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Control of fruit fly (*Batrocera cucurbitae* S.) with sesame leaf ethanolic extract in bitter gourd (*Momordica charantia* L.)

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Abstract

The increasing demand for eco-friendly agricultural practices has spurred interest in the development of botanical pesticides. The study aimed to investigate the effects of sesame leaf extract (ethanolic) to control insect pests of bitter gourd, *Momordica charantia* L. specifically fruit fly, *Batrocera cucurbitae* S. and to check its effect on the agronomics of the test crop. The study was conducted at Isabela State University – Cabagan campus for dry season C.Y. 2023 only. The treatments involved one negative control, one positive control (using commercial synthetic insecticide), pure sesame leaf extract and four treatments with varying concentration of sesame leaf ethanolic extract. Growth parameters (plant length), pest infestation rates, and yield components (number of fruits and average fruit weight) were measured. Results of the statistical analysis using Statistical Tool for Agricultural Research (STAR) software under Two-Factorial Randomized Complete Block Design revealed certain results. Hybrid variety consistently outclassed open pollinated variety on all agronomic parameters. The application of commercially available synthetic insecticide (T_2) had recorded highest numbers in almost all parameters while plots applied with pure sesame leaf extract (T_3) and sesame leaf ethanolic extract (T_4-T_7) also logged higher numbers compared to the untreated plants (T_1) suggesting that the treatments employed had positive results. Economically, the use of 105ml/l sesame leaf ethanolic extract can be used hand-in-hand with commercial pesticide for better pest control especially fruit fly in bitter gourd. These results support the integration of botanical pesticides into sustainable agriculture and provide foundation for further explorations into naturally derived crop protection strategies.

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Introduction

The vegetable *Momordica charantia* L., Cucurbitaceae, is known variously as bitter gourd, balsam pear, bitter melon, bitter cucumber, and African cucumber Bitter gourd (Behera *et al.*, 2010) The genus *Momordica* is a native of the Paleotropics and comprises about 60 species. Bitter gourd grows in tropical and subtropical areas, including parts of East Africa, Asia, the Caribbean, and South America, where it is used not only as a food but also as a medicine. The plant is monoecious, annual climber with long-stalked leaves and yellow, solitary male and female flowers borne on the leaf axils. The warty and oblong or elliptical-shaped fruit is botanically a 'pepo.' The plant grows well in a variety of soils and begins flowering about one month after planting (Asna *et al.*, 2020). It has been part of the Filipino diet since time immemorial. All succulent parts of the plant have been consumed as viand by Filipino households to wit it has been shown to have essential nutrients that is beneficial to humans. Due to the medicinal properties of the plant, some companies have also made herbal supplements out of this crop.

In Isabela, the major producers of bitter gourd are the municipalities of Roxas, Aurora, Mallig, Reina Mercedes, and the Cauayan city according to the Department of Agriculture.

Though according to the report of Philippine Statistics Authority, the regionwide production data states that the production volume of bitter gourd declines by 14% in 2020.

Bitter gourd (*Momordica charantia* L.) is a commercially and nutritionally important market vegetable in Asia cultivated mainly by smallholder farmers (Dhillon *et al.,* 2018).

Households generally purchase vegetables three times a week and predominantly from the wet market. While most households consider price as their primary criteria for purchase, quality in use is considered important. Wives continue to play a major role in the decision to purchase, cook and serve vegetables. Stakeholders in the vegetable supply chain, including smallholder farmers can focus their strategies to develop a strong domestic market for vegetables through increased consumption, and better-quality management systems to defend their products against the threat of imports (Concepcion, 2005).

Insect pests are a major constraint for increasing the production and productivity of this Bitter gourd *(Momordica charantia* L.*)*. Bitter gourds are attacked by several insect pests, among them the fruit fly is one of the most destructive insect-pests (Panday *et al.*, 2008). Melon fruit flies (Diptera: Tephritidae: Dacinae) are economically important pests of the cucurbits and are geographically distributed throughout the tropics and subtropics of the world (Chinajariyawong *et al.*, 2003), especially in most countries of South East Asia (Allwood *et al.*, 1999). The extent of losses varies between 30 and 100% depending on the cucurbit species and the season (Pareek and Kavadia, 1995; Kapoor, 1993; Panday *et al.*, 2009). The melon fly has been observed on 81 host plants, with watermelon being a highly-preferred host, and has been a major limiting factor in obtaining good-quality fruits and high yield (Nath and Bhushan, 2006).

The term pesticide covers a wide range of compounds including insecticides, fungicides, herbicides, rodenticides, molluscicides, nematicides, plant growth regulators and others.

Ideally a pesticide must be lethal to the targeted pests, but not to non-target species, including man. Unfortunately, this is not the case, so the controversy of use and abuse of pesticides has surfaced. That is aside from the fact that the cause of pesticide is also an addition to the costs of production.

As a result of the recent efforts, made by the Environmental Protection Agency, to reduce the use of harmful insecticides, especially, organophosphates, organochlorines, some carbamates and pyrethroids, in the agricultural crops, the trend has now shifted towards an integrated pest management (IPM) for the control of tephritid fruit flies (Roger *et al.*, 2010).

