EFFICACY OF SELECTED PESTICIDES AND BIOPESTICIDES AGAINST MAJOR PEST INFESTING *Solanum melongena* L.

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ABSTRACT

Terung Telunjuk also known as Terung Kuning (*Solanum melongena* L.), is an edible fruit belonging to the family Solanaceae, one of the largest families in vegetables. Even though identification of the major pests of *S. melongena* has been widely done, however information about the management of these pests remains scarce. Therefore, the objective of this study was to evaluate the effectiveness of selected biopesticides and insecticides (application type) and spraying time (before and after application) against these insect pests' population of *Terung Telunjuk.* Experiments were laid out in a Randomized Complete Block Design (RCBD) with three replications and eight treatments. A two-way analysis of variance (ANOVA) was used to evaluate the influence of two independent variable (application type, spraying time) on the number of sucking insects found on *Terung Telunjuk.* The application treatments were: (T1) garlic oil; (T2) neem oil; (T3) Pest Guard™; (T4) Shelter X™; (T5) wood vinegar; (T6) Confidor™; (T7) Abenz™ and (T8) control (water only), respectively. Result showed that there is significant difference on the application type on number of sucking pest (df=7, F=2.95, p<0.05). On the other hand, spraying time yielded (df=1, F=0.18, p>0.05) indicate that the effect of spraying time was not significant. Similarly, the interaction effect between application type and spraying time was also not significant [df=7, = 0.28, p>0.05]. There was no significant different between the spraying time (p>0.05), indicating that there were no differences in the total number of sucking insects before and after spraying. Confidor was found to be the most effective treatment to control sucking pest. Whereas the wood vinegar and neem oil did were between the application treatments toward borer insects, surprisingly, neem oil recorded the lowest number of damage/infected fruits. Information gained from this study may be used as a baseline for future insect pest and biological control related studies on other Solanaceae including the traditional vegetables.

Keyword: *Terung Telunjuk,* biopesticide, insecticides, pest

ABSTRAK

Terung Telunjuk atau dikenali juga sebagai Terung Kuning (*Solanum melongena* L.) adalah sayuran buah yang boleh dimakan berasal dari family Solanaceae. Walaupun pengecaman spesies perosak utama ini telah dilakukan secara meluas, namum maklumat mengenai pengurusan perosak ini masih sukar didapati. Objektif kajian ini adalah untuk menilai keberkesanan biopestisid dan racun serangga terpilih (jenis aplikasi) dan masa penyemburan (sebelum dan sesudah aplikasi) terhadap kawalan populasi perosak pada Terung Telunjuk ini. Eksperimen dijalankan dalam Reka Bentuk Blok Rawak Penuh (RCBD) dengan tiga ulangan dan lapan rawatan. Analisis varians dua arah (ANOVA) digunakan untuk menilai pengaruh dua pemboleh ubah bebas (jenis aplikasi, masa penyemburan) terhadap jumlah serangga penghisap yang terdapat pada Terung Telunjuk. Rawatan aplikasi adalah: (T1) minyak bawang putih; (T2) minyak neem; (T3) Pest Guard ™; (T4) Tempat perlindungan X ™; (T5) cuka kayu; (T6) Confidor ™; (T7) Abenz ™ dan (T8) kawalan (air sahaja), masing-masing. Hasil kajian menunjukkan bahawa terdapat perbezaan yang signifikan pada jenis aplikasi dengan serangga penghisap (df = 7, F = 2.95, $p < 0.05$). Sebaliknya, kesan semburan sebelum dan selepas (df = 1, F = 0.18, $p > 0.05$) adalah tidak signifikan. Begitu juga, interaksi antara jenis dan masa penyemburan juga tidak signifikan [df = 7, = 0.28, $p > 0.05$]. Tiada perbezaan yang signifikan di antara masa semburan ($p > 0.05$) menunjukkan tidak terdapat perbezaan terhadap jumlah serangga penghisap yang hadir sebelum dan selepas semburan. Confidor didapati menjadi rawatan paling berkesan untuk mengawal perosak jenis penghisap manakala cuka kayu dan minyak neem paling kurang berkesan. Walaupun tiada perbezaan signifikan antara rawatan aplikasi terhadap serangga pengorek ($p = 0.141$, $p > 0.05$), namun, minyak neem mencatat jumlah kerosakan / buah yang dijangkiti terendah. Maklumat yang diperoleh dari kajian ini dapat digunakan sebagai rujukan asas untuk kajian serangga perosak dan kawalan biologi di masa akan datang mengenai Solanaceae lain termasuk sayuran tradisional lain.

