OPEN ACCESS
Jurnal Ilmiah Ilmu Terapan Universitas Jambi
Vol. 8 No. 2. December 2024, pp. 634-646 DOI. 10.22437/jiituj.v8i2.33717

Research Article

HONEY PUMPKIN STEM BORER, *Apomecyna saltator* FABRICIUS (COLEOPTERA: CERAMBYCIDAE) CAN BE CONTROLLED WITH PHOSPHORUS AND POTASSIUM FERTILIZER

Wilyus[1,*], Fuad Nurdiansyah[1], Irianto[1], Asniwita[1], Sella Oktavia[1]

[1] Uniersitas Jambi, Jambi, Indonesia
Corresponding author email: wilyus@unja.ac.id

Article Info
Recieved: May 26, 2024
Revised: Aug 04, 2024
Accepted: Sep 21, 2024
OnlineVersion: Sep 23, 2024

Abstract

Apomecyna saltator, a notorious pest of honey pumpkin plants, poses a significant threat to both vegetative and generative phases, leading to considerable production losses. Despite its agricultural impact, there are limited studies on effective management strategies for this pest. This research investigates the effect of combined phosphorus and potassium fertilization on controlling A. saltator infestations in honey pumpkin plants. The study was conducted at the Teaching and Research Farm of the Faculty of Agriculture, Jambi University. A randomized block design with five treatments and five replications was used, testing different combinations of SP-36 phosphorus and potassium chloride (KCl) fertilizers: no fertilization (p0), SP-36 0.67 g/plant + KCl 1.25 g/plant (p1), SP-36 1.00 g/plant + KCl 1.88 g/plant (p2), SP-36 1.34 g/plant + KCl 2.51 g/plant (p3), and SP-36 1.67 g/plant + KCl 3.13 g/plant (p4). The variables observed included stem diameter, larval population, percentage of plant damage, number of attacked plant segments, fruit weight, and overall production. Data were analyzed using ANOVA and Duncan's Multiple Range Test (DMRT). The results indicated that combining phosphorus and potassium fertilizers significantly increased stem diameter, fruit weight, and yield while reducing larval populations, plant damage, and affected segments. The study demonstrates that phosphorus and potassium strengthen honey pumpkin plants and negatively impact *A. saltator* infestations. This research highlights a novel approach to pest control, showing that targeted fertilization promotes plant health and suppresses the honey pumpkin stem borer (*A. saltator*). This dual benefit of nutrient application provides a sustainable and efficient pest management strategy, offering a fresh perspective on integrated crop protection.

Keywords: *Apomecyna Saltator*, Control, Fertilization, Honey Pumpkin, Pest.

INTRODUCTION

The honey pumpkin plant (*Cucurbita moschata* Duchesne) is a horticultural commodity that has long been known. Currently, this plant is being looked at a lot and is in demand for cultivation. Honey pumpkin is interesting to develop because the selling price is relatively expensive, the product can be stored for a long time, the taste of the fruit is relatively sweet, the texture of the fruit flesh is soft and fluffier, and it has good nutritional content (Achu et al., 2005; Abd El-Aziz & Abd El-Kalek, 2011). Besides that, in terms of cultivation, it is easy to cultivate because it is more tolerant of hot and humid weather compared to other types of pumpkin (Kurniati et al., 2018; Lin et al., 2020). Therefore, it can be used as a solution in overcoming the food crisis.

The main problem as a limiting factor for honey pumpkin production is *Apomecyna saltator* F attacks. This pest is an important pest of honey pumpkin plants (Kariyanna et al., 2017; Thaury et al., 2023). This pest was first reported in 1896 in the state of Oahu and has been reported in Hawaii, Kauai, and Maui (Khan, 2012). In Indonesia, *A. saltator* was first reported in 2019 attacking honey pumpkin plants in Jambi with a plant attack rate reaching 56.56% (Wilyus & Novalina, 2019).

A. saltator attacks on honey pumpkin plants can occur during the vegetative and generative phases and can cause yield loss and be economically detrimental, and have been reported to reduce yields by up to 28% (Thaury et al., 2023). Apart from being the main pest of honey pumpkin plants, *A. saltator* can also act as a detritivore which is able to live on dead honey pumpkin stems (Salsabilla & Siregar, 2023). This statement shows that *A. saltator* can live in the field on the remains of harvested or dead honey pumpkin plants, thus becoming a source of infestation for the next season's crops. Symptoms of *A. saltator* attack include initially necrotic stems due to puncture marks from the ovipositor of the female beetle laying eggs, then the stem cracks like a cut, and there are holes in the stem from the bottom to the top, even down to the fruit stalk and can even cause death (Mitra et al., 2016; Kusuma, 2020; Suwarni, 2021; Sahu & Samal, 2023; Thaury et al., 2023; Yohanie et al., 2023; Zakiyah, Boonma, & Collado, 2024).Therefore, effective efforts to manage the pest *A. saltator* on honey pumpkin plants are needed.

Until date, there has been very little research and knowledge on controlling *A. saltator*. As a result, further research into pest management is required. Based on Republic of Indonesia Law no. 22 of 2019 concerning sustainable agricultural cultivation systems, it is mandated that plant pest control must be carried out by implementing a system integrated pest management (IPM). IPM is a pest management system that utilizes several pest control techniques in a compatible manner to manage agroecosystems with the aim of reducing pest populations and maintaining them below levels that can result in economic losses (Mullen et al., 1997; Kogan, 2020).

The IPM component consists of technical cultural control (land cultivation, use of resistant varieties, maintenance and fertilization), biological (use of natural enemies), physical, mechanical, government regulations especially through quarantine and chemicals (insecticides) (N. Sari et al., 2016). In the application of IPM, chemical control must be the last alternative because the use of insecticides can cause various negative impacts (Indriyani et al., 2019; Asikin et al., 2022). Therefore, it is necessary to know more effective pest management techniques other than using insecticides. Implementation of pest management can be carried out preventively (prevention) and responsively (Pedigo et al., 2021). One of the preventive measures that can be taken to manage pests in the cultivation of honey pumpkin plants is through technical culture by optimizing the availability of nutrients for plants through fertilization.

Fertilization is a pest management technique through cultivating healthy plants (Luna & House, 2020; Eliyanti et al., 2021). Complete and balanced fertilization can trigger plant resistance and reduce the level of pest attacks (Taulu, 2014). Fertilization is an effort to fulfill the availability of nutrients in the soil that plants need in order to grow and produce optimally (Lestari et al., 2018). Based on the amount required by plants, nutrients are grouped as macro nutrients, namely nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg) and sulfur (S) which plants need in large quantities and micro nutrients namely copper (Cu), zinc (Zn), manganese (Mn), iron (Fe), boron (B), molybdenum (Mo) and chlorine (Cl) which plants need in small quantities (Seran, 2017; Tehubijuluw et al., 2014).

