Efficacy Testing of Nuclear Polyhedrosis Virus (NPV) Against Fall Army Worm [Spodoptera Frugiperda (J.E. Smith)]

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Abstract
Fall Army Worm (Spodoptera frugiperda) is identified as one of the most destructive insect pests of corn, affecting corn production in the Philippines, particularly in Bukidnon. The rapid spread of Fall Army Worm and its increasing resistance to synthetic insecticides have created serious concerns about crop losses, environmental safety, and sustainable pest management. This study aims to (1) determine the most effective concentration of NPV for the control of FAW, and (2) assess the extent of damage on corn as affected by different NPV concentrations. It was conducted at the Northern Mindanao Agricultural Crops and Livestock Research Complex (NMACLRC), Dalwangan, Malaybalay City, Bukidnon. The Results confirmed that NPV at a high concentration of 21 larvae/16 L of water recorded the highest larval mortality and the lowest leaf damage rating, while the control treatment recorded the lowest mortality and the highest damage rating, indicating severe damage. The study concluded that NPV strains applied at higher concentrations are effective, environmentally safe, and sustainable biological control agents for managing fall army worm in corn production systems in Bukidnon.

Keywords: Fall Army Worm, nuclear polyhedrosis virus, biological control agents, sustainable pest management

1. INTRODUCTION

Corn (Zea mays) is one of the economically important staple food crops in the Philippines, following rice in its agricultural resource utilization. This is also a major commodity for livestock and manufacturing, and is used as animal feed and in industrial applications.

Over the past few years, fall army worm (Spodoptera frugiperda) or FAW has become one of the new but major pests in the Philippines. On June 20, 2019, the first possible case of FAW was recorded in Piat, Cagayan (Bureau of Plant Industry, 2020). As of October 2020, the incidence rate was 17.22% in Northern Mindanao due to the affected 1,626.71 hectares (Bureau of Plant Industry, 2020).

The rapid spread, adaptability, and resistance to chemical pesticides are rendering conventional tear-out-and-spray control methods ineffective and environmentally detrimental.

The occurrence of FAW presents sustainability challenges for global agriculture as it destroys the most important crops in the world, such as corn, rice, sorghum, and cotton. It has spread faster than chemical pesticides can control and is quickly developing resistance to most available chemicals, making sustainable controls all the more necessary.

Exploring alternative pest management approaches such as biological control agents is essential. Among these, nuclear polyhedrosis virus (NPV) is an attractive candidate for use as a biological pest control agent which is an extremely specific and safe biocontrol agents targeting only the desired group of insects while not affecting human, animal, or other non-target species.

International studies in both laboratory and field conditions in countries such as Brazil, India, and the U.S. point to NPV's promising potential as a bio-insecticide (Hussain et al., 2021). One important thing to consider is the interactions between NPV and other biological agents. Bogema et al. (2020) demonstrated that the addition of a parasitic insect to a post-viral infection increases mortality rates of FAW populations.

However, despite its global success, there is no evaluation of NPV efficacy against FAW in the Philippines, where climate and agroecological conditions could influence the outcomes. Targeting this region for research could provide further validation for NPV scalability and refine its application protocols for tropical environments. This gap may help NPV potentially provide a long-term and sustainable management strategy to alleviate the economic and ecological damage caused by this invasive pest.

Hence, this research aims to address these gaps by assessing the potential of NPV as a biological control agent for FAW in Bukidnon.

Objectives:

This study aims to:

1. determine the most effective concentration of NPV for the control of FAW; and
2. assess the extent of damage on corn as affected by different NPV concentrations.

Location of the study:

The study was conducted at Northern Mindanao Agricultural Crops and Livestock Research Complex (NMACLRC), Dalwangan, Malaybalay City, Bukidnon, from April to July 2025.

2. REVIEW OF RELATED LITERATURE

Corn is the third largest area crop after rice and coconut in the Philippines, making the country the fourth largest corn producer in Asia. Corn is also an important source of livelihood for around 600,000 farmers in the Philippines (Prasanna et al., 2021). This is a multi-purpose crop that is a foundational food, livestock feed, and a raw material for several industrial goods (Bureau of Plant Industry, 2020).

