Requirement of Environmental Friendly Plant Protection approaches for a Sustainable Rubber Plantation Industry in Sri Lanka

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Introduction

Natural Rubber is very significant in our economy. It makes export earning, provides livelihood for thousands of people, supplements thousands of hectares to the forest cover and provides many socio-economical and ecological benefits. In terms of ecological benefits, rubber plantations contribute thousands of hectares as a forest crop that ultimately results in environmental sustainability. Furthermore the cultivation is being expanded in to nontraditional areas and therefore future expectations are much more.

Over the next two decades, the increase in crop production will be essential to meet the rising needs of the world. Measures should be adopted without causing much harm to the environment. The government of Sri Lanka is encouraging towards a green agriculture and therefore needs to identify alternative methods to manage harmful disease conditions of economically important agricultural crops. Hence plant protection approaches should be developed to suit the future prospects making the processes more environmental friendly. Integrated pest management (IPM) is the ideal concept for sustainable disease management. For this chemical, biological, and agronomic controlling systems play equally important roles. For the development of IPM systems for rubber plantations, biopesticides play an important role.

Generally biopesticides are found in nature and are made of living things. Biopesticides make less risk to the environment than the chemical pesticides (Villasenor *et al*., 2012). Currently, biopesticides fulfill approx. 5% share of the global chemical pesticide market. The use of biopesticides is hindered mainly by the high cost, slow action and short supply. Their biodegradable nature and low toxicity levels make them important. They are also specific in action, causing less pest resistance issues. Use of biopesticides in sustainable agriculture provides social acceptability, sustainable economic productivity fascilitating environmental stewardship. At the same time, sudden changes in the protection products from chemical pesticides to biopesticides may have implications short-term or long-term. Intensive agricultural programmes that have been conducted for long periods have influenced the naturally inhabiting microbe populations especially in agricultural soils. Most of our agricultural soils are "sick" in nature due to the prevailing intensive agricultural practices. Hence the rehabilitation process should be undertaken slowly reducing the chemical usage and promoting the application of biological agents. In biological agricultural systems, the short-term benefits are always less but there are long-term benefits.

Biopesticides consists of naturally occurring organisms or compounds that suppress the growth of pests. They are classified into three main groups;

- Microbial biopesticides
- Biochemical biopesticides
- Plant incorporated protectants (PIPs)

Microbial biopestices

Micro-organisms such as bacteria, fungi, viruses and protozoa are generally used as biopesticides. They are more targeted in action. Some common microbial biopesticides are entamopathogenic fungi, *Beauveria bassiana* or *Trichoderma species*. These biopesticides are targeted for plant pathogenic bacteria, fungi, insects and weeds. One of the most widely used microbial biopesticide is the insect pathogenic bacteria - *Bacillus thuringiensis* (Bt). There are other entamopathogenic Baculoviruses and fungi. At least 170 different biopesticide products based on entomopathogenic fungi like *Beauveria bassiana* or *Metarhizium anisopliae* have been developed. Microbial biopesticides based on different *Trichoderma* spp. are active against *Rhizoctonia*, *Pythium*, *Fusarium*, *Rigidoporus* and other soil-borne pathogens while specific strains of *Bacillus subtilis*, *Pseudomonas fluorescens* and *Pseudomonas aureofaciens* are being used against a range of plant pathogens including damping-off and soft rots. Microbial antagonists, including yeasts, filamentous fungi and bacteria are also used as control agents of post-harvest diseases. On the other hand, plant pathogens are being used as microbial herbicides. Two products, 'Collego' (*Colletotrichum gloeosporioides*) and 'DeVine' (*Phytophthora palmivora*) are already used in the USA (Onilude & Seyi-Amole, 2018).

