Title	**Efficacy Evaluation of Agrovit Organic Pesticide against Fruit and Shoot Borer (*Leucinodes orbonalis*) of Eggplant (*Solanum melongena*) under Kapalong, Davao Del Norte Condition**
Introduction **-Product** **-Target Pests** **-Economic relevance (statistical data)**	*Solanum melongena* L. or eggplant, *brinjal*, aubergine or *talong* in different languages, has spread throughout Southeast Asia and in subtropical and tropical regions due to its adaptability and many uses (Mamaril et al., 2013). In the Philippines, 60.5% of the country's production came from the Ilocos region, and the rest of the 39.5% are from CALABARZON, Central Luzon, and Cagayan Valley (Philippine Statistics Authority [PSA], 2021). The Covid-19 pandemic took its share of the production losses, especially in the producing regions (Mapa, 2020). Moreover, pests and diseases are still the main challenges, aggravated by environmental factors. Eggplant is generally susceptible to pests and diseases from the seedling to maturity. The most persistent pests are the fruit and shoot borer (Mamaril et al., 2013). In the Philippines and other Asian countries, the Eggplant Fruit and Shoot Borer (EFSB) causes year-round damage. Mannan et al. (2015) noted a narrow gap between shooting initiation to flowering, making it more suitable for infestation. The life cycle is brief at only 3-6 weeks with five overlapping generations. The voracious eating habit of the larva hampered nutritional assimilation hence wilting to death is inevitable (Javed et al., 2017). Furthermore, a significant 20-30 tons per hectare harvest loss is incurred if pests are left unmanaged (SHEP PLUS JICA, 2016). Proper management through Integrated Pest Management (IPM) is the key to maximizing harvest up to 60 tons/ha. This would also reduce chemical usage by 40% (International Service for the Acquisition of Agri-biotech Applications [ISAAA], 2020). Among the IPM strategies, using an organic product with an insecticidal property could be incorporated, such as Agrovit Organic Insecticide. It is a byproduct of Palm Kernel Shell (PKS) charcoal production. It is a liquefied fresh wood, burned anaerobic. Consequently, this product is a concoction of different compounds such as acetic acid, phenol, ethyl-valerate, tar, methanol, and 200 more. These compounds are known to have insecticidal properties (Hashemi et al., 2014) but are safe for pollinators, improve soil quality, improve orchard health, induce pest resistance, and are safe for humans (Food and Fertilizer Technology Center [FFTC], 2005). Agrovit Organic Insecticide's main active ingredient, Acetic acid, has been known for its many uses as pest and disease control. Kim et al. (2008) and Hashemi et al. (2014) mentioned that a large amount of acetic acid may influence the permeability of the insects' cuticle layer, increasing its vulnerability to other compounds such as carbosulfan thus

enhancing its penetration into the insect's cuticle. The result was promising against EFSB in Agusan at 2 Liter/ 200L water per hectare rate and was comparable with the standard chemical insecticide (Amas, 2018).

The main objective of this study is to further validate the efficacy of Agrovit organic insecticide to control and manage the eggplant FSB (*Leucinodes orbonalis*) in different locations and environment. More specifically, it aims to determine the following:

1. effective dose of Agrovit organic pesticide against fruit and shoot borer Eggplant (*Solanum melongena* L.)
2. phytotoxicity effect of Agrovit organic pesticide on the leaf and the eggplant fruit.
3. effect of Agrovit organic pesticide on the growth and yield of eggplant.

Results & Discussion

Fruit and Shoot borer (FSB) Population

The presence of insect pests such as the FSB was already detected 15 days after transplanting. Therefore, the application of all treatments as shown in Table 1 commenced 15 days earlier. However, data were reckoned at 30 days after transplanting (DAT). At the reproductive stage, the infestation was visible and damage was clear in shoots (Figure 1). As shown in Table 2 (page 4), all rates of Agrovit organic insecticide and the standard chemical check, Trial 5 (T5), showed a significant difference in the number of FSB at different periods compared to the untreated (T1). The least mean number of FSB was seen in eggplants applied with the double rate of Agrovit organic insecticide (T4), with only 0.98 FSB.