A study had found that the phytochemical result of leaf and stem ethanolic extract indicated the presence of certain phytochemicals such as alkaloids, carbohydrates, cardiac glycosides, diterpenoids, flavonoids, proteins, saponins, steroids, tannins and triterpenoids that were proved to be vital in the insecticidal activity of the extracts. Thus, the stem and leaf ethanolic extracts of sesame are effective botanical insecticides against *C. tomentosicollis* especially at 20.00 mg/l of the leaf extract. With this result, it may also be effective to fruit fly with the same geniality and may help reduce the use of pesticides for the sustainable agriculture.

Generally, the study aims to evaluate the effectiveness of sesame leaf ethanolic extract to control fruit fly (*Batrocera cucurbitae* S.) on bitter gourd fruits.

Specifically, it aims to evaluate the efficacy of sesame leaf ethanolic extract on fruit fly (*Batrocera cucurbitae* S.), assess effect of sesame leaf ethanolic extract on fruit fly (*Batrocera cucurbitae* S.) on the growth and yield of bitter gourd, determine the most effective level and best method of application of sesame plant ethanolic extract responsive to *Batrocera cucurbitae* S. in bitter gourd and analyze the cost and return of the different treatments.

Materials and methods

Procurement and preparation of materials

Prior to the conduct of the study, all materials that are of immediate need have been purchased. A temporary laboratory area as well as storage cabinet/refrigerator was prepared and sanitized to avoid contamination prior to the extraction process.

Preparation of sesame leaf ethanolic extract

Ethanolic extracts of sesame leaf and stem was prepared with concentrations based on the result of other studies before the planting of bitter gourd.

Pre-testing (Bioassay) of sesame leaf ethanolic extract

Prior to the conduct of the trial, fruit fly samples were collected and sprayed following a modified Poter's Tower method, with the sesame leaf ethanolic extract (SLEE) at 20 mg/L concentration (result from literature) to confirm the effectivity of SLEE in fruit fly. All other treatment dosages were also administered to check the laboratory result of each treatment.

Result/observation was noted and explained in the Results and Discussion section.

Site selection

The site for the establishment of the trial was a parcel of land at the Central Experiment Station of Isabela State University – Cabagan campus, Garita, Cabagan, Isabela with an area of 576 sq. meter.

Land preparation

The area was cleaned from weeds and stubbles prior to land cultivation. Land preparation was done by using mechanical tractor to plow the area twice with an interval of 7 days. No pre-emergent herbicide was applied before planting.

Experimental treatments

The study was conducted in a Two-factorial Randomized Complete Block Design with the following treatments to be employed:

Variety
V1- OPV
V2- Hybrid

Level of Concentration
T1-Negative Control (No Application)
T2-Positive Control (Commercial chemical insecticide)
T3-Pure Sesame Leaf Extract
T4-75mg/gal Sesame Leaf Ethanolic Extract (baseline)
T5-85mg/gal Sesame Leaf Ethanolic Extract
T6-95mg/gal Sesame Leaf Ethanolic Extract
T7-105mg/gal. Sesame Leaf Ethanolic Extract

Planting

Prior to planting, a seed germination test was conducted to make sure the seeds procured are of good quality and it yielded satisfactory result of 90% and 80% germination rate for hybrid and OPV varieties respectively. Planting was made manually by dropping at most 2 seeds per hill with a spacing of 50 cm in between.

Fertilizer application

For the nutrient management, the general/ national fertilizer recommendation for bitter gourd under the Department of Agriculture's Package-of-Technology (POT) was utilized and no other fertilizer was added.

Fruit fly introduction

During the conduct of the study where rainfall has been frequently pouring, the researcher opted to collect and to introduce a controlled number of fruit fly from neighboring plants/ trees such as mabolo where the same species of fruit fly has been observed. A total of 90 adult fruit flies was collected and introduced in the covered area of the study. A blanket with fine mesh was deployed covering the plots for Treatment T3 (Pure Sesame Leaf Extract) to T7 (105mg/gal. Sesame Leaf Ethanolic Extract) before the introduction to avoid spread of the pests.

Application of treatments

Due to the erratic weather condition during the onset of fruiting stage of the bitter gourd, the treatments were employed following the above mentioned pesticide and pesticide concentration to be used. The frequency of application was every two weeks which started from June 22, 2023.

Data to be gathered

For the data gathered, agronomic data such as plant height/length, number of fruits (marketable/non-marketable), length and diameter of fruits, weight of fruits, actual and estimated yield, etc., was be tabulated and recorded.

Insect Mortality (Bioassay): The data gathered during the bioassay testing was recorded per treatment (dosage). Percent mortality was calculated using Abbott's formula (*1982*) since some insects die in the untreated (distilled water) treatment:

% Mortality (corrected)={% survival (untreated)-% survival (treated)}/{% survival (untreated)}× 100

Plant Length at harvest: Measurement starts from the base of the main stem to the tip of the shoot.

Pest Incidence: Data on the number of fruit fly observed in each treatment was recorded. Other insects present in the study area was also noted. To assess or estimate the severity of damage by the number of insects, a matrix (Teh, 2022) was used as reference (Fig. 1).