Biochemical biopesticides

Biochemical biopesticides include plant materials like essential oils, semiochemicals, plant growth promoting regulators, insect growth regulators. They tend to control pests without killing them. For example, they may repel pests, disturb their mating or growth of secondary metabolites or natural minerals. Plants produce a wide variety of secondary metabolites that prevent herbivores from feeding on them. Some have been identified to be used as biopesticides. The most widely used botanical compound is neem oil, an insecticidal chemical extracted from seeds of *Azadirachta indica.* A semiochemical is a chemical signal produced by one organism that causes a behavioural change in an individual of the same or a different species. The most widely used semiochemical for crop protection are insect sex pheromones, some of which can now be synthesized and are used for monitoring or pest control by mass trapping

Plant incorporated protectants (PIPs)

PIPs are transgenic plants. The genes are introduced into plants by genetic engineering so that they are capable in protecting themselves from pests.

Advantages of biopesticides

Biopesticides have a range of attractive properties that make them good components of disease controlling (Mitchell & Dix, 1975; Singh *et al*., 2012). Most are selective, produce little or no toxic residue, and development costs are significantly lower than those of conventional synthetic chemical pesticides. Biopesticides can be applied with spray equipment and many biopesticides are suitable for local scale production.

- Chances of developing resistance is less compared to the chemical pesticides since they show multiple modes of actions against targeted pests
- The environmental negative impacts like pesticide related pollutions, bioaccumulation of chemicals, biodiversity losses, insurgence of secondary pests and elimination of natural beneficial enemies are less with the use of biopesticides
- With the prohibitive restrictions towards the synthetic pesticides, biopesticides have become beneficial
- Low toxicity properties
- Slight negative impacts on non-target organisms or humans
- Biodegradable
- No postharvest contaminations
- Stability against abiotic stresses
- Compatibility in integrated pest management (IPM)

Limitations of Biopesticides

The disadvantages of biopesticides include a slower rate of controlling compared with the conventional chemical pesticides, shorter persistence in the environment and susceptibility to unfavourable environmental conditions. Because most of the biopesticides are not as effective as conventional chemical pesticides and also they are not suited for use as stand-alone treatments.

- High cost
- Inability to meet market demand
- High specificity which may require an exact identification of the pest/pathogen and the use of multiple products to be used
- Susceptibility towards environmental factors
- Slow action
- Some biopesticides showing effects on beneficial organsisms
- Users need more knowledge to use biopesticides effectively.

Prospects of Biopesticides

IPM is a pest-control option, equivalent to an effective multi-faceted approach involving the combination of cultural, chemical and biological practices and other suitable control tactics into one management program to achieve a long-lasting reduction of pest population. The limitations are to be addressed through research breakthroughs in the coming years as research and developmental activities related to biopesticides have received more attention during the past.

Challenges and opportunities for Integrated Pest Management (IPM)

Integrated pest management tool is the most efficient disease controlling strategy in the world.

The chemical controlling methods are very popular among the growers and the other agronomic practices and physical methods are too familiar among the growers. Use of biopesticides in the management of diseases have been restricted only to laboratory or protected house conditions in many countries. Improvement of productivity levels is of importance for the sustainability of the agriculture and one way to increase is to effective management of pests. There are around 67,000 different crop pest species in the world and it has been estimated that together they cause about 40% reduction in the world's crop yields, even though improved plant varieties, plant protection, plant nutrition, and other stimulants have increased the yields by nearly 70%. The use of synthetic pesticides has increased significantly during the recent past owing to, injudicious use of broad spectrum pesticides affecting human and environment health, prophylactic use of pesticides excessively poses the development of heritable resistance

There is an urgent requirement for alternative methods for the sustainability of crop protection. Hence IPM is promoted as the best way forward as different crop protection practices are combined with careful monitoring. Therefore the shortcomings of individual methods are reduced. The overall aim would be to not to eradicate pest problems but managing them below levels that cause economic damage. Some of the approaches are given below;

- Use of synthetic chemical pesticides
- Use of resistant cultivars
- Crop practices such as crop rotation , intercropping
- Physical methods
- Natural products like plant extracts
- Biological control measures

