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Toxico: Insecticidal of botanical compounds and formulated insecticides on major insect pests and beneficial arthropods in eggplant

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Abstract
The study explored the effect of different botanical compounds and formulated insecticides on the population of the major insect pests, determine the effect of botanical compounds and formulated insecticides on the population of beneficial arthropods, evaluate the yield and determine the cost benefit analysis in eggplant. A Statistical tool for agricultural research software was used during the analysis of data. The application of botanical compounds and formulated insecticides did not affect nor influence the population of the predatory beetle. botanical compounds application offered residual control against whiteflies. neem leaves extract application could affect or influence the infestation of EFSB and can still kill the major insect pests in eggplant. makabuhai vines and neem leaves tree extracts treated plants significantly produced more fruit yield and highest net income compared to formulated insecticides and be part of IPM program in eggplant to ensure maximum yield since these were found effective, cheapest and available already in the local area.

Keywords: botanical extracts, formulated insecticides, insect pests and beneficial arthropods

Introduction
Eggplant is an major important vegetable in the Philippines. It is vigour to the domestic vegetable industry making the country the rank 7th of eggplant producer in the world. It initiated of many small-scale farmers their major source of employment and livelihood. It accounted for 28 % or 177,000 metric tons, of the total volume of vegetables produced during 2003. The amount of eggplant production is the highest among Philippine vegetables at PhP1.8 billion (Chen and Li, 2008) [1].
According to Srinivasan, 2009 that in the tropics, eggplant production was severely constrained by several insect pests. The major insect pests include eggplant fruit and shoot borer, leafhopper, whitefly, thrips, aphid, spotted beetles, flea beetle. The growers rely heavily on chemical pesticides to protect their eggplant crop. The eggplant farmers in the Philippines used chemical specifically insecticides up to 56 times spraying during a cropping season; the volume of pesticide used per hectare of eggplant was about 41 litters of different active ingredients belonging to the four major pesticide groups. Pesticide mishandling has adverse effects on the nature and human health and also increases the cost of production.
With the rising costs coupled with health and environment hazards of synthetic pesticides, there is a need to find and develop practical, safe and effective alternatives. The use of plant derivatives has been studied throughout the world. Over 2, 000 plant species have been reported to possess pest control characteristics (Baidoo and Adam, 2012) [3]. Tacio, 2009 [4] said that the insect pest controls like botanicals are safer to the user and the environment. As botanical pesticides are prepared from natural extraction, the application of these materials has a minimal impact on the environment than chemicals. Once proven that certain botanical plants are useful and comparable to their synthetic counterparts, more farmers will adopt these alternatives without reservations (Baloc and Bulong, 2013). The study was undertaken to find out the effective botanical compounds and formulated insecticides for the management of major insect pests in eggplant and to know the toxicity effect on the population of beneficial insects in eggplant.

Materials and methods
Experimental Design
The study was conducted at the Municipality of Makilala in North Cotabato and carried out in a Randomized Complete Block Design (RCBD) with Seven (7) treatments replicated three (3) times. Each plot had an inside dimension of 16 sq m (3.2 m x 5 m) with a distance at 0.80 m x 1.0 m between plants and 1.0 m between replication (Fig. 1).

Fig 1: Experimental set up laid-out in RCBD with 7 treatments replicated 3 times. Brgy. Katipunan II, Makilala, Cotabato. December 2018 to March 2019.

Seedling Production
A healthy seed were soaked in water for 24 hours to hasten germination and were sown in seedbed which was keep from excessive sun, rain, and wind. It was pressed slightly

to prevent splashing out of seeds during watering. The seeds were treated with fungicide to avoid damping-off in the seedbed. Seed boxes were watered regularly to provide sufficient moisture

Pricking
Pricking was done when the first two true leaves appeared or 24 days after sowing. Starter solution of 50 g of Ammonium Sulfate per gallon of water was applied right after pricking. The seedlings were gradually exposed to sunlight two weeks before transplanting to harden them.

Land Preparation
The area was thoroughgoing prepared by plowing and harrowing until a fine tilth of soil was attained. The plots were established and laid out following the measurement specified in the layout.