Fruit Yield: Data on the fruit yield was gathered at harvesting time. Minimum of three (3) priming was made starting from July 4, 2023 and each week after. From this data, the fruits were segregated into Marketable and Non-marketable fruits according to the local market standards.

Weight of Fruit: After harvesting, data on the weight of fruits harvested per treatment was collected and recorded for the calculation of yield and economics. The average weight of ten samples were used in the statistical analysis.

Projected Yield per Hectare: With data on the harvested fruits, yield per hectare was calculated by multiplying the yield from the study area by 10,000 m2 (1 hectare).

For the economic analysis, all expenses were recorded. Current market price during the harvesting time was accessed from the nearest market of Cabagan Public Market to calculate the return on investment of utilizing the treatments.

Harvesting

Harvesting of the first batch of immature fruits was done on July 4, July 11, and 18, 2023. For the first two priming, only mature bitter gourd fruits were harvested while on the third priming all fruits was harvested as well as the plant itself was uprooted to facilitate the gathering of data on plant length.

Probability / Severity	Rare (1)	Remote (2)	Occasional (3)	Frequent (4)	Almost Certain (5)
Catastrophic (5)	5	10	15	20	25
Major (4)	4	8	12	16	20
Moderate (3)	3	6	9	12	15
Minor (2)	2	4	6	8	10
Negligible (1)	1	2	3	4	5

Fig. 1. Pest risk matrix

Statistical analysis

The data was analyzed using the using the Statistical Tool for Agricultural Research (STAR) software for RCBD two-factorial experiment. Tukey's Honest Significant Difference test was also used to further analyze the difference among the treatment means.

Results and discussion

General growth of the plants

The plants in the OPV side had exhibit slower vine growth compared to the Hybrid side must be mainly because of heterosis (hybrid vigor). The hybrid bitter gourd typically matured faster, translating into an earlier onset of fruiting as early as 65 DAP in T_1 and T_3. These could be supported by the study of Duvick (2005), hybrids typically exhibit faster early growth, greater biomass accumulation, and improved stress resilience compared to open-pollinated varieties.

Observable fruit damage by fruit fly

Through frequent visits in the experimental area, damages in the fruits of bitter gourd were observed such as oviposition marks in the fruits, discoloration or yellowing of young fruits, tunneling inside the infested fruits, premature fruit drop, and rotting or foul smell from fruits (Fig. 2-4).

Most fruits found in the experimental area especially before the application of treatments are exhibiting discoloration and a puncture mark. Apparently, these observable symptoms are critical for early detection and effective management of fruit fly infestations in cucurbits—including bitter gourd—thereby helping to mitigate yield losses and quality deterioration (Singh *et al.*, 2008).

Fig. 2. Discolored fruits with oviposition marks of fruit fly

Fig. 3. Cross-section of fruit fly infested bitter gourd with larvae and tunnel marks

Fig. 4. Cross-section of fruit fly infested bitter gourd with rotting flesh and foul smell

As infestation progressed, most discolored fruits when dissected had a number of larvae inside and a conspicuous tunnel marking in the flesh of the fruits.

Additionally, the study of Walia, Kaur, and Singh (2013) also found significant differences in symptom severity among various bitter gourd cultivars. Some cultivars exhibited a degree of natural tolerance or resistance, suggesting that genetic factors can influence the extent of damage inflicted by fruit flies.

The damage of fruit fly in this study was more prominently observed in the OPV variety compared to the Hybrid variety, maybe thanks to the inherent pest resistance.

The rotting of flesh in fruit flies infested fruits, often prematurely fallen, has been evident once cut. A certain unpleasant smell is also emanating from the fruit which can be attributed to the presence of bacteria in the bitter gourd's flesh as the oviposition mark can be an entry point for such microorganisms or as stated by Walia, Kaur, and Singh (2013) environmental conditions—particularly higher temperatures and humidity—can be factors that aggravated symptom development and accelerated the rate of tissue breakdown.

Unfortunately, data on the length of tunnel and other internal damages as well as larval count was not made due to limitations of time and proper equipment. These quantifications of the extent of internal damage can be correlated with the reduction in marketable yield that could have helped establish a damage threshold that could signal when economic loss becomes significant.

Bioassay trial

Bioassay is an experimental procedure that determines the concentration or potency of a substance by measuring its effect on living organisms or biological systems. Using a modified Potter Spray Tower model, collected fruit flies (n=10 per treatment) were applied with five varying dosages of Sesame Leaf Extract, recommended rate of commercial pesticide, and control (distilled water).

As shown in Table 1, accidental mortality was made during the setup of the tower for the T_1 that is why there is one mortality hence for the computation of percent (%) mortality, a corrected formula (Abbott, 1982) was used. The table showed positive results as T_6 and T_7 obtained 88.89% mortality though the use of commercial insecticide is still significantly higher (100%), a study conducted by Dougoud *et al.* (2019) had concluded that there is some evidence that homemade botanical insecticides could contribute to reducing losses in food production.

Pest incidence (No. of insects)

For the number of insects, during the harvesting (priming) of fruits the number of insects present in the plot was counted. This includes both larvae and adult insects in the plants. Data on the insect count was then recorded and analyzed and shown in Table 2.

