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Effect of Pre-harvest Spraying of Insecticides and Botanicals against Pulse Beetle (*Callosobruchus* spp.) on Storage Chickpea

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ABSTRACT: As the infestation of pulse beetle starts from the field, the adult female lays eggs on the maturing pods. It is necessary to manage the pest in the field itself thereby delimiting the damage during storage. In present study efforts were made to identify most economical and feasible insecticides and botanicals for the management of stored grain pest which carry the infestation from field to storage. Field cum-laboratory experiment was conducted to study the effect of pre-harvest spray of insecticides and botanicals for the control of pulse beetle (*Callosobruchus* spp.) on chickpea at Seed Technology Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, during *Rabi* 2022. The experiment was laid out in the Factorial Randomized Block Design consisted of 15 treatments and three spraying schedules involving three replications. Number of eggs laid, adult emergence and percent seed damage by beetle differed significantly due to pre-harvest spraying of insecticides and different spraying schedules. The lowest number of eggs laid, adult emergence and percent seed damage was recorded in treatment Lambda-cyhalothrin 5% EC @ 16.6 ml/10 L followed by Indoxacarb 15.80% EC @ 6.6 ml/10 L, Emamectin benzoate 5 SG @ 3 g/10 L. In case of spraying scheduled lowest number of eggs laid, adult emergence and per cent seed damage were recorded in spraying at 50 % pod maturity and pod maturity as compared to others. In interaction effect significantly lowest number of eggs laid, adult emergence and per cent seed damage were recorded in pre-harvest spraying of Lambda-cyhalothrin 5% EC @ 16.6 ml/10 L at 50 % pod maturity and pod maturity stage to check the infestation of pulse beetle during storage up to three months.

Keywords: Pre-harvest spray, insecticides, chickpea, and pulse beetle.

