Recent Developments in Research on Coconut at MARDI*

A. SIVAPRAGASAM AND MANSOR, P.

Rice and Industrial Crops Center, Ibu Pejabat MARDI, Peti Surat 12301,Pejabat Besar Pos, 50774 Kuala Lumpur, Malaysia

The Malaysian Agricultural Research and Development Institute (MARDI) has geared its research initiatives to meet the current challenges of the Malaysian coconut industry. They are, viz. to increase the income of coconut farmers and to meet the demand for nuts as feedstock for the domestic small and medium coconut-based industries. The research strategies adopted entailed activities along the production value chain, such as: (1) Development of new and specialty coconut varieties; (2) To encourage coconut-based mixed farming to maximize the income per unit area of coconut farmers through efficient crop husbandry and optimal use of resources with reduced dependence on external inputs; (3) Promote mechanization of post harvest operations, and (4) Develop new food (e.g. VCO) and non food (e.g. coir fibre) coconut-based products to stimulate downstream development.

Keywords: *Coconut, MARDI, research, value chain.*

The major objectives of Malaysia's coconut re-vitalization program in the Ninth Malaysia Plan are to increase the income of coconut farmers and to meet the raw material needs (especially the supply of nuts) for the domestic small and medium coconut-based industries. Pivotal to achieving these objectives is the strengthening of the research and developmental aspects along the coconut production value chain. The Malaysian Agricultural Research and Development (MARDI) has been involved with various aspects of research and development (R&D) on the coconut since the early 1970s. However, the broad objectives of this paper are to highlight MARDI's current R&D goals and activities undertaken for coconut in the country.

GOALS AND STRATEGIES FOR R&D

The national goals for the coconut industry are to: (i) Increase the smallholder income, (ii) Meet the demand for nuts for the sustenance of the domestic coconut-based industries and (iii) Promote and expand the interests in coconut through value-addition of both food and non food based coconut products. MARDI's strategies has therefore been to leverage its R&D activities along the production value chain by focusing on: (i) Breeding and selection of varieties; (ii) Improved management practices, *viz.* by proper fertilization and pest management practices to increase nut production; (iii) Developing mixed farming systems; (iv)

* Reproduced with permission from the Proceedings of the National Coconut Conference 2009 - Opportunities for a Sunrise Industry, organised by MARDI, co-organised by the Department of Agriculture, Malaysia, Federal Agricultural Marketing Authority and The Incorporated Society of Planters, in collaboration with the Ministry of Agriculture and Agro-based Industry on 28-29 July 2009.

Research on production of coir from coconut husk; and (v) Developing new food and health coconut-based products (e.g. virgin coconut oil, VCO).

RESEARCH ACTIVITIES

Breeding and selection of varieties

The activities entailed selection and evaluation of varieties suitable for smallholders. These include evaluation of number of other varieties currently available in MARDI's germplasm collection for specific uses and those which are agronomically-robust under the existing resource-stressed smallholder management system. The strategy to re-examine the germplasm has its merits due to the fact that the conventional strategy for developing a coconut variety takes too long (>10 years), and in many instances, parent materials used in the original crossing are either not available or difficult to procure. It is also important to consider the many challenges and demands in the use of hybrids, such as the MATAG and MAWA, which unlike the robust Talls, affect the their performance under the usually resource-constraint smallholder-based system.

MARDI's overall target is to provide a range of varieties to smallholders to complement the currently promoted varieties. Studies are in progress towards the selection of varieties which have other superior characteristics besides nut yield. In this respect, the variety, Pinggan Pinggan Tall, has shown better weight in terms of fruit, husk, water, shell and kernel compared to existing hybrids, such as MATAG and MAWA (*Table 1*) (Ahmad, 2008). Certain varieties could also be promoted for the fresh tender nut industry (Ahmad Ngalim and Nubaidillah, 2009).

