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Evaluation of biological control agents for post-harvest management of potato tuber moth, *Phthorimaea operculella* (Zeller)

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Abstract

An experiment was conducted under ambient condition at AICRP on Potato, Zonal Agricultural Research Station, Ganeshkhind Pune (MPKV, Rahuri) Maharashtra to evaluate biocontrol agents for the management of potato tuber moth damage. Tubers after harvesting were subjected to dip treatments using two concentrations of *Bacillus thuringiensis* var. *kurstaki* and neem oil and compared with untreated control. The incidence of potato tuber moth damage was subsequently documented at 15 days interval for up to 90 days of storage under room temperature conditions. The data revealed that tuber dip treatment with a *Bacillus thuringiensis* var. *kurstaki* formulation at a 2 percent concentration was the most effective, exhibiting the lowest mean incidence of tuber damage up to 90 days of storage under ambient condition.

Keywords: Potato tuber moth, *Bacillus thuringiensis*, neem oil

Introduction

Potato (*Solanum tuberosum* L.) is a globally significant vegetable, ranking as the third most important food crop for human consumption after rice and wheat. In India, potato cultivation covered an estimated 23.22 lakh hectares during 2023-24, yielding a production of 570.53 lakh tonnes. However, within Maharashtra, the crop is grown on approximately 14,450 hectares, with production of 3.86 lakh tones which centered in the Pune, Satara, and Ahilyanagar districts. (Anonymous, 2023) ^[1]

However, potato production is significantly hampered by various insect pests, among which the potato tuber moth, *Phthorimaea operculella* (Zeller), is a key cosmopolitan pest of major economic importance. Its high reproductive capacity and adaptability to diverse climatic conditions have enabled its establishment in potato-growing regions worldwide. *P. operculella* originally introduced to India in the year 1906 and it infests potato crops both in the field and more critically, during post-harvest storage. The larval stage is responsible for the damage, mining leaves and petioles in the field and boring characteristic tunnels into the tubers. While foliar damage rarely causes significant yield loss, tuber infestation can lead to devastating losses ranging from 36 to 85 percent and potentially up to 100 percent in untreated, non-refrigerated storage conditions. (Chandel *et al.*, 2020) ^[2]

The challenge of controlling *P. operculella* is magnified during storage. Many farmers store their harvest for two to three months to await better market prices. Lacking access to or the ability to afford cold storage facilities, they often keep tubers in rustic shelters where the pest can multiply rapidly. These traditional storage environments, often characterized by darkness and poor ventilation, create ideal conditions for pest proliferation. Infested tubers harvested from the field serve as the primary source of infestation, allowing the pest to complete multiple generations and cause extensive damage.

Current management strategies in storage rely heavily on the application of chemical insecticides, such as chlorpyrifos or quinalphos dusts and dips in insecticidal solutions. However, this approach presents a significant human health risk, as these tubers are directly used for consumption. Furthermore, the indiscriminate use of these synthetic pesticides has raised concerns about the development of insecticide-resistant pest populations, environmental contamination and harmful effects on non-target organisms.

The direct application of toxic chemicals to a food product intended for the table makes conventional pest control in storage both difficult and hazardous.

Despite the severity of this issue, research into safe, sustainable and effective alternatives for managing *P. operculella* under ambient storage conditions is limited. There is an urgent need to develop eco-friendly and economically viable management tactics that can be readily adopted by farmers. Therefore, the present study was undertaken to evaluate the efficacy of biocontrol agents as safer alternatives for the management of the potato tuber moth in storage.

Materials and Methods

The management study was conducted under laboratory conditions at All India Coordinated Research Project on Potato, Zonal Agricultural Research Station, Ganeshkhind, Pune, for two consecutive years (2017-18 and 2018-19). Freshly harvested, medium-sized, clean and healthy potato tubers (*Solanum tuberosum* L.) of the 'Kufri Jyoti' variety were used. All tubers selected were uniform and free from any prior insect damage or mechanical injury. The experiment was laid out in a Completely Randomized Design (CRD) with four replications. Each treatment replication consisted of 10 kg of potato tubers. The experiment included five distinct treatments to evaluate their efficacy are T₁: Tuber dip in Neem oil @ 1%, T₂: Tuber dip in Neem oil @ 2%, T₃: Tuber dip in *Bacillus thuringiensis* var. *kurstaki* formulation @ 1%, T₄: Tuber dip in *Bacillus thuringiensis* var. *kurstaki* formulation @ 2% and T₅: Untreated Control.

