

Biological control is among the options apart from fungicides in controlling phytopathogen. Many species of microorganisms including actinomycetes, bacteria and fungi have the ability to be an effective control agent of plant disease. The use of *Streptomyces* as biological control agent of *Ganoderma* disease is of interest. The *Streptomyces* genus in actinomycetes group showed a high inhibition percentage towards *Ganoderma boninense* *in vitro* through antibiosis and the lysis of hyphae resulting in abnormal hyphae growth (Tan *et al.*, 2002).

The *Streptomyces* spp. was proven to inhibit the growth of *G. boninense* *in vitro* (Shariffah-Muzaimah *et al.*, 2011). MPOB has developed a powder formulation of *Streptomyces* GanoSA1 for controlling *Ganoderma* disease in oil palm.

BENEFITS OF *Streptomyces* GanoSA1 POWDER

- Effective in controlling *Ganoderma* disease of oil palm.
- Cost-effective.
- Easy handling and storage.
- Environmental-friendly technology.

PREPARATION OF *Streptomyces* GanoSA1 POWDER

The *Streptomyces* GanoSA1 (Figure 1) was grown in an enriched medium at 28°C for seven days with agitation. The *Streptomyces* GanoSA1 culture was added into carrier at 10⁸ colonies forming unit per millilitre (CFU ml⁻¹) and mixed well under sterile conditions. The *Streptomyces* GanoSA1 powder was prepared using vermiculite as a carrier for nutrient supply and stored at room temperature.



Figure 1. *Streptomyces* GanoSA1: (a) pure culture, (b) powder formulation, (c) product packaging.

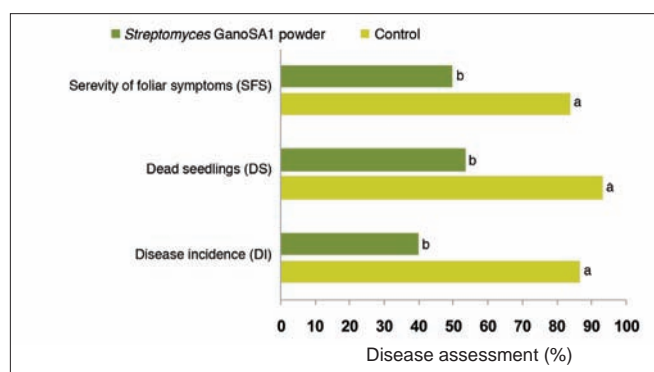
QUALITY OF *Streptomyces* GanoSA1 POWDER

The quality of *Streptomyces* GanoSA1 powder was determined in terms of colony forming unit per gramme (CFU g⁻¹) of *Streptomyces* population up to nine months in room temperature (27±2°C). The viability of the powder formulation remained at 10⁶ CFU g⁻¹ after six months and reduced to 10⁵ CFU g⁻¹ after nine months of storage.

NURSERY EVALUATION OF *Streptomyces* GanoSA1 POWDER AGAINST *Ganoderma boninense*

Streptomyces GanoSA1 powder was examined for its efficacy as a biological control agent (BCA) and in disease control in oil palm seedlings against *G. boninense*. The effectiveness of formulated powder in controlling basal stem rot (BSR) development in oil palm seedlings was evaluated based on quantitative assessment measured as percentage of disease incidence (DI), percentage of severity of foliar symptoms (SFS), percentage

of dead seedlings (DS) and percentage of disease reduction (DR). The study was performed for 10 months. At six months after treatment, *Streptomyces* GanoSA1 powder was able to significantly reduce the DI with 53.3% compared with untreated seedlings with 93.3% (Figure 2). For SFS, seedlings treated with *Streptomyces* GanoSA1 powder showed significant different with 49.7% compared to untreated seedlings with 83.8%. The seedlings treated with *Streptomyces* GanoSA1 powder recorded significantly lower percentage of dead seedlings at 40.0% compared to untreated seedlings with 86.7%.



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.

Disease development was evaluated using area under disease progress curve (AUDPC). The AUDPC values indicate the amount of disease developed in each treatment in which, the lowest AUDPC value indicate the effectiveness of BCA in reducing the disease. The ability of the BCA to reduce *Ganoderma* infection was expressed as the percentage of disease reduction (DR) calculated from the values of AUDPC. About 59.8% of BSR disease incidence was reduced in treated seedlings with *Streptomyces* GanoSA1 powder compared to the untreated seedlings (Table 1).

ECONOMIC ANALYSIS

The fixed cost of a pilot plant for producing *Streptomyces* GanoSA1 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.

TABLE 1. EFFECT OF *Streptomyces* GanoSA1 POWDER ON BASAL STEM ROT (BSR) DISEASE DEVELOPMENT IN OIL PALM SEEDLINGS AT SIX MONTHS AFTER TREATMENT

Treatments	AUDPC [#]	DR ^{##} (%)
Seedlings untreated with <i>Streptomyces</i> GanoSA1 powder and inoculated with <i>G. boninense</i> (control)	273.3	-
Seedlings treated with <i>Streptomyces</i> GanoSA1 powder and inoculated with <i>G. boninense</i>	110.0	59.8

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

CONCLUSION

The powder formulation of *Streptomyces* GanoSA1 has the ability in inhibiting the growth of *G. boninense* *in vitro*, and effectively reduced *Ganoderma* infection in oil palm.

REFERENCES

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- SHARIFFAH-MUZAIMAH, S A; IDRIS, A S; DZOLKHIFLI, O; KAMARUZZAMAN, S; PETER-CHEONG, C H and SATOSHI, N (2011). Isolation of potential actinomycetes from oil palm (*Elaeis guineensis*) plantations as biological control of *Ganoderma* disease. *Proc. of the Third MPOB-IOPRI International Workshop Seminar: Integrated Oil Palm Pests and Disease Management*. p. 192-196.

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