Application of Bio-Pesticides To Improve Paddy Yield - Malaysia

Project Leader

AP Dr Suzana Yusup[2]

Team Members

Mrs Raudah Talib[1]; Mr Ashr Mohd Hanifah[1]; Mr Sharizal Abdul[1];
Mrs Mardyhwati Abd Rahim[1]; and Mrs Nor Asiah Yusup[1]

Mr Mior Jailla Mior Hasan[1]; Mr Ramlan Aziz[1]; Mr Mohamed Osmi Salleh[1];
and Mr Hamsi Mohammad[1]

[1] Department of Agriculture (MOA) Malaysia

Dr. Rohani binti Salleh[2]; Dr. Noridah binti Osman[2]; Mrs Hayani binti Harun[2];
Mrs Puteri Kamarulzaman[2]; Mrs Farhana Mohd Salim[2]; Mr M Jailing Kassim[2]; and
Mr Mohamad Amir Firdaus[2]

Ms Noor Hafizah Ramli[2]; Mr Benjamin Kueh Wei Bin[2]; Mr Muhammad Illham Zainuddin[2];
Mr Amin Hasmi[2]; Ms. Siti Nurul Ain Aida Mohammad[2]; Ms Ayu Nadzirah Alias[2] and
Ms Nur Hanis Haszrudin[2]

[2] University Technology Petronas

Mr KE Tan[3]

[3] Okada Ecotech (Singapore)

Tuan Haji Abu Bakar Haji Ahmad[4] and En Sulaiman bin Mokhtar Haji Ahmad[4]

[4] Bio-X Techno (Malaysia)

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The bio-efficacy of a commercially available, neem-based Bio-Pesticide was field-tested and compared to common Chemical/Conventional-Pesticides. The paddy plant components with their yields were recorded and statistically analyzed to determine trait associations.

In the Field-Test, Bio-Pesticide Plot (A2) demonstrated a higher net yield of 10.94 mt/ha versus the Control Plot (B1) with a net yield of 5.38 mt/ha. An improvement of 203.4% (2 times),

The Glass-House Test, Bio-Pesticide Pot (T1) sprayed with a combined Bio-Pesticide Solution of 612EC and 500WS recorded the highest projected yield of 23.04 mt/ha, followed by Control Pot (C1) with a projected yield of 6.65 mt/ha and Bio-Pesticide Pot (T2) sprayed with only a Bio-Pesticide 500WS Solution and had a projected yield of 6.64 mt/ha. An improvement of 346.5% (3.5 times).

Higher yields with higher panicle growth were observed in the Field- and Glass-House Tests, when Bio-Pesticide Solution was applied.

Field-Test Bio-Pesticide Plot (A2) had a total panicle growth of 368.79m^2 compared to 279.33 m^2 for the Conventional-Pesticide Plot. An improvement of 132.0% (1.3 times).

The total panicle in the Glass-House Test Bio-Pesticide Pot (T1) was 985m^2 which was higher by about 125.4% (1.3 times) over the Glass-House Test Conventional-Pesticide Pot (C1) at 785.40m^2 and about 309.4% (3.1 times) over the Glass-House Test Bio-Pesticide Pot (T2) at 318.40m^2.

The above Field results were achieved during the rainy season (Sept to Dec - Q4/2016) with proper irrigation. The Glass-House results were conducted in a well-controlled environment.

Keywords : Bio-Pesticides, neem, rice, yield, correlation

1.0 CHAPTER 1 - INTRODUCTION

1.1 Introduction

Rice, scientifically known as Oryza Sativa plays a vital role in contributing towards food security and it is widely consumed as staple food by about 2 billion people in Asia alone (International Rice Research Institute, 1993; Pareja and Fernandez-Alba, 2011). To increase the production of rice, with an increasing regional and world population, there is an urgent need to enhance and improve the productivity of irrigated paddy fields.

However, Malaysia's warm and humid climate attracts a number of pests, pathogens, insects and viruses that severely affect the productivity of paddy fields, leading to reduced overall rice yields.

Approximately, over 800 herbivore insect species inhabit the eco-system (Prasad, 2010). According to Matteson (2000), the major reason for low rice yields in tropical Asian Regions are vitiations of insects and pests. Adding to this, various types of diseases cause by viruses, bacterium and fungi also impairs the growth of rice yields. However, a reliance on Conventional/Chemical-Pesticides to address these issues has resulted in ecological adversity with health-related problems (Cantrell et. al., 2012 and Wakil et. al., 2001).

Chemical-Pesticides have a massive, harmful and long-term residual effect on the soil, general health, paddy productivity and contaminates ground water. They seep into the food-chain via the eco-system, creating human health hazards. The need for a more environmentally-friendly form of pesticide is now greater than ever.

Bio-Pesticides are a form of pesticide based on natural products or micro-organisms. The acknowledgement of Bio-Pesticides has expanded widely in recent years as vast research has enhanced their effectiveness against a large number pests and consequently improved paddy yields. A number of researchers around the world are undertaking research aimed at enhancing techniques for the augmentation and application of Bio-Pesticides for paddy plants. In response to demands from retailers and consumers, farmers are also trying to reduce the amount of Conventional-Pesticides used on crops especially in rice production. However, they need continued access to a diverse range of plant protection products if they are to sustain yields and improve rice productivity. Without pesticides and other complementary products, food security and food safety will be compromised and rice prices will rise.

There are concerted efforts that have been made to utilize organic resources to produce less harmful and non-poisonous Bio-Pesticides that could effectively solve these problems. Recent studies showed that a bio-active secondary metabolite Azadirachtin ($C_{35}H_{44}O_{16}$) compound which is present in Neem (Azadirachta Indica) could be used to produce effective Bio-Pesticides. This compound possesses insecticidal properties such as an anti-feedant, repellence, ovipositor deterrent, molting inhibition and a growth retardant for a variety of insects and arthropods (Massaguni and Latip, 2012; Kannaiyan, 2002. Azadirachtin considered to be a future biocidal agent due to its selectivity, simple preparation, locally available renewable resource, readily bio-degradable and safe for humans (Yar'adua, 2007). The Neem tree has been proposed in this study as it carries Azadirachtin compounds and are recognized for their plant-derived insecticidal properties.

The enormous advantages of Bio-Pesticides are their high selectivity to targeted pests and safe to non-targeted and beneficial organisms. In a sustainable intensification of agriculture through green economy, Bio-Pesticides have a large and important role. They are compliant to bio-intensive pest management and ideally suited for paddy cultivation. They are sustainable, renewable with low pesticide residue.

Plant-derived extracts and phyto-chemicals have long been a subject of research for the improvement of paddy yield, in an effort to develop alternatives to Conventional-Pesticides but with reduced health and environmental impact. Due to these reasons, the synthesized Bio-Pesticide are aimed to offer a better impact on the growth and yield of paddy and thus provide recommendations to improve existing commercial Bio-Pesticide. Natural products such as Neem are an excellent alternative to Synthetic-Pesticides as a means to reduce negative impacts to human-health and the environment. It has been well recognized that plant-based insect-control agents could be developed into products suitable for Integrated Pest Management (IPM) Programs for rice field cultivation. They are selective to pests, have little or no harmful effects on non-targeted organisms and the environment. In addition, they act in many ways on various types of pest complexes and may be applied to the plant in the same way as Conventional-Pesticides. Besides that, plant extracts and essential oils from Neem are also known as an efficient soil ameliorate.

In addition to an increase in paddy yield, a significant reduction in the number of pests is possible with improvements to soil enrichment and fertility as well.

A move towards Green Chemistry Challenges with Processes calls for the continued development of new crop protection tools with novel modes-of-action. Thus, the discovery and commercialization of natural Green-Pesticide products as a better alternative to Conventional/Chemical-Pesticides is imperative when one considers any improvements to paddy yield.

As rice is consumed, the safety issue plays a major concern besides having high productivity of rice. Many plant essential oils show a wide spectrum of activity against pest insects and plant pathogenic fungi ranging from insecticidal, anti-feedant, repellent and growth regulatory activities. Though well received by consumers for use against home and garden pests, Green-Pesticides can also prove effective in agricultural situations, particularly for rice production. Further, while resistance development continues to be an issue for many synthetic pesticides, it is probable that resistance will develop more slowly to essential oil based pesticides. This is due to the complex mixtures of constituents that characterize pesticides based on plant essential oils. These features show that pesticides based on plant essential oils can be use in difference ways to control a huge number of pests and hence improving the productivity of paddy plants for higher rice production.

This project is a collaboration with the Department of Agriculture Perak Tengah; Unit Biosekuriti Tumbuhan and Bio-X Techno Sdn Bhd. It was conducted in Pusat Kecemerlangan Padi, Titi Serong, and at Unit Biosekuriti Tumbuhan, which are both in Parit Buntar, Perak, for the Field-Test and Glass-House Test Trials respectively.

1.2 Research Objectives

The primary objective of this research is to study the application of a Neem-based Bio-Pesticide to potentially improve Paddy Plants Components and subsequently their Yield.

The secondary goals are as follows :-

- To understand existing Bio-Pesticide Solutions and to formulate added functionalities, against paddy pest, pathogens, insects and viruses using Neem;
- To conduct a Field-Test and a Glass-House Test so that a comparative understanding between Conventional/Chemical-Pesticides and commercially available Bio-Pesticides are known and
- To study farmers' acceptance and mindset towards Bio-Pesticide use.

1.3 Research Work Scope

The scope of works are as follows :-

- A Bio-Pesticide was tested on a paddy field at the District of Perak Tengah, Malaysia during September - December 2016 in one season to compare its effectiveness against :-
  - Pests such as :-
    - Rattu Argentiventer;
    - Pamocea Caniculata;
    - Leptocorisa Oratorius; and
    - Scotinophara Coarctata.
  - Pathogens such as :-
    - Xanthamonas Oryzae;
    - Pseudomonas Fuscovaginae;
    - Pyricularia Oryzae; and
    - Helminthosporium Oryzae that causes plant diseases such as :-
      - Leaf Blight;
      - Sheath Brown;
      - Leaf Blast; and
      - Brown Spot.
- Bio-Pesticide bio-efficacy was also tested in a Glass-House Test to compare its effectiveness on Brown Plant-Hoppers (BPH), Nilaparvata Lugens; and
- Correlation Analysis was conducted between Grain Yields obtained with growth characteristics of Paddy :-
  - Plant Height (cm);
  - Panicle Length (cm);
  - Panicles/m^2 (#);
  - Spikelets/Panicle (#);
  - Productive Spikelets/Panicle (#);
  - Productive Spikelets (%);
  - 1,000 Grains Weight (g); and
  - Grains Yield (g/m^2).

1.4 Research Report Content

According to the objectives, the content of the report are as follows :-

- *Chapter 1* - Presents an introduction, research scope, objectives and problems;
- *Chapter 2* - Elaborate on literature reviewed with an analytical focus on the problems of Conventional/ Chemical-Pesticide use; pesticide attacks on paddy fields; increasing demands for rice; neem-based Bio-Pesticides as a green technology alternative; and the advantages of using Bio-Pesticides to improve paddy yields;
- *Chapter 3* - Describes the methodologies used; experimental procedures and set-ups; test locations, product application techniques; and sampling with analytical methods are discussed;
- *Chapter 4* - Results and discussions on growth characteristics and their correlation with paddy yields obtained; and
- *Chapter 5* - Conclusion on the results obtained, challenges and way forward in order to improve on the current research.

2.0 CHAPTER 2 - LITERATURE REVIEW

2.1 Introduction

Rice, scientifically known as Oryza sativa plays a vital role in contributing towards food security and it is widely consumed as staple food by about 2 billion people in Asia (International Rice Research Institute, 1993; Pareja et al., 2011). Most of the world's population rely on rice as their major daily source of calories and protein (Tiwari et al.,2014).

The cultivation of paddy in Malaysia covers an area of 204,246 ha and is principally planted in 8 Granaries : -

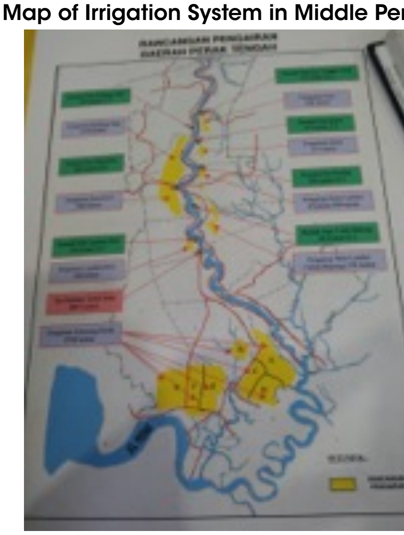
- Muda Agricultural Development Authority - MADA (96,558 ha);
- Kemubu Agriculture Development Authority - KADA (32,167 ha);
- Kerian Sungai Manik Project (27,829 ha);
- Northeast Selangor Project (18,482 ha);
- Penang Integrated Agricultural Development Project (10,305 ha);
- Seberang Perak Project (8,529 ha);
- Kemasin Semerak Integrated Agricultural Development Project (5,220 ha); and
- North Terengganu Integrated Agricultural Development Project (5,156 ha).

It is reported that most (Massaguni and Latip 2012) of the paddy planted in Malaysia are wet-land paddy. Dry-land paddy has a very small acreage and is mostly in Sarawak and Sabah. Fig. 1 shows the cultivation of paddy as a wet-land paddy.

The irrigation process of paddy fields are supplied by the Department of Irrigation and Drainage (DID) where pumps are used to supply water to the field. The map below (Fig. 2) shows the irrigation system in Middle Perak provided by Department of Agriculture (DOA Perak).

Fig. 1
Wet-Land Paddy Cultivation in Malaysia

Fig. 2
Map of Irrigation System in Middle Perak



2.2 Pests and Diseases

Losses because of pests and diseases are major constraints to rice yield and production (El-shakh et. al., 2015). Pests, pathogens and weeds which are biotic stresses, has caused more than 40% losses to the world's annual rice crop production (Hossain, 1996). Bacterial leaf blight (Xanthamonas Oryzae pv. oryzae) and sheath brown rot (Pseudomonas Fuscovaginae) are widely known bacterial diseases of rice in Asia (Kala et. al. 2015) and are amongst the most serious bacterial diseases in many of the global rice growing regions (Xu et. al., 2010, Adorada et. al., 2012). Rice blast (Pyricularia Oryzae) and brown leaf spot (Helminthosporium Oryzae) are the major fungal diseases of rice which occurs in almost all rice growing areas (Singh, 2005; Sharma and Bambawale, 2008).

2.2.1 Rattus Argentiventer (rats)

Often a major pest in rice fields are rice field rats, a rodent species also known as Rattus Argentiventer (Maryanto, 2003). It is the dominant species in the rice fields of Indonesia, Malaysia, Vietnam and the Southern and Central Islands of the Philippines (Buckle and Smith, 2015). Singleton and Petch (1994) reported that every year at least 5 – 15% of the world-wide rice crop are lost to rodents. Rodents move hundreds of meters in a night in rice fields once the developing crop reaches the booting stage (Singleton et. al. 1994). Fig. 3 shows rat damage to growing rice at the booting stage.

2.2.2 Pomacea Canaliculata (snails)

Pomacea Canaliculata or commonly known as Golden Apple Snails (Fig. 4) is the most feared pests of farmers especially in Asia (Halwart, 1994; Yusa and Wada, 1999). San Martin et. al. (2008) and Ito (2002) reported that golden apple snails are a major and serious pest in paddy fields as they caused a lot of damage by completely eating young leafs and stems at the base of the paddy plant resulting in the death of the damaged plant. It cuts the base of young seedlings with its layered tooth (radula) and munches on the succulent tender sheath of rice.

Fig. 3
Damage by Rats to Growing Rice at the Booting Stage (Buckle, A & Smith, R. 2015)

2.2.3 Leptocorisa Oratorius (bugs)

Rice bugs (Fig. 5) also known as Leptocorisa Oratorius are common rice pests throughout Asia (Jahn et. al. 2004; Dale, 1994). They can be found in all rice environments but are more prevalent in rain-fed, wet- or up-land rice (Heinrichs, 1994). They also feed on flowers of a range of grassy weeds that occur in and around the paddy eco-systems (Nugaliyadde et. al. 2000). Rice bugs contaminate the grain endo-sperm with micro-organisms in the process of feeding (Sherpard et. al. 1995) resulting in unfilled or partially filled grains (Morril, 1997) and misshapen grain with yellow and brown stains that milling does not remove (Lee et. al. 1986). Heinrichs (1994) also reported that the yield loss in certain areas exceeds 25% in the Malay Peninsula.

Fig. 4
Pomacea Canaliculata in the Rice Field

2.2.4 Scotinophara Coarctata (bugs)

Scotinophara Coarctata or commonly known as black paddy bug (Fig. 6) is a pest of rice that causes serious problems in many areas of the World including Malaysia. The nymph and adults feed at the base of stems often just at water level where affected plants fail to develop and consequently die (Hill, 2008).

2.2.5 Xanthamonas Oryzae (bacterial leaf blight)

In 1884, bacterial leaf blight disease (Fig. 7) was first observed by the farmers of Japan (Tagami and Mizukumi, 1962) causing 10 to 20% losses in moderate conditions and up to 50% in highly conducive conditions in several Asian and Southeast Asian countries (Mew, 1993; Kala, 2015). Originally, it was believed to be caused by acidic soil (Nino–Liu et. al. 2006). Bacterial leaf blight can however also be spread through plant debris (Goto et. al. 1953; Guo et. al. 1980; Sakthivel et. al. 2001), wild rice (Aldrick et .al. 1973), weeds (Goto et. al. 1953; Valluvaparadesasan and Mariappan, 1989) and water (Singh, 1971; Srivasatava, 1972). Symptoms that occur in older plants, < 30 days is call ed crackling (Asfarian et. al. 2013).