Bukidnon is known in Mindanao as the “Food Basket of the South,” where corn is one of the foremost agricultural products. The Philippine Statistics Authority identified this region of the Philippines as one of the main producers of yellow corn in the country, contributing major supplies of corn to the Philippines (PSA, 2020). Its large areas of fertile land and favorable climate conditions make the province an ideal area for growing corn. Corn farming in Bukidnon is a primary source of livelihood for thousands of farmers, and it is a significant supplier of corn to both local and national markets (Prasanna et al., 2021).

Nonetheless, corn production in the province of Bukidnon is threatened by a number of pests, most notably FAW. This insect pest was first detected in the Philippines in 2019 (Bureau of Plant Industry, 2020) and has drastically reduced corn yields in Bukidnon and other areas. Corn is highly susceptible to infestations by various pests, which can significantly impact the overall yield and value of the crop.

FAW is extremely invasive and eats a wide range of crops including corn, rice, sorghum, sugarcane, wheat, millet, and other plants - 353 larval host plants have been recorded. FAW larvae can cause extensive crop damage, resulting in reduced yields and major economic losses. It mainly eats the leaves of corn but can also attack the ears, although these are not (normally) eaten by people (FAO, 2017). It feeds on corn plants, damaging them from the early vegetative stages and throughout the period before a plant bears fruit, causing significant loss (Valdez, 2023). Furthermore, its infestations have been particularly harmful in Bukidnon, a major corn-producing province. As a result, its outbreak has already led to significant yield losses in the province, putting additional lives at risk for those whose livelihoods depend on farming corn (Bureau of Plant Industry, 2020).

In Bukidnon, the infestation of FAW underscores the urgent need for effective pest management strategies. Since corn is important economically and agriculturally, finding sustainable solutions in controlling this pest can aid in ensuring food security and the farmers' livelihoods in the province. In addition, biological control agents, such as Nuclear Polyhedrosis Virus (NPV), have also emerged as a potential tool for most effectively settling damages caused by FAW in an eco-friendly manner.

Baculoviridae is a family of double-stranded DNA viruses, a group of which are endearingly called Nuclear Polyhedrosis Virus (NPV). NPVs are fastidious pathogens that occur in a wide variety of insect host species, especially, but not exclusively, lepidopterans. Moreover, these beneficial insects are considered valuable agents in biological pest control due to their environmental safety, host specificity, and ability to reduce pest populations. NPVs are known to mainly infect larval forms, where they develop into a disease called polyhedrosis, in which the host's body liquefies after the insect dies (Hernandez-Crespo et al., 2001).

Due to their host-specificity and environmental safety, NPVs are valuable tools for sustainable pest management. Although NPV strains have been characterized internationally, studies in the Philippines and Bukidnon are essential to tailor their use. Local indigenous isolates, like Spodoptera frugiperda NPV, can be the most useful tools against the Bukidnon's valuable corn industry.

3. METHODOLOGY

3.1. Experimental Design and Treatments

The study was conducted using a Randomized Complete Block Design (RCBD) with four (4) treatments replicated three (3) times. Analysis of variance (ANOVA) was carried out to determine the significant differences among treatments using the Statistical Tool for Agricultural Research (STAR).

Treatments

T1 – Control (water only)
T2 – Low concentration (7 larvae/16L of water)
T3 – Medium concentration (14 larvae/16L of water)
T4 – High concentration (21 larvae/16L of water)

3.2. Establishment of Experimental Setup

Soil was placed into the polyethylene bags measuring about 5 × 8 inches. A total of 60 bags was prepared for the experiment. These were arranged according to the layout to ensure unbiased treatment distribution. To prevent pest infestation and cross-contamination during the study, protective nets were installed, with one net covering the corn plants in five polybags (Figure 1).

Figure 1. Field set up of the study

3.3. Fertilizer Application

Each pot was fertilized by incorporating one tablespoon of complete fertilizer (14-14-14 NPK) into the soil prior to planting. Application of urea was done at 15 days after seedling emergence. One tablespoon of urea was applied to each plant.

3.4. Sowing of the seeds

Three USM Var 10 - OPV corn seeds were sown in each pot.

3.5. Care and Maintenance

All pots were watered regularly to maintain the soil moisture needed for seed germination.

Prior to fertilization, thinning was done, leaving only one healthy and vigorous corn plant per pot to reduce intraspecific competition.