There has been no significant result recorded between varieties in terms of the number of insects in all priming activities (Table 2). It can also be noted that during the first priming, no statistically significant difference was observed among the treatments employed. It is important to note that during this period most insects were not the target pest (fruit fly) as adult fruit flies may still be acclimatizing or propagating.

However, from second to third priming a statistically high significant difference was calculated explicitly exposing the high pest incidence in untreated plots (T_1) while treated plots (T_2-T_7) show similarly lower average pest incidence. Notable also that the higher number of insects was recorded outside of the cover net installed (T_1 & T_2). Reddy *et al.* (2011) in their study demonstrated that bitter gourd plots receiving scheduled insecticide applications experienced a significant reduction in key pest populations (especially fruit flies and other sucking pests) compared with untreated plots.

In terms of risk assessment, based on the data recorded and comparing it to the Pest Risk Matrix the highest number (average) of insects fall under Remotely catastrophic to a little Occasionally Major threat.

Table 1. Efficacy of sesame leaf ethanolic extract on fruit fly in a bioassay trial

Treatment	Number of survival	Number of insect mortality	Percent (%) mortality
T1 - Negative Control (Distilled water)	9 (90%)	1	10 (accidental mortality)
T2 – Positive Control (Commercial chemical insecticide)	0 (0%)	10	100
T3 – Pure Sesame Leaf Extract	3 (30%)	7	66.67
T4 – 75mg/gal Sesame Leaf Ethanolic Extract (baseline)	2 (20%)	8	77.78
T5 – 85mg/gal Sesame Leaf Ethanolic Extract	3 (30%)	7	66.67
T6 – 95mg/gal Sesame Leaf Ethanolic Extract	1 (10%)	9	88.89
T7 – 105mg/gal. Sesame Leaf Ethanolic Extract	1 (10%)	9	88.89

Table 2. Effect of different insecticides on the no. of insects of two bitter gourd varieties

Treatments	No. of insects		
	90 DAP (1st Priming)	97 DAP (2nd Priming)	104 DAP (3rd Priming)
Variety (a)			
V_1 – Native/ OPV	3.90	1.29	3.10
V_2 - Hybrid	4.48	1.81	2.14
ANOVA Result	ns	ns	ns
Pest control (b)			
T_1 – Negative Control (No application)	11	6^{a}	10^{a}
T_2 – Positive Control (Commercial Insecticide)	9	3^{ab}	6^{ab}
T_3 – Pure Sesame Leaf Extract	8	2^{b}	5^{b}
T_4 – 75mg/gal Sesame Leaf Ethanolic Extract (baseline)	5	2^{b}	5^{ab}
T_5 – 85mg/gal Sesame Leaf Ethanolic Extract	7	2^{b}	3^{b}
T_6 – 95mg/gal Sesame Leaf Ethanolic Extract	9	2^{b}	4^{b}
T_7 – 105mg/gal. Sesame Leaf Ethanolic Extract	10	4^{ab}	3^{b}
ANOVA Result	ns	**	**
C.V. (a) %	15.07	26.38	32.80
C.V. (b) %	58.82	50.18	41.87

Means with the same letter are not significantly different with each other using Tukey's HSD

Legend: *- Significant @ 5% **- Significant @ 1% ns- Not Significant

Table 3. Plant length of bitter gourd as affected by different insecticides at harvest

Treatments	Plant length (cm)
	104 DAP (3rd Priming)
Variety	
V_1 – Native/ OPV	207.93^{b}
V_2 - Hybrid	306.70^{a}
ANOVA Result	*
Pest control	
T_1 – Negative Control (No application)	555.40
T_2 – Positive Control (Commercial Insecticide)	592.43
T_3 – Pure Sesame Leaf Extract	511.27
T_4 – 75mg/gal Sesame Leaf Ethanolic Extract (baseline)	472.73
T_5 – 85mg/gal Sesame Leaf Ethanolic Extract	479.20
T_6 – 95mg/gal Sesame Leaf Ethanolic Extract	507.73
T_7 – 105mg/gal. Sesame Leaf Ethanolic Extract	483.67
ANOVA Result	ns
C.V. (a) %	16.44
C.V. (b) %	15.94

Means with the same letter are not significantly different with each other using Tukey's HSD

Legend: *- Significant @ 5% **- Significant @ 1% ns- Not Significant

Plant length at harvest

The plant height/length of the bitter gourd plants were taken at harvest or during the third priming. It was measured starting from the base up to the tip of the shoot of the primary stem.

According to Sahu and Sinha (2005), the average length of a bitter gourd vine should be at least 2.1 to 3.4 meters given the optimal growing conditions. In the study, the difference between treatments was not statistically significant however numerically; plants applied with commercial pesticide (T_2) recorded the highest mean length with 592.43 cm length. For the varietal difference in length, the data presented in Table 3 shows that OPV (V_1) has significantly shorter average length (207.93 cm) compared to Hybrid (V_2) with 306.70 cm vine length. This could possibly indicate that more fruits can be produced by the variety with longer length. Longer vines generally correlated with more vigorous plants, which may contribute to higher yield potential and better adaptation to certain growing practices. The variation in vine length has practical implications for cultivar selection depending on the intended cultivation practices and agro-climatic conditions (Sahu and Sinha, 2005).