Fig. 5
Leptocorisa Oratorius - Rice Bug
(Heinrichs, 1994)

Fig. 6
Scotinophara Coarctata - Black Paddy Bug
(Hill, 2008)

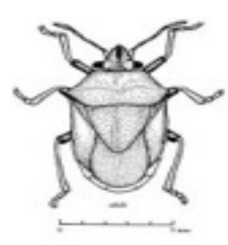


Fig. 7
Bacterial Leaf Blight Disease

2.2.6 Brown Plant-Hoppers (insects)

The brown plant-hopper, Nilaparvata Lugens is a plant-hopper species that is a major threat to paddy plants. The attack by brown plant-hoppers usually causes up to 60% yield loss in susceptible rice cultivars, where they suck the sap from the paddy plant and eventually lead the plant to become dry with a yellowish color and eventually die. The plant hoppers also spread rapidly from dying plants to adjacent plants and causes severe losses in a very short period of time. This phenomenon is commonly known as hopper-burn.

Fig. 8
Brown Plant-Hopper

2.3 Pesticides

The application of any substance or mixture of substances for destroying, preventing, deterring or mitigating any pest or weed is known as a Pesticide (Arias-Estévez et. al. 2008). The use of pesticides are always considered to be easy, fast and a cheap solution for controlling insect pests in paddy farms. The use of pesticides has significantly increased the quantity and enhanced the quality of food to support the a nation's food security. However, the application of pesticides comes with various negative effects.

Pesticide use has brought many diverse effects especially to human health and environmental pollution including ground water- and soil-contamination. Table 1 shows common pesticides recommended by the Department of Agriculture for rice farmers in Permatang Keriang, Penang, Malaysia (Ahmad et. al. 2014). Different types of pesticides used during rice farming seasons are insecticides, herbicides, fungicides and rodenticides.

The adverse health impact on society in general and vulnerable population like children in particular, are one of the consequences of indiscriminate use of Conventional/Chemical-Pesticide (Bhardwaj and Sharma, 2013). Some of the well-known health effects of pesticide exposure includes acute poisoning, cancer, neurological effects and reproductive and developmental harm amongst human beings. Bhardwaj and Sharma (2013) also stated that prolonged pesticide exposure includes malfunction of liver, immune malfunction, neurologic impairment and reproductive effects yielded inconclusive results. An excess mortality from cardiovascular and respiratory diseases was uncovered, possibly related to the psychosocial consequences of the accident in addition to the chemical contamination.

Table 2 shows total cases and deaths caused by pesticide from year 2005 to 2010 as recorded by the District Hospital of Tanjung Karang, Selangor, Malaysia (Fuad et. al. 2012). In their study, they found that health cases had increased between February to April and from the final week of June until the middle of November, a period where the cultivation and treatment of paddy plants with Conventional/Chemical-Pesticides are conducted.

Table 1
Common Pesticides used in Permatang Keriang (Ahmad et.al. 2014)

Pesticide Formulation	Pesticide Group	Pesticide Class
Actara	Insecticide	Class IV
Karate	Insecticide	Class II
Nurelle 505	Insecticide	Class Ib
Nominee 100 SC	Herbicide	Class III
Score	Fungicide	Class III
Tapisan	Insecticide	Class III
Yosodion	Rodenticide	Class IV

Pesticides contaminates the environment. In addition to killing insects and/or weeds, pesticides can be very toxic and poisonous to a host of other organisms including birds, fish, beneficial insects, and non-targeted plants. Insecticides are generally the most acutely toxic class of pesticides. A world-wide problem caused by pesticide contamination is ground water- and soil-contamination. Organochlorine insecticides are amongst many pesticides used that were still detectable in surface water 20 years after their use and has been subsequently banned (Larson et. al. 1997). A long-time is required for contamination to disperse, when ground water is polluted with toxic chemicals (Aktar et. al. 2009). In addition, treatment is expensive when specific and specialized subject-matter experts (SMEs) are needed with sophisticated handling equipment to remove and/or neutralize dangerous chemicals.

Table 2
Pesticide Incidents and Deaths 2005 - 2010 (Fuad et.al. 2012)

Year	Incidents	Deaths
2005	17	2
2006	19	1
2007	9	3
2008	17	3
2009	24	2
2010	9	3
Total	**94**	**14**

2.4 Bio-Pesticides as an Alternative Solution

To avoid damage due to pests, there is a wide range of methods that has been applied, such as physical, chemical, and cultural methods with chemical spraying being the most common practice and has been used extensively for the control of pests for years (Shahid et. al. 2003). This is because there are direct and immediate results after its use with easy handling. Thus, in recent years an increase in the production and consumption of pesticides has been observed (Debashri and Tamal, 2012). It cannot be denied using Chemical-Pesticides does increase agricultural production (Debashri and Tamal, 2012). However, the reliance on Chemical-Pesticides to address these issues has resulted in ecological adversity and health related problems (Cantrell et. al. 2012 and Wakil et. al. 2001). It has also caused dangerous wellness problems to laborers throughout the preparation, manufacture and filling exercises (Ansari & Kumar, 1988). It is already reported that in the long term, Chemical-Pesticides have massive harmful residual effects not only to the soil, health and crop productivity but they also contaminate the ground-water levels and are assimilated into the food chain in the eco-system which results in human health hazards (Datta, 2012).

Therefore, the requirements for safer, environmentally-friendly and ecologically-balanced forms of pesticide use is a must.

In crop protection, Bio-Pesticides have an important role, even when applied in combination with other tools and methods, including Chemical-Pesticides as part of a Bio-Intensive Integrated Pest Management (IPM) Program (Roychowdury et. al. 2014). Typically, Bio-Pesticides are Botanical-Pesticides which are extracted directly from plants that contain toxic compounds to control pests. Their harmful residues are not detectable.

One of the most beneficial advantages of Bio-Pesticides are when they are locally produced and are relatively cheaper and more easily available when compared to most Chemical-Pesticides (Bhardwaj and Sharma, 2013).

Salako (2002) also reported that the use of neem in Bio-Pesticides is another added and clear advantage. Complex mixture of active ingredients functions differently on various parts of an insects' life-cycle and physiology and this makes it difficult for pests to develop resistance systematically which protects the plant from within. This has provided protection for rice, wheat, barley, sugar-cane, tomatoes and more, from damaging insects. Besides this, neem in Bio-Pesticides can control insects including migratory locusts, army worms, white-fly and even head lice. It is also bio-degradable and in the long term it will be more effective than Chemical-Pesticides.

Bio-Pesticides are a serious potential alternative to Chemical-Pesticides, as they are less toxic and poisonous. Thus, they are inherently less harmful and have a lesser environmental-load, when designed to effect only one specific pest and/or in some cases, a few targeted organisms (Gupta and Dikshit, 2010).

In addition, (Gupta and Dikshit 2010) they also stated that the interests in Bio-Pesticides are based on other advantages, in that they are often effective in very small quantities, decompose quickly resulting in lower exposures and largely avoiding pollution problems, have little or no residual effects and have acceptability-of-use in organic farming. Studied by Tiwari et. al. (2014) on the effects of Bio-Pesticides, these advantages were observed with regards to rice grain yields in India. They found that there was an increase in grain yield on rice by application of Bio-Pesticides. Bio-Pesticides provided environment al-friendly alternative to Chemical - Pesticides but faces a number of constraints in their development, manufacture and utilization. Fig. 9 shows the global consumption and market share in Bio-Pesticides with the largest from the United States and Canada with 44%, followed by Europe with 20%, Asia 13%, Oceania 11%, Latin America 9%, and the lowest for Africa at 3%.

2.5 Neem-Based Bio-Pesticides

Juss (Neem) Tree whose anti-viral, anti-fungal, anti-bacterial and insectidal properties have been known for many years (Harikrishnan et. al. 2003).

Fig. 9
Global Bio-Pesticide Market and Use
(Roettger and Reinhold 2003)

Azadirachtin is active in nearly 550 known insect species, mostly in Coleoptera (Beetless and weevils); Dictyoptera (cockroaches and mantids); Diptera (flies); Heteroptera (true bugs); Homoptera (aphids, leaf-hoppers, wasps, and ants); Isoptera (termites); Lepidoptera (moths and butterflies); Orthoptera (grass-hoppers, katydids); Siphonaptera (fleas); and Thysanoptera (thrips) (Debashri and Tamal, 2012).

Recent studies show that bio-active secondary metabolite azadirachtin ($C_3H_{44}O_{16}$) compound which is present in Neem (Azadirachta Indica) can be use to produce effective BioPesticides. An anti-feedant, repellence, ovi-position deterrent, molting inhibition and a growth retardant for a variety of insects and arthropods are the insectidal properties found in this compound (Massaguni and Latip, 2012; Kannaiyan, 2002).

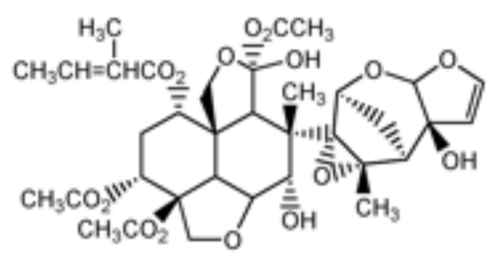
Botanically, the Neem Tree is known as Azadirachta Indica A. Juss. and belongs to the family Meliaceae tribe Melieae and the genus Azadirachta is a tropical evergreen related to mahogany. There are 2 genera of tribe Melieae which are Azadirachta and Melieae. The species belonging to Melia genus and are distributed in Indo-Myanmar, Indonesia, Philippines, China, Fiji, Malaysia, Mexico and Africa as reported by Chowdhary and Singh (2008). Melia azedarach Linn. also known as "gora neem" or "bakayan" (Persian Lilac) is often confused with Neem (Azadirachta indica A. Juss) but both species are quite different, the former being a native of the Middle East. There are 2 varieties of neem Azadirachta indica A. Juss which one of it is Azadirachta indica Juss variety. Siamensis Valeton (Siamese Neem Tree) was reported by Arora et. al. (2008). This variety is found throughout Southeast Asia (Cambodia, Laos, Myanmar and Thailand). The Siamensis variety is phenotypically different from the Indian variety. Less branching, longer and thicker leaflets, a larger and denser inflorescence and larger fruit are the characteristics of the Siamensis variety. This plant is native to the coastal fringe forests of the drier tropical region of east India, Sri Lanka and Burma and currently it is established in at least 30 countries world-wide and in several Asian countries which includes Pakistan, Myanmar, Thailand, Malaysia, Indonesia, Africa and Central/South-America (Csurhes, 2008; Mathur, 2013).

The Neem Tree is able to grow almost anywhere in low-land tropics unlike most other multi-purpose tree species and can grow well in moist, dry, stony, clayey and/or shallow soils and even on soils having hard calcareous or clay pan, at shallow depths but in general, the best performances in areas with annual rainfall of 400 - 1200 mm (Tomar and Singh, 2008) and does well on black cotton soil and deep, well-drained soil with good sub-soil water (Mathur, 2013). Mathur (2013) also stated that neem tree can also improve the fertility of soil and water-holding capacity as it has a unique property of calcium mining, which changes acidic soils into neutral one. According to Mathur (2013), it has adapted to a wide range of climates. It thrives well in hot weather where the maximum shade temperature is as high as 49° C and tolerates cold up to 0° C on altitudes up to 1,500 meters. Negative effects on seed-eating insects were found by applying leaf powder, the seed oil and all kinds of extracts (Boeke et. al. 2004) but if plant parts are used to treat stored - seed against insects, the mammalian consumer of these seeds especially humans are not affected by residue of this treatment.

In particular, Neem seems to be safe for humans and the environment, as it has not been found to possess toxic and/or poisonous compounds. Azadirachtins considered to be a future Biocidal-Agent due to its selectivity, simple to prepare, locally available renewable resource, readily bio- and photo-degradable, user-friendly and safe for humans (Yar'adua, 2007).

The Neem-based Bio-Pesticide has been proposed in this study as its carries azadirachtins compounds and is recognized for their plant-derived insecticidal properties. Azadirachtin, an active compound extracted from the Azadirachta indica A or also known as Neem is one of the most promising natural compounds amongst natural products. The Neem Tree is a fast growing hardy and evergreen tropical and sub-tropical plant belonging to the same family as mahogany, Meliaceae (Atawodi et. al. 2009). The leafs have been shown to contain crude-fibre (11-24%), carbohydrates (48-58%), crude protein (14-18%), fat (2.3-6.9%), ash (7.7-8.5%), calcium (0.8-2.4%) and phosphorus (0.13-0.24%), as well as a number of amino acids (Debashri and Tamal, 2012). The crude neem extracts and products induce anti-feedant effects (Khater, 2012). Products derived from neem tree performs great Insect Growth Regulators (IGR) and also helps in controlling some nematodes and fungi (Lokanadhan et. al. 2012).

Fig. 10
Chemical Structure of Azadirachtin
(Morgan, 2009)



2.6 Sustainability

In an effort to move towards operationalizing the concept of sustainability, a number of sustainability dimensions were taken into account. It was believed that consideration for each is critical, since they influence the different stages of the project cycle, as well as reflects different outcomes.

2.6.1 Long-term Technological Sustainability

The use of this research's Bio-Pesticide is primarily from Neem, a locally available renewable resource. This plant is ideal for reforestation programs and for rehabilitating arid, semi-arid and degraded lands, because of its hardy, multi-purpose and multi-functional properties.

In Somalia and Mauritania, Neem has been used for preventing the spread of the Sahara Desert. Also, Neem is a favored tree along avenues, in markets and near homesteads because of the shade it provides. However, it is best planted in mixed stands and has all the good characters for various social forestry programs (Zhu et. al. 2000). Hence, there are many uses for Neem that enables it to be a renewable source especially in Asian countries where the climate is optimal for its growth. In fact, in Arizona, Neem Trees can withstand frost up to -8° C which makes them very durable.

The systemic action of Neem is a unique and universal method of enabling the seedlings to absorb and accumulate neem compounds to allow the plant to be resistant to pests (Zhu et. al. 2000). Advanced technological findings may not be able to compare with this method, as the mechanism of Neem is natural, free and does not require external influence for this to happen. However, insects often evolve resistance to insecticides within a decade (Kaul and Wahab, 2004). Luckily, neem formulation contains a broad spectrum of compounds that are able to restrict the development of resistance to a great extent (Zhu et. al. 2000). In fact, the addition of ginger, garlic and/or red chilli when added to the list of insecticidal compounds, can further enhance the paddy's resistance with a formulated Bio-Pesticide.

2.6.2 Social Sustainability

Social sustainability signifies the nature-society relationships mediated by work, as well as relationships within society. It is applicable if the projects are able to satisfy and extended a set of human needs and are shaped to enable the preservation of nature's reproductive capabilities. It is also a positive condition within communities and a process within communities that can achieve such conditions (McKenzie, 2004). In this project, the main characters that play a role in social sustainability are the Farmers, Bio-X Techno (BXT - Malaysia), Okada Ecotech (OE - Singapore) and University Technology Petronas (UTP)

Considering the nature of Bio-Pesticides as a natural, cheap and practical Bio-Pesticide, it has a high potential in being applied in fields to replace Conventional/Chemical-Pesticides.

Hence, BXT and OE contributed a lot of effort in educating the farmer about the benefits of their solutions. One of their efforts is this collaboration was to make available their solutions at no charge. The objective of this was to enable the farmer to be involved and spread news about the effects of the solution on the paddy plants once applied. The farmer provided their honest opinions and this may enable other interested farmers to apply the product and hence benefit the society and the environment over the long term. Further improvements to the Bio-Pesticide, especially after considering the formulations of the synthesized Bio-Pesticide, can also aid the farmers to produce healthy paddy yields as long as they are committed to its use.

2.6.3 Environmental Sustainability

It is believed that this sustainable category plays a crucial role in maintaining the effectiveness of the product and most importantly, in ensuring the health of the people and animals around. Hence, careful considerations were taken into account on ensuring its sustainability to the environment. We divide this category into a few subtopics so that all aspects that are considered important are highlighted.

2.6.3.1 Contribution of BXT and OE to the Environment

Based on Integrated Pest Management (IPM) Programs, Bio-Pesticides originating from Neem are well-suited to the environment because of its natural properties. This water-based Bio-Pesticide is absolutely non-poisonous to higher animals, 100% photo- and bio-degradable, ecologically-balanced and environmental-friendly. It affects the pest's behavior and physiology but does not kill them. This prevents the food chain of animals to be unaffected by ensuring that the pests' natural enemies does not go into starvation and die because of poisoned food. 100% of the solution is not detectable after 11 days.

Today, there are several million Neem Trees along the East Coast of Africa. This number does not include the ones that are available in other countries. The plantation of Neem Trees requires minimal ecological demands on the soil and water, hence helps in preventing erosion. It is useful in areas that have low rainfall and high wind-speed. In fact, in Majjia Valley in Niger, Neem Trees have been planted in double rows to protect millet crops, which resulted in 20% increase in the grain yield. Since the leaf part of the tree is the only one required for the production of Bio-Pesticides, deforestation of neem trees could be prevented and thus preserves the environment.

2.6.3.2 Maintaining Soil Fertility

Since 1945, poor management of water, soil erosion and poor fertilizer has enabled 17% of vegetated land to undergo human-induced soil degradation and loss of productivity (Zhu et. al. 2000). This is due to the continuous cropping and inadequate replacement of nutrients during the removal of harvested materials. Nutrients are also lost through leaching, erosion and/or gas emissions which deplete fertility and cause the decrease in the soil organic matter to half or less of the original levels. Unlike other Conventional-Pesticides, Bio-Pesticides that will be formulated in this project is photo- and bio-degradable in nature. It does not influence the nutrient content levels of the soil and hence does not affect the deterioration of the soil.

The solution actually "conditions" and thus improves the soil.