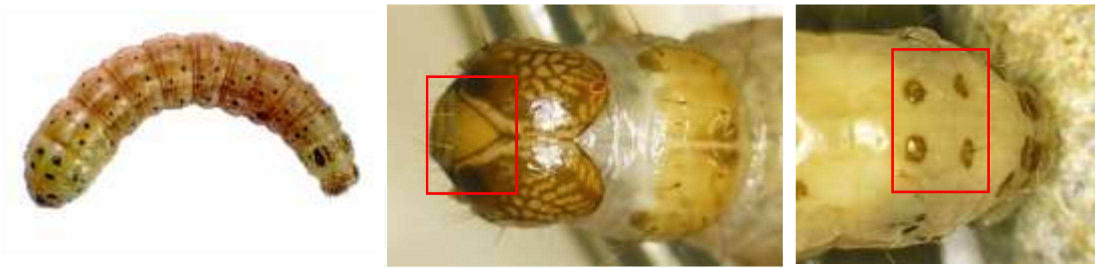
3.6. Collection and Rearing of Spodoptera frugiperda

Egg masses of FAW were carefully collected from corn fields to obtain a uniform population of larvae for laboratory rearing and experimental use. The collected egg masses were placed in clean mesh-covered rearing jars under room conditions for incubation. Upon emergence, the first instar larvae were carefully transferred using a fine camel hair brush into clean mesh-covered rearing jars to minimize injury and escape.

Fresh corn leaves were provided daily as larval food. The leaves were collected from healthy corn plants, washed with clean water to remove dust and contaminants, air-dried, and cut into suitable sizes before feeding. Uneaten and dried leaves were removed regularly and replaced with fresh leaves to maintain adequate nutrition and cleanliness inside the rearing containers. Dead larvae, fecal materials, and spoiled food were immediately removed to prevent microbial contamination and disease development within the culture.

The reared specimens were morphologically identified and confirmed as Fall Army Worm, based on their distinct diagnostic characteristics. Identification was established through the presence of an inverted “Y”-shaped marking on the head capsule and the characteristic arrangement of four dark spots forming a square pattern on the eighth abdominal segment (Figure 2).

To minimize cannibalism, which is common among FAW larvae, regular sorting was conducted by separating smaller larvae from larger and more aggressive individuals. Larvae were maintained individually or in small groups whenever necessary to reduce larval predation. Continuous feeding and monitoring were performed until the larvae reached the third instar stage, which served as the test insects for the study.



a b c

Figure 2. Magnified images of Spodoptera frugiperda larva (3.8 cm in length) showing:

(a) larval habitus, (b) head, line forming inverted Y shape epicranial suture, and

(c) posterior dorsal view showing pinacula forming a square on the eighth tergum

3.7. Preparation of NPV Suspension

The preserved NPV-infected larvae of FAW from the Regional Crop Protection Center (RCPC) -10 were carefully counted according to the required number of larvae per treatment (Figure 3). For initial suspension preparation, each infected larva was individually soaked in distilled water at a ratio of 2 mL per larva inside clean 500 mL polyethylene (PET) bottles. All containers were tightly sealed, labeled, and stored in a refrigerator for 24 hours. After a 24-hour of incubation period, the softened larvae were thoroughly macerated to ensure complete disruption of tissues and release of occlusion bodies. The resulting homogenate was then filtered using a fine mesh to remove cuticular debris and undigested tissues, producing a viral suspension.

The filtered NPV suspension was transferred into a clean, sterile container and prepared into different concentrations per treatment using tap water as the diluent. For the low concentration treatment, 1.75 mL of the stock NPV suspension was measured and added to tap water, and the total volume was adjusted to 2.0 liters. For the medium concentration treatment, 3.5 mL of the stock suspension was similarly measured and diluted with tap water to reach a final volume of 2.0 liters. For the high concentration treatment, 5.25 mL of the stock suspension was measured and likewise diluted with tap water to a final volume of 2.0 liters.

Each treatment solution was thoroughly mixed to ensure homogeneous distribution of viral particles throughout the suspension.

a b c

Figure 3. Magnified images of NPV-infected Spodoptera frugiperda larva (3.8 cm in length) showing: (a) larval habitus, (b) head, line forming inverted Y shape epicranial suture, (c) posterior dorsal view showing pinacula forming a square on the eighth tergum

3.8. Treatment Application

One (1) third instar FAW larva was placed gently on the whorl of each 30-day-old corn plant using a fine brush to avoid injury (Figure 3). After larvae placement, each corn plant was uniformly sprayed with 10ml suspension containing the assigned NPV concentration using a hand sprayer. Spraying was done directly on the entire corn plant, with particular attention given to the whorl and leaf surfaces where the larvae were actively feeding. The control plants were sprayed with water only instead of NPV suspension, and the same procedure was followed, including larval placement, spraying method, application volume, and timing of application, were carried out similarly with the treated plants.

