The Potential of Biological Management of Basal Stem Rot of Oil Palm: Issues, Challenges and Constraints

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ABSTRACT

Biological control of basal stem rot of oil palm can be achieved through the use of a highly effective biocontrol strain of *Trichoderma* spp. The strain must not only have the appropriate mechanisms for biocontrol, such as antibiosis and mycoparasitism, but also a strong competitive ability to displace *Ganoderma* so as to minimize the pathogen’s opportunity for colonization. It must be able to compete and persist in the environment in which it will operate, and be able to colonize and proliferate on existing and newly formed roots well after application.

ABSTRAK

Kawalan biologi reput pangkal sawit boleh dicapai melalui penggunaan strain *Trichoderma* spp. yang berkesan. Strain ini bukan sahaja mempunyai mekanisme kawalan biologi yang sesuai seperti antibiosis dan mikoparasitisme tetapi juga mempunyai kebolehan untuk bersaing yang kuat supaya dapat menjauhan *Ganoderma* dan mengurangkan keupayaan patogen untuk menjajah perumah. Ia mesti boleh bersaing dan membiak di atas akar yang sedia ada dan yang baru dibentuk pada tempoh yang lama selepas rawatan.

Keywords: basal stem rot, *Trichoderma* spp., management strategy.

INTRODUCTION

Although basal stem rot (BSR) of oil palm was recorded in this country as early as 1928, it was not until oil palm was planted on areas containing old coconut plantations, and subsequently in second and third generation oil palm, that it became of economic importance. However, despite over 20 years of research, the control measures have continued to produce inconsistent and sometimes conflicting results, and BSR still remains a silent but fatal enemy of oil palm, resulting in decreases in oil palm stands and yield. Thus, production is uneconomic. What makes the current control practices of clean clearing, tree surgery and chemicals ineffective and short-term?

ISSUES

Clean clearing practices are based on the assumption that infection occurs by mycelial spread from root to root and that removal of infected debris will eliminate any residual inoculum. However, long-range disease dispersal, with spores spread by wind or vectors, has been strongly implicated (Sanderson et al., 2000) and supported by earlier evidence by independent researchers (Ariffin et al., 1996; Miller et al., 1994). This has raised doubts on the efficiency of this approach, with evidence from a number of oil palm estates suggesting that infection can still become established progressively earlier with each planting cycle. Therefore, the success or failure of the control strategy not only depends on the actions being taken during the replanting cycle, but concurrently, how well control is being maintained in all the other facets of plantation management and surrounding vegetation.

Attempts in the use of fungicides for BSR control in the field have not been successful, although *in vitro* screening has identified chemicals effective against *Ganoderma*. The inadequacy of *in vitro* screening has prompted research into possible *in vivo* screening assays (Sariah et al., 1999), where the movement of fungicides within infected and healthy tissues can be monitored. However, this approach is limited by the fact that both visibly infected and sub-clinical palms may already harbour established infections by the time treatment is applied.

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Since the implementation of the control strategy has to be maintained throughout the growing cycle of the oil palm plant - replanting, establishment and growing cycle - alternative approaches need to be explored. The success of biological control for numerous pathosystems has shifted the interest of researchers to explore the potential of BSR control through manipulation of saprophytic antagonistic microorganisms. This can be achieved through conservation or augmentation so that the strong competitive ability of non-pathogenic microorganisms can displace Ganoderma so as to minimize the pathogen’s opportunity for colonization. This has led to many reports of potential antagonistic fungi against Ganoderma. Their mechanisms of action have been well studied in vitro and conditions for culturing optimized (Sariah and Zakaria, 2000; Soepena and Purba, 1998; Purba et al., 1996). However, experimental evidence of the actual mode and method of operation of this type of control in the field, especially with respect to the oil palm pathosystem, has been scarce. The most studied fungi are species aggregates of Trichoderma, although Aspergillus and Penicillium have also been implicated, but none of these agents has been used in practice successfully to control BSR so far.

Trichoderma spp. are fungi that are present in substantial numbers in nearly all agricultural soils and in other environments such as decaying wood. Among their activities, they grow tropically towards the hyphae of other fungi, coil around them in a lectin-mediated reaction and degrade cell walls of the target fungi. This process limits the growth and activity of plant pathogenic fungi. In addition to, and sometimes in conjunction with mycoparasitism, individual strains may produce antibiotics, or are good competitors for nutrients and space. Figure 1 shows a hypha of Trichoderma in relation to the hypha of a pathogen.

CHALLENGES

In spite of the numerous observations and reports on antagonistic fungi and their potential as bioagents of Ganoderma, what are the barriers to the progress from petri dish microcosm and pot trials to practical field application? Our earlier work demonstrated that Trichoderma spp. have the ability to control fungal pathogens such as Sclerotium rolfsii, Pythium sp., Rhizoctonia solani and Fusarium sp. However, the level of efficacy and the reliability of simple approaches to biocontrol that were comparable to or less than those of fungicides. Biocontrol systems, therefore, must be developed based on pathosystems if effective results are to be obtained. A series of studies have been conducted related to the practical implementation of Trichoderma for controlling BSR, and some of the results will be presented for discussion.