Improved management practices to increase nut production

Fertilizer trials on MATAG

Proper fertilization is important for optimal performance of hybrids - and poor productivity of hybrids under smallholder farms has generally been attributed to poor or no fertilizer application. Preliminary fertilization trials on 8-year old neglected MATAG coconut trees in mineral soil at MARDI, Kluang indicated that recommended fertilizer application gave significant yield increases of the hybrid. Thus, fertilized trees gave about 59% higher mean

TABLE 1
MEAN (± SD) VALUES OF VARIOUS PHYSICAL CHARACTERISTICS OF SELECTED TALLS AND HYBRIDS, MAWA AND MATAG

Varieties	*Nut (g)*	*Husk (g)*	*Shell (g)*	*Kernel (g)*	*Oil (%)**
Tagnanan Tall	1494±235	392± 92	247±37	481±65	64±4
Laguna Tall	1293±323	382±105	204±50	388±95	65±3
Pinggan Pinggan Tall	1764±388	578±218	239±45	491±108	61±4
Fiji Tall	1044±220	464±145	155±26	288±60	65±3
MAWA	1147±107	487± 92	163±13	288±17	68±2
MATAG	1419±198	409±126	212±46	432±47	64±5

* Weight after extraction/weight before extraction x 100

bunch and fruit numbers per tree compared to the unfertilized trees (*Figure 1*). It is also important to note that the fertilization of the trees need to be complemented by an effective pest management program against major pests particularly the rhinoceros beetle, *Oryctes rhinoceros* L. and the red stripe palm weevil, *Rhynchoporous vulneratus* Panzer (refer Section b).

Pest management

Pest management systems had also been formulated for the rhinoceros beetle, the red stripe palm weevil, *R. vulneratus* and the coconut hispine beetle, *Brontispa longissima* Gestro (*Figure 2*).

The Farmer Field School (FFS) approach was advocated to implement the integrated pest management approach for the management of

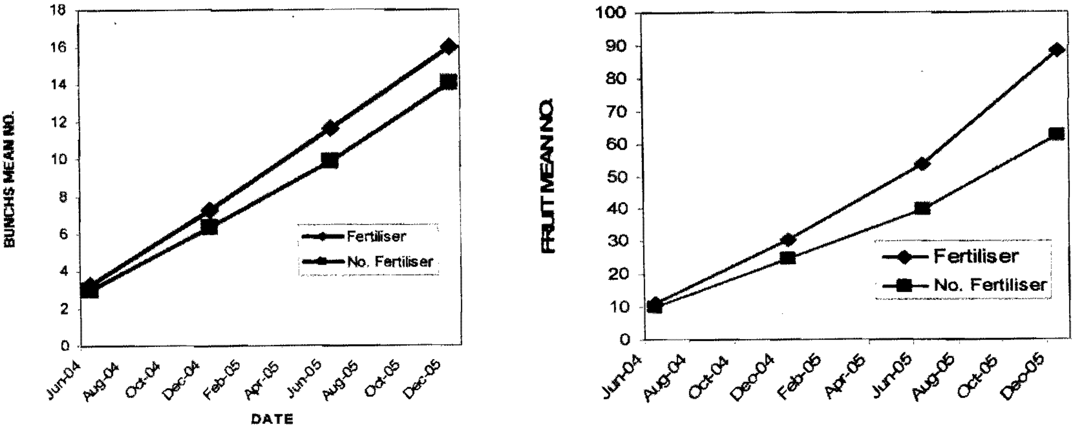

Figure 1 Cumulative (a) Bunch and (b) Fruit (nut) yield/tree of 8-year old MATAG coconut after fertilization with recommended rates of compound fertilizer at MARDI, Kluang.

Figure 2 Adult Brontispa longissima *(left) and damaged palm (right)*

the rhinoceros beetle, which is a key problem of young coconut transplants in the field (Sivapragasam *et al.*, 2007a). Evaluation of environment-friendly approaches using pheromone traps, green muscardine fungus, *Metarhizium anisopliae*, the virus, *Oryctes baculovirus*, and log traps either singly or in combination were not able to reduce significantly rhinoceros beetle populations on coconut palms and improve coconut productivity (Sivapragasam *et al.*, 2007b). However, the cost of implementing the strategy was relatively high (RM190.66/ha). It is also recommended that an area-wide management program is implemented for the pests.