2.6.4 Economical Sustainability

The production of the formulated Bio-Pesticide requires a simple experimental procedure without involving high-end equipment and expensive chemicals. As long as the supply of traditional herbal extracts are available, the production of the Bio-Pesticide would be continuous as long as there is a demand. In addition, the application of this Bio-Pesticide only requires a small budget with the use of cheap main materials.

No other Conventional-Pesticide is required and/or used in this research when applying Bio-Pesticide to the Bio-Pesticide Plot.

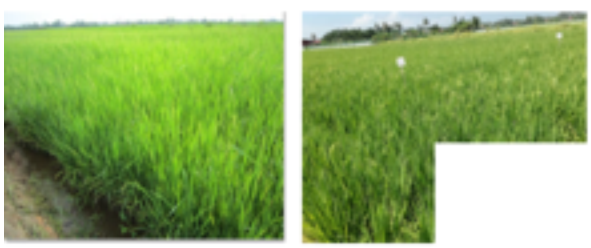
3.0 CHAPTER 3 - METHODOLOGY

3.1 Sampling Sites

The Field Test were conducted at the Paddy Centre of Excellence, Titi Serong, Parit Buntar, Perak, Malaysia which is within the Middle Perak District.

Both Bio-Pesticide Plot (A2) and Chemical/Conventional-Pesticide Plot (B1) were tested in the paddy fields to compare their effectiveness towards improving rice yield as shown in the figures below. The Bio-Pesticide was obtained from BXT and OE as part of this collaborative research.

Fig. 11
Field Test Plots



Bio-Pesticide Plot 0.95 ha

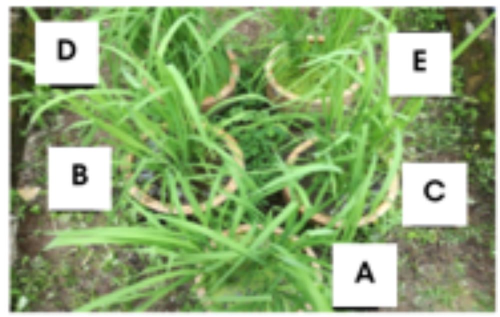
Conventional-Pesticide Plot 0.60 ha

The Field Test Plots are divided into 3 parts : Top, Middle and Bottom to study the effects of Water-Inlet and Water-Outlet on paddy plant growth and yield in terms of mass transfer. There are 6 plots altogether for both Bio-Pesticide Plots and Conventional Plots with 18 Paddy Plants studied in each plot.

As for the Glass-House Test, it was conducted at the Plant Bio-Security Unit of the Department of Agriculture (DOA), Titi Serong, Parit Buntar, Perak, Malaysia. The study was divided into 3 parts : T1 Bio-Pesticide Plot Enhanced - Solution Sprayed was 612EC and 500WS; T2 Bio-Pesticide Plot Normal - Solution Sprayed was 500WS only; and C1 Control Plot.

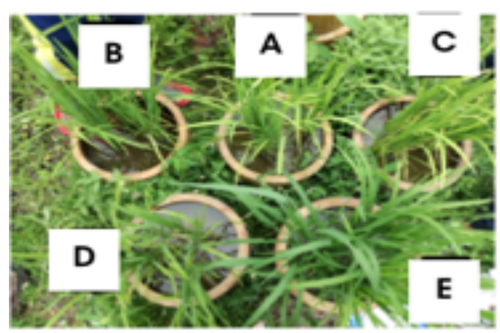
Each of the plots have 5 Vases and are labeled accordingly as shown below with known soil quantities.

Fig. 13
Glass-House Test Sampling Sites
Located in an Insect-House



Vase T1 : Bio-Pesticide Solution 500WS + 612EC

Vase T2 : Bio-Pesticide Solution 500WS



Vase C1 : Control

Fig. 14
Glass-House Test Vase Dimensions
with Soil Depth

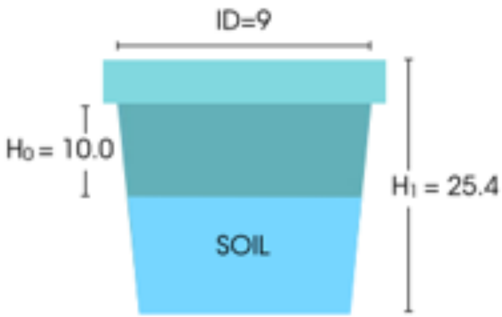


Table 3
Soil Density

Componet	Measure
Vase Volume (cm³)	1,615.88
Soil Volume in the Vase (cm³)	979.71
Soil Mass (kg)	13.55
Soil Density : Mass/Volume (kg/cm³)	0.0138

3.2 Paddy Plant Cultivation

The complete cycle for paddy cultivation was 112 days and divided into 6 Stages :-

- Planting;
- Tillering;
- Panicle Initiation;
- Heading;
- Ripening; and
- Harvesting.

3.2.1 SOP Field Test Paddy Plant Cultivation Processes
Early Stage

The Field Test Paddy Plant Cultivation Processes are as follows :-

- Field Test Sterilization Process;
- Field Test Filtration Process;
- Field Test Sowing Process; and
- Field Test Plantation Process.

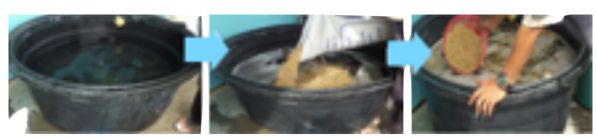
3.2.1.1 Field Test Sterilization Process

"Fresh-Water" was cured for 1 week to reduce chlorine in the water, to become "Clean-Water" (Completed Aug 12th 2016). This clean water was then mixed with a 500WS Solution. Paddy Seeds ((MR 219 variety) were then added to this solution to eventually be transplanted to the Bio-Pesticide Plot A2 (Treated Plot).

In contrast, only clean water was prepared and added to the seeds (MR 219 variety) that will eventually be transplanted to the Conventional-Pesticide Plot B1 (Control Plot).

Paddy Seeds that floated on the water were removed and the rest are soaked for 1 day. All of this were completed by Aug 19th 2016.

Fig. 16
Field Test Seed Sterilization Process



3.2.1.2 Field Test Filtration Process

The seeds were then filtered from the Combined Solution (Clean Water with the 500WS Concentrate). The balance of the Combined Solution are retained/ stored to be subsequently applied/

sprayed into the Bio-Pesticide Plot A2. The toast seeds are allowed to rest for 24 hrs.

Fig. 17
Field Test Filtration Process

3.2.1.3 Field Test Sowing Process

The top soil is put in the tray using a machine. A 1ha paddy field usually needs about 250 trays. The Paddy Seeds (Toast Seeds) are then placed in trays by a machine and are cover with a scarf for 14 - 15 days against direct sunlight to allow them to grow uniformly. This were completed between Aug 21st and Sept 5th 2016.

3.2.1.4 Field-Test Plantation Process

The fields are flattened and sprayed with a Weed-Pesticide (Paraquat) after 10 days. The water is channeled into the paddy fields till it reaches the standard level, this after 5 days. After 2 days, Golden Snail Pesticides (Baylucides) was sprayed. After a few days, ploughing starts and the water in the paddy fields are allowed to dry-out. The Bio-Pesticide Plot A2 is also sprayed, but uses the Combined Solution from the Sterilization Process. The growing seeds are then planted into the paddy fields using a transplanter and a Weed-Pesticide (Sofit) is sprayed after a few days.

This was completed on Aug 20th 2016.

Fig. 18
Field Test Sowing Process

Fig. 19
Field Test Transplantation Process

3.2.2 SOP Glass-House Test Paddy Plant Cultivation Processes
Early Stage

There processes are as follows :-

- Glass-House Test Sterilization Process;
- Glass-House Test Filtration Process; and
- Glass-House Test Sowing Process

3.2.2.1 Glass-House Test Sterilization Process

Table 4 shows the Sterilization Process for Paddy Seeds Soaked with 500WS which was completed Sept 7th 2016. It shows the figures and steps involved from the treatment of fresh-water to clean-water to soaking of paddy seeds in clean-water as well as being mixed together with the 500WS Solution. For controlled conditions, the seeds are first weigh using a weight balance. Then, fresh-water is measured using a measuring cylinder and poured into a beaker. Lastly, the paddy seeds are kept in the beaker with fresh-water and allowed to be soaked for 24 hrs.

Fig. 12
Field Test Sampling Sites
with Water Depth (cm)

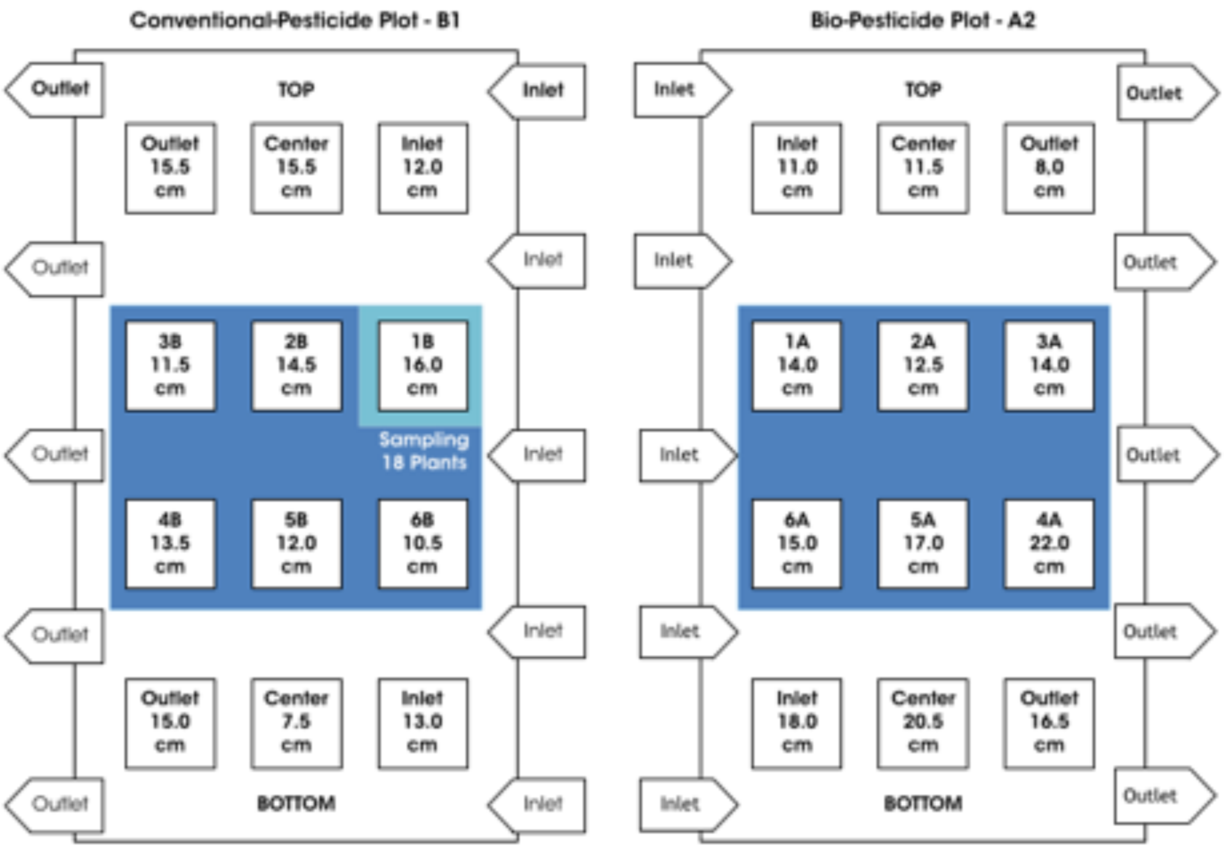


Fig. 15
Paddy Cultivation

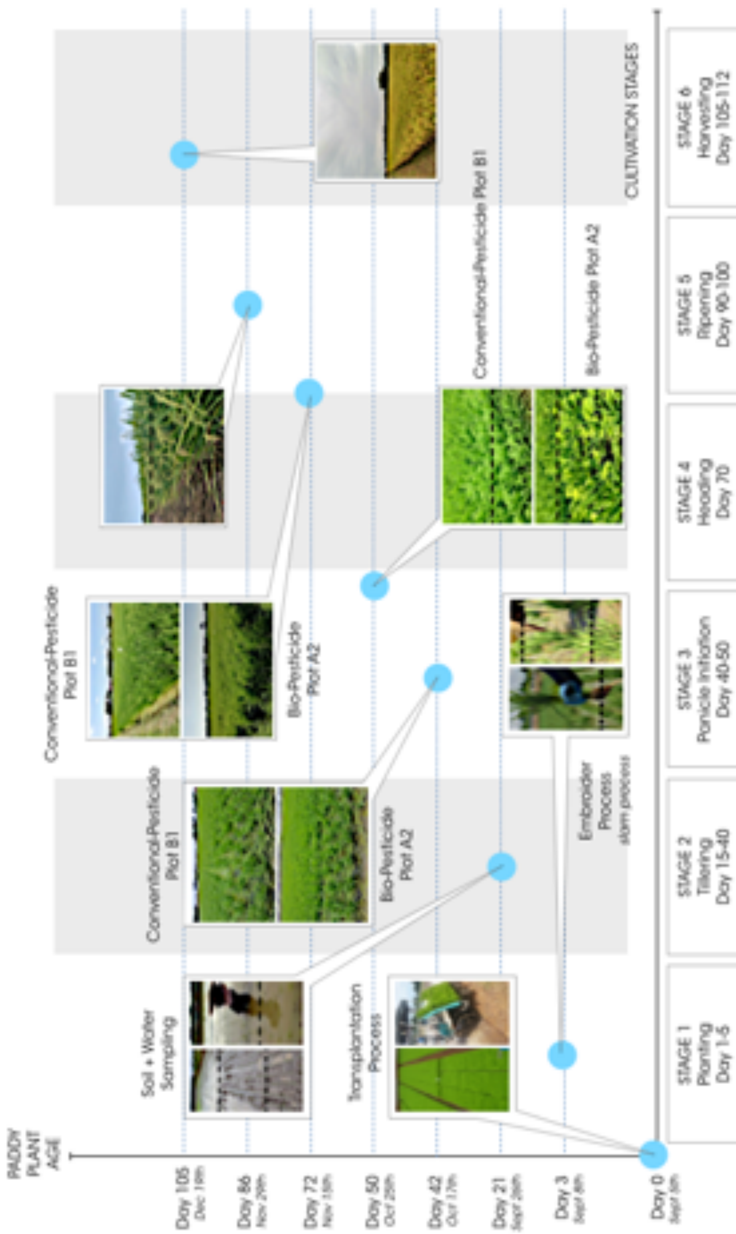


Table 4
Glass-House Test Sterilization Process for Paddy Seeds Soaked with 500WS

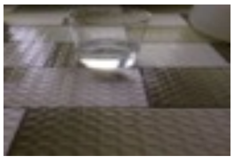


Fig. 20 - Cure Water

STEP 1 : Clean water is cured for 24 hours to reduce chlorine in the water.

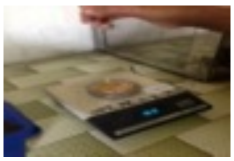


Fig. 21 - Weight Balance

STEP 2 : Paddy seeds are weigh with a weight balance.

Fig. 22 - Measure Clean Water

STEP 3 : Clean water is measured and poured into a beaker.

Fig. 23 - Adding and Stirring 500WS Concentrate Solution

STEP 4 : 500WS Solution is added into the same beaker by using a pipette.
The Combined Solution (Clean water + 500WS Solution) is stirred till it is completely dissolved.

Fig. 24 - Soaking of Paddy Seeds

STEP 5 : The paddy seeds are put into a beaker and soak for 24 hours.

Table 5
Glass-House Test Sowing Process

Fig. 26 - Preparation of Combined Solution

STEP 1 : 500WS Solution + Clean-Water (balance of the Combined Solution from the Sterilization Process) are prepared in a container.

Fig. 27 - Mixture of 500WS to Sterilized Solution

STEP 2 : 500WS Solution is prepared and added to the balance of the Combined Solution (500WS Solution + Clean Water) that has been used from the previous Sterilization Process.

Fig. 28 - Stirring Process of 500WS Solution

STEP 3 : The Solution is stirred until the 500WS Solution is completely dissolved.

Fig. 29 - Planting of Paddy Seeds

STEP 4 : Nine (9) seeds are planted/vase where the seeds must be placed at three (3) different and separate locations (3 seeds/location).

Seeds soaking in the Combined Solution are planted in Vase T1 and Vase T2. Seeds soaking in Clean Water are planted only in Vase C.

Fig. 30 - Spraying of Combined Solution

STEP 5 : Ten (10) Vases (T1 and T2) were sprayed with 0.08 ml of the Combined Solution during Step 2.

The Vases in Row C will not be sprayed with any Solution and is designated the Control Test.

Fig. 31 - Growing Paddy Plants in Protected Space

STEP 6 : All Vases are kept in a cover area to protect them from rain for 7 - 10 days to allow the paddy seeds to grow until they reach 2" in height.

3.2.2.2 Glass-House Test Filtration Process
Completed Sept 8th 2016

After 24 hours, the paddy seeds are filtered out from the combined solution (500WS + Clean Water) for the treated test and the balance of this combined solution are stored/kept for future use. The paddy seeds with the clean water for the control test were also filtered out. Both sets of paddy seeds filtered out from the combined solution (treatment test) as well as from the clean water (control test) are left "rested" for 24 hours.

Fig. 25
Glass-House Test Filtration Process

3.2.2.3 Glass-House Test Sowing Process
Competed Sept 9th 2016

The steps involved in the sowing process of the seeds into the Vase are summarized in Table 5. The first part of this process involves the preparation of a diluted 500WS Solution, whereas the second part covers the sowing of the seeds into the Vase with the spraying of a Bio-Pesticide.

