Utilization of Organic Wastes and Natural Systems in Malaysian Agriculture

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Abstract

Malaysia produces about 35 and 59 percent of the world's supply of rubber and palm oil, respectively. It is also the third largest producer of cocoa, (200,000 Mg of raw cocoa beans annually) and the fourth largest producer of pepper (14,200 Mg annually). Other crops produced are rice, pineapple, vegetables, and tropical fruits. To maintain its competitiveness in the world market, there are efforts to reduce the production costs of these crops. The goal is to develop highly efficient management practices without sacrificing environmental quality and the living standard of agricultural workers. Production costs can be reduced by using agricultural waste products for fertilizers and practicing biological pest control, while increasing crop productivity and soil fertility. During the past decade, research was directed toward the use of agricultural wastes and natural systems for crop production. The agricultural wastes include palm oil mill effluent (POME), rubber mill effluent (RME), empty oil palm fruit bunch (EFB), and animal wastes. The natural systems include barn owl, rhizobium, Elaeidobius kamerunicus beetles, and honey bee. Currently, the plantation sector is extensively utilizing POME, RME, and EFB as substitutes for chemical fertilizers, Elaeidobius kamerunicus for pollinating oil palm fruit bunches, barn owl for rodent control, and rhizobium for nitrogen fixation by legume crops. The vegetable and fruit farmers are using animal and agricultural waste products as sources of plant nutrients and as soil conditioners. They are using honey bees to improve pollination of coconut and fruit crops.

Introduction

Malaysia, with an area of 329,293 km^2, leads the world in rubber production with about 1.5 million Mg annually. This supplies about 35 percent of the world's rubber requirement. Malaysia is also the world's largest producer of palm oil, supplying about 59 percent of the world's needs or 4,530,000 Mg of palm oil per year; the third largest producer of cocoa, with an annual production of about 200,000 Mg of cocoa beans; and the fourth largest producer of pepper with an annual production of 14,200 Mg of white and black pepper. In addition to these, Malaysia also produces rice, vegetables, fruits, pineapple, and a variety of other crops.

With a population of about 16 million people, Malaysia can ill afford to mismanage its agricultural resources. It must be very efficient to sustain production and competitiveness in the world market, without sacrificing the living standard of its people and environmental quality. Towards this end, Malaysian agriculture has been relatively successful. Currently, Malaysian farmers and workers are earning higher incomes than ever before and environmental pollution is being contained. Part of this success is due to the utilization of agricultural wastes as fertilizers and soil conditioners, and the use of natural systems, which have made our agriculture more profitable, efficient, and sustainable.

Palm Oil Mill Effluent (POME)

The production of 4.53 million Mg of crude palm oil generates about 13.5 million Mg of effluent. This is a potential source of pollution since raw POME has an average biochemical oxygen demand (BOD) of 35 g 1^{-1}, or 100 times that of sewage (Mohd Tayeb et al., 1987). The chemical composition of POME (Table 1) indicates that it can be used as a source of fertilizer. Indeed, experiments conducted during the last 20 years have shown that proper utilization of POME can improve crop yields, reduce production costs, and can be used without causing environmental pollution. Application of POME can be done either through furrow, flat-bed, sprinkler, or tractor/tanker systems. Application rates must be carefully controlled because an excessive application can decrease crop yields and increase environmental pollution, especially in the waterways. Examples of POME utilization and its expected benefits are shown in Table 2.

Table 1. Nutrient Content of Palm Oil Mill Effluent (Zin et al., 1988).

Type	BOD	N	P	K	Mg
			mg 1^{-1}		
Raw Effluent	25000	948	154	1960	345
Digested (Anaerobic)					
Stirred tank	1300	900	120	1800	300
Supernatant	450	450	70	1200	280
Bottom slurry	2000	3550	1180	2390	1510
Digested (Aerobic)					
Supernatant	100	52	12	2300	539
Bottom slurry	225	1500	461	2380	1000

Table 2. Effect of Palm Oil Mill Effluent on Oil Palm Yield (Wood and Lim, 1989).

Soil Type	Effluent Type	Application System	Application Rate	Application Frequency	Yield Increase
			cm	*Round y^{-1}*	*%*
Loamy	Supernatant	Flatbed	10.0	6	20
Loamy	Tank	Flatbed	6.7	4	23
Loamy	Raw	Flatbed	3.3	4	8
Clayey	Tank	Sprinkler	2.5	6	18
Loamy	Supernatant	Sprinkler	18.0	6	19
Loamy	Raw	Tractor/tanker	4.6	12	12
LCL*	Supernatant	Furrow	38.0	12	39

* LCL: loamy clay (lateritic)

Empty Fruit Bunch (EFB)

Empty fruit bunch of oil palm (EFB) comprises about 22 percent of fresh fruit bunch, and it is estimated that 5 Mg of EFB are produced per hectare per year (Chan et al., 1 980). With a total of 1.6 Mha now planted to oil palm, about 8.0 million Mg of EFB are produced every year. Since EFB is relatively rich in nutrients (Table 3), it is currently used as a source of fertilizer.

Table 3. Nutrient Content of Empty Fruit Bunch from Oil Palm (Chan et al., 1980).

Nutrient	Concentration	Amount
	%	*Kg ha^{-1}*
Nitrogen	0.35	5.4
Phosphorous	0.03	0.4
Potassium	2.29	35.3
Calcium	0.18	2.7
Magnesium	0.15	2.3

Empty fruit bunch can be applied directly to the field or applied as bunch ash, which is especially good for acid sulphate soils. However, because of air pollution caused by burning of EFB, the current practice is direct application of EFB to the field. Methods of application vary from spreading between rows, around the palms, or piled at the center of four palms. Which ever method is selected, the pile thickness should not be more than 50 cm to reduce the probability of providing a breeding ground for rhinocerous beetles. The best way is to spread it out rather than piling (Loong et al., 1987).

Application of EFB has been shown to increase yields of oil palm grown on acidic soils. Application of 15 Mg of EFB ha^{-1} y^{-1} can increase yields up to 23 percent (Hong and Halim, 1980). Rates of application vary from 12.5 Mg ha^{-1} y^{-1} to 150 Mg ha^{-1} y^{-1} (Khoo and Chew, 1978; Singh et al., 1981). Zin and Tarmizi (1983) recommended the use of 30 to 50 Mg ha^{-1} y^{-1} for immature palms and 50 to 100 Mg ha^{-1} y^{-1} for mature palms. Loong et al. (1987) recommended the use of 37 Mg ha^{-1} y^{-1} of EFB supplemented with urea and CIRP, while Singh et al. (1989) obtained an increase of up to 23 percent with EFB applied at a rate of 75 Mg ha^{-1} y^{-1} together with 0.75 kg of urea and 1.0 kg of rock phosphate. Recent results showed that it is best to apply EFB at the time of field planting. This can shorten the immaturity period by several months and can increase yield as much as 75 percent (Lim and Chan, 1989).

The use of EFB also improved the nutrient content of the soil, increased the soil pH and cation exchange capacity, reduced erosion, decreased nitrogen losses, and controlled weed growth (Singh et al., 1981; Loong et al., 1987). Utilization of EFB in oil palm production enabled the plantations to save from $31 to $173 ha^{-1} y^{-1} compared with the use of chemical fertilizers.

Rubber Factory Effluent (RFE)

Producing and processing 1.5 million Mg of rubber produces 9 million Mg of effluents which consist mainly of block rubber, sheet rubber, crepe rubber, and concentrated latex effluents (Yeow, 1983). The BOD generated by these effluents is estimated to he about 200 Mg d^{-1} which is equivalent to the BOD generated by 4.6 million people. If not treated and utilized, it can become a major pollutant in Malaysian waterways. Since RFE contains reasonable amounts of plant nutrients (Table 4), it can be used as a fertilizer substitute.

Table 4. Nutrient Content of Rubber Factory Effluent (Yeow, 1983).

Element	Mixed Concentrate/Cuplump	Block Rubber
	mg kg^{-1}	*mg kg^{-1}*
Nitrogen	718	182
Phosphorus	43	81
Potassium	461	246
Magnesium	28	51
Calcium	133	10
Zinc	0.63	0.42
Copper	0.20	0.22

The estimated fertilizer equivalent from the total annual production of RFE is 45.3, 11.4, 41.2, and 35.6 thousand Mg of ammonium sulphate, rock phosphate, muriate of potash, and kieserite, respectively (Yeow, 1983).

RFE has been shown to be beneficial in the production of oil palm and some annual crops. Proper application of RFE can increase oil palm yield by up to 20 percent, and rubber by 5 to 10 percent. Recommended application rates are 2.0 to 2.5 kg N equivalent per palm per year for oil palm, and 100 kg N per hectare per year for rubber (Wood and Lim, 1989).

Biological Nitrogen Fixation

In Malaysian agriculture, particularly in rubber and oil palm production, the planting of leguminous cover crops inoculated with rhizobium bacteria, between rows and on slopes, is done to fix atmospheyic nitrogen and to control soil erosion. The increased utilization of rhizobium is evidenced by the ever increasing sales of rhizobium inoculum. For example, the sales made by the Rubber Research Institute of Malaysia (RRIM) increased from 1170 kg in 1984 to 1500 kg in 1988, The sales for 1989 through September surpassed 1580 kg (Noordin, 1989). *Centrosema pubescens* has been reported to fix 238 kg N ha^{-1} y^{-1} (Watson, 1961). Tan et al. (1976) reported that growing a mixture of *Calapogonium caeruleum* and *Pueraria phaseloides* can greatly reduce or eliminate the application of fertilizer nitrogen in rubber for up to 15 years. Currently, leguminous cover crops inoculated with rhizobium are extensively used in the new planting and replanting of rubber, oil palm, and fruit orchards. Rhizobium bacteria is also widely used to inoculate the seeds of other legume crops such as groundnut and soybean.

Animal Wastes as Fertilizers

Animal wastes are used extensively by vegetable and orchard farmers. Among these are chicken dung, cow dung, prawn dust, pig dung, and goat/sheep dung. The nutrient composition of these materials is shown in Table 5.

Table 5. Nutrient Content of Some Animal Waste Materials (Sundram and Shamsuddin, 1983).

Waste	N	P	K
		%	
Chicken dung	3.99	2.10	1.52
Cattle dung	2.00	0.65	2.00
Pig dung	1.90	1.30	0.30
Goat dung	2.00	0.87	2.17
Prawn dust	2.17	1.36	0.27

In one survey it was found that 10 percent of the vegetable farmers used only organic fertilizers. Some 48 percent used both organic and inorganic fertilizers, 51.5 percent used chicken dung, 20.4 percent used cow dung, 4.7 percent used prawn dust, and 6.7 percent used pig dung (Sundram and Shamsuddin, 1983).

Pollination of Oil Palm

Elaeidobius kamerunicus was introduced in Malaysia in 1981 to enhance the pollination of oil palm. Since its introduction, the weevil has helped oil palm growers to increase yields and reduce their production costs by eliminating the need for assisted pollination (Chan et al., 1987). Among the changes caused by this weevil are increased fresh fruit bunch yield; increased bunch weight; decreased number of bunches produced; and improved bunch components. The average bunch weight was increased from 14.1 to 28.6 kg (Chan et al., 1987); bunch number was reduced from 135 ha^{-1} to 110 ha^{-1}; the fresh fruit bunch yield was increased by about 12 percent; and the kernel to bunch extraction was increased from 4.4 to 6.2 percent (Chan et al., 1989).