Kata kunci: Terung Telunjuk, biopestisid, racun serangga, perosak

INTRODUCTION

Eggplant (*Solanum melongena* L.) or locally known as *terung* is enlisted as a classical commodity for both local consumption and exportation. Cultivation of eggplant in Malaysia is an activity carried out throughout the year wherein 2018, an area of 2406 hectares was planted with an estimated production of 39,311 metric tons worth 106,141 million (DOA 2018). This edible fruit belongs to the family Solanaceae, one of the most prominent families in vegetables. It has many varieties, and some are known as indigenous eggplant including *Terung Telunjuk* (Figure 1). Only a small number of farmers cultivate and commercially grow *Terung Telunjuk* due to a lack of knowledge and information on the cultivation system, nutritional value, and quality of seed supply (Umikalsum et al. 2019).

Our preliminary study in 2018 found that plant hoppers, aphids, thrips, fruit borer and fruit fly, are recognised as the major pests to attacking *Terung Telunjuk* field. The mode of action of the sucking guild insects such as hopper, aphid and whitefly are to pierce the plant tissue using their mouthpiece, resulting in curling and stunting the new growth or punching a hole or scraping the cells of the plant's leaf or fruit surface and feeding on the cell contents (Brust 2013). Pesticides have been an effective method to protect the solanaceous plant to maintain the crop production (Siti Norhafiza & Nazrizawati 2010). However, injudicious use of pesticides has created emerging issues such as resistance amongst pests like aphid and whiteflies (Eleftherianos et al. 2008; Foster et al. 2007; Horowitz & Denholm 2001; Mushtaq

& Shamim 2013). It is vital to find an alternative method to overcome this issue. Hence, the idea of utilizing biopesticides may provide a reasonable solution in order to manage these pests.

The biopesticides approach in Malaysia has only started in the early 2000's and is still trying to fit in our agricultural landscape (Kamarulzaman et al. 2012; Ng 1999). Several studies have been conducted on several essential oils and plant extracts as biopesticides against the pest insect's species e.g. by Isman & Greineisen (2014); Zoubiri & Baaliouamer (2014); Pavela (2016); Bett et al. (2017); Abdullah et al. (2020). As biopesticides are considered much safer to the environment, less toxic, affect only the target pest and closely related organisms, it may be promising and offer a feasible long-term option solution. Biopesticides are defined as naturally occurring substances that can suppress pests by nontoxic mechanisms (EPA). Neem and garlic plant extract, a bacterial agent such as *Bacillus thuringiensis*, and pheromones are all known as natural products that have been commonly reported as a potential alternative to be used as biopesticides in papers and articles. Even though promising, the performances of biopesticides in the field on specific pest problems in various cropping systems remain unclear (Damalas & Koutrobas 2018). Therefore, this study was carried out to evaluate the efficacy of selected biopesticide and chemical insecticides (both of which are widely accessible commercially) against the major pests of *Terung Telunjuk* in the field.

