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Management of Gram Caterpillar, *Helicoverpa armigera* (Hubner) with *Bt* Formulation in Chickpea under Organic Conditions

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ABSTRACT

Background: Chickpea is an important pulse crop and grown widely in the world. Similar to other crops it is vulnerable to a broad range of insect-pests. Mainly, the gram pod borer, *Helicoverpa armigera* severe pest being that causes huge losses to chickpea crop. Farmers generally rely on chemical measures for its management that leads to various problems *viz.* resistance development, pest resurgence and residue problem along with environmental degradation.

Methods: During 2018-19 and 2019-20 microbial pesticide *viz. Bacillus thuringiensis* var. *kurstaki* 0.5 WP (DOR *Bt* 1) was tested @ 1.5, 1.75 and 2.0 kg/ ha for the management of gram caterpillar, *Helicoverpa armigera* in chickpea at Organic Research Farm, Punjab Agricultural University (PAU), Ludhiana. The application of spray was carried out, first at pod initiation and second 15 days thereafter. The observations were recorded on the larval population per meter plant row after 7 and 15 days of spray. The pod damage was recorded at the time of harvest wherein random samples of 200 pods per plot per replication were collected to observe the number of damaged pods.

Result: On overall mean basis at 15 DAS, the lowest larval population was observed in DOR *Bt*-1 @ 2.0 kg/ha (1.19 larvae/ 5 plants) followed by 1.75 kg/ha (1.54 larvae/ metre plant row) and 1.5 kg/ha (1.79 larvae/ metre plant row) as against highest larval count in untreated control (3.20/metre plant row) on chickpea. The DOR *Bt*-1 @ 2.0 kg/ha performed better due to highest pest reduction (62.81%) than its lower dosages DOR *Bt*-1 @ 1.75 kg/ha (51.88%) and DOR *Bt*-1 @ 1.5 kg/ha (44.06%) at 15 DAS. Also, DOR *Bt*-1 @ 2.0 kg /ha recorded highest pod damage reduction (76.14%) over its lower dosages, *i.e.*, DOR *Bt*-1 @ 1.75 kg/ha (54.18%) and DOR *Bt*-1 @ 1.5 kg/ha (38.24%). DOR *Bt*-1 @ 2.00 kg/ha (1275 kg/ha) was better due to highest yield compared to its lower dosages and the untreated control, where there was lower yield.

Key words: *Bt* formulation, Chickpea, *H. armigera,* Larval population, Management, Organic conditions, Pod damage, Yield.

INTRODUCTION

Chickpea (*Cicer arietinum* L.) also known as gram, Bengal gram, Egyptian pea, garbanzo, garbanzo bean and *chana*. It is an important legume crop among the various pulses which is also a good source of protein and belongs to the family Fabaceae, subfamily Faboideae (Jukanti *et al.* 2012). Depending upon its shape, size and colour of seeds, chickpea is divided into two types, *viz. desi* and *kabuli*. Gram contains 59.6% carbohydrates, 24% protein and 3.2% minerals (Bakr *et al.* 2004). Chickpea also improves the fertility of the soil by fixing the atmospheric nitrogen besides its importance as human and animal feed. Initially about 7000 years ago chickpea was introduced in the Middle East for the first time and in present time this crop is popular in 40 countries. Among these major chickpea growing countries are India, Turkey, Pakistan, Iran, Mexico, Australia, Ethiopia, Myanmar, and Canada. Global production of chickpea is 13.10 million tons from an area of 13.54 million hectares with the productivity of 968 kg/ha (FAOSTAT, 2015).

Different biotic and abiotic stresses lead to drastic reduction in the production and productivity of chickpea. This crop is vulnerable to a wide range of insect-pest and diseases. Majorly eleven insect- pests have been reported to cause huge losses to the chickpea crop (Rahman *et al.* 1982). Among different insect pests, gram caterpillar,

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Helicoverpa armigera (Hubner) is a serious pest of the chickpea. Larvae of this pest feed upon leaves, flowers and pods in chickpea crop that results in huge loss reaches upto 90% in the fields (Ahmad *et al.* 2015).

Gram caterpillar is a cosmopolitan and widely distributed insect pest in the world. It attacks nearly all legume crops and causes huge losses to these crops. Besides chickpea, *H. armigera* is also major pest on cotton, pigeonpea, sunflower, corn, chilli, tomato and okra (Wubneh, 2016). In India, gram caterpillar attacks nearly 181 legume species (45 families) that including both cultivated and uncultivated ones. This insect is reported from different regions of the world that including Palearctic, Oriental, Ethiopian and

Australian provinces. It survives in different climatic conditions *viz.,* Tropical, Dry and Temperate (CAB, 2000).

In chickpea and other legumes 1st, 2nd and 3rd instar larvae feed on the young leaves of the plant whereas in cotton and pigeonpea the larvae feed on the flowers and flower buds. Along with the development, larvae shift from foliage to developing seeds and fruits (Reed and Pawar, 1982). Young seedlings of chickpea may be destroyed completely specially under tropical climatic conditions in southern India. The later larval instars bore into pods/bolls and consume the developing seeds inside the pod (Patil *et al.* 2017).