3.3 Paddy Seed Variety MR 219

A new rice variety, MR 219, was developed by the Malaysian Agricultural Research and Development Institute (MARDI). It was officially released in January 2001. It was the first variety to be developed by means of a direct seeding planting system. Selection from F2 to F6 of the segregating generations was done visually, using a direct seeding system.

The emphasis was on panicle component characters, mainly the grain size and the number of grains per panicle. As a result, a single grain of MR 219 variety can weigh as much as 28 – 30 mg, and the number of grains can be as high as 200, higher than most rice varieties previously released. The capability of this variety for producing higher yields depends mainly on these 2 components.

Other good characteristics of this variety includes a short maturation period (105 – 111 days), fairly tall with strong clumps, and resistance to blast and bacterial leaf blight, with the rice marketed as a long-grain variety. In addition, the cooked rice of MR 219 has a soft texture (amylase content of 21.4%), as preferred by most local consumers. The planting area of this variety in the first season after it was released was estimated to be about 30% of the total major rice granary areas. The coverage rose to about 48.4% in the second season of planting. With good water management and additional input of fertilizers, the MR 219 variety is capable of producing yields of more than 10 mt/ha.

[Source : MARDI, Malaysia]

Other information :-

- MR 219 : Mix from Variety MR 137 and MR 151;
- Ability to withstand diseases, pests and bacterium : Neck Rots, Bacterial Leaf Blight, Blast Disease, Brown Plant-Hoppers;
- Amylose Content : Low @ ~ 21.4%;
- Seed Length : 10.33 mm;
- Seed Width : 2.51 mm; and
- 1,000 Seed Weight : 25.9 – 28.3 grams.

3.4 Application Schedule of Bio-Pesticides and Conventional-Pesticides

The application of both Bio-Pesticides and Conventional-Pesticides are scheduled as below in Table 6 for the field-test plots. Different types of pesticides and herbicides were used such as Baylucides, Paraquat and others with proper dosage compiled.

As for the Glass-House Test, the time-line and schedule of both application of Bio-Pesticide 612EC and 500Ws are as in Table 7. The release date of plant hoppers are also monitored in Table 8.

3.5 Post Harvest Analysis

3.5.1 Paddy Yield Calculations

For the paddy yield calculations, the data for the number of spikelets, total productive spikelets, total number of panicles as well as area of sampling were collected and calculated.

Table 7
Application of Bio-Pesticides for Plot A2

Date	Age of Paddy	Activity
6th	1 Day	Spray 500WS at A2
3rd	25 Days	Spray 612EC at A2
18	43 Days	Spray 612EC at A2
8th	64 Days	Spray 612EC at A2
29	85 Days	Spray 612EC at A2

Table 8
Application of Bio-Pesticides and the Released of Brown Plant-Hoppers at the Insect-House

Date	Age of Paddy	Activity
9th	1 Day	Spray 500WS at T1 and T2 Vases
25	46 Days	Release brown plant-hoppers at T1 and T2 vases
3rd	52 Days	Spray 612EC at T1 Vases
7th	56 Days	Release brown plant-hoppers at T1 and T2 Vases
14	63 Days	Spray 612EC at T1 Vases

Table 6
Application of Conventional-Pesticides for Plots A2 and B1

Date	Pesticide Type	Pump Type	Pump Capacity	Number of Pumps Used	Total Amount
24/8/2016 pre-plantation	BAYLUCIDES *Golden Apple Snail Pesticide*	Power Sprayer	30 g	7	210 g
1/9/2016 pre-plantation	PARAQUAT *Weed Pesticide*	MOTOBLOWER @ 20 L Water	300 ml	7	2,100 ml
8/9/2016 Stage 1 Plantation Week	SOFIT *Weed Pesticide*	MOTOBLOWER @ 20 L Water	150 ml	7	1,050 ml
20/9/2016 Stage 2 Tillering	RUMPAS M *Weed Pesticide*	Power Sprayer @ 17 L Water	60 ml	3	180 ml
23/9/2016 Stage 2 Tillering	MATCH *Pest Pesticide*	MOTOBLOWER @ 20 L Water	10 ml	7	70 ml

4.0 RESULTS AND DISCUSSIONS

4.1 Field Test Data Collection

The following Field Test Data were collected :-

- Plant Growth Observations;
- Plant Growth Analysis; and
- Correlation Analysis between Plant Yield Components and Plant Grain Yields.

4.1.1 Plant Growth Observations

The following Plant Growth metrics were observed :-

- Plant Leaf Colors;
- Plant Growth Conditions;
- Plant Weed Problems; and
- Plant Pest Problems.

4.1.1.1 Observation Plant Leaf Colors

Based on our observations of plant leaf colors (refer to Fig. 32), the leafs start to change from an overall greenish to an overall yellowish color for both Bio-Pesticide Plot (A2) and Conventional-Pesticide Plot (B1) at the end of the Harvest Stage.

On Day 50, the plant leafs in Bio-Pesticide Plot A2 started to turn a yellowish color, but with the introduction spray of Bio-Pesticide Solution 612EC, the leafs started to turn back into a greenish color.

4.1.1.2 Observation Plant Growth Conditions

From our observations of plant growth conditions (refer to Fig. 33), both the Bio-Pesticide Plot and the Conventional-Pesticide Plot plant conditions were similar, as they face common diseases like brown leaf blight, neck rot, dead leafs and holes in the leaf. An approach is now required to control these plant diseases in the field.

4.1.1.3 Observation Plant Weed Problems

From our observations of plant weed problems (refer to Fig. 34), it was found that different types of weeds species (broad-leaf weeds and perennial weeds) were present at both plots. The common weeds found were Mimulus Orbicularis, Monochoria Vaginalis, Borreria Latifolia, Yellow Bur-head as well as Duck Weeds.

It was now obvious that both Bio-Pesticide and Conventional-Pesticide Plots requires the growth of weeds to be controlled to prevent nutrient and sun-light competition between paddy plants and paddy weeds. It has been well known and documented that the growth of paddy plants around paddy weeds makes for slower plant growth and a shorter plant height.

Fig. 32
Field Test : Observation Plant Leaf Colors

Fig. 33
Field Test : Observation Plant Growth Conditions

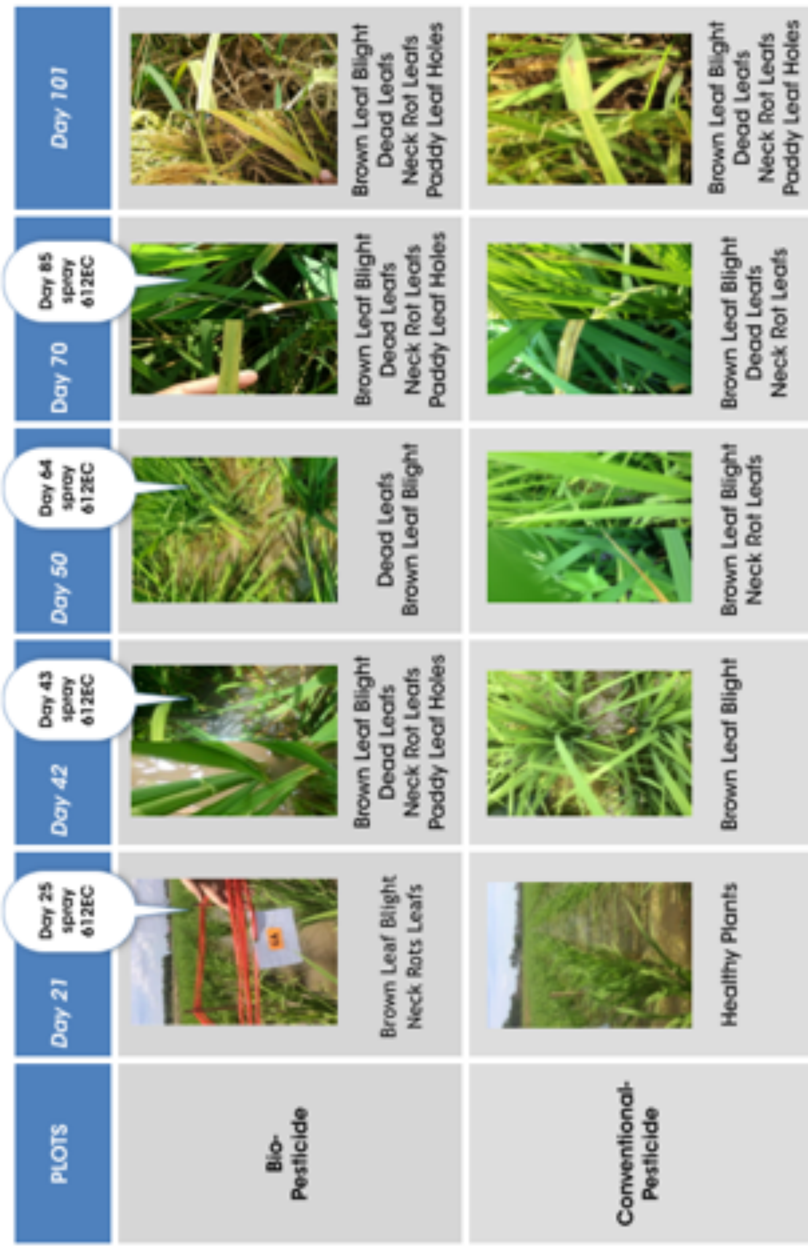


Fig. 34
Field Test : Observation Plant Weed Problems

Fig. 35
Field Test : Observation Plant Pest Problems

4.1.1.4 Observation Plant Pest Problems

As for plant pest problems, less pests were observed in the Bio-Pesticide Plot (A2) when compared to the Conventional-Pesticide Plot (B1). It was recorded that the Bio-Pesticide Solution 612EC, when sprayed was very effective in controlling the pests in the paddy field.

It important to note that, the primary difference between the application/ spray of the 2 Bio-Pesticides Solutions 500WS and 612EC in this research study have 2 different and separate targets and function. The 500WS was applied to strengthen and inoculate seeds to effectively compete against paddy weeds. It also enriches and conditions the soil. The later was applied to manage pest, pathogens, viruses and insects - infestations.

The application of 612EC is conditional with the presence and level of field infestation. If there is no evidence of infestation, then the application of 612EC is not required. It is recommended that a weekly observation for infestation be conducted at the start of each week. A recommendation to apply and spray should be done at the onset of infestation and not to wait till the end of the week when infestation may be heavier.

However, it was also recommended that the application and spray of 612EC be done with or without the observation of infestation to provide general field maintenance to prevent infestation. This of course has both pro- and con-cost implications in the operations of paddy cultivation.

In the Conventional-Pesticide Plot, the presence of pests such as Golden Apple Snails and Leprocorisa Varicornis insects were detected and this led to paddy plant infections.

4.1.2 Plant Growth Analysis

The following Plant Growth components were analyzed :-

- Plant Height (cm);
- Plant Tillers (#);
- Plant Leafs (cm); and
- Plant Leaf Width (cm).

4.1.2.1 Plant Height (cm)

From the Field Test Plant Height (cm) results (refer to Table 9 and Fig. 36), both Plots were comparable in plant height with not much difference as observed from the inlet, middle and bottom sites.

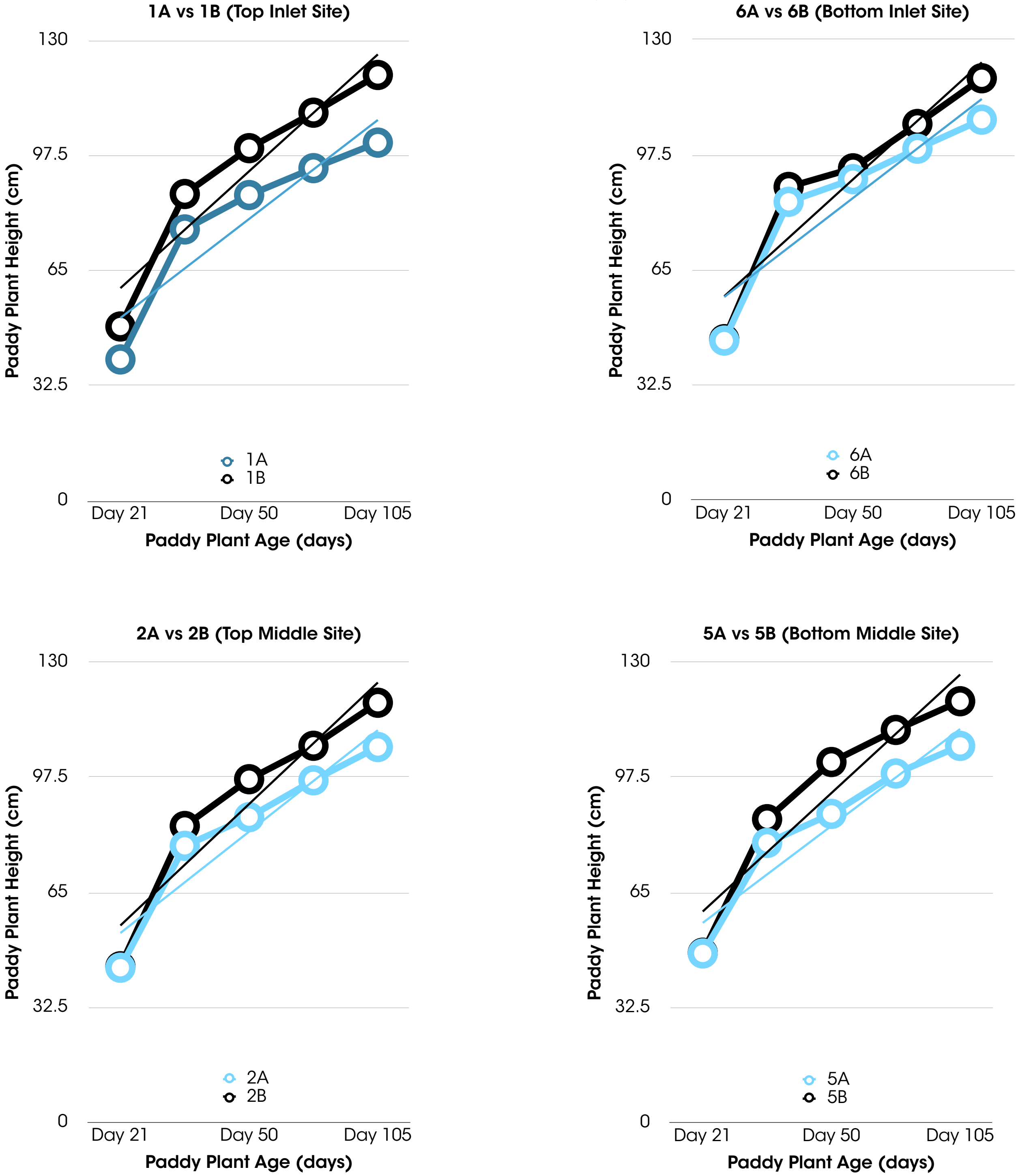
4.1.2.2 Plant Tillers (#)

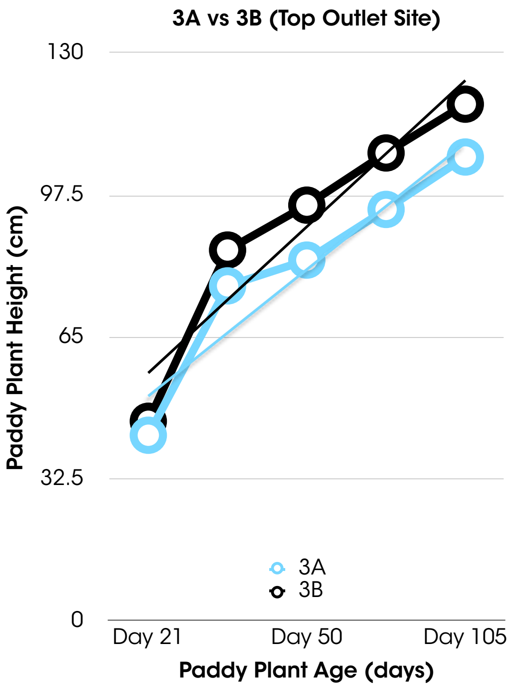
From the Field Test Plant Tillers (#) results (refer to Table 10 and Fig. 37), all the graphs show a dramatic increase in the number of tillers on Day 42 and subsequently remained constant thereafter. It was also observed and recorded that the Bio-Pesticide Plot yielded a higher number of tillers when compared to the Conventional-Pesticide Plot, for all 6 plots from the inlets, middle and outlet sites.

