

Biological control agents (BCA) using fungal antagonists have gained considerable attention as a viable alternative to chemical control (Papavizas, 1985). *Ganoderma* disease can be controlled by many species of beneficial microbes including fungi, bacteria and actinomycetes.

In vitro study showed that a pure culture of the endophytic fungus *Phlebia* GanoEF3 was capable in inhibiting the growth of *Ganoderma boninense* and effectively used in controlling *Ganoderma* infection in oil palm seedlings (Noor Haida and Idris, 2009). A further study was conducted to develop *Phlebia* GanoEF3 into a powder formulation for controlling *Ganoderma* disease in oil palm.

PREPARATION OF *Phlebia* GanoEF3 POWDER

Formulation of *Phlebia* GanoEF3 powder was conducted based on the method described by Nasyaruddin and Idris (2011) with modifications. The *Phlebia* GanoEF3 powder was prepared using vermiculite as a carrier for nutrient supply. Fungal spores were propagated in liquid media consisting of potato dextrose broth (PDB). The concentration of spores was determined with a haemocytometer prior to powder preparation. The inoculation of 10^8 colony forming unit per millilitre (CFU ml⁻¹) of *Phlebia* GanoEF3 was added into the carrier and mixed well under sterile condition (Figure 1).

QUALITY OF *Phlebia* GanoEF3 POWDER

The quality of *Phlebia* GanoEF3 powder was reported in terms of fungal population as colony forming units per gramme (CFU g⁻¹). The viability test of *Phlebia* GanoEF3 in the powder formulation during storage was assessed *in vitro* at monthly intervals. The initial population of the fungus in the powder formulation was 10^8 CFU g⁻¹. After three months storage, the population remained at 10^8 CFU g⁻¹. After four months, the viability of

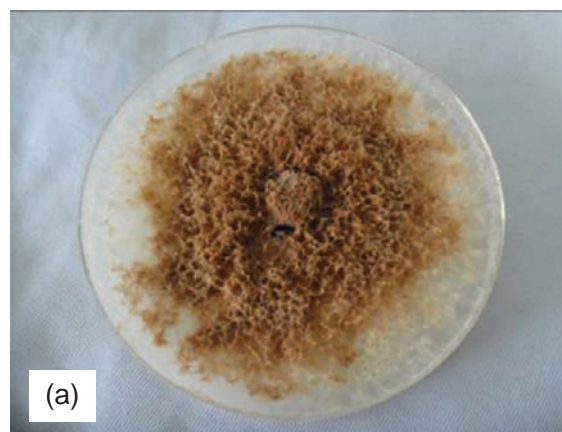


Figure 1. *Phlebia* GanoEF3; pure culture on potato dextrose agar (PDA) (a), powder formulation (b).

Phlebia GanoEF3 in the powder formulation declined to 10^7 CFU g⁻¹ and after seven months to 10^6 CFU g⁻¹.

BENEFITS OF *Phlebia* GanoEF3 POWDER FORMULATION

- Effectively controlling *Ganoderma* disease in oil palm.
- Easy application.
- Extended shelf-life as the microbial cells continue to grow and multiply since the favourable nutrients are maintained.
- Easy storage.

NURSERY EVALUATION OF *Phlebia GanoEF3* POWDER AGAINST *Ganoderma boninense*

The efficacy of *Phlebia GanoEF3* powder in controlling *Ganoderma* disease was evaluated based on nursery trial conducted over 10 months (Figure 2). At six months of artificially infected with *G. boninense*, seedlings treated with *Phlebia GanoEF3* powder showed a significant lower percentage of disease incidence (DI) at 42.2% compared with untreated seedlings at 95.6%. Disease assessment was monitored based on the percentage of severity of foliar symptoms (SFS). The *Phlebia GanoEF3* powder treated to oil palm seedlings significantly reduced the percentage of SFS with a value of 50.7% compared with uninoculated seedlings with SFS of 90.7%. Dead seedlings in the untreated was significantly higher at 90% compared with the seedlings treated with *Phlebia GanoEF3* powder at 40%.

