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Determination of the efficacy of novel pesticides against potato tuber moth (*Phthorimaea operculella zeller*) in laboratory conditions on seed potato

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Abstract
Potato tuber moth (*Phthorimaea operculella* Zeller) is a key pest of potato for storage and field as well. In order to determine the efficacy of novel pesticides a bioassays was done using different pesticides selected at different concentrations. An experiment on "Determination of the efficacy of novel pesticides against potato tuber moth (*Phthorimaea operculella* Zeller) in laboratory condition on seed potato" was carried out in the Laboratory of Entomological Division, NARC, Khumaltar, Lalitpur from 20th April 2022 to 20th August to determine the efficacy of novel pesticides used to control against potato tuber moth. Bioassays were used to determine the effect of pesticides selected at different concentrations. Mass rearing of potato tuber moth was conducted, and the temperature and humidity were also noted in the laboratory (±27˚C) and ±70%. The different biological features and the damage index of potato tubers have been evaluated and found to be highest on Bacillus thuringiensis, the highest mortality% was studied, and the live population and adult emergence were reported highest at the mid-time of trial. The study revealed the effectiveness of the pesticides against potato tuber moths, three pesticides Chlorantraniliprole, Spinosad, and, Bacillus thuringiensis have higher efficacy than Bojho and the mortality rate was Chlorantraniliprole (100%), Spinosad (85%), Bacillus thuringiensis (70%) whereas, the lowest mortality rate in treatment Bojho (60%). High Infestation was also seen in Bojho as compared to the other three pesticides. All the novel pesticides used were found to be effective against the pest in reducing the population in laboratory conditions; however, their effectiveness was directly proportional to the concentration and exposure periods. The study has demonstrated the possibility of using novel compounds against potato tuber moth in storage condition potato.

Keywords: Bojho (*Acorus calamus*), chlorantraniliprole, bacillus thuringiensis, Spinosad, novel compounds.

Introduction

Global potato production currently stands at 378 million tons, and it is grown on an estimated 19 million hectares of farmland (Kroschel, 2013) [11]. After rice, maize, and wheat, potatoes (*Solanum tuberosum* L.) are Nepal's fourth-most significant staple crop (Timsina *et al*., 2019; Kalika *et al*., 2020) [21, 10]. Potatoes are a major source of food in the country. Among the food crops farmed in Nepal (wheat, rice, potato. maize, and finger millet), it ranks fifth in terms of area coverage, second in terms of total production, and first in terms of productivity (Upadhyay, *et al*., 2020) [22]. It makes up 2.17 percent of GDP and 6.57 percent of GDP from agriculture. According to MOALD (2019), the area and production productivity of potatoes in 2017-18 were 2,881,829 tons, 195,173 ha, and 14.7 t/ha, respectively. In Nepal, potatoes postharvest losses were 25% (Upadhyay, *et al*., 2020) [22]. They are also a good source of vitamin C and vitamin B complex. Potatoes are 80% water, 18% starch, and 2% protein, and contain minerals, Vitamin C, and vitamins B1 and other nutrients. A review of common agricultural illnesses and insect pests that cause Nepal to lose between 25 and 35 percent of its annual crop yield was conducted. Red ants (*Dorylus orientalis)* Potato tuber moth *(Phthorimaea operculella*) are two insect pests that may cause harm to potatoes. Under NARC, the National Potato Research Program (NPRP) is tasked with researching the potato crop. Up to 2019, five potato varieties were registered in Nepal and eleven had been released by NARC. According to Gallego *et al*. (2020), plant diseases and viruses account for 40.3% of losses on average, animal pests for 21.1%, and weeds for 8.3% of losses.