Table 1. Treatment concentration of Agrovit organic insecticide against FSB (*Leucinodes orbonalis*) of eggplant (*Solanum melongena*)

Treatment	Description	Rate/Has	Rate (ml/L)
1	Untreated	-	-
2	Agrovit (1RR) *	1 L/200 L water	5
3	Agrovit (1.5x RR)	1.5 L/200 L water	7.5
4	Agrovit (2x RR)	2 L/200 L water	10
5	Chix 2.5 EC	450 g/200 L water	2.25 g/L

*RR-Recommended Rate

Figure 1. Presence of fruit and shoot borer larvae inside an Eggplant shoot (arrow). The right photo showed early damage caused by the insect. Later, this predisposed shoot will dry up and be infected with secondary fungal invaders. The fruit will fall off and will be underdeveloped. If the fruit is lucky enough to continue its development, FSB has already transferred while the fruit was young.

Percent Reduction of FSB in Shoot

Percent reduction of FSB infestation in shoots was calculated respective to the untreated (T1) as shown in Table 3 (page 4) to further elucidate efficacy of Agrovit organic insecticide. The standard control, Chix 2.5 EC (T5), is the lowest mean percent reduction. This is significantly different compared to the mean percent reduction of the three varying rates of Agrovit organic insecticide, which ranged from 68% to 72%. It can be noted that certain data points showed significant differences in the percent reduction, vis-à-vis 48 DAT, 63 DAT, and 123 DAT. This was attributed to the partial leaf trimming done before the next application at this time. This was done only to mitigate the deaths of some branches. Moreover, trimming was also done in all treatments.

Table 2. Number of FSB in shoots at different periods as affected by the different rates of Agrovit organic insecticide

Description	33DAT	37DAT	48DAT	52DAT	63DAT	67DAT	78DAT	82DAT	93DAT	97DAT	108 DAT	112 DAT	123 DAT	127 DAT	Mean
T1-Untreated	3.65a	3.33a	4.10a	5.90a	4.98a	5.13a	5.85a	6.20a	6.35a	2.73a	3.84a	2.58a	2.99a	3.01a	4.26a
T2-1RR Agrovit	2.10b	1.55bc	1.88c	0.88b	2.28b	0.53b	0.45b	0.60b	0.68b	0.70b	1.35b	0.20b	0.08b	0.96b	1.05b
T3-1.5 RR Agrovit	1.98b	1.38c	2.35b	0.90b	1.85cd	0.50b	0.60b	0.70b	0.78b	1.00b	1.13b	0.15b	0.47b	1.43b	1.08b
T4-2RR Agrovit	1.95b	1.60bc	1.63c	0.95b	1.60d	0.55b	0.43b	0.58b	0.68b	0.93b	1.15b	0.10b	0.15b	1.14b	0.98b
T5-Chix 2.5 EC	2.08b	1.98b	1.65c	1.33b	2.10bc	0.75b	0.60b	0.73b	0.70b	1.03b	1.23b	0.28b	1.10b	1.48b	1.18b
p-value	0.001**	0.001**	0.001**	0.001**	0.001**	0.001**	0.001**	0.001**	0.001**	0.001**	0.0001**	0.0001**	0.0001**	0.0003**	0.0001**

DAT=Days after Transplanting; Means with the same letter are significantly comparable at p=0.05. Mean comparison was analyzed using ANOVA and Tukey's HSD

Table 3. Percent (%) reduction on the number of FSB in shoots at different period as affected by various rates of Agrovit organic insecticide

Description	33DAT	37DAT	48DAT	52DAT	63DAT	67DAT	78DAT	82DAT	93DAT	97DAT	108 DAT	112 DAT	123 DAT	127 DAT	Mean
T2-1RR Agrovit	42%	53%	54%a	85%	54%c	90%	92%	90%	89%	74%	65%	93%	97%a	68%	70%ab
T3-1.5 RR Agrovit	46%	58%	43%b	85%	63%ab	90%	90%	89%	88%	63%	70%	94%	83%ab	51%	68%ab
T4-2RR Agrovit	46%	51%	60%a	84%	68%a	89%	93%	91%	89%	65%	70%	96%	95%a	59%	72%a
T5-Chix 2.5 EC	43%	40%	60%a	77%	58%bc	85%	90%	88%	89%	62%	69%	89%	60%b	47%	66%b
p-value	0.6624 ns	0.0700 ns	0.0005**	0.1629 ns	0.0008**	0.4244 ns	0.0934 ns	0.1337 ns	0.6856 ns	0.2404 ns	0.8835 ns	0.5050 ns	0.0432*	0.5296 ns	0.0001**

