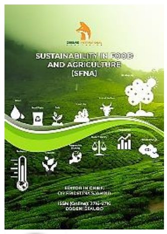
ZIBELINE INTERNATIONAL™ PUBLISHING
ISSN : 2716-6716 (Online)
CODEN: SFAUBO

Sustainability in Food and Agriculture (SFNA)

DOI: http://doi.org/10.26480/sfna.01.2022.11.14



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RESEARCH ARTICLE

A STUDY ON EFFICACY OF DIFFERENT PESTICIDES AGAINST POTATO TUBER MOTH (*PHTHORIMAEA OPERCULELLA*) IN STORAGE SEED POTATO

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ARTICLE DETAILS

Article History:

Received 15 September 2021
Accepted 18 October 2021
Available online 22 November 2021

ABSTRACT

Mass rearing of potato tuber moths was conducted in a biocontrol laboratory to seek out appropriate management for the pest. The larvicidal efficacy of insecticides was studied by using four insecticides Bojho, Emamectine benzoate, Spinosad, Neem. The study discovered the effectiveness of all the insecticides, however the three pesticides had higher efficacy compare to Neem. The overall result indicates the highest mortality rate in treatments Bojho (100%), Emamectine benzoate (100%), and Spinosad (100%) whereas the lowest mortality rate in treatment Neem (94%). The infestation was conjointly high in Neem compare to the other three pesticides. To examine the efficacy of pesticides against PTM the applied treatments Bojho, Emamectine benzoate, and Spinosad was found to be the best insecticide among the trials in bringing down the PTM population as Neem showed to be less effective out of the total four pesticides applied. All the pesticides were effective in reducing insect population under laboratory conditions; however, their effectiveness was directly proportional to concentration and exposure periods. The study has demonstrated the possibility of using novel compounds in the IPM program.

KEYWORDS

Bojho, Emamectine benzoate, Spinosad, IPM, Bio-pesticides

1. INTRODUCTION

Potatoes were originally introduced to Nepal in 1793, though it remained a small crop for the next 180 years, some researchers say that its early introduction to the high-altitude Himalayas helped fuel the increase of Buddhist civilization in northern Nepal. After rice, the potato is currently Nepal's second most important food crop, with per capita consumption nearly doubling to 51 kilograms per year since 1990. Within the 1970s, a national potato development program focused on improving the standard of seed potato which stimulated a rapid expansion of both cultivated area and production of potato, which increased from 300000 tons in 1975 to a record 1.97 million tons in 2006.Potato occupies the fifth position in the area, fourth in production, and first in productivity in Nepal with its cultivation in 143027 ha of land, 1643357 Mt productions, and 11.48 Mt/ha productivity, respectively (Tiwari et al., 2006). Potato is one of the important vegetable crops in Nepal, it is used as secondary food as part of vegetables in the terai region, whereas as a staple food in Hill and Mountain Regions of Nepal. It's an advertisement non-cereal product of Nepal and a vital supply of financial gain for the farmers (Aryal and Simkhada,2020).

Post-harvest losses were considerably high in South-Asian countries; India and Bangladesh incurred 24 and 20% losses while in Nepal it was as high as 25%. Losses in storage are caused by one of the notorious pest potato tuber moths, P. operculella (Zeller) (Lepidoptera: Gelechiidae), which is one of the major hosts of potato along with other various solanaceous crops like tomato, eggplant, and others (Aryal and Simkhada, 2020). The potato tuber moth (PTM), P. operculella, is one of the destructive pests in tropical and subtropical countries, it is considered as one of the damaging and ubiquitous pests of solanaceous crops especially potato Solanum tuberosum L (Sporleder et al., 2004). Potato Tuber Moth must have been introduced in Nepal when potato varieties were brought for adaptive research from India to Kathmandu under the Indian Aid Mission program during the early sixties. PTM has been reported in Nepal from more than 15 districts including high altitudes (Aryal and Simkhada, 2020). P. operculella is presumably originated in Western South America together with its main host, the potato (Rondon, 2010). In South-Central Asia, it's believed that P. operculella was introduced in 1906 to metropolis, India, from Italy (Lefroy 1907).