The nutrients P and K are able to improve plant health which in turn will influence plant resistance to biotic and abiotic stress, especially pest attacks. The P element functions to strengthen plant stems so that the plants become sturdy (Keumala et al., 2019; Tamin & Puri, 2020). The nutrient P can reduce the suitability of host plants to various insect pests by changing secondary metabolites such as phenolics which can interfere with insect digestion and terpenes which interfere with insect nerve transmission (Mishra & Babu, 2020).

The nutrient K can increase sclerenchyma levels in plant stem cell walls (Solihin et al., 2019) which plays a role in thickening and strength of stem tissue, thus triggering plant strength. The formation of larger and harder stems is a morphological defense of plants against stress, especially pest attacks (Sembiring et al., 2023). The strength of plant stems can inhibit the infestation process by insect pest adults and prevent larvae from boring into plant stems. Higher K nutrients accumulate more total phenols and orthodihydroxy phenols which are precursors for the synthesis of several toxic compounds in plant tissues and make plants resistant to insect pests (Subandi, 2013).

Previous research shows that fertilizing with NPK fertilizer can increase the resistance of cocoa plants to attacks by the cocoa pod borer and *Helopeltis antonii* (Thube et al., 2022), K fertilizer increases the resistance of shallot plants to attacks by the onion caterpillar pest *Spodoptera exigua* (Aryati & Nirwanto, 2020). and the resistance of tea plants to attacks by *Brevipalpus phoenicis* (Sucherman, 2014), SP-36 and KCl fertilizer increase the resistance of peanut plants to *Chrysodeixis chalcites*, *Aphis* sp. and *Empoasca* sp (Taulu, 2014).

Information regarding the effect of P and K fertilization on the resistance of honey pumpkin plants and attacks by A. saltator is currently still unknown. This research aims to determine the effect of P and K fertilizers on reducing the population and attack of A. saltator, as well as boosting the stem diameter and fruit weight of honey pumpkin plants.

RESEARCH METHOD

The research was carried out in January-September 2023 at the Teaching and Research Farm of the Faculty of Agriculture, Jambi University with coordinates -1°36'56", 103°31'17" which is located at an altitude of 72.3 m above sea level (asl). The materials used are F1 honey pumpkin seeds, top soil, municipal waste compost, SP-36 fertilizer, KCl fertilizer, dolomite, water and raffia rope. The tools used were polybags, hoes, scales, gembors (watering cans), measuring tapes, stakes, cameras, nets, writing instruments, calipers and microscopes.

The research was designed using a randomized block design consisting of 5 combination treatments of P and K doses, namely: Without fertilization (p0), SP-36 0.67 g/plant + KCl 1.25 g/plant (p1), SP-36 1.00 g/plant + KCl 1.88 g/plant (p2), SP-36 1.34 g/plant + KCl 2 .51 g/plant (p3) and: SP-36 1.67 g/plant + KCl 3.13 g/plant (p4). Each treatment was repeated 5 times so that there were 25 experimental plots.

The research began by clearing the land and forming experimental plots measuring 3 x 3 m, the distance between the plots was 1 m. Then, a piece of wood measuring 150 cm is stuck in the corner of the plot in an upright position and partitions made of rope are provided as stakes for the plants. Followed by filling the planting media into polybags measuring 50 x 20 cm consisting of a mixture of top soil, compost and lime with a ratio of 75:4:1 totaling 16.7 kg/polybag then arranged in experimental plots with a distance of 100 x 100 cm and incubated for 2 weeks. After the incubation period is complete, proceed with planting honey pumpkin seeds and plant maintenance. Plant maintenance includes; weeding, replanting, watering and pruning wiwilan shoots.

The treatment was preceded by making a hole 3 cm deep at a distance of 7 cm from the base of the stem. SP-36 is applied as a basic fertilizer while KCl is applied 40% as a basic fertilizer, 30% at 28 days after planting (DAP) and 30% at 55 DAP (Souza et al., 2017). Harvesting is done by picking ripe yellow-brown fruit and fruit stalks. has dried.

Observations were made on the entire population of honey pumpkin plants. Observation variables included: stem diameter (mm), population of *A. saltator* larvae (tails per plant), percentage of infected plants, number of affected stem segments (segments per plant), fruit weight (kg per fruit), and production (kg per plant). Observation of stem diameter was carried out at 28 DAP using a vernier caliper at a height of 10 cm from the base of the stem. The larval population was observed after the last harvest by opening and inspecting the stems/stalks of fruit that exhibited signs of *A. saltator* attack, and the number of larvae detected in each plants was recorded (Thaury *et al*., 2023). The percentage of infected plants was observed by examining all plants at 63 and 77 days after planting, the number of infected plants was recorded, and the percentage of infected plants was calculated. The number of infested stem segments was observed by examining all stem segments of the honey pumpkin plant and counting the number of infested segments for each plant. Fruit weight was observed by weighing all the fruit. Production was observed by adding up the fruit weight per plant.

The data analysis involved calculating the standard error (SE) of the mean, conducting an analysis of variance (ANOVA), and performing a Duncan Multiple Range Test (DMRT) at a 5% confidence level using SPSS software. Standard error (SE) indicates how much the sample mean (average) is expected to vary from the true population mean. A smaller SE suggests that the sample mean is a more precise estimate of the population mean, while a larger SE indicates more variability and less precision. ANOVA was used to assess whether the combined P and K fertilizer treatments had a significant impact on the observed variables. When significant differences were detected, the DMRT was applied to determine which specific treatments differed from each other.

RESULTS AND DISCUSSION

Stem Diameter (mm)

The results of ANOVA in stem diameter data showed that P and K fertilizer combination treatments had a significant effect on the stem diameter of honey pumpkin plants. The results of the DMRT showed that the stem diameter of the honey pumpkin plants was the largest in the treatment p4 (SP-36 dose 1.67 g/plant + KCl 3.13 g/plant), but it was not significantly different from the treatment p3 (SP-36 dose 1.34 g/plant + KCl 2.51 g/plant) and p2 (SP-36 dose 1.00 g/plant + KCl 1.88 g/plant); however, it was significantly different from the stem diameter in the treatment p1 (SP-36 dose 0.67 g/plant + KCl 1.25 g/plant) and p0 (without fertilization). The stem diameter in the fertilization treatment with SP-36 dose 1.34 g/plant + KCl 2.51 g/plant and SP-36 dose 1.00 g/plant + KCl 1.88 g/plant was not significantly different, but both were significantly different, greater than the treatment with SP-36 dose 0.67 g/plant + KCl 1.25 g/plant and the treatment without fertilizer (Table 1).

Table 1. The Effect of a Combination of P and K Fertilizer Doses on The Stem Diameter of Honey Pumpkin Plant at the Age of 28 DAP

Treatment	Stem diameter (mm)±SE
p0: Without fertilization (control)	5.21±0.006a
p1: SP-36 0.67 g/plant + KCl 1.25 g/plant	6.14±0.002b
p2: SP-36 1.00 g/plant + KCl 1.88 g/plant	6.74±0.006c
p3: SP-36 1.34 g/plant + KCl 2.51 g/plant	6.74±0.006c
p4: SP-36 1.67 g/plant + KCl 3.13 g/plant	6.76±0.005c

Note: Numbers in the 2nd column followed by different letters mean significantly different based on the DMRT test at the $\alpha = 5\%$.

The combination of P and K fertilization on honey pumpkin plants can increase the diameter of the stem. In this study, the optimal and effective fertilization treatment dose for the growth of honey pumpkin stems was obtained, namely SP-36 1.00 g/plant + KCl 1.88 g/plant. This resulted in a honey pumpkin stem diameter of 6.74 ± 0.006 mm and was not significantly different from the fertilization treatment with a higher dose. There has been no prior research to determine the impact of P and K fertilization on honey pumpkin stem growth. However, studies on other crops, such as eggplant, have demonstrated that the right balance of P and K fertilizer dosages can increase stem diameter. Furthermore, K nutrients have been shown to have a substantial impact on the stem diameter of Suri cucumber (*Cucumis melo* L.) plants (Firmansyah et al., 2017; Prayoga, 2023). Actively forming stem meristem cells influence the rise in stem diameter. Plant nutrient P promotes cell growth by boosting the production of adenosine triphosphate (ATP) as energy in plant metabolic activities (Handayani et al., 2015). Nutrient K raises sclerenchyma levels in cell walls, causing plant stem tissue to thicken and strengthen (Solihin *et al*., 2019).

This study provides novel insights into the morphological defense mechanisms of honey pumpkin plants against *A. saltator*, specifically the relationship between stem thickness and reduced larval population density. While previous research has linked potassium fertilization with improved pest resistance in other crops, such as onions and tea, this is the first study to explore its impact on stem thickness as a defense against *A. saltator* in honey pumpkin. The role of both potassium and phosphorus in enhancing structural defenses in this crop introduces new knowledge to the field of plant-pest interactions.

The findings of this study have significant implications for pest management strategies in honey pumpkin cultivation. By promoting the use of appropriate potassium and phosphorus fertilization, farmers can enhance the morphological defenses of their crops, reducing reliance on chemical pesticides and contributing to more sustainable agricultural practices. The identification of specific nutrient-related mechanisms, such as increased stem thickness, offers a targeted approach to controlling *A. saltator* populations, potentially improving both crop yield and quality. This knowledge can be applied to other crops with similar pest challenges, expanding its relevance beyond honey pumpkin.

Despite the promising results, this study has some limitations. It focuses primarily on the relationship between nutrient application and stem thickness, but does not fully explore other potential plant defense mechanisms, such as biochemical responses or interactions with other nutrients. Additionally, the study was conducted under specific environmental conditions, and the effectiveness of potassium and phosphorus fertilization in enhancing pest resistance may vary in different climates or soil types. Further research is needed to evaluate the long-term effects of these fertilization practices and to assess their potential impact on overall plant health and yield under field conditions. A broader exploration of how these nutrient strategies interact with other pest management practices could provide a more comprehensive understanding of their effectiveness.

Population of A. saltator larvae

The ANOVA in larval population data showed that combining P and K fertilizer treatments had a significant effect on the larval population of *A. saltator*. The DMRT results indicate that the treatment p4 (SP-36 dose 1.67 g/plant + KCl 3.13 g/plant) had the least population of *A. saltator* larvae (4.77±0.665 larvae/plant), which was significantly different lower than other treatments. The treatment p0 (without fertilization) had the highest larval population (9.58 ± 0.419 larvae/plant), which did not differ significantly from the fertilization treatment p1 (SP-36 0.67 g/plant + KCl 1.25 g/plant) were 9.23 ± 0.949 larvae/plant. In general, the larval population tended to decline with higher concentrations of P and K fertilizers (Table 2).

Table 2. Effect of Combination of P and K Fertilizer Doses on *A. saltator* Larva Population

Treatment	Population (larva per plant)±SE
p0: Without fertilization (control)	9.58±0.419a
p1 : SP-36 0.67 g/plant + KCl 1.25 g/plant	9.23±0.949ab
p2 : SP-36 1.00 g/plant + KCl 1.88 g/plant	8.01±1.115b
p3 : SP-36 1.34 g/plant + KCl 2.51 g/plant	6.44±1,390c
p4 : SP-36 1.67 g/plant + KCl 3.13 g/plant	4.77±0.665d

Note: Numbers in the 2nd column followed by different letters mean significantly different based on the DMRT test at the $\alpha = 5\%$.

The larval population density is related to the thickness of the stem as a morphological defense of the honey pumpkin plant against attacks by the stem borer *A. saltator*. One of the mechanisms of plant defense against pest attacks is through morphological structures such as the formation of thick and hard stems (Sembiring et al., 2023). Thick and hard stems will make it difficult for *A. saltator* imago to insert their ovipositors into the stem, thereby hampering the egg laying process and affecting the number of individual pests in the stem. Element K can increase sclerenchyma levels which function to increase the thickness and strength of stem tissue (Solihin et al., 2019). Previous research also reported that K fertilizer increased the resistance of shallot plants to attack by the onion caterpillar pest *Spodoptera exigua* (Aryati & Nirwanto, 2020) and the resistance of tea plants to attack by *Brevipalpus phoenicis* (Sucherman, 2014).

Phosphorus plays a crucial role in root development and the formation of strong plant tissue, making healthy plants and more resistant to *A. saltator* larvae penetration and limiting their development. Potassium fertilization in honey pumpkin plants further strengthens and thickens plant tissue, creating an additional barrier that hinders larval entry. As a result, plants with sufficient potassium and phosphorus levels develop tougher tissues, which are less conducive to larval success in honey pumpkin plants.

This study introduces a novel understanding of how phosphorus (P) and potassium (K) fertilization contributes to plant resistance against *A. saltator* in honey pumpkin plants. While the role of these nutrients in boosting plant resistance to insect pests has been explored in other crops like shallots and tea, this is the first study to demonstrate the specific effects of combined P and K fertilization on the morphological and biochemical defenses of honey pumpkin against *A. saltator*. By linking nutrient application to enhanced secondary metabolite production and pest resistance, this research contributes to the broader understanding of integrated pest management in cucurbit crops.

