Pseudomonas GANOEB3 POWDER FOR THE CONTROL OF *Ganoderma boninense* IN OIL PALM

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Basal stem rot (BSR) disease in oil palm, caused by *Ganoderma* species, is considered the most destructive disease in the oil palm industry in Southeast Asia (Susanto *et al.*, 2005; Idris, 2009). The efficacy of bacteria from the genera *Pseudomonas* and *Burkholderia* in controlling *Ganoderma boninense* has been reported (Sapak *et al.*, 2008; Bivi *et al.*, 2010; Idris *et al.*, 2010). Maizatul and Idris (2009) reported that a pure culture of the endophytic bacterium *Pseudomonas syringae*, also called *Pseudomonas* GanoEB3, has the capability of inhibiting the growth of *G. boninense in vitro*, and is effective in controlling *G. boninense* infection in oil palm seedlings. However, the utilisation of a bacterial cell suspension is impractical for large-scale field application due to difficulties faced during storage, transport and handling (Vidhyasekaran *et al.*, 1997). The application technique in the delivery system is crucial in the field, and can reduce the effectiveness of the bacteria as a biocontrol agent against *Ganoderma* disease. This article reports the efficacy of *Pseudomonas* GanoEB3 powder in controlling *Ganoderma boninense* in oil palm seedlings.

BENEFITS OF *Pseudomonas* GanoEB3 POWDER

- Effective control of BSR disease in oil palm.
- Easy application technique – by direct contact with the root system.
- Ability to support good growth and survival of bacteria.
- Easy handling and storage.
- Environmental friendly technology.

BASIC PREPARATION OF *Pseudomonas* GanoEB3 POWDER

The bacteria *Pseudomonas* GanoEB3 is grown in an enrichment medium at 30°C for 24 hr. The *Pseudomonas* GanoEB3 powder is prepared using vermiculite as a carrier for the nutrient supply. The bacteria cell suspension is harvested at 10^8 colony-forming units per millilitre (CFU ml^{-1}), added into the carrier, and mixed well under sterile conditions. The powder is stored at room temperature (27 ± 2°C) (*Figure 1*).

Figure 1. Pseudomonas *GanoEB3 powder.*

QUALITY OF *Pseudomonas* GanoEB3 POWDER

The quality of the *Pseudomonas* GanoEB3 powder was determined in terms of bacteria population by colony-forming units per gramme (CFU g^{-1}). Viabi-lity tests were performed at monthly intervals up to nine months at room temperature (27±2°C). At one month after storage, the quantity remained at 10^8 CFU g^{-1}. There was a slight reduction in viable cells to 10^7 CFU g^{-1} in the vermiculite carrier after six months of incubation at room temperature. Finally, the number of viable bacteria cells in the vermiculite carrier declined to 10^6 CFU g^{-1} after nine months' storage.

For antagonistic activity based on a dual culture *in vitro* test, 66% inhibition of radial growth of *G. boninense* was observed compared with the control after one month. The efficacy of the viable cells in *Pseudomonas* GanoEB3 powder was reduced to 60% inhibition of radial growth after six months. After nine months, the *Pseudomonas*

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GanoEB3 powder stored at room temperature showed low efficacy in the *in vitro* study with only 52% inhibition of radial growth.

NURSERY EVALUATION OF *Pseudomonas* GanoEB3 POWDER AS A BIOLOGICAL AGENT AGAINST *Ganoderma boninense*

Pseudomonas GanoEB3 powder was further examined for its efficacy as a biological control agent (BCA) and in subsequent disease control in oil palm seedlings against *G. boninense*. The effectiveness of the formulated powder in controlling BSR development in oil palm seedlings was evaluated based on a quantitative assessment measured as a percentage of disease incidence (DI), a percentage of severity of foliar symptoms (SFS), a percentage of dead seedlings (DS) and a percentage of disease reduction (DR). This study was performed over eight months. At six months after treatment, it was shown that the *Pseudomonas* GanoEB3 powder was able to significantly reduce DI, with only 53.30% of the oil palm seedlings showing *G. boninense* infection as compared with the untreated seedlings which had 93.30% DI ($p<0.05$) (*Figure 2*).