Table 9
Field Test Plant Heights (cm)

Site	Day 21 *Tillering Stage*	Day 42 *Tillering Stage*	Day 50 *Panicle Initiation Stage*	Day 73 *Heading Stage*	Day 105 *Ripening Stage*
1A	39.9	76.6	86.3	93.9	101.1
1B	49.2	86.6	99.5	109.6	120.2
2A	43.7	78.1	86.2	96.6	106.0
2B	44.1	83.7	96.9	106.4	118.5
3A	42.6	76.8	82.7	94.3	106.3
3B	45.8	85.0	95.3	107.23	118.4
4A	44.3	83.3	84.5	100.2	110.7
4B	45.9	82.9	93.9	106.1	118.8
5A	47.8	79.0	87.2	98.6	106.4
5B	48.0	85.7	101.8	110.9	119.0
6A	45.1	84.3	90.7	99.3	107.5
6B	45.5	88.5	93.76	106.3	119.2

Fig. 36
Field Test Plant Heights (cm)




3A vs 3B (Top Outlet Site)
130
97.5
65
32.5
0
Paddy Plant Height (cm)
3A
3B
Day 21
Day 50
Day 105
Paddy Plant Age (days)

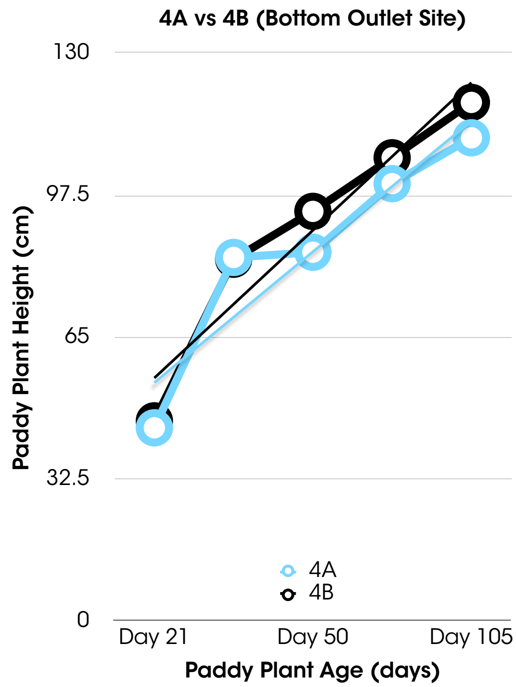
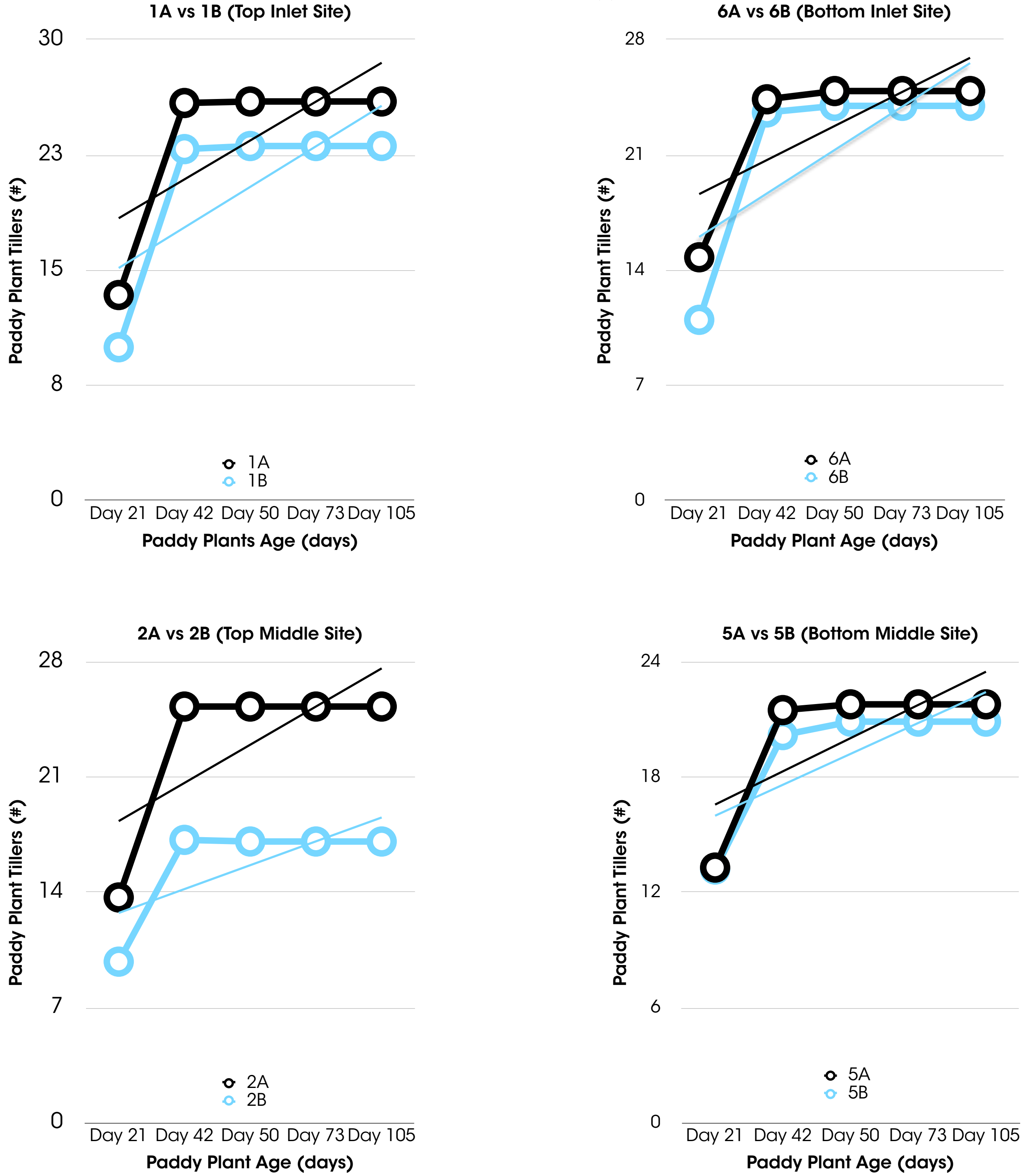
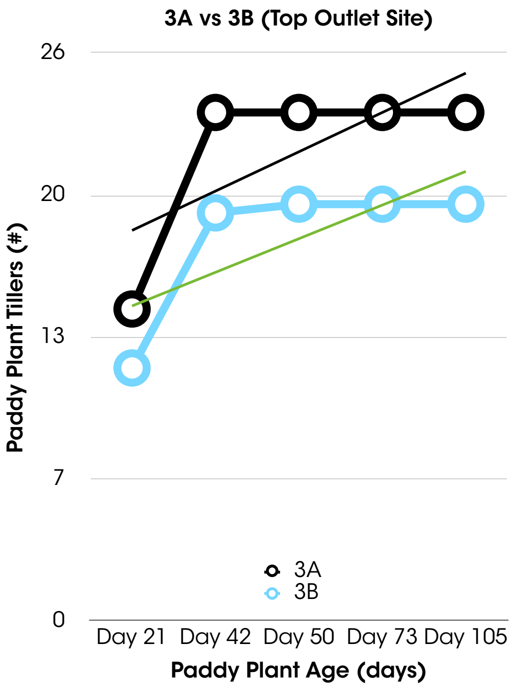

4A vs 4B (Bottom Outlet Site)
130
97.5
65
32.5
0
Paddy Plant Height (cm)
4A
4B
Day 21
Day 50
Day 105
Paddy Plant Age (days)

Table 10
Field Test Pant Tillers (#)

Site	Day 21 *Tillering Stage*	Day 42 *Tillering Stage*	Day 50 *Panicle Initiation Stage*	Day 73 *Heading Stage*	Day 105 *Ripening Stage*
1A	13	26	26	26	26
1B	10	23	23	23	23
2A	14	25	25	25	25
2B	10	17	17	17	17
3A	14	23	23	23	23
3B	12	19	19	19	19
4A	15	23	24	24	24
4B	12	20	20	20	20
5A	13	22	22	22	22
5B	13	20	21	21	21
6A	15	24	25	25	25
6B	11	24	24	24	24

Fig. 37
Field Test Plant Tillers (#)




3A vs 3B (Top Outlet Site)
26
20
13
7
0
Paddy Plant Tillers (#)
3A
3B
Day 21
Day 42
Day 50
Day 73
Day 105
Paddy Plant Age (days)

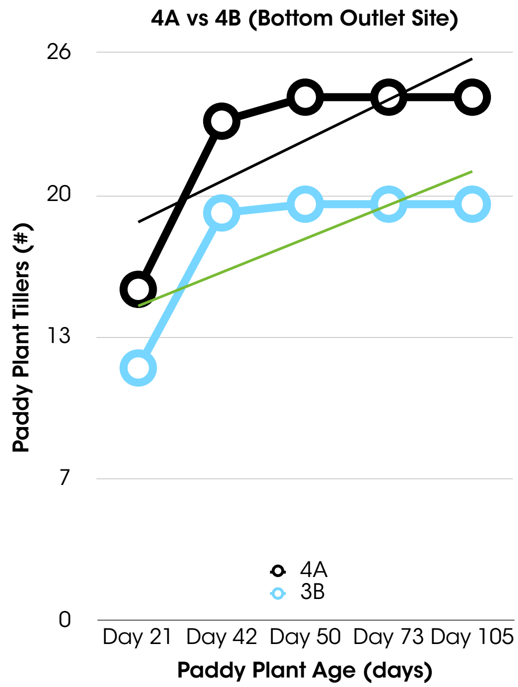
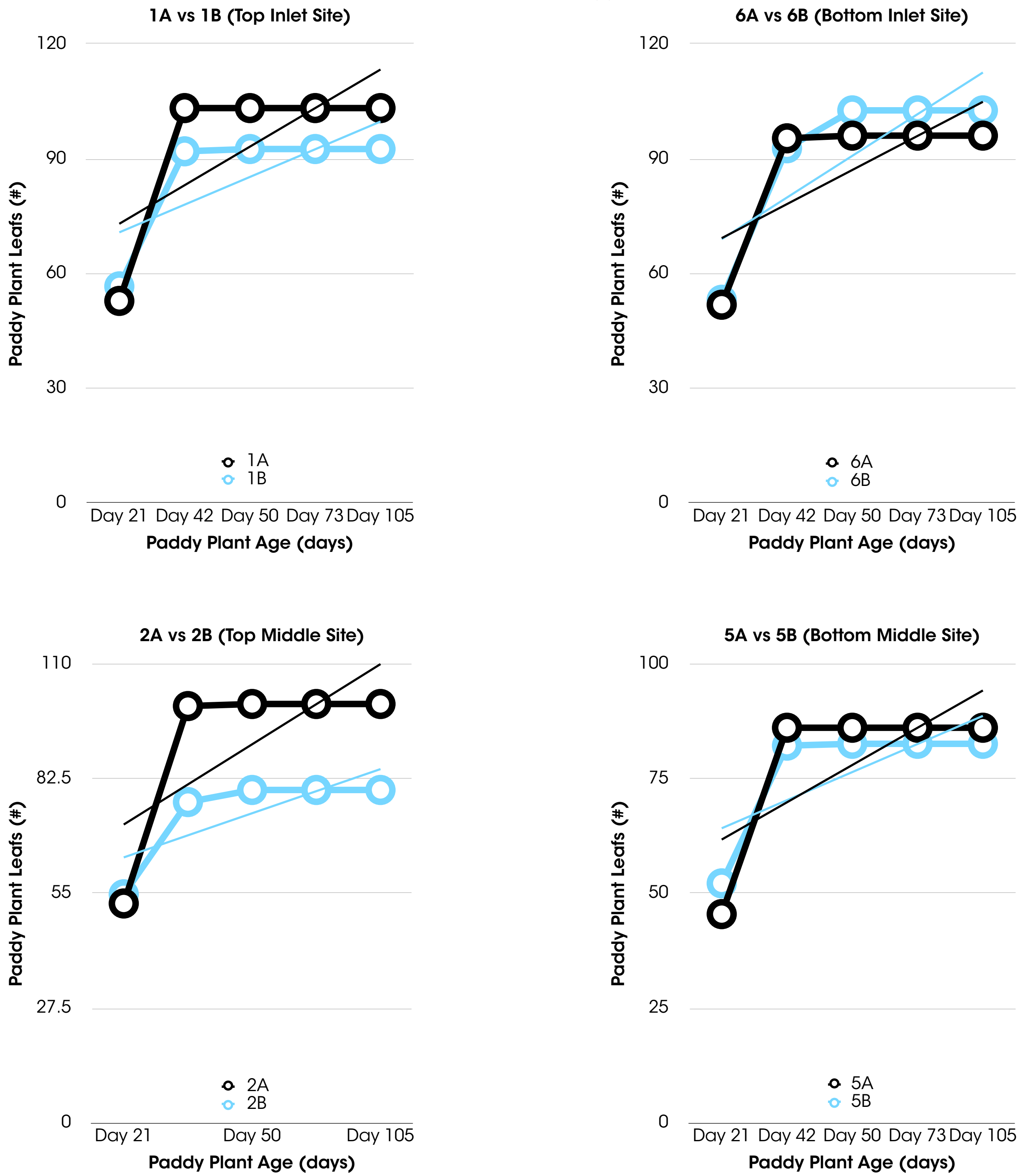
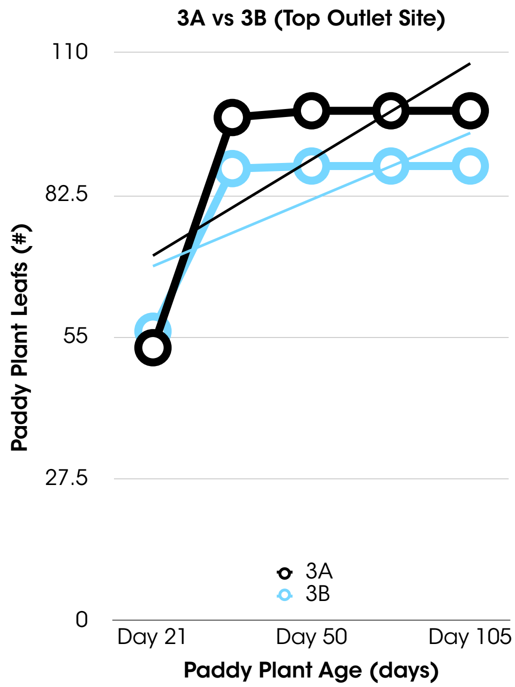

4A vs 4B (Bottom Outlet Site)
26
20
13
7
0
Paddy Plant Tillers (#)
4A
3B
Day 21
Day 42
Day 50
Day 73
Day 105
Paddy Plant Age (days)

Table 11
Field Test Plant Leafs (#)

Site	Day 21 *Tillering Stage*	Day 42 *Tillering Stage*	Day 50 *Panicle Initiation Stage*	Day 73 *Heading Stage*	Day 105 *Ripening Stage*
1A	52.9	103.3	103.3	103.3	103.3
1B	56.7	92.0	92.6	92.6	92.6
2A	52.6	99.9	100.4	100.4	100.4
2B	54.8	76.9	79.8	79.8	79.8
3A	53.0	97.6	98.9	98.9	98.9
3B	56.2	87.7	88.2	88.2	88.2
4A	46.6	90.5	90.5	90.5	90.5
4B	55.2	82.6	82.9	82.9	82.9
5A	45.5	86.1	86.1	86.1	86.1
5B	52.2	82.2	82.6	82.6	82.6
6A	51.9	95.4	96.1	96.1	96.1
6B	53.2	92.8	102.7	102.7	102.7

Fig. 38
Field Test Plant Leafs (#)




3A vs 3B (Top Outlet Site)
110
82.5
55
27.5
0
Paddy Plant Leafs (#)
3A
3B
Day 21
Day 50
Day 105
Paddy Plant Age (days)

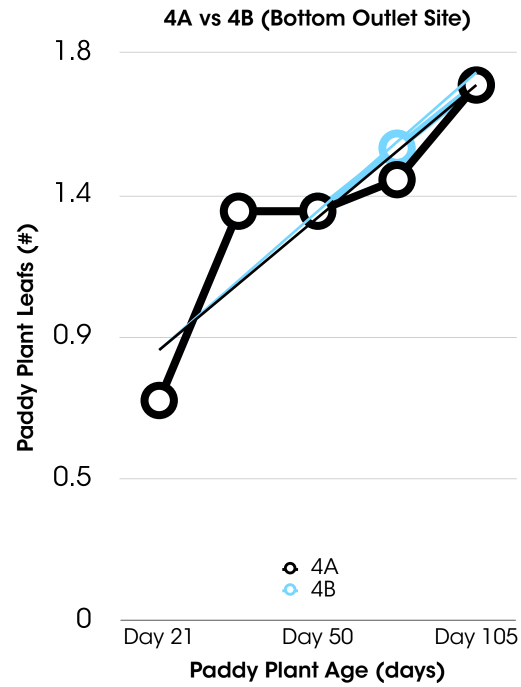
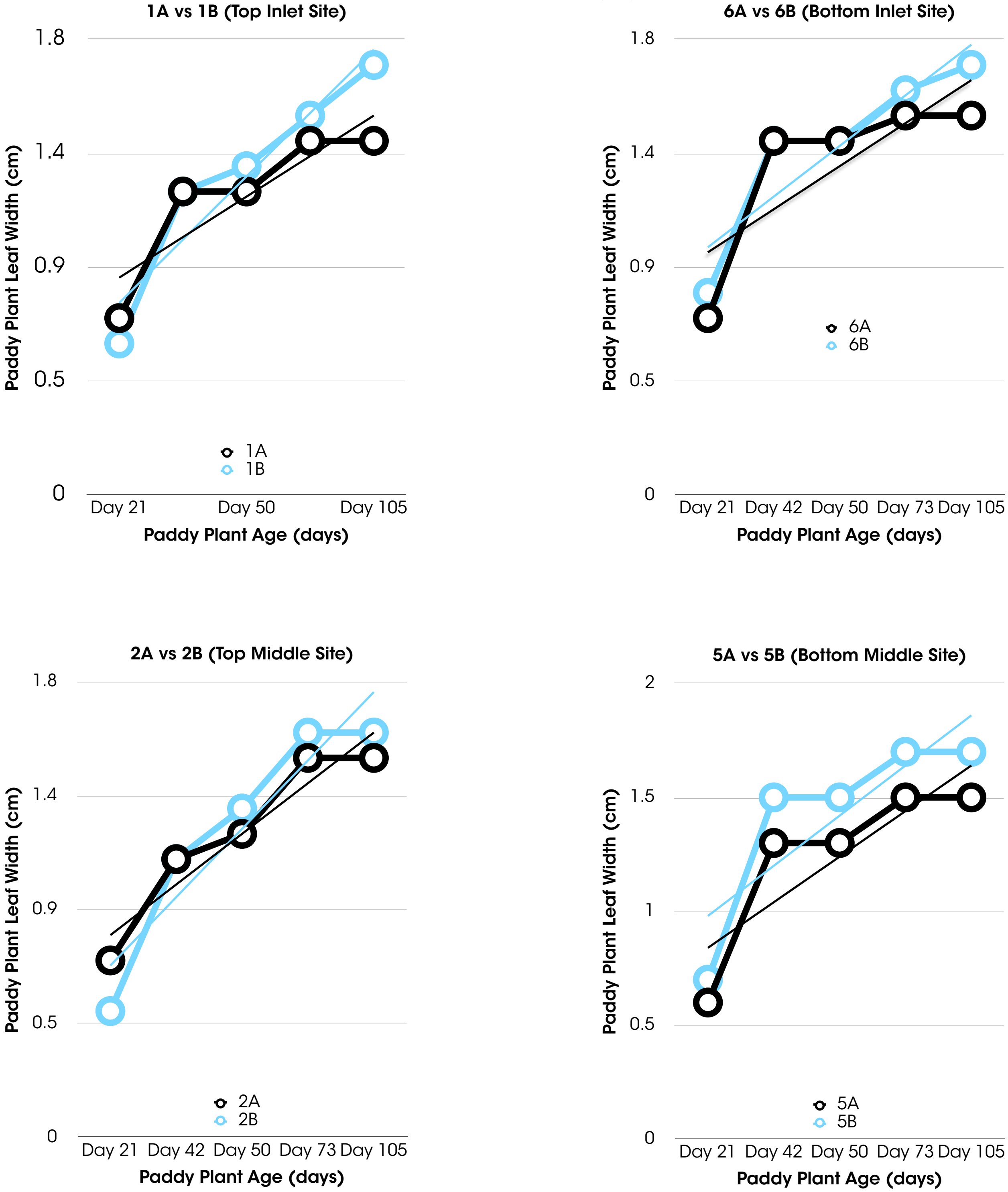
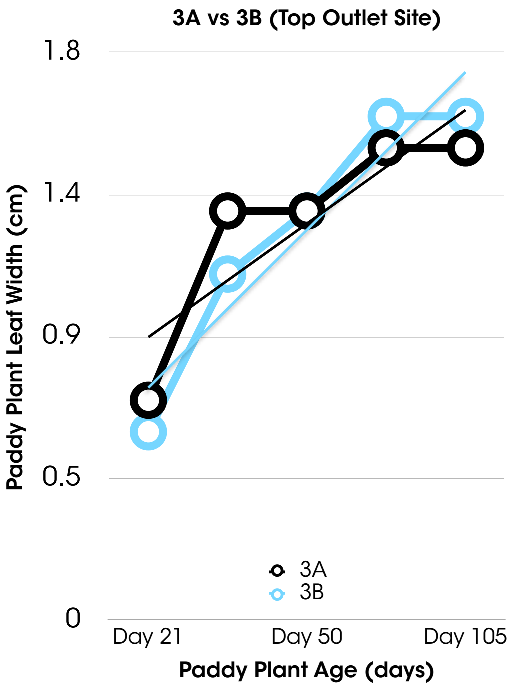