Chemical insecticides are commonly used for the management of *H. armigera* but heavy dependence on chemical insecticides have resulted into the development of resistance in this insect (Kranthi *et al.* 2002; Yang *et al.* 2013; Bird, 2018). Along with development of resistance, excessive use of insecticides is also harmful to different beneficial arthropods, non-target organisms and human health (Mesnage and Seralini, 2018). The high use of chemical insecticides can be effectively reduced by integrating biopesticides in different pest management programs for *H. armigera*. The use of biopesticides is effective and environmentally safest method for the management of *H. armigera* (Abid *et al.* 2020).

Bacteria based insecticides are specific for the target insect-pests and do not harm the beneficial organisms like parasitoids and predators. Due to the development of more effective strains of *Bacillus thuringiensis* (*Bt*) and its improved commercial formulations, these biopesticides are getting more international support for its use against agriculturally important insect-pests. Similar attempts were made in the present studies to evaluate the *Bt* based biopesticide for the management of gram caterpillar in chickpea.

MATERIALS AND METHODS

In the present investigations the recommended variety of chickpea, *i.e.,* PBG 5 was grown under organic conditions at Organic Research Farm, Punjab Agricultural University (PAU) at Ludhiana in Punjab. As per PAU Package of Practices for *Rabi* crops, the chickpea crop was sown over total area of 480 m^2 (5 m × 4 m replicated plot size). Chickpea seed quantity was used as per recommendation (15-18 kg/ acre) at 30 cm row to row spacing during 1st fortnight of 5-10 November in 2019-20 and 2020-21 (Anonymous 2021). Also, 1.20 tonnes of farm yard manure was applied in the field to fulfill the nutrient requirement of the crop. The seed was moistened in water and inoculated with recommended quantity of Mesorhizobium (LGR-33) and Rhizobacterium (RB-1) biofertilizers before sowing. The *Bt* based biopesticide, *B. thuringiensis* var. *kurstaki* 0.5 WP (DOR *Bt* 1) was applied @1.5, 1.75 and 2.0 kg/ha for the management of *H. armigera* on chickpea on 2018-19 and 2019-20. An untreated control was also kept for the comparison. A total of three replications were kept during experimentation. The first biopesticide spray was applied at pod initiation and second at 15 days thereafter. The observations were recorded on the larval population as the number of larvae per metre plant row after 7 and 15 days of the spray. The per cent pod damage was worked out based on number of damaged pods by taking a random sample of 200 pods per plot per replication at harvest time. Grain yield data were also recorded from each plot after harvest and calculated to per hectare basis. The data were analyzed by Randomized Block Design and square root transformations using computer programme CPCS1 (Cheema and Singh 1990).

RESULTS AND DISCUSSION

All the biopesticide treatments showed better performance than the untreated control in terms of larval population, pod damage reduction and yield gain. The detailed results have been presented below.

Larval population

The average larval population of *H. armigera* varied significantly from 1.19-3.20 per 5 plants in different treatments, including the untreated control (Table 1). Based on pooled mean of both years, all treatments performed significantly better than untreated control after seven and fifteen days of spray. At 7 DAS, pooled sum of two sprays of DOR *Bt*-1 @2.0 kg/ha revealed significantly better due to low larval counts of gram caterpillar (0.87 larvae/ metre plant row) than its lower dosages @ 1.75 kg/ha (1.31 larvae/ metre plant row) and 1.5 kg/ha (1.44 larvae/ metre plant row) and the untreated control where significantly higher larval population (2.56 /metre plant row) was recorded. At 15 DAS, in DOR *Bt*-1 @2.0 kg/ha significantly lower larval counts

Table 1: Effect of *Bt* formulation on larval population of *Helicoverpa armigera* in chickpea under organic conditions.

Treatments	Dose (kg/ha)	Larval population (no./5 plants)		PROC	
		7 DAS	15 DAS	7 DAS	15 DAS
Bacillus thuringiensis var. *kurstaki* 0.5 WP (DOR *Bt*-1)	1.5 kg	1.44	1.79	43.75	44.06
Bacillus thuringiensis var. *kurstaki* 0.5 WP (DOR *Bt*-1)	1.75 kg	1.31	1.54	48.83	51.88
Bacillus thuringiensis var. *kurstaki* 0.5 WP (DOR *Bt*-1)	2.0 kg	0.87	1.19	66.02	62.81
Untreated control	-	2.56	3.20	-	-
LSD (p=0.05)		0.16	0.15	-	-

PROC: Per cent reduction over control; DAS: Days after spray.

was recorded (1.19 larvae/ metre plant row) based on pooled sum of two sprays than its lower doses, *i.e*. 1.75 kg/ha (1.54 larvae/ metre plant row) and 1.5 kg/ha (1.79 larvae/ metre plant row) as compared to the untreated control (3.20 larvae/ metre plant row). The present investigations are in agreement with those of Gudipati and Mondal, 2020) who also registered low larval population in *Bt* treated plots (0.32 larvae/ plant) as compared to untreated control (0.78 larvae/ plant). They also recorded higher yield in *Bt* treated plots (1.95 t/ha) over untreated control (1.33 t/ha) which also supports the present work. Similarly, findings by Taggar *et al.* (2014) that lowest larval population in native *Bt* isolate @ 1.5 kg/ha (3.66/plant) and *Bt*-1 @1.5 kg/ha (3.66/plant) over the untreated control (5.87/plant) also supports the present studies for lower pest population in *Bt* formulation.