White grubs, cutworms, potato tuber moths, Cutworms, red ants, mole crickets, and termites are the insect pests that harm tubers. Aphids, leafhoppers, thrips, and white flies are examples of sap-feeding insects that cause harm to plants by feeding on various plant sections directly and acting as plant virus carriers. *Thysanoplusia orichalcum, Spilosoma obliqua, Heliothis armigera, and Spodoptera spp*. are the significant leaf-feeding caterpillars. Hadda beetles, flea beetles, and blister beetles are the most devastating pests among coleopterans. (Alyokhin, *et al*., 2022) [2]

The three main strategies for early prevention and control are irrigation, deep sowing, and the selection of resistant types. Integrated pest management, is used to reduce pest density below the economic threshold and reduce the usage of toxic chemical pesticides. The administration of sterile bugs in the field, stockpiling, and exchange might be worked on by momentum research on the utilization of sex pheromone and botanicals, illumination for isolation, and the sterile bug strategy (SIT) program. At the International Potato Center (CIP), biological control, sex pheromones, resistant cultivars, and other integrated pest management techniques are prioritized for supervising potato insect pests. These methods offer sufficient control while minimizing the need for insecticides (Raman, 1998) [16]. Potato tuber moth prevention and control have also shifted to novel approaches involving sterile insect techniques and transgenic insect-resistant potatoes.

Materials and Methods

The experiment was carried out at the NARC, Khumaltar, and the laboratory of the Entomological Division. The materials and methodology used to conduct several trials to fulfill the study's objectives have been made available here.

Description of Treatments and Experimental Process

The effectiveness of several innovative pesticides against the Potato Tuber Moth *(P. operculella*) in storage seed potatoes was tested in a field experiment. From April 13 to May 14, 2021, the potato tuber moth was mass-reared at the Nepal Agricultural Research Council's (NARC) Entomological Division's laboratory in Khumaltar, Lalitpur. In a laboratory environment, *Phthorimaea operculella* were mass-reared under hygienic circumstances and at the right temperature. Potato tubers infested with potato moths that were gathered from a separate field served as the starting point for the rearing process (Kavre and Dhulikhel). The tubers were incubated at room temperature (±27ºC) in a vessel measuring 30x23x14.5 cm that was partially filled with finely sterilized sand.

As shown in Table 1 below, four distinct pesticides—Chlorantraniliprole, Spinosad, *Bacillus thuringiensis*, and Bojho have been chosen for testing, and their efficacy was evaluated using water spray as a check. The pesticides were transported from the Lagankhel, Lalitpur, and agro-vet clinic. For the purpose of testing the pesticides' effectiveness against potato tuber moths in a lab setting, a separate beaker containing the pesticide solutions in varying concentrations was filled with droppers. Before the seed potato was placed inside, the plastic boxes were properly cleaned and dried. First, cut paper towels were arranged on the box's bottom. Using a dropper, each seed potato was sprayed with the prescribed pesticide solution in a Petri dish. The potato was then allowed to air dry for at least an hour. Five of the treated seed potatoes were placed in each of the several boxes, and with the meticulous use of a camel hair brush, a total of twenty-five Potato Tuber Moth larvae were introduced into each box. There are five numbers of treated seed potatoes in each plastic box. To guarantee that the larvae have enough air to breathe, a hole was cut in the lid and covered with a netted cloth that was adhered with adhesive. Four duplicates of each treatment were conducted. After 21 days, the total number of larvae, the damage the larvae caused during the trials, the number of moths, the total infestation on the potato, and the emergence were all counted.

Table 1: Pesticide compounds experimented for seed potato against potato tuber moth.

Common name	Trade name	Active ingredient %	Formulation type	Chemical group
Chlorantraniliprole (0.3ml/ltr)	Coragen	18.5	SC	Ryanoide
Spinosad (0.3ml/ltr)	Tracer	45	SC	Spinosyn
Bacillus Thuringenesis (2ml/ltr)	Dipel		WP	Microbial
Bojho (3kg/ml)	Bojho		WP	
Control	-	-	-	-

Classification of pesticides on basis of their effectiveness

Statical Analysis

The data acquired for each research parameter were examined using one-way analysis of variance (ANOVA) to search for any significant differences between the different treatments. The gathered data were subjected to variance analysis, and the means were compared using Duncan's test. The number of dead moths/treatments and the total number of larvae × 100 were used to compute the death rate.

Fenemore's formula was used to find the mean of the tuber damage index (D.I.) for each trial.

$$DI=\frac{(n^{\circ}slight\times1)+(n^{\circ}Moderate\times2)+(n^{\circ}Severe\times3)\times10}{\text{Total no of tubers}}$$

The efficacy of pesticides is calculated by the formula given below. The increment of pesticide efficacy over control is calculated by the formula:

$$\frac{(\text{Treatment-Control})*100\%}{\text{Control}}$$

The total number of dead larvae was calculated by the formula:

$$\frac{\text{Dead larval }*100\%}{\text{The Total no of the larva introduced}}$$

The proportion of infested eyes was calculated by the formula given below:

$$\frac{\text{Eyes with frass}}{\text{No. of eyes with frass} + \text{No. of eyes without frass}}$$

Results and Discussions

The efficacy of the pesticides under test against the Potato Tuber Moth *(Phthorimaea operculella Zeller)* under store house conditions.