The treatments were applied by dipping the tubers in respective solutions for 20 minutes and were subsequently air-dried in the shade. Following this, miniature storage heaps for each replication were constructed 2 meters apart to prevent cross-infestation. A uniform artificial infestation was created by releasing twenty-five pairs of virgin potato tuber moths (*Phthorimaea operculella*) into each heap for a 72-hour period to allow for mating and oviposition. Data on potato tuber moth incidence was recorded at 15, 30, 45, 60 and 90 days after infestation. The percentage of tuber damage for each replication was calculated by counting the number of damaged and total tubers used. To ensure statistical validity, the percentage data was transformed using an arcsine transformation before being analyzed using an Analysis of Variance (ANOVA) to determine the significance of differences among the treatments.

Results and Discussion

The research experiment was conducted for 2017-18 and 2018-19 and pooled data on efficacy of biocontrol agents are presented in tables 1 & 2. It can be seen from the pooled data table; there was a significant difference in different treatments for recording tuber infestation. The data was collected 15 days after the beginning of the experiment indicated that the potato treated with neem oil @ 1 percent and *Bacillus thuringiensis* var. *kurstaki* at 1 and 2 percent respectively was free from potato tuber moth infestation. However untreated control showed infestation of 7.50 percent.

Similarly, at 30 days after tuber treatment, maximum tuber moth infestation (20.00%) was observed in untreated control. The tubers treated with *Bacillus thuringiensis* var. *kurstaki* at 1 and 2 percent was free from tuber damage

indicate that the complete protection up to one month after treatment. Among the remaining treatments significantly least tuber damage was found in treatment comprised with tuber dip treatment with neem oil 2%.

After 45 days of storage, all the treatments registered moderate to heavy potato tuber moth infestation. The potato tuber moth infestation ranged from 3.63 to 38.50 percent. The significantly minimum (3.63%) infestation was recorded in treatment with *Bacillus thuringiensis* at 2 percent and found at par with *Bacillus thuringiensis* var. *kurstaki* at 1 percent. The potato tubers treated with neem oil @ 1 and 2 percent also exhibit good protection than the control treatment.

The trend in potato tuber moth infestation at 60 days after treatment was almost similar as observed at 45 days after treatments. Although there was 7.50 percent infestation in treatment with *Bacillus thuringiensis* var. *kurstaki* at 2 percent at 60 days of storage but the intensity of potato tuber moth infestation i.e. number of holes and fresh excreta per tuber was very low in said treatment as compared to control. At 75 days over the observation period, infestation was in the range of 13.00 to 73.50 percent. However, significantly minimum (13.00%) infestation was observed in treatment of tuber dip treatment with *Bacillus thuringiensis* var. *kurstaki* at 2 percent.

At end of the follow-up period i. e. after 90 days studies, the potato tuber moth infestation was increased gradually in all treatments including control. When the tubers were cut open at the end at 90 days after treatments, dead larvae were found in treated tubers and there was no production of fresh excreta on tubers. However, when untreated tubers cut opened, there was many developing larvae as well as pupae were noticed inside the tubers. In most of the untreated tubers, eye buds were also destroyed due to potato tuber moth infestation.

There was 91.25 percent tuber infestation in control treatment. The significantly minimum (21.75%) tuber moth infestation was observed in treatment of tuber dip treatment with *Bacillus thuringiensis* 2% and followed by in treatment of tuber dip treatment with 1 percent. Similarly, among remaining treatments, the tubers with neem oil @ 1 and 2 percent recorded significantly less infestation as compared to untreated control.

It is also observed that, treatment of *Bacillus thuringiensis* var. *kurstaki* at 2 percent gave 76.16 percent control of potato tuber moth infestation over control treatment during the storage period of 90 days under ambient condition. Similarly, *Bacillus thuringiensis* var. *kurstaki* 1 percent, neem oil 1 and 2 percent treatments also recorded 63.56, 53.98 and 40.82 respectively percent reduction in potato tuber moth infestation over the control treatment.

Therefore, from this management studies under ambient condition, it is cleared that the tuber dip treatment with *Bacillus thuringiensis* var. *kurstaki* at 2 percent was found effective for the management of potato tuber moth infestation. These results find support from the works of Pokharkar and Jogi (2000) [3] and Prasad *et al.* (2020) [1] they reported the effectiveness of different formulation and application method of *Bacillus thuringiensis* against potato tuber moth under storage condition. Persistence of *B. thuringiensis* up to three months observed during present study is also in accordance with Salama *et al.* (1995) [4]. Their study revealed that in stores where shady conditions exist, the persistence of *B. thuringiensis* lasts longer as

compared to the short persistence in the field where ultraviolet radiation is the main effective factor. Further they reported that *B. thuringiensis* could protect the potato tubers when applied inside stores for periods up to 255 days, particularly at high doses. Similarly, about 40.82 to 53.98 percent reduction of potato tuber moth infestation was

observed in neem oil treatments during present studies are supported by the Salma and Salem (2000) ^[4] who reported that neem oil alone or in combination with *Bacillus thuringiensis* was found effective against potato tuber moth in field and storage condition.

