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Bioefficacy of Physical, Chemical and Bio-pesticide Seed Treatment against Pulse Beetle (*Callosobruchus chinensis*) in Chickpea

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ABSTRACT

Background: The effectiveness of chemical insecticides in comparison to other alternative treatments *viz.,* neem-based bio-pesticide formulation, chitin synthesis inhibitor, radiation technique and synthetic pyrethroid as seed treatment was studied to manage pulse beetle incidence with a view to determine the best option to prevent seed damage and also to maintain seed quality during storage.

Methods: The experiment was carried out under laboratory conditions following completely randomized block design with three replications. Four seed protectant treatments and untreated control was taken to study the effectiveness of the treatments on adult mortality and per cent seed weight loss. The insects were exposed to the treated seeds drawn from the treatment stock at 24, 48, 72, 96 and 120 hours after treatment (HAT). Observations for the study parameters were recorded at 30, 60, 90 and 120 days after storage (DAS) of insects on the treated seeds.

Result: The treatment with deltamethrin 2.8% EC @ 1.4 mg a.i./kg seed, diflubenzuron 25% WP @ 1.0 mg a.i./kg seed, neem oil based EC containing Azadirachtin 0.03% @ 6.0 mg a.i./kg seed and UV radiation @ 254 nm exposure for 5 min were found effective against *Callosobruchus chinensis* in descending order based on adult mortality and per cent seed weight loss.

Key words: Azadirachtin, Bioefficacy, *C. chinensis,* Chickpea, Deltamethrin, Diflubenzuron, UV radiation.

INTRODUCTION

A huge toll of agricultural produce in storage is destroyed each year specifically due to the infestation by stored grain pests and deprive the needy, poor, low dwelling population from the sufficient food intake. In addition, the loss of food grains, pulses, spices, oilseeds, bakery products and other processed food items by the insect infestation is a most common problem in the villages and townships of tropical and subtropical regions. The basic reasons behind the scene may be defined as prevailing warm and humid conditions, poor sanitary activities and non-availability of adequate food storage facilities like jute bags, poly bags, storage bins, silos, *etc*. A number of insect species and mites are on record infesting important food items and other store products in storage.

A serious problem of food grain loss in storage is due to the infestation by pulse beetles. The pulse beetles, *Callosobruchus maculatus* F. and *C. chinensis* L. are most common species infesting a variety of food grains in storage like chickpea (*Cicer arientum*), black gram (*Vigna mungo*), lentil (*Lens culinaris*), cowpea (*Vigna unguiculata*), mung bean (*Vigna radiate*), pigeon pea (*Cajanus cajan*), grass pea (*Lathyrus sativus*), garden pea (*Pisum saptivum*), *etc*. It is on record that *Callosobruchus* spp. caused 33% damage in stored leguminous seeds and 3% damage in cucurbitaceous, solanaceous and oilseed crops (Rathore and Sharma, 2001). Chickpea is a vital component of human nutrition, serving as an excellent source of plant-based protein (Seetharamu *et al.,* 2020). Chickpea seeds are prone to bruchid infestations in poor storage conditions, requiring pesticides and better practices to maintain quality (Sharma *et al.,* 2013).

Though *C. chinensis* causes damage to a variety of pulses in storage, but chickpea is the most preferred food grain for the population multiplication. The adult beetles lay eggs on the upper surface of the grain and after hatching, the emerged larvae called grubs bore into the grains and feed on internal contents. That is why, the grub

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stage of the beetle is primarily responsible for the grain damage and making the seeds unfit not only for human consumption, also for sowing.