There were notable effects from the pesticide focuses that were tried against potato tuber moth hatchlings on potato tuber; of the four pesticides tried, three had a high death rate. In light of the larval demise rate, Table 1 shows that Spinosad and Chlorantraniliprole had the most effects. The effectiveness of insecticides against potato tuber moths is displayed in Figure 1. Chlorantraniliprole was shown to be the most effective insecticide in the testing, followed by spinosad. It was discovered that *Bacillus thuringiensis* was more efficient than Bojho.

Table 1: The death rate of Larva (±SE) of potato tuber moth after the application of the treatment.

Treatments	Death Rate
Chlorantraniliprole	25±0
Spinosad	22.6±3.91
Bacillus thuringiensis	17.2±4.6
Bojho	16.6±3.84
Control	15±4.52
C.V%	0.18
Grand mean	19.28

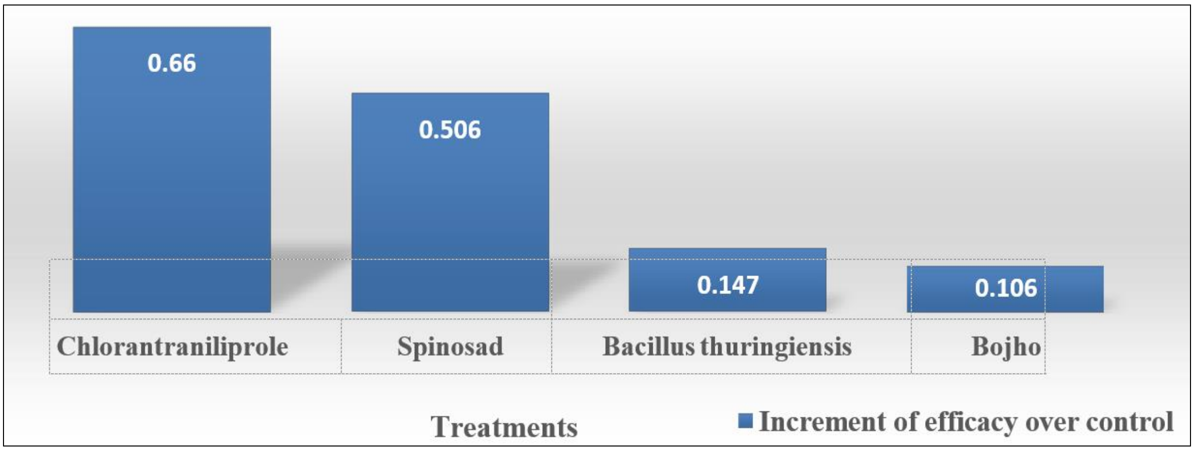

Fig 1: Increment of the efficacy of pesticides over control

Tuber damage Index

According to the results, every pesticide was extremely significant (p<0.001). There were differences in the damage index between the 17.2 and 23.2 levels, compared to 25 tunnels for the control group that did not receive treatment. These findings are in line with recent research that found that chlorantraniliprole offers the best protection for tubers, with a mean damage index reduction of 17.2 at a concentration of 03 milliliters per liter. At a concentration of 0.3 milliliters per liter, the Spinosad treatment results in a damage index at the mean of 18.8 tunnels. Similarly, at a concentration of 2 milliliters per liter, *Bacillus thuringiensis* creates the damage index with a mean of 20.8; Bojho provides the damage index on the tunnels with a mean of 20.4. Similarly,±25˚C and±90% relative humidity were recorded for the temperatures and humidity.