Applications were applied in the late afternoon, approximately 4:00 PM, since extreme heat and direct sunlight can damage viral particles, making them less effective.

3.9. Data Gathered

3.9a. Number of dead larvae at 3, 6, 9, and 12 days after treatment application per treatment. The percent mortality was computed using the formula:

$$\% \text{ Mortality} = \frac{\text{Number of dead larvae}}{\text{Total number of larvae introduced}} \times 100$$

3.9b. Damage rating at 3, 6, 9, and 12 days after treatment application per treatment (Table 1). The percent severity damage was computed using the formula:

$$\% \text{ Severity Damage} = \frac{\sum (n \times v)}{N \times Z} \times 100$$

I = attack intensity
Z = Highest score (score) (9)
N = number of plants observed
n = number of plants that have a “v” value (crop damage)
v = the value (score) of crop damage based on the criteria in Table 4

Table 1. The fall army worm leaf damage rating scale from 1 to 9 (Prasanna, 2018)

SCORE	DESCRIPTION
1	No visible damage
2	Few short holes on several leaves
3	Short holes on several leaves
4	Several leaves with short holes and a few long lesions
5	Several holes with long lesions
6	Several leaves with lesions less than 2.5 cm
7	Long lesions common on one half of the leaves
8	Long lesions are common on one-half to two-thirds of the leaves
9	Severe damage; most leaves with long lesions and complete defoliation

4. RESULTS AND DISCUSSIONS

The findings are presented according to the sequence of the specific problems of the study stated in Chapter 1.

Table 2. Percent mortality of FAW as affected by different NPV concentrations at 3 to 12 days after application

Treatment	Mean FAW Mortality Days After Application			
	3	6	9	12
T1 - Control (water only)	0.00[b]	0.00[c]	6.67[c]	13.33[c]
T2 - Low concentration (7 larvae/16L of water)	26.67[a]	46.67[b]	60.00[b]	60.00[b]
T3 - Medium concentration (14 larvae/16L of water)	26.67[a]	53.33[ab]	73.33[ab]	73.33[a]
T4 - High concentration (21 larvae/16L of water)	40.00[a]	66.67[a]	80.00[a]	80.00[a]
F-test	**	**	**	**
CV %	37.80	17.89	13.55	11.76

Means with the same letter in a column are not significantly different at 5% level using Tukey's HSD Test.
**- highly significant

The results showed that strain concentration significantly influenced the mortality of FAW larvae. The results revealed that larval mortality varied depending on the concentration applied. Generally, mortality was highest during the earlier observation periods, particularly from 3 to 6 days after application (DAA), and gradually declined toward 12 DAA. The results suggest that NPV infection was most active during the early stages after application, which is consistent with the biological mode of action of baculoviruses that require ingestion, replication, and systemic infection before visible mortality occurs. According to Lacey and Shapiro-Ilan (2015), microbial insecticides such as baculoviruses normally exhibit delayed pathogenicity because viral replication inside the insect host requires several days before death occurs. This explains why mortality was more pronounced during the early to middle observation periods rather than immediately after application.

The results showed that the highest percent mortality at 3 DAA was recorded in T4 with 40.00%, followed by T2 and T3 with 26.67%, and T1 with no mortality observed. Statistical analysis showed that T2, T3, and T4 were not significantly different from each other but were all significantly higher than T1. This indicates that NPV strains were able to cause FAW mortality as early as 3 DAA, although differences between concentrations were minimal at this stage.

At 6 DAA, still no mortality was recorded in the control treatment (T1). The highest mortality was observed in treatment T4 with 66.67%, followed by T3 with 53.33%, while T2 obtained 46.67% mortality. The statistical analysis also shows that T4, T3, and T2 were not significantly different from each other, significantly different from untreated control (T1).

According to Harrison and Hoover (2012), field applications of baculoviruses often exhibit variable efficacy due to environmental degradation and inconsistent ingestion by insect populations.