Population Dynamics of Trichoderma spp. in Oil Palm Ecosystem

Trichoderma spp. can be used for biological control through their conservation or augmentation in a particular environment rather than by introduction of new species. The choice of these approaches is in part because there is usually a diverse set of species already associated with the plants. These species can provide substantial opportunity for the development of the resident species as competitors or antagonists to Ganoderma. A study on the population dynamics, its distribution and frequency of occurrence was conducted on two different sites. There was a positive correlation between the population of Trichoderma and the age of the palms, disease incidence and soil profile. Trichoderma spp. were significantly more abundant in mature fields with high disease incidence than in younger plantings with no/low disease incidence. Distribution was concentrated in the first 0-60 cm in the magnitude of 10^3/g air-dry soil. Inland soil and jungle soil tend to harbour larger populations of Trichoderma than coastal soils. Does this mean that the population of antagonistic Trichoderma in the oil palm ecosystem is generally low and not sufficient to produce the desired effects?

Augmentation is based on mass culturing of indigenous species/isolates and adding them to the soil to increase the numbers or to modify the distribution in the system. To do this, a highly effective biocontrol strain must be obtained which is able to compete and persist in the environment in which it will operate, and colonize and proliferate on newly formed roots well after application.

Strain Specificity

Four species aggregates (T. harzianum, T. virens, T. koningii and T. longibrachiatum) were present in all the areas sampled, with T. harzianum and T. virens being predominantly more abundant. We confirmed the variability within the species aggregates based on DNA polymorphism and this phenomenon had a significant influence on its biological activity.
against Ganoderma. A few strains were very powerful as plant growth promoting fungi (PGPF) and bioprotectants, but some were moderate in their ability and/or effective only in compatible hosts and environmental conditions. Specificity of Trichoderma has been a deterrent to its commercial use. This reflects the lack of accuracy of agar plate screening and the need for in vivo screening. Secondary screening by modifying the technique used in pathogenicity testing was found to be more reliable than agar testing. However, this is very time consuming, especially when attempts are made to ensure that the environmental conditions simulate the field conditions in which they are ultimately expected to work. However, the major difficulty is to demonstrate the efficacy of treatments in an environment where biological variation within sites and between seasons confounds the standards of trial design and statistical analysis.

Rhizosphere Competency

Rhizosphere competency is defined as the proliferation of microorganism in, on and around roots. It includes the dispersal of microorganisms from a source of inoculum to the actively growing roots, and multiplication or growth in the rhizosphere. Information on the distribution and establishment of Trichoderma on the oil palm roots (root colonization process) would enable effective management of the rhizosphere population to achieve biological control of BSR. Using the most promising strain, it was found that the rhizosphere competency decreased with an increase in distance of the roots from the point of application of the bioagents. Since Trichoderma is applied outside the plant, and its mode of action is through competition and parasitism (Figures 1 and 2), its ability to disperse from the source of inoculum to the actively growing roots and to proliferate on or around the roots will determine its efficiency as a potential bioagent. A potential biocontrol candidate based on primary and secondary screening may not perform as expected when tested in field conditions.

Delivery System

To be effective, biological control of BSR depends not only on a suitable effective Trichoderma strain, but also on the methods and strategies for introducing and maintaining the population level and activity of the organism in association with the palms. There will be a sudden drop in the population of Trichoderma augmented into the soil in the form of conidia and mycelium (30%-40%), and the population will be maintained at most for about 10-12 weeks, after which it will reach equilibrium of around $10^2$-$10^3$ just like in normal agricultural soils. Soil factors (pH, moisture, texture etc.) are assumed to have an influence; however, we do not have data to substantiate this hypothesis. However, the use of desiccation-tolerant propagules of Trichoderma together with appropriate food bases (soil amendments) improves the survival rate of the introduced inoculum. This production system is currently being optimized. One of the major requirements for the successful development of Trichoderma as a biofungicide is the large-scale production of fungal propagules with good shelf life and desiccation-resistance. The production system must also be inexpensive.

FUTURE PROSPECTS OF BIOLOGICAL CONTROL OF BASAL STEM ROT (BSR)

Biological control holds the solutions to BSR disease problems affecting oil palm and to the needs for environmental protection of natural ecosystems. The ecological principles which underlie the contributions of biological control to both managed and natural ecosystems do not change with the passage of time. They are basic to the interactions between species and are inherent in the structure of the ecosystems. A formidable global problem – environmental pollution, will necessitate alternative plant pest management strategies. Biological control agents have an added feature that can be exploited. Many promote plant growth, and the additional increments of growth can compensate for the cost of application.

Since the greatest practical significance for the control of Ganoderma in oil palm are (i) during/soon after planting and the establishment period, and (ii) later in the planting cycle, control of BSR has to be approached on a more holistic manner. Biological control would be effective during the early phases of planting and establishment followed by chemicals for sustainable control. Sanitation and good cultural practices apply to all phases of the growth cycle.

Even though biological control might not be the key answer to managing BSR, it can play an important role where there is limited success with other methods of control. Trichoderma survives as chlamydospores under unfavourable conditions, and is fairly resistant to common fungicides and herbicides. Research on manipulation of resident antagonistic species
Figure 1. Light microscopy micrograph showing the hypha of Trichoderma (T) growing along the pathogen's hypha (G) and attaching itself through the production of hook-like structure.

Figure 2. SEM micrograph showing Trichoderma (T) coiling around the pathogen's hypha (G) producing appressoria-like structure as penetration pegs, 72 hr of co-incubation.
through soil amendments, apart from augmentation, should be done simultaneously in an attempt to define the optimum delivery and application methods so that biocontrol agents grow well to achieve their purpose.

REFERENCES


