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A Study on the Efficacy of Different Botanicals Against Potato Tuber Moth (Phthorimaea Operculella) in Stored Potatoes

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Abstract

The Potato Tuber Moth (Phthorimaea operculella) is a destructive pest that poses a significant threat to stored potato crops, leading to substantial economic losses worldwide. The use of chemical insecticides to control this pest has drawbacks such as environmental pollution and potential harm to human health. As a result, it is critical to investigate alternate control strategies, such as botanical extracts. This study aimed to evaluate the efficacy of different botanicals, Azadirachta indica (Neem), Acorus calamus (sweet flag), Sapindus mukorossi (Soapnut) and their combination against the Potato Tuber Moth in stored potatoes. The research followed a randomized sampling technique, with seven treatments {T1: sweet flag (100%), T2: Neem (100%), T3: neem (50%)+ soapnut(50%), T4: soapnut powder (100%), T5: sweet flag (50%)+ Neem (50%), T6: sweet flag (50%)+ soapnut(50%), T7: control }. The treatments were applied to potatoes and data were observed, recorded, and tabulated. Our results showed that there was not a huge difference in the final result of mortality in all the treatments, all showing similar results. But when observed by counting the time factor, Acorus calamus outsmarted other bio-pesticides by killing 100% of insects in much less time. Further, all the treatments significantly affect the weight loss of potato tuber. Potato tuber treated with T1 showed the least weight loss of 1.88% of total weight followed by T6 and T4 with 2.56% and 2.58% of weight loss respectively. There was also some weight loss in the untreated potatoes due to evaporation and other physical factors. To sum up the overall result of our study, the experiment concluded that Acorus calamus (T1) had given the best result and thus it stood to be the best bio-pesticide among all.

Keywords: PTM, Storage, bio-pesticides, weight loss, Acorus calamus

1. Introduction

Potato is the third most consumed food after rice and wheat, with a global production of 359 Million Tones (MT). China is the world's top potato producer, followed by India. (FAO stat, 2020). It is a Nepalese commercial non-cereal product and a significant source of revenue for farmers (Upadhyay et al., 2020).

Recent data shows that the area, production, and productivity of potatoes in Nepal are 195,173 ha, 2,881,829 tons and of 14.7 t/ha, respectively during the year 2017/18 (MoALD, 2019). Losses due to insect pests in potatoes are estimated to be 16 percent on a global scale (Oerke et al.,1994). In South-Asian nations, post-harvest losses were quite severe. India and Bangladesh suffered losses of 24 and 20 percent, respectively, while Nepal suffered a loss of up to 25 percent (Prasad et al., 1989; Karki, 2002; Satter et al., 2002). The potato tuber moth, Phthorimaea operculella (Lepidoptera: Gelechiidae), which is the main host of potatoes, is among the most well-known pests, causing losses in storage (Kroschel & Koch, 1994). It causes serious damage to potato crops in fields and storage (Arnone et al, 1998) as well as in marketing (Rondon, 2010). Presence of PTM in storage causing yield losses up to 100% (Joshi 1989; Rondon, 2010).

In both field and storage conditions, the larva tunnels and feeds on potato leaves and tubers (Joshi, 1989, 2004; Raman and Radcliffe, 1992) by digging uneven tunnels, this pest leaves excreta behind, resulting in a significant yield loss (Herman et al, 2005). It causes harm by tunneling and feeding, which usually results in rotting due to bacteria/fungi infestation, rendering it unsuitable for ingestion. In the field, the delay in harvesting might result in highly damaged tubers (Alvarez et al., 2005).

Insecticides are a common approach used to manage pest populations (Kljajić and Perić, 2006). Excessive and permanent use of chemical insecticides resulted in the appearance of resistant insects, contamination of ecosystems, and food and feed (Kljajić and Perić, 2006). Insecticides can have economic and environmental consequences (Kljajić and Perić, 2006). Because pesticides failed to suppress tuber infestation by larvae of the potato tuber moth Phthorimaea operculella (Foot, 1974), the prospect of adopting cultural practices as control techniques were studied. Botanical pesticides are an essential part of current pest management technology since they are the safest, easiest, and slow but most efficient methods of managing the majority of pests, including PTM. All of this necessitates the development of bio-insecticides that are both environmentally friendly and ensure food safety (Pavela, 2008; Vučinić et al., 2011). The purpose of this study was to develop an appropriate control method against potato tuber moth using novel pesticides, as well as to investigate the efficacy of pesticides against Potato Tuber Moth (P. operculella) in storage seed potatoes.