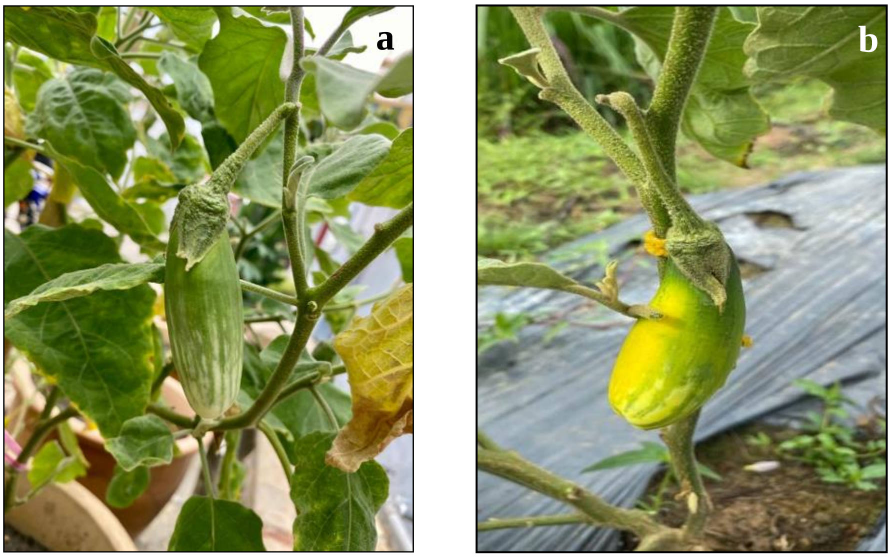

Figure 1. *Terung Telunjuk* harvest stages. (a) The best stage for consumption (b) Overripe stage

MATERIALS AND METHODS

Sampling Site and Sampling Duration

The field trial was conducted in the *Terung Telunjuk* plot in Malaysian Agricultural Research and Development Institute (MARDI), Serdang, Malaysia from June 2019 to September 2019. The plot area was maintained on mineral soil. The *Terung Telunjuk* was transplanted at a planting distance of 0.5 m within row, and 1.0 m between row, respectively.

Insects Sampling

Spraying was carried out in the field on a weekly interval using the manufacturer's recommended rate. The spraying was done for 16 consecutive weeks. Evaluation for the sucking insect's guild (abundance) was done via direct counting on five randomly selected plants. To compare these treatments' efficacy, three rows (replicate) were sprayed with water only and treated as control (T8). Another factor that we worked on was the spraying time (before and after), which the pest population was recorded one-day prior spraying (before), and three days after treatment application (after).

Experimental Designs

Experiments were laid out in a Randomized Complete Block Design (RCBD) with three replications and eight treatments. The treatments were: (T1) garlic oil; (T2) neem oil; (T3) Pest Guard™; (T4) Shelter X™; (T5) wood vinegar; (T6) Confidor™; (T7) Abenz™ and (T8) control (water only), respectively. The treatments included both biopesticides (T1-T5) and pesticides (T6-T7) and were chosen based on their commercial availability (sale from the pesticide store) (Table 1). Spraying was carried out in the field on a weekly interval using the manufacturer's recommended rate. The spraying was done for 16 consecutive weeks. Evaluation for the sucking insect's guild (abundance) was done on five randomly selected plants. To compare these treatments' efficacy, three rows (replicate) were sprayed with water only and treated as control (T8). Another factor that we worked on was the spraying time (before and after), which the pest population was recorded one-day prior spraying (before), and three days after treatment application (after).

Data Analysis

A two-factor ANOVA was conducted to compare the main effects of the treatment types and spraying time and the interaction effect between treatment types and spraying time on the number of sucking pest insects on *Terung Telunjuk*. On the other hand, the borer's guide's evaluation was done according to the *Terung Telunjuk* yield and damage. The yield from 10 random plants of each treatment were observed, recorded, and weighted to ascertain fruit fly and fruit borer infestation. Damage fruits were observed to calculate damage percentage ratio (Damage ratio (%) = number of damage fruit / number of total fruit harvested x 100). Statistical analyses were computed using the Minitab 19® software.

Table 1. List of treatments and its active ingredient

Treatment		Type	Active ingredient
T1	Garlic oil	Biopesticide	Garlic oil concentration
T2	Neem oil		Neem extract
T3	Pest Guard™		Microbes consist of fungus *Beauvaria bassiana* + *Metarhizium anisopliae* + *Bacillus thurigiensis*
T4	Shelter-X™		Plant fatty acids oil
T5	Wood Vinegar		Charcoal by product
T6	Confidor™	Chemical insecticide	Imidacloprid
T7	Abenz™		Emamectin benzoate
T8	Control	Water only	

