Title	**Efficacy Trial Terminal Report: Plant Shield 0.6SL against Leafhoppers *(Idioscopus clypealis),* Twig Borer (*Niphonoclea capito*), and Cecid Fly (*Procontarinia frugivora*) on Mango**
Introduction	Mango is one of the country's major fruit exports. The Philippines is among the top suppliers of mango in the world. The Philippine Carabao Mango is acknowledged as one of the best-tasting mango varieties worldwide. Because of low production and quality of harvest, exporters are not able to meet the demand of the market. Mangoes are prone to heavy infestation of pests and diseases at any growth stage. Some of the prevalent insect pests of mango are mango plant hoppers, twig borers, and cecid fly. Among the mango insect pests, mango hopper is one of the most serious and widespread pests throughout the country (Hussain, 2022). Both the nymph and adult stages of mango hoppers puncture and suck the sap from tender shoots, inflorescences, and leaves causing the flower to dry and premature fall resulting in the non-setting of flowers and fruit. The twig borer damage is wilting of newly flushed leaves followed by the drying and breaking-off of damaged twigs. Results of the study conducted by Adoro, et.al. 2017 indicate that mango twig borers were found in many mango trees in almost all Luzon provinces. Cecid fly had emerged as a very destructive pest of mango. It commonly lays its eggs on the fruit surface and young mango leaves. As the larva bores into the fruits and feeds, the larva causes circular spots or holes in the fruits. When cecid fly attacks at an early stage of fruit development, the fruits fall off from the tree. Infested mature fruits, on the other hand, develop randomly distributed circular brown scab-like spots on their surface, making the fruit unmarketable (Micua, 2018). Adults which are mosquito–like in appearance prefer to lay eggs on new flushes (young leaves). The larvae, which develop from eggs, mine the leave producing galls or swelling tissues. Under heavy infestation, the leaves wrinkle and remain yellow. Findings of Wu J. et. Al (2019) revealed alternate pest control strategies, such as entomopathogenic fungi or their application in combination with other natural chemicals, are of great importance to solve the above-mentioned problems. Lengai, et.al. (2020) stated that the increased demand for food to feed the ever-growing population led to the development and adoption of synthetic chemicals as a quick and effective strategy for managing crop pests and diseases. However, overreliance on chemical pesticides is discouraged due to their detrimental effects on human health, the environment, and the development of resistant pest and pathogen

	strains. This, coupled with increasing demand for organically produced foods, stimulated search for alternative approaches, and botanical pesticides are particularly gaining importance. Botanical pesticides are efficacious in managing different crop pests, inexpensive, easily biodegraded, have varied modes of action, their sources are easily available, and have low toxicity to non-target organisms. Their varied modes of action are attributed to the phytochemical composition of different plants. Therefore, they can be incorporated into integrated pest management systems and contribute to sustainable agricultural production. The paper also presents chemistry data of selected botanical pesticides, their biodegradation, their role in integrated pest management, and the challenges facing their adoption and utilization for sustainable crop pest management. Plant Shield 0.6SL is a natural plant extract that is refined and produced from several wild medical plants such as *Sophora flavescens* Ait, *Vetarum nigrum* L, and *A. carmichaeli*. The active ingredient of this plant extract is matrine, which is known to act on the central nervous system of pests, thus leading to breath inhibition and motion imbalance. Plant shield is registered to various crops in China such as tea trees, rice, fruit trees, and vegetables. Based on MSDS, the raw material was imported from Beijing King Biotech Co.Ltd. The trade name is Kingbo. The proposed local name is Plant Shield 0.6 SL. It is a formulated product that contains Marine 0.6 %, and the product classification is Botanical. The product ownership is through a distributorship agreement. High income from mango production can be achieved with the application of Plant Shield 0.6SL by producing quality fruits that will command higher prices in the local market. Good quality of fruits preferred by consumers was obtained with the spray application of Plant Shield 0.6 SL which effectively controlled the infestation and damage caused by major insect pests of mango. The best result was based on the statistical data revealed in the study.
Objective	The general objective of efficacy trials was to generate efficacy data of Plant Shield 0.6 SL to support product registration with DA-BAFS. Specifically, these trials aimed to: 1. Evaluate the effects of Plant Shield 0.6SL against hoppers, twig borer and cecid fly in mango; and 2. Determine the optimum rates of Plant Shield 0.6SL against hoppers, twig borers and cecid fly in mango
Methodology	**1. Time and location of study** The trials were conducted in two locations: a) Site 1: Umingan, Pangasinan; and, b) Site 2: Science City of Munoz, Nueva Ecija. **2. Trial Duration** The trials were conducted from January 2022 to May 2022.