At 7 DAS, the DOR Bt-1 @2.0 registered higher per cent reduction of larvae over control (66.02%) than its lower dosages of 1.75 kg/ha (48.83%) and 1.5 kg/ha (43.75%). At 15 DAS, DOR *Bt*-1 @2.0 kg/ha performed better with per cent reduction of larvae (62.81%) than its lower dosages of 1.75 kg/ha (51.88%) and 1.5 kg/ha (44.06%). The studies by Gudipati and Mondal (2020) that 59.40 per cent reduction of *H. armigera* larvae due to *Bt* on chickpea have supported the present findings. Similarly, Allahyari *et al.* (2020) who reported 59.82 per cent larval reduction of *H. armigera* larvae by *B. thuringiensis* subsp. *kurstaki* (Btk) in chickpea also falls in the range pf larval reduction during present work.

Pod damage

The pod damage ranged from 3.28 to 25.30 per cent in all the treatments including untreated control in both the years (Table 2). The pod damage in DOR *Bt*-1 @2.0 kg /ha (3.28%) was significantly lower as compared to its lower doses, *i.e.,* DOR *Bt*-1 @1.75 kg /ha (4.95%) and DOR *Bt*-1 @1.5 kg /ha (5.79%) during 2018-19. Similar trend was observed for pod damage during 2019-20, *i.e.,* lower pod damage in DOR *Bt*-1 @2.0 kg/ha (4.00%) than its lower dosages, *i.e.,* DOR *Bt*-1 @1.75 kg/ha (11.00% and DOR *Bt*-1 @1.5 kg/ha (17.00%). Based on overall mean, DOR *Bt*-1 @2.0 kg/ha was better with lowest pod damage (3.64%) than its lower dosages-DOR *Bt*-1 @1.75 kg/ha (7.98%) and DOR *Bt*-1 @1.5 kg/ha (11.40 %). Highest pod damage reduction recorded during 2018-19 and 2019-20 was 68.09 and 84.19 per cent in DOR *Bt*-1 @2.0 kg /ha than its lower dosages. On overall mean basis, DOR *Bt*-1 @2.0 kg /ha recorded highest pod damage reduction (76.14%) than at its lower dosages, *i.e.,* DOR *Bt*-1 @ 1.75 kg /ha (54.18%) and DOR *Bt*-1 @1.5 kg/ha (38.24%).

The present studies for pod damage in chickpea are in agreement with findings by Chaudhary and Sharma (1982) who reported 7-10 per cent pod damage in chickpea due to single larvae of *H. armigera* that resulted in 5.4 per cent yield loss. Russel *et al*. (1999) recorded an average 10-30 per cent chickpea yield loss on account of damage caused due to *H. armigera*, and this is in accordance with the present work. A work from Pakistan, by Sarwar *et al*. (2009, 2011) who reported 26.01 to 40.08 and 10.53 to 39.14 per cent losses due to *H. armigera* on susceptible and tolerant genotypes from early vegetative to fruiting stage on chickpea, respectively, also supports the current findings. In a study, *Bt* based insecticides-Biobit, Delfin and DiPel together with NPV recorded low pod damage due to *H. armigera* in chickpea (4.2 to 16.7%) over the untreated control (12.4 to 38.6%) (Anonymous, 1997) have also

Table 2: Efficacy of *Bt* formulation against *Helicoverpa armigera* in chickpea under organic conditions.

Treatments	Dose	Pod damage (%)			PROC		
	(kg/ha)	2018-19	2019-20	Mean	2018-19	2019-20	Mean
Bacillus thuringiensis var. *kurstaki* 0.5 WP (DOR *Bt*-1)	1.5 kg	5.79 (13.90)	17.00 (24.32)	11.40 (19.11)	43.68	32.81	38.24
Bacillus thuringiensis var. *kurstaki* 0.5 WP (DOR *Bt*-1)	1.75 kg	4.95 (12.80)	11.00 (19.31)	7.98 (16.06)	51.85	56.52	54.18
Bacillus thuringiensis var. *kurstaki* 0.5 WP (DOR *Bt*-1)	2.0 kg	3.28 (10.33)	4.00 (11.47)	3.64 (10.90)	68.09	84.19	76.14
Untreated control	-	10.28 (18.68)	25.30 (30.20)	17.79 (24.44)	-	-	-
LSD (p=0.05)		2.35	3.41	1.84	-	-	-

*Figures in parentheses are arc sine transformed values; PROC: Per cent reduction over control.

Table 3: Effect of *Bt* formulation on yield of chickpea crop under organic conditions.

Treