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Efficacy of different plant extracts against potato tuber moth, *Phthorimaea operculella*

Primiya R Lyngkhoi • Kennedy Ningthoujam* • Mahesh Pathak • T. Rajesh • Veronica Kadam

College of Post Graduate Studies in Agricultural Sciences, Central Agricultural University (Imphal), Umiam, Meghalaya -793 103

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ABSTRACT

The efficacy of three different aqueous plant extracts, lantana (*Lantana camara*), black turmeric (*Curcuma caesia*) and lemongrass (*Cymbopogon* spp.) was evaluated under laboratory conditions. Three different concentrations; 5 %, 10 % and 15 % of the plant extracts were used for the bioassay. Potato and egg dipping methods were employed for studying the various biological parameters of potato tuber moth. The results of potato dipping method revealed that black turmeric at the highest concentration (15 %) was more effective than lemongrass and lantana against *Phthorimaea operculella* where larval mortality was 92.96 % with 3.33 % pupation and 3.33 % adult emergence. The damage index of tubers was 1.11 in 15 % black turmeric treated tubers. Whereas, in egg dipping, black turmeric extracts (15 %) resulted in 5 % egg hatching and there was no adult emergence. Among all the three botanical extracts, black turmeric was found to be very effective against *P. operculella* both in potato and egg dipping methods.

1. Introduction

Potato tuber moth, *Phthorimaea operculella* is a significant pest of potato that attacks the potato crop both in field and in storage conditions. The larva of the pest which affects the entire vegetative portion of the potato is the most destructive stage. In the field and during storage, the larvae consume potato tubers as well as leaves, stems and petioles.

The economic importance of PTM is mostly due to damage produced by larvae in potatoes under storage conditions (Chandel *et al*., 2008). The pest multiplies rapidly in storage and if the tubers are not treated, the PTM infection might cause catastrophic damage. A single larva is sufficient to cause damage to the tubers. By tunneling through potatoes and stuffing the tunnels with frass and webs, the tuber-eating larvae damage the potatoes. The tubers infected with PTM larvae are declared unfit for marketing. (Chandel *et al*., 2005). Potato is a readily consumable produce, thus, the approach of using synthetic insecticides is limited due to its various drawbacks such as persistence, non-specific toxicity and health hazards. Consequently, the need to search for newer methods or to employ earlier innovations with suitable modifications which are economical, effective and environmentally safe has deepened and use of plant products has gained worldwide attention. More than 600 plant species have been found to contain pesticidal qualities that are poisonous, antifeedant, and repellant to dangerous insects and pests (Ghosh, 1991). Botanical pesticides are a crucial part of contemporary pest management technology since they are the safest, simplest and slowest but most successful means of eradicating the majority of pests that are dangerous including PTM.

Thus, the current study has been undertaken to exploit the effects of the three different plant extracts which are commonly found in the Meghalaya region of North Eastern India.

2. Materials and Methods

The present study was carried out in the Entomology laboratory, School of Crop Protection, College of Post Graduate Studies in Agricultural Sciences, CAU (Imphal), Umiam, Meghalaya during the year 2021-22.

2.1 Insect strain

Infested tubers and adults of potato tuber moth were collected from ICAR-Central Potato Research Station, Upper Shillong, Meghalaya.

*Corresponding author: kennedy1982@gmail.com

2.2 Establishment and maintenance of insect colony

Potato tuber moth used in the experiment was collected from the storage rooms of ICAR-Central Potato Research Station, Upper Shillong, Meghalaya. The insects were reared in wooden rearing cages (45×45×54 cm). The infested tubers kept in the rearing cages were incubated at 25±2 °C with RH 70±5 %. After the completion of the larval stage, the pupae (with their cocoons) were collected. New clean tubers were introduced every twenty days to maintain the insect culture. The collected pupae were air-dried and placed in a cylindrical plastic container (10 x 3.5 cm) and covered with muslin cloths. After adult emergence, a filter paper (Whatman No. 1) was placed on the muslin cloth as oviposition medium. Cotton swabs with 5 % sugar solution was provided as a source of food for the adults. The filter papers containing the eggs were collected and were placed in clean plastic containers until hatching. Upon hatching, the neonates were provided with fresh tubers for second generation. In this way, the rearing cycle was continued to multiply the PTM for providing sufficient eggs for experiments (Aryal and Jung, 2018).

2.3 Plant material

The plants under study *viz.*, Lantana (*Lantana camara*), Lemongrass (*Cymbopogon* spp.) and Black turmeric (*Curcuma caesia*) were harvested and collected from the fields of CPGS-AS, CAU (I), Umiam, Meghalaya. The plants were cleaned and dried at room temperature (25± 1°C). The plants were then grounded into powder form and stored in containers.

2.4 Extract preparation

The method suggested by Mazrou *et al.* (2021) was undertaken to create the aqueous extracts of particular plants. 50 grams of crushed dried plant material was infused into 500 ml of boiled distilled water. The solution was stirred continuously for 24 hours. After that, it was put through Whatman filter paper. The filtrate was then baked at 40°C and kept at 4°C in containers.

2.5 Biological Test Methods

The selected plant extracts *Lantana camara*, *Cymbopogon* spp., and *Curcuma caesia* were tested using bioassays at doses of 5%, 10%, and 15%. The studies were carried out in a laboratory environment at 27±1 °C, RH 70± 5%, and a photoperiod of 14:10 Light:Dark. The concentrations were prepared with distilled water. Three replications of the tests using a completely randomised design (CRD) were conducted.

Potato dipping

One tuber each was dipped in the different extracts for 30 seconds. The tuber was then dried for 30 minutes. After drying, the tubers were kept in (11 × 9 cm) beakers, each with 10 newly hatched larvae. The following biological features: larval mortality %, pupation %, adult emergence % and damage index were then studied for each concentration.

Corrected mortality percentage was calculated using Abbott's formula (Abbott, 1925)

$$\text{Corrected mortality percentage (\%)} = \left[\frac{(\text{Po-Pc})}{(100\text{-Pc})}\right]\times 100$$

Where Po – Mortality in treatment

Pc – Mortality in control

Damage index of the potato tubers

The damage index was accessed conferring to the infestation classes based on the number of larval tunnels visible outside. The mean of the tuber damage index (D.I) for each experiment was determined by the formula given by Fenemore, 1980.

$$\text{D.I} = \frac{(\text{n° Slight} \times 1) + (\text{n° Moderate} \times 2) + (\text{n° Severe} \times 3)}{\text{Total number of tubers}} \times 10$$

The highest index is 30 tunnels/tuber if all tubers fall under severe class (Table 1).

Table 1. Classes of infestation of tuber damage for calculating damage index

Class	Definition	Factor
Clean	Absence of an obvious infestation	0
Slight	One or two mines, easily removable	×1
Moderate	Two or more mines with possible surface damage to up to one-third of the tuber	×2
Severe	Over a third of the tuber's surface was damaged.	× 3

Egg dipping

The eggs of PTM placed on the filter paper were added up with the help of a magnified glass. The filter paper with counted eggs were dipped in different concentrations to test the toxicity of the extracts. The control group treatment was carried out with distilled water. After dipping, the eggs were dried for twenty minutes after which the treated eggs were placed in plastic containers (20 × 20 × 10 cm) with potato tubers. After 3 days, the percentage of hatching and the percentage of adult emergence was studied.

2.6 Data Analysis

All the data pertaining to the present investigation were statistically analyzed using Fisher's method of analysis of variance in Completely Randomized Design (CRD). The differences between treatments were analyzed at a significance level of 0.05.

3. Results and discussion

3.1 Potato dipping

The corrected larval mortality, pupation % and adult emergence % obtained from the potato dipping method is presented in Table 2.

The aqueous extract of Black turmeric was found to give more reliable protection to tubers at highest dose with 92.96 % larval mortality. Tubers treated with Lemongrass 15 % recorded larval mortality of 78.52 % which was statistically at par with Lantana 15 % where larval mortality was 75.19 %. The plant extracts at lower concentrations (5 %) were found to be least effective with 21.11 %, 32.22 % and 39.26 % mortality in Lantana, Lemongrass and Black turmeric, respectively.

Similarly, Mazrou *et al.* (2021) and Erdogan and Yilmaz (2018) reported that the plant extracts at the maximum dose resulted in 100% larval mortality in the potato tuber dipping method. Khongrymmai et al. (2018) also found that patchouli oil, citronella oil, and lemongrass oil at high concentrations of 1.0% reduced larval mortality by 79.99%, 73.33%, and 69.99%, respectively. Abd El-Hamed et al. (2011) discovered that clove flower powder was efficient against PTM larvae, followed by *Matricaria chamomilla* flowers and seeds of *Piper nigrum*. Khatter (2010) discovered comparable results while examining the efficacy of plant extracts of *Piper nigrum* and *Matricaria chamomilla* dissolved in four solvents: petroleum ether, chloroform, acetone and water on larval stages at 5%, 10%, and 15% concentrations. He reported that the fatality rate increased significantly with increasing concentration and time of exposure.

Similarly, Niroula and Vaidya (2004) discovered that the effects of dry powders of *Lindera neesiana* fruits and *Acorus calamus* rhizomes continue for longer periods of time, resulting in a high proportion of larval death and fewer adult emergence in the first generation.

Pupation % of potato tuber moth was only 3.33 % at the highest dose of Black turmeric. Lemongrass extract at 10 % and 15 %, was found most effective in reducing the pupation with 43.33 % and 20 % and highest pupation (63.33 %) was recorded at 5 % lemongrass. Different concentrations of Lantana extract recorded pupation of 73.33 % at 5 %, 50.00 % at 10 % and 23.33 % at 15 %. Highest pupation % was observed with potato tubers with dipped only in water (93.33 %). Studies conducted by Mazrou *et al.* (2021) recorded no pupation in the highest concentration (2 %) of *Ammoides verticillate* and *Reseda alba* but in 2 % *Phlomis crinitei*, 30.55 % pupation was recorded. Moawad and Ebadah (2007) also recorded that pupation % was reduced particularly at a higher concentration (1.5%) with pupation of 3.3%, 20% and 40% for cardamom, rosemary and terpinin oils, respectively. Khongrymmai *et al.* (2018) reported that citronella oil (1 %) and patchouli oil (0.4 %, 0.8 % and 1 %) prevented pupation of the treated larvae.

The adult emergence in all the treatments was reduced when tubers were dipped in the aqueous plant extracts. At 15 % concentration, there was 3.33 % adult emergence in Black turmeric and 6.67 % adult emergence in Lemongrass. In Lantana treatment, adult emergence of 13.33 % was recorded even at 15 % concentration. Adult emergence of 83.33 % was observed in control treatment. Niroula and Vaidya (2004) reported that the dehydrated powders of *Acorus calamus and Lindera neesiana* resulted in emergence of only 12.6 and 6 adults of *Phthorimaea operculella.*

Table 2. Effectiveness of plant extracts tested by potato dipping method against PTM

Extracted Plant	Treatment concentration (%)	Larval Mortality* (%)	Pupation *(%)	Adult emergence*(%)
Lantana	5	21.11 (26.94) ^{f}	73.33 (59.01) ^{b}	53.33 (46.92) ^{b}
	10	46.67 (43.08) ^{cde}	50.00 (45.00) ^{cde}	23.33 (28.78) ^{cd}
	15	75.19 (60.18) ^{b}	23.33 (28.78) ^{fg}	13.33 (21.15) ^{ef}
Black turmeric	5	39.26 (38.77) ^{de}	56.67 (48.85) ^{cd}	30.00 (33.21) ^{c}
	10	60.74	36.67	10.00

		(51.23) [c]	(37.23) [ef]	(18.44) [ef]
	15	92.96 (77.37) [a]	3.33 (6.15) [h]	3.33 (6.15) [g]
Lemongrass	5	32.22 (34.58) [ef]	63.33 (52.78) [bc]	46.67 (43.08) [b]
	10	53.71 (47.13) [cd]	43.33 (41.16) [de]	16.67 (23.86) [ef]
	15	78.52 (62.40) [b]	20.00 (26.57) [g]	16.67 (23.86) [de]
Control	(DW)	6.67 (12.29) [g]	93.33 (77.71) [a]	83.33 (66.15) [a]
SE(m) (±)		3.36	3.34	3.31
C.D (p=0.05)		9.91	9.87	9.78

Note: * Values are the mean of three replications

Figures within parentheses are angular transformed values

Means having common letter are not significantly different at 5 % level

DW= Distilled Water

3.2 Tuber Damage Index

Table 3 represents the damage index ranging from 1.11 to 18.89 as compared to 25.56 tunnels/tuber for the control (untreated group). Black turmeric and Lemongrass treatments at 15 % concentration recorded 1.11 and 2.22 damage index as there was very limited tunnel formation in the tubers. Damage index of 4.44 and 6.67 was observed in 10 % Black turmeric and Lemongrass. In Lantana extract treated tubers, highest damage index (18.89) was observed at 5 % and least (8.89) damage index at 15 % lantana treated tubers. Similar results were demonstrated by Mazrou *et al.* (2021), Sharaby and Fallatah (2019) and Moawad and Ebadah (2007). Sisay and Ibrahim (2012) concluded that *Lantana camara*, *Eucalyptus globulus* and *Pyrethrum* flowers protect seed potatoes from damage. Sharaby and Fallatah (2019) found that the tubers treated with coriander and zygophyllum powder gave full shield to the treated tubers.