3. Target Pests

a) Mango leafhoppers (*Ideoscopus clypealis*)- The mango leafhoppers suck the sap from the flowers and heavy production of honeydew associated with sooty mold growth may retard tree vigor and lead to fruit drop. If left untreated, leaves and flowers will be damaged and fruit production can be severely affected.

b) Twig borer *(Niphonoclea capito)* - The mango twig borer is a major pest of mango in the Philippines. Wilting of newly flushed leaves, followed by the drying and breaking-off of damaged twigs are some indications of borer infestation.

c) Cecid fly *(Procontarinia frugivora)* - cause black spots in the skin of mango fruit, ultimately causing it to rot and drop from the tree.

4. Target Crop

Mango is one of the most important tropical fruit crops in the world and is ranked fifth in production among major fruit crops. Mangoes are produced in over 90 countries worldwide. FAO estimates that the mango harvest will be around 28 million tons in 2014, that is, 35% of the production of the world's tropical fruit. Skin color has been used as a standard maturity index for harvesting of mangoes. The maximum red coloration is a more sensitive maturity index than the maximum yellow coloration. Sometimes plant biologists determine the appearance of red color on the skin is not a reliable index of maturity. At the start of bearing at the age of 3 – 4 years the yield may be as low as 10-20 fruits (2-3 kg) per tree, rising to 50-75 fruits (10-15 kg) in the subsequent years, and to about 500 fruits (100 kg) in its tenth year. In the age group 20- 40 years, a tree bears 1,000-3,000 fruits (200-600 kg) in a year.

5. Experimental Design and Layout

There were 16 sampling trees per trial The trials were laid out in a Randomized Complete Block Design (one tree/replicate) with four replications. All gathered data were analyzed using Analysis of Variance (ANOVA) in Statistical Tool for Agricultural Research (STAR). Comparison among treatment means was tested by using Tukey's Test at a 0.5 percent confidence level of significance.

T1	T4	T2	T3
T4	T1	T3	T4
T3	T2	T1	T2
T2	T3	T4	T1
R1	R2	R3	R4

Each tree represented the replication *(four trees represented four replications).* 20 panicles per tree were tagged as samples. A colored ribbon (respective to its treatment) was tied to the panicle for monitoring of insect pests and damages. All trials were sprayed by using a power sprayer with different 100L drums per test product to avoid contamination. There were (5) applications of Plant Shield 0.6SL for the control of insect pests. Damage on panicles and twigs was assessed. The fruits were bagged to fully assess the damage of cecid-fly. Additional sprays were done in between scheduled spray intervals if there were drastic changes in the pest population.

6. Treatment Application Rates and Frequency

Treatment	Dosage	Frequency (DAFI)
T1	Untreated Control (water) 100L water	15,24,36,43, and 60
T2	0.5 RR Plant Shield 0.6SL 150 ml/100L water	15,24,36,43, and 60
T3	1.0 RR Plant Shield 0.6SL 300 ml/100Lwater	15,24,36,43, and 60
T4	2.0 RR Plant Shield 0.6SL 600 ml/100L	15,24,36,43, and 60

Note:
DAFI - days after flower induction
100L drum/4 trees
40trees/hectare

7. Cultural Management Practices

The experimental trees were induced to flower by using Calcium Nitrate (CaNO3) at the rate of 5 kg/100L water. Organic fertilizer was used in the trial at the rate of 50 kg/tree. The experimental area was sprayed with foliar fertilizer 12 days after flower induction. Irrigation was applied once after the application of organic fertilizer. Weed management was employed by cutting of grasses for sanitation and cleanliness purposes followed by spraying of herbicide.