INTRODUCTION

Chickpea is the one of the most important leguminous crops and is extensively cultivated as a cool season annual crop under a wide range of agro-ecological conditions mainly of rain-fed nature (Ghafoor *et al.*, 2003). Chickpea (*Cicer arietinum* L.), also called garbanzo bean or Bengal gram, is an Old-World pulse and one of the seven Neolithic founder crops in the Fertile Crescent of the Near East (Lev-Yadun and Gopher 2000). It is an excellent source of protein and carbohydrate and its protein is of high quality as compared to other pulse crops (Ercan *et al.*, 1995). It is also used as feed for livestock and has a significant role in farming systems as a substitute for fallow in cereal rotations, where it contributes to the sustainability of production and reduces the need for N fertilization through fixing atmospheric nitrogen (Singh, 1997). India is the leading producer of chickpea in the world with an area of 10.56 Mha, production 11.38 Mt and productivity 10.78 q/ha in 2017-18 (Anonymous, 2019). In India, Madhya Pradesh (4.60 Mt), Maharashtra (1.78 Mt), Rajasthan (1.67 Mt), Karnataka (0.72 Mt), Andhra Pradesh (0.59 Mt), Uttar Pradesh (0.58 Mt), Gujarat (0.37 Mt), Chhattisgarh (0.32 Mt) and Jharkhand (0.29 Mt) are the major chickpea producing states contributing over 95% area (Anonymous, 2018). More than 150 insect pests attack pulses during storage. Among them, the most important pests are bruchids (*Callosobruchus* spp.) i.e., *Callosobruchus maculatus*, *C. chinensis*, *C. analis*, and *C. phaseoli* (Mishra *et al.*, 2015). The production of chickpea is greatly hampered by both biotic and abiotic stresses and while addressing the biotic stresses, insect pests of chickpea play a significant role both in the field and in storage, limiting the chickpea production and market value. Generally, pulse beetle are more prolific, breed and increases their population within short span. Its infestation starts either in the field on the maturing pod and is carried to the stores with the harvested crops or it originates in the storage itself. If appropriate management is not adopted, then it can damage 100% of stored pulses within few months of storage (Seni and Mishra 2022). Pulse beetle, *Callosobruchus chinensis* (L.) is one of the most destructive and cosmopolitan pests of stored legume. It not only causes qualitative and quantitative losses but also reduce germination ability of seeds. It is observed that up to 60 per cent of weight loss of the stored seed occurs due to pulse beetle (Golnaz *et al*., 2011). Adult beetle don't feed on pulses and females of *C. maculatus* lay eggs on the surface of the pulses (Ahmad *et al*., 2018). Due to infestation, seeds undergo biochemical alterations which results in the loss of various constituents of the seeds. The bruchid completes its entire immature life in individual legumes seeds, where they cause reduced germination potential, weight loss, seed infestation and also diminish the market as well as nutritional value of the commodity. Bruchids infest seeds at the final stage of maturation either directly from the field, or they may migrate from diseased seeds in nearby granaries or seed godowns that lack expression at the field. Controlling these pests in the field prevents them from entering godowns and spreading further to uninfected seeds (Prevett, 1961). Such infested seeds carry the bruchid population to storage and cause the infestation. The infested seeds can be recognized by the white eggs glued on the seed surface and the round exit holes with the 'flap' of the seed coat (Southgate, 1979). Farmers of our country are mostly marginal and sub-marginal, and stores most of their seeds produced in gunny bags where the seed produced suffers great loss due to infestation of insects pests, it is infeasible to fumigate the rural storage structure at farm level as they lacks availability of air tight store room. It is very challenging to protect our seed produce during storage period as the storage pest are very devastating in nature and cause heavy losses during storage. In this circumstance, it is requisite to find out strategy which is helpful to control this pest. According to the damaging pattern of this pest (infestation starts right from the field) pre-harvest sanitation spray is novel method to arrest this insect pest in the field itself and preventing the carry-over of pest into the storage. It involves the spraying of insecticides and botanicals at the formation and development of pod with advisable concentrations at suitable intervals (Vijayakumar, 2001). Earlier, the effect of pre harvest spraying of insecticides and botanicals for management of pulse beetle on storage pulses have been studied by workers Raghu *et al.* (2016), Hosamani *et al.* (2018) Dhobi and Board (2019), Jayaraj *et al.* (2019), Patoliya *et al.* (2020), Padmasri *et al.* (2021) and it is essential to control this pest at right stage of its infestation. Hence, a study has been carried out to evaluate the efficacy of pre-harvest spaying of insecticides and botanicals against Pulse beetle on storage chickpea.

MATERIALS AND METHODS

To evaluate efficacy of pre-harvest spray of insecticides and botanicals for the management of field infestation of pulse beetle on storage chickpea, this field cum laboratory experiment was conducted at Seed Technology Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during *Rabi* season 2022-2023.

In field

The field trail was carried out with chickpea variety JAKI-9218 adopting Factorial Randomized Block Design with two factors i.e. first factor was insecticides (Factor A) and second factor was spraying schedules (Factor B) with three replications. The seed plot of chickpea was raised after following recommended agronomical practices in a plot size of 5m × 3m. Insecticidal spray was applied as per the schedules i.e. spraying at 50% pod maturity (S1), spraying at pod maturity (S2), and spraying at 50% pod maturity and pod maturity (S3). The crop was imposed with pre-harvest spray using Emamectin benzoate 5SG @ 3g/10 L (T1), Azadirachtin T/S 10,000 ppm @ 60 ml/10 L (T2), Indoxacarb 15.80% EC @ 6.6ml/10 L (T3), and Lambda-cyhalothrin 5%EC @ 16.6 ml/10 L (T4) with knapsack sprayer as prophylactic measure against pulse beetle in storage. The unsprayed plot served as control (T5). The harvesting of crop was done by leaving border rows.

