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Biological suppression of potato tubermoth, *Phthorimaea operculella* (Zeller) with exotic parasitoids and microbial agents under field and storage conditions

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ABSTRACT: **Investigations on bioefficacy of parasitoids and microbial agents against potato tubermoth (PTM), *Phthorimaea operculella* (Zeller) (Lepidoptera: Gelechiidae) were carried out under field and storage conditions of potato during 1996-1997. The results showed that three sprays of endosulfan 0.05 per cent at 10 days interval proved to be the most effective and on par with four releases of *Chelonus blackburni* Cameron @ 15000 adults/ha/release at weekly interval, *Copidosoma koehleri* Blanchard @ 50000 adults/ha/release and *Trichogramma chilonis* Ishii @ 50000 adults/ha/release at weekly interval, and three sprays of *Bacillus thuringiensis* Berliner @ 1 kg/ha at 10 days interval. Amongst the parasitoids, maximum parasitism was recovered through retrieval with *C. blackburni* (71.78%), followed by *C. koehleri* (69.39%) and *T. chilonis* (61.33%). Under storage conditions (*Arnies*), initial release of *C. blackburni* @ 2 adults/kg tubers recorded minimum tuber infestation (7.21%) after 60 days.**

KEY WORDS: *Bacillus thuringiensis*, *Chelonus blackburni*, *Copidosoma koehleri*, Granulosis virus, *Phthorimaea operculella*

The potato tubermoth (PTM), *Phthorimaea operculella* (Zeller) (Lepidoptera: Gelechiidae) is a key cosmopolitan pest of stored potatoes. However, it also attacks potato foliage (as leafminer) and exposed tubers in the field in many countries of the world, particularly with tropical and subtropical climates. In India, until recently, it was recognized as minor pest in the potato field, but it actually caused serious losses (36 to 85%) in standing crop as well as in stores (Lal, 1993; Trivedi *et al.*, 1994). The crop was extensively cultivated during both *kharif* and *rabi* seasons and potatoes were stored with local storage methods (*Arnies*) in summer in Maharashtra State.

Due to complex biological habits of PTM, the present pest control strategies could provide inadequate control in the field and *Arnies*. Hence, it was thought worthwhile to suppress PTM population by introducing exotic parasitoids and entomopathogens. The parasitising efficacy of *Chelonus blackburni* Cameron and *Copidosoma koehleri* Blanchard has been proved by Khandge *et al.* (1979) and Ballal *et al.* (1989). Whereas potential of granulosis virus (GV) and *Bacillus thuringiensis* Berliner infectious to PTM has been endorsed by Amonkar *et al.* (1979). Thereafter, not much impetus has been given in this direction for releasing bioagents at the active sites of PTM and to develop them as component of integrated pest management system. With this view, the promising parasitoids and microbial agents were attempted to evaluate for their efficacy against PTM under field and storage conditions.

MATERIALS AND METHODS

Experiment was conducted on farmers' field at Peth, District Pune, Maharashtra during *rabi* 1996-97 by raising potatoes (*var.* Kufri Jyoti) in 10 x 5m^2 plots at 50 x 25cm plant spacing. All the recommended crop management practices except insecticide applications were followed to maintain healthy crop growth. The trial was laid out in randomized block design with seven treatments and three replications. The treatments consisted four inundative releases of parasitoids *viz.*, *C. blackburni* @ 15000 adults/ha/release, *C. koehleri* @ 50000 adults/ha/release, *Trichogramma chilonis* Ishii @ 50000 adults/ha/release at weekly interval commencing 45 days after planting; three sprays of GV @ 500 larval equivalent (LE)/ha, *B. thuringiensis* @ one kg/ha and endosulfan (0.05%) at 10 days interval initiating 52 days after planting the crop and untreated control. The parasitoids and GV were mass multiplied in Biological Control Laboratory of the Department of Entomology, College of Agriculture, Pune. *B. thuringiensis* (Delfin WG) and endosulfan (Thiodan 35 EC) were procured from market. GV suspension was standardised to contain 1.1x10^9 capsules/ml (=1 LE). Sandovit (0.1%) was added in it while preparing spray fluid. The sprayable material was calibrated to 2.5 l/plot with high volume knapsack sprayer for uniform and thorough coverage. Observations on leaf mines/m row were recorded at three places in each plots as pre-count, a day before application of treatments and postcounts at weekly interval till termination of treatments. Tuber infestation from 3m^2 area in treatment plots and yield of marketable tubers per plot were recorded at the time of harvesting of the crop. The data were transformed and subjected to analysis of variance.

