Promoting Bio-Tools for Sustainable Oil Palm Management

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ABSTRACT

There is a growing concern that agriculture, as fundamental as it is to the existence of man, is also responsible for many of the environmental ills faced by the world today. Land degradation and loss of fertility caused by soil erosion is a major problem in many parts of the world, and is especially rampant in the tropics. Although agrochemicals increase production and are becoming an integral and indispensable component of modern agriculture, it is also known to cause detrimental side effects. Many plantation companies have turned to sustainable agricultural management as a reasonable step to reduce the significant negative impacts to society and the environment. In sustainable oil palm management, the use of beneficial microbes provides opportunities as bio-tools such as bio-fungicide, bio-insecticide, bio-fertiliser and bioremediation. Beneficial microbes are acknowledged for their great potential as bio-tools; yet it has not been fully exploited. There are many challenges faced in the potential utilization of bio-tools and subsequently maximizing these potentials in order to achieve sustainability in oil palm plantation industry.

KEY WORDS

Beneficial microbes, bio-control, bio-tools.

Amongst the 8 major recommendations made in the "*Manila Declaration of Green Productivity*" in December 1996, during the Special Meeting held by Asian Productivity Organization as published in its special reports "*Green Productivity: In Pursuit of Better Quality of Life*" are:

1) Industrial development to be supported by technological advancement with more focus on indigenous capacity to develop and practice application of green products and production methods that support natural conservation.

2) Reorientation of agricultural development in applying environmental friendly methods towards ensuring sustainable food and nutrition security for the growing population.
3) Major industry which contributes significantly to national income and employment need to be the leader in green productivity by demonstrating its efficiency in implementing the concept and practice.

This paper analyses the potentials of using bio-tools developed from naturally isolated microbes towards supporting these recommendations and promoting the sustainability of the Oil Palm. In addition, this paper will briefly mention selected microbial species that have these promising functions.

MICROBES

Malaysia and Indonesia are amongst the two blessed countries with mega biodiversities. There are over one million species of microbes that can be potentially harnessed from their rich microbial resources. Currently only 5-10% of these microbes have been identified and studied. Microbial Kingdom is generally divided into four different major groups of interests, which are: virus, bacteria, fungi and protista. Two more of its complicated microbial mergers are left untouched in the discussions. A brief description of each group and the differences are as listed below.

a) Virus - Made of a single strand DNA that needs a host cell to function. The one relatable to our lives is the influenza virus.
b) Bacteria - Made of a single cell, with DNA not in a special structure or nuclei. Different bacteria can live in widely varying temperatures ranging from above the boiling point to freezing water and in varying environments including fossils. Bacteria

ranges from the famous *Bacillus anthracis* that cause Anthrax, the deadly disease in cow and potential biological weapon, to the *Lactobacillus bulgariaus* that helps to turn milk into cheese, yogurt and other dairy products.

c) Fungi - Tends to be of a more complex structure, which has sexual and asexual morphological structures. Its famous traditional member is the single cell yeast that has been responsible in bread and beer making industry.

d) Protista - Made of plants like algae.

The complexities of these microbes are differentiated through their specificity in functions, host specificity and range, and are further differentiated through the level of virulence and effectiveness based on the environment in which these microbes are isolated. In the sustainable plantation management these microbes provide opportunities in the exploitation as bio-fungicide, bio-pesticide, bio-fertiliser and bioremediation. Some of the anaerobic bacteria can be utilised to reduce the chemical oxygen demand (COD) and biological oxygen demand (BOD) level of palm oil mill effluent (POME) treatment ponds in the mills, whereas the different isolates of *Metarrhizium* fungi can be used to manage rhinoceros beetle, *Oryctes rhinoceros* (L.) and termite infestations.

BIO-CONTROL

Bio-control, involves the application of one organism to control the other micro-organism. In general, it applies the concept of antagonism in which one microbe suppresses the growth of the other. The suppression can occur via it becoming predator, inhibiting the growth or out-competing the other. More broadly, the term biological control also has been applied to the use of the natural products extracted or fermented from various sources. These formulations

may be very simple mixtures of natural ingredients with specific activities or complex mixtures with multiple effects on the host as well as the target pest or pathogen. And, while such inputs may mimic the activities of living organisms, non-living inputs should more properly be referred to as bio-pesticides or bio-fertilisers, depending on the primary benefit provided to the host plant (Pal & Gardener, 2006).

Some endophytes (fungi that live within plant tissue) have been identified as vertically inherited by plants through the seeds as they provide protection against predator via production of alkaloid toxins (Clay, 2004).

The shortlisted microbes that have been demonstrated to have the potential to be efficiently developed and utilized as bio-tools in sustainable plantation management are discussed below.

