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Screening of popularly grown potato varieties against potato tuber moth (*Phthorimaea operculella*) in storage condition

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Abstract

The study was conducted in the laboratory of the Department of Entomology, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh to find out screening of potato varieties against potato tuber moth, *Phthorimaea operculella* in storage condition. The experiment was laid out in Completely Randomized Design (CRD) with three replications. The potato varieties tested were; BARI Alu-1 (Hira), BARI Alu-7 (Diamant), BARI Alu-8 (Cardinal), BARI Alu-12 (Dhira), BARI Alu-13 (Granolla), BARI Alu-25 (Asterix), BARI Alu-43 (Atlas), Lal-Pakhri, Shil-Bilati and BARI TPS-1. It was found that none of the varieties were completely immune to *Phthorimaea operculella*. But Significant differences were observed among ten potato varieties on the highest number of adult emergences occurred in BARI Alu-12 (Dhira) (50.66±0.57) and the lowest number of adult emergences was found in BARI Alu-25 (Asterix) (22.33±0.57). The highest adult life span of *P. operculella* was observed in BARI Alu-12 (Dhira) (9.66±1.15) whereas, the lowest life span was observed in BARI Alu-25 (Asterix) which was 6.00±0.0. Mean number of dead adults of *P. operculella* from different varieties of stored potatoes at different days more or less same and range was 2.0±1.22-2.0±2.82. The highest tuber content loss was observed in BARI Alu-12 (Dhira) (33.5%) and the lowest was BARI Alu-25 (Asterix) (8.5%). Among the potato varieties BARI Alu-12 (Dhira) was found the most susceptible host for *P. operculella* in respect of both growth and development and food consumption. On the other hand, BARI Alu-25 (Asterix) was the least susceptible variety for *P. operculella*.

Keywords: *Phthorimaea operculella*, storage, susceptibility, life span, tuber content loss

1. Introduction

The potato is the world's most important nongrain food crop worldwide under Solanaceae family (Sanwen Huang *et al.*, 2011) ^[1]. It is grown in more than 125 countries and consumed almost daily by more than a billion people. Potato as well as potato products are nowadays are being produced and exported by developing countries. The total world potato production is estimated at 364,808,768 tons in 2012 (FAOSTAT, 2012) ^[8]. It is the third largest food crop in Bangladesh and has recently occupied an important place in the list of major food and cash crops of Bangladesh (Ali and Haque, 2011) ^[2]. There are about 27 local varieties of potatoes cultivated in different parts of the country. Among these most popular potato varieties are: Diamant, Cardinal, Asterix, Courage, Granola and Lady Rosetta (BARI, 2019) ^[4]. Different insect pest like cutworm (*Agrotis ipsilon*), Aphid (*Macrosiphum euphorbiae*), Potato tuber worm (*Phthorimaea operculella*), Leaf hopper (*Empoasca fabae*) are the major insect pests of potato in Bangladesh. Among these the potato tuber worm, *Phthorimaea operculella* Zeller, is one of the most economically significant insect pests of cultivated potatoes worldwide. By 2003, the pest was a major concern to all producers in the region after potatoes from several fields were rejected by processors because of tuber damage. Since then, potato tubeworm has cost growers in the Columbia Basin millions of dollars through increased pesticide application and unmarketable potatoes (Rondon, 2010) ^[10]. Tubeworm larvae behave as leaf miners. They can also live inside stems or within groups of leaves tied together with silk. The most important damage is to tubers, also a food source for the larvae, especially exposed tubers, or those within centimeters of the soil surface. Larvae can infest tubers when foliage is vine killed or desiccated right before harvest (Clough *et al.*, 2010) ^[6]. Mostly potato tuber moth (PTM), *Phthorimaea operculella* (Zeller) is a serious pest of stored potatoes in Bangladesh.

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The potato storage period in Bangladesh falls in the summer season. The pest may cause 100% damage to home-stored potatoes in Bangladesh without any control measures being taken (Das, 1992) [7]. Sometimes the farmers sell the potatoes at a very low price when the first PTM infestation is observed. The purpose of this study is to find out how commonly grown potato cultivars are susceptible to *P. operculella* in storage. Through the process of screening these varieties, it is possible to discover those that may have an innate resistance or tolerance to the pest, which can yield important insights for environmentally friendly pest management techniques.

2. Materials and Methods

An experiment on the potato tuber moth, *P. operculella* was conducted in the laboratory of Department of entomology, Sher-e-Bangla Agricultural university (SAU), Dhaka during November 2022 to April 2023. This time was selected due to the favorable condition for growth and development of potato tuber moth. In the experiment, study was made on the reaction of potato tuber moth on different varieties of potato.

2.1 Collection of insect and stock culture

The study was made with a major stored tuber insect pest, potato tuber moth, *P. operculella*. Several adults of potato tuber moth were collected from different sources. The collected insects were maintained in the laboratory of entomology, Sher-e-Bangla Agricultural University (SAU). Adult moths were separated from infested tubers and then transferred to plastic container (26cm x10cm) supplied with fresh potato for multiplication. The different stages of *P. operculella* were produced in the container. The newly emerged potato tuber moths from this stock culture were utilized in the experiment. The stock culture was maintained in the laboratory temperature and relative humidity.

2.2 Identification of male and female moth

The sexes of *P. operculella* could be easily recognized by the size of the moths. The male moth was smaller in size than the female moth. The female moth on an average measures 6.5 mm long and 1.2 mm broad and the male is 5 mm long and 1.1mm broad. The female had wider wing span the male but fringed wing in both sexes. Both the male and female were straw-colored.

2.3 Collection and preparation of test material

Ten potato varieties V₁=BARI Alu-1 (Hira), V₂=BARI Alu-7 (Diamant), V₃=BARI Alu-8 (Cardinal), V₄=BARI Alu-12 (Dhira), V₅=BARI Alu-13 (Granolla), V₆=BARI Alu-25 (Asterix), V₇=BARI Alu-43 (Atlas), V₈=Lal-Pakhri, V₉=Shil-Bilati, V₁₀=BARI TPS-1. The mouth of each container sealed with a cover on the top surrounded by mud plaster to free from insect, microorganism of any other tuber.

$$\% \text{ Infestation (by Number)} = \frac{\text{Number of infested potato tuber}}{\text{Total number of potato tuber}} \times 100$$

$$\% \text{ Infestation (by Number)} = \frac{\text{Number of infested potato tuber}}{\text{Total number of potato tuber}} \times 100$$

The final weight of tuber was taken to obtain weight loss. The weight loss of potato tuber was found out by subtracting the final weight from the initial weight (2kg). The weight losses were converted into percentage of weight loss of potato tuber.

2.4 Study on reaction of potato tuber moth

Tuber of ten potato varieties V₁=BARI Alu-1 (Hira), V₂=BARI Alu-7 (Diamant), V₃=BARI Alu-8 (Cardinal), V₄=BARI Alu-12 (Dhira), V₅=BARI Alu-13 (Granolla), V₆=BARI Alu-25 (Asterix), V₇=BARI Alu-43 (Atlas), V₈=Lal-Pakhri, V₉=Shil-Bilati, V₁₀=BARI TPS-1 were kept in polythene bag separately after collection. Each variety had 2 kg of potato. Each variety of potato was then taken in individual petridish. Each variety was replicated the potato and each replicate contained 2kg tuber. Five pair's adults of both sexes were released into the petridish. All the petridishes were closed with their lids. The petridishes were left on the table and the moths were allowed to lay eggs on the potato.

2.5 Adult mortality and new emergence

The petridish were observed from outside after one day intermission to examine the death of released adult moths. The mortality of adult was recorded against each variety. After 27-30 days, new adults started emerging from potato tuber. The number of emergent potato tuber moth at different days from each variety was recorded. The counting of the emergent adult was made by opening the lid. Few moths came out from the petridish at first and the rest of them came out after gently shaking the container.

2.6 Damage and weight loss of potato tuber

When the emergences of the moth were completed, the tuber were cleaned and the numbers of damaged and normal tuber were counted. Tuber with holes considered as damaged tuber or infested tuber. To determine the percentage of damaged tuber, number of holed tubers were calculated. The final weight of these tubers was taken to obtain tuber weight loss for each variety. The potato tuber was cleaned by sieving. The weight losses of potato tuber were found out by subtracting the final weight from the initial weight (2 kg). The weight losses were converted into percentage of the weight losses of potato tuber.

2.7 Laboratory temperature and humidity record

The present study was carried out in the laboratory. During the period of conducting research, temperature was recorded in three times viz. 9 am, 12 noon, and 3 pm daily using the dry and wet bulb thermometer (ZEAL). The relative humidity was calculated from the corresponding data of the dry and wet bulb reading from a chart.

2.8 Observation on damage and weight loss of potato tuber:

To determine the percentage of damaged potato tuber, number of tubers having hole and normal tuber was counted per Petri dish or replicate and percentage of damaged tuber were calculated by using the following formula

2.9 Statistically analysis

The data obtained from the experiments were statistically analyzed in accordance with one factor Completely Randomized Design (CRD). Percent data were transformed

into square root and the mean values were compared by Duncan's Multiple Range Test (DMRT) under Microsoft

Statistics (MSTAT) program in a computer.

3. Results

Table 1: Adult life span of *P. operculella* on different varieties of potato in storage condition

Varieties	Duration (days) per replicate			Mean duration (days), (Mean \pm SD)
	1	2	3	
BARI Alu-1 (Hira)	8.0	7.0	8.0	7.66 \pm 0.57
BARI Alu-7 (Diamant)	7.0	7.0	7.0	7.00 \pm 0.0
BARI Alu-8 (Cardinal)	9.0	8.0	7.0	8.00 \pm 1.0
BARI Alu-12 (Dhira)	11.0	9.0	9.0	9.66 \pm 1.15
BARI Alu-13 (Granolla)	9.0	7.0	7.0	7.66 \pm 1.15
BARI Alu-25 (Asterix)	6.0	6.0	6.0	6.00 \pm 0.0
BARI Alu-43 (Atlas)	7.0	6.0	6.0	6.33 \pm 0.57
Lal-Pakhri	9.0	8.0	8.0	8.33 \pm 0.57
Shil-Bilati	8.0	7.0	8.0	7.66 \pm 0.57
BARI TPS-1	8.0	8.0	7.0	7.66 \pm 0.57

Table 2: Mean number of dead adults of *P. operculella* from different varieties of stored potato tuber

Date/Observation	Tuber Weight (kg)	Mean adult dead (no) on different potato varieties									
		BARI Alu-1 (Hira)	BARI Alu-7 (Diamant)	BARI Alu-8 (Cardinal)	BARI Alu-12 (Dhira)	BARI Alu-13 (Granolla)	BARI Alu-25 (Asterix)	BARI Alu-43 (Atlas)	Lal-Pakhri	Shil-Bilati	BARI TPS-1
1 st	2	0.0	0.0	0.0	0.0	0.0	6.0	5.0	1.0	0.0	0.0
2 nd	2	2.0	1.0	1.0	1.0	0.0	4.0	5.0	1.0	2.0	1.0
3 rd	2	2.0	4.0	1.0	2.0	1.0	0.0	0.0	2.0	3.0	3.0
4 th	2	3.0	2.0	3.0	3.0	4.0	0.0	0.0	2.0	4.0	2.0
5 th	2	3.0	3.0	5.0	4.0	5.0	0.0	0.0	4.0	1.0	4.0
Mean \pm SD	2	2.0 \pm 1.22	2.0 \pm 1.58	2.0 \pm 2.0	2.0 \pm 1.58	2.0 \pm 2.34	2.0 \pm 2.82	2.0 \pm 2.73	2.0 \pm 1.22	2.0 \pm 1.58	2.0 \pm 1.58

Table 3: Mean development time from egg to adult emergence of *P. operculella* in different varieties of potato

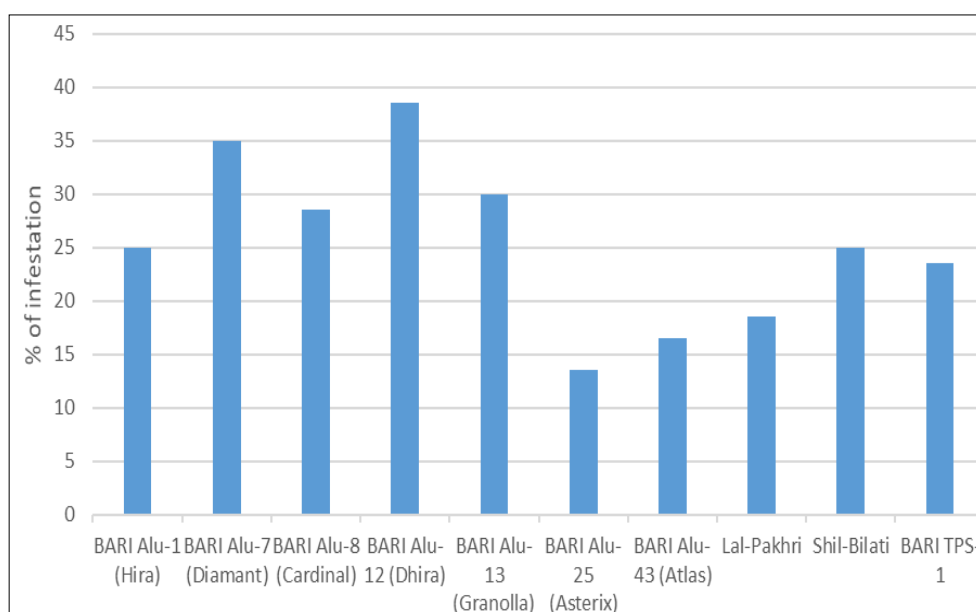
Varieties	Duration (days) per replicate			Mean Duration (days) per replicate (Mean \pm SD)
	1	2	3	
BARI Alu-1 (Hira)	25	25	27	25.66 \pm 1.15
BARI Alu-7 (Diamant)	34	33	33	33.33 \pm 0.57
BARI Alu-8 (Cardinal)	30	32	33	31.66 \pm 1.52
BARI Alu-12 (Dhira)	36	34	34	34.66 \pm 1.15
BARI Alu-13 (Granolla)	30	30	33	31 \pm 1.73
BARI Alu-25 (Asterix)	27	24	24	25 \pm 1.73
BARI Alu-43 (Atlas)	29	28	32	29.66 \pm 2.08
Lal-Pakhri	26	26	28	26.65 \pm 1.15
Shil-Bilati	30	29	33	30.62 \pm 2.08
BARI TPS-1	31	33	34	32.64 \pm 1.52

Table 4: Mean number of emergent adults of *P. operculella* in different varieties of potato tubers

Varietis	Total tubers of Weight (Kg)	Emergent adults(no) per replicate			Mean emergent adults (no.), (Mean \pm SD)
		1	2	3	
BARI Alu-1 (Hira)	2	45	46	45	45.33 \pm 0.57
BARI Alu-7 (Diamant)	2	47	46	47	46.67 \pm 0.57
BARI Alu-8 (Cardinal)	2	34	34	35	34.33 \pm 0.57
BARI Alu-12 (Dhira)	2	51	50	51	50.66 \pm 0.57
BARI Alu-13 (Granolla)	2	48	47	47	47.33 \pm 0.57
BARI Alu-25 (Asterix)	2	22	23	22	22.33 \pm 0.57
BARI Alu-43 (Atlas)	2	25	24	24	24.33 \pm 0.57
Lal-Pakhri	2	48	47	48	47.66 \pm 0.57
Shil-Bilati	2	40	39	40	39.66 \pm 0.57
BARI TPS-1	2	45	46	44	45 \pm 0.57

Table 5: Weight loss of different varieties of stored potato tubers by *P. operculella*.

Varieties	Total tubers Weight(kg)	Mean tuber weight loss(kg), (Mean ± SD)	Tuber weight loss (%)
BARI Alu-1 (Hira)	2	0.4±0.1	20
BARI Alu-7 (Diamant)	2	0.6±0.1	30
BARI Alu-8 (Cardinal)	2	0.47±0.05	23.5
BARI Alu-12 (Dhira)	2	0.67±0.11	33.5
BARI Alu-13 (Granolla)	2	0.5±0.1	25
BARI Alu-25 (Asterix)	2	0.17±0.05	8.5
BARI Alu-43 (Atlas)	2	0.23±0.05	11.5
Lal-Pakhri	2	0.27±0.05	13.5
Shil-Bilati	2	0.4±0.1	20
BARI TPS-1	2	0.37±0.05	18.5

**Fig 1:** Percent infestation of different varieties of stored potato tubers by *P. operculella*

4. Discussion

4.1 Adult Lifespan / longevity of Potato tuber moth: After release of four pairs of adult moths, their mortalities were counted daily up to the death. From these mortality data, adult lifespan was calculated. The moths lived up to the highest 11 days on BARI Alu-12 (Dhira) and the lowest six days on BARI Alu-25 (Asterix) and BARI Alu-43 (Atlas). The mean life span of *P. operculella* moth ranged from 6.00 to 9.66 days on ten different varieties of stored potatoes. The highest mean duration of adult was 9.66 ± 1.15 days in BARI Alu-12 (Dhira) were statistically identical to others varieties of stored potato tubers. On the other hand, the lowest duration of adult life span of *P. operculella* was found in BARI Alu-25 (Asterix) (6.00 ± 0.0) days followed by BARI Alu-43 (Atlas) (6.33 ± 0.57 days) on storage condition. This result coincides with Sporleder *et al.*, (2004) [13], *P. operculella* commonly live for 1-2 weeks. Mating begins around 24 hours after emergence and most eggs are laid within the first quarter of the female's life.

4.2 Adult mortality from different varieties: Five pairs of adult moths of *P. operculella* released on potato in petridishes died in different dates in different varieties. In the 1st observation / first day, (June 30) 0-6 adults died per container (Table 2). All adults died in all varieties in five days (June 30 to July 4). BARI Alu-25 (Asterix) had the maximum mean number of adults dead of 6.00 moths on June 30, followed by BARI Alu-43 (Atlas) (4.0). The complete dead of adult moths occurred on July 4. After 5th observations, the highest mean

number of adult dead of *P. operculella* was recorded from BARI Alu-25 (Asterix) (2.0 ± 2.82) and second highest mean number of adult dead was in BARI Alu-43 (Atlas) (2.0 ± 2.73) among the different varieties of stored potatoes (Table 2). This result matches with (Fenemore, 1978) [9], Peak oviposition for females occurs 2-5 days after emergence and declines to much lower levels by day.