For the red stripe palm weevil, the pheromone (4-methyl-5-nonanol)-kairomone (mixture of low volatile alcohols and acetates) system (Ferrugion, Semiochem[R]) was found to be a useful monitoring tool for *Rhynchophorus vulneratus* (Sivapragasam *et al.*, 2009). Recently, we have also recorded the red palm weevil, *R. ferrugineus*, the con-generic species of the red stripe weevil, infesting coconut in Kelantan, Malaysia.

To manage *B. longissima* Gestro, a recently introduced invasive pest, the insecticide, chlorpyrifos + cypermethrin (Nurelle[R]) was effective in causing almost 100 percent mortality in the field compared to the insecticide, acephate, which was only effective in the laboratory and showed poor efficacy in the field. The incidence and host range of *Brontispa* was also investigated and we found that most cultivated palms were damaged by the beetle (Sivapragasam, 2007). More recently, the gregarious parasitoid *Asecodes hispinarum* (Family: Eulophidae) was also recorded in the country (Wan Khairul Anuar *et al.*, 2009).

Trunk injection using monocrotophos is generally used to manage pests, such as leaf feeders, on palms that are not reachable by normal sprays. Such a practise has implications on the consumption of tender coconut water which is becoming a popular drink. Ma *et al.* (2009) reported that trunk injection of 3 year old palms (MATAG) at the recommended rate of 10ml/palm, resulted in residues of monocrotophos above the maximum residue limit (MRL) of 0.05 ppm until 49 days after treatment (DAT) in the kernel and water of young tender coconut.

Developing mixed farming systems

Coconut is generally grown as a monocrop - a cropping system that generally utilizes only about 20% of the land and allows a significant tract of land under coconut underutilized. As a strategy towards maximal utilization of land and greater sustainability, there has been increasing efforts towards mixed farming systems under coconut. Work towards developing mixed farming systems under coconut was initiated by MARDI in phases, *viz.*, (i) Selection of components of the system such as the crop and animal components, utilizing the Linear Programming Technique (Abdul Munir and Sivapragasam, 2004). The crop components selected were pineapple and banana and goat was chosen as the animal component in the system; (ii) Testing of the crop components *i.e.* mixed cropping trial; (iii) Testing of the mixed farming system (crop-animal-coconut). The overall objectives were to evaluate the potential for coconut-based mixed farming to maximize the income per unit area of coconut farmers through efficient crop husbandry and optimal use of resources with reduced dependence on external inputs.

Mixed cropping trials: An illustration of mixed cropping under coconut carried out by MARDI is shown in *Figure 3*. Our trials using two test

Figure 3 An example of a mixed cropping system with banana and pineapple under coconut

banana varieties, *viz.*, Rastali and Tanduk, chosen based on linear programming and market demand in the trial location, showed that the cultivar Rastali was a better choice than Tanduk in terms of better vegetative growth, yield, lower costs of production, flower production, biomass and marketing of produce. In terms of pests and diseases, Rastali was prone to infection by the Panama disease caused by *Fusarium oxysporum f. sp.cubense* (FOC) (race 4) whereas Tanduk is highly susceptible to the weevil, *Cosmopolites sordidus*. For pineapple, the cultivar Morris was a clear choice compared with N36 based on vegetative growth, yield, pests and diseases, costs of production, flowering pattern and market demand (Anon, 2006). The number of heads harvested was also higher for Morris (98%) compared to N36 (79%) and almost 90% of Morris conformed to the normal fruit weight (0.5 - 1.2 kg) compared to less than 5% for N36 (normal fruit weight 1.5 - 2.0 kg). N36 however had a higher biomass based on the number of leaves and would be useful for making silage for the animal component.

Mixed farming trials: The mixed farming trial to evaluate crop integration with goats was done following the mixed cropping trial. The trial included banana (cv. Rastali), pineapple (cv. Morris) and goat (Jamnapari cross from Indonesia) as components. Results showed that the banana-pineapple-goat suggested the potential of such a system towards increasing farmer income. However, there are few key issues that need to be resolved such as the problem of diseases (e.g. *Fusarium)* due to the continuous cultivation of banana and goat problems due to parasites. The sustainability of the mixed farming system *via* recycling waste biomass from pineapple and banana and dung from goat revealed that weight gain of goats was highest (59.7%) in the treatment fed on 70% pineapple silage and 30% of concentrate.