Bio-control (with bio-fungicide and bio-pesticide)

Problem	Bio Control Agent	Note
Rat	*Sarcocystis singaporensis*	Protozoa
Moth	*Cordyceps militaris*	Fungus
Fusarium and Pythium	*Pseudomonas fluorescens*	Bacteria
Bag worm	*Bacillus thuringiensis*	Bacteria
Ganoderma	*Trichoderma harzianum*	Fungus
Rhinoceros beetle	*Metarhizium anisopliae*	Fungus

Bio-fertiliser

Bio-fertiliser microbes implement their functions through several mechanisms which amongst them include production of sideophores, which are binding molecules specific to certain nutrients such as iron or nitrogen (Hillel, 2005). These microbes will compete with

other non-beneficial microbes in terms of space, resources, blocking of bio-chemical pathways such as salicyclic or jasmonic acid and forming better colonization with intra and inter species of beneficial microbes.

There are reasons why these microbes have poor establishment in the tropical soils and amongst others, failure to physically establish a link with the host plant, washed away in soil run-off during heavy rain, lack of organic matters in the soil which resulting un-favorable living conditions for microbial establishment and colonized by more virulent non-beneficial microbes. Some of the microbes involved as bio-fertilisers are discussed below.

Plant growth promoting microbes

A number of organisms fall into this category. They play different roles.

- *1) Enhancing nutrient uptake/transferr* - Arbuscular Mycorrhiza Fungi (AMF)
- *2) Promoting plant growth - Trichoderma* spp.
- *3) Symbiotic nitrogen fixation - Rhizobium* spp.
- *4) Non-symbiotic nitrogen fixation* - Azotobacters
- *5) Phosphate solubilisation - P*hosphate solubilising bacteria (PSB)
- *6) Promoting plant growth – Flavobacterium, Kluyvera, Serratia*

Bioremediation

1) *Conversion of green waste into organic fertiliser*
    a. *Bacillus* spp., Actinomycetes and *Trichoderma* spp.
2) *Waste water treatment*
    a. *Azospirillum* spp.
3) *Establishment of Oil Palms in sandy, dry and arid areas*
    a. Arbuscular Mycorrhiza fungi

PROBLEMS AND POTENTIALS

There is huge potential for the use of the microbial resources. However, though the potential is acknowledged it is yet not fully exploited. What are the challenges facing the potential exploitation? How can we maximise and leverage on these potentials in order to achieve sustainability in the plantation industry? Some aspects are:

1) Among the challenges facing the development of the bio-tools are the capabilities to isolate and taxonomically identify them. There is a need to foster better collaborations between the local and international scientists in order to enable sharing of taxonomic expertise and facilities.

2) Isolates with poor virulence and effectiveness hamper the development of potential products. Further research and acclimatization of these microbes need to be done by the developer in order to have significant effectiveness and field efficacy for these microbes.

3) Formulating these microbes into a product requires understanding over formulation skills as there is a need to develop a stable product that ensures the shelf life, viability, purity and efficacy of these microbes over certain shelf life.

4) Logistics post another challenge as some of the microbial products are quite sensitive to the period required to transport them and extreme heat in the containers should they be transported *via* sea cargo. There is therefore heavier reliance for air cargo for some of these microbial products.

5) There is also a need to review the delivery systems to suit the field conditions and cultural practice, as different apparatus and timing need to be employed when applying these microbes as it cannot be applied together with other chemical products.

6) Distribution of bio-fertiliser *via* bio-organic fertiliser programme provides amongst the best method of delivery to distribute the microbial population to the field.

7) Lack of certified microbiological labs with the ability to access the genuineness and purity of these microbial products. Often the buzz words used by the manufacturer is "We are keeping our microbes as secrets!". There is a need to have a more transparent working arrangement between user and manufacturer when dealing with these microbial based products. The manufacturer needs to supply proper Material Safety Data Sheet (MSDS) and provide protocol as Quality Control Assessment Method (QCAM) specific to the supplied products in order for the clients to objectively access the quality of the products.

8) Transfer of microbes cross continents need to be fully regulated and monitored by all stakeholders as beneficial microbes in another area might be a potential pathogen in others due to induced mutation by the environmental and chemical stress.

9) Developing the right and optimum dosage of microbial products to the field application is a unique challenge; it requires a continuous research and development for an on-going incremental enhancement of product effectiveness and efficacy.

10) Globally, the technology involved in production of beneficial microbes are still being further refined and developed by the players. It tends to be specific as there are criteria for growth environment and conditions for these microbes are different.

The following are important properties of a good microbiological product:

1) The microbes are viable.
2) Quantity or units of the active ingredient can be quantified on the basis of weight or volume.
3) Declaration of any `helper microbes' or contaminants.
4) Particle size (if required).
5) Moisture content.
6) Species declaration.
7) Host specificity.
8) Proper QCA Protocol.

CONCLUSION

Effective and quality microbial products have promising future as they are less dependent on the oil and gas sector and practically manageable renewable resources and often produced in good controlled environment and quality monitoring. Proper quality control assessment (QCA) can be made available by suppliers to the users in order to determine viability and overall quality.

The concept of soil health with optimal microbial community population need to be seriously considered in order to continue to benefit from the same area for years to come. Beneficial microbes can be efficiently integrated in the cultural practice of plantation

management without sacrificing the overall productivity. A more proactive efforts in determining best practices by integrating these bio-tools and current methods need to be seriously considered for the economical and environmental benefits of the plantation industry.

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