The fruits were harvested 120 days after flower induction (~120 DAFI). Manual harvesting using "sunggapong" as practiced by mango growers was followed. Marketable fruits were weighed and separated from non-marketable fruits with insect damage. Damage caused by cecid fly wasonly visible on fruits and considered non-marketable. The damage was circular spots or holes on the fruits, and randomly distributed circular brown scab-like spots on the fruit's surface called "kurikong". Twig borer damage was on twigs, while leafhopper damage was on panicles. No damages were observed on fruits for both twig borer and leafhopper.

Data to be Gathered

1. Phytotoxicity

One week after each treatment application or just before the next application and onwards, crop injury in the form of stunting, chlorosis, tip burn, leaf curling, or growth retardation was assessed with reference to the untreated control using the standard rating scale below:

Scale	Crop Injury
1	None
3	1-10%
5	11-20%
7	21-30%
9	>30%

2. **Insect pest population**
Leafhopper population was taken per 20 tagged panicles before each treatment application, three and seven days after each treatment application.

3. **Fruit retention** was taken by counting the number of fruits retained from 20 tagged panicles per treatment per replicate at 40, 55, 75, and 120 DAFI.

4. **Percent damage panicles due to Leaf hopper:**

$$\% \text{ Damage} = \frac{\text{No. of Panicle Damaged}}{\text{Total Number of Panicle}} \text{ X100}$$

5. **Percent damage fruit due to Cecid Fly:**

$$\% \text{ Damage} = \frac{\text{No. of Fruits Damaged}}{\text{Total Number of Fruits Sampled}} \text{ X100}$$

6. **Percent damage shoots due to Twig Borer:**

$$\% \text{ Damage} = \frac{\text{No. of Shoots Damaged}}{\text{Total Number of Shoots Sampled}} \text{ X100}$$

7. Population of beneficial insects before and after each treatment application.

8. Agrometeorological data secured from the nearest agrometeorological station

Results & Discussion

1. **Percent reduction in the severity of leafhopper damage.** The average percent reduction per site location is shown in Tables 1.1 and 1.2. The application rates of Plant Shield 0.6 SL at 300ml and 600ml for both sites are effective against mango leafhopper with 52.15% and 57.25%, and 56.66% and 62.71% efficacy, respectively.

Table 1.1. Site 1 Cayambanan, Urdaneta, Pangasinan

Treatments	Dosage rate per 100 L of water	Average efficacy against control *(3DATA and 7DATA Assessment)*
T3-PLANT SHIELD 0.6SL (1.0 RR)	300ml	52.15
T4-PLANT SHIELD 0.6SL (2.0 RR)	600ml	56.66

Table 1.2. Site 2 Purok Villa Jaview, Bantug, Science City of Munoz, Nueva Ecija

Treatments	Dosage rate	Average efficacy against control *(3DATA and 7DATA Assessment)*
T3-PLANT SHIELD 0.6SL (1.0 RR)	300ml	57.25
T4-PLANT SHIELD 0.6SL (2.0 RR)	600ml	62.71

2. **Percentage of retained fruits as affected by cecid fly damage.** The percentage of retained fruits is shown in Tables 2.1 and 2.2. Only Plant Shield 0.6 SL at 600 ml rates passed the efficacy with 65.18% and 62.00% for Sites one and two, respectively. ,The percent retained fruit is associated with the decrease in damage caused by cecid fly.

Table 2.1. Site 1 Cayambanan, Urdaneta, Pangasinan

Treatments	Dosage rate	45 DAFI	55 DAFI	75 DAFI	Mean Percentag e
T4-PLANT SHIELD 0.6SL (2.0 RR)	600ml	50.53	81.48	63.53	65.18

Table 2.2. Site 2 Purok Villa Jaview, Bantug, Science City of Munoz, Nueva Ecija

Treatments	Dosage rate	45 DAFI	55 DAFI	75 DAFI	Mean Percentag e
T4-PLANT SHIELD 0.6SL (2.0 RR)	600ml	68.07	52.36	65.55	62.00

3. **Twig borer damage.** No data were collected to support the efficacy of Plant Shield 0.6 SL against the population and damage caused by twig borer.