Lal (1987) reported that the leaves of *Lantana aculeate* provided maximum protection to the tubers preventing damage compared to *Eucalyptus globulus* and *Bacillus thuringiensis* but in our present study the effectives of Lantana extracts were significantly less effective compared to Black Turmeric and Lemongrass.

3.3 Egg dipping

The egg hatching was reduced with increasing concentration of the plant extracts. In Black turmeric, 5.00 % egg hatching was observed at 15 % concentration followed by 13.33 % egg hatching observed at 10 % whereas at 5 % concentration, the hatching percentage of egg was considerably higher (20.00 %) (Table 4).

Lemongrass extract treatments followed similar trend with 11.67 % egg hatching at 15 % concentration and the highest egg hatching (21.67%) was observed at 5 %. Lantana extract treatment was least effective in reducing the egg hatching as 30.00 %, 21.67 % and 16.67 % egg hatching was recorded in 5 %, 10 % and 15 % respectively.

Per cent adult emergence of *P. operculella* eggs treated with Black turmeric and Lemongrass was very effective as there was no adult emergence in 15 % concentration. Lantana 5 % extract had highest adult emergence (55.56 %) and the control treatment had 92.46 % adult emergence.

These findings are similar to those of Rafiee-dastjerdi *et al.* (2014) where fumitory and licorice extracts had significantly lower number of egg hatchability compared to control. Mazrou *et al.* (2021) also reported that negligible egg hatching in all concentrations (1, 1.5 and 2 %) of *Reseda alba* plant extracts. Similarly, Moawad and Ebadah (2007) recorded lower egg hatching percentages, 27% and 11% at 0.03 and 0.05% concentrations of cardamom oil, respectively compared to 83 % for the control. Sharma *et al.* (1997) reported that most of the plants such as *Pinus roxburgii* and *Eucalyptus globulus* extracted using different solvents like alcohol possess ovicidal activity.

Table 3. Damage Index of potato tubers dipped with the different plant extracts

Extracted plant	Treatment concentration (%)	Damage Index*
Lantana	5	18.89[b]
	10	14.44[c]
	15	8.89[d]
Black turmeric	5	5.56[def]
	10	4.44[efg]
	15	1.11[g]
Lemongrass	5	7.78[de]
	10	6.67[de]
	15	2.22[fg]
Control	DW	25.56[a]
SE(m) (±)		1.49
C.D (p=0.05)		4.40

Note: * Values are the mean of three replications

Means having common letter are not significantly different at 5 % level

DW=Distilled Water

Table 4. Effectiveness of extracts tested by egg dipping method against PTM

Extracted plant	Treatment concentration (%)	Egg hatchability* (%)	Adult emergence* (%)
Lantana	5	30.00 (33.21) [b]	55.56 (48.25) [b]
	10	21.67 (27.71) [c]	46.67 (43.05) [bc]
	15	16.67 (24.05) [cd]	30.55 (33.51) [cd]
Black turmeric	5	20.00 (26.57) [c]	41.67 (40.00) [bc]
	10	13.33 (21.34) [de]	22.22 (23.51) [d]
	15	5.00 (12.92) [f]	0.00 (0.00) [e]
Lemongrass	5	21.67 (27.71) [c]	46.67 (43.05) [bc]
	10	16.67 (24.05) [cd]	30.56 (33.51) [cd]
	15	11.67 (19.89) [e]	0.00 (0.00) [e]
Control	DW	68.33 (55.85) [a]	92.46 (74.07) [a]
SE(m) (±)		1.86	4.50
C.D (0.05)		3.88	13.29

Note: * Values are the mean of three replications

Figures within parentheses are angular transformed value

Means having common letter are not significantly different at 5 % level

DW= Distilled Water

4. Conclusion

The present study concluded that among the three different aqueous plant extracts, Black turmeric was found to be very effective and thus has a potential to be incorporated as a part of integrated pest management after further trials in storage and field conditions.

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