Preparation of Plant Extracts
The targeted plant parts (Fig. 2) were collected from the local area, Plant parts were washed to remove the impurities, and each plant part was spalled separately with mortar and pestle. A solution of each plant extract was prepared by mixing 100 g powder in a 100 ml of water (Fig. 3). The mixture was thoroughly shaken and left for 24 hours and filter thoroughly by the use of muslin cloth to remove the impurities (Fiaz *et al.,* 2012) [5]. Ten (10) ml of liquid soap was added to the extracts to improve their delivery and to allow them to stick unto the surface of the leaves of the treated plants (Mochiah *et al*., 2013) [6].

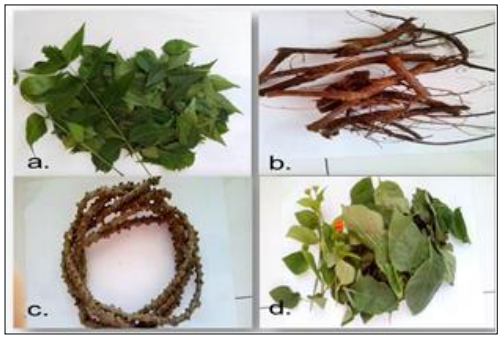

Fig 2: The plant parts used as treatments (a. Neem leaves, b. Derris roots, c. Makabuhai vines, and d. Lantana leaves).

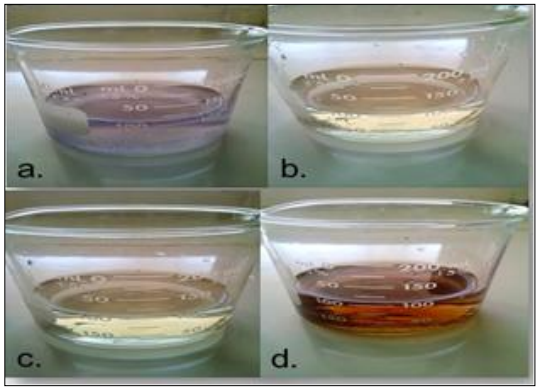

Fig 3: The plant extracts solution (a. Neem leaves, b. Derris roots, c. Makabuhai vine and d. Lantana leaves extract).

Watering
Watering was done daily during its early or immature stage. However, during its maturing phase, this was done alternately within the week.

Harvesting
Harvesting was done as soon as the fruits reached marketable size. Harvesting interval on 3 to 4 days from 60 to 90 days after transplanting.

Data Collection and Analysis
Population Count of Whiteflies A visual count was done one day before spraying and 3 days after each spray application by counting the number of whiteflies present from the first ten tagged sample leaves per treatment per replication.

Population Count of Eggplant Fruit and Shoot borer Larva/Pupa was assessed by counting the number of larvae and pupae present from the first ten tagged sample plants per plot per harvest period.

Beneficial Arthropods Population Count was taken at one day before spraying and 3 days after each spray of the application based from 10 plants per plot per treatment per replication.

Weight of Marketable and Nonmarketable Fruits All marketable and non-marketable fruits of eggplant were taken during harvest based on plants within two middle rows, and these were counted and weighed in kilograms.

Fruit Yield. This was taken by weighing all fruits taken from 6.4 sq m area at the middle of each plot until 17th harvest. Data were expressed in tons per hectare using the following formula below.

Fruit Yield (t/ha)	**Fruit yield (kg)** / Sampling area (m^2)	**X**	**10,000 m2 / ha** / 1,00 kg / tons

Results & Discussion
Whiteflies Population
Pre-spray assessment at 59 DAT, whiteflies population count was evenly distributed among the experimental plots. Population count ranged from 13.33 to 35.00 per 10 leaves per plants (Table 1). Post-spray assessment at 3 days after spray (DAS), at 63 and 73 DAT, the application of botanical plant extracts and formulated insecticides did not affect the population of whiteflies in the fields.
However, at 83 and 93 DAT, neem leaves and derris roots extracts applications offered effective control against whiteflies as reflected by significantly lower counts per 10 leaves. Notably, makabuhai vines and lantana leaves extracts showed lower population counts which were comparable to the other botanical plant extracts and commonly used insecticides. The untreated plots produced the highest population counts in all those observation dates.
This means that botanical plant extracts application offered residual control against whiteflies. Cruz-Estrada (2013) [7], reported that the aqueous botanical plant extracts showed high insecticidal effects on *B. tabaci*.

Table 1: Whiteflies population counts based on 10 plants with 10 leaves samples as affected by the application of different botanical compounds and formulated insecticides taken at one day before spray (DBS) and three days after spray (DAS).