To check the losses by pulse beetles in storage a number of insecticides are approved for use. The insecticide formulations aluminium phosphide 56% (3 g tablets and 10 g pouches), aluminium phosphide 15% (12 g tablets), aluminium phosphide 77.50% GR, Ethylene dichloride + Carbon tetrachloride (3:1) and Methyl bromide 98% are registered under the Insecticides Act, 1968 for use as fumigants to control insect pests in storage. Whereas, synthetic pyrethroid Deltamethrin 2.5% WP is approved for use as surface spray on stacks and on walls, ceilings and floors of godowns to control the stored grain insect pests. Since Methyl bromide depletes the ozone layer, many countries phasing out its production and consumption. The repeatedly improper use of chemical pesticides results in causing serious problems like resistance development, pest resurgence, residual toxicity, risk to vertebrates and environmental hazards (Zettler and Cuperus, 1990; Guedes *et al.,* 1997), Hence it directed the need for effective, safer and biodegradable products to control the stored grain pests (Elhag, 2000; Raghavan and Kapadia, 2003; Talukder and Howse, 2000). In the recent years, Effect of different botanical extract have been studied for the management of this pest (Satwika *et al.,* 2024).

The awareness has created immense interest in the scientific community for the evaluation of alternative ecofriendly strategies such as use of botanical extracts (Rahman *et al.,* 2013), botanical products (Elhag, 2000), botanical derivatives (Rahman and Talukder, 2006), vegetable oils (Rani *et al.,* 2000; Raghavan and Kapadia, 2003; Singh, 2003). Keeping the above facts in view, the present study has been undertaken for the evaluation of Neem based product, insect growth regulator, UV radiation in comparison to synthetic pyrethroid insecticide against *C. chinensis* on chickpea seeds under laboratory conditions.

MATERIALS AND MEHTODS

Experiments were carried out at Insect Physiology and Toxicology Laboratory, Department of Entomology and Agricultural Zoology, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi. The commercial neem formulation (Neem Oil based EC containing Azadirachtin 0.03% w/w min,), synthetic pyrethroid insecticide (Deltamethrin 2.8% EC), UV radiation and insect growth regulator (Diflubenzuron 25% WP) were used as preventive seed treatments from the infestation of pulse beetle, *C. chinensis* and also to safeguard viability of chickpea seeds. The treatments and dosage used were: Deltamethrin 2.8% EC @ 1.4 mg a.i./kg seed (=0.06 ml formulation/kg seed), Diflubenzuron 25% WP @ 1.0 mg a.i./kg seed (=4.0 mg formulation/kg seed), Neem oil based EC containing Azadirachtin 0.03% w/w min @ 6.0 mg a.i./kg seed (=20 ml formulation/kg seed) and UV Radiation @ 254 nm for 5 min (UV lamp fixed inside a wooden container was used). No seed treatment was done in untreated control.

The experiment was carried out at a constant dose of each treatment. One kg of local variety of whole disinfected chickpea seeds were taken in clean glass jars (18 cm × 20 cm) and treated by each treatment. The jars were tightened with lids and shaken to ensure uniform coating by the treatments.For UV radiation, the chickpea seeds were exposed under U.V. lamp and for control untreated seeds were taken. In the experiment five treatments and three replications were maintained for each exposure period to study the effect of treatments on adult mortality and seed weight loss. The covered jars were kept in a BOD incubator maintained at 30±1°C temperature and 70±5% relative humidity throughout the experimental period.

A sample of 25 gm chickpea each time from the treated bulk seeds were drawn at 24, 48, 72, 96 and 120 hours after treatment (HAT) application and laboratory reared (Jaiswal *et al.,* 2018) three pairs of newly emerged male and female adults were released per jar. After 10 days, the adults were removed and the jars were observed regularly for the seed weight loss and adult emergence. Observations for different parameters were recorded at 30, 60, 90 and 120 days after storage (DAS) for the samples drawn at each time interval after treatment application. The data were recorded as per schedule and analyzed statistically.

Adult mortality of pulse beetle was calculated on the basis of number of dead insects at 3, 5, 7 and 10 days interval after exposure. The apparent and total seed weight loss was assessed by categorizing in to infested and not infested grains. The per cent loss in weight was worked out using the following formula (Girish *et al.,* 1975).

$$\text{Apparent weight loss (\%)} = \frac{(Wa) - (Wb)}{(Wa)} \times 100$$

$$\text{Total weight loss (\%)} = \frac{(Wa) - (Wc)}{(Wa)} \times 100$$

Where,
Wa = Weight of seeds before infestation.
Wb = Weight of seeds after infestation.
Wc = Weight of seeds after removal of frass and excreta.

$$\text{Frass produced (\%)} = \frac{z}{x} \times 100$$

Where,
X = Weight of seeds before infestation.
X'= Weight of damaged grains with frass and excreta.
Y = Weight of damaged seeds after removal of frass and excreta.
Z = X' - Y.

RESULTS AND DISCUSSION

Adult mortality

The data on adult mortality of *C. chinensis* recorded at 3, 5, 7 and 10 days after release at 24, 48, 72, 96 and 120 HAT

have been presented in Table 1a. The per cent mortality calculated over control (Table 1b) showed that in the samples drawn at different time intervals, deltamethrin 2.8% EC @ 1.4 mg a.i./kg seed was found most effective with higher per cent mortality being 88.83 to 100% after 3, 5, 7 and 10 days of exposure at 24 HAT and effectiveness continued up to 120 HAT with 38.83 to 100% at different time intervals of observation. It was followed by diflubenzuron 25% WP @ 1.0 mg *a.i.*/kg seed with 66.67 to 100% and 33.33 to 66.67% mortality at 24 HAT and 120 HAT, respectively. Neem oil based EC containing Azadirachtin 0.03% w/w min @ 6.0 mg a.i./kg seed was next best treatment but per cent mortality declined sharply with time from 33.33 to 88.83% at 24 HAT to 27.83 to 61.17% at 120 HAT. UV radiation @ 254 nm for 5 min was least effective at each observation time. The present finding corroborated with the results of Jain and Yadav, (1989) against *C. chinensis* on green gram for deltamethrin treatment, Ramzan, (1994) against *C. maculatus* on moong for synthetic pyrethroids, Srivastava and Jha, (2007) against *Callosobruchus* spp. for synthetic pyrethroids and Pathania and Thakur, (2012) against *C. chinensis* on black gram. From the present study, it may be concluded that deltamethrin 2.8% EC @ 1.4 mg a.i./kg seed and diflubenzuron 25% WP @ 1.0 mg a.i./kg seed may be used for effective protection of chickpea seeds from *C. chinensis* infestation.

Per cent seed weight loss

The weight loss in seeds treated with deltamethrin 2.8% EC @ 1.4 mg a.i./kg seed were found significantly superior providing complete protection from pulse beetles when observed at 24 to 120 HAT on storage for 30, 60, 90 and 120 DAS. Hence, no weight loss occurred up to 120 DAS as there was no any development of bruchid (Fig 1-4). Subsequently, diflubenzuron 25% WP @ 1.0 mg a.i./kg seed was found second best effective treatment against pulse beetle in chickpea as minimal apparent and total weight loss along with frass produced were found in the sample drawn at 120 HAT up to 30 DAS. Thereafter, the apparent and total weight loss along with frass was observed in the samples drawn 24 to 120 HAT for 60, 90 and 120 DAS. Whereas, neem oil-based EC containing Azadirachtin 0.03% w/w min @ 6.0 mg a.i./kg seed and U.V. radiation @ 254 nm for 5 min gave least protection against *C. chinensis* and apparent and total weight loss along with frass produced were found in increasing pattern from 24 to 120 HAT drawn samples for 30, 60, 90 and 120 DAS.

The present finding thus is in close accordance with the findings of Srivastava and Jha, (2007) against *Callosobruchus* spp., Athanassiou *et al.* (2004) against *Sitophilus oryzae*, Dales and Golob (1997) against *Prostephanus truncates* and Lal and Dikshit, (2001) against *C. chinensis* who have reported full protection of grains with synthetic pyrethroid and other insecticidal treatments. The chickpea seed infestation by *C. chinensis* on treatment with deltamethrin has been reported to protect the seeds up to 120 DAS (Jaiswal *et al.,* 2019). From the present study, it is concluded that deltamethrin 2.8% EC @ 1.4 mg a.i./kg seed and diflubenzuron 25% WP @ 1.0 mg a.i./kg seed may be used for successful protection of chickpea seeds viability up to 120 DAS.

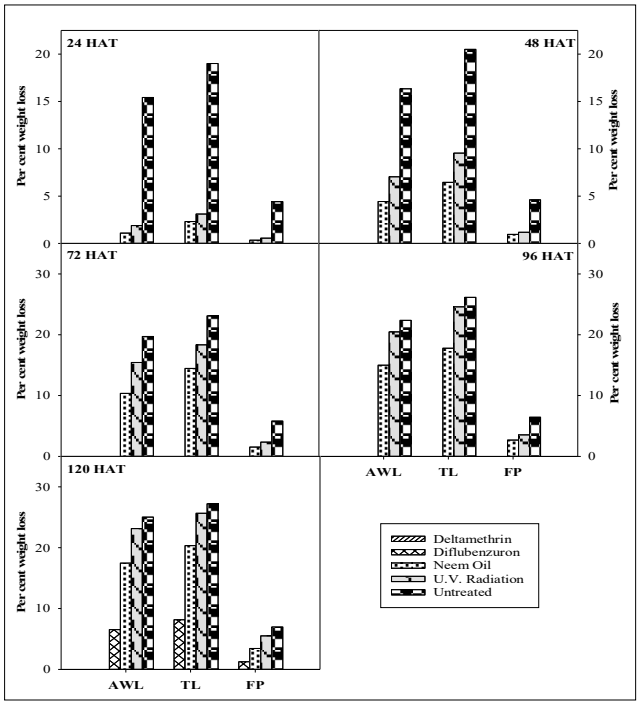


Fig 1: Efficacy of seed treatments on per cent weight loss caused by *C. chinensis* (30 days after storage) in chickpea.

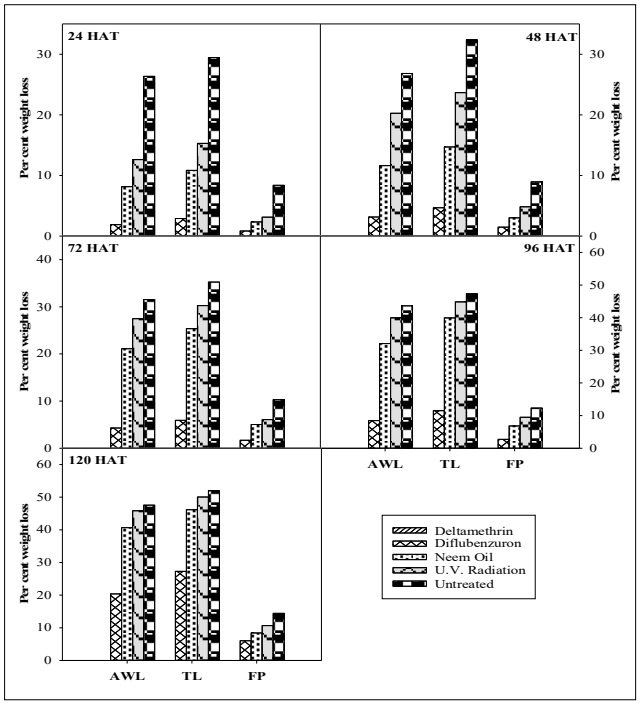


Fig 2: Efficacy of seed treatments on per cent weight loss caused by *C. chinensis* (60 days after storage) in chickpea.

Table 1a: Efficacy of seed treatments on adult mortality of *C. chinensis* in chickpea.

Treatments	Mean number of adult mortality of *C. chinensis* observed on different days of release																			
	24 HAT				48 HAT				72 HAT				96 HAT				120 HAT			
	3 DAR	5 DAR	7 DAR	10 DAR	3 DAR	5 DAR	7 DAR	10 DAR	3 DAR	5 DAR	7 DAR	10 DAR	3 DAR	5 DAR	7 DAR	10 DAR	3 DAR	5 DAR	7 DAR	10 DAR
Deltamethrin	5.33	6.00	6.00	6.00	5.00	5.33	6.00	6.00	4.33	5.00	5.33	6.00	3.33	4.00	5.00	6.00	2.33	3.67	5.33	6.00
2.8% EC	(2.41)	(2.55)	(2.55)	(2.55)	(2.34)	(2.41)	(2.55)	(2.55)	(2.19)	(2.34)	(2.41)	(2.55)	(1.93)	(2.12)	(2.34)	(2.55)	(1.68)	(2.04)	(2.41)	(2.55)
Diflubenzuron	4.00	5.33	6.00	6.00	3.67	4.00	5.00	6.00	2.67	3.67	4.67	5.33	2.33	3.33	4.00	5.00	2.00	3.33	3.67	4.00
25% WP	(2.11)	(2.41)	(2.55)	(2.55)	(2.04)	(2.11)	(2.34)	(2.55)	(1.77)	(2.02)	(2.27)	(2.41)	(1.68)	(1.93)	(2.12)	(2.34)	(1.58)	(1.94)	(2.04)	(2.12)
Neem oil based	2.00	2.67	3.33	5.33	2.00	2.33	3.00	5.00	1.67	2.33	2.67	4.00	1.67	2.00	3.00	3.33	1.67	2.00	3.00	3.67
EC cont Azad	(1.58)	(1.77)	(1.95)	(2.41)	(1.56)	(1.68)	(1.86)	(2.34)	(1.46)	(1.68)	(1.77)	(2.08)	(1.46)	(1.56)	(1.86)	(1.95)	(1.46)	(1.56)	(1.86)	(2.04)
0.03% min																				
U.V. Radiation	1.67	2.00	2.00	3.00	1.33	2.00	2.33	3.00	1.33	1.67	2.00	3.33	1.33	1.67	2.67	3.00	1.33	1.67	2.00	3.33
	(1.46)	(1.56)	(1.56)	(1.86)	(1.34)	(1.56)	(1.68)	(1.86)	(1.34)	(1.46)	(1.56)	(1.93)	(1.34)	(1.46)	(1.77)	(1.86)	(1.34)	(1.46)	(1.56)	(1.95)
Untreated	0.67	0.67	1.00	1.33	0.67	1.00	1.00	1.33	1.00	1.00	1.33	1.33	1.00	1.00	1.33	1.33	1.00	1.00	1.33	2.00
control	(1.05)	(1.05)	(1.22)	(1.34)	(1.05)	(1.22)	(1.22)	(1.34)	(1.22)	(1.22)	(1.34)	(1.34)	(1.22)	(1.22)	(1.34)	(1.34)	(1.22)	(1.22)	(1.34)	(1.56)
S. Em (±)	0.14	0.15	0.12	0.11	0.16	0.08	0.04	0.10	0.11	0.10	0.08	0.15	0.13	0.09	0.11	0.11	0.09	0.15	0.13	0.11
C.D (P=0.05)	0.46	0.46	0.37	0.35	0.49	0.26	0.14	0.33	0.36	0.31	0.26	0.46	0.43	0.29	0.36	0.35	0.28	0.47	0.42	0.35

Fig in parentheses are square root transformed values (x + 0.5); HAT: Hours after treatment; DAR: Days after release.

Table 1b: Efficacy of seed treatments on per cent adult mortality of *C. chinensis* in chickpea.

Treatments	Per cent adult mortality of *C. chinensis* observed on different days of release																			
	24 HAT				48 HAT				72 HAT				96 HAT				120 HAT			
	3 DAR	5 DAR	7 DAR	10 DAR	3 DAR	5 DAR	7 DAR	10 DAR	3 DAR	5 DAR	7 DAR	10 DAR	3 DAR	5 DAR	7 DAR	10 DAR	3 DAR	5 DAR	7 DAR	10 DAR
Deltamethrin 2.8% EC	88.83	100.00	100.00	100.00	83.33	88.83	100.00	100.00	72.17	83.33	88.83	100.00	55.50	66.67	83.33	100.00	38.83	61.17	88.83	100.00
Diflubenzuron 25% WP	66.67	88.83	100.00	100.00	61.17	66.67	83.33	100.00	44.50	61.17	77.83	88.83	38.83	55.50	66.67	83.33	33.33	55.50	61.17	66.67
Neem oil based EC cont Azad 0.03% min	33.33	44.50	55.50	88.83	33.33	38.83	50.00	83.33	27.83	38.83	44.50	66.67	27.83	33.33	50.00	55.50	27.83	33.33	50.00	61.17
U.V. Radiation	27.83	33.33	33.33	50.00	22.17	33.33	38.83	50.00	22.17	27.83	33.33	55.50	22.17	27.83	44.50	50.00	22.17	27.83	33.33	55.50
Untreated control	11.17	11.17	16.67	22.17	11.17	16.67	16.67	22.17	16.67	16.67	22.17	22.17	16.67	16.67	22.17	22.17	16.67	16.67	22.17	33.33

HAT: Hours after treatment; DAR: Days after release.

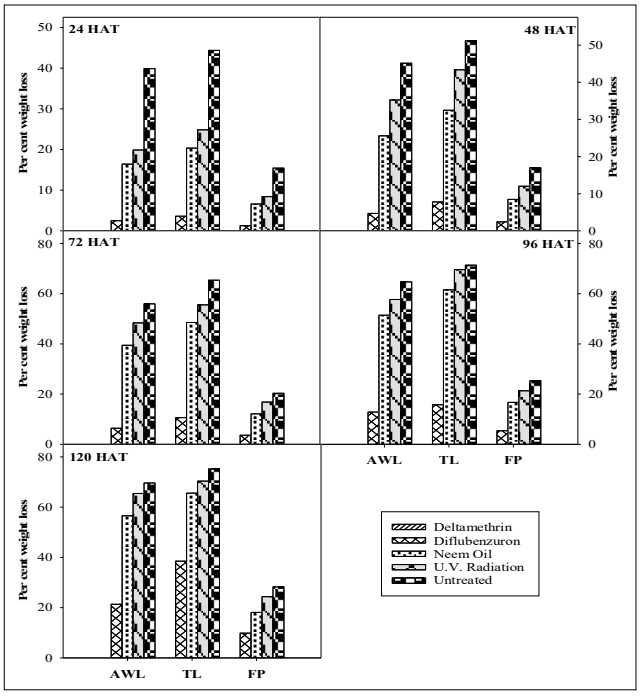


Fig 3: Efficacy of seed treatments on per cent weight loss caused by *C. chinensis* (90 days after storage) in chickpea.

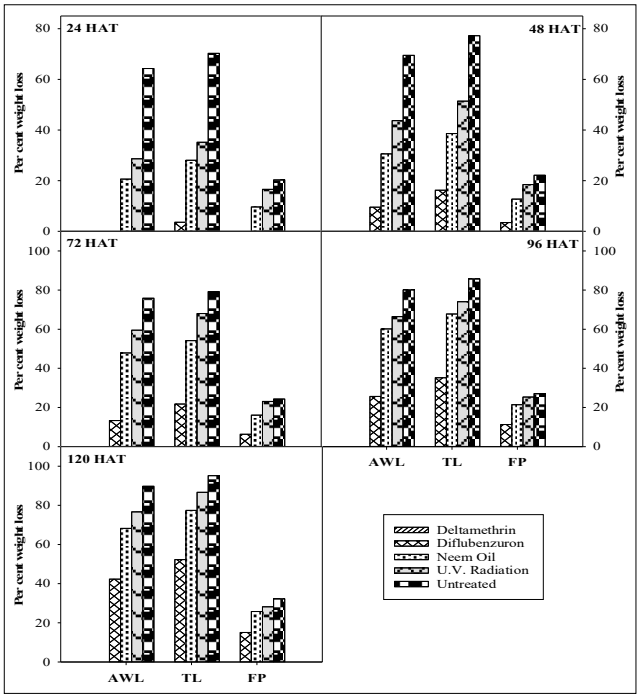


Fig 4: Efficacy of seed treatments on per cent weight loss caused by *C. chinensis* (120 days after storage) in chickpea.

CONCLUSION

The compiled results demonstrate that deltamethrin 2.8% EC @ 1.4 mg a.i./kg seed is the promising treatment followed by diflubenzuron 25% WP @ 1.0 mg a.i./kg seed in respect of low *C. chinensis* adult mortality and seed weight loss of chickpea seeds up to 120 days. Neem oil based EC containing Azadirachtin 0.03% w/w min @ 6.0 mg a.i./kg seed and UV irradiated seeds @ 254 nm for 5 min were moderately effective for adult mortality and poorly effective to check seed weight loss.

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Conflict of interest

All authors declared that there is no conflict of interest.

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