PTM larvae can mine leaves, stems, petioles or tubers, and cause serious damage to potato plants within the field likewise as potato tubers in storage (Zheng et al., 2020). Through mining into tubers, the PTM larvae cause severe damage to stored potatoes that lead to rotting of potato by penetration of fungal and bacterial agents (Rafiee-dastjerdi et al., 2013). Although insecticides square measure effective against foliar infestation by tuber moths (Foot,1974a,1976a) however cannot directly prevent tuber infestation (Foot, 1979). Instead, alternative management practices got to be practiced to guard soil conditions that square measures vital within the protection of developing tubers (Foot, 1974b; 1976b). The most effective management choices are also the incorporation of host plant resistance alongside insectides and acceptable biological and cultural practices, like covering hills, irrigation, and limitation of exposure time within the field (Rondon, 2010).

Quick Response Code	Access this article online	
	Website: www.sfna.org.my	**DOI:** 10.26480/sfna.01.2022.11.14

Cite The Article: Reshu Basnet, Aakash Adhikari, Garima Bhandari, Resona Simkhada (2022). A Study On Efficacy Of Different Pesticides Against Potato Tuber Moth (Phthorimaea Operculella) In Storage Seed Potato. *Sustainability In Food And Agriculture, 3(1): 11-14.*

Although P. operculella is considered as primarily a pest of potato, it can also be found in other solanaceous plants such as eggplant (Solanum melongena L.), tomato (Solanum lycopersicum L.), black nightshade (S. nigrum L.), silver leaf nightshade (S. elaegnifolium Cav.), chili pepper (Capsicum frutescens L.), tobacco (Nicotiana tabacum L.), cape gooseberry (Physallis peruviana L.), field ground cherry (Rondon, 2010). PTM damage under field and storage conditions ranged from 20-30% in normal conditions whereas harvesting the potato at peak infestation period together with improper storing conditions end up in 25 to 100 % damage (Aryal and Simkhada, 2020). This study was carried out to devise a suitable control measure against potato tuber moth with the use of novel pesticides and also to study the efficacy of pesticides against Potato Tuber Moth (P. operculella) in storage seed potato.

2. Materials and Method

A field experiment was conducted to evaluate the efficacy of different pesticides against Potato Tuber Moth (P. operculella) in storage seed potato. Potato tuber moth was mass-reared at the laboratory of the Entomology Division Khumaltar, Lalitpur, of the Nepal Agriculture Research Council (NARC); from 13th April to 14th May 2021. Mass rearing of P. operculella was performed in a laboratory setting by maintaining appropriate temperature, and sanitary conditions. The rearing was initiated with potato tuber moth-infested potato tubers collected from a different field (Kavre, Dhading, Lalitpur). The tubers were placed in a plastic box (30x23x14.5 cm), which was partially filled with fine sterilized sand, and incubated at ambient temperature (±27ºC).

Then, the newly hatched larva of P. operculella was placed in a P. operculella rearing plastic box, open end of the rearing box was covered with a black cloth until pupae developed. Pupa developed inside the puparium from larva within 15 to 16 days after eggs were placed in the rearing box which transformed into adults within about 12-16 days, and these adults were collected with the help of a glass tube. Four different pesticides; Bojho, Emamectine benzoate, Spinosad, and Neem were selected and for control water spray was used for testing the efficacy which is described below in Table 1. The pesticides were brought from the Agro vet near NARC, Khumaltar. Each potato tuber was dipped in a solution of the recommended dose of pesticide as well as in water solution for 30 seconds and left for air drying. Total 25 larvae each which emerged from the adult during the mass rearing of PTM in a laboratory were used for the study by using camel hairbrush. The total damage made by larva during feeding on potato tuber was counted and total adult emergence was noted after 30 days. Following different pesticides and control used in the experiment against P. operculella at Khumaltar, Lalitpur.

Table 1: Description of different pesticide and control used in the experiment against P. operculella

S. no.	Treatments	Mode of action	Concentration (rate)
1	Bojho (*Acorus calamus)*	Repellent activity, interstitial cell activity, antifeedant and growth inhibitory effects	2gm/ltr
2	Emamectin benzoate	Chloride channel activators, penetrates leaf tissues (translaminar activity) and forms a reservoir within the leaf.	0.4gm/ltr
3	Spinosad	Nicotinic acetylcholine receptor agonists (allosteric)	0.3ml/ltr
4	Azadirachtin (*Azadirachta indica)*	Antimicrobial effect, antifeedant	5ml/ltr
5	Control	-	5ml/ltr

2.1 Statistical analysis

Data obtained for respective study parameters were evaluated employing one-way analysis of variance (ANOVA) to check for significant differences between the various treatments. The obtained results were submitted to variance analyses and the mean values were compared by Duncan's test. Significant differences (p=0.05) were calculated by the program: Genstat. The death rate was calculated as the Number of dead moth's /treatments total number of moths × 100.