Many researchers have discovered that wild medicinal and ornamental plants have pesticide characteristics that function as antifeedants, repellents, growth regulators, and/or toxicants against a variety of insect pests (Sharaby, 1988; Onu et al. 2015 and Chandel et al. 2018). The current research aims to assess the potential for three plant extracts to be used as biopesticides against PTM, giving protection to stored tubers in stores and through marketing, as well as the duration of their use for damage prevention.

2. Research Methodology

2.1 Experimental sites

An experiment was conducted at the experimental lab, Department of Entomology, Gokuleshwor Agriculture and Animal Science College, Dilasaini, Baitadi from 13th April to 2nd July 2021, situated at 29.6880°N latitude and 80.5494°E longitude at an elevation of 850 masl.

2.2 Procedure for trails

Mass rearing of P. operculella larva was performed in a laboratory of Gokuleshwor Agriculture and Animal Science College, Baitadi. Potato tubers infested with the potato tuber moth were taken from the locality and were carefully arranged within plastic boxes with sterilized sand. The tubers were subjected to controlled incubation conditions (27 ± 5 °C, 75 ± 5% RH, and 16-hour photoperiod) for about 25-30 days until adult emergence. After adult emergence, filter papers were placed in the insect-rearing boxes as oviposition sites, and the adults were provided with a diluted honey solution for feeding. The filter papers, containing the eggs, were changed daily and collected every 24 hours. These collected eggs were then frozen at 10°C, ensuring an adequate supply of larvae after a week for the experiments. For the experiment, 500g experimental potato tubers of each sample were artificially infested with potato tuber moth (PTM) larvae using the fine brush at the rate of 350 larvae per 1kg tuber, and tissue papers were used for better visualization of larvae. The botanical treatments were given on the same day of the infestation.

2.3 Sampling technique and size

A random sampling technique was used for the study. Six samples of potatoes each weighing 500g were placed in plastic boxes.

2.4 Preparation of Plant Extracts

a. Preparation of Acorus calamus (calamus, sweet flag, sweet sedge, Bojho)
   Acorus calamus was bought from the local market. It was then dried in the shade for a week to boost effectiveness before being crushed into powder with a grinder. The fine powder was spread over the stored potatoes at the rate of 5 g/kg potatoes.
b. Preparation of Azadirachta indica (nim or Indian lilac, Neem)
   Azadirachta indica oil, when concentrated, might have affected the potato tubers. In order to ensure proper use it was prepared by being diluted to 0.2%, i.e. 2 ml per liter of water.
c. Preparation of Sapindus mukorossi (soapnut, soapberry, Ritha)
   Sapindus mukorossi was collected from the local village. It was then dried for a week in the shade before being ground into a powder using the grinder.

2.5 Application

- Acorus calamus was applied in the form of powder. It was applied at 150 g per 100 kg potato tubers in different layers of the tubers. 100% of A. calamus was applied in T1 and 50% in T6 and T7
- Azadirachta indica oil was diluted and sprayed in all parts of the potato tubers. 100% of A. indica used in T2 and 50% in T3 and T5
- Sapindus mukorossi was also applied in powdered form. It was applied at 200 g per 100 kg potato tubers in different layers of the tubers. 100% of S. mukorossi is used in T4 and 50% in T3 and T6.

2.6 Interval of observation

The potatoes stored were observed at a regular time interval of 1 week to measure the weight loss. Moreover, the potatoes were monitored daily to see the cases of larval mortality around the spot.

2.7 Data Collection

The mortality rate of Phthorimaea operculella larva was recorded every 24 hours whereas weight loss of potatos was recorded in every 1 week in grams and collected in a tabulated manner. The mortality of larvae was calculated in percentage for each sample differently. The percentage is calculated by the formula:

percentage larvae dead = dead larvae * 100% total larvae sample

2.8 Statistical analysis:

Data were entered in MS-excel 2016 and were subjected to 1-way analysis of variance (ANOVA) using R-Studio. Duncan's multiple range test (DNMRT) was done to compare the set of means between the treatments which are significantly different.

3. Results and Discussion

3.1 Result

The resul can see in the Table 1.

