various studies are now being undertaken to determine the vector of the viroid (26) as well as the development of rapid diagnostic procedures.

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Present and Prospective Development in the Palm Oil Processing Industry

M.S.A. KHEIRI, Palm Oil Research Institute of Malaysia

ABSTRACT

Malaysia, the leading producer of palm oil, is now also the major producer and exporter of processed palm oil (PPO). Since 1977 she has been exporting PPO in increasing amounts. As a result about 50% of world production of palm oil is now traded as PPO in the international market.

Currently, Malaysia has processing capacity far exceeding her production of crude palm oil. Guaranteed capacities for physical refining, fractionation and chemical neutralization are 12,075, 9,940 and 4,949 metric tons (MT) per day, respectively. These can be increased to 16,285, 12,705 and 6,170 MT per day, respectively, by some modification and rationalization. Thus Malaysia is geared to cope with increased production of PPO at least up to 1990.

The PPO products exported are the results of primary down streaming of crude palm oil. The production and export of these products are very well established. The emphasis is now on further down-streaming of PPO products into specialized products such as food ingredients, nonfood applications and finished products such as shortenings, margarines, cocoa butter replacer fats and oleochemicals both for local consumption and export. By the end of the decade, Malaysia is likely to become a center for the manufacture of basic oleochemicals and their derivatives.

INTRODUCTION

Palm oil had a tremendous growth during the past decade and as a result is now playing an increasingly important role in the world oils and fats trade. It is now the second largest vegetable oil, after soybean oil, both in terms of world production and export.

The bulk of palm oil is produced in a number of Southeast Asian and Pacific Basin countries, notably in Malaysia and Indonesia. In order to increase the domestic added value and also to open new markets for palm oil, substantial resources have been invested in processing industry.

Malaysia, the leading producer of palm oil, is now also the major producer and exporter of processed palm oil (PPO). Since 1977 she has been exporting PPO in increasing amounts. Consequently, in 1984 about 41% of world production and about 66% of world export of palm oil was traded as PPO in the international market.

Before Malaysian export of PPO there was no established international trade in fully processed edible oils and fats, and most of the oils and fats were traded in crude form. The steps taken by Malaysia have had a great impact on almost all activities (such as trading contracts, surveying, shipping, bulk storage) involved in this established trade. These steps have also consolidated her position not only as one of the leading producers of edible oils and fats but also as a major exporter of processed edible oils and fats in the international market. She is likely to keep this position because of the dynamic nature of the industry and also the understanding and cooperation which exist between the policy makers and the palm oil industry in this country. Both the policy makers and the palm oil industry have been able to anticipate and respond to the demand, the competitive nature of the edible oils and fats market and the new technology to improve their competitive position.

Because of Malaysia's leading position and dynamic nature, the current situation and the prospective developments in the Malaysian industry will accurately reflect the current situation and development in the palm oil processing industry on a global basis. This paper will discuss the palm oil processing industry in Malaysia.

PROCESSING TECHNOLOGY

The edible oil processing industry has never been a "high technology" industry. Many basic processes, such as extraction, refining, bleaching, deodorization, hydrogenation, interesterification, fractionation, etc. go back decades. Much of the progress affecting the world edible oil processing industry originated in other sectors of the economy, especially the chemical industry, government and private sector research and development organizations, equipment designers and suppliers.

The above is also true for the palm oil processing industry in Malaysia, where the technology of processing crude palm oil (CPO) was supplied by the equipment suppliers. The technology provided by these sources is based on the existing established technology used in the developed countries for processing edible oils and fats. The technology in some cases was modified either by the equipment suppliers or by the local refiners to suit palm oil and also to increase efficiency.

The palm oil processing industry in Malaysia is based on two basic technology groups: refining and fractionation. These two technologies have enabled the industry to offer up to 14 types of partially and fully processed products of CPO to the world market (Table I).

Refining

Most of the refining plants installed in the early 1970s were of conventional type, consisting of a chemical neutralization section, an earth bleaching section and a steam deodorization section. By the late 1970s the industry realized the economic benefit of the physical refining process. Consequently, all the new refineries installed during this period as well as some old ones incorporated a physical refining plant. In 1984, out of 51 refineries already installed 46 refineries have physical refining plants. Twenty-two refineries have kept or included chemical neutralization section in order to enlarge their product range.

In Malaysia, the technology of refining plants can be