DAT=Days after Transplanting; Means with the same letter are significantly comparable at p=0.05. Mean comparison was analyzed using ANOVA and Tukey's HSD

Results & Discussion

Number of FSB in Fruits as affected by the different rates of Agrovit Organic Insecticide

Table 4 (page 6) showed the number of FSB in the fruits. This was taken randomly during the 10 harvest peaks by dissecting the sample fruits longitudinally. The highest mean number of FSB was on the untreated fruits. Meanwhile, the chemical standard treated fruits had the lowest mean of FSB, which is statistically comparable to all Agrovit organic insecticide rates. From the 10-harvest time, six harvest periods showed significant results. Consistently, Agrovit organic insecticide and the standard control (Chix 2.5 EC) were statistically comparable among each other while significantly different from the untreated.

Some damaged sample fruits were devoid of actual borers, and some of these fruits were infected with secondary invaders (Figure 2). It was observed that secondary invaders started its infection from the hole made by the fruit borers. It can be observed further that infestation had a declining trend towards the end of the harvest (Figure 3).

Figure 2. Harvested eggplant showing clean and damaged pulp created by FSB. In T1, a small rotted fruit due to secondary invaders. (a-b) T1-Untreated; (c) T2-Agrovit (1x); (d) T3- Agrovit (1.5x); (e) T4- Agrovit (2x).

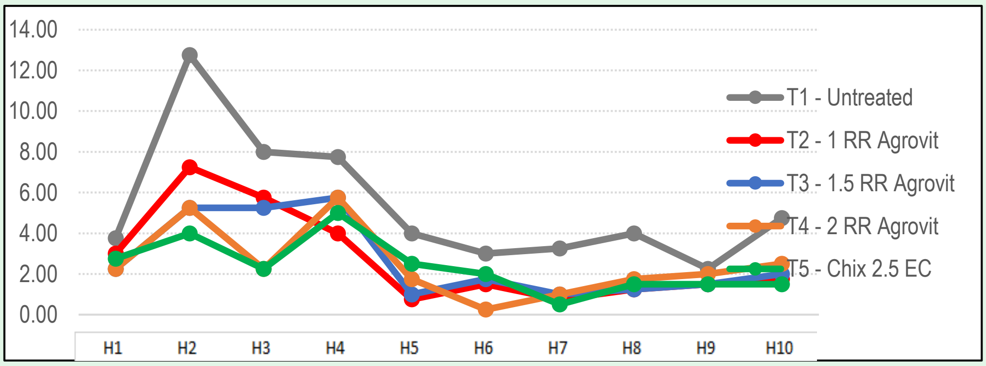

Figure 3. Population trend of FSB in eggplant fruit from the first to the 10th harvest peak as affected by the application of Agrovit Organic Insecticide.

Table 4. Number of FSB in the fruit at different harvest period as affected by the varying rates of Agrovit organic insecticide

Description	H1	H2	H3	H4	H5	H6	H7	H8	H9	H10	Mean
1 Untreated	3.75	12.75	8.00a	7.75	4.00a	3.00a	3.25a	4.00a	2.25	4.75a	5.35a
2 1RR Agrovit	3.00	7.25	5.75ab	4.00	0.75b	1.50ab	0.75b	1.25b	1.50	1.75ab	2.75b
3 (1.5) RR Agrovit	2.25	5.25	5.25ab	5.75	1.00ab	1.75ab	1.00b	1.25b	1.50	2.00ab	2.70b
4 2RR Agrovit	2.25	5.25	2.25b	5.75	1.75ab	0.25b	1.00b	1.75ab	2.00	2.50ab	2.48b
5 Chix 2.5 EC	2.75	4.00	2.25b	5.00	2.50ab	2.00a	0.50b	1.50b	1.50	1.50b	2.35b
p-value	0.8097ns	0.1458ns	0.0496*	0.3392ns	0.0447*	0.0023**	0.0008**	0.0173*	0.8196ns	0.0330*	0.0001**

H1=First Harvest Peak; H2= Second Harvest Peak and so on. Means of different letters are significantly different at p=0.05. Mean comparison was analyzed using ANOVA and Tukey's HSD.