In storage

After threshing, seeds were collected from each treatment, replication wise. Such quantity of seed was kept in cloth bag ensuring protection from cross infestation during the storage period. The observations on adult emergence, per cent seed damage and number of egg laid by insect was counted at weekly interval for three months in storage. For this purpose, 500 seeds were randomly selected from each treatment replication wise. The data recorded on number of egg laid by insect, adult emergence and per cent seed damage were subjected to FRBD statistical analysis, as per Gomez and Gomez (1984).

Fig. 1. Pre-harvest spraying operation.

Fig. 2. Seeds kept in cloth bags to ensure cross protection against *Callosobruchus* spp.

RESULTS AND DISCUSSION

Effect of insecticides and botanicals on number of eggs laid by *Callosobruchus* spp.

The results of the pre-harvest sanitation spray (Table 1) revealed that the chickpea crop sprayed with Lambda-cyhalothrin 5% EC @ 16.6 ml/10 L (T4) (0.18) recorded minimum cumulative mean number of eggs laid by pulse beetle, followed by insecticide treatment with Indoxacarb 15.80% EC @ 6.6 ml/10 L (T3) (0.45), next effective insecticide treatment was Emamectin benzoate 5 SG @ 3 g/10 L (T1) (1.15) and treatment Azadirachtin T/S 10,000 ppm @ 60ml/10 L (T2) (1.69). Eggs laid by pulse beetle on stored chickpea seeds varied significantly among insecticidal spray. Statistical difference on eggs laid by adult pulse beetle in storage was observed due to pre-harvest spray schedule. Lowest cumulative mean number of egg laid was noticed in spraying of insecticides at 50% pod maturity and pod maturity stage (S3). Significant difference on number of egg laid was noticed in treatment combination i.e. interaction of insecticidal treatment (Factor A) and spray schedules (Factor B). Lowest cumulative mean number of egg laid was observed in treatment combination T4S3 (Lambda-cyhalothrin 5% EC @ 16.6 ml/10 L spraying at 50% pod maturity and pod maturity) (0.00) which was at par with T4S2 (Lambda-cyhalothrin 5% EC @ 16.6 ml/10 L spraying pod maturity) (0.11) and T3S3 (Indoxacarb 15.80% EC @ 6.6 ml/10 L spraying at 50% pod maturity and pod maturity) (0.11).

The above findings are in corroboration with the research results of Raghu *et al*. (2016) reported that pre-harvest spraying of insecticides and botanicals with different spraying schedule resulted in less number of infested seeds. Similar findings were also reported by Hosamani *et al.* (2018) who reported that insecticidal sprays (one at physiological maturity stage and second at a day before harvest) varied significantly with respect to the oviposition of bruchids. Also, Dhobi and Borad (2019) carried out experiment to evaluate the efficacy of pre-harvest spraying of insecticides for control of pulse beetle in green gram and reported that minimum number of egg laid by pulse beetle was recorded in pre-harvest spraying of Indoxacarb 14.5 SC and it was at par with Profenofos 50 EC. In case of spraying scheduled lower number of eggs laid was recorded in spraying at maturity. The results of present studies finds support in the research work of Nirmala *et al*. (2023) evaluated the efficacy of pre-harvest spray of insecticides and botanicals on seed yield to control field infestation of pulse beetle in mung bean and reported that the highest seed yield (kg plot-1) and seed yield (q ha-1) were recorded in treatment Emamectin Benzoate@ 0.3 ml/L followed by Neemazal @ 4 ml/L, it signifies that the pre- harvest spraying of insecticides reduced egg laying by pulse beetle on maturing pod thereby increasing seed yield, if these seeds are stored suffers less damage by pulse beetle.

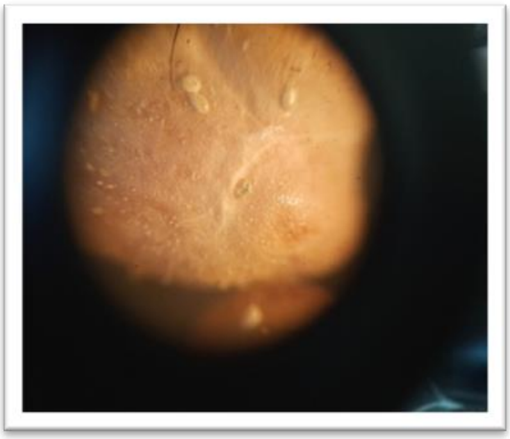

Fig. 3. Microscopic image of eggs laid by *Callosobruchus spp.* on chickpea seed.

Fig. 4. Eggs laid by *Callosobruchus* spp. on stored chickpea seeds.

Effect of insecticides and botanicals on number of adult emergence *Callosobruchus* spp.

The cumulative mean data presented in Table 1, revealed that pre-harvest sanitation spray with different insecticides in the field at pod maturing stages in chickpea crop, statistical difference on number of adult emergence was significant due to different insecticides. The maximum cumulative mean number of adult emergence was observed in unsprayed control (T5) (8.17), while minimum cumulative mean number of adult emergence was reported in insecticide treatment (T4) Lambda-cyhalothrin 5% EC @ 16.6 ml/10 L (0.06) followed by insecticide treatment (T3)

Indoxacarb 15.80% EC @ 6.6 ml/10 L (0.33), (T1) Emamectin benzoate 5 SG @ 3 g/10 L (0.82) and treatment (T2) Azadirachtin T/S 10,000 ppm @ 60 ml/10 L (1.11). In case of spraying the application of insecticides at 50 % pod maturity and pod maturity stage (S3) recorded least cumulative mean number of adult emergence (1.96). The results of interaction effects were found significant due to different treatment combinations. Cumulative mean number of adult emergence was significantly lowest in treatment combination T4S3 (Lambda-cyhalothrin 5% EC @ 16.6 ml/10 L spraying at 50% pod maturity and pod maturity) (0.00) which was at par with T4S2 (Lambda-cyhalothrin 5% EC @ 16.6 ml/10 L spraying at pod maturity) (0.03) and T3S3 (Indoxacarb 15.80% EC @ 6.6 ml/10 L spraying at 50% pod maturity and pod maturity) (0.08).

The present findings pertaining to efficacy of pre-harvest spraying of insecticides and botanicals against Pulse beetle on storage chickpea finds support in the research carried out by earlier workers. Dhobi and Borad (2019) revealed that significantly lower number of adult emergence were recorded in pre-harvest spraying of Indoxacarb 14.5 SC (1.57) followed by Profenofos 50 EC (2.99) at maturity stage as compared to other spraying schedule. Similarly, Padmasri *et al.* (2021) who revealed that interaction effect of insecticidal spray and spraying schedule were found significant and lowest adult emergence was recorded in treatment combination Profenophos 50 EC spraying at 50% maturity stage and maturity in red gram. Moreover, the experimental results of Jayaraj *et al*. (2019) showed that pre-harvest spraying of botanicals resulted in the minimum number of adult emergence in storage.

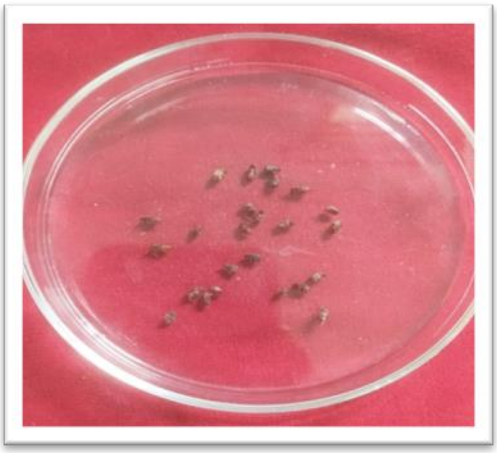

Fig. 5. *Callosobruchus* spp. adult emerged from stored chickpea seeds.