Table 1: Effect of biological control agents on potato tuber moth infestation during storage period of initial 45 days

Treatment details	Tuber infestation (%) Days after treatment								
	15 days			30 days			45 days		
	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled
T ₁ : Tuber dip treatment with neem oil @ 1%	6.50 (14.74)	8.50 (18.82)	7.50 (15.86)	18.0 (25.08)	22.00 (27.89)	20.00 (26.53)	34.50 (35.94)	42.50 (40.44)	38.50 (38.21)
T ₂ : Tuber dip treatment with neem oil @ 2%	0.00 (0.00)	2.50 (6.43)	1.25 (4.52)	4.00 (11.34)	5.50 (13.13)	4.75 (12.36)	12.50 (20.65)	19.00 (25.58)	15.75 (23.23)
T ₃ :Tuber dip treatment with <i>Bt</i> formulation @ 1%	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	2.50 (8.98)	4.00 (11.34)	3.25 (10.29)	9.00 (17.43)	14.50 (21.98)	11.75 (19.94)
T ₄ : Tuber dip treatment with <i>Bt</i> formulation @ 2%	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	5.00 (12.85)	10.00 (18.35)	7.50 (15.88)
T ₅ : Control	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	2.00 (8.13)	5.25 (13.03)	3.63 (10.88)
SE(d)	0.36	2.50	1.70	1.03	1.77	1.12	1.04	4.25	2.44
C.D.	0.77	5.38	3.66	2.21	3.80	2.40	2.24	9.14	5.25
CV%	17.07	76.11	59.0	15.98	23.87	16.04	7.74	25.15	15.97

Table 2: Effect of biological control agents on potato tuber moth infestation during storage period of 60 to 90 days

Treatment details	Tuber infestation (%) Days after treatment								
	60 days			75 days			90 days		
	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled
T ₁ : Tuber dip treatment with neem oil @ 1%	62.00 (28.62)	59.00 (50.27)	60.50 (51.07)	79.00 (62.78)	68.00 (55.62)	73.50 (59.07)	93.00 (74.83)	89.50 (71.64)	91.25 (72.97)
T ₂ : Tuber dip treatment with neem oil @ 2%	23.00 (23.47)	30.50 (33.34)	26.75 (31.05)	35.50 (36.54)	43.00 (40.94)	39.25 (39.77)	56.00 (48.43)	52.00 (16.16)	54.00 (47.29)
T ₃ :Tuber dip treatment with <i>Bt</i> formulation @ 1%	16.00 (20.63)	21.00 (27.21)	18.50 (25.39)	27.50 (31.60)	32.00 (34.41)	29.75 (33.02)	43.00 (40.94)	41.00 (39.76)	42.00 (40.35)
T ₄ : Tuber dip treatment with <i>Bt</i> formulation @ 2%	12.50 (14.08)	17.00 (24.22)	14.75 (22.55)	20.00 (26.54)	23.00 (28.51)	21.50 (27.58)	34.50 (35.95)	32.00 (34.38)	33.25 (35.18)
T ₅ : Control	6.00 (3.05)	9.00 (17.32)	7.50 (15.86)	12.00 (20.22)	14.00 (21.86)	13.00 (21.08)	24.50 (29.64)	19.00 (25.71)	21.75 (27.75)
SE(d)	1.69	3.29	1.86	1.38	2.43	1.54	1.71	3.17	2.09
C.D.	3.50	7.07	3.99	2.96	5.23	3.32	3.68	6.82	4.50
CV%	8.30	15.25	9.00	5.48	9.47	6.08	5.26	10.30	6.62

Conclusion

Across all of the studies, the tuber dip treatment with *Bacillus thuringiensis* var. *kurstaki* at 2 percent for 20 minutes demonstrated a consistently superior ability to minimize tuber infestation. By nearly 76 percent compare to control. Considering harmful effect of chemical insecticides, *Bacillus thuringiensis* is best eco-friendly alternative for management of potato tuber moth under ambient condition

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