RESULTS AND DISCUSSION

Five species of insects were identified as major pest attacking *Terung Telunjuk* plant. Three species of insects have been identified to cause severe damage to *Terung Telunjuk* leaves by sucking the leaves (sucking insects guild) namely plant hopper (*Amrasca* sp.) (n=7406), aphids (*Aphis* sp) (n=1325) and whiteflies (*Bemisia tabaci*) (n=541). Meanwhile two species of insects namely: fruit fly (*Bactrocera* sp.) (n=67) and fruit borer (*Leucinodes* sp.) (n=104), were observed attacking and making holes on the fruit (borer insect guild). A two-way ANOVA was conducted on the influence of two independent variables (application type, spraying time) on the number of sucking insects found on *Terung Telunjuk* (Table 2). There was a significant difference between the treatments of application type (df=7, F=2.95, p<0.05). On the other hand, spraying time yielded (df=1, F=0.18, p>0.05) indicate that the effect of spraying time was not significant. Similarly, the interaction effect between application type and spraying time was also not significant [df=7, = 0.28, p>0.05]. There was no significant different between the spraying time (p=0.677, p>0.05), indicating that there were no differences in the total number of sucking insects before and after spraying (Table 3). Surprisingly, Table 3 illustrates no significant differences between spraying (either biopesticide or pesticide) and not spraying (control). However, Confidor was significantly better at reducing the number of sucking pests compared to wood vinegar (p=0.005, p<0.05) and Neem oil (p=0.02, p<0.05).

Table 2. Two-way ANOVA showing the effects of type of application and spraying time on sucking pest population

Source	***df***	**Sum of squares**	**Mean square**	**F-value**	**P-value**
Application type (Biopesticide/Insecticide)	7	13496	1928	2.95	0.005*
Spraying time (before/after)	1	118	118.1	0.18	0.671
Interaction	7	1286	183.7	0.28	0.963
Error	375	245437	654.4		
Total	383	259051			

* indicates significant differences at p <0.05

Table 3. Interaction of mean number of sucking insects found on *Terung Telunjuk*

Treatment	**Mean number ± SE of sucking insects**		
	Before	**After**	**Overall**
Application type (Biopesticide/Insecticide)			
T1: Garlic oil	23.79 ± 2.89	25.13 ± 2.80	24.45 ± 1.99 ab
T2: Neem oil	31.96 ± 8.81	31.42 ± 6.62	31.69 ± 5.45 a
T3: Pest Guard	21.29 ± 3.46	21.13 ± 3.04	21.21 ± 2.28 ab
T4: Shelter-X	24.42 ± 2.56	30.17 ± 3.73	27.29 ± 2.27 ab
T5: wood vinegar	36.50 ± 12.7	31.08 ± 7.19	33.81 ± 7.22 a
T6: Confidor	16.04 ± 2.44	12.67 ± 1.51	14.35 ± 1.44 b
T7: Abenz	23.17 ± 4.02	16.79 ± 2.48	19.98 ± 2.38 ab
T8: Control	23.63 ± 3.30	23.58 ± 3.06	23.60 ± 2.22 ab
Spraying time (before/after)			
Before	-	-	25.10 ± 2.16 a
After	-	-	23.99 ± 1.55 a

*means that do not share a letter in the same column are significantly different at p<0.05, *Tukey Pairwise*

Imidacloprid (Confidor) is known to be chloronicotinyl insecticide, killing the targeted pest by attacking the insect’s central nervous system. The chemical compound act by inhibiting the transmission of stimuli in the insect nervous system then causes a blockage in a neuronal pathway (nicotinergic) that is more abundant in insects than in warm-blooded animals. This blockage leads to the accumulation of acetylcholine, an important neurotransmitter, resulting in the insect's paralysis, and eventually death (Schroeder & Flattum 1984; Cloyd 2003; Cloyd 2016). It works well in controlling sucking insects, including rice truffles, aphids, thrips, whiteflies, and mealybug (FAO) . It is effective on contact and via stomach action (Kidd & James, 1994). Altmann & Elbert (1992), Elbert et al. (1991) and Hernandez et al. (1999) reported similar observations on the efficacy of imidacloprid against aphids infesting different crops. Vostrel (1998) observed 100 percent mortality when treated with imidacloprid in resistant wheat aphid populations. In a similar study on the effectiveness of imidacloprid and other insecticides, Tolmay et al. (1997) found that the seed treatment of imidacloprid increased the grain yield in Russian wheat aphid resistant as well as susceptible wheat cultivars. The present findings are in line with Khattak et al. (2004) who reported Confidor 200 SL, which effectively controlled sucking pests. The present findings also confirm the reports of Saleem and Khan (2001) who observed good control of sucking insects are using Imidacloprid 20 SL@250 ml/acre. In addition, Singh & Kumar (2006) revealed that alternation of spraying Imidacloprid 70 WG 40 g a. i. /ha and Acetamiprid 20 SP 50 g a. i. /ha are effective in reducing number of *Amrasca biguttula* significantly in okra. While there is a lot of evidence indicating the efficacy of Confidor in managing sucking insects, our finding did not show any significant difference between Confidor and the control. Further study will need to be conducted and repeated in a larger scale to eliminate potential errors. From a different perspective, our finding indicated no significant difference between not applying anything (control) and applying biopesticide or pesticide. Indirectly, this shows the potency of the *Terung Telunjuk* to be cultivated organically or to a lesser extent – free from chemical sprayings.

