Bacillus thuringiensis, TERAKIL-1 (WP) FOR BIOLOGICAL CONTROL OF BAGWORMS

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Bacillus thuringiensis (Bt.), which harbours Cry 1 delta-endotoxins is effective for the control of several lepidopteran insect pests. It is lepidopteran specific, environmental friendly, does not affect man, bird, fish and therefore, an ideal alternative for chemical insecticide. New *Bt.* strains and formulations rapidly introduced in the 1990s had further increased the Bt market. In Europe and North America, *Bt.* has been widely used in control programmes against lepidopteran pest (Amos Navon, 2000). PCR screening for gene content of MPOB indigenous isolates showed that several of these isolates harbour toxins effective for oil palm lepidopteran pest such as bagworms, nettle caterpillars and bunch moths (Ramlah Ali and Basri, 2002).

In Malaysia, the use of *Bt.* in pest management strategies has a bright prospect compared to chemical pesticides. The government, private organization and public awareness on the undesirable effect of chemical pesticides on the environment, it's ecosystems and biodiversity has created a niche market for the use of environmentally safe alternative, *Bt.* In oil palm industry, defoliators such as bagworms, nettle caterpillars (Siti Ramlah *et al.*, 2003) and bunch moth can be effectively controlled using *Bt.* products (Mohd Basri *et al.*, 1994; Siti Ramlah and Mohd Basri, 1997). Bt isolates containing the appropriate Cry proteins propagated at pilot-scale is a better and cheaper alternative to those imported.

MODE OF ACTION

The active ingredients of Bt are the parasporal crystalliferous δ-endotoxins and the spores. They are stomach poison, therefore must be ingested by the pest. Several Cry proteins or δ-endotoxins have receptor proteins in gut lining of *M. plana* (Siti Ramlah, 2000). Toxin receptor binding complex leads to insertion of toxin into receptor (Siti Ramlah, 2000), creation of pores, osmotic lysis and insect death.

FERMENTATION / UPSTREAM

Indigenous MPOB Bt1 culture and the high magnifying micrograph of cells and crystals are shown in *Figures 1a, b* and *c* respectively. It contains Cry proteins effective for the control of bagworms (*Figure 1d*). MPOB fermentation medium, Agronat 1 was developed using agricultural raw materials. The medium, Agronat 1, has been tested both at lab and pilot-scale production and was found to give high yield of colony forming unit (CFU) as well as spore count (SC) and δ-endotoxin concentration compared to eight media for commercial production. Agronat 1 performance compared with the eight commercial media is as shown in *Figure 2*.

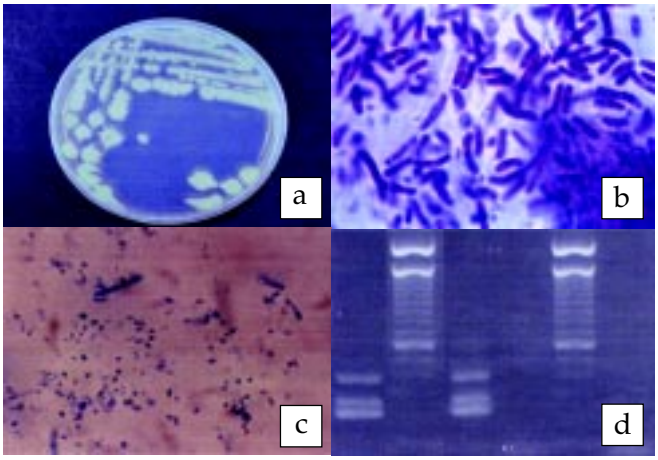

Figure 1. The indigenous culture on (a) nutrient agar, (b) cell micrograph magnification 4000X, (c) crystalliferous Cry proteins 4000X and (d) detection of cry genes in MPOB Bt1 using PCR.

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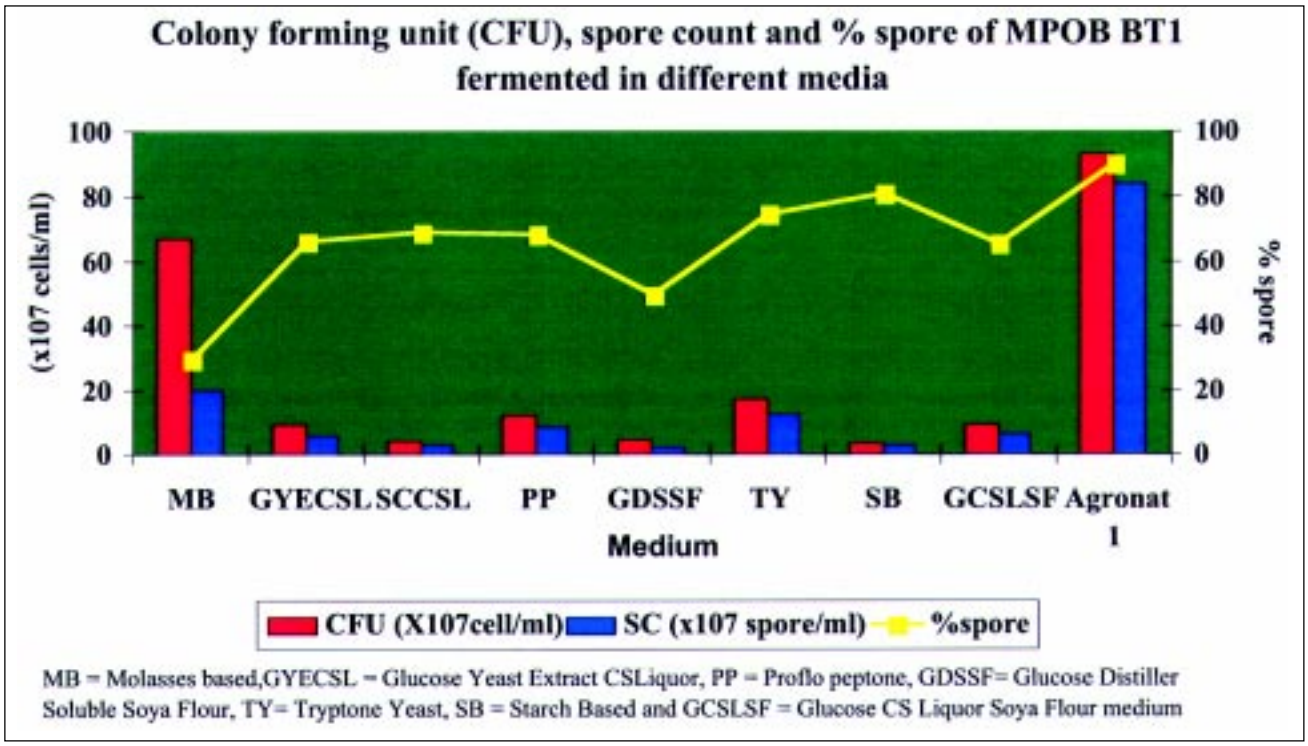

Figure 2. Colony forming unit, spore count and spore percentage of MPOB BT1 produced in liquid fermentation using various media.

The novel cheap medium based on easily available raw materials from agriculture is used for pilot-scale production of MPOB *Bt*. The quality of product obtained using Agro-Nat 1 is superior than that in the commercial media.

Production of MPOB Bt1 at pilot-scale in Microbial Technology and Engineering Centre (MICROTEC) is presently conducted using batch fermentation.

DOWNSTREAM PROCESS

The downstream process involved centrifugation, spray drying (*Figure 3*). Fermented liquid culture were spun and the concentrate was stored in storage tank. The concentrate was then spray-dried using fluidized spray-dryer to form wettable powder, Terakil-1 (*Figure 3*).

LABORATORY BIOASSAY

Laboratory bioassay of Terakil-1 at different concentrations against larval instars of *Pteroma pendula* was conducted. Given at recommended dose, C5 Terakil-1 resulted in 100% kill at seven days after treatment (DAT). At economical dose, C4 Terakil-1 resulted in 85% kill at seven DAT (*Figure 4*).

FIELD TRIAL

Field evaluation of Terakil-1 at recommended rate of 5.9×10^{9} CFU ml^{-1}, was foliar sprayed at Yew Lian Estate, Sabak Bernam infested with multistages infestation by bagworms mainly the *Pteroma pendula*, on 18 April 2005 using P55 Turbo mist blower. When the first spray was conducted, the infesting bagworms were in their late instars and mostly pupated. Three weeks later, on 10 May 2005, the second spray was conducted when the unaffected pupae begun hatching (*Figure 5*). Experiment was conducted using CRBD with treatments including cypermethrin, untreated and Terakil-1.

The field trial was conducted in replicates of four, with plots size 10 x 10 palms and three rows of guard palms. Central 6 x 6 palms were used as recording palms. Result indicated that Terakil-1 was comparable to cypermethrin in the control of *P. pendula*. However, Terakil-1 has an extra advantage of being a selective biological agent and safe to beneficial insects, the environment, its ecosystems and human.