Moreover, Reddy *et al.* (2011) explored in their study that insecticide-treated plots exhibited reduced pest pressure, allowing the plants to allocate more energy toward growth. This indirectly promoted better vegetative development, including longer and more robust vine growth. This would explain the longer average vine length in untreated plots (T1) since they are close to the plots treated with commercial insecticide (T2). Coincidentally, Reddy *et al.* (2011) also noted that inappropriate pesticide dosages or the use of highly phytotoxic chemicals can result in adverse effects. Over application may lead to phytotoxicity, which in some cases can stunt vine growth. This underscores the importance of applying pesticides at recommended levels to support plant health rather than hinder it as in the case of plots applied with 105mg/gal. Sesame Leaf Ethanolic Extract (T_7).

Fruit weight

Fruit weight was gathered and analyzed (Table 4) revealing no significant difference among treatment means for the first and second priming when comparing the pesticidal effect but a statistically significant (5%) difference among treatments was calculated from fruits harvested during the third priming. For first and second priming, the fruits harvested under plots applied with 95mg/gal Sesame Leaf Ethanolic Extract (T_6) and 105mg/gal. Sesame Leaf Ethanolic Extract (T_7) recorded the highest average fruit weight (51.84g & 81.40g respectively) compared to the other treatments.

Table 4. Effect of different insecticides on the weight of fruits of two bitter gourd varieties

Treatments	Weight of fruits (g)		
	90 DAP (1st Priming)	97 DAP (2nd Priming)	104 DAP (3rd Priming)
Variety (a)			
V_1 – Native/ OPV	26.34^b	25.21^b	39.87^b
V_2 - Hybrid	66.00^a	126.38^a	102.01^a
ANOVA Result	**	*	*
Pest control (b)			
T_1 – Negative Control (No application)	38.34	64.43	63.50^b
T_2 – Positive Control (Commercial Insecticide)	42.46	78.77	76.88^a
T_3 – Pure Sesame Leaf Extract	47.20	75.65	71.55^{ab}
T_4 – 75mg/gal Sesame Leaf Ethanolic Extract (baseline)	46.88	75.23	71.57^{ab}
T_5 – 85mg/gal Sesame Leaf Ethanolic Extract	50.23	75.97	70.76^{ab}
T_6 – 95mg/gal Sesame Leaf Ethanolic Extract	51.84	79.10	70.93^{ab}
T_7 – 105mg/gal. Sesame Leaf Ethanolic Extract	46.27	81.40	71.39^{ab}
ANOVA Result	ns	ns	*
C.V. (a) %	13.26	72.81	42.89
C.V. (b) %	23.68	11.94	7.06

Means with the same letter are not significantly different with each other using Tukey's HSD

Legend: *- Significant @ 5% **- Significant @ 1% ns- Not Significant

On the third priming, those plots treated with commercial (synthetic) pesticide (T_2) recorded the highest mean fruit weight of 76.88g which was statistically the same with plants applied with pure sesame leaf extract (T_3) and sesame leaf ethanolic extract (T_4-T_7) while plants in the untreated plots recorded the lowest average fruit weight throughout. Effective pesticide application helps in reducing pest infestations—especially from fruit flies and sucking insects—that would otherwise cause physical damage (e.g., punctures, larval tunneling) and stress the plants. With reduced pest pressure, bitter gourd plants can allocate more of their metabolic resources toward fruit development, resulting in heavier fruits. For example, in the study by Reddy *et al.* (2011), insecticide-treated plots not only experienced lower pest populations but also showed an overall improvement in plant vigor and yield components, including increased fruit weight.

For variety, a highly significant difference (1%) was obtained from fruits harvested during the first priming wherein Hybrid (V_2) recorded higher mean fruit weight than OPV (V_1) as seen in Table 4. For the second and third priming, significant difference at 5% has been calculated and it still follows the same trend where Hybrid (V_2) is higher than OPV (V_1). As significant variability in fruit weight among bitter gourd cultivars can be achieved because of heterosis. Reported values indicated that the fruit weight could range, for example, from around 150 grams to 300 grams, depending on the genetic material and growing conditions (Singh *et al.*, 2002).

Table 5. Effect of different insecticides on the no. of fruits of two bitter gourd varieties

Treatments	No. of fruits		
	90 DAP (1st Priming)	97 DAP (2nd Priming)	104 DAP (3rd Priming)
Variety			
V_1 – Native/ OPV	22.52	19.86	24.52
V_2 - Hybrid	11.62	19.33	24.14
ANOVA Result	ns	ns	ns
Pest control			
T_1 – Negative Control (No application)	40.67^{ab}	37.00	49.67
T_2 – Positive Control (Commercial Insecticide)	48.67^{a}	38.33	51.00
T_3 – Pure Sesame Leaf Extract	32.00^{ab}	39.00	48.67
T_4 – 75mg/gal Sesame Leaf Ethanolic Extract (baseline)	28.00^{b}	39.67	47.33
T_5 – 85mg/gal Sesame Leaf Ethanolic Extract	31.33^{b}	41.67	50.00
T_6 – 95mg/gal Sesame Leaf Ethanolic Extract	28.00^{b}	41.67	49.67
T_7 – 105mg/gal. Sesame Leaf Ethanolic Extract	30.33^{b}	37.00	44.33
ANOVA Result	*	ns	ns
C.V. (a) %	48.26	15.02	7.79
C.V. (b) %	27.38	11.31	9.44

Means with the same letter are not significantly different with each other using Tukey's HSD

Legend: *- Significant @ 5% **- Significant @ 1% ns- Not Significant

Fruit yield per plot

The data on the fruit yield was gathered three (3) times following the priming schedule. Data gathered were the number of fruits per sample plant.

From the data presented in Table 5, apparently no statistical difference was revealed for varieties although numerically more fruits were harvested from the OPV variety (V_1) compared to the Hybrid (V2). No significant difference was also obtained for harvested fruits during second and third priming. However, for the first priming, statistically significant (5%) result was recorded stating that plots under positive control (T_2) had higher fruit yield compared to plots treated with Sesame Leaf Ethanolic Extract (T_4-T_7) but is statistically the same as plots treated with Pure Sesame Leaf Extract as well as the untreated (T_1) plots although T_4-T_7 is also statistically the same as those under T_3 and T_1.

These results were also as reported by Prakash *et al.* (2013) in their study which states that the plots treated with synthetic pesticides recorded the highest yields, mainly due to enhanced protection from pests. Botanical treatments also improved yield and quality over untreated controls, though not to the same extent as the synthetic options. Untreated plants suffered from higher pest damage, which negatively affected both yield and fruit quality.

Table 6. Effect of different insecticides on the number of marketable fruits of two bitter gourd varieties

Treatments	No. of marketable fruits		
	90 DAP (1st Priming)	97 DAP (2nd Priming)	104 DAP (3rd Priming)
Variety			
V_1 – Native/ OPV	12.38^a	14.19	17.67
V_2 - Hybrid	4.71^b	13.62	17.00
ANOVA Result	*	ns	ns
Pest control			
T_1 – Negative Control (No application)	10.67^{ab}	8.67^b	12.33^b
T_2 – Positive Control (Commercial Insecticide)	14.33^a	13.33^{ab}	19.67^a
T_3 – Pure Sesame Leaf Extract	9.17^b	14.00^{ab}	18.17^a
T_4 – 75mg/gal Sesame Leaf Ethanolic Extract (baseline)	6.17^b	15.33^a	16.67^{ab}
T_5 – 85mg/gal Sesame Leaf Ethanolic Extract	6.83^b	16.50^a	18.17^a
T_6 – 95mg/gal Sesame Leaf Ethanolic Extract	4.83^b	14.83^a	19.83^a
T_7 – 105mg/gal. Sesame Leaf Ethanolic Extract	7.83^b	14.67^a	16.50^{ab}
ANOVA Result	*	**	**
C.V. (a) %	57.34	26.42	6.23
C.V. (b) %	50.57	17.11	12.34

Means with the same letter are not significantly different with each other using Tukey's HSD

Legend: *- Significant @ 5% **- Significant @ 1% ns- Not Significant

Table 7. Effect of different insecticides on the number of non-marketable fruits of two bitter gourd varieties

Treatments	No. of non-marketable fruits		
	90 DAP (1st Priming)	97 DAP (2nd Priming)	104 DAP (3rd Priming)
Variety			
V_1 – Native/ OPV	10.14^a	5.67	6.86
V_2 - Hybrid	6.90^b	5.71	7.14
ANOVA Result	*	ns	ns
Pest control			
T_1 – Negative Control (No application)	9.67	9.83^a	12.50^a
T_2 – Positive Control (Commercial Insecticide)	10.00	5.83^b	5.83^b
T_3 – Pure Sesame Leaf Extract	6.83	5.50^b	6.17^b
T_4 – 75mg/gal Sesame Leaf Ethanolic Extract (baseline)	7.83	4.50^b	7.00^b
T_5 – 85mg/gal Sesame Leaf Ethanolic Extract	8.83	4.33^b	6.83^b
T_6 – 95mg/gal Sesame Leaf Ethanolic Extract	9.17	6.00^b	5.00^b
T_7 – 105mg/gal. Sesame Leaf Ethanolic Extract	7.33	3.83^b	5.67^b
ANOVA Result	ns	**	**
C.V. (a) %	15.78	47.04	13.77
C.V. (b) %	37.55	25.80	22.26

Means with the same letter are not significantly different with each other using Tukey's HSD

Legend: *- Significant @ 5% **- Significant @ 1% ns- Not Significant

To further substantiate the results of the study, the harvested fruits were then classified base on external appearance as to the marketability of the produce. Data on the number of marketable and non-marketable fruits was recorded and analyze to produce the following results shown in Table 6 and Table 7.

For the number of marketable fruits per plant, the statistical difference between varieties was only recorded during the first priming (5%) where more marketable fruits were harvested in OPV plants (12.38) than the hybrid variety (4.71). Variation in the marketable fruits harvested in terms of pest control had recorded significant results at 5% level of significance for first priming while at 1% level of significance for the second and third priming. From the data presented in Table 6, more marketable fruits had been harvested in treatments outside the insect net (T_1 and T_2) for the first priming maybe because the effect of the treatments is still weak during the harvesting since in the second and third priming more marketable fruits had been gathered inside (T_3 – T_7) compared to the plants under T_1. Singh *et al.* (2015) also recorded in their study that plants treated with the botanical extract produced a significantly higher percentage of fruits that met quality standards. They further stated that the botanical pesticide reduced the severity of pest infestations (e.g., damage from fruit flies), which in turn safeguarded the fruits against defects.