4A vs 4B (Bottom Outlet Site)
1.8
1.4
0.9
0.5
0
Paddy Plant Leafs (#)
4A
4B
Day 21
Day 50
Day 105
Paddy Plant Age (days)

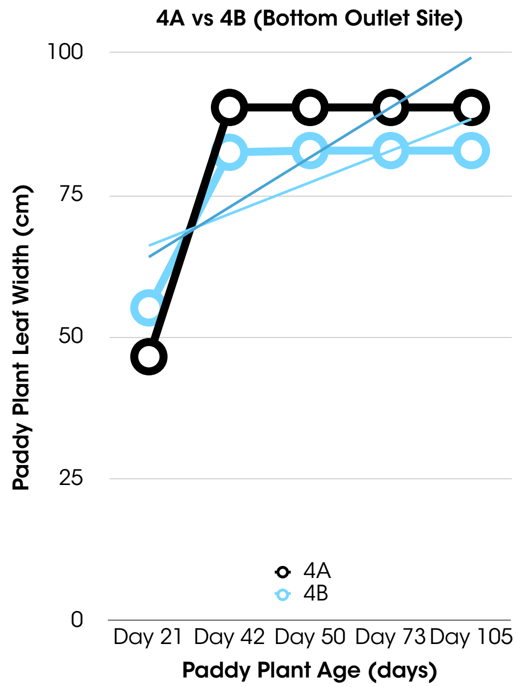
Table 12
Field Test Plant Leaf Width (cm)

Site	Day 21 *Tillering Stage*	Day 42 *Tillering Stage*	Day 50 Panicle Initiation Stage	Day 73 Heading Stage	Day 105 Ripening Stage
1A	0.7	1.2	1.2	1.4	1.4
1B	0.6	1.2	1.3	1.5	1.7
2A	0.7	1.1	1.2	1.5	1.5
2B	0.5	1.1	1.3	1.6	1.6
3A	0.7	1.3	1.3	1.5	1.5
3B	0.6	1.1	1.3	1.6	1.6
4A	0.7	1.3	1.3	1.4	1.7
4B	0.7	1.3	1.3	1.5	1.7
5A	0.6	1.3	1.3	1.5	1.5
5B	0.7	1.5	1.5	1.7	1.7
6A	0.7	1.4	1.4	1.5	1.5
6B	0.8	1.4	1.4	1.6	1.7

Fig. 39
Field Test Plant Leaf Width (cm)




3A vs 3B (Top Outlet Site)
1.8
1.4
0.9
0.5
0
Paddy Plant Leaf Width (cm)
3A
3B
Day 21
Day 50
Day 105
Paddy Plant Age (days)


4A vs 4B (Bottom Outlet Site)
100
75
50
25
0
Paddy Plant Leaf Width (cm)
4A
4B
Day 21
Day 42
Day 50
Day 73
Day 105
Paddy Plant Age (days)

The Bio-Pesticide Solution, 612EC enhanced the growth of Plant Tillers which led to higher production of grains.

We believe this enhancement happens because with less infestation, plants grow with less stress (cause by pest, pathogens, viruses and insects) will improve their ability to improve.

4.1.2.3 Plant Leafs (cm)

From the Field Test Plant Leafs (cm) results (refer to Table 11 and Fig. 38), it was observed and recorded the leafs grow significantly between Day 21 and Day 42 and subsequently remained constant thereafter. This is similar to the results observed with the plant tiller data. The Bio-Pesticide Plot also had a slightly higher number of leafs compared to the Conventional-Pesticide Plot. Bio-Pesticide 612EC Solution enhanced the growth of the plant.

4.1.2.4 Plant Leaf Width (cm)

As for the width of the paddy plants, the Conventional-Pesticide Plot had a slightly wider leaf than the Bio-Pesticide Plot, but the differences are comparable and the data confirms the metrics are close to each other (refer to Table 12 and Fig. 39). This is also similar to the Field Test Plant Height data characteristics mentioned earlier.

4.1.3 Correlation Analysis between Plant Yield Components and Plant Grain Yields

Estimates for mean, range and standard deviation for selected components of Bio-Pesticide and Conventional-Pesticide are shown in Table 13 - Descriptive Statistics for Bio-Pesticide and Chemical-Pesticide Components.

The data for both cases revealed that in the case of Bio-Pesticides, the growth characteristics were *significantly higher* when compared to Conventional-Pesticides for the following components :-

- Panicle Length (cm)
- Panicles/m^2 (cm)
- Productive Spikelets/Panicle (%)
- 1,000 Grains Weight (g)
- Grains Yield (g/m^2)

Higher result were observed by using Bio-Pesticides when compared to Conventional-Pesticides except for the following components :-

- Plant Height (cm);
- Spikelets/Panicle (#); and
- Productive Spikelets/Panicle (#).

The t-test value from the analysis given in Table 2 indicates that Bio-Pesticides are significantly higher at the 5% level of significance for all the components studied when compared to Conventional -Pesticides.

4.1.3.1 Correlation Analysis

The correlation degree amongst the characters are important factors especially in economic and complex characters sets such as yield (Akinwale et. al. 2011). Correlations are a measure of the intensity-of-association between traits associations (Steel and Torrie, 1984).

The selection of a trait can result in the progress analysis for all characters that are positively correlated and retrogress for traits that are negatively correlated.

Tables 3 and 4 reveals the correlation analysis and results as shown by their correlation coefficients.

4. 1.3.1.1 Plant Height (cm)

Plant Height is one of the most important components associated with Bio-mass Production (Akita, 1989) and Paddy Plant Grains Yield (Yang et. al. 2006) and are a key predicting indicator for Paddy Plant Yield potentials (Confalonieri et. al. 2011).

Plant Height has a significant relationship with 1,000 Grains Weight for Bio- and Conventional-Pesticides (Table 3 and 4).

It has a negative and significant correlation with the number of productive spikelets per panicle, percentage of productive spikelets and grains yield as far as Conventional-Pesticides are concerned.

Plant Height are also positively associated with Panicle Length (Nayak et. al. 2001; Kole et. al. 2008; Khan et. al. 2009; and Ravindra Babu et. al. 2012), and the Number of Panicle/m^2, but are negatively associated with the Percentage of Productive Spikelets for both pesticides.

4. 1.3.1.2 Panicle Length (cm)

Significant positive association was noticed for Panicle Length with Number of Spikelets/Panicle (Lakshmi et. al. 2014) for Bio-Pesticides. They are also positively correlated with the Number of Productive Spikelets/Panicle, Plant Height, 1,000 Grains Weight and Grains Yield, but recorded negative associations with the Number of Panicle/m^2 and Percentage of Productive Spikelet whilst positive association was noticed for Panicle Length with all the components for Conventional-Pesticide.

4.1.3.1.3 Panicles/m^2 (#)

The Number of Panicles/m^2 showed a significant and positive associations with Grains Yield for Bio- and Conventional-Pesticides. It also recorded negative associations with all the yield components for Bio-pesticide whilst it had only a positive correlation with Plant height, Percentage of Productive Spikelets/Panicle, 1,000 Grains Weight and Grains Yield for Conventional-Pesticides.

4.1.3.1.4 Spikelets/Panicle (#)

The Number of Spikelets/Panicle was positively and significantly correlated with the Number of Productive Spikelets/ Panicle and Grains Yield for both Pesticides (Table 3 and 4). Sharma and Chou bey (1985) and Prasad et. al. (1988) have also reported a positive correlation between the Number of Spikelets/Panicle and Grains Yield.

The Number of Spikelets/Panicle is one of the most important components of yield and probably this character will help to break the yield plateau (Bai et. al. 1992).

It was recorded that a positive association between Percentage of Productive Spikelets/Plant and 1,000 Grains Weight was attained.

4.1.3.1.5 Productive Spikelets/Panicle (#)

The Number of productive spikelets per panicle was positively and significantly correlated with percentage of productive spikelets per panicle and grains yield for biopesticide and chemical pesticide. It was also recorded significant and has positive association with 1000 grains weight and number of spikelets per panicle for biopesticide. This result was similar as that obtained by Bhatti et al. (2005) and Ranawake and Amarasinghe (2014).

4.1.3.1.6 Productive Spikelets/Panicle (%)

Significant and positive correlation was recorded by percentage of productive spikelets with grains yield for both pesticides. Luzikihupi, (1998), Bai et al. (1992) and Bhatti et al. (2005) also reported a highly significant correlation between percentage of productive spikelets and grain yield. Productive spikelet is a critical and dynamic factor that determined the grain yield (Takai et al. 2005; Bu-hong et al. 2006). Climate, soil, variety, fertilizer application and insect and pest attacks are the several factors that affect the productive spikelets percentage (Yoshida, 1972).

4.1.3.1.7 1,000 Grains Weight (g) and Grains Yield (g/m^2)

Both of the Bi-Pesticide and Conventional -Pesticide Tables presents the results and indicates that 1,000 Grain Weight was positively correlated with Grains Yield for both pesticides. The results proves that the 1,000 Grains Weight has significant influence on Paddy Yield. Rajeshwari and Nadarajan (2004) and Ranawake et. al. (2014) also found that there was a positive correlation between Grains Weight and Grains Yield.

The claims of Paddy Yield accessions with the use and application of Bio-Pesticides was statistically proven to be positively interdependence with all the Plant Yield Components studied. Higher results were obtained for each component when applying Bio-Pesticides compared to Conventional-Pesticides except for the Number of Productive Spikelets/Panicle, Percentage of Productive Spikelets and Panicle Length.

Based on these obtained results from Correlation Analysis, it was concluded that in order to increase the productivity of paddy, it is recommended that Paddy Yield Components such as Panicle Length, Number of Panicle/m^2, Percentage of Productive Spikelets and 1,000 Grains Weight … can be achieved with Bio-Pesticide utilization, since it has the strongest components that have positive effects on productivity.

Table 13
Descriptive Statistics for Bio-Pesticide and Chemical-Pesticide Components

Components	Pesticide	Mean ± SE	Min-Max	Std. Dev.
Plant Height (cm)	Bio-	104.25 ± 0.44	101.00 - 110.70	3.02
	Conventional-	114.84 ± 0.73	105.00 - 120.20	5.09
Panicle Length (cm)	Bio-	25.27 ± 0.19	22.00 - 27.00	1.33
	Conventional-	25.15 ± 0.16	23.00 - 26.00	1.09
Panicles/m	Bio-	368.79 ± 11.41	204.00 - 537.00	79.09
	Conventional-	279.33 ± 10.90	148.00 - 519.00	75.54
Spikelets/Panicle (#)	Bio-	140.73 ± 3.77	88.90 - 198.00	26.09
	Conventional-	182.08 ± 5.47	110.10 - 266.20	37.89
Productive Spikelets/Panicle (#)	Bio-	113.93 ± 3.60	61.60 - 166.30	24.92
	Conventional-	127.90 ± 5.33	59.80 - 209.80	36.96
Productive Spikelets (%)	Bio-	80.77 ± 1.13	54.51 - 93.63	7.85
	Conventional-	69.81 ± 1.77	43.99 - 91.02	12.24
1,000 Grains Weight (g)	Bio-	27.68 ± 0.10	26.80 - 29.10	0.67
	Conventional-	25.61 ± 0.09	24.30 - 26.70	0.62
Grains Yield (g/m	Bio-	1151.30 ± 46.77	562.60 - 2089.00	324.06
	Conventional-	897.47 ± 41.37	255.15 - 1556.02	286.64

Table 14
t-test of Paddy Yield Components for Bio-Pesticide and Conventional-Pesticide

Components	Mean Difference	t-test Value	p-Value
Plant Height (cm)	10.59	12.40	0.00*
Panicle Length (cm)	0.56	2.62	0.01*
Panicle/m	89.46	5.67	0.00*
Spikelets/Panicle (#)	41.34	6.22	0.00*
Productive Spikelets/Panicle (#)	13.97	2.17	0.03*
Productive Spikelets (%)	10.97	5.22	0.00*
1,000 Grains Weight (g)	2.07	15.64	0.00*
Grains Yield (g/m	253.83	4.07	0.00*

Note : [*] Significance at 5% level

Table 15
Correlation Coefficient Amongst Various Bio-Pesticide Paddy Yield Components

Components	Plant Height	Panicle Length	Panicles/ m	Spikelets/ Panicle	Productive Spikelets/ Panicle	Productive Spikelets	1,000 Grains Weight	Grains Yield
Plant Height (cm)		0.393*	0.141	0.248	0.081	- 0.282	0.611*	0.225
Panicle Length (cm)			- 0.176	0.373*	0.265	- 0.142	0.0129	0.106
Panicles/m (#)				- 0.225	- 0.236	- 0.132	- 0.122	0.582*
Spikelets/ Panicle (#)					0.912*	0.130	0.404*	0.576*
Productive Spikelets/ Panicle (#)						0.518*	0.301*	0.634*
Productive Spikelets (%)							- 0.105	0.316*
1,000 Grains Weight (g)								0.214
Grains Yield (g/m2)								

Note : [*] Significance at 5% level

Table 16
Correlation Coefficient Amongst Various Conventional-Pesticide Paddy Yield Components

Components	Plant Height	Panicle Length	Panicles/ m	Spikelets/ Panicle	Productive Spikelets/ Panicle	Productive Spikelets	1,000 Grains Weight	Grains Yield
Plant Height (cm)		*0.298	0.110	-0.249	*-0.444	*-0.429	*-0.47 2	*-0.299
Panicle Length (cm)			0.045	0.093	0.134	0.133	0.108	0.196
Panicles/m (#)				*-0.445	-0.273	0.101	0.070	*0.461
Spikelets/ Panicle (#)					*0.820	0.176	0.014	*0.408
Productive Spikelets/ Panicle (#)						*0.697	0.221	*0.697
Productive Spikelets (%)							*0.328	*0.702
1,000 Grains Weight (g)								*0.333
Grains Yield (g/m2)								

Note : [*] Significance at 5% level

Thus, with higher positive relationships between Grain Yield and its Components resulting in improved metrics, a higher preference by farmers for the acceptance and adoption of Bio-Pesticides in paddy cultivation over Conventional-Pesticide can be expected.

The above results are applicable in as far as the tests were conducted during the rainy season with a good and proper irrigation system. The results stems from one from a comparative set of data and not one of absolute value.

4.2 Glass-House Test Data Collection

4.2.1 Plant Growth Observations

4.2.1.1 Observation Plant Leaf Colors

Based on observation of color of leafs in Figure 41, the leafs start to change to yellowish color after 42 days of paddy growth. Start from the tillering stage, the pest and bacteria start to infest the paddy plants and leafs resulted yellowish leafs increased and tends to die if not undergo any treatment. The application of BV612EC during 55 and 67 days of paddy growth at T1 lead the yellowish leafs start to change back to green and accelerated the plant growth compared to T2 and C1 which the yellowish and dead leafs increased till the end of cultivation.

4.2.1.2 Observation Plant Growth Conditions

From the observations in Figure 42, the plant diseases like brown leaf blight and neck rot start to present from 42 days of paddy growth. Besides, the grasshopper population ate the leafs and left holes on leafs. The pest and bacteria infestation also caused the increasing of affected tillers resulted reduction of panicles during heading stages. Therefore, T1 produced highest panicles than T2 and C1 due to application of BV500WS and BV612EC that accelerated the plant growth and reduced the plant diseases and pest infestation start from 60 days of paddy growth.