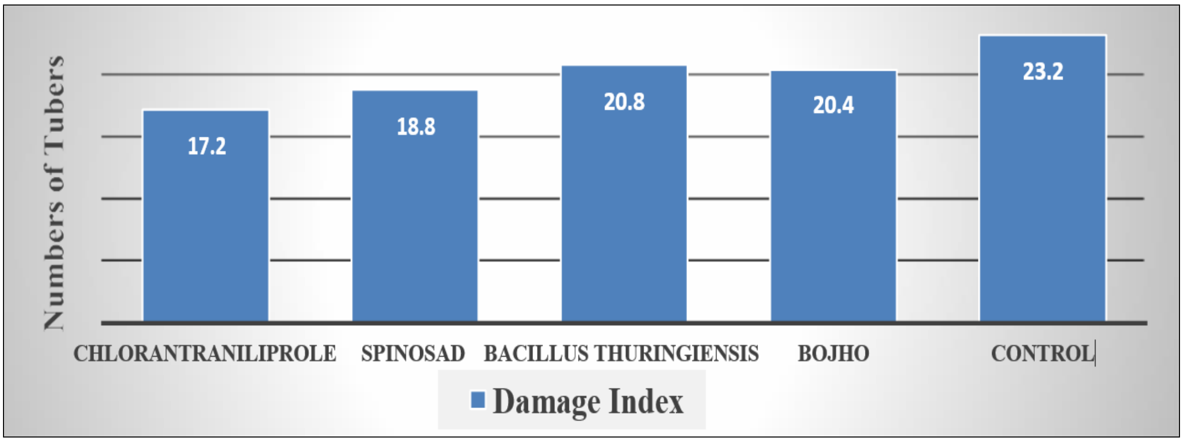

Fig 2: Damage index of potato tubers

Infestation Pattern of Potato tuber moth after treatment application

In every sampling, it was discovered that the infestation was reduced in all pesticide-treated plots compared to the untreated control. Because of the various pesticides and their concentrations, it was discovered that the infestation of potatoes varied greatly among the seed potatoes that were studied. The tubers treated with *Bacillus thuringiensis* had the highest level of infestation, whereas the tubers treated with Chlorantraniliprole and Spinosad had the lowest levels.

Because of the rotten potatoes found during the calculation of the results, the infestation in the case of the Bojho-treated tubers appears to be rather low. When compared to the Untreated Control, all four pesticides significantly at p=0.05 reduced their ability to block the potato tuber moth's effect on storage seed potatoes. Comparing potato tubers treated with chlorantraniliprole to those treated with spinosad, bojho, and *Bacillus thuringiensis*, the results show that the highest level of infestation was seen. The table shows that at a p-value < 0.001, a different letter indicates a significant difference between the pesticides while a similar letter indicates no significant difference between them.

Table 3: Mean Infestation Pattern of Potato Tuber Moth (±SE) on Treatments with different Pesticides on Potato Seed in Storage.

Treatments	Infested eyes	Non Infested eyes
Chlorantraniliprole	1.28±1.47b	4.44±2.62d
Spinosad	1.20±1.35b	3.88±1.32d
Bacillus thuringiensis	6.12±3.56b	3.24±1.14d
Bojho	3.48±2.70b	3.64±1.56d
Control	6.08±3.06b	3.64±1.87d

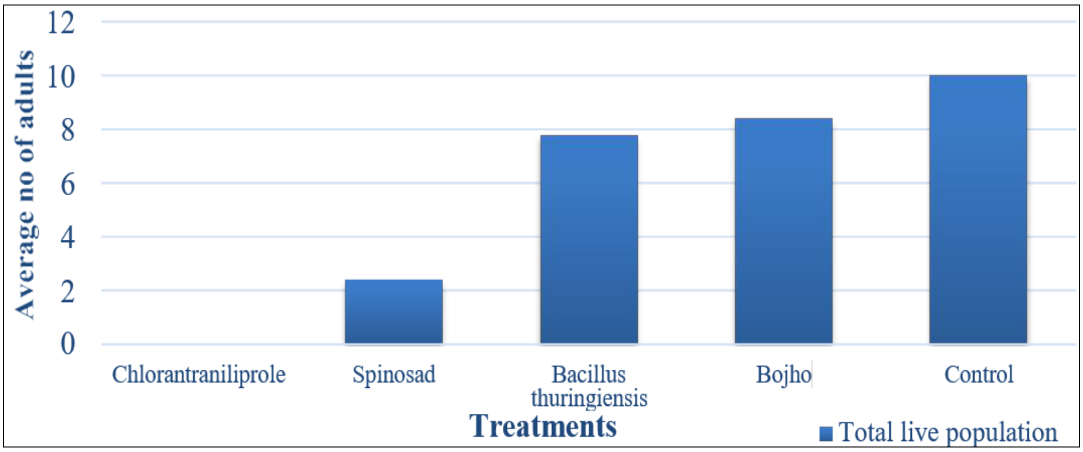

Fig 3: Total live population observed

Tunnel length in untreated potato and tunnel formation in treated seed potato

The average number of the tunnel and the average tunnel length were highly significant. All the pesticide treatments used resulted in lower tuber damage levels when compared to the untreated control. Among the treatments, Bojho-treated tubers were highly affected by the potato tuber moth infestation, the number of tunnels and the tunnel length were high as compared to other treatments. *Bacillus thuringiensis* also shows a high tunnel length and tunnel number in comparison to Chlorantraniliprole and Spinosad. The test of pesticide efficacy against potato tuber moth was statically significant for both an average number of tunnels and an average number of tunnel lengths. The test of pesticides against potato tuber moth was counted and measured in all treated potatoes which was statically significant where F= 8.99; $p<0.001$, Cv% = 30.17 for an average number of tunnels and for an average number of tunnel length F= 9.9; $p<0.001$, Cv%= 33.05.

Table 4: Average number of tunnels and average tunnel length (± SE) on potato by potato tuber moth when treated with different pesticides along with the control

Treatments	Average Number of Tunnel	Average Tunnel length
Chlorantraniliprole	1.2±0.42	11.51±4.32
Spinosad	0.72±0.36	11.93±5.48
Bacillus thuringiensis	3.96±1.17	59.06±20.35
Bojho	5.32±1.90	78.53±36.19
Control	4.08±0.76	65.2±8.43
Grand mean	3.056	45.246
Cv%	30.17	33.05

Infestation Pattern of Potato tuber moth after treatment application.

In comparison to the untreated control, the infestation was found to be shallow in every pesticide-treated plots in all samplings. Because of the various pesticides and their concentrations, it was discovered that the infestation of potatoes varied greatly among the seed potatoes that were studied. *Bacillus Thuringia's is* treated tubers had the highest level of infestation, whereas Chlorantraniliprole-treated tubers had the lowest level, followed by Spinosad. Given the rotten potatoes found during the results computation, the infestation in these Bojho-treated tubers appears to be quite low. When compared to the Untreated Control, all four pesticides significantly at p=0.05 reduced their ability to block the potato tuber moth's effect on storage seed potatoes.

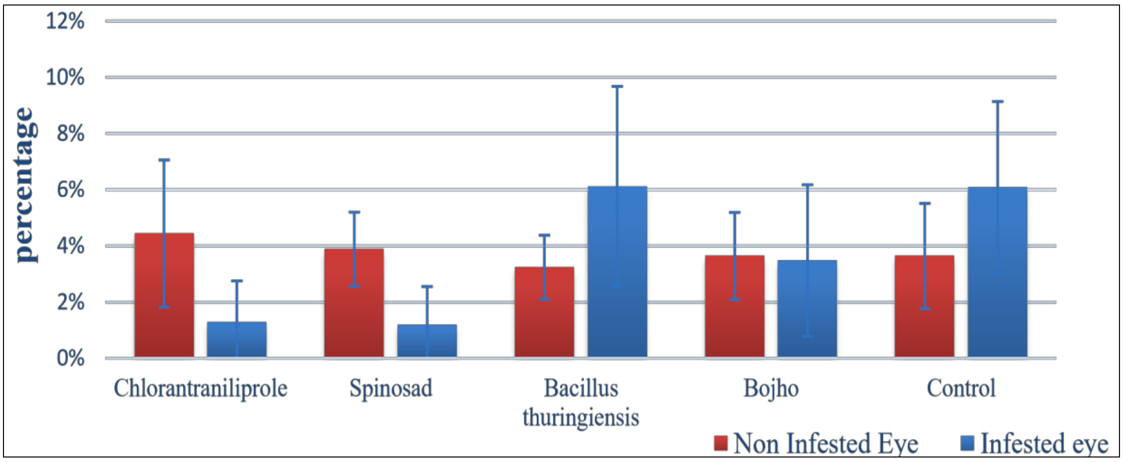

Fig 4: Mean Infestation pattern of PTM on potato tubers (Infested and non-Infested eyes) after treatment with pesticides

The potato tuber moth (*Phthorimaea operculella Zeller*) has attacked the potato crop so severely that it is causing a significant loss in global potato production and storage. The study carried out to estimate the effectiveness of pesticides against potato tuber moth in storage seed potatoes appeared to be both intricate and fruitful. The applied treatments chlorantraniliprole, *Bacillus thuringiensis*, and spinosad were determined to be the most effective pesticide for reducing the population of potato tuber moths in order to assess the performance of pesticides. All of the pesticides were successful in lowering the quantity of insects in the laboratory when compared to the control group, but the length of exposure and concentration had a direct impact on how effective they were.

From the larval stage on, chlorantraniliprole showed promise in combating the potato tuber moth. Its high efficacy % against the moth at all stages following the insertion of larvae in the tubers demonstrated the insecticide's immediate action. The total result showed that Chlorantraniliprole had the greatest fatality rate (100%). Fewer galleries were noted, there were fewer adult emergences, and the low tuber infestation caused less harm. Driven by Rynaxypyr, an off-white, semi-viscous liquid, chlorantraniliprole is a new insecticide belonging to the anthranilic diamide class. It provided fair control across all larval instars.

After chlorantraniliprole, spinosad was the second most effective medication. About 81% of the efficiency against potato tuber moth is attributed to it. Spinosad is used to manage a variety of pests that are lepidopteran and affect vegetables. According to Gomaa and El-nenaey (2006), spinosad exhibits control on potato tuber moth infestations and gallery numbers at the specified dosage. Implementing Spinosad in integrated management of potato tuber moths could offer a more enduring solution for managing this pest in potato stores. In reality, the primary new pesticide employed in the INRPSS to combat potato tuber moth and reduce both quantitative and qualitative potato losses during the summer is spinosad.

In the trial, *Bacillus thuringiensis* demonstrates a 70% efficiency against the potato tuber moth. Bacillus thuringiensis's increased sensitivity to temperature and humidity in the environment may be the cause of its reduced toxicity effects when used alone against the potato tuber moth larval stage. According to Sahid *et al*. (2021), seed potatoes treated with the recommended dosage of *Bacillus thuringiensis* before storage can significantly lower the rate of potato tuber moth infestation. *Bacillus thuringiensis* functions as a pesticide by generating a crystal-shaped protein (Cry toxin) that kills specific insects.

Bojho, the other insecticide under examination, exhibits high tuber infestation, high adult emergence rates, high mortality rates, and extremely destructive percentages in potato tubers. Because the larvae mortality's toxicity was so low, it could be disregarded and was discovered to be roughly 50%. In case of the potato tuber moth in the experiment, the larva was introduced in the bojho-treated containers closed by a cap so the larvae could not escape and it infected the potato by damaging its tubers. However, bojho acts as a repellent in nature and affects the insects in its reproductive potential, so it doesn't let insect harm. Bojho is the most effective treatment against potato tuber moths, as demonstrated by other research; nonetheless, in our investigation, the damage percentage was observed at the highest ratio. The fact that fewer tubers were discovered to be rotting may be the cause of the lower damage percentage shown in the results when compared to previous outcomes.

Since no treatments were used, the untreated control group appeared to be the most impacted by the potato tuber moth infestation. The results at the damage, infestation number, and adult calculation decreased because there were fewer rotting potato tubers seen; however, the control showed the maximum amount of infestation and gallery number. The results show that the potatoes were injured, which accounts for the increased larval intensity. Chlorantraniliprole, Spinosad, and *Bacillus thuringiensis* can be recommended as very good, safe alternative novel pesticides against potato tuber moth based on a comparison of the percentage of larval mortality of the four pesticides. Recommendations for the best-performing treatment are required because the effectiveness of the therapies depends heavily on the climate. Farmers may find this experiment useful in controlling potato tuber moths in the field and storage conditions as it employs a variety of pesticides with varying modes of action, the majority of which offer good to outstanding control.

Conclusion

According to our research, spinosad, and chlorantraniliprole appeared to be quite efficient against potato tuber moths and can be recommended for use in opposition to them while stored. While Bojho and *Bacillus thuringienesis* can be employed against the Potato tuber moth in storage conditions, their effectiveness looked to be lower than that of the other insecticides. Nevertheless, the results appeared to be good. Since these insecticides appeared to be most effective when stored seed potatoes were being protected from potato tuber moths, they can be used successfully in field settings. It has been shown that controlling potato tuber moths with these pesticides at the suggested rate and treatment method is cost-effective and lucrative. More research must be done on the new chemicals used to combat potato tuber moths.

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References
1. Ajamhasani M, Salehi L. Effect of three non-cultivated plants on host preference and on oviposition rate of the potato tuber moth (*Phthorimaea operculella*). Journal of Agriculture Sciences. 2004;1(5):112-119.
2. Alyokhin A, Rondon S, Gao Y. Insect pests of potato: global perspectives on biology and management. Academic Press; c2022.
3. Anonymous. Potato tuber moth (Lepidoptera: Gelechiidae), South Africa: Pests of field crop South Africa; c2011.
4. Aryal S. *Phthorimaea operculella* (Zeller). EPPO Bulletin. 1981;11(1):1-6.
5. Chandel R, *et al*. The potato tuber moth, *Phthorimaea operculella* (Zeller), in India: biology, ecology, and control. Potato Research. 2020;63(1):15-39.
6. Galvan T, Koch R, Hutchison W. Effects of spinosad and indoxacarb on survival, development, and reproduction of the multicolored Asian lady beetle. Biological Control. 2005;34(1):108-114.
7. Gamal E, Hanem S, Hagar A, Moustafa N. Sublethal effect of spinosad on the cotton leaf worm (Lepidoptera: Noctuidae). Journal of Plant Protection Research. 2013;53(3):275-284.
8. Ghimire N. Adoption of improved potato technology in Chitwan, Nepal. Economic Journal of Nepal. 2005;28(3):188-199.
9. Isolate G, Aryal S. Kathmandu: submitted to the Tribhuvan University Institute of Agriculture and Animal Science Rampur, Chitwan, Nepal; c2011.
10. Kalika U, *et al*. Storability of potato varieties under ordinary storage condition in Panauti, Nepal. Sustainability in Food and Agriculture; c2020.
11. Kroschel J, Koch W. Studies on the use of chemicals, botanicals, and *Bacillus thuringiensis* in the management of the potato tuber moth in potato stores. Crop Protection. 1996;15(2):197-203.
12. Kroschel J, Schaub B. Biology and ecology of potato tuber moths as major pests of potato. In: Insect pests of potato: global perspectives on biology and management. Elsevier; c2013, p. 165-192.
13. NARC. Entomology Division, National Agricultural Research Institute Annual Technical Report. Nepal Agricultural Research Council; c2005, p. 16.
14. Niroula S, Vaidya K. Efficacy of some botanicals against potato tuber moth, *Phthorimaea operculella* (Zeller, 1873). Our Nature. 2004;2(1):21-25.
15. Pandey N, *et al*. Advances in quality potato production and post-harvest management. S.L.: S.N.; c2016.
16. Raman K. Control of potato tuber moth *Phthorimaea operculella* with sex pheromones in Peru. Agriculture, Ecosystems & Environment. 1998;21(1-2):85-99.
17. Rondon S, Gao Y. The journey of the potato tuber worm around the world. In: Moths-pests of potato, maize, and sugar beet. Intech Open; c2018, p. 17-52.
18. Sansimemea E. Discovery and description of *Bacillus thuringiensis*. *Bacillus thuringiensis* Biotechnology. 2012;3-18.
19. Sileshi G, Teriessa J. Tuber damage by potato tuber moth, *Phthorimaea operculella* Zeller (Lepidoptera: Gelechiidae), in the field in eastern Ethiopia. International Journal of Pest Management. 2001;47(2):109-113.
20. Sunil A, Chuleui J. IPM tactics of potato tuber moth. Department of Bioresource Sciences, Graduate School, Andong National University, Korea; c2015.
21. Timsina K, *et al*. Returns to potato research investment in Nepal. Journal of Agriculture and Natural Resources. 2019;2(1):1-13.
22. Upadhyay N, Ghimire Y, Sharma B. Adoption of improved potato varieties in Nepal. Black Sea Journal of Agriculture. 2020;3(2):139-145.