Effect of insecticides and botanicals on per cent seed damage by *Callosobruchus spp.*

All insecticidal treatments were found to be superior over untreated control in respect of per cent seed damage. The maximum cumulative mean per cent seed damage was recorded in insecticidal treatment with Lambda-cyhalothrin 5% EC @ 16.6 ml/10 L (T4) (0.01). The next effective treatment was treatment Indoxacarb 15.80% EC @ 6.6 ml/10 L (T3) (0.07) followed by treatment Emamectin benzoate 5 SG @ 3 g/10 L (T1) (0.17) and the least effective treatment was Azadirachtin T/S 10,000 ppm @ 60 ml/10 L (T2) (0.25). Significantly highest cumulative mean per cent seed damage was observed in unsprayed control (T5) (1.63). The results of pre-harvest spraying of insecticides at 50% pod maturity and pod maturity stage (S3) show minimum cumulative mean per cent seed damage (0.40) as compared to (S1) and (S2). The interaction between insecticides and schedules of spray brought significant variation on per cent seed damage caused by bruchids in the storage. Pre-harvest spraying of Lambda-cyhalothrin 5% EC @ 16.6 ml/10 L with spraying at 50% pod maturity and pod maturity T4S3 resulted in significantly minimum cumulative mean per cent seed damage (0.00) which was at par with treatment combination T4S2 (Lambda-cyhalothrin 5% EC @ 16.6 ml/10 L spraying at pod maturity) (0.01), T3S3 (Indoxacarb 15.80% EC @ 6.6 ml/10 L spraying at 50% pod maturity and pod maturity) (0.02) andT4S1 (Lambda-cyhalothrin 5% EC @ 16.6 ml/10 L spraying at 50% pod maturity) (0.02).

The present results are in conformity with the research work of Patoliya *et al.* (2020) who reported that treatment combinations, Profenofos 50 EC 1ml/ L Spraying at 50 & 100% pod maturity stage (1.08) resulted in lowest number of exit hole. Maximum per cent seed damage was reported in untreated control (14.97). Similarly, Dhobi and Borad (2020) in their experiment to evaluate effect of pre-harvest spray of insecticides for control of pulse beetle in green gram, found that minimum per cent seed damage was recorded in treatment combination Indoxacarb 14.5 SC 0.012% at 50% pod maturity and pod maturity stage (26.24). Padmasri *et al.* (2021) also studied efficacy of pre-harvest spraying of insecticides for control of Pulse beetle in pigeonpea revealed that minimum seed damage (0.01%) was recorded in pre-harvest spraying of Profenophos 50EC followed by Malathion 50EC spraying at 50% pod maturity and pod maturity. This experiment had significantly reduced per cent seed damage caused by *Callosobruchus chinensis* during storage.

Fig. 6. Seeds damaged by *Callosobruchus* spp.

Table 1: Effect of insecticides and botanicals on number of eggs laid, number of adult emergence and per cent seed damage by *Callosobruchus* spp.