Recovery of parasitoids was assessed by releasing the *C. blackburni* @ 15000 adults/ha, *C. koehleri* 50000 adults/ha and *T. chilonis* @ 50000 adults/ha in 10 x 20m^2 potato plots selected 20m apart. The parasitoids were released in the crop canopy 52 and 67days after planting. Five strips of unparasitised one-day-old eggs of PTM were displayed in each plot, which were retrieved 48 hours after release of the parasitoids. The egg strips collected from *C. blackburni* and *C. koehleri* released plots were reared on punctured tubers till formation of mummies of the parasitoids and PTM. Whereas the eggs parasitised by *T. chilonis* turned black. The per cent parasitism was worked out on the basis of formation of parasitoid and PTM.

In order to study the efficacy of the parasitoids and microbial agents against PTM in country stores (*Arnies*), clean healthy medium sized potatoes in sufficient quantity were collected after harvesting of *rabi* crop of 1996-97. These were confined in mosquito curtain net and 25 newly emerged pairs of PTM were released for 24 hours to create artificial infestation. From these tubers, 11 miniatures of *Arnies* each of 20kg capacity were constructed at 5m apart in the laboratory. These *Arnies* were covered thickly with double layer of grass to avoid easy cross infestation of PTM from outside sources. The adults of *C. blackburni*, *C. koehleri* and *T. chilonis* were released in the respective *Arnies*. GV and *B. thuringiensis* were applied to infested tubers before construction of *Arnies*. Unpurified GV suspension containing 1.1 x 10^9 capsules/ml equivalent to 1 LE was sprayed with atomizer on tubers, which were dried in shade under medium speed fan. Whereas the powder formulation of *B. thuringiensis* var. *kenyae* supplied by Bhabha Atomic Research Centre, Mumbai was smeared to potatoes. Observation on tuber infestation were recorded by collecting 100 tubers in three repeats from each *Arnies* twice, first at one month and second at termination of *Arnies* namely two months after application of treatments. Healthy and infested tubers were counted to compute per cent infestation. The data on transformation were subjected to analysis of variance.

RESULTS AND DISCUSSION

The data (Tables 1 and 2) revealed that all the treatments were significantly superior over untreated control in recording mean leaf mines, tuber infestation and potato yield. Endosulfan (0.05%) which showed 2 mean leaf mines/m row, 8.26 per cent tuber infestation and 232 q/ha tuber yield, proved to be the best and on par with the parasitoids and microbial agents except GV for mean leaf mines and tuber infestation. The efficacy of *C. blackburni* and *C. koehleri* improved in the third and fourth weeks from initiation of their release and recorded minimum leaf mines (1.33 and 0.66/m row) in the corresponding weeks. There was drastic reduction in leaf mines after two weeks in the case of GV treated plots. GV and *B. thuringiensis* treatments showed similar leaf mines in third and fourth weeks. As regards the tuber infestation and yield, *C. blackburni* and *B. thuringiensis* were promising ones whilst GV was the least effective. The findings of Kurhade and Pokharkar (1997) in respect of reduction in leaf mines, tuber infestation and increase in potato yield due to *C. blackburni* and *B. thuringiensis* are in agreement with the present results. On the contrary, superiority of endosulfan in the present investigation was due to its 3 sprays whereas earlier workers followed only 2 sprays.

Recovery of parasitoids through retrieval

Table 1. Efficacy of parasitoids and microbial agents in comparison to endosulfan against *P. operculella* on potato leaf mines

Treatment/ dose	Leaf mines/m row					
	Pre-count	Post-count after week				Pooled mean
		I	II	III	IV	
C. blackburni @ 15000 adults/ ha/ release	6.33 (2.61)	4.33 (2.19)	2.66 (1.77)	1.33 (1.35)	0.66 (1.07)	2.25 (1.65)
C. koehleri @ 50000 adults/ ha /release	6.00 (2.54)	4.66 (2.27)	3.00 (1.87)	1.33 (1.35)	0.66 (1.07)	2.41 (1.73)
T. chilonis @ 50000 adults / ha / release	5.66 (2.48)	4.66 (2.27)	3.33 (1.95)	2.00 (1.58)	1.33 (1.35)	2.83 (1.86)
Granulosis virus @ 500 LE/ha	6.33 (2.61)	6.66 (2.67)	5.66 (2.48)	1.66 (1.47)	1.00 (1.22)	3.83 (2.08)
B. thuringiensis @ 1 kg/ha	6.00 (2.54)	4.33 (2.19)	2.33 (1.68)	1.66 (1.47)	1.00 (1.22)	2.33 (1.68)
Endosulfan 0.05%	6.00 (2.54)	3.33 (1.95)	1.66 (1.47)	2.33 (1.68)	0.66 (1.07)	2.00 (1.58)
Untreated control	6.33 (2.61)	7.00 (2.73)	7.33 (2.79)	6.33 (2.61)	3.66 (2.03)	6.08 (2.56)
CD (P=0.05)	(N S)	(0.48)	(1.06)	0.40	(0.55)	(0.31)