3. Result and Discussion

From the application of different pesticides against PTM the death rate observed in three pesticides was high out of a total of four pesticides.

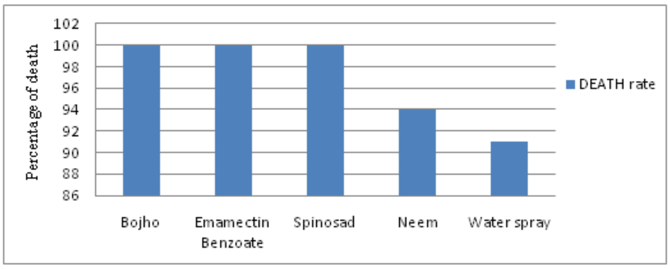

Figure 1: Death rate of potato tuber moth

It indicates the high protection was caused by Bojho, Emamectine benzoate, and Spinosad as they gave complete protection to the treated tubers. Next to the untreated control, the highest PTM number was recorded from Neem. The rest treatments were equal in the total number of PTM death rates captured during the entire research. Similarly, the maximum number of adult PTM emerged from the untreated control (total 8, average2). On the contrary, the lowest PTM population emerged from seed potato collected from Bojho followed by Emamectine benzoate and Spinosad. Among all treatments, seed potato collected from Neem harbored the highest PTM population (8). During the total 30 days as observed the date rate of Neem was lower compare to the other three pesticides. The death rate of Bojho, Emamectine benzoate, and Spinosad was seen high than in Neem.

Table 2: Average no. of eye and average no. of infested eye (SE±) on potato by potato tuber moth when treated with different pesticides along with water control

Treatment	Average no. of eyes	Average no. of infested eye
Bojho	11a(±1.080)	0.000a
Emamectine benzoate	9a(±1.225)	0.000a
Spinosad	11a(±1.414)	0.000a
Neem	8.75a(±1.797)	3b(±1.354)
Control	13.75a(±2.496)	7.25c(±0.854)
d.f	4	4
Grand mean	10.7	2.05
Lsd	5.066	2.158
Cv%	31.4	69.8

The infestation was observed to be reduced in all insecticides treated plots in all samplings compared to untreated control. The potato infestation was found significantly different among the tested seed potato due to the use of different pesticides. The high infestation was found in Neem whereas the least was found in Bojho followed by Emamectine benzoate and Spinosad. All the four pesticides (Bojho, Emamectine benzoate, Spinosad, and Neem) tested significantly at P=0.05 inhibited the effect of pesticide against PTM in storage seed potato compare to control. The findings demonstrate that the highest infestation was observed in potato tuber treated with Neem as compared to Bojho, Emamectine benzoate, and Spinosad. According to table 2 different letter signifies that the pesticide is significantly different and similar letters signifies that the pesticides are not significantly different with each other at p-value <0.001. The test of pesticides for an average number of eyes was statistically non-significant for the average number of an eye was cv=31.4, F=1.43; d.f=4; P=0.272, whereas the test for an average number of an infested eye was statistically significant cv=69.8; F=19.78; d.f=4; P<0.001. The following result demonstrates that the eye infestation was high in Neem than on any other pesticide i.e. Bojho, Emamectine benzoate, and Spinosad. Among the four pesticides used to treat PTM in storage seed potatoes the least effective was found to be Neem. Most effective was found to be Bojho, Emamectine benzoate, and Spinosad respectively.

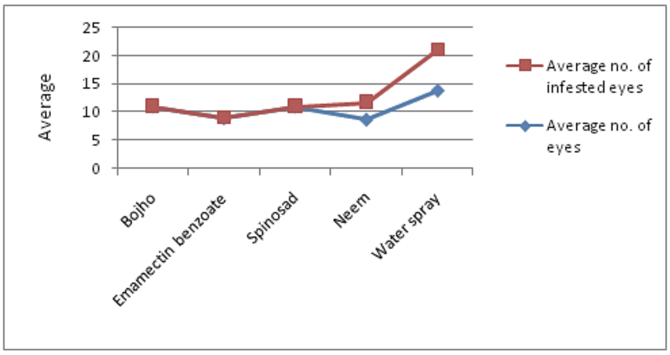

Figure 2: Relation between average numbers of eyes and average no. of infested eye

Table 3: Average length of tunnel and average no. of tunnel (SE±) on potato by potato tuber moth when treated with different pesticides along with water control

Treatment	Average length of Tunnel	Average no. of Tunnel
Bojho	0.000a	0.000a
Emamectine benzoate	0.000a	0.000a
Spinosad	0.000a	0.000a
Neem	7.860b(±2.699)	4.25b(±1.652)
Control	12.04c(±1.465)	6.5b(±0.289)
d.f	4	4
Grand mean	3.98	2.15
Lsd	4.140	2.261
Cv%	69.0	69.8

As shown above-average number of the tunnel and total tunnel length per tuber were highly significant. All insecticide treatments resulted in a lower root tuber damage level when compared to the untreated control. The result in table 3 demonstrates among the four pesticides used against the PTM control in storage seed potato Neem was highly affected by the PTM. The number of tunnels and the length of the tunnel is high compare to the other three pesticides. Both the number of tunnels and total tunnel length made by potato tuber moth was counted and measured in all the treated potato. The test of pesticides against potato tuber moth was statistically significant for both average length of tunnel F=16.90; d.f=4; P<0.001, CV=69.0 and for an average number of tunnel F=16.53; d.f=4; p<0.001, CV=69.8. The highest number of tunnel and highest number of total tunnel length was found in seed potato treated with Neem other than water control. Root tubers collected at the end of research were free from damage except for Neem. Observation, at last, reveals that Neem recorded the highest tuber damage next to the untreated control and the rest of the insecticides recorded similarly lower tuber damage.

Table 4: Adult moth emergence (SE±) on potato by potato tuber moth when treated with different pesticides along with water control

Treatment	Total adult moth emergence
Bojho	0.000a
Emamectine benzoate	0.000a
Spinosad	0.000a
Neem	1.5b(±0.645)
Control	2b(±0.577)
d.f	4
Grand mean	0.75
Lsd	1.167
Cv%	110.7

While conducting the research occurrence of PTM in the treated tuber was seen highly in Neem other than the untreated control. Neem exhibits the highest populations of PTM while there was no emergence of PTM in seed potato treated with other three different pesticides. From the treatments the emergence of PTM was high in Neem total of 6 moths (3 females, 3 male), there were no signs of moth from the three other treatments. Untreated control showed the highest number of moth emergence i.e.8 (5 females, 3 male). The result in table 4 demonstrates the total adult emergence among the four pesticides Bojho, Emamectine benzoate, Spinosad, and Neem used against the PTM control in storage seed potato. Neem was the least effective during the treatment. During the observation, the moth emergence rate was high in Neem other than control. The test of pesticides was statistically non-significant for an average number of moth emerged F=6.33; d.f=4, P=0.003, cv =110.7.

The research conducted to test the efficacy of pesticides against PTM in storage seed potato seemed complex as well as promising. To check the efficacy of pesticides against PTM the applied treatments Bojho, Emamectine benzoate, and Spinosad was found to be the best insecticide in bringing down the PTM population. When compared to the control, all the pesticides were effective in reducing insect population under laboratory conditions; however, their effectiveness was directly proportional to concentration and exposure periods. The overall result indicated the highest mortality rate in treatments Bojho (100%) for application rate of 2gm/ltr, Emamectine benzoate (100%) for application rate of 0.4gm/ltr, and Spinosad (100%) for application rate of 0.3ml/ltr whereas the lowest mortality rate in treatment Neem (94%) for application rate of 5ml/ltr. The least effective pesticide seemed to be Neem as a total of 6 moths emerged from the treated seed potato and the infestation was also seen at the highest level compared to the other three treatments.