While at 9 DAA, T4 recorded the highest mean mortality of 80.00%, followed by T3 with 73.33% and T2 with 60.00%, while the control treatment (T1) had the lowest mortality of only 6.67%. This result confirms that the application of NPV significantly enhanced larval mortality compared with the untreated control. Statistical analysis showed significant differences, indicating that strain concentration significantly influences mortality under field conditions.

Furthermore, at 12 DAA, the results showed that larval mortality remained high in T4, indicating the sustained effectiveness of the virus against FAW larvae over time. The control treatment (T1) recorded only 13.33%, which may be attributed to natural causes and environmental factors rather than viral infection. In contrast, mortality in the NPV-treated plots ranged from 60.00% to 80.00%, demonstrating the pathogenic effect of the virus under field conditions. T4 recorded the highest mean mortality of 80.00%, followed by T3 with 73.33% and T2 with 60.00%. Treatments were statistically similar to each other but significantly higher than the control treatment.

These findings clearly indicate that increasing viral concentration significantly enhanced infection success and larval mortality. Higher concentrations likely increased the number of viral occlusion bodies ingested by the larvae, resulting in faster viral replication and more severe systemic infection. The concentration-dependent response observed in the study agrees with the findings of the Department of Agriculture–BAR (2021), which emphasized that higher viral concentrations improve infection efficiency and increase biological control success under actual field conditions. Similarly, Yasin et al. (2020) reported that greater viral inoculum density accelerates infection progression and increases mortality because larvae ingest larger quantities of viral particles. Baculoviruses infect insect hosts primarily through ingestion of contaminated plant material containing viral occlusion bodies. Once ingested, the viral occlusion bodies dissolve in the alkaline environment of the larval midgut, releasing virions that infect epithelial cells and subsequently spread throughout the insect body. Higher concentrations therefore, increase the probability of successful infection and systemic viral replication. According to Moscardi (1999), viral dosage is one of the most important factors affecting baculovirus pathogenicity because infection success depends largely on the amount of virus consumed by susceptible larvae.

The decreasing mortality observed at lower concentrations further supports the principle that viral load strongly influences infection intensity and disease progression. Treatments exposed to lower concentrations likely received fewer viral particles, resulting in slower infection development and reduced mortality. In lower concentration treatments, larvae may have continued feeding and developing before viral replication reached lethal levels. This explains why T2 and T3, which all utilized low and medium concentrations, recorded only moderate effectiveness despite still producing substantially higher mortality than the untreated control. Cory and Myers (2003) explained that baculovirus infections are strongly influenced by pathogen dosage because low viral exposure may result in delayed or sublethal infections, allowing some larvae to survive or complete development before death occurs.

Table 3. Mean leaf damage rating of corn plants as affected by different NPV concentrations at 3 to 12 DAA under field conditions

Treatment	Mean FAW Mortality Days After Application			
	3	6	9	12
T1 - Control (water only)	74.82[a]	85.93[a]	92.59[a]	95.56[a]
T2 - Low concentration (7 larvae/16L of water)	40.74[b]	46.67[b]	54.07[b]	52.59[b]
T3 - Medium concentration (14 larvae/16L of water)	28.15[c]	34.07[c]	37.78[c]	40.00[c]
T4 - High concentration (21 larvae/16L of water)	23.70[d]	27.41[d]	29.63[d]	29.63[d]
F-test	**	**	**	**
CV %	2.66	2.53	5.18	1.52

Means with the same letter in a column are not significantly different at 5% level using Tukey's HSD Test.

** - highly significant

The study evaluated how the application of NPV affected the actual larval feeding damage of Fall Army Worm (FAW) on corn plants applied with different concentration of NPV.

Table 3 presents the mean leaf damage rating of corn plants as affected by different NPV concentrations from 3 to 12 DAA under field conditions. At 3 DAA, T4 had the lowest leaf damage rating of 23.70, followed by T3 with 28.15, while T1 produced the highest mean damage rating of 74.82 and was significantly different from all treated strains. All treatments significantly differ from each other this indicates that higher concentrations of NPV were more effective in suppressing larval feeding activity even during the early stage after application.

Among the NPV-treated plots at 6 DAA, leaf damage ratings ranged from 27.41 to 46.67. T1 recorded the highest mean damage rating of 85.93, followed by T2 with 46.67, and the lowest damage rating was observed in T4 with 27.41. The statistical analysis indicates that T4 were more effective in reducing leaf damage compared with T3 and T2. The low damage ratings observed in T4 indicate that higher viral concentrations caused earlier infection and more rapid suppression of larval feeding activity. According to Yasin et al. (2020), higher concentrations of NPV significantly increase infection success because larvae ingest larger quantities of viral particles, resulting in faster disease progression and earlier feeding suppression. Similarly, Moscardi (1999) explained that baculovirus pathogenicity is highly dependent on inoculum density because higher viral loads improve the probability of successful infection and accelerate systemic viral replication.

The lowest overall mean leaf damage rating at 9 DAA was 29.63, followed by T3 with 37.78, T2 with 54.07, while T1 recorded the highest mean damage rating of 92.59. The statistical analysis indicates that T4 was the most effective strain in reducing leaf damage at this observation period. The lower damage ratings observed in T4 imply that this concentration may possess greater virulence or faster suppression of larval feeding compared with the other concentrations.

Moreover, at 12 DAA, T1 obtained the highest mean damage of 95.56, followed by T2 with 52.59, T3 with 40.00, and T4 with 29.63. The untreated control (T1) recorded the highest leaf damage rating of 95.56 and was significantly different from all treated strains.

Higher concentrations consistently produced lower leaf damage ratings because infection occurred more rapidly and suppressed feeding behavior earlier. In contrast, lower concentrations likely delayed infection progression and allowed larvae to continue feeding for longer periods, resulting in greater crop injury. This highlights the importance of optimizing viral dosage to maximize biological control efficacy and minimize economic losses. According to Hernandez-Crespo et al. (2001), effective baculovirus-based pest management programs require proper dosage optimization because insufficient viral concentrations may reduce infection success and delay suppression of pest activity.

The findings also support the observations of Lacey and Shapiro-Ilan (2015), who emphasized that microbial insecticides contribute to pest management not only through direct mortality but also through behavioral suppression and feeding inhibition. Unlike synthetic insecticides that often rely on rapid knockdown effects, microbial agents such as NPV provide progressive suppression of pest activity through physiological disruption and disease progression. This makes NPV particularly advantageous in integrated pest management programs because crop protection begins shortly after infection, even if mortality requires several days to occur.

5. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The study was conducted with the following objectives: 1) to determine the most effective concentration of NPV for the control of FAW, and 2) to assess the extent of damage on corn as affected by different NPV concentrations. The study was conducted at Northern Mindanao Agricultural Crops and Livestock Research Complex (NMACLRC), Dalwangan, Malaybalay City, Bukidnon.

The experiment was laid out using the Randomized Complete Block Design (RCBD) with four (4) treatments at three (3) replications each. The treatments were the following:

T1 – Control (water only)

T2 – Low concentration (7 larvae/16L of water)

T3 – Medium concentration (14 larvae/16L of water)

T4 – High concentration (21 larvae/16L of water)

Results showed that larval mortality was observed from Day 3 to Day 12 after application. NPV strain at higher concentration recorded the highest mean larval mortality of 80.00%, while the control treatment recorded only 13.33% mortality.

The study revealed that a higher concentration resulted in higher larval mortality. In terms of larval feeding damage on corn plants, at higher concentration, the lowest mean damage rating of 29.63, described as "Several leaves with lesions (less severe damage)," while the control treatment recorded the highest damage rating of 95.56, corresponding to severe damage; most leaves with long lesions. This indicates that NPV application not only increased larval mortality but also significantly reduced feeding damage by causing infected larvae to become weak, sluggish, and less capable of feeding before death.

The significant differences existed among treatments in terms of leaf damage severity. The results proved that NPV is effective not only in suppressing FAW populations but also in protecting corn plants from severe economic damage.

Overall, the study demonstrated that NPV, particularly when applied at higher concentrations, can serve as effective, environmentally safe, and sustainable biological control agents against Fall Army Worm in Bukidnon corn production systems.

In conclusion, NPV at the highest concentration produced the highest larval mortality and significantly reduced larval feeding damage on corn plants. This confirms that NPV contributes to crop protection not only by killing larvae but also by reducing feeding activity before death occurs.

Based on the findings, the highest concentration of 21 larvae per 16 liters of water is therefore recommended for field application, and further studies should be conducted on large-scale field trials across different seasons and environmental conditions to evaluate the long-term consistency and performance of NPV under varying agroecological conditions.

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