Syed and Salleh (1987) reported that 1500 adult *E. kamerunicus* weevils can pollinate a female inflorescence to an acceptable minimum level of pollination, or about 50 percent fruit set. To obtain an optimum level of fruit set, about 70 percent, nearly 3000 adult weevils per female inflorescence are required. This requires extra precaution to ensure that the number of predators (i.e., rats) are kept to a minimum. Unfavorable climatic conditions can also reduce the weevil population.

Barn Owl for Rodent Control

The increase in oil palm hectarage from 3200 ha in 1925 to 1.6 Mha in 1987, has correspondingly increased the rat population which feeds on the oil palm fruits. Rats can be controlled to some extent by using either poison bait or biological control measures. Currently, some oil palm plantations in Peninsular Malaysia are using barn owls (*Tyto alba*) to combat the rat problem. Studies conducted on oil palm estates showed that the diet of the barn owl is almost exclusively rats. An adult owl consumes at least two rats per day (Duckett, 1986). A method has been developed to increase the barn owl population, whereby nest boxes are built on tall poles which attract pairs of young birds. In due course, they produce young which also need nest boxes. When properly constructed, positioned, and maintained, the nest boxes proved to be an effective and economic investment for rodent control (Duckett and Karuppiah, 1989). Since rats are also a major pest in rice fields, research is underway to determine if the barn owl can be used effectively as a control measure. Thus far, results have been encouraging.

Honey Bee for Pollination of Coconut and Fruit Crops

The use of the honey bee (*Apis cerana*) in Malaysian agriculture started in a serious way in 1981 with the formation of the Malaysian Bee Keeping Research and Development Team, spearheaded by University of Agriculture, Malaysia. This team obtained grants from the International Development Research Centre (IDRC), Canada, from 1983 to 1986 and from 1987 to 1990. Currently, IDRC has also provided a grant for promotion of bee keeping from 1989 until 1991. About 1000 bee keepers are registered in the Malaysian Bee Keepers Association formed in 1988. Historically, the honey bee has been the natural pollinator of coconuts and, with the current intensification of bee keeping, coconut yields have increased from 30 to 50 percent. With the current increase in star fruit production, honey bees are also being used in this industry. An increase of up to 100 percent in star fruit production has been obtained due to honey bee assisted pollination (Makhdhir, 1989). A serious problem facing honey bee assisted pollination is the indiscriminate use of pesticides which can drastically reduce honey bee populations.

The future of the honey bee in Malaysian agriculture is very promising considering that the Malaysian government is expanding the fruit orchard industry which forms the basis of honey bee assisted pollination. Research is also being conducted on carpenter bees (*Xylocopa latipes*) for the pollination of passion fruit.

Conclusions

The use of agricultural waste products and natural systems have helped Malaysian agriculture in improving crop yields, production efficiency, and profitability while, at the same time, reducing the risk of major pollutants generated by the processing of agricultural crops like rubber and oil palm. The ability to use these products safely and profitably can be attributed to the research carried out by government agencies and the private sector. This research has focused on solving problems which beset the agricultural industry, and which if not solved would lead to environmental pollution of major proportions.

Research is also being conducted to determine the feasibility and practicability of using biological methods for controlling weed and pest infestations, and the use of microorganisms to improve nutrient use efficiency by crops grown on highly weathered soils.

Little actual natural farming is yet practiced in Malaysia. Although some experiments on natural farming systems have been conducted, research results so far are not encouraging. Among the various constraints and problems that limit natural farming in Malaysia are:

1) Weed infestations;
2) Insect pests;
3) Plant diseases and pathogens;
4) Infertile and unproductive soils; and
5) Weather conditions which promote weed, pest, and disease infestations.

Nevertheless, a few individuals are still trying to produce food through natural farming methods. Perhaps with the help of innovative research carried out by scientists who are dedicated to the principles of natural farming, proper and effective methods and techniques can be developed so that natural farming will one day become a reality in Malaysia.

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