Shown in Table 7 is the data on the non-marketable fruits harvested in the experimental area for three priming. No statistical difference was calculated among varieties for the second and third priming however for the first priming, a significant variation (5%) was calculated revealing that more non-marketable fruits was harvested in plots planted with OPV (V_1) with an average count of 10.14 while hybrid variety (V_2) recorded a mean of 6.90 fruits.

Table 8. Project yield per hectare of bitter gourd applied with different pest control measures

Treatments	Projected yield (KG/HA) (1st – 3rd Priming)
Variety	
V_1 – Native/ OPV	764.24^b
V_2 - Hybrid	2425.56^a
ANOVA Result	*
Pest control	
T_1 – Negative Control (No application)	1385.60^b
T_2 – Positive Control (Commercial Insecticide)	1650.88^a
T_3 – Pure Sesame Leaf Extract	1619.99^a
T_4 – 75mg/gal Sesame Leaf Ethanolic Extract (baseline)	1614.03^a
T_5 – 85mg/gal Sesame Leaf Ethanolic Extract	1641.34^a
T_6 – 95mg/gal Sesame Leaf Ethanolic Extract	1634.54^a
T_7 – 105mg/gal. Sesame Leaf Ethanolic Extract	1617.93^a
ANOVA Result	**
C.V. (a) %	39.09
C.V. (b) %	5.44

Means with the same letter are not significantly different with each other using Tukey's HSD

Legend: *- Significant @ 5% **- Significant @ 1% ns- Not Significant

Table 9. Cost and return analysis of bitter gourd applied with different pest control measures (Variety 1)

Particulars	T1	T2	T3	T4	T5	T6	T7
Production Costs, in Php							
Seeds	9000	9000	9000	9000	9000	9000	9000
Fertilizer	11200	11200	11200	11200	11200	11200	11200
Labor	6000	6000	6000	6000	6000	6000	6000
Land preparation (tractor)	2500	2500	2500	2500	2500	2500	2500
Harvesting	25200	25200	25200	25200	25200	25200	25200
Added Costs, in Php							
Commercial Pesticide	-	2400	-	-	-	-	-
SLEE	-	-	2200	2300	2300	2300	2300
Labor (Spraying)	-	840	840	840	840	840	840
Total Cost of Production, Php	53900	57140	56940	57040	57040	57040	57040
Average Yield per hectare, kg	635.00	825.53	805.36	791.67	786.47	777.00	728.64
Price/kg	90	90	90	90	90	90	90
Gross Income, Php	57150	74298	72482	71250	70782	69930	65578
Net Income, Php	3250	17158	15542	14210	13742	12890	8538
ROI, %	6.03	30.03	27.30	24.91	24.09	22.60	14.97
MBCR, Php	-	5.30	5.11	4.53	4.38	4.11	2.72

Coincidentally, no statistically significant difference was recorded during the first priming in terms of data on the effect of pest control measures on the number of non-marketable fruits but during the second and third priming a highly significant statistical difference was calculated revealing that the plots with no pest control measure recorded a consistently high number of non-marketable fruits compared to those applied with insecticide whether commercial (synthetic) or botanical pesticide (PSLE & SLEE). Similarly, based on the data reported by Sharma and Kumar (2019), bitter gourd plants treated with neem-based formulations showed a notable improvement in fruit quality. In their study, untreated plants produced fruits that were marketable at a rate of about 60%, whereas the plants treated with the botanical pesticide achieved approximately an 85% marketable yield. This difference of roughly 25 percentage points suggests that the neem-based treatment substantially reduced pest damage, leading to a higher proportion of fruits that met commercial quality standards.

In Table 8, data shows that highly significant results (1%) obtained from using different treatments for pest control. It is noticeable that the use of commercial pesticide (T_2) could possibly yield a mean value of 1650.88 kilograms which is the highest yielder and is significantly different from estimated yield from plots that is not treated (T_1) with only 1385.60 kg per hectare. However, estimated yield for T_2 is statistically the same as those applied with Pure sesame leaf extract (T_3) and Sesame Leaf Ethanolic Extract (T_4-T_7). The result may infer that the application of pest control measures can significantly affect production of bitter gourd. The findings are subsequently supported by the research of Hernandez and Ramirez (2010) which revealed that proper pesticide management reduced insect-induced fruit damage and premature fruit drop. Consequently, optimal treatments led to enhanced fruit yield. The findings suggest that minimizing pest-associated stresses through chemical control can translate into a higher number of fruits per plot, benefiting overall crop productivity.