Percent (%) Fruit Damage caused by FSB

To understand the magnitude of damage relative to the number of FSB in fruits, the % fruit damage is calculated. The mean % damage in untreated fruits reached up to 57% (Table 5). This was followed by T3 (Agrovit 1.5x RR), T5 (Chix 2.5EC), and T4 (Agrovit 2RR) with a mean of 29%, 28%, and 27% mean fruit damage, respectively. The recommended rate T2 (Agrovit 1RR) had the least % damage. Nevertheless, the percent reduction of all treated fruits was statistically comparable while different from the untreated.

Table 5. Percent fruit damage caused by FSB as affected by the application of Agrovit organic insecticide

Description	H1	H2	H3	H4	H5	H6	H7	H8	H9	H10	Mean
1 Untreated	68%a	73%a	68%a	42%	65%a	40%a	55%a	60%	45%	60%	57%a
2 1RR Agrovit	38%b	27%b	37%ab	20%	15%b	30%ab	10%b	25%	30%	30%	26%b
3 (1.5) RR Agrovit	36%b	48%ab	31%b	28%	20%ab	30%ab	20%b	25%	25%	30%	29%b
4 2RR Agrovit	34%b	31%b	19%b	29%	30%ab	5%b	20%b	30%	35%	39%	27%b
5 Chix 2.5 EC	50%ab	31%b	15%b	24%	40%ab	40%a	10%b	25%	20%	30%	28%b
p-value	0.0216*	0.0016**	0.0034**	0.1696ns	0.0443*	0.0131*	0.0014**	0.0479*	0.4159ns	0.3712ns	0.0001**

H1=First Harvest Peak; H2= Second Harvest Peak and so on. Means of different letter are significantly different at p=0.05. Mean comparison was analyzed using ANOVA and Tukey's HSD.

Results & Discussion

Percent (%) Reduction on Fruit Damage

In Table 6 (page 9), the % reduction in fruit damage was calculated comparative to the untreated. Treatment 4 had the largest mean % reduction of 52%, while T3 had the least mean % reduction. All harvest periods were comparable except for H6, where the difference was affected by the slight increase in the standard control (T5). However, there were more instances that T2 gave the highest % reduction. Moreover, in the ninth harvest instances, all treated plants were statistically comparable relative to the untreated.

Productivity and Yield

Insect infestation would translate to yield loss and reduced productivity. Fruit and shoot borer is the main insect pest of eggplant, and it greatly damages not only the aesthetic value but also of yield (tons/ha). Table 7 (page 9) showed that the yield of eggplant (tons/ha) in 10 harvest periods were significantly different among treatments. It clearly presented that the recommended rate of Agrovit organic insecticide gave the highest yield of 1.89 tons/ha. This was followed by the double rate of Agrovit organic insecticide with 1.66 tons/ha. It was also observed that the first plots to harvest were the Agrovit organic insecticide plots. All plots were able to harvest a minimum of 1 ton/ha. However, when the insect pest is properly managed, the potential of reaching the maximum harvest is totally feasible. Consistently, T2 and T4 gave superior results. Figure 4 showed the harvest trend of eggplant. Food supply for the pest has peaked at harvest 4. It is not guaranteed though that the pulp was clean and devoid of larvae because there were small and invisible bores already made by the insect and some fruits were rejected due to severe damage, making it unmarketable (Figure 5).

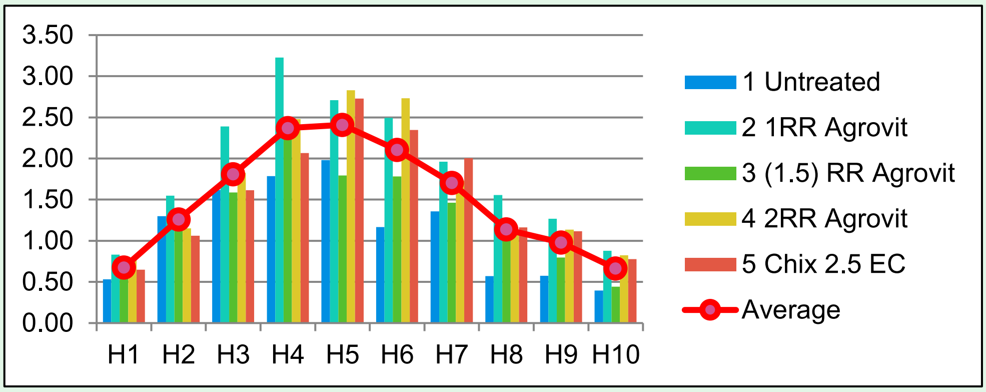

Figure 4. Harvest trend of eggplant from the first to the 10th harvest peak as affected by the application of Agrovit organic insecticide. Harvest 4 had the greatest number of fruits harvested, while it tends to flatten towards senescence stage