Conclusion

1. The Plant Shield 0.6 SL was able to reduce the severity of damage caused by leafhopper and increased the fruit retention affected by the cecid fly. However, the product has no data to support the efficacy claim for twig borer damage.

	2. Plant Shield 0.6 SL was able to meet the percent efficacy standard, > 50 percent in the PNS/BAFS 182:2016 for leafhopper and cecid fly, except twig borer.
Researchers and Company Profile	**CONSTANCIA C. DACUMOS, PhD** BAFS Certified Researcher DA Special Order No. 065 series 2022 **ORACLE CHEM CORP** #104 Merit Drive, Carmelaray Industrial Park 1, Canlubang, Calamba City
References	Adoro, L., Domingo, F., and Farin, E. (2017). Distribution and feeding hosts of mango twig borers in mango Growing provinces in Luzon, Philippines. Research, Extension and Training Ramon Magsaysay Technological University, Iba, Zambales, Philippines. Journal of Basic and Applied Scientific Research. J. Basic. Appl. Sci. Res., *7(10) 32-38,* 2017, Retrieved from: Text Road Publication. ISSN 2090-4304. Hussain, S. I. (2022). Plantwise factsheets for farmers. Mango Hopper Pakistan. Department of Wet Warning and Quality Control of Pesticide. Retrieved from https://www.plantwise.org Lengai, G. J. Muthomi, E. Mbega (2020) Phytochemical activity and role of botanical pesticides in pest management for sustainable agricultural crop production. Scientific African, volume (7) Micua, L. (2018). Mango growers advised to sanitize farms vs. cecid fly. The Philippine News Agency. Presidential Communications Office. Copyright 2022 Tenorio, A.M., Lizarondo, R.C., and Inocencio, T.Q. (1991). Integrated Pest Management (IPM) approach for the control of mango twig borer, *Niphonoclea capito* Pasc.[Philippines]. Department of Agriculture Regional Crop Protection Center, Munoz, Nueva Ecija. Wu, J., Xintong, Y., Xiaoshuang W., Liangde, T. and Shaukat, A. (2019). Matrine enhances the pathogenicity of *Beauveria brongniliartii* against *Spodoptera litura (Lepidoptera: Noctuidae).* Key Laboratory of Bio-Pesticide Innovation and Application, Engineering Research Centre of Biological Control, South China Agricultural University, Guangzhou, China and Key Laboratory of Integrated Pest Management on Tropical Crops, Ministry of Agriculture, Environment and Plant Protection Institute, Chinese Academy of Tropical Agricultural Sciences, Haikou, China. Front. Microbiol. https://doi.org/10.3389/fmicb.2019.01812

Annex

-Photo Documentation

Figure 1. Preparation (top left), mixing (top right) and spraying of flower inducer (below)