4.2.1.3 Observation Plant Weed Problems

The weed population such as yellow bur-head, duck weeds, goose grass, cogon grass, etc. distracted the plant growth of paddy as they will compete with paddy plant to get nutrient from water and soil. Increasing the weed population caused the paddy get less nutrients and also leads to reduction of paddy yield. However, the bio-pesticides also seem can help in reducing the weed population as from the observation, only C1 showed the increasing populations of weed till the end of cultivation.

Fig. 40
Comparative Metrics between Bio-Pesticide Plots and Conventional-Pesticide Plots

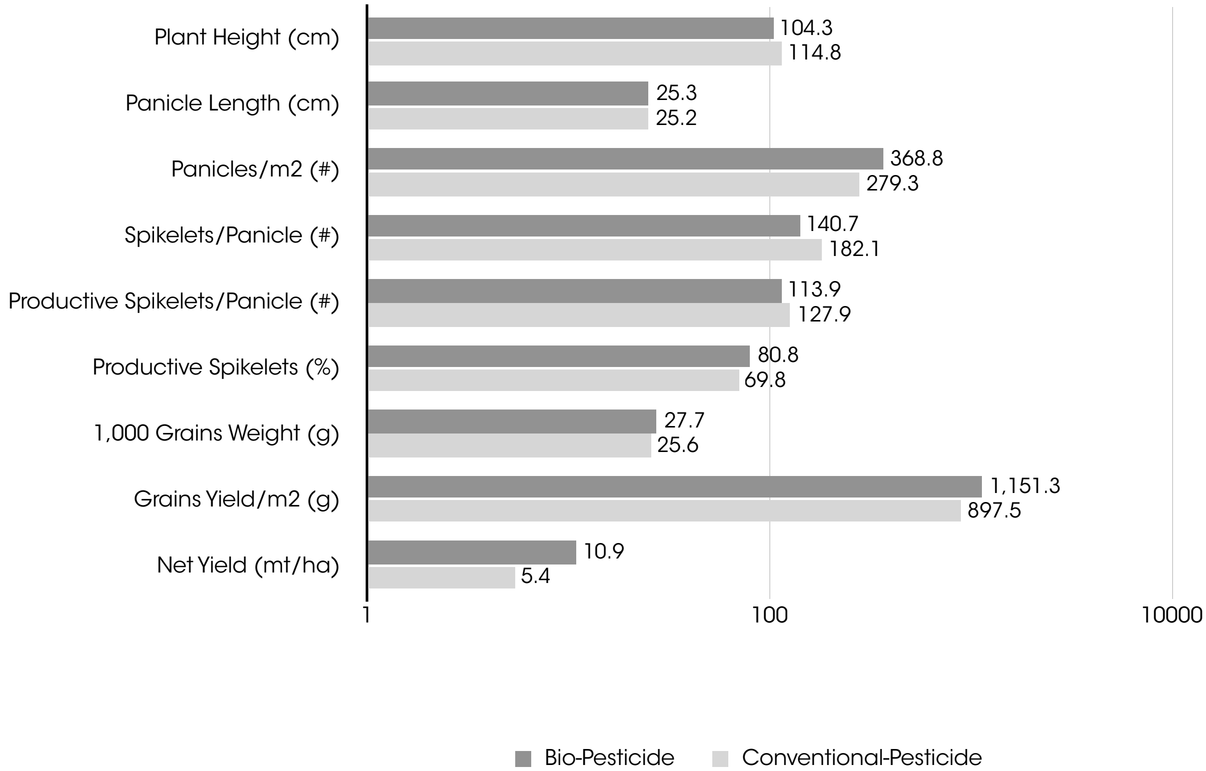


Fig. 41
Glass-House Test Plant Leaf Colors

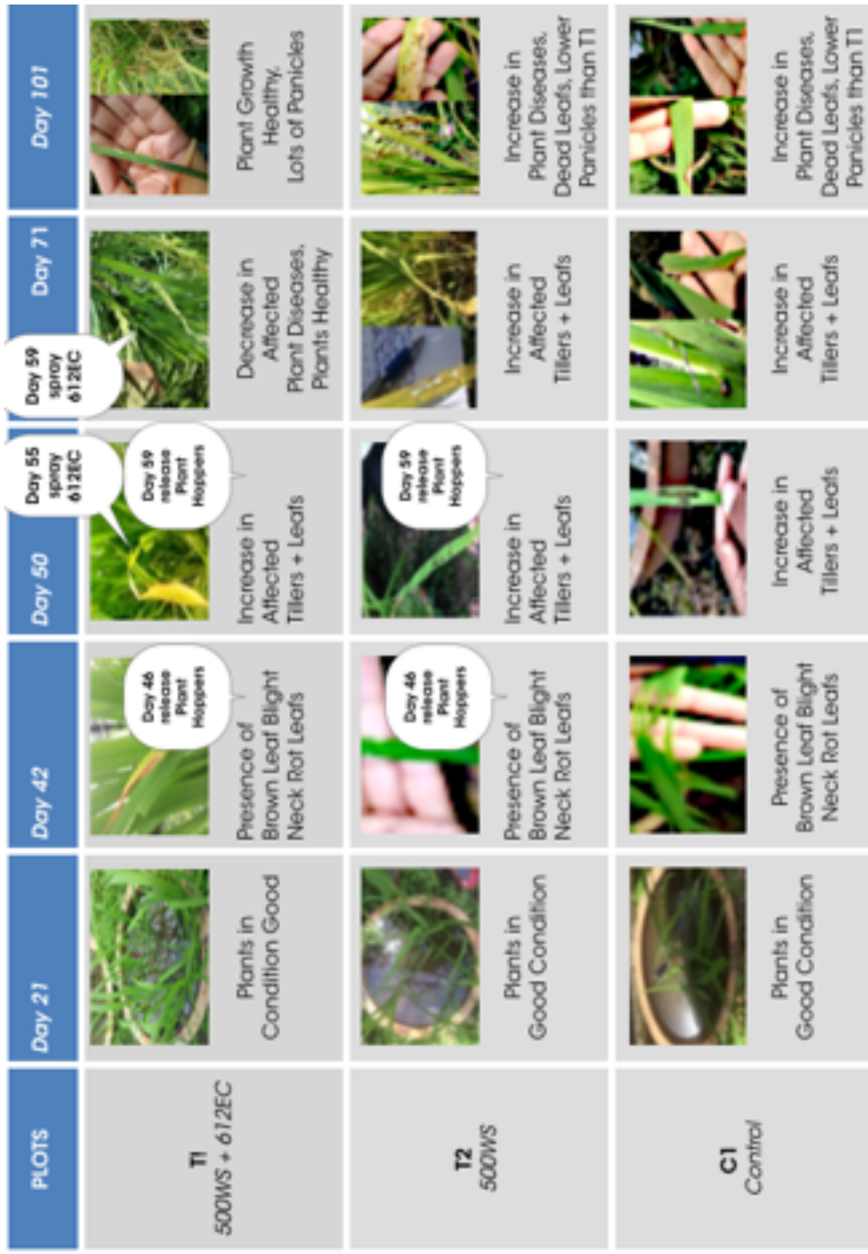
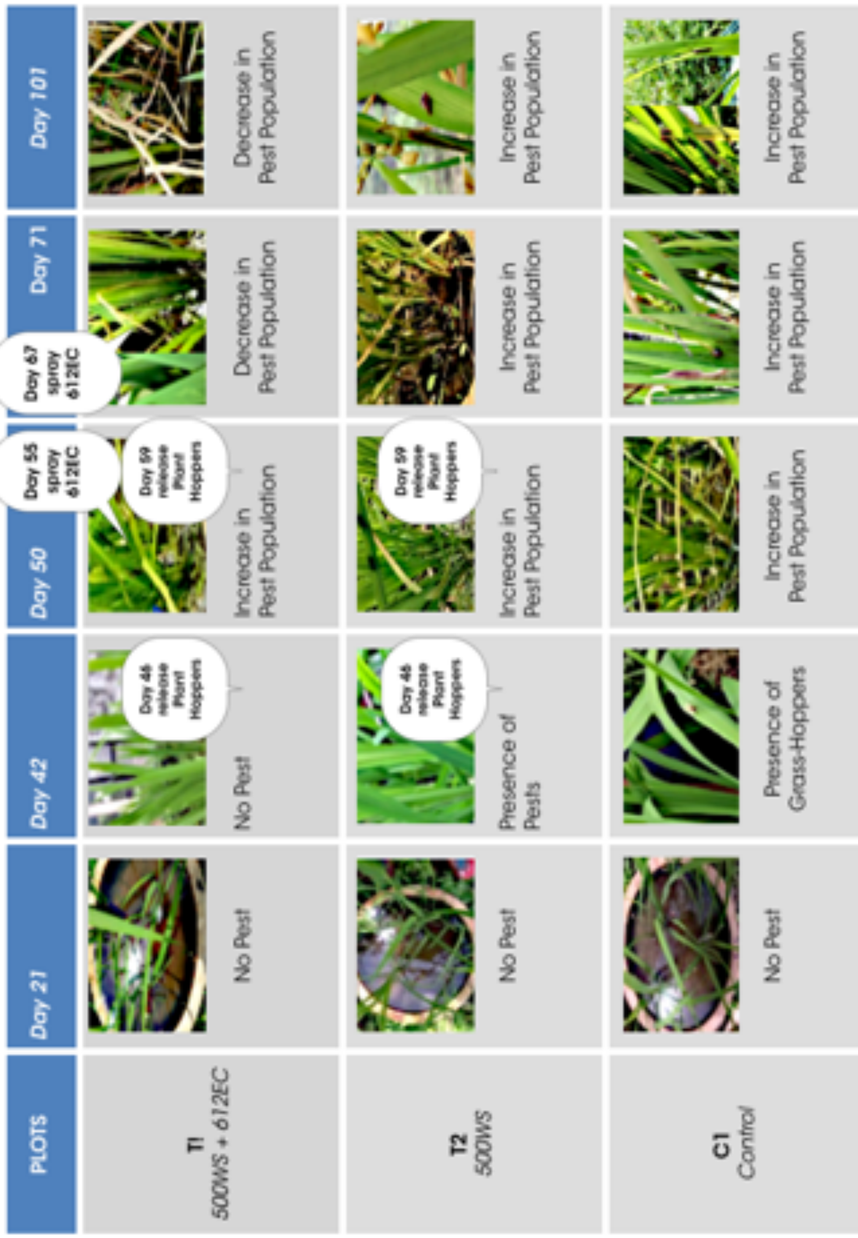


Fig. 42
Glass-House Test Plant Growth Conditions

Fig. 43
Glass-House Test Plant Weed Problems

Fig. 44
Glass-House Test Plant Pest Problems



4.2.1.4 Observation Plant Pest Problems

Pest problems significantly affects plant growth. Brown plant-hoppers and golden apple snails attack tillers along with insects like grass-hoppers, bugs and bacteria, leading to increases in dead leafs and tillers.

There was 3 dead paddy plants in C1 due to a serious pest infestation and this resulted in higher hollowed spikelets with lighter grain weight, as compared to T1 and T2. T1 was more successful at reducing pest infestations as it was sprayed with the Bio-Pesticide Solution 3 times during cultivation.

4.2.2 Analysis of Plant Growth

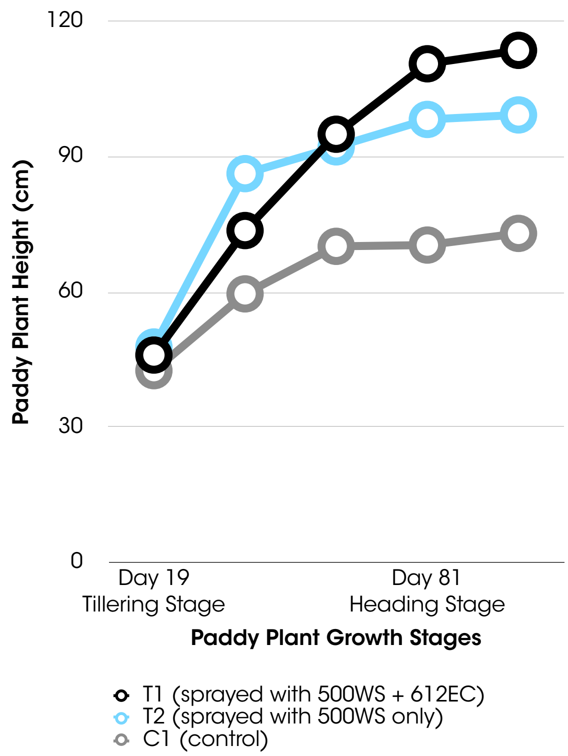
4.2.2.1 Plant Height (cm)

The results in Fig. 45 shows that the application of Bio-Pesticides 500WS with 612EC in Vase T1 resulted in it having the highest Plant Height. It was followed by Vase T2 and then by Vase C1. It was concluded that spraying the Bio-Pesticide Solution enhanced growth in Plant Height.

4.2.2.2 Plant Tillers (#)

The graph in Fig. 46 shows a drop in the number of tillers beginning in Day 66 due to the release of brown plant-hoppers during Day 55 and Day 59. The pest attacked the tillers and cause them to die. In Vase T1, the application of the Bio-Pesticide Solution seems to help defend the plants against pest infestation as it recorded the highest number of tillers. It was concluded that spraying the Bio-Pesticide Solution enhanced growth in Plant Tillers.

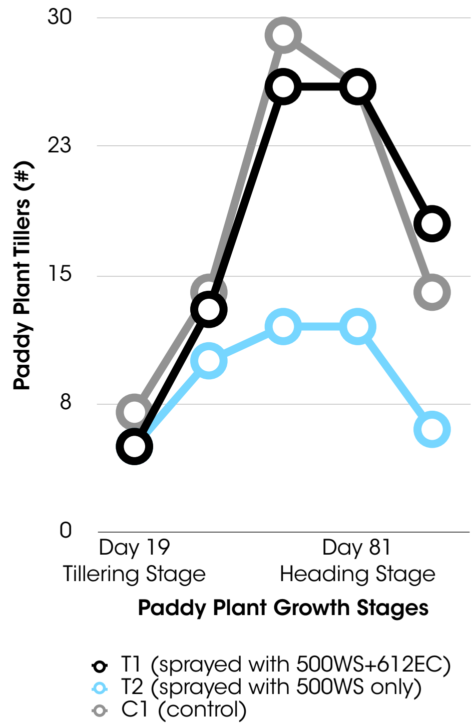
Fig. 45
Plant Height (cm) of T1, T2 and C1



4.2.2.3 Plant Leafs (#)

The number of Plant Leafs can help determine Plant Growth. A healthy plant that produces a higher number of leafs will lead to higher yields. Vase T1 had the highest number of leafs as it was less affected by infestation from pests and diseases as compared to the other Vases. This was due to the application of the Bio-Pesticide Solution during the infestation states.

Fig. 46
Plant Tillers (#) of T1, T2 and C1



4.2.2.4 Plant Leaf Width (cm)

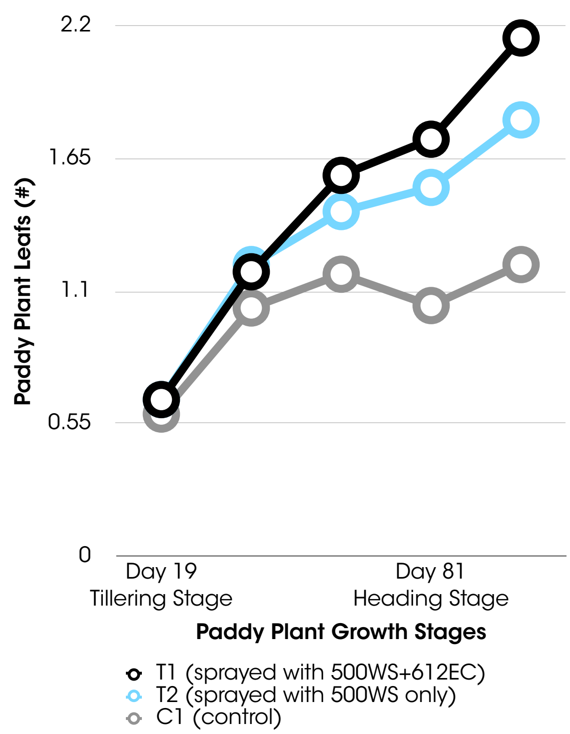
The width of leafs can also be use to determine the condition of Plant Growth. Healthy paddy plants can produce large leafs like in Vase T1. Here, the application of the Bio-Pesticide Solution improved the Plant Growth and help showcase Vase T1 with the highest width of leafs. However, all paddy plants showed a positive growth of leafs as they increase in stages.

4.2.2.5 Plant Brown Plant-Hoppers (#)

Table 21 shows the release of Plant-Hoppers and its mortality with and without the application of the Bio-Pesticide Solution 612EC. It was shown that Vase T1 when sprayed with 500WS and 612EC had the lowest mortality of Plant-Hoppers followed by Vase C1, the controlled vase and lastly Vase T2.

It was also taken into account that because Vase T1 was located between Vase C1 and Vase T2 and it was close to Vase C1 ... the possibility of Bio-Pesticide Solution 612EC's scent spreading to Vase C1 could have lead to a lesser number of Plant-Hoppers in Vase C1 as compared to Vase T2. It could also be due to the Bio-Pesticide's ability to act as a repellant to surrounding areas.

Fig. 47
Plant Leafs (#) of T1,T2 and C1



4.2.3 Analysis of Variance ANOVA

The one-way analysis of variance (ANOVA) is used to determine whether there are any statistically significant differences between the means of 3 or more independent (unrelated) groups.

The correlation of Plant Growth is analyzed using an ANOVA Table to determine the interaction of factors towards Grains Yield.