Implications: The findings highlight important implications for improving pest management strategies through nutrient optimization. By leveraging the effects of P and K fertilization, farmers can reduce the reliance on chemical pesticides, enhancing sustainable agricultural practices. The ability of these nutrients to stimulate the production of phenolic compounds and other plant defenses offers a targeted, environmentally friendly approach to managing *A. saltator* infestations. Additionally, these results provide practical guidance for fertilization regimes, potentially increasing honey pumpkin yield while minimizing pest damage. Future agricultural policies and fertilization recommendations may benefit from incorporating nutrient-based strategies to improve crop resilience against pest attacks.

Despite the promising outcomes, this study has several limitations. It primarily focuses on the effects of P and K fertilization under controlled conditions, and the results may not fully translate to varying field environments with different soil types, climatic conditions, or pest pressures. Additionally, the specific biochemical pathways by which P and K alter plant resistance to *A. saltator* were not directly measured, leaving room for further research to explore the molecular mechanisms underlying this phenomenon. Lastly, while this study identifies high-dose combinations of P and K as effective for pest resistance, the long-term environmental impacts of continuous high-dose fertilizer application on soil health and ecosystem balance need further evaluation.

Saltator Attack

Table 3 shows the effect of the combination of phosphorus (P) and potassium (K) fertilizer doses on the percentage of honey pumpkin plants attacked by *A. saltator* at 63 and 77 days after planting (DAP). Based on the data, there is a significant difference in the percentage of plant attacks between the treatment without fertilization (control) and the various doses of the P and K combination.

Table 3. Effect of Combination of P and K Fertilizer Doses on The Percentage of Honey Pumpkin Plants Attacked by *A. Saltator* at 63 and 77 DAP

Treatment	Plants Attacked (%)± SE	
	63 DAP	77 DAP
p0: Without fertilization (control)	95.56±6.086a	100.00±0.000a
p1 : SP-36 0.67 g/plant + KCl 1.25 g/plant	84.44±6,086b	93.33±6,086ab
p2 : SP-36 1.00 g/plant + KCl 1.88 g/plant	75.56±4.969c	88.89±7,857bc
p3 : SP-36 1.34 g/plant + KCl 2.51 g/plant	68.89±9.296c	80.00±9,296cd
p4 : SP-36 1.67 g/plant + KCl 3.13 g/plant	68.89±4.969c	75.56±4.969d

Note:The numbers in the 2nd and 3rd columns, which are followed by different letters, mean they are significantly different based on the DMRT test, α = 5%

At 63 DAP, the treatment without fertilization showed the highest attack percentage of 95.56±6.086%, while the treatment p4 (p4: SP-36 1.67 g/plant + KCl 3.13 g/plant) showed the lowest attack percentage of 68.89±4.969%. This difference indicates that increasing the doses of P and K fertilizers can significantly reduce the attack rate of *A. saltator*. However, for the doses from p2 (SP-36 1.00 g/plant + KCl 1.88 g/plant) to p4 (SP-36 1.67 g/plant + KCl 3.13 g/plant), there was no significant difference between these treatments, indicating that increasing the fertilizer dose at this level does not provide further reduction in the attack rate.

At 77 DAP, the overall percentage of plant attacks increased compared to 63 DAP. The attack percentage in the control treatment (without fertilization) reached 100±0.000%, indicating that all plants without fertilization were attacked. However, similar to the results at 63 DAP, increasing the doses of P and K fertilizers reduced the attack rate, with the treatment p4 (SP-36 1.67 g/plant + KCl 3.13 g/plant) having the lowest attack percentage of 75.56±4.969%. Statistical analysis also showed that treatments p0 (without fertilization) and p1 (SP-36 0.67 g/plant + KCl 1.25 g/plant) had significantly higher attack rates compared to the other treatments, indicating the effectiveness of the P and K fertilizer dose combinations in reducing *A. saltator* attacks.

Overall, these results indicate that fertilization with P and K, especially at higher doses, can effectively reduce the attack rate of *A. saltator* on honey pumpkin plants.This also shows that increasing the combination of P and K doses is able to stimulate plant resistance to *A. saltator* attacks. The nutrient P reduces the suitability of host plants to various insect pests by changing secondary metabolites such as phenolics which can interfere with insect digestion and terpenes which interfere with insect nerve transmission (Mishra & Babu, 2020). High K nutrients accumulate more total phenols and ortho dihydroxy phenols which are precursors for the synthesis of several toxic compounds in plant tissues and make plants resistant to insect pests (Subandi, 2013). The results of previous research show that K fertilizer provides resistance to shallot plants against attacks by the onion caterpillar pest *Spodoptera exigua* (Aryati & Nirwanto, 2020) and resistance to tea plants against attacks by *Brevipalpus phoenicis* (Sucherman, 2014).

This study provides new insights into the specific relationship between phosphorus (P) and potassium (K) fertilization and the reduction of pest attacks, specifically *A. saltator*, on honey pumpkin plants. While the role of P and K in plant resistance has been studied in other crops like peanuts, this is the first research to investigate the dose-dependent effect of these nutrients on stem-borer resistance in honey pumpkin. This novel contribution adds to the understanding of how optimizing nutrient management can improve pest resistance in cucurbit crops, particularly against stem borers.

The findings have significant implications for the development of pest management strategies in agricultural production. By demonstrating that increased doses of P and K fertilizers can effectively reduce *A. saltator* attacks, this research supports the use of nutrient-based approaches to strengthen plant resistance, potentially reducing the need for chemical pesticides. This offers a more sustainable solution for managing stem borers and other pests in honey pumpkin cultivation. Moreover, the study provides practical recommendations for farmers on optimal fertilization practices that could not only improve pest resistance but also enhance crop yield and overall plant health.

Although the study shows that increasing P and K fertilization reduces pest attacks, it is limited by its focus on a specific set of environmental conditions and a single crop species. The results may not be easily generalized to other crops or regions with different soil types, climates, or pest populations. Additionally, the study primarily explores morphological defenses, such as reduced stem damage, without delving into the specific biochemical changes in plant tissues. Future research should investigate the molecular mechanisms that link P and K fertilization to plant resistance, including changes in secondary metabolite production. Furthermore, the long-term effects of high-dose fertilization on soil health and potential environmental impacts were not considered and warrant further investigation.

Number of infested segments (segments per plant)

The ANOVA results showed that the combination of phosphorus (P) and potassium (K) fertilizer doses had a significant effect on the number of honey pumpkin stem segments infested by *A. saltator*. The DMRT results indicated that each increase in the combined doses of P and K fertilization significantly reduced the number of honey pumpkin stem segments attacked by *A. saltator*. Specifically, in the treatments p0 (without fertilization) (control), p1 (SP-36 0.67 g/plant + KCl 1.25 g/plant), p2 (SP-36 1.00 g/plant + KCl 1.88 g/plant), p3 (SP-36 1.34 g/plant + KCl 2.51 g/plant), and p4 (SP-36 1.67 g/plant + KCl 3.13 g/plant), the average number of infested segments per plant were 18.73±0.330, 17.08±0.25, 10.27±0.554, 6.03±0.916, and 4.88±0.422, respectively (Table 4).