Table 10. Cost and return analysis of bitter gourd applied with different pest control measures (Variety 2)

Particulars	T1	T2	T3	T4	T5	T6	T7
Production Costs, in Php							
Seeds	20833	20833	20833	20833	20833	20833	20833
Fertilizer	11200	11200	11200	11200	11200	11200	11200
Labor	6000	6000	6000	6000	6000	6000	6000
Land preparation (tractor)	2500	2500	2500	2500	2500	2500	2500
Harvesting	25200	25200	25200	25200	25200	25200	25200
Added Costs							
Commercial Pesticide	-	2400	-	-	-	-	-
SLEE	-	-	2200	2300	2300	2300	2300
Labor (Spraying)	-	840	840	840	840	840	840
Total Cost of Production, Php	65733	68973	68773	68873	68873	68873	68873
Yield per hectare, kg	2136.19	2476.22	2434.61	2436.39	2496.19	2492.08	2507.22
Price/kg	120	120	120	120	120	120	120
Gross Income, Php	256343	297146	292153	292367	299543	299050	300866
Net Income, Php	190610	228173	223380	223494	230670	230177	231993
ROI, %	289.98	330.82	324.81	324.50	334.92	334.20	336.84
MBCR, Php	-	70.42	73.48	71.18	73.46	73.30	73.88

Economic data

The economic analysis of the treatments employed were calculated using simple cost and return analysis featuring the production costs required for all treatments, added costs for treatments with additional inputs, gross and net income as well as return-on-investment and marginal benefit cost ratio.

Shown in Table 9 is the simple cost and return analysis of bitter gourd production utilizing different treatments for Open Pollinated variety (V_1). The table revealed that at a price of 90 pesos per kilogram (prevailing price during the harvesting period) of bitter gourd fruits, the highest return on investment could be garnered by using T_2 (commercial pesticide) with 30.03%. It can also be noted that for every 1-peso investment (marginal cost), the highest marginal benefit can be obtained by using commercial pesticide (T_2) with 5.30 pesos, followed by Pure sesame leaf extract (T_3) with 5.11 pesos, 75mg/gal Sesame Leaf Ethanolic Extract (T_4) with 4.53 pesos, 85mg/gal Sesame Leaf Ethanolic Extract (T_5) with 4.38 pesos, 95mg/gal Sesame Leaf Ethanolic Extract (T_6) with 4.11 pesos and 105mg/gal. Sesame Leaf Ethanolic Extract (T_7) with 2.72 pesos.

These shows that while the long-term environmental and health benefits of botanical options were acknowledged by many authors, it can also be noted that, due to variability in efficacy and the need for more frequent reapplications, the immediate economic benefits (e.g., yield improvements relative to the input costs) were sometimes lower than those achieved with synthetic pesticides (Mishra and Singh, 2012). Mulei and Gichuru (2018) also stated in their study that these factors increased the cost per unit yield compared to synthetic pesticides, which tend to offer longer-lasting suppression of pest populations and, therefore, a more favorable short-term economic return.

For the hybrid variety (V_2), Table 10 revealed that the utilization of 105mg/gal. Sesame Leaf Ethanolic Extract (T_7) could help attain the highest return on investment (336.84%) among other treatments although plots treated with 85mg/gal Sesame Leaf Ethanolic Extract (T_5) and 95mg/gal Sesame Leaf Ethanolic Extract (T_6) also yielded high ROI with 334.92% and 334.20% respectively. Meanwhile, taking a look at the marginal cost benefit ratio of the treatments, the plots treated with 105mg/gal. Sesame Leaf Ethanolic Extract (T_7) could give the highest value for money with 73.88 pesos for every 1-peso investment. In comparison, commercial pesticide (T_2) would only yield 70.42 pesos for every 1-peso investment (marginal costs). In research conducted to compare synthetic and botanical pesticide by Mulei and Gichuru (2018), the authors found that while synthetic pesticides sometimes offered rapid pest knockdown, the lower input costs and reduced environmental impact of botanical pesticides could yield comparable or even favorable economic returns, particularly for small-scale or organic producers.

Conclusion

Based on the study findings, it can be concluded that (1) Hybrid varieties can produce better fruits based on agronomic characteristics measured in the study compared to the open pollinated variety. (2) The number of fruit fly mortality in the bioassay testing was higher the more concentrated the dosage. (3) Varied responses can be collected from the study in terms of number of fruits, fruit weight, etc. but mostly the plots applied with synthetic commercially available pesticide recorded the highest numbers. (4) Fruit fly introduced were not seen again during the third and final priming which can be inferred as a result of the application of treatments and can be supported by the result of preliminary testing (bioassay) of SLEE that fruit flies sprayed with it typically dies at 22 seconds after. Lastly, (5) Economically, T_7 (105ml Sesame Leaf Ethanolic Extract*)* recorded highest ROI and MBCR for Hybrid (V_2) of bitter gourd while T2 (Commercial Pesticide) had highest ROI and MBCR for Open pollinated variety (V_1).

Recommendations

It is therefore recommended that utilization of Pure Sesame Extract may give bitter gourd plants added nutrients thus improving its agronomic characteristics. While utilization of Sesame Leaf Ethanolic Extract (SLEE) even at baseline quantity can help eradicate fruit fly in bitter gourd. The use of 105ml Sesame Leaf Ethanolic Extract will yield best result. Sesame Leaf Ethanolic Extract at 105ml/l can be used to regulate insect pests (fruit fly) especially for Hybrid variety of bitter gourd while Commercial Pesticide (synthetic) for Open pollinated variety. Further study on its effect during wet season, as well as the effect of SLEE and PSE in a fully open-field setting should be conducted.

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