Table 1: Effect of different botanicals on mortality percentage of Phthorimaea operculella larvae in indicated days

Treatments	Botanicals	Larval mortality percentage after indicated days					
		first day	second day	third day	fourth day	fifth day	sixth day
T1	Sweet flag powder (100%)	35^{a}	60^{a}	90^{a}	100^{a}	100^{a}	100^{a}
T2	Neem oil (100%)	0^{c}	15^{cd}	45^{bc}	55^{b}	75^{bc}	90^{a}
T3	Neem (50%)+ soapnut (50%)	5^{c}	15^{cd}	40^{c}	60^{b}	65^{c}	90^{a}
T4	Soapnut powder (100%)	10^{bc}	35^{b}	50^{bc}	70^{b}	85^{ab}	100^{a}
T5	Sweet flag (50%) + Neem (50%)	10^{bc}	20^{bc}	40^{c}	65^{b}	85^{ab}	90^{a}
T6	Sweet flag (50%) + soapnut (50%)	20^{b}	35^{b}	60^{b}	75^{b}	90^{ab}	100^{a}
Control	-	0^{c}	0^{d}	0^{d}	0^{c}	0^{d}	0^{b}
Mean		11.42	25.71	46.42	60.71	71.42	81.42
EMS		66.7	133.3	166.7	252.21	152	57
CV (%)		71.46	44.89	27.8	26.14	17.26	9.27
$LSD_{(0.05)}$		12.01***	16.97***	18.98***	23.34***	18.12***	11.10***

Percentage mortality of larvae PTMs was found to be high in Sweet flag (35%) as compared to other treatments on the first day of treatment, while neem oil and control showed no mortality at all. Sweet flag + soapnut has a much greater mortality rate (20%) than neem + soapnut (5%), whereas soapnut and neem + soapnut both had a mortality rate of 10%. As the time increased the value gradually increase (Table-2).

On the second day, there was a considerable death rate of 60% PTM larva in T1 whereas both soapnut and Sweet flag + soapnut has the mortality of 35%. The control group exhibited no mortality, the Sweet flag + neem, neem , and neem + soapnut groups indicated 20%, 15%, and 15% mortality, respectively.

On the third day, 90% of PTM in potatoes treated with Sweet flag died, whereas controls once more exhibited no effect. Acorus calamus + soapnut and neem + soapnut both showed 40% mortality while Acorus calamus + soapnut and soapnut alone showed 60%, 50%, and 45% mortality respectively.

On the final three days of treatment, Acorus calamus had a 100% mortality rate. Sweet flag + soapnut and soapnut had respective death rates of 75%, 90%, 100%, and 70%, 85%, and 100% on the 4th, 5th, and 6th days of treatment. Neem oil, neem with soapnut, and Acorus calamus + neem all resulted in 90% death, but control had no effect on any of the three days. Weight loss responses with different botanical materials after indicated weeks can see in Table 2.

Table 2: Weight loss responses with different botanical materials after indicated weeks.

		Weight loss (%)			
Treatments	**Botanicals**	**first week**	**second week**	**third week**	**fourth week**
T1	Sweet flag powder (100%)	0.61 ^{b}	0.94^{d}	1.26^{d}	1.88^{e}
T2	Neem oil (100%)	0.70 ^{b}	1.44^{cd}	1.80^{cd}	2.88^{cd}
T3	Neem (50%)+ soapnut (50%)	0.87^{b}	1.74^{bc}	2.28^{c}	3.47^{c}
T4	Soapnut powder (100%)	0.68^{b}	1.13^{cd}	1.60^{d}	2.58^{de}
T5	Sweet flag (50%) + Neem (50%)	1.17^{b}	2.09^{b}	2.96^{b}	4.43^{b}
T6	Sweet flag (50%) + soapnut (50%)	0.71^{b}	1.43^{cd}	1.79^{cd}	2.56^{de}
Control		2.60^{a}	4.87^{a}	9.23^{a}	15.06^{a}
Mean		1.05	1.95	2.99	4.69
EMS		0.63	0.18	0.16	0.35
CV (%)		75.94	21.91	13.65	12.59
$LSD_{(0.05)}$		1.17*	0.62***	0.60***	0.86***

The weight of potatoes was measured by using a weighing balance. In the first week, least weight loss is shown in Acorus calamus (0.61%) treated potatoes and more weight loss was seen in control (2.60%). The weight loss of neem oil, neem+ soapnut, soapnut, Acorus calamus +neem and Acorus calamus + soapnut were 0.70%, 0.87%, 0.68%, 1.17% and 0.71% respectively.

Acorus calamus treatment had the lowest weight loss in the second week, accounting for just 0.94% of the overall reduction. Neem, Acorus calamus + soapnut, and soapnut all produced results of the same kind, causing weight losses of 1.44%, 1.43%, and 1.13%, respectively. Bojo+neem reported a weight reduction of 2.09%, whereas neem+ soapnut reported a weight loss of 1.74%.