Economically important diseases of rubber plantations

Today, the rubber tree is susceptible to many foliar diseases. Powdery mildew, Colletotrichum leaf disease, Corynespora leaf fall disease and Phytophthora leaf disease are the economically important diseases. A new leaf fall disease is also spreading in many rubber growing countries posing a threat to the rubber plantation industry. Most of the rubber clones show resistance towards the stem and panel diseases and hence currently they do not play an economic factor for the industry. Three root diseases such as white, brown and black root diseases play a major role in the rubber plantations. White root disease is more prevalent in the wet rubber growing areas and shows a rapid spread resulting poor tree stand leading to reduced yield levels in rubber plantations. This pathogen shows a wide host range as well fascilitating the spread in agricultural lands (Fernando and Madushani, 2013). Brown root disease is found more in non-traditional rubber growing areas of the country since the disease is associated with forestry crops. Black root disease is present in the district of Kegalle and incidence is very rare. In spite of the fact that the correct land clearing techniques play a main role in the prevention of the root diseases, chemical controlling methods are very popular among the growers. As a result of extensive research programmes, the use of chemicals against diseases has been reduced to a minimum. Growers are requested to adopt integrated disease management systems as much as possible. Disease resistant clones have been introduced for almost all the economically-important leaf diseases as the most long-term and effective strategy in managing diseases.

Table :- 1 Economically important diseases of rubber plantations and their causative agents

Plant Part	Disease	Causative agent
LEAF DISEASES	Powdery mildew	*Oidium heveae*
	Colletotichum leaf disease	*Colletotichum* spp.
	Corynespora leaf fall disease	*Corynespora cassiicola*
	Phytopthora Leaf Fall disease	*Phytophthoro* spp.
STEM DISEASES	Phytopthora bark rot	*Phytophthoro* spp.
	Ustulina stem rot	*Ustulina deusta*
	Pink disease	*Corticium salmonicolar*
ROOT DISEASES	White root disease	*Rigidoporus microporus*
	Brown root disease	*Phellinus noxius*
	Black root disease	*Xylaria thwatsii*
	Patch canker disease	*Pythium spp. & Fusarium spp.*

Recent developments to introduce native biopesticides

Antagonistic fungi isolated from rubber growing soils showed effectiveness in biological controlling the most destructive root disease in Sri Lankan rubber plantations, white root disease caused by the fungus of *Rigidoporus microporus*, the causative agent of the white root disease (Jayasuriya and Thennakoon, 2007; Kaewchai & Soytong, 2010). Among the twenty three antagonistic fungi isolated for biological controlling the pathogen, three fungal species were identified as most effective. *Trichoderma* spp. was proven to effective in controlling the pathogenic fungus and mode of actions have also been identified. The diffusible metabolites and fungal cell wall degrading enzymes, volatile metabolites also contributed to control the pathogen. Increase of available phosphorus level is an additional benefit that can be gained by these antagonistic fungi to overcome the phosphorus deficiency in the soil. Combinations of these isolates may increase the effectiveness. Indole Acetic Acid is an important phytohormone which has significant impacts to stimulate and facilitate plant growth. The selected fungi show the production of IAA also.

According to the results from the trials, the highest effectiveness was recorded by two native fungi; *Trichoderma koningi* and *H. lixii* (teleomorph of *Trichoderma harzianum*). *Trichoderma* isolates form symbioses with plant parts especially the roots, playing an important role in plant growth, yield, nutrient cycling and energy conversion in soil (Halifu *et al.*, 2019). Moreover, several mechanisms of *Trichoderma* include root colonization, solubilization of the minerals, increasing the availability of insoluble nutrients and therefore plant nutrient uptake, secretion of plant growth regulatory materials, vitamins and enzymes. The two biopesticides after conducting the trials to show the effectiveness have been forwarded to the Registrar of Pesticides for registration. The use will reduce the chemical pesticide usage in the country.

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