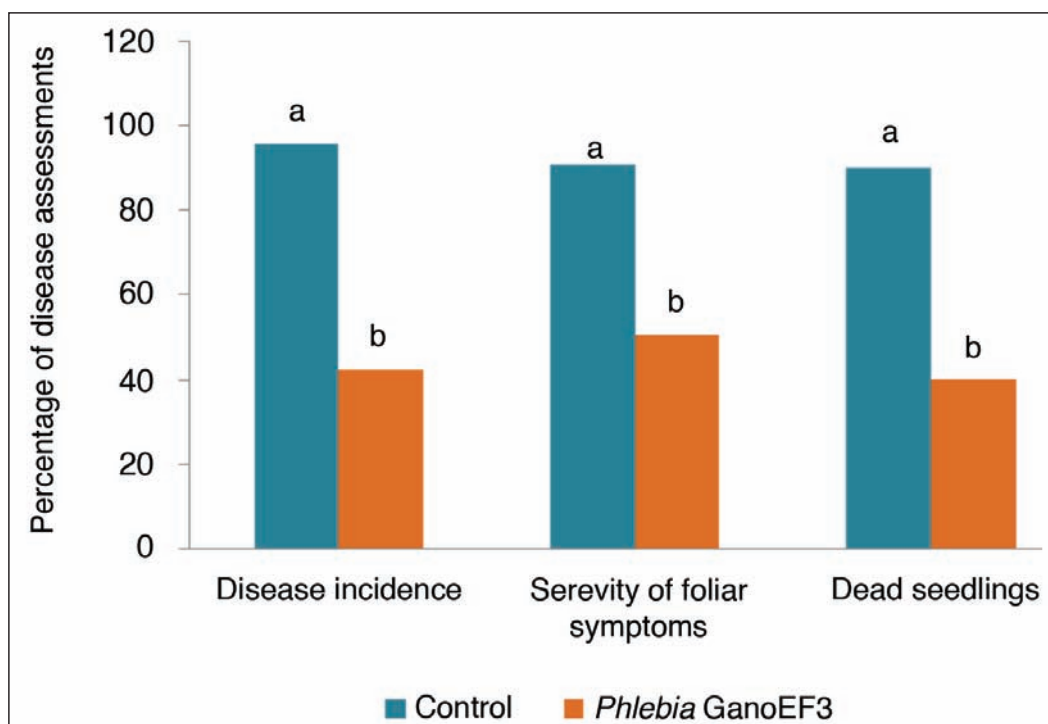
Effectiveness of *Phlebia GanoEF3* powder in controlling basal stem rot (BSR) is shown in Table 1. The area under disease progress curve (AUDPC) values suggest the severity of disease developed in each treatment. The seedlings treated with *Phlebia GanoEF3* powder

gave an AUDPC of 100.0 compared with that of the untreated seedlings of 191.1. A reduction of 47.7% in BSR disease incidence was observed in seedlings treated with *Phlebia GanoEF3* powder compared with the control.

TABLE 1. EFFECT OF *Phlebia GanoEF3* POWDER ON BASAL STEM ROT (BSR) DISEASE DEVELOPMENT IN OIL PALM SEEDLINGS AT SIX MONTHS AFTER TREATMENT

Treatments	AUDPC [#]	DR ^{##} (%)
Seedlings untreated with <i>Phlebia GanoEF3</i> powder and inoculated with <i>G. boninense</i> (control)	191.1	-
Seedlings treated with <i>Phlebia GanoEF3</i> powder and inoculated with <i>G. boninense</i>	100.0	47.7

Note: [#]area under disease progress curve.
^{##}Disease reduction.



Note: means within a group with different letters are significantly different at $p < 0.05$ according to t-test.

Figure 2. Disease incidence (DI), severity of foliar symptoms (SFS) and dead seedlings (DS) due to *Ganoderma boninense* infection at six months after treatment.

ECONOMIC ANALYSIS

The fixed cost of a pilot plant for producing *Phlebia* GanoEF3 powder is estimated at RM 5 200 000. The payback period is four years, with an internal rate of return (IRR) of 12%, while the net present value (NPV) at 10% discount rate is RM 320 646.38. The benefit: cost ratio (B:C) for the discount rate of 10% is 1.45 and the return on the investment (ROI) is 32.46%. As the B:C is >1, the NPV is positive and IRR is greater than the opportunity cost of capital; the investment is financially feasible.

CONCLUSION

This study showed that *Phlebia* GanoEF3 powder significantly suppressed BSR disease development *in vitro* and effective in controlling *Ganoderma* disease in oil palm.

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