Figure 2. Spraying of Plant Shield 0.6SL

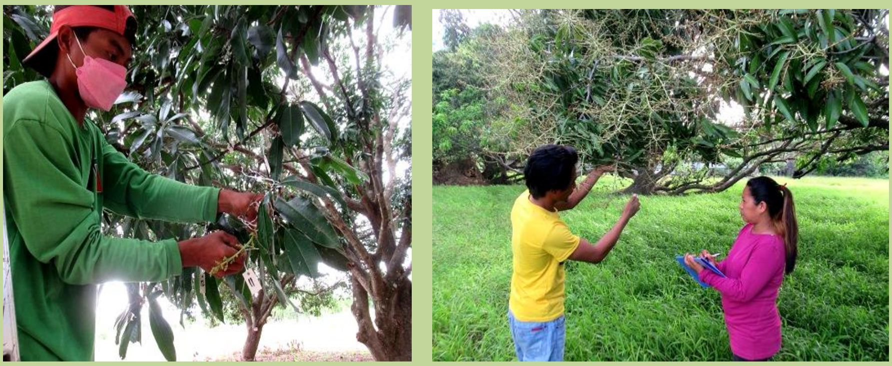
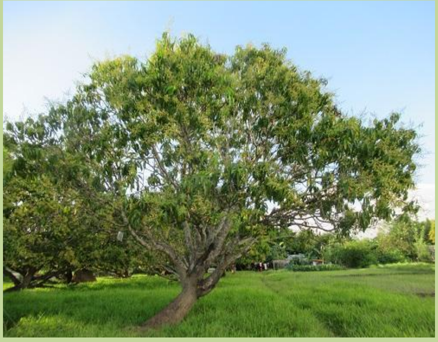
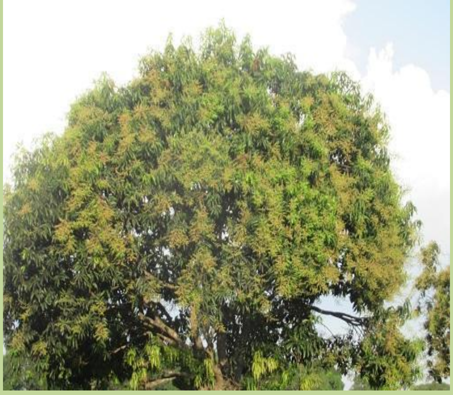


Figure 3. Data gathering of insect pests population and fruit development



T1 – Untreated Control (water)



T2 – 0.5 RR Plant Shield 0.6SL

T3 – 1.0 RR Plant Shield 0.6SL

T4 – 2.0 RR Plant Shield 0.6SL

Figure 4. Representative treatment trees at pre-full bloom

T1 – Untreated Control (water)

T2 – 0.5 RR Plant Shield 0.6SL

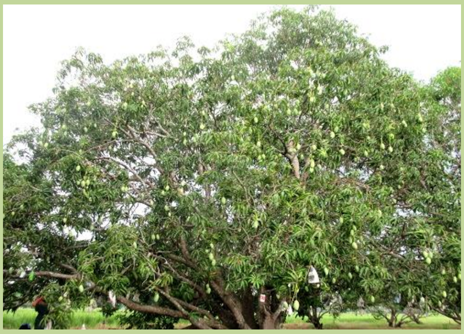
T3 – 1.0 RR Plant Shield 0.6SL

T4 – 2.0 RR Plant Shield 0.6SL

Figure 5. Representative treatment trees at 40 DAFI

T1 – Untreated Control (water)

T2 – 0.5 RR Plant Shield 0.6SL



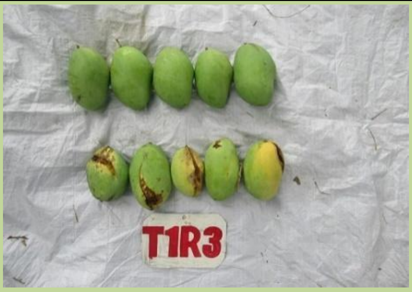
T3 – 1.0 RR Plant Shield 0.6SL

T4 – 2.0 RR Plant Shield 0.6SL

Figure 6. Representative treatment trees at maturity stage

Figure 7. General view of the experimental area

Figure 8. Harvesting and sorting of mango fruits



T1 – Untreated Control (water)

T2 – 0.5 RR Plant Shield 0.6SL

T3 – 1.0 RR Plant Shield 0.6SL

T4 – 2.0 RR Plant Shield 0.6SL

Figure 9. Representative sample fruits per treatment based on 20 tagged panicles

Figure 10. Leafhopper damage on the inflorescence (drying of flowers)

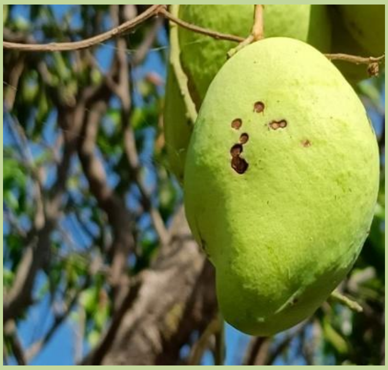


Figure 11. Cecid fly "kurikong" damage

Figure 12. Fruitfly damage characterized by holes and oozing of substance.