Title	**TERMINAL REPORT: Efficacy Testing of Paviso against Black Sigatoka (*Mycosphaerella fijiensis)* of Cavendish Banana *(Musa acuminata)***
Introduction	Banana, with its many potential health benefits, is one of the most important fruit crops in the Philippines. There are three major varieties produced in the country: 1) cavendish, the primary variety (50% of the total banana production), generates 329,648 jobs in the country, providing P42.3B in annual wages; 2) lakatan, a popularly known dessert, contributes 11% of the total banana production; and 3) saba, a major cooking-type banana, comprises 29% of the total banana production. According to FAOStat (2017), the Philippines is the 3rd largest producer of bananas globally, following India and China in 2014. Based on data from the Philippine Statistics Authority (PSA) (2019), the Davao region is the top producer of bananas with 3.43M mt or 37.4% of the total banana production (PCAARRD, 2023). The industry's major problem is its susceptibility to major diseases such as banana bunchy top disease (BBTD), Sigatoka, and Fusarium wilt (FW), also known as Panama disease (PCAARRD, 2023). The banana Black Sigatoka disease, also known as Black Leaf Streak (BLS), is the most economically important leaf spot disease of bananas in the region affecting a wide range of cultivars, and often completely defoliating more vulnerable cultivars before fruit bunches are mature. It can cause yield depletion of more than 50% and premature ripening, which can be catastrophic for exporting, according to a report from The American Phytopathological Society (Byington, 2020). It is caused by the airborne fungus *Mycosphaerella fijiensis Morelet,* which is spread from plant to plant by wind, rain, and irrigation water splashes. The fungal pathogen infects plants and impedes photosynthesis by the blackening parts of the leaves, eventually killing the entire leaf. Characteristic symptoms include dark leaf spots that eventually enlarge and coalesce, causing much of the leaf area to turn yellowish and brown. Often, infected plants show early death of the leaves and the development of large brownish-colored streaks on the underside, especially of the fourth leaf. The numerous streaks coalesce later resulting in black necrotic patches appearing on the topside of the leaf. Up to 50 annual air-spray cycles are needed to control BLS, thus costing 15–27% of the total annual production costs (Muimba-Kankolongo, 2018). Currently, the banana plantations practice controlling and managing diseases, especially for Black Sigatoka, through an integrated approach. They manage through cultural practices such as ground control (deleafing), sanitation (cleaning of ground debris), and

	fertilization (application of the right amount of fertilizer to supplement nutrient needs for plant resistance). However, most of the time, they manage disease control through pesticide or chemical application following the Fungicide Resistance Action Committee (FRAC) guidelines in using fungicide products. Most of the banana plantations use 60 to 70 cycles a year to control the disease, where 10% comprises biological products, 30% of Systemics, and 60 % of contacts. Use of contact and systemic fungicides requires the needed Market Maximum Residue Limit, which limits growers with their use. Recently, banana plantations have been exploring the use of crop protection products like organic and biologicals, which do not require the generation of MRL for ease of trade. Locally, only a few of these products are registered for banana use. Thus, Syngenta aims to introduce a good biological product that can control the black sigatoka. Paviso is the trademark of Syngenta Philippines, Inc., a biological control agent with *Baccilus amyloliquefaciens* strain FZB24. The product produces antimicrobial metabolites that act against the pathogen. Paviso is a *Bacillus subtilis*-based bio-fungicide. It offers broad-spectrum disease control at a very low application rate on a variety of crops. Hence, initially applied to control of banana Sigatoka disease.
Objective	The general objective of the efficacy trial was to generate efficacy data on Paviso to support product registration with the Department of Agriculture-Bureau of Agriculture and Fisheries Standards (DA-BAFS). Specifically, the trial aimed to: 1. determine the efficacy of Paviso against Black Sigatoka disease on cavendish banana; and 2. determine the most effective dose/s of Paviso against Black Sigatoka on cavendish banana.
Methodology	**1. Efficacy Trial Period and Location** The trial was conducted in New Visayas, Sto Tomas, Davao del Norte from April to December 2022. **2. Target Crop and Disease** The target disease and crop was the Black Sigatoka (causal agent *Mycosphaerella fijiensis*) of cavendish banana. This is the most economically important leaf spot disease of bananas in the region affecting a wide range of cultivars, and often completely defoliating more vulnerable cultivars before fruit bunches mature. **3. Efficacy Trial Design and Layout** There were 6 sampling units per treatment plot in each replicate as shown in Figure 1. The trial was laid out randomly with four replications.

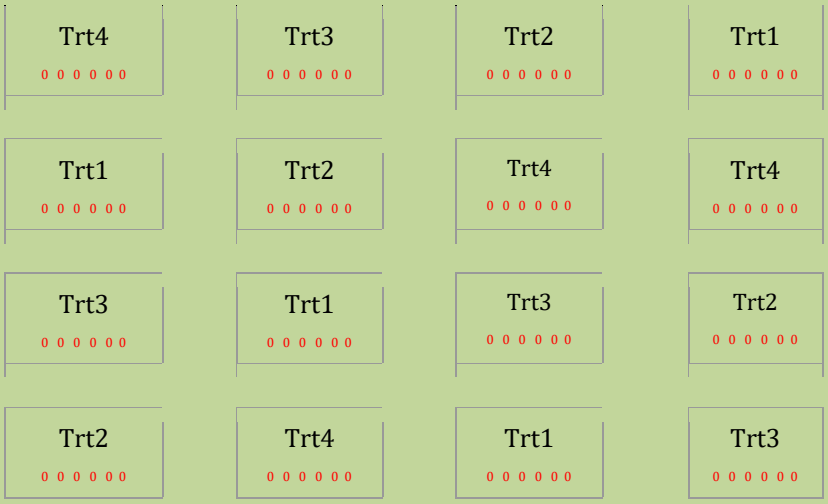

Figure 1. Efficacy trial layout

The plots measured 9m x 3m providing a total of 27 sqm per treatment. In each plot, the banana seedlings were planted at a distance of 1.5m between hills and 3m between rows or 6 plants per plot.

4. Treatment protocols

The dosages and frequency of treatment applications are shown in Table 1.

Table 1. Dosages and Frequency

Treatment	Dosages	Frequency
1	Untreated	*The treatments were applied 7 times at 7 days interval*
2	Paviso 13WP at 24g *ai/ha	
3	Paviso 13WP at 36g ai/ha	
4	Paviso 13WP at 48g ai/ha	

Note:
**ai is an active ingredient, computation for the standard plantation calibration for the treatments is provided in a separate document.*

5. Cultural Management Practices

Approximately, an area of 450 sqm prepared for the trial was divided into blocks and treatments, which also included the spaces between plots. Tissue-cultured seedlings of the cavendish banana variety grand naine were used in this study. Sample plants were planted in the middle of each plot while observing the desired distances.

Fertilization management for this trial followed the plantation practice based on the required NPK of 450 kg N/ha, 60 kg P/ha, and 500 kg K/ha. The N was applied

monthly while P and K started at the shooting stage. There was no application of fungicides except the treatments. For insect pests like aphids at early growth of banana plant, cypermethrin at the recommended rate was used as needed. Weeds were managed by hand weeding at an early age of growth and followed by glufosinate at 2.0 L/ha as needed.

Personal Protective Equipment (PPE) was used during spray application as a standard safety procedure for applicators. Mitigation measures were observed to avoid drift from aerial spraying from other plantations since the location of the trial area is far from nearby areas where aircraft spraying is being used. The plantation has a 50-meter buffer zone along its boundaries. Moreover, spraying was done early in the morning when wind velocity was slow and the spray height was maintained at 4-6 meters.

6. **Sampling**
   There were 6 sample plants for each plot per replicate. The sample leaves were tagged for the disease development time (DDT), and the disease manifested. The assessment commences for sample plants once the disease has manifested 7 days after treatment application.

7. **Analysis of Results**
   The data gathered were subjected to analysis by comparing the difference of mean of treatments against untreated control. The standard percent comparison is set in the *Philippine National Standard (PNS) – Organic Bio-control Agents (OBCA) – Microbials and Botanicals – Minimum requirements (PNS/BAFS 182:2016)*.