Figures in parentheses are $\sqrt{(n+0.5)}$ transformations.
NS = Not significant

Table 2. Efficacy of parasitoids and microbial agents in comparison to endosulfan against *P. operculella* on tuber infestation and yield of potato

Treatment/dose	Tuber infestation (%)	Yield of marketable tubers (q/ha)
C. blackburni @ 15000 adults/ha/release	8.34 (16.78)	230.0
C. koehleri @ 50000 adults/ha/release	10.45 (18.86)	219.0
T. chilonis @ 50000 adults/ha/release	10.54 (18.95)	218.0
Granulosis virus @ 500 LE/ha	12.30 (20.53)	216.3
B. thuringiensis @ 1 kg/ha	9.22 (17.68)	224.0
Endosulfan 0.05%	8.26 (16.70)	232.0
Untreated control	24.23 (29.90)	184.0
CD (P=0.05)	(2.40)	23.3

Figures in parentheses are arcsine-transformed values.

(Table 3) showed that the mean parasitism of *C. blackburni* was significantly high and on par with *C. koehleri.* The per cent parasitism in case of *C. blackburni* and *C. koehleri* recorded by Divakar and Pawar (1979) and Khandge *et al.* (1979) confirmed present findings regarding existence of the parasitoids for 48 hours under field conditions. It indicated that the parasitoids could survive in the crop canopy, disperse and parasitize the PTM eggs in the potato field.

Under storage condition, it was observed that

Table 3. Recovery of parasitoids against *P. operculella* under field conditions

Parasitoid	Per cent parasitism		
	Retrieval - I	Retrieval –II	Mean
C. blackburni @ 15000 adults / ha	67.51	76.06	71.78
C. koehleri @ 50000 Adults / ha	66.93	71.86	69.39
T. chilonis @ 50000 adults/ha	58.26	64.40	61.33
CD (P=0.05)	5.87	3.82	2.76

all the parasitoids and microbial agents were statistically superior to untreated control for the suppression of PTM infestation up to two months namely termination of *Arnies* (Table 4.) Release of *C. blackburni* @ 2 adults/kg tubers gave minimum tuber infestation and proved to be the best. It was, however, on par with remaining bioagents except GV, *T. chilonis* and *B. thuringiensis* at their lower dosages after 60 days of their applications. Parlekar *et al.* (1979) recorded *C. kohleri* to be effective for the control of PTM in *Arnies*, which is in conformity with the present findings. Whereas the observation of Das *et al.* (1992) in respect of *B. thuringiensis* and GV are in agreement with the results of the current studies.

Thus, it could be inferred from the present investigations that inundative release of parasitoids *viz.*, *C. blackburni* and *C. koehleri* and sprays of *B. thuringiensis* could be employed for the control of PTM in fields whereas their initial release/ application may be given in storage conditions.

Table 4. Efficacy of parasitoids and microbial agents against *P. operculella* on potato in storage conditions

Treatment / dose per kg tubers	Per cent tuber infestation after	
	30 days	60 days
C. blackburni @ 1 adult	9.10 (17.46)	10.67 (19.07)
C. blackburni @ 2 adults	5.51 (13.56)	7.21 (15.57)
C. koehleri @ 5 pair of adults	7.56 (15.95)	9.80 (18.24)
C. koehleri @ 10 pair of adults	5.60 (13.69)	7.25 (15.62)
T. chilonis @ 50 adults	7.10 (15.45)	12.39 (20.62)
T. chilonis @ 100 adults	5.66 (13.76)	10.35 (18.76)
Granulosis virus @ 1 LE	11.70 (20.00)	12.93 (21.06)
Granulosis virus @ 2 LE	7.59 (16.00)	9.55 (18.00)
B. thuringiensis @ 1 g	9.03 (17.49)	12.19 (20.44)
B. thuringiensis @ 2 g	6.75 (15.06)	9.44 (17.89)
Untreated control	22.23 (28.13)	26.64 (31.06)
CD (P=0.05)	(4.11)	(4.68)

Figures in parentheses are arcsine- transformed values.

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