Figure 5. Fruit damage caused by fruit and shoot borer. (A) 1 Untreated (B) 1RR Agrovit (C) 1.5 RR Agrovit (D) 2RR Agrovit (E) Chix 2.5 EC

Phytotoxicity Test

One week after the first application, the seedlings did not manifest any symptom of phytotoxicity as presented in table 8, page 9. The observation was extended until three weeks. There was still no burning or scalding found on the leaves (Figure 6). The maximum rating recorded was 1.5, and the least rating was 0.5. All ratings from 33 DAT to 127 DAT belonged to the non-toxic with slight discoloration and non-lasting category (Figure 7).

Figure 6. Eggplant leaves showing no signs of phytotoxicity at the first Agrovit organic insecticide applications. (a) 1RR Agrovit (b) 1.5 RR Agrovit (c) 2RR Agrovit.

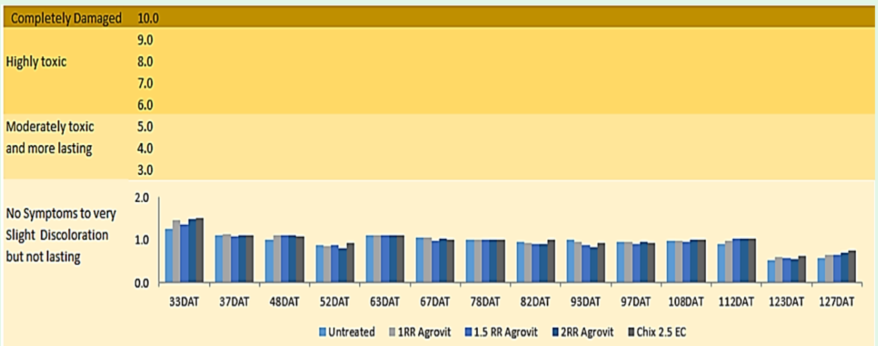

Figure 7. Phytotoxicity rating on eggplant leaves as affected by the application Agrovit organic insecticide as adapted from Nalini and Parthasarathi (2017).

Table 6. Percent (%) reduction on fruit damage caused by FSB as affected by the application of Agrovit organic insecticide

Description	H1	H2	H3	H4	H5	H6	H7	H8	H9	H10	Mean
2 1RR Agrovit	38%	63%	39%	50%	75%	17%ab	79%	60%	29%	41%	49%
3 (1.5) RR Agrovit	47%	33%	52%	27%	67%	4%ab	56%	52%	46%	48%	43%
4 2RR Agrovit	61%	58%	71%	35%	58%	92%a	60%	46%	21%	19%	52%
5 Chix 2.5 EC	17%	57%	75%	43%	35%	-4%b	81%	56%	54%	41%	46%
p-value	0.3983ns	0.3288ns	0.2348ns	0.6559ns	0.4727ns	0.0410*	0.5067ns	0.9459ns	0.7827ns	0.8311ns	0.0881ns

H1=First Harvest Peak; H2= Second Harvest Peak and so on. Means of different letters are significantly different at p=0.05. Mean comparison was analyzed using ANOVA and Tukey's HSD

Table 7. Eggplant yield (tons/ha) as affected by the application of Agrovit organic insecticide

Description	H1	H2	H3	H4	H5	H6	H7	H8	H9	H10	Mean
1 Untreated	0.53b	1.3ab	1.62b	1.79c	1.98b	1.17c	1.36c	0.57b	0.58c	0.40c	1.13d
2 1RR Agrovit	0.83a	1.55a	2.39a	3.23a	2.71a	2.50a	1.96ab	1.56a	1.27a	0.88a	1.89a
3 (1.5) RR Agrovit	0.6ab	1.25ab	1.59b	2.29bc	1.80b	1.78b	1.46bc	1.27a	0.80bc	0.44bc	1.33cd
4 2RR Agrovit	0.77a	1.15ab	1.83ab	2.48b	2.83a	2.73a	1.73abc	1.13a	1.14ab	0.83a	1.66ab
5 Chix 2.5 EC	0.65ab	1.06b	1.62b	2.07bc	2.73a	2.35a	2.01a	1.16a	1.12ab	0.78ab	1.55bc
p-value	0.008*	0.029*	0.012*	0.000*	0.001*	0.000*	0.006*	0.000*	0.001*	0.002*	0.000*

H1=First Harvest Peak; H2= Second Harvest Peak and so on. Means of different letters are significantly different at p=0.05. Mean comparison was analyzed using ANOVA and Tukey's HSD.