	RATES	1 DBS	3 DAS			
Treatments	**(g or ml FP/ha)**	**59 DAT^{ns}**	**63 DAT^{ns}**	**73 DAT^{ns}**	**83 DAT****	**93 DAT***
Neem tree leaves extract	20.00	20.00	12.67	63.67	100.33^{ab}	207.45^{b}
Lantana leaves extract	20.00	13.33	18.00	81.33	130.67^{ab}	241.33^{b}
Derris roots extract	20.00	22.00	19.00	42.67	100.33^{ab}	219.67^{b}
Makabuhai vines extract	20.00	14.33	16.67	44.00	117.33^{ab}	227.00^{b}
Profenofos	2.00	14.67	20.67	95.67	126.00^{ab}	255.33^{b}
Malathion (Chemical check)	3.00	28.67	15.00	58.00	122.00^{ab}	238.33^{b}
Untreated	-	35.00	30.00	90.00	191.00^{a}	353.33^{a}

* - Means in a column with common letter superscript are not significantly different from each other at 5%, Tukey's Tes
**- Means in a column with common letter superscript are not significantly different from each other at 1%, Tukey's Test.
ns - Not-significant

EFSB Population Counts

Assessments at 71, 80, 84, 92 and 100 DAT, revealed larval and pupal counts of EFSB were evenly distributed among the experimental plants. Population count ranged from 0.00 to 9.00 based on ten (10) plants harvested fruits (Table 2). At 75, 88 and 96 DAT, Neem tree leaves and Derris roots extracts applications offered effective control against EFSB as reflected by significantly lower counts per 10 plants. Notably, makabuhai vines extract application generally gave lower population counts which were comparable or better than lantana leaves extract and other commonly used insecticides. The untreated plant produced the highest population count in all those observation dates. The result agreed with the study conducted by Schumtterer and Singh (1995) [8], that Neem tree *(Azadirachta indica* Juss.*)* has insecticidal properties derived from the tropical and subtropical tree. It is a wide spectrum of actions on insects such as repellant, antifeedant, insect growth regulator (IGR), anti-ovipositional, fecundity and fitness reducing properties. This indicates that neem leaves extract and other plant extracts can still kill the EFSB as a major insect pest in eggplant and ca is a part of IPM program to eggplant to ensure good yield.

Table 2: Population counts of EFSB based on 10 plants as affected by the application of different botanical plant extracts and formulated insecticides taken at different days after spray (DAT).

	RATES	EFSB Population Counts							
Treatments	**(g or ml FP/ha)**	**71 DAT^{ns}**	**75 DAT****	**80 DAT^{ns}**	**84 DAT^{ns}**	**88 DAT****	**92 DAT^{ns}**	**96 DAT****	**100 DAT^{ns}**
Neem tree leaves extract	20.00	1.67	0.33^{b}	1.67	4.33	2.33^{b}	6.00	3.33^{bc}	3.67
Lantana leaves extract	20.00	3.33	1.67^{ab}	2.33	1.67	5.33^{ab}	7.67	4.33^{abc}	3.67
Derris roots extract	20.00	1.33	2.33^{ab}	2.33	3.33	3.33^{ab}	3.33	2.67^{c}	4.67
Makabuhai vines extract	20.00	0.67	1.33^{ab}	2.67	3.67	6.33^{ab}	6.00	4.00^{ab}	4.33
Profenofos	2.00	0.67	2.00^{ab}	2.67	5.00	4.00^{ab}	6.33	5.67^{abc}	5.67
Malathion (Chemical check)	3.00	0.67	2.00^{ab}	3.67	3.00	8.33^{ab}	5.00	2.67^{c}	2.67
Untreated	-	4.33	6.67^{a}	7.33	5.00	7.33^{ab}	9.67	7.67^{a}	9.00

**- Means in a column with common letter superscript are not significantly different from each other at 1%, Tukey's Test.
ns - Not-significant

Predatory Beetle Population Count

Pre-spray assessment at 29 DAT, predatory beetle count was evenly distributed among the experimental plots. Population count ranged from 0.00 to 0.33 per 10 plants. Post-spray assessments at 3days after spray (DAS) as shown in Tables 3, respectively revealed that botanical plant extracts and formulated insecticides plots showed no significant difference as reflected by lower population counts per 10 plants which ranged from 0.00 to 5.67. However, numerically botanical plant extracts showed lower population counts compared to formulated insecticides. The result confirmed the study of Baltazar (2016) [9] that botanical extracts and formulated insecticides generate acute poison and sub-lethal effects on good insects which help for natural pest control and pollination. However, botanicals are often utilized as safe and environmentally sound but for the use for insect pests control should always be done with proper handling. This manifested that application of botanical plants extracts and formulated insecticides did not affect nor influence the population of the predatory beetle in the field in all observation dates.