For SFS, seedlings treated with *Pseudomonas* GanoEB3 powder showed a significantly lower severity of 40.63% (at $p<0.05$) compared with the untreated seedlings with SFS of 84.68% (*Figure 2*). Meanwhile, the seedlings treated with *Pseudomonas* GanoEB3 powder also recorded a significantly lower percentage of dead seedlings at 33.33% as compared with the untreated seedlings at 73.30% (*Figure 2*). BSR disease incidence was reduced by about 51.85% in the seedlings treated with *Pseudomonas* GanoEB3 powder compared with the untreated seedlings (*Table 1*).

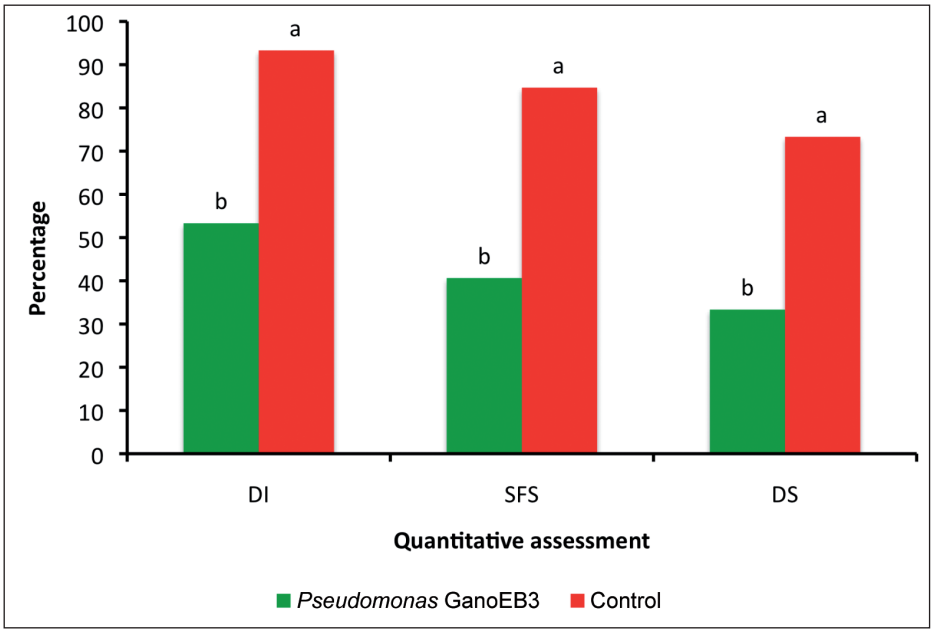
TABLE 1. THE EFFECT OF *Pseudomonas* GanoEB3 POWDER ON BSR DISEASE DEVELOPMENT IN OIL PALM SEEDLINGS AFTER SIX MONTHS

Treatment	AUDPC[1]	DR[2] (%)
Seedlings treated with *Pseudomonas* GanoEB3 powder and inoculated with *G. boninense*	173.00	51.85
Seedlings untreated with *Pseudomonas* GanoEB3 powder and inoculated with *G. boninense*	359.98	-

Note: [1] Area under disease progress curve (AUDPC). [2] Disease reduction (DR).

ECONOMIC ANALYSIS

The fixed cost for a pilot plant producing *Pseudomonas* GanoEB3 powder is RM 5 000 000.00 The payback period is six years, with an internal rate of return (IRR) of 12%, while the net present



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

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

value (NPV) at 10% discount rate is RM 314 339.00. The benefit: cost ratio (B:C) for the discount rate of 10% is 1.45.

CONCLUSION

Pseudomonas GanoEB3 powder has the capability of inhibiting the growth of *G. boninense in vitro*, and also to effectively control *Ganoderma* infection in oil palm seedlings.

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