On the other hand, contrasting results were observed in controlling the fruit fly and fruit borer. Naturally, based on Table 4, the highest fruit number harvested was recorded when the plot was sprayed with Confidor (451). In contrast, the lowest fruit harvested was collected in the garlic oil treatment (109). In addition to that, the control also recorded the highest damage ratio – 24.6% damage followed by the garlic oil treatment (17.4%). Apart from these two treatments, all other treatments recorded a lower than 10% damage ratio. Neem oil (T2) showed to be the lowest of mean weight of fruit infested however there were no significant differences between the weight of the harvested fruits (Table 4). Being left unattended without any spraying will cause considerable lost to the farmers. Our study found that being unsprayed, the mean weight of the infested fruit was the highest (55%).

Table 4. Total number of fruits, damage ratio and weight fruit of *Terung Telunjuk* infested recorded after 4 times harvest

Treatments	**Total number of fruits harvested (n)**	**Total number of fruits with borer infestation (n)**	**Damage ratio (%)**	**Mean weight of fruit harvested (g)**	**Mean weight of fruit infested (g)**
T1: Garlic oil	109	19	17.4	790.0	13.30_a
T2: Neem oil	217	6	2.8	1568.3	10.42_a
T3: Pest Guard	247	10	4.0	1590.0	15.42_a
T4: Shelter-X	346	10	2.9	2226.7	17.92_a

T5: wood vinegar	268	13	4.9	1770.0	19.58_a
T6: Confidor	451	27	6.0	3063.3	39.20_a
T7: Abenz	334	29	8.7	2440.0	21.25_a
T8: Control	122	30	24.6	3510.1	55.00_a

*Means that do not share a letter in the same column are significantly different at 0.05 level

Neem (*Azadirachta indica*) belonging to the Meliaceae family has been used as alternative pesticide as it has emerged as a highly potent bio-pesticide (Akhtar 2000). This fast-growing plant known as the Indian lilac (Schmutterer 1990) provides enormous antifeedant properties at concentrations much lower than 1 component per million due to its effectiveness in suppressing the feeding sensation in insects (Isman et al. 1991; Schmutterer 1990). Neem oil contains more than a dozen azadirachtin analogs, but the major contributor to the insecticidal activity is azadirachtin. Azadirachtin prevents the maturation of insect from larva to pupa during the immature stage, causing mutation in their development of various critical components for their survival, as it affects their ability to oviposit and hatch in the mature stage of the larval stage (Giglioti 2011; Primo et al. 2018). The remaining triterpenoids including nimbin, salannin, and their derivatives have repellent and antifeeder effects over many insects (Brechelt 2004; Isman 2006). Moreover, neem oil is non-toxic to mammals, birds and fishes and exhibits fewer chances of resistance, due to its multiple modes of action on insects. Similar findings were reported by Murugesan & Murugesh (2009) and Rahman et al. (2009) where they used neem to control *Leucinodes orbonalis* in damaging brinjal. However, Murgesan & Murugesh (2009) also noted that using neem was not as effective as the standard chemical pesticide they were using which was carbaryl. Recently, the antifeedant and repellent efficacy of neem leaves was validated in a study where enrichment of organic fertilizers with neem leaf powder and boiler ash was observed to significantly improve resistance of plants against infestation by aphids (Brotodjojo & Arbiwati 2016).