In the third week, neem + soapnut and Acorus calamus + neem both contributed to the largest overall weight loss of 2.96% and 2.28%, respectively. The subsequent results for neem and Acorus calamus + soapnut were 1.80% and 1.79%, respectively. Soapnut resulted in a 1.60% weight decrease. Acorus calamus, with 2.96% of the total weight lost, contributed the least weight loss.

Acorus calamus performed best during the final week of observation, with 1.88% of total weight loss. Acorus calamus + soapnut resulted in a weight loss of 2.56%, which was comparable to soapnut's 2.58% weight loss. Neem and neem+ soapnut caused weight loss of 2.88% and 3,47%, respectively. The combination of A. calamus and neem caused the greatest weight loss, which was 4.88%.

3.2 Discussions

It is clear from the laboratory experiment and the data analysis of the table that Acorus calamus was a biopesticide with extraordinary effects on insects. In just 4 days after the treatment, Acorus calamus killed the 100% PTM larvae. Although the EMS is often high because of the limited sample size of the larvae, there is no denying that the effectiveness of Acorus calamus in eliminating the insects is really incredible. It can be said that Acorus calamus has the most potential among the treated biopesticides for eliminating PTM insects in a laboratory setting. It can be said that Acorus calamus has the most potential among the treated biopesticides for eliminating PTM insects in a laboratory setting.

Even previous experiments, (Niroula and Vaidya, 2004; Pandey et al.,1982; Basnet et al., 2022) reported that the rhizome of A. calamus 5% w/w is very effective to control PTM in storage potatoes with 70%-100% mortality in stored potatoes. A similar result was obtained in another experiment where 1% emergence of PTM adult was observed in tuber treated with A. calamus whereas in control there was 56.43% emergence (Adhikari et al., 2022). Sweet flag powder's efficacy in this study is also comparable with prior research on its insecticidal activity against wheat weevil, with 98.33% mortality (Khanal et al., 2021). In another study, A. calamus outperformed Pirimiphos methyl and rotenone at 25 g/kg in suppressing Sitophilus oryzae in stored wheat (Umoetok and Gerard 2003). Similarly, (Chandel et al., 2020) observed that the A. calamus offers superior storage protection due to its deterrent and killing effects against insect infestation. (Giril et al., 2013) also found that applying A. calamus stolon dust @5 g kg^{-1} of tubers effectively protects tubers from PTM for four months in farmers' rustic potato stores. Also, findings from (Sharma et al., 1983; Rama, 1989; Trivedi and Rajagopal, 1992) suggest that neem extracts and oil exhibit potent oviposition deterrence and antifeedant activity against lst-instar larvae of potato tuber moth (PTM). Moreover, spraying tubers with aqueous neem seed extract and using jute sacks for storage significantly reduced PTM damage compared to traditional farmer practices in Sudan (Siddig, 1986). Shelke et al., (1987) also reported the effectiveness of neem oil (0.03-0.1%) in controlling damage caused by PTM during potato storage.

(Kroschel and Koch, 1996) stated that Larval mining in tubers reduced potato tuber weight and quality. Botanical Treatment can lower infestation and minimizes weight loss, but the actual impact depends on the infestation intensity. In the second experiment, the A. calamus demonstrates the potential to mitigate maximum physiological weight loss in stored potatoes. This happened as a result of reduced evaporation caused by the A. calamus dust covering the majority of the potato surface. In general, this is helpful in dealing with the loss in large storage. Less weight loss leads to more economic gain and distribution. Even in previous experiments, it was evident that A. calamus exhibited the lowest weight loss (12.11%), while the control group recorded the highest physiological weight loss (48.56%) (Adhikari et al., 2022).

To summarize the findings, A. calamus performed the best in terms of both eliminating the insect and controlling the weight loss of stored potatoes. A. calamus is the best-treated biopesticide, according to this testing.

4. Conclussion

According to the research, A. calamus, A. calamus + soapnut, and soapnut appeared to be highly efficient biopesticides, hence these pesticides can be recommended against PTM in storage conditions. Neem was the least effective pesticide, but it still produced a satisfactory outcome and can be recommended for use against PTM under storage conditions. PTM larvae have a significant risk of injury making a significant loss of potatoes that weren't treated. However, the harmful potential of the insects was reduced and caused less loss of potatoes after treatment with biopesticides than before. Furthermore, A. calamus is suggested as the ideal pesticide for managing PTM because it is found to be the least expensive, the most effective, and is widely available in the market. Likewise, it may be cultivated in one's own home. However, combining the biopesticides did not enhance their performance and mixing them did not result in a noticeable change.

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