Table 8. Phytotoxicity data of Agrovit organic insecticide applied to eggplant seedlings, 1 week after transplanting and the succeeding weeks thereafter

Description	33DAT	37DAT	48DAT	52DAT	63DAT	67DAT	78DAT	82DAT	93DAT	97DAT	108 DAT	112 DAT	123 DAT	127 DAT
Untreated	1.3	1.1	1.0	0.9	1.1	1.1	1.0	1.0	1.0	1.0	1.0	0.9	0.5	0.6
1RR Agrovit	1.5	1.1	1.1	0.9	1.1	1.1	1.0	0.9	1.0	1.0	1.0	1.0	0.6	0.7
1.5 RR Agrovit	1.4	1.1	1.1	0.9	1.1	1.0	1.0	0.9	0.9	0.9	1.0	1.0	0.6	0.7
2RR Agrovit	1.5	1.1	1.1	0.8	1.1	1.0	1.0	0.9	0.8	1.0	1.0	1.0	0.6	0.7
Chix 2.5 EC	1.5	1.1	1.1	0.9	1.1	1.0	1.0	1.0	0.9	0.9	1.0	1.0	0.6	0.8
p-value	*0.234ns*	*0.963ns*	*0.702ns*	*0.702ns*	*1.000ns*	*0.447ns*	*1.000ns*	*0.369ns*	*0.121ns*	*0.988ns*	*0.947ns*	*0.871ns*	*0.898ns*	*0.468ns*

DAT=Days after Transplanting; ns means not significantly different at p=0.05. Mean comparison was analyzed using ANOVA and Tukey's

Conclusion	All rates of Agrovit organic insecticides were comparably effective against FSB (*Leucinodes orbonalis*) of eggplant with 70-72% infestation reduction. However, for cost consideration, especially for commercial applications, it is recommended to use the standard rate of 1 L/200 L water (T2). Moreover, depending on the damage, an application can range up to 2 L/200 L water since Agrovit organic insecticide is not phytotoxic to the fruits and leaves and poses no detrimental effect to beneficial insects. Subsequently, T2 gave the highest yield of 1.89 tons/ha followed by T4 of 1.66 tons/ha. A clear indication that the product is effective against the insect. Furthermore, it is best that application should commence the earliest time possible or one week after transplanting for protection against insect population build-up.
Researchers and Company Profile	**HOA Trading Corporation** HOA Trading Corporation was established in 2016 and became the sole distributor of Taiwan's YUAM DA Technology Co. Ltd. in the country. To come up with the most suitable formula for the Philippine farming land, which would improve overall quality production, the company collaborated with the local farmers to experiment more with different plants and analyses in terms of local weather and soil quality. HOA Trading Corporation envisions to be the preferred brand known for credibility in the market that everyone can trust in quality, effectiveness, price, and services. **VINE'S PHYTO-LAB AND AGRI-CONSULTANCY** **Door 2, 2/F KS Biz Center, J. Abad Santos St.,** **Magugpo Poblacion, Tagum City** **Contact No.: 0917-176-3177** Vine's Phyto-Lab and Agricultural Consultancy was established in 2020 and is based in Tagum City, Davao Del Norte Philippines. The company is engaged in applied research for product registration to Bureau of Agriculture and Fisheries Standards (BAFS) (for organic soil amendments) and Fertilizer and Pesticide Authority (FPA). Further, the company is also engaged with banana tissue culture. The researcher was a former Senior Scientist at Dole Philippines, Inc. for 7 years, handling banana and diversified crops research. She finished her bachelor's degree in Agriculture at the University of Southern Mindanao, major in Plant Pathology with a minor in Plant Breeding and Genetics. She pursued her Master's Degree in Nematology in Ghent University, Belgium focusing in Natural and Agro-Ecosystem. She completed her PhD degree in Agriculture major in Horticulture at the University of Southeastern Philippines, Tagum City. The researcher is a registered Agriculturist and recently, a part-time teacher in a State College and University.

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