Table 3: Predatory beetle population counts based on 10 plants as affected by the application of different botanical plant extracts and formulated insecticides taken at one day before spray (DBS) and three days after spray (DAS).

	RATES	1 DBS	3 DAS						
Treatments	**(g or ml FP/ha)**	**29 DAT^{ns}**	**33 DAT^{ns}**	**43 DAT^{ns}**	**53 DAT^{ns}**	**63 DAT^{ns}**	**73 DAT^{ns}**	**83 DAT^{ns}**	**93 DAT^{ns}**
Neem tree leaves extract	20.00	0.00	0.00	0.33	1.00	2.00	3.00	3.00	5.00
Lantana leaves extract	20.00	0.00	0.00	0.67	0.33	2.00	2.33	3.67	4.00
Derris roots extract	20.00	0.33	0.33	1.00	0.33	1.33	1.67	4.67	3.67
Makabuhai vines extract	20.00	0.00	0.00	0.33	0.67	2.67	1.67	4.00	4.33
Profenofos	2.00	0.00	0.00	0.33	1.00	1.00	2.33	4.00	4.00
Malathion	3.00	0.33	0.33	0.00	0.33	1.67	2.67	4.33	5.00
Untreated	-	0.33	0.00	1.00	0.67	2.00	3.33	3.67	4.67

ns - Not-significant

Weight (kg) of Non – Marketable, Marketable Fruits and Fruit Yield (t/ha)

Weights (kg) of non-marketable and marketable fruits were taken at harvest (Table 4). Result revealed no significant difference was observed in weight of non-marketable fruits which ranged from 3.93 to 5.53 kg, respectively. However, weight of marketable fruits showed significant difference among the experimental plots. Neem tree leaves and makabuhai vines applications produced heavier fruit weights which were comparable to derris roots extract, lantana leaves extract and malathion (chemical check). This might be attributed by their effective control against eggplant fruit and shoot borer (EFSB) which is a contributory factor in the reduction of marketable fruits. Finally, in terms of fruit yield all botanical plant extracts treated plants (makabuhai vines, neem tree leaves, lantana leaves and derris roots extracts) significantly produced more fruits comparable with the commonly used insecticides (profenofos and malathion). The untreated control gave the lowest yield of 3.06 t/ha (Table 4). This might be attributed to botanical plant extracts and commonly used insecticides which effectively control the major insect pests such as aphids and leafhopper.

Table 4: Non - Marketable, Marketable and Fruit Yield of eggplant as affected by the application of different botanical plant extracts and formulated insecticides.

Treatments	RATES (g or ml FP/ha)	Weight (kg) of Non - marketable Fruits^{ns}	Weight (kg) of Marketable Fruits **	Fruit Yield (t/ha) **
Neem tree leaves extract	20.00	5.15	29.14^{a}	4.08^{a}
Lantana leaves extract	20.00	5.43	27.60^{ab}	3.94^{a}
Derris roots extract	20.00	4.60	29.43^{a}	4.05^{a}
Makabuhai vines extract	20.00	4.62	30.60^{a}	4.19^{a}
Profenofos	2.00	4.04	25.07^{ab}	3.55^{a}
Malathion (Chemical check)	3.00	4.41	27.03^{ab}	3.74^{a}
Untreated	-	4.55	26.56^{b}	3.06^{b}

**- Means in a column with common letter superscript are not significantly different from each other at 1%, Tukey's Test.
ns - Not-significant

Conclusions

Botanical plant extracts such as neem leaves and makabuhai vines extract offered effective control to the major insect pests of eggplant and least toxic to the beneficial arthropods and can be a substitute on formulated insecticides since these were found out effective, economical, environmentally safe. Hence, neem leaves and makabuhai vines extracts at the rates of 20 ml / Li can be applied for effective management of EFSB and whiteflies. These can also be a part of IPM in eggplant. Moreover, further study shall be conducted using the different dosage following the Fertilizer Pesticide Authority protocol. Another research for the future reference is needed to determine the toxic effect of both botanical compounds and formulated insecticides on beneficial arthropods and other major insect pests of eggplant

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