Data Gathered

1. **Disease Severity.** The severity of Black Sigatoka is gathered 7 days after treatment application, including 14 days after the last application of the treatments. Table 2 shows the scale for the Black Sigatoka Disease Severity Scale prescribed by the DA-BAFS OBCA Manual.

Table 2. Black Sigatoka Disease Severity Scale

Scale	Proportion of Leaves with Infection Symptoms
0	no visible symptoms of the disease
1	Less than 1% (only streaks or up to 10 spots on the leaf)
2	1 to 5% leaf area with symptoms
3	6 to 15% leaf area with symptoms

4	16 to 33% leaf area with symptoms
5	34 to 50% leaf area with symptoms
6	51 to 100% leaf area with symptoms

2. **Youngest Leaf Spotted.** Youngest leaf with a visible streak or youngest leaf infected (YLI). Youngest Leaf Spotted (YLS) Score by counting downwards from the first top unfurled leaf to the youngest leaf that shows spots (>10) with a necrotic dry center. The index of non-spotted leaves (INSL) can be derived as follows:

   INSL = 100(YSL-1)/NSL

3. **Number of clean leaves.** The total number of clean leaves or those leaves without infection of Black Sigatoka was counted every assessment period.

Results & Discussion

1. **Disease Severity. Percent Severity Control of Black Sigatoka.** The treatments and their percent control in the severity of Black Sigatoka disease, which passed the standard efficacy set by the PNS/BAFS 182:2016, are shown in Table 3.

Table 3. Percent Severity Control of Black Sigatoka

Treatment	% Decrease in Infection of Black Sigatoka Mature Spots
T2- Paviso at 24g ai/ha	54.58%
T3- Paviso at 36g ai/ha	55.23%
T4- Paviso at 48g ai/ha	70.26%

2. **Youngest Leaf Spotted (YLS).** Increased in the average YLS trend suggested the treatments were effective in slowing down the formation of necrotic lesions. It means that the formation of new necrotic lesions was slower than the rate at which new leaves were emitted. Therefore, different rates of Paviso were effective in slowing down the formation of necrotic lesions and had higher mean values than the untreated control, as shown in Table 4.

Table 4. Leaf position of the youngest leaf

Treatment	Leaf Position of YLS
Untreated	4.44
T2- Paviso at 24g ai/ha	5.30
T3- Paviso at 36g ai/ha	5.38
T4- Paviso at 48g ai/ha	5.42

3. **Average Number of Clean Leaves.** The results suggested that the Paviso-treated bananas have a higher average number of clean leaves in comparison with untreated.

Table 5. Average Number of Clean Leaves

Treatment	Average No of Clean Leaves
Untreated	2.21
T2- Paviso at 24g ai/ha	3.00
T3- Paviso at 36g ai/ha	3.29
T4- Paviso at 48g ai/ha	3.26

Conclusion and Recommendation

Conclusion and recommendation

The product Paviso was able to meet the efficacy standards set by the PNS/BAFS 182: 2016 at ≥50 percent, and as required by the Department Circular No. 01, series of 2021. Thus, the product is recommended to apply for product registration with DA-BAFS.

Practical Implication

The efficacy results suggest that the product can be used to control the severity of Black Sigatoka disease in Cavendish bananas with the following dosage as shown in Table 6.

Table 6. Disease, dosage, and frequency of application

Disease	Dosage and Frequency of application
Banana Black Sigatoka Disease	24 g to 48 g ai/ha Applied with 7 days interval

Further, factors such as YLS and number of leaves are crucial for the growth, development, and quality of banana. Hence, the results of the Paviso treatment are an indicator of the effectiveness of the product against the Black Sigatoka disease of banana.

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Annex

-Photo Documentation

Figure 2. SMALL PLOT TEST during application of treatments. From left to right: Untreated, Paviso at 24 g ai/ha, Paviso at 36 g ai/ha, Paviso at 48 g ai/ha.

Figure 3: SMALL PLOT TEST seven (7) days after application. From left to right: Untreated, Paviso at 24 g ai/ha, Paviso at 36 g ai/ha, Paviso at 48 g ai/ha.

Figure 4: SMALL PLOT TEST Twenty-three (23) days after application. From left to right: Untreated, Paviso at 24 g ai/ha, Paviso at 36 g ai/ha, Paviso at 48 g ai/ha.