Transplanting-Cultivation (provided there are proper spaces between plants), will cause paddy plants to produce more tillers and increase the number of panicles/m^2, as they utilized the soil nutrients more effectively (T. H. Awan, 2011). Even though the paddy plants for Vases T1, T2 and C1 were infected with pests and bacteria, they still produced positive production of Grains Yield due to Transplanting-Cultivation.

The higher results for Plant Height (cm), Plant Tillers (#), Plant Leafs (#) and Plant Leaf Width (cm) at Vase T1 compared to Vase T2 and Vase C1 was due directly to the application of Bio-Pesticides 500WS and 612EC. They influenced the plants to produce higher numbers of panicles per m^2, more spikelets per panicle, more productive spikelets per panicle and higher grains yield.

Improvements in growth characteristics as a result of the application of organic and green pesticides might be due to enhanced metabolic activities which lead to an increase in various plant metabolites responsible for cell division and elongation (Morteza Siavoshi, 2013). Base on the result in Table 20 and Fig. 48, Vase T1 produced higher yields of 23.05 mt/ha, followed by Vase C1 with 6.65 mt/ha and Vase T2 with 6.64 mt/ha respectively. This is proof that the application of Bio-Pesticides 500WS and 612EC are effective in improving Plant Growth and increased Grains Yield components. Even though Vase T2 was severely infected by pests, it still manage to produce comparable yields with Vase C1.

Besides and according to Table 21, all yield components : Plant Height (cm); Panicle Length (cm); Panicles/m^2 (#); Spikelets/Panicle (#); Productive Spikelets/Panicle (%); 1,000 Grains Weight (g), Grains Yield (g/m^2) except 5% of productive spikelet are significantly affected by the application of Bio-Pesticides in Paddy Cultivation at the p-Value < 5%.

Fig. 48
Leaf Width (cm) of T1,T2 and C1

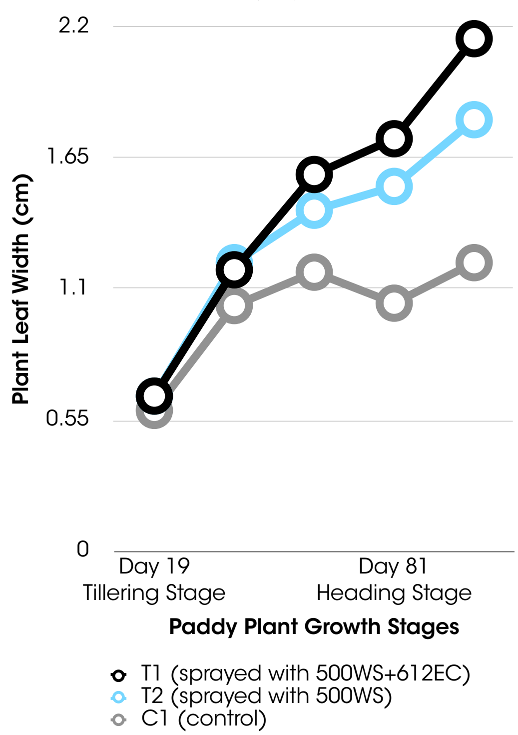


Fig. 49
Yield Components of T1, T2 and C1

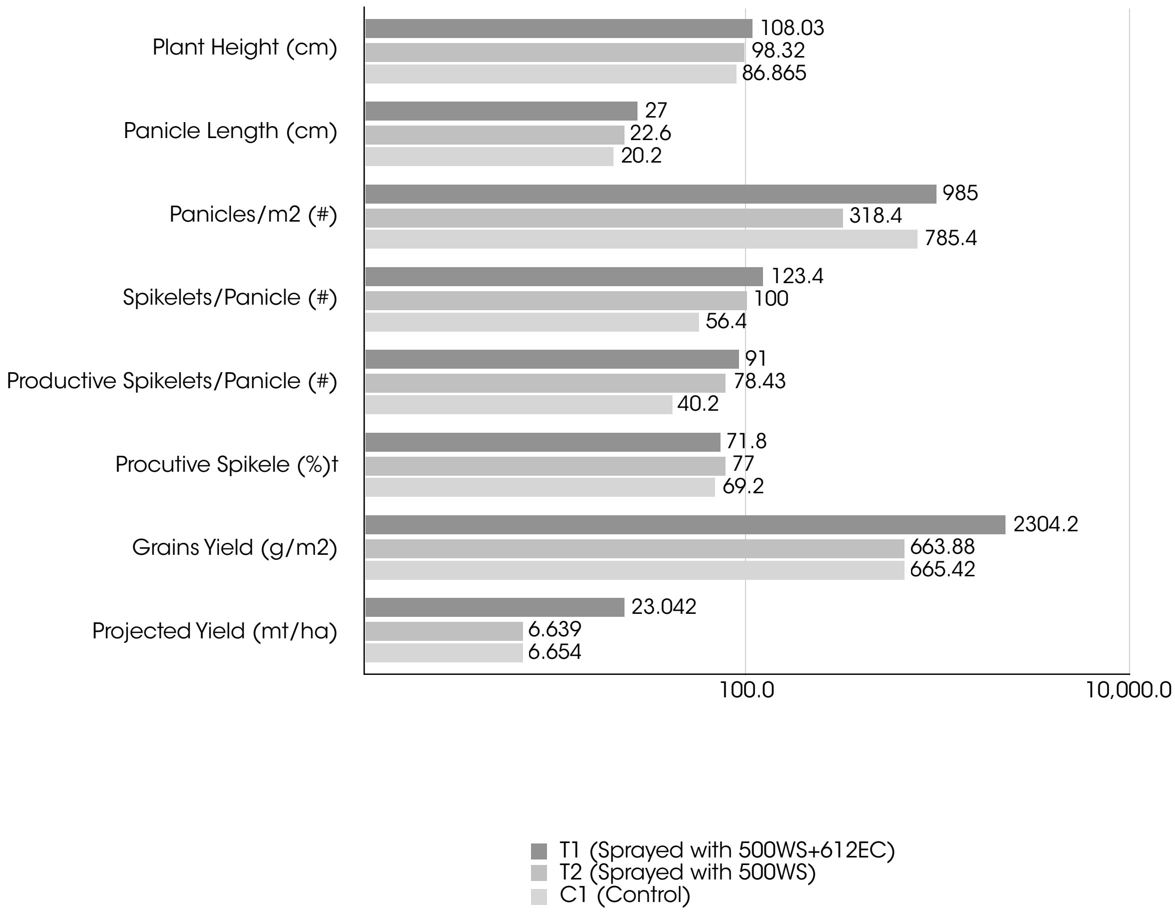


Table 17
Plant Height (cm) of T1 ,T2 and C1

Vase	Day 19 *Tillering Stage*	Day 38 *Tillering Stage*	Day 66 Panicle *Initiation Stage*	Day 81 *Heading Stage*	Day 101 *Ripening Stage*
T1 (sprayed with 500WS + 612EC)	45.98 ± 2.76	73.59 ± 2.36	94.95 ± 8.57	110.57 ± 11.52	113.55 ± 10.05
T2 (sprayed with only 500WS)	47.77 ± 2.66	86.21 ± 3.04	92.15 ± 2.64	98.23 ± 4.66	99.23 ± 4.77
C1 (control)	42.52 ± 1.67	59.55 ± 5.14	70.09 ± 11.02	70.37 ± 38.58	72.96 ± 39.26

Table 18
Plant Tillers (#) of T1,T2 and C1

Vase	Day 19 *Tillering Stage*	Day 38 *Tillering Stage*	Day 66 Panicle *Initiation Stage*	Day 81 *Heading Stage*	Day 101 *Ripening Stage*
T1 (sprayed with 500WS + 612EC)	5.20 ± 1.42	12.67 ± 4.06	25.87 ± 7.67	25.87 ± 7.67	17.73 ± 4.10
T2 (sprayed with only 500WS)	5.20 ± 1.42	9.67 ± 3.48	12.40 ± 4.56	12.40 ± 4.56	5.73 ± 1.91
C1 (control)	6.80 ± 3.38	14.33 ± 7.4	28.47 ± 15.33	26.33 ± 18.48	14.13 ± 10.40

Table 19
Plant Leafs (#) of T1,T2 and C1

Vase	Day 19 *Tillering Stage*	Day 38 *Tillering Stage*	Day 66 Panicle *Initiation Stage*	Day 81 *Heading Stage*	Day 101 *Ripening Stage*
T1 (sprayed with 500WS + 612EC)	15.60 ± 4.27	51.07 ± 14.83	93.80 ± 27.90	93.80 ± 27.90	93.80 ± 27.90
T2 (sprayed with only 500WS)	27.73 ± 8.16	42.80 ± 12.28	48.13 ± 12.90	48.13 ± 12.90	48.13 ± 12.90
C1 (control)	27.73 ± 8.16	53.47 ± 26.69	56.53 ± 26.69	46.27 ± 35.19	46.27 ± 35.19

Table 20
Plant Leaf Width (cm) of T1,T2 and C1

Vase	Day 19 *Tillering Stage*	Day 38 *Tillering Stage*	Day 66 Panicle *Initiation Stage*	Day 81 *Heading Stage*	Day 101 *Ripening Stage*
T1 (sprayed with 500WS + 612EC)	0.65 ± 0.13	1.18 ± 0.07	1.58 ± 0.13	1.73 ± 0.16	2.15 ± 0.12
T2 (sprayed with only 500WS)	0.65 ± 0.11	1.21 ± 0.08	1.43 ± 0.08	1.53 ± 0.10	1.81 ± 0.10
C1 (control)	0.59 ± 0.12	1.03 ± 0.17	1.17 ± 0.16	1.04 ± 0.56	1.21 ± 0.64

Table 21
Number of Brown Plant-Hoppers

Vase	Day *Activity*	Tillers (#)	Brown Plant-Hoppers (#)
T1 Sprayed with 500WS + 612EC	Day 48 *Released brown plant-hoppers*	190	200
	Day 55 *Sprayed 612EC Bio-Pesticide*	388	200
	Day 58 *Observation Day*	388	0
	Day 59 *Release brown plant-hoppers*	388	200
	Day 67 *Sprayed 612EC Bio-Pesticide*	388	200
	Day 81 *Observation Day*	388	0
	Day 101 *Observation Day*	266	33

Vase	Day *Activity*	Tillers (#)	Brown Plant-Hoppers (#)
T2 Sprayed with 500WS only	Day 46 *Released brown plant-hoppers*	145	200
	Day 58 *Observation Day*	186	375
	Day 59 *Release brown plant-hoppers*	186	575
	Day 81 *Observation Day*	186	578
	Day 101 *Observation Day*	86	184

Vase	Day *Activity*	Tillers (#)	Brown Plant-Hoppers (#)
C1 Control	Day 46 *Observation Day*	215	0
	Day 58 Observation Day	427	195
	Day 59 *Observation Day*	427	195
	Day 81 *Observation Day*	395	7
	Day 101 *Observation Day*	212	90

Table 22
Descriptive Table of Plant Yield Components for T1, T2 and C1

Components	Condition Type	Mean ± SE	Min - Max	Std. Dev.
Plant Height (cm)	T1 (sprayed with 500WS + 612EC)	108.03 ± 1.99	102.70 – 112.70	4.46
	T2 (sprayed with 500WS)	98.32 ± 1.04	94.93 – 101.27	2.32
	C1 (control)	86.87 ± 3.71	74.75 – 94.67	8.29
Panicle Length (cm)	T1 (sprayed with 500WS + 612EC)	27.00 ± 0.00	27.00	0.00
	T2 (sprayed with 500WS)	22.60 ± 0.60	22.00 – 25.00	0.60
	C1 (control)	20.20 ± 1.43	18.00 – 25.00	3.19
Panicle/m (#)	T1 (sprayed with 500WS + 612EC)	985.00 ± 57.78	815.00 – 1111.00	129.18
	T2 (sprayed with 500WS)	318.40 ± 22.91	278.00 – 407.00	51.23
	C1 (control)	785.40 ± 156.97	278.00 – 407.00	351.00
Spikelets/Panicle (#)	T1 (sprayed with 500WS + 612EC)	123.40 ± 13.94	98.00 -164.00	40.08
	T2 (sprayed with 500WS)	100.00 ± 9.20	75.00 - 131.00	20.58
	C1 (control)	56.40 ± 7.44	33.00 – 80.00	16.64
Productive Spikelet/ Panicle (#)	T1 (sprayed with 500WS + 612EC)	91.00 ± 17.92	49.00 - 146.00	40.08
	T2 (sprayed with 500WS)	78.43 ± 11.65	48.00 – 108.00	26.06
	C1 (control)	40.20 ± 8.68	21.00 -71.00	19.41
Productive Spikelets (%)	T1 (sprayed with 500WS + 612EC)	71.80 ± 7.98	49.00 – 89.00	17.85
	T2 (sprayed with 500WS)	77.00 ± 6.58	59.00 – 93.00	14.71
	C1 (control)	69.20 ± 6.97	49.00 – 89.00	15.58
1,000 Grains Weight (g)	T1 (sprayed with 500WS + 612EC)	25.50 ± 0.00	25.55	0.00
	T2 (sprayed with 500WS)	26.00 ± 0.00	26.00	0.00
	C1 (control)	20.20 ± 0.00	20.20	0.00
Grains Yield (g/m	T1 (sprayed with 500WS + 612EC)	2304.20 ± 491.42	1133.81 – 3644.04	1098.86
	T2 (sprayed with 500WS)	663.88 ± 128.41	373.63 – 1050.15	287.13
	C1 (control)	665.42 ± 183.30	117.83 – 1221.73	409.89

Table 23
ANOVA Table

Components	Condition Type	Sum of Squares	df	Mean Square	F-value	P-value
Plant Height (cm)	Between Groups	1,122.128	2	561.064	17.894	0.000*
	Within Groups	376.264	12	31.355		
	Total	1,498.391	14			
Panicle Length (cm)	Between Groups	118.933	2	59.467	14.867	0.001*
	Within Groups	48.000	12	4.000		
	Total	166.933	14			
Panicles/m (#)	Between Groups	1,170,474.533	2	58,5237.267	12.320	0.001*
	Within Groups	570,056.400	12	47,504.700		
	Total	1,740,530.933	14			
Spikelets/Panicle (#)	Between Groups	11,562.533	2	5,781.267	10.372	0.002*
	Within Groups	6,688.400	12	557.367		
	Total	18,250.933	14			
Productive Spikelets/ Panicle (#)	Between Groups	7,000.296	2	3,500.148	3.945	0.048*
	Within Groups	10,647.209	12	887.267		
	Total	17,647.506	14			
Productive Spikelet (%)	Between Groups	0.016	2	0.008	.304	0.743
	Within Groups	0.311	12	0.026		
	Total	0.327	14			
1,000 Grains Weight (g)	Between Groups	103.30	2	0.000	2.058E32	0.000*
	Within Groups	0.000	12	0.000		
	Total	0.000	14			
Grains Yield (g/m	Between Groups	8,960,824.318	2	4,480,412.159	9.219	0.004*
	Within Groups	5,831,845.090	12	485,987.091		
	Total	1.479E7	14			

Note : [*] Significance at 5% level

5.0 CHAPTER 5 - CONCLUSION

The productivity of the studied accessions of paddy yield by using Bio-Pesticide was statistically proven to have a positive interdependence with all the components studied. Higher approximate yield results were obtained for each component using Bio-Pesticides compared to Chemical/Conventional Pesticides.

In the Field Test, Bio-Pesticide Plot (A2) recorded a significantly higher net yield of 10.94 mt/ha compared to the Chemical/Conventional-Pesticide Plot (B1) with a net yield of 5.38 mt/ha. Bio-Pesticide Plot (A2) was more than 2 times the Chemical/Conventional Plot (B1) yield.

As for the Glass-House Test, it was recorded that Bio-Pesticide Solution *Enhanced* (T1) sprayed with both 500WS and 612EC recorded the highest "projected" yield of 23.04 mt/ha. This was followed by Control Solution (C1) with 6.65 mt/ha and a similar record by Bio-Pesticide *Normal* (T2) sprayed with only 500WS at 6.64 mt/ha. TI was 3.5 times more than C1 and T2.

It was recorded that the higher yields due to higher total panicle count, was achieved during Field and Glass-House Tests when Bio-Pesticides was applied.

The Field Test Plot (A2) had a panicle count of 368.79/m2 vs 279.33/m2 for Conventional Plot. Bio-Pesticide Plot (A2) was 1.3 times more productive than the Conventional Plot (C1).

With regards to Glass-House Test panicle count in T1, it gave a panicle count of 985.0/m2 which was higher than C1 at 785.40/m2) and T2 at 318.40/m2). T1 was about 1.25 times more productive than C1 and about 3.1 times more than T2.

However, the above results were achievable under conditions of a rainy season with proper irrigation and for the glass-house it was conducted in a well-controlled environment.

Therefore, these are comparative data and does not represent absolute values.

Efforts of various agencies to promote Integrated Pest Management (IPM) Programs with the use of Bio-Pesticides is a very important consideration moving forward. This research can become a stepping stone for the Government of Malaysian (GOM) to reduce its dependency on Conventional/Chemical Pesticides and alternatively use a much more safer control agents such as Bio-Pesticides to overcome the hazardous problem caused by Conventional/ Chemical Pesticide-use before it become too serious in the very near future. The acceptance of the farmers towards the application of Bio-Pesticides are welcomed and thus further action are required to be aggregated towards the application of greener solutions towards the control and management of pests, pathogens, viruses, insects and related diseases in general in the paddy field.

In future research and development, Glass-House Tests will be conducted to target the control of (a) Paddy Weeds; and (b) Golden Apple Snails which are 2 major "pests" troubling the paddy cultivation industry. This added functionality when added to Bio-Pesticides will strongly improve their efficacies in it's use to Improve Paddy Yields in Malaysia and the Industry at large.

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