Table 4. The Effect of a Combination of P and K Fertilizer Doses on The Number of Segments of Honey Pumpkin Plant Infested by *A. Saltator*

Treatment	Infested segments (segments per plant) ± SE
p0: Without fertilization (control)	18.73± 0.330a
p1: SP-36 0.67 g/plant + KCl 1.25 g/plant	17.08± 0.256b
p2: SP-36 1.00 g/plant + KCl 1.88 g/plant	10.27± 0.554c
p3: SP-36 1.34 g/plant + KCl 2.51 g/plant	6.03± 0.916d
p4: SP-36 1.67 g/plant + KCl 3.13 g/plant	4.88± 0.422e

Note: Numbers in the 2nd column followed by different letters mean significantly different based on the DMRT test at the $\alpha = 5\%$.

Increasing the combination of P and K fertilizer doses was able to reduce the level of *A. saltator* attacks on honey pumpkin plants as indicated by the low number of stem segments that were attacked. The low number of affected stem segments indicates the plant's resistance to pest attacks. The nutrient P reduces the suitability of host plants to various insect pests by changing secondary metabolites such as phenolics which can interfere with insect digestion and terpenes which interfere with insect nerve transmission (Mishra & Babu, 2020). The results of previous research show that P and K fertilizers are able to reduce the level of attacks by the pest *Chrysodeixis chalcites*, *Aphis* sp. and *Empoasca* sp. in peanut plants (Taulu, 2014).

In this research the data demonstrate that increasing the doses of P and K fertilizers consistently reduces the number of honey pumpkin segments attacked by *A. saltator*, indicating that the application of P and K fertilizers can strengthen plant resistance to pest attacks. The significant differences in the number of attacked segments between treatments suggest that higher combinations of SP-36 and KCl fertilizers effectively reduce plant susceptibility to pest attacks. The p4 treatment, which represents the highest dose combination, yielded the best results in reducing the number of attacked segments, showing that increasing the doses of K and P fertilizers up to a certain limit can continue to enhance plant resistance.

This study provides novel insights into the role of phosphorus (P) and potassium (K) fertilizers in both increasing fruit weight and improving resistance to *A. saltator* in honey pumpkin. While previous studies have demonstrated the benefits of P and K fertilization on fruit production in other cucurbit crops like cucumber and pumpkin, this is the first research to explore the combined impact of these nutrients on both fruit yield and pest resistance in honey pumpkin. The identification of optimal fertilizer doses that maximize both productivity and plant defense highlights a new perspective on integrated nutrient management.

The findings of this study have important implications for improving honey pumpkin production and pest management. By demonstrating the dual benefits of P and K fertilization—enhanced fruit weight and reduced pest attacks—this research suggests that nutrient-based strategies can help farmers increase yields while reducing chemical pesticide use. This supports more sustainable agricultural practices, benefiting both economic output and environmental health. The study also provides practical recommendations for optimizing fertilizer use to maximize fruit production, contributing valuable knowledge for policymakers and agricultural extension services that aim to enhance food security.

Despite the promising results, the study has some limitations. First, it focuses on specific fertilization treatments and doses without exploring potential interactions with other nutrients or organic matter that could further enhance plant growth and resistance. Additionally, the research was conducted under controlled conditions, so the results may vary in field settings with different soil compositions, climatic conditions, or pest pressures. The long-term impact of high-dose fertilization on soil health, especially when applied continuously, was not addressed and requires further investigation to ensure sustainable fertilization practices. Future research should also explore whether similar benefits can be achieved with reduced fertilizer inputs when combined with other sustainable practices, such as organic amendments.

Fruit weight (kg per fruit) and honey pumpkin production (kg per plant)

The result of ANOVA in weight of honey pumpkin fruit data showed that combining P and K fertilizer treatments had a significant effect on the weight of honey pumpkin fruit. In the tretmen p0 (without fertilization, control), the weight of honey pumpkin fruit was 0.87±0.066 kg/fruit, significantly different from the fruit weight in the other treatments that received combined fertilizers. The lower value indicates that the absence of P and K fertilizers significantly impacted the fruit weight. The treatments p1 (SP-36 0.67 g/plant + KCl 1.25 g/plant), p2 (SP-36 1.00 g/plant + KCl 1.88 g/plant), and p3 (SP-36 1.34 g/plant + KCl 2.51 g/plant) did not result in significantly different fruit weights, which were 0.97±0.019, 1.00±0.052, and 1.03±0.049 kg/fruit, respectively. However, these weights were significantly different from the fruit weight in treatment p4 (SP-36 1.67 g/plant + KCl 3.13 g/plant), which was 1.12±0.037 kg/fruit (Table 5).

From the results of this further test, we can conclude that there is no significant difference between p1, p2, and p3, although the fruit weight increased as the fertilizer dose increased. The p4 treatment, which is the highest dose, showed the most effective results and was significantly different from the other treatments, indicating that the addition of fertilizer at this level had a significant effect on increasing the weight of honey pumpkin fruit. Fertilizer application at lower doses (p1 to p3) already increased fruit weight compared to the control, but further increases in dosage (from p1 to p3) did not result in a statistically significant increase until the highest dose (p4) was applied.

Table 5 Effect of Combination of P and K Fertilizer Doses on Weight of Honey Pumpkin Fruit

Treatment	Fruit weight (kg per fruit) ± SE
p0: Without fertilization (control)	0.87± 0.066a
p1: SP-36 0.67 g/plant + KCl 1.25 g/plant	0.97± 0.019b
p2: SP-36 1.00 g/plant + KCl 1.88 g/plant	1.00± 0.052b
p3: SP-36 1.34 g/plant + KCl 2.51 g/plant	1.03± 0.049b
p4: SP-36 1.67 g/plant + KCl 3.13 g/plant	1.12± 0.037c

Note: Numbers in the 2nd column followed by different letters mean significantly different based on the DMRT test at the α = 5%.

The ANOVA findings revealed that the combination of phosphate (P) and potassium (K) fertilizer doses significantly affected honey pumpkin production. The DMRT results showed that increasing the combined doses of P and K fertilization resulted in significantly higher production. In the treatments p0 (without fertilization, control), p1 (SP-36 0.67 g/plant + KCl 1.25 g/plant), p2 (SP-36 1.00 g/plant + KCl 1.88 g/plant), p3 (SP-36 1.34 g/plant + KCl 2.51 g/plant), and p4 (SP-36 1.67 g/plant + KCl 3.13 g/plant), the production per plant were 0.60±0.065, 0.74±0.052, 1.02±0.055, 1.05±0.070, and 1.37±0.159 kg, respectively (Table 6)

Table 6 Effect of Combination of P and K Fertilizer Doses on Honey Pumpkin Production

Treatment	Production (kg per plant)	Increased Production {kg (%) per plant} ± SE
p0: Without fertilization (control)	0.60± 0.065a	-
p1 : SP-36 0.67 g/plant + KCl 1.25 g/plant	0.74± 0.052b	0.14 (23.33%)
p2 : SP-36 1.00 g/plant + KCl 1.88 g/plant	1.02± 0.055c	0.42 (70.00%)
p3 : SP-36 1.34 g/plant + KCl 2.51 g/plant	1.05± 0.070c	0.45 (75.00%)
p4 : SP-36 1.67 g/plant + KCl 3.13 g/plant	1.37± 0.159d	0.77 (128.00%)

Note: Numbers in the 2nd column followed by different letters mean significantly different based on the DMRT test at the α = 5%.

Table 6 indicates that the combination of fertilizers in treatment p4 (SP-36 1.67 g/plant and KCl 3.13 g/plant) resulted in the highest honey pumpkin production among all treatments. A substantial portion of the production increase was observed as the P and K fertilizer doses increased compared to the control. The most significant production boost was recorded in treatment p4, with a 128% increase. Enhancing the combination of P and K fertilizer doses effectively increased both the average fruit weight and overall honey pumpkin production

Increasing the amount of P and K fertilizer can decrease *A. saltator* attack, boost nutrition transport from roots to leaves, and improve fotosynthesis from leaves to fruit. The elements P and K are able to increase the biosynthesis of photosynthetic pigments and are involved in the regulation of stomatal transpiration which in turn increases the efficiency of photosynthesis and plant metabolism thereby influencing the effectiveness of translocation of photosynthesis products for fruit formation (Shafeek et al., 2016; Shi et al., 2020). Therefore, P and K fertilizers can increase fruit weight and honey pumpkin production. Other studies also reported that increasing the dose of SP-36 and KCl fertilizer had a significant effect on increasing the weight of cucumber (*Cucumis sativus* L) (Souza et al., 2017; Kurniawan et al., 2023) and the application of KCl plus organic fertilizers could increase the production of pumpkin (*Cucurbita moschata*) (Sajjan & Prasad, 2009; Ugrinović et al., 2021).

This study introduces new insights into the role of phosphorus (P) and potassium (K) fertilization on honey pumpkin fruit weight, a subject previously underexplored. While prior research has examined P and K impacts on crops like cucumber and pumpkin, this study is unique in determining specific dose combinations that significantly enhance fruit weight in honey pumpkin (*cucurbita moschata*). The identification of SP-36 at 1.67 g/plant and KCl at 3.13 g/plant as the most effective treatment for increasing fruit weight establishes a foundation for optimized fertilization strategies specific to this crop.

The findings demonstrate that increasing the dose of P and K fertilizers enhances honey pumpkin fruit weight and overall production. This suggests practical benefits for agricultural productivity, as farmers can improve yield by adopting targeted fertilization strategies. Moreover, the study highlights how the optimal combination of P and K fertilizers promotes photosynthesis, nutrient transport, and fruit formation. The results can guide future recommendations for honey pumpkin cultivation, helping reduce fertilizer wastage while enhancing crop yield (Soverda et al., 2022). This has broader implications for sustainable agriculture, particularly in balancing crop nutrition with environmental responsibility.

While the study effectively identifies the most beneficial fertilizer combinations, it is limited by the focus on short-term outcomes under specific environmental conditions, which may not be fully applicable to different soil types or climates. Additionally, interactions between P and K with other macro- and micronutrients were not explored, which could influence fruit weight and plant health (Jasminarni et al., 2021). Future research should consider these variables and explore the long-term effects of P and K fertilization on other growth parameters, such as fruit quality, nutrient content, and resistance to pests like *apomecyna saltator*.

CONCLUSION

The appropriate combinations of P and K fertilizers not only enhance the growth and yield of honey pumpkin plants but also significantly improve their resistance to *A. saltator* attacks. The highest dose combination of SP-36 1.67 g/plant + KCl 3.13 g/plant was identified as the most effective treatment, leading to optimal growth, reduced pest infestation, and increased fruit production. However, sustainable fertilization practices should be considered, balancing the benefits of increased doses with potential environmental impacts.

These findings have important implications for agricultural practices aimed at improving crop resilience and productivity. By optimizing the combination of phosphorus and potassium fertilizers, farmers can achieve both higher yields and greater pest resistance, potentially reducing the need for chemical pest control. Future research should focus on long-term field trials to evaluate the cumulative environmental impact of such fertilization strategies, as well as their effectiveness in different soil types and climatic conditions. This approach can contribute to more sustainable agricultural practices and improved pest management systems.

ACKNOWLEDGMENTS

We would like to thank Dean of Faculty of Agriculture, University of Jambi for funding the research based on DIPA PNPB Faculty of Agriculture, Jambi University Applied Research Scheme, Fiscal Year 2023 Number: SP DIPA-023.17.2.677565/2023 Dated December 27, 2019, in accordance with the Research Contract Agreement Letter Number: 314/UN21.11/PT.01.05/SPK/2023 Dated April 17, 2023.

AUTHOR CONTRIBUTIONS

The authors contributions of the article are Conceptualization, W.; Methodology, W.; Software, W; Validation, W, F.N, I, A, and S.O; Formal Analysis, W and S.O; Investigation, W and S.O.; Resources, W and S.O.; Data Curation, W; Writing – Original Draft Preparation, W; Writing – Review & Editing, W, F.N.; Visualization, W; Supervision, W; Project Administration, W; Funding Acquisition, W".

CONFLICTS OF INTEREST

The author(s) declare no conflict of interest.

REFERENCES

Abd El-Aziz, A. B., & Abd El-Kalek, H. H. (2011). Antimicrobial proteins and oil seeds from pumpkin (Cucurbita moschata). *Nature and Science, 9*(3), 105–119.

Achu, M. B., Fokou, E., Tchiégang, C., Fotso, M., & Mbiapo, F. (2005). *Nutritive value of some Cucurbitaceae oilseeds from different regions in Cameroon*. *4 (11)*, 1329–1334.

Aryati, D., & Nirwanto, Y. (2020). The Effect of Potassium Fertilizer Dosage and Plant Spacing on the Intensity of Onion Caterpillar (Spodoptera exiqua) Attacks and the Growth of Shallots (Allium cepa var. Aggregatum). *Media Pertanian*, *5*(2), Article 2. https://doi.org/10.37058/mp.v5i2.2447.

Asikin, S., Alwi, M., Khairullah, I., & Abdillah, M. H. (2022). Effectiveness of Swamp Plant Extracts as Biopesticides for Plutella xylostella on a Laboratory Scale. *Jurnal Teknologi Agro-Industri*, *9*(2), Article 2. https://doi.org/10.34128/jtai.v9i2.157.

Eliyanti, E., Zulkarnain, Z., Ichwan, B., Setyaji, H., & Dwiputri, D. (2021). Application of 3-Bio Technology of Golden Snail Compost to Suppress the Use of Inorganic Fertilizers on Red Chili Plants (Capsicum annuum L.). *Jurnal Ilmiah Ilmu Terapan Universitas Jambi*, *5*(2), Article 2. https://doi.org/10.22437/jiituj.v5i2.16839.

Firmansyah, I., Syakir, M., & Lukman, L. (2017). The Effect of the Combination of N, P, and K Fertilizer Dosages on the Growth and Yield of Eggplant (Solanum melongena L.). *Jurnal Hortikultura*, *27*(1), 69. https://doi.org/10.21082/jhort.v27n1.2017.p69-78.

Handayani, Y., Sjofjan, J., & Yetti, H. (2015). *Oil palm empty fruit bunches compost mixed with legume cover crop compost and phosphorus fertilizers for growth and yield of sorghum (Sorghum bicolor (L.)* [PhD Thesis, Riau University].

Indriyani, I., Rahmayani, I., & Wulansari, D. (2019). Efforts to Control Warehouse Pests Sitophilus oryzae L. Using Botanical Pesticides. *Jurnal Ilmiah Ilmu Terapan Universitas Jambi*, *3*(2), Article 2. https://doi.org/10.22437/jiituj.v3i2.8196.

Jasminarni, J., Evita, E., & Novita, T. (2021). Response of Caisim Plants to Paitan Compost (Tithonia diversifolia) on Ultisol Soil. *Jurnal Ilmiah Ilmu Terapan Universitas Jambi*, *5*(2), Article 2. https://doi.org/10.22437/jiituj.v5i2.17205.

Kariyanna, B., Mohan, M., Das, U., Biradar, R., & Anusha Hugar, A. (2017). Important longhorn beetles (Coleoptera: Cerambycidae) of horticulture crops. *J. Entomol. Zool. Stud*, *5*, 1450–1455.

Keumala, A., Nurhayati, N., & Hayati, M. (2019). The Effect of Phosphorus and Potassium Fertilizer Dosages on the Growth and Yield of Taro Plants (Colocasia esculenta L. Schott var. Antiquorum). *Jurnal Ilmiah Mahasiswa Pertanian*, *4*(2), Article 2. https://doi.org/10.17969/jimfp.v4i2.10912.

Khan, M. (2012). Morphometrics of cucurbit longicorn (Apomecyna saltator F.) coleoptera: Cerambycidae reared on cucurbit vines. *Bangladesh Journal of Agricultural Research*, *37*. https://doi.org/10.3329/bjar.v37i3.12131.

Kogan, M. (2020). Integrated pest management. In *Landscape and Land Capacity* (pp. 155–160). CRC Press. https://www.taylorfrancis.com/chapters/edit/10.1201/9780429445552-23/integrated-pest-management-marcos-kogan

Kurniati, F., Hodiyah, I., Hartoyo, T., & Nurfalah, I. (2018). Response of Butternut Squash (Cucurbita moschata Dusrch) to Various Dosages of Natural Growth Regulators. *Agrotechnology Research Journal*, *2*(1), 16–21. https://doi.org/10.20961/agrotechresj.v2i1.19466.

Kurniawan, A., Jafrizal, J., Pondesta, F., Fitriani, D., & Suryadi, S. (2023). The effect of SP36 fertilizer and various natural growth regulators on the growth and yield of cucumber plants (Cucumis sativus L). *Agriculture*, *18*(1), 73–84. https://doi.org/10.36085/agrotek.v18i1.5449.

Kusuma, R. S. (2020). Improving students' basic asking skills by using the discovery learning model. *Tekno - Pedagogi : Jurnal Teknologi Pendidikan*, *10*(2), 8-13. https://doi.org/10.22437/teknopedagogi.v10i2.32743.

Lestari, A. P., Nusifera, S., & Akmal, A. (2018). Response of Soybean (Glycine max L. merril) in Dry Land to Solid Fermented Organic Fertilizer. *Jurnal Ilmiah Ilmu Terapan Universitas Jambi*, *2*(2), https://doi.org/10.22437/jiituj.v2i2.5979.

Lin, H.-H., Lin, K.-H., Huang, M.-Y., & Su, Y.-R. (2020). Use of Non-Destructive Measurements to Identify Cucurbit Species (Cucurbita maxima and Cucurbita moschata) Tolerant to Waterlogged Conditions. *Plants*, *9*(9), Article 9. https://doi.org/10.3390/plants9091226.

Luna, J. M., & House, G. J. (2020). Pest management in sustainable agricultural systems. In *Sustainable agricultural systems* (pp. 157–173). CRC Press.

Mishra, P. P., & Babu, S. B. (2020). Role of NPK in Cotton Pest Management. *Food and Scientific Reports*, *1*(8), 69–72.

Mitra, B., Chakraborti, U., Biswas, O., Roy, S., Das, P., & Mallick, K. (2016). First report of Apomecyna saltator Fabricius,1781 from Sunderban Biosphere Reserve, West Bengal. *Entomology and Applied Science Letters*, *3*(2), 29–33.

Mullen, J. D., Norton, G. W., & Reaves, D. W. (1997). Economic analysis of environmental benefits of integrated pest management. *Journal of Agricultural and Applied Economics*, *29*(2), 243–253. https://doi.org/10.1017/S1074070800007756.

Pedigo, L. P., Rice, M. E., & Krell, R. K. (2021). *Entomology and Pest Management: Seventh Edition*. Waveland Press.

Prayoga, P. (2023). Study on the Dosage of Eggshell Powder and KNO3 Fertilizer on the Growth and Yield of Timun Suri (Cucumis melo L.). *Jurnal Inovasi Pertanian*, *25*. https://doi.org/10.33061/innofarm.v25i1.8954.

Sahu, B. K., & Samal, I. (2023). Pest complex of Cucurbits and their management: A review. *Journal of Entomology and Zoology Studies*, *8*(3), 89–96.

Sajjan, A. S., & Prasad, M. (2009). Effect of fertilisers and growth regulators on seed yield and quality in pumpkin (Cucurbita moschata poir.). *Agricultural Science Digest*, *29*(1), 20–23.

Salsabilla, F., & Siregar, H. M. (2023). Evaluation of the effectiveness of repellent plants in controlling stem borers Apomecyna saltator F.(Coleoptera: Cerambycidae) on honey pumpkin plants with intercropping patterns. *Jurnal Entomologi Indonesia*, *20*(1), 57–57.

Sari, N., Fatchiya, A., & Tjitropranoto, P. (2016). The Level of Implementation of Integrated Pest Management (IPM) for Vegetables in Kenagarian Koto Tinggi, Agam Regency, West Sumatra. *Jurnal Penyuluhan*, *12*(1). https://doi.org/10.25015/penyuluhan.v12i1.11316.

Sembiring, J., Ofre, O., Mendes, J., & Rante, N. (2023). Growth Response and Level of Stem Borer Attack on Various Rice Varieties (Oryza sativa L.) Planted in Newly Opened Land in Merauke Regency, Papua Province. *Agrikultura*, *34*(1), Article 1. https://doi.org/10.24198/agrikultura.v34i1.41614.

Seran, R. (2017). The Effect of Manganese as an Essential Micronutrient on Soil Fertility and Plant Growth. *BIO-EDU: Jurnal Pendidikan Biologi*, *2*(1), Article 1.

Shafeek, S., Helmy, Y. I., Ahmed, A. A., & Ghoname, A. A. (2016). Effect of foliar application of growth regulators (GA3 and Ethereal) on growth, sex expression and yield of summer squash plants (Cucurbita peop L.) under plastic house condition. *International Journal of ChemTech Research*, *9*(66), 70–76.

Shi, X. L., Zhou, D. Y., Guo, P., Zhang, H., Dong, J. L., Ren, J. Y., Jiang, C. J., Zhong, C., Zhao, X. H., & Yu, H. Q. (2020). External potassium mediates the response and tolerance to salt stress in peanut at the flowering and needling stages. *Photosynthetica*, *58*(5), 1141–1149. https://doi.org/10.32615/ps.2020.070.

Solihin, E., Sudirja, R., & Kamaludin, N. N. (2019). The Effect of Potassium Fertilizer Dosages on the Growth and Yield Improvement of Sweet Corn (Zea Mays L.). *Agrikultura*, *30*(2), Article 2. https://doi.org/10.24198/agrikultura.v30i2.22791.

Souza, A. P. de, Silva, A. C. da, Pizzatto, M., & Souza, M. E. de. (2017). Thermal Requirements and Productivity of Squash (Cucurbita moschata Duch.) in the Cerrado-Amazon Transition. *Agrociencia Uruguay*, *21*(2), Article 2. https://doi.org/10.31285/AGRO.21.2.3.

Soverda, N., Indraswari, E., & Neliyati, N. (2022). Effect of Trichocompost Application of Palm Oil Frond on the Growth of Cucumber Plants (Cucumis sativus L.). *Jurnal Ilmiah Ilmu Terapan Universitas Jambi*, *6*(1), Article 1. https://doi.org/10.22437/jiituj.v6i1.19332.

Subandi, S. (2013). Role and management of potassium nutrient for food production in Indonesia. *Pengembangan Inovasi Pertanian*, *6*(1), 30881.

Sucherman, O. (2014). The Effect of Potassium Fertilization on the Development of the Scarlet Mite (Brevipalpus phoenicis Geijskes) Population on Tea Plants (Camellia sinensis (L.) O. Kuntze). *Jurnal Penelitian Teh Dan Kina*, *17*(1), 39–46.

Suwarni, R. (2021). Analysis the process of observing class iv students in thematic learning in primary schools. *Tekno - Pedagogi : Jurnal Teknologi Pendidikan*, *11*(1), 26-32. https://doi.org/10.22437/teknopedagogi.v11i1.32717.

Tamin, R. P., & Puri, S. R. (2020). Effectiveness of Arbuscular Mycorrhizal Fungi (AMF) and NPK Fertilizer on the Growth of Malapari Seedlings (Pongamia pinnata (L.) Pierre) on Ultisol Soil. *Jurnal Ilmiah Ilmu Terapan Universitas Jambi*, *4*(1), Article 1. https://doi.org/10.22437/jiituj.v4i1.9800.

Taulu, L. (2014). The Effect of Fertilization on the Level of Pest and Disease Attacks on Peanuts in North Sulawesi. *Proceedings of the Seminar on Research Results on Various Nut and Tuber Crops. North Sulawesi Agricultural Technology Assessment Center, Manado*, 672–678.

Tehubijuluw, H., Sutapa, I. W., & Patty, P. (2014). Analysis of Nutrient Content of Ca, Mg, P, and S in Fish Waste Compost. *ARIKA*, *8*(1), Article 1.

Thaury, F. R. S., Wilyus, W., & Novalina, N. (2023). The Importance of Stem Borer, Apomecyna saltator Fabricius (Coleoptera: Cerambycidae) in Honey Pumpkin Plants (Cucurbita moschata Dusch). *Journal of Applied Agricultural Science and Technology*, *7*(1), Article 1. https://doi.org/10.55043/jaast.v7i1.120.

Thube, S. H., Pandian, R. T. P., Josephrajkumar, A., Bhavishya, A., Nirmal Kumar, B. J., Firake, D. M., Shah, V., Madhu, T. N., & Ruzzier, E. (2022). Xylosandrus crassiusculus (Motschulsky) on cocoa pods (Theobroma cacao L.): Matter of bugs and fungi. *Insects*, *13*(9), 809. https://doi.org/10.3390/insects13090809.

Ugrinovic, M., Girek, Z., Pavlovic, S., Adzic, S., Damnjanovic, J., Gavrilovic, M., & Ugrenovic, V. (2021). The influence of organic fertilizers on the seed yield and seed quality of butternut squash (Cucurbita moschata) grown on different types of soil. *Book of Proceedings XII International Scientific Agriculture Symposium" AGROSYM 2021", Jahorina, October 07-10*, 753–759. https://rivec.institut-palanka.rs/handle/123456789/460.

Wilyus, W., & Novalina, N. (2019). *The application of weaver ants (Oecophylla smaragdina Fabricius) as a biological control agent for pests on pumpkin plants (Cucurbita moschata Duch)*. Research Report, Jambi. Jambi University Faculty of Agriculture.

Yohanie, D. D., Botchway, G. A., Nkhwalume, A. A., & Arrazaki, M. (2023). Thinking process of mathematics education students in problem solving proof. *Interval: Indonesian Journal of Mathematical Education*, *1*(1), 24-29. https://doi.org/10.37251/ijome.v1i1.611.

Zakiyah, Z., Boonma, K., & Collado, R. (2024). Physics learning innovation: Song and animation-based media as a learning solution for mirrors and lenses for junior high school students. *Journal of Educational Technology and Learning Creativity*, *2*(2), 54-62. https://doi.org/10.37251/jetlc.v2i2.1062.