Figure 3. (a) Spray-drying, (b) spray-dried and (c) packed Terakil-1.

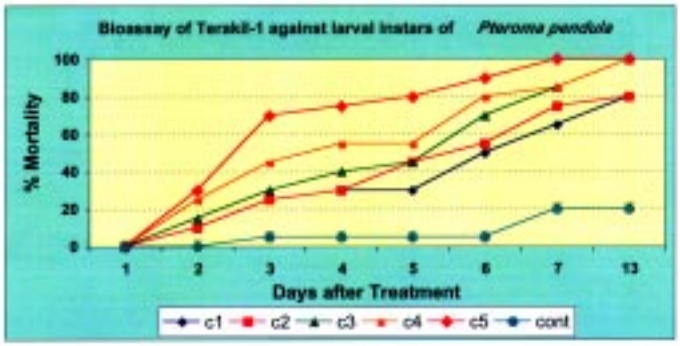

Figure 4. Bioassay of Terakil-1 against larval instars of Peroma pendula.

Figure 5. Second generation foliar spray of Terakil-1 at Yew Lian Estate, Guthrie.

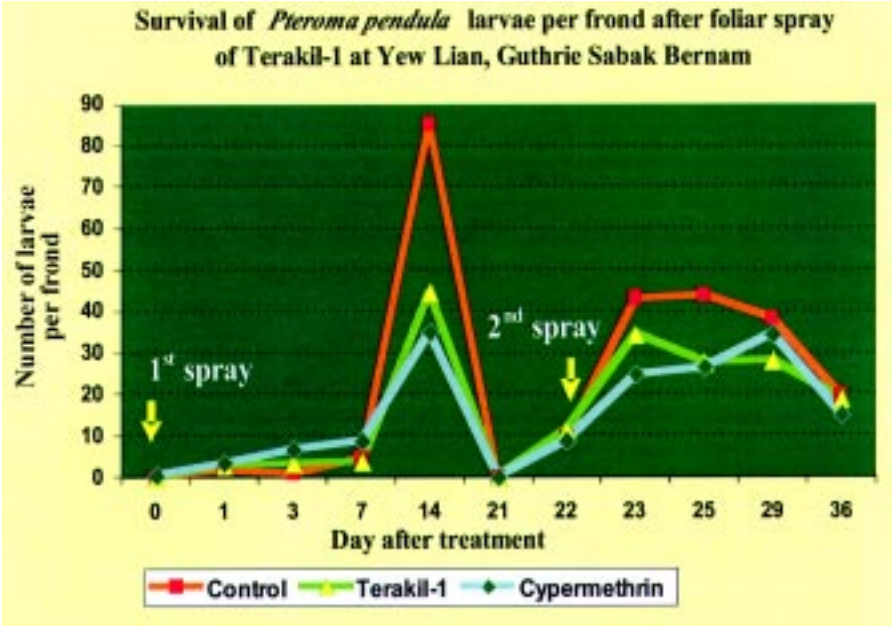

Figure 6. First and second generation field application of Terakil-1 on multi-stages infestation of Pteroma pendula *at Yew Lian Estate, Guthrie, Sabak Bernam.*

BENEFIT OF THE PRODUCT

Terakil-1 is environmental safe and not toxic to non-targeted pests, insects, animals, human and biodiversity. The product can be economically sprayed from the ground using tractor mounted P55 turbo mist blower. By adjusting the nozzle, the effective and economic spray volume per palm can be adjusted to 0.3 – 0.8 litre palm^{-1}. It is water soluble, easily sprayable and the active ingredients remained viable long enough on the foliage for control of palm insect pests. The cost is cheaper compared to the imported product.

ECONOMIC ANALYSIS

The fixed cost for MICROTEC is RM 10 000 000. The pay back period is seven years, with internal rate of return (IRR) of 16% and the net present value (NPV) at 10% discount rate is RM 4 729 893. The benefit cost ratio (BCR) for discount rate of 10% is 1.38.

RECOMMENDATION

The use of one to two foliar spray of Terakil-1 is recommended for larval instars of bagworms for single stage infestation. At least two more rounds of spray are normally essential for multi-stages infestation of bagworms to bring the pest to below threshold level, 10 larvae per frond. Unlike chemical, the use of Terakil-1 will not affect the beneficial insects which are essential nature gift for natural biological control of oil palm insect pests.

CONCLUSION

Terakil-1 is recommended to decrease reliance on chemical pesticides for the control of not only bagworms but also nettle caterpillars and bunch moth under oil palm.

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