Other biopesticide treatment such as Pest Guard™, Shelter X™ and wood vinegar also showed good results in controlling borer compared to sucking pest, however there was no significant result recorded (Table 2 and Table 3). Pest Guard™ formulation based on a selected strain of naturally-occurring microbes consist of fungus *Beauvaria bassiana* + *Metarhizium anisopliae* + *Bacillus thurigiensis* which is known as entomopathogenic fungi. Entomopathogenic fungi are components of natural agents that attack and infecting its host and are known to develop swift and spectacular epizootics when host densities are high (Lacey & Shapiro-Ilan 2008; Singkaravanit et al. 2010). The life cycle of insect pathogenic fungi involves an infectious spore process that germinates on the host cuticle. It then forms a germ tube that penetrates the host cuticle and ultimately occupies the host cuticle (Akbar et al. 2012). Many researchers also described *Bacillus thurigensis* as a good soil bacterium that may control pest as it produces β-endotoxins which act as an influential intestinal toxin for various insect pests (Vidyarthi et al. 2002). Studies mainly focused on the spores and crystal toxin produced in the midgut of the susceptible pest. The crystal toxin damages the gut cells, subsequently causing leakage of hemolymph into the midgut thus lowering pH and permitting the spores to propagate (Heimpel & Harshbarger 1965). Wood vinegar had been used as biopesticide based on old tradition and knowledge of users and local producers. The effectiveness of wood vinegar as insect repellent had been studied by Rahmat et al. (2014). The study reported a decrease in the number of damages of maize grain because it suppresses the appetite of the maize weevil, *Sitophilus zeamais*. Another report by Chalermsan & Peerapan (2009), wood vinegar had potentials for post-harvest applications in reducing egg-laying and the number of damaged seeds by the *Collosobruchus maculates* (cowpea beetle). Shelter X™ was derived from plant oil fatty acid and formulated in the form of powder; however, the company did not disclose the type of plant that they use in the ingredient. Another chemical pesticide treatment that has been used is Abenz™. The active ingredient inside Abenz™ is emamectin benzoate, known to be a foliar insecticide derivative of abamectin. It stimulates the release of γ-aminobutyric acid, an inhibitory neurotransmitter, thus causing insect paralysis within hours of ingestion and subsequent insect death 2–4 days later (FAO). Emamectin benzoate is more effective in controlling lepidopteran pests and is being developed for use on major field crops and vegetables, such as soybean, cotton, cabbage and radish (Argentine et al. 2002; Ishaaya et al. 2002). Study done by Awasthi et al. (2013) showed that aphids are comparatively resistant towards emamectin benzoate and indoxacarb compared to another pest.

More studies are needed to determine the impact of these insecticides on the natural enemy and other beneficial insects, as the mode of action of imidacloprid has been reported to be similar to non-target beneficial insects, including honeybees, predatory ground beetles and parasitoid wasps (Fossen 2006). Study done by Chung & Srinivasan (2002) showed integrated pest management (IPM) strategy and the application of malathion 50% EC did not adversely affect the foraging activity of honeybees. However, one day after application, it resulted in substantial honeybee mortality. These organisms can serve as effective biological control agents, thus preventing the need for chemical pesticides to be used unnecessarily. Other than that, repetition in using the same chemical pesticide may cause the pest to develop a resistance to the chemical and make it no longer effective to control the pest at the same rate (Bethke 2009). In managing pest through integrated pest management (IPM), the 3 strategies that can be adapted to slow down and combating the pest resistance are avoid by reducing the reliance on chemical, delay by using chemical from different chemical classes and reversal by allowing time between applications of a class of pesticide to permit resistant populations to become diluted by pesticide-susceptible individuals (Bethke 2009).

CONCLUSION

The most effective treatment to control pest-sucking insects was found to be Confidor™. However, based on the results from our study, this pesticide may not suitable to be used in managing fruit fly and fruit borer in *Terung Telunjuk*. In contrast, Neem oil was not effective in managing the sucking pests but were observed to be excellent in controlling fruit fly and fruit borer. Based on the overall results, the best recommendation to the farmers would be to use Confidor™ during early stage of planting *Terung Telunjuk* to minimize infestation of the entire sucking pests, and use Neem™ during fruiting stage to get the best yield of *Terung Telunjuk* fruit according to the label recommendation.

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