Evaluation of tolerant banana varieties: The continuous cultivation of banana (var.: Rastali), *viz.*, first season crop is banana followed by banana in the second season, posed significant problems due to incidence of Sigatoka disease (*Mycosphaerella musicola*) and the Panama disease caused by *Fusarium oxysporum* var. *cubense*. The problem was less severe when banana was rotated with pineapple. Pineapple cultivation is feasible if the problems of weeds and pests are overcome. However, to sustain banana in the coconut mixed cropping system, there is a need to screen potentially tolerant banana varieties as there are no effective fungicides against *Fusarium*. We evaluated tolerant cultivars, such as Nipah and Berlin, to this pathogen in the field. Results taken at week 19 after transplanting in the field showed that the plots planted with Nipah and Berlin had lower infestation levels of about 15% and 22.5%, respectively, to Panama disease compared to the 'test' cultivar Berangan which had 42.5% infested plants.

De-husking and coir production

To promote the mechanization of post harvest operations, MARDI has successfully developed and privatized the production of the coconut de-husking machine (*Figure 4*). Currently, research efforts are concentrated towards the refinement of the de-husker to meet various nut sizes. According to Md. Akhir *et al.* (2009), preliminary results testing the efficiency of the machine on four local coconut varieties were as follows: Malayan Tall (ripened and matured nut 92.5% and 85%, respectively); MATAG (85%), MAWA (77%) and the Malayan Yellow Dwarf (46%). They also suggested that the machine was capable of de-husking 270 - 300 nuts/hr or took 7-10s per nut.

Many products of greater value can be produced from coconut husk such as floor mats, soil erosion mats, mattresses and coco pith. The

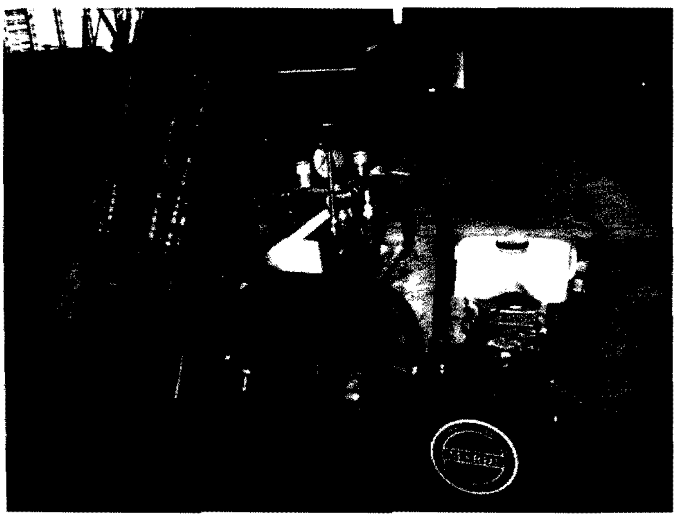

Figure 4 Coconut de-husking machine developed by MARDI

basic material for these products is coir fibre which is the primary product from the husk and its by-product is coco pith which is popular as a plant substrate. On coir fibre production from coconut husk, MARDI has been developing and systemizing husk processing machines and system (consists of a beating machine, an inclined conveyor, a decorticating machine and a screening machine) into a manufacturing process suitable for rural areas that entail safe environment and user friendly-processing techniques (Mohd. Taufik and Md. Akhir, 2009). The products from the system are both baled fibre and coco pith. There are also efforts to use coconut fibres as filler material to produce hybrid bio-composite (Aznan *et al.*, 2009).