4.3 Effect of Varieties on Developmental Time: The developmental time of *P. operculella* from egg to adult emergence was counted from the time when 50 per cent of five pairs of released adults died to the time when new adults emerged (Table 3). This was the time in which *P. operculella* laid eggs and immatures (larvae and pupae) developed in the tubers followed by the adult emergence. The developmental time ranged from 24 to 36 days on ten different varieties of stored potato tubers. The highest Mean development time from egg to adult emergence of *P. operculella* was recorded from BARI Alu-12 (Dhira) (34.66 ± 1.15 days) and second highest was in BARI Alu-7 (Diamant) (33.33 ± 0.57 days) among the different varieties of stored potato tubers. On the other hand, the lowest mean development time from egg to adult emergence of *P. operculella* was recorded from BARI Alu-25 (Asterix) (25 ± 1.73 days) and the second lowest was in BARI Alu-1 (Hira) (25.66 ± 1.15 days) among the different varieties of stored potato tubers (Table 3). These results are in agreement with Askar *et al.*, (2021) [3] who found that the life span of the *P. operculella* varies 35.9 to 40.90 days depending on the potato variety.

4.4 Adult emergence on different varieties of potato tubers:

There was variation in respect of the number of adults emerged from different varieties of potato tubers. Total number of emergent moths ranged from 22 to 51 per 2 kg of tubers in Ten varieties (Table 4). The mean of the total number differed significantly among varieties. The highest number of adults emerged (50.66 ± 0.57) from potato tubers of BARI Alu-12 (Dhira). The second highest number of adults emerged from Lal-Pakhri (47.66 ± 0.57). The lowest adult emergence occurred in BARI Alu-25 (Asterix) (22.33 ± 0.57) and BARI Alu-43 (Atlas) (24.33 ± 0.57) in storage condition. Singh and Charles (1977) ^[12] also reared potato tuber moth from egg to adult for 3 generations on an artificial diet, at 30 ± 2 °C with a 16-h photoperiod. They found that the total life cycle was completed in 23 days, compared with 18.5 days on potato tubers.

4.5 Tuber weight losses of different potato varieties:

The cleaned tubers except the infested ones in each container of each variety weighed separately. The weight losses were found out by subtracting the final weight from initial weight (2 kg). The weight losses were calculated into percentage of the weight losses of potato tubers. The weight losses of potato tubers of ten varieties ranged from 8.5 to 33.5% in a replicate (Table 5). The highest mean weight loss was 33.5% obtained in BARI Alu-12 (Dhira) tubers and this type of potato variety was more susceptible to *P. operculella* (Table 5). The lowest weight loss of 8.5% was found on BARI Alu-25 (Asterix) that was least susceptible to *P. operculella*. The second highest of tuber weight loss was 30% in the variety BARI Alu-7 (Diamant) followed by BARI Alu-13 (Granolla). This result coincides with Adhikari *et al.*, (2022) ^[1] who found that the Potato Tuber Moth (*P. operculella*) significantly impacts potato tuber weight loss, with reported losses varying widely. In controlled studies, weight loss due to this pest ranged from 1.88% to 26.03%, depending on the treatment and potato cultivar used. For instance, untreated potatoes experienced a physiological weight loss of 26.03%, while those treated with *Acorus calamus* showed a much lower loss of 12.11%.

4.6 percent infestation in different Potato Varieties:

From the figure, it was found that the highest percentage infestation was in BARI Alu-12 (Dhira) which is 38.5% and the lowest percentage infestation was in BARI Alu-25 (Asterix) which is 8.5%. According to Chandel *et al.*, (2020) ^[5] the infestation of potato tubers by the potato tuber moth (*P. operculella*) varies significantly, with reported damage ranging from 1% to as high as 72.5% in endemic regions of India, and even up to 100% losses in certain storage conditions.

5. Conclusion

According to the findings the order in terms of susceptibility of potato varieties to the tuber content loss by *P. operculella* was BARI Alu-12 (Dhira) > BARI Alu-7 (Diamant) > BARI Alu-13 (Granolla) > BARI Alu-8 (Cardinal) > Shil-Bilati > BARI Alu-1 (Hira) > BARI TPS-1 > Lal-Pakhri > BARI Alu-43 (Atlas) > BARI Alu-25 (Asterix).

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