Treatments		**Number of egg laid**	**Number of adult emergence**	**Per cent seed damage**
T1	Emamectin benzoate 5 SG	1.15 (1.25)	0.82 (1.10)	0.17 (0.81)
T2	Azadirachtin T/S 10,000 ppm	1.69 (1.46)	1.11 (1.22)	0.25 (0.86)
T3	Indoxacarb 15.80% EC	0.45 (0.94)	0.33 (0.88)	0.07 (0.75)
T4	Lambda-cyhalothrin 5% EC	0.18 (0.79)	0.06 (0.74)	0.01 (0.72)
T5	Control	10.75 (3.30)	8.17 (2.76)	1.63 (1.41)
F test		Sig.	Sig.	Sig.
SE (m) ±		0.02	0.01	0.00
CD @ 5%		0.07	0.03	0.02
Spraying schedule		**Number of egg laid**	**Number of adult emergence**	**Per cent seed damage**
S1	Spraying at 50% pod maturity	2.94 (1.66)	2.12 (1.40)	0.43 (0.93)
S2	Spraying at pod maturity	2.84 (1.56)	2.04 (1.34)	(0.42) (0.91)
S3	Spraying at 50% pod maturity and maturity	2.64 (1.43)	1.96 (1.27)	(0.40) (0.89)
F' test		Sig.	Sig.	Sig.
S.Em. ±		0.01	0.00	0.00
CD at 5 %		0.05	0.03	0.02
Interaction		**Number of egg laid**	**Number of adult emergence**	**Per cent seed damage**
T1S1	Emamectin benzoate 5 SG spraying at 50% pod maturity	1.67(1.45)	1.25 (1.27)	0.22 (0.86)
T1S2	Emamectin benzoate 5 SG spraying at pod maturity	1.50 (1.26)	0.75 (1.08)	0.16 (0.81)
T1S3	Emamectin benzoate 5 SG spraying at 50% pod maturity and pod maturity	0.61 (1.01)	0.47 (0.95)	0.09 (0.77)
T2S1	Azadirachtin T/S 10,000 ppm spraying at 50% pod maturity	2.23 (1.64)	1.53 (1.37)	0.35 (0.91)
T2S2	Azadirachtin T/S 10,000 ppm spraying at pod maturity	1.67 (1.46)	1.06 (1.20)	0.23 (0.85)
T2S3	Azadirachtin T/S 10,000 ppm spraying at 50% pod maturity and pod maturity	1.17 (1.28)	0.75 (1.08)	0.17 (0.81)
T3S1	Indoxacarb 15.80% EC spraying at 50% pod maturity	0.83 (1.14)	0.59 (1.05)	0.12 (0.78)
T3S2	Indoxacarb 15.80% EC spraying at pod maturity	0.42 (0.92)	0.33 (0.88)	0.07 (0.74)
T3S3	Indoxacarb 15.80% EC spraying at 50% pod maturity and pod maturity	0.11 (0.77)	0.08 (0.75)	0.02 (0.72)
T4S1	Lambda-cyhalothrin 5% EC spraying at 50% pod maturity	0.42 (0.92)	0.11 (0.78)	0.02 (0.73)
T4S2	Lambda-cyhalothrin 5% EC spraying at pod maturity	0.11 (0.77)	0.03 (0.72)	0.01 (0.72)
T4S3	Lambda-cyhalothrin 5% EC spraying at 50% pod maturity and pod maturity	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
T5S1	Control	9.56 (3.12)	7.11 (2.59)	1.42 (1.35)
T5S2	Control	11.31 (3.14)	8.67 (2.84)	1.73 (1.44)
T5S3	Control	11.31 (3.14)	8.67 (2.84)	1.75 (1.45)
F' test		Sig.	Sig.	Sig.
S.Em.±		0.04	0.02	0.01
CD @ 5%		0.12	0.06	0.03
CV%		4.57	2.68	2.26

*****Figures in parentheses are square root transformed values

CONCLUSIONS

From the above study, it was observed that infestation of pulse beetle in storage chickpea can be reduced by pre-harvest spraying of insecticides and botanicals in the field. Among the various insecticidal treatments, the number of eggs deposited by insects and the number of adult emergence and per cent seed damage were considerably lower in the insecticidal treatment i.e. Lambda-cyhalothrin 5%EC @16.6 ml/10. Spraying insecticides at 50% pod maturity and pod maturity stage (S3) recorded minimum number of eggs laid, number of adult emergence and per- cent seed damage. Treatment combination Lambda-cyhalothrin 5%EC @1 6.6 ml/10 L application at 50% pod maturity and pod maturity stage (T4S3) recorded significantly lower number of eggs, number of adult emergence, and percent seed damage by *Callosobruchus* spp.

FUTURE SCOPE

Present investigation will help in identifying inexpensive and reasonable insecticides and botanical for the management of pulse beetle which carry the infestation from the field to storage. Findings of this investigation will be useful to farmers for effective use of insecticides and botanical apart from this it will be encouraging for researcher for further investigation.

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Conflict of interest. The authors declare no conflicts of interest.

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