Developing new food and health coconut-based products (e.g. virgin coconut oil, VCO)

Virgin coconut oil (VCO) can be utilized as functional foods, pharmaceuticals, nutri-ceuticals, infant foods and cosmoceuticals. An emerging application of VCO is its medical use and functional benefit to human health. MARDI has developed a value added VCO (modified VCO; MVCO) - a product with broad spectrum of antimicrobial activities (Kamariah *et al.*, 2009). *In vitro* studies showed that the value added VCO acts against gram positive bacteria (e.g. *Staphyloccus aureus* and *Listeria monocytogenes*); gram negative bacteria (e.g. *Escherichia coli* and *Salmonella typhi*) and fungi (e.g. *Candida albicans*). A recent study done by MARDI revealed that the MVCO was very effective against dandruff, scabies and candidiasis and has potential to treat skin diseases in both humans and animals. MARDI has also been successful in the production of MVCO and had recently obtained funding with an industry partner for pre-commercialization studies. MARDI has also embarked on a project to improve the quality of VCO obtained from natural fermentation process by introducing the beneficial or potential microbes categorized as bacteria and yeast. One of the bacterial isolates was identified as *Lactobacillus casei* and the two yeast isolates were identified as *Candida utilis* and *C. fermata*. These yeast isolates have been considered safe and classified as Group 1 organisms (Kamariah *et al.*, 2009).

On-going and future studies

The following studies are on-going or are planned for the future: (i) Development of a model farm; (ii) Development of an environment and worker-safe coir processing system (Mohd Taufik and Md. Akhir, 2009); (iii) Development of innovative food and non food products (Engku Hasmah *et al.*, 2009; Norma *et al.*, 2009); (iv) Utilization of mature coconut water as by-product (Mohd Nizam *et al.*, 2009); (v) Mechanization of harvesting and (vi) Developing monitoring tools and intervention methods for the management of new invasive pests such as the eriophyid mite and Cadang cadang-like viroids (CCLVs).

CONCLUSION

Malaysia is optimistic on the future growth of the coconut industry. However, to underpin this sentiment, there is need to put the following in place: (i) Consolidate and strengthen the current R&D initiatives and the necessary enablers especially human resource support; and (ii) Develop greater collaborative efforts on key focus areas across various disciplines (especially in biotechnology), sectors and institutions.

ACKNOWLEDGEMENTS

This paper is dedicated to all those involved in the coconut industry. The authors appreciate the support of Datuk Dr. Abd. Shukor Abd. Rahman, the Director General of MARDI to present the paper at the Conference; Tuan Hj. Ariffin Tawang, the former Director of the Rice and Industrial Crops Center, MARDI for his general guidance support of actiivities; coconut project staff from MARDI, *viz.*, Mr Ahmad Ngalim, Mr Mohd. Taufik, Dr Kamariah Long, Mr Kamarudin Harun and Mr Hairudin Mohd Amir. The collaboration and contributions of Mr. Mohd. Idrus and his staffs from the Department of Agriculture (DOA) in the IPM Farmer Field School Program is sincerely appreciated.

REFERENCES

ABDUL MUNIR JAAFAR and A. SIVAPRAGASAM. 2004. Mixed farming system: methodology and application of linear programming. (mimeo) 8 pp.

AHMAD, N. 2008. Progress report presented at the Program RI01 Monitoring Meeting, 1 - 2 December 2008, MTBIC, MARDI, Serdang (mimeo.)

AHMAD, N and O. NUBAIDILLAH. 2009. Physical characteristics of young tender nuts from different coconut varieties for use as fresh drink. Poster paper presented at the National Coconut Conference 2009, 28 - 30 July, 2009 Swiss-garden Golf Resort & Spa, Damai Laut, Perak.

ANON. 2006. Risalat "*Sistem penanaman campuran bagi meninggikan pendapatan pekebun kecil kelapa*". Published by the Rice and Industrial Crops Center, MARDI

AZNAN, W M W A, MOHAMMUD, C H, AB. RAHMAN A, M TAUFIK, A, and M SHAMSUL FARID, S. 2009. Processibility study of hybrid bio-composite – an initial step to transform agro-waste material to value added product. Poster paper presented at the National Coconut Conference 2009, 28 - 30 July, 2009 Swiss-garden Golf Resort & Spa, Damai Laut, Perak.

ENGKU HASMAH, E.A., NORMA, H., SHARIZAN, A., MOHD SHUKRI, M.A., and ABDUL GHANI, O. 2009. Production and evaluation of virgin coconut oil enriched with ginger. Poster paper presented at the National Coconut Conference 2009, 28 - 30 July, 2009 Swiss-garden Golf Resort & Spa, Damai Laut, Perak.

KAMARIAH LONG, KOH SOO PENG, AZMI AZALI and ROSMAWATI ABDULLAH. 2009. Research and development of virgin cocont oil in Malaysia. Paper presented at the National Coconut Conference 2009, 28 - 30 July, 2009 Swiss-garden Golf Resort & Spa, Damai Laut, Perak.

MA, C.K., A. SIVAPRAGSAM, M. MOHD JUSOH, AYUB DIN, B. RAZALI and K.P. LIM. 2009. Monocrotophos residue levels in coconut leaves, kernel and water. Poster paper presented at the National Coconut Conference 2009, 28 - 30 July, 2009 Swiss-garden Golf Resort & Spa, Damai Laut, Perak.

MD. AHKIR HAMID, MOHD. TAUFIK AHMAD and AHMAD NGALIM. 2009. Design and performance of a coconut dehusker machine. Poster paper presented at the National Coconut Conference 2009, 28 - 30 July, 2009 Swiss-garden Golf Resort & Spa, Damai Laut, Perak.

MOHD TAUFIK, A. and H. MD. AKHIR. 2009. Development of coir fibre processing system. Poster paper presented at the National Coconut Conference 2009, 28 - 30 July, 2009 Swiss-garden Golf Resort & Spa, Damai Laut, Perak.

MOHD NIZAM M. N., OTHMAN, M.T., ABU BAKAR, M. H. and GHANI S. 2009. A feasibility study on setting up a factory producing carbonated drink from matured *Cocos nucifera* nuts. Poster paper presented at the National Coconut Conference 2009, 28 – 30 July, 2009 Swiss-garden Golf Resort & Spa, Damai Laut, Perak.

NOR HASHIM UJANG. 2005. Kajian socio ekonomi penanam kelapa di Sabak Bernam, Selangor (mimeo).

NORMA, H., ENGKU HASMAH, E.A., SULAIMAN, T., IBTAHIM, B., and ABDUL GHANI, O. 2009. Production of potassium soap base form coconut and palm oil mixtures for commercial toiletry and biopesticides products. Poster paper presented at the National Coconut Conference 2009, 28 - 30 July, 2009 Swiss-garden Golf Resort & Spa, Damai Laut, Perak.

SIVAPRAGASAM A. 2007. *Brontispa longissima* - its status and management in Malaysia. Paper presented at the Asian and Pacific Coconut Community/FAO-RAP/APPPC Consultative Meeting on the IPM of *Brontispa longissima*, 27 - 28 February 2007, Bangkok, Thailand.

SIVAPRAGASAM, MOHD. IDRUS ABD. HAMID and MOHD. ANUAR ABBAS. 2007a. Coconut IPM - Implementation of FFS in Malaysia. Paper presented at the Third Annual Meeting cum Terminal Review, 2-5 May 2007, Kochi, India. Organized by CFC/DIFD/APCC/FAO Project on Coconut Integrated Pest Management.

SIVAPRAGASAM, MOHD. ANUAR ABBAS and MOHD. IDRUS ABD. HAMID. 2007b. CFC/DIFD/APCC/FAO Coconut IPM Project: Integrated Pest Management (IPM) of the Rhinoceros beetle, *Oryctes rhinoceros* - An Overview. Paper presented at the Third Annual Meeting cum Terminal Review, 2-5 May 2007, Kochi, India. Organized by CFC/DIFD/APCC/FAO Project on Coconut Integrated Pest Management.

SIVAPRAGASAM, A. AHMAD NGALIM, B. RAZALI and MOHD SANI SUKAIME. 2009. Field trapping of the red stripe weevil, *Rhynchoporous vulneratus* (Panzer) with an aggregation pheromone in a coconut ecosystem. Poster paper presented at the National Coconut Conference 2009, 28 – 30 July, 2009 Swiss-garden Golf Resort & Spa, Damai Laut, Perak.

WAN KHAIRUL ANUAR WAN ALI, A. SIVAPRAGASAM and RAZALI BAKI. 2009. *Brontispa longissima*: an invasive pest of coconut. Poster paper presented at the National Coconut Conference 2009, 28 – 30 July, 2009 Swiss-garden Golf Resort & Spa, Damai Laut, Perak.