The effects of these two treatments L. neesiana and A. calamus persist for long periods, which cause high percentage mortality of larvae and less adult emergence in the first generation. A. calamus seems to be the best alternative of the chemical pesticides and recommended to use 5% w/w weekly for the control of Potato tuber moth in storage potatoes (Niroula and Vaidya, 1970). Based on the review by it is possible to say that spinosad has a slight effect on the natural enemies, but shows a more negative effect on parasitoids (Biondi et al., 2012). A studied the result of Spinosad on arthropod genus (Lepidoptara: Gelechiidae) and there of natural enemies by comparision with effects of some artificial insecticides (Ghosh et al., 2010). The results of the study showed that Spinosad is effective against the pest and safe. A group researchers announced in a study about the efficiency of 11 different larvicides on newly emerged and older larvae of Tuta absoluta under controlled laboratory conditions that Spinosad had an extreme effect on the pest (Nannini et al., 2011).

A studied the effectiveness of two bio-pesticide, Emamectin benzoate, and Spinosad against larval stages of T. absoluta under laboratory conditions (Gacemi et al., 2016). Their results showed that the Emamectin benzoate and Spinosad were very effective on larvae of T.absoluta. The Emamectin benzoate caused complete mortality of treated larvae. Neem manifests low toxicity on many parasitoids, so they successfully finished their growth and flew out from mummified hosts. It was also proved that Neem applied in small doses had no negative effect on parasitoids of harmful insect species even in glasshouses (Hoelmer et al., 1990). The toxicity of Neem is highly negligible compare to the other three treatments. The larvae of PTM treated with Neem probably die because of starvation due to the antifeedant effect of Neem on P. opercullela. A high index of Neem antifeedancy was conformed throughout the research.

According to this, bio-insecticides used in the present study had an important effect on larvae of PTM and were highly effective on the achievement of pupation and adult emergence of larvae. It's attainable to mention in line with the results obtained from the current laboratory test that bio-insecticides could have a possible use rather than artificial insecticides in dominant the pest. However, these results should certainly be supported by large-field experiments. In cases of necessarily chemical application, the usage of bio-insecticides instead of synthetic ones is more appropriate in terms of ensuring successful control, environmental pollution, and human health. Plants have been reported to have photochemical which act as chemical defenses against herbivores and other organisms in the environment (Nta et al., 2018). Some plants produce chemical substance for their defense which is poisonous and indigestible to pest (Herms and Matson, 1992).

Chemical defense is classified into two categories: quantitative defense, with mass production of indigestible substance, and qualitative defense with limited production of a toxic substance (Fenny, 1976). So, their effectiveness against different treatments differs according to the nature of pesticides and their application dose. According to our results, it is suggested that all three pesticides i.e. Bojho, Emamectine benzoate, and Spinosad could be highly effective against the PTM. Due to the high effectiveness of bio-pesticides against the PTM, it is recommended to use this pesticide for treatment in storage conditions as well as in field conditions with proper measures. Eventually, based on our results it could be concluded that the treatment of potato tubers with environmentally friendly pesticides can help in having a healthy product.

4. Conclusion

As per the study Bojho, Emamectine benzoate, and Spinosad seemed highly effective bio-pesticides so these pesticides can be suggested against Potato Tuber Moth in storage conditions. Though Neem was least effective among the other pesticide its final result was satisfactory and can be suggested to use against the PTM in storage conditions with a slight increase in dose. These pesticides could be successfully applied under field conditions as the pesticides seem to be much more effective in the laboratory against PTM. Field experiments under different environments, field sizes, and moth densities will be required to approve its applicability under practical conditions. A further potential application of this technology can be found in protecting potato tubers in storage from PTM losses. Moreover, based on the criteria of cost, effectiveness, and availability, Bojho is recommended to be the best pesticide for effective management of PTM as it is revealed to be the cheapest, the most effective, adequately available in the market, and can be grown in own household. Check efficacy of pesticide against PTM the applied treatments Bojho, Emamectine benzoate, and Spinosad were found to be the best insecticide in bringing down the PTM population.

Acknowledgment

We express the deepest sense of gratitude to Prof. Dr. Binayak Prasad Rajbhandari, Executive Chairperson of Himalayan College of Agricultural Sciences and Technology (HICAST), Chief of National Entomology Research Center (NERC), Nepal Agricultural Research Council (NARC), and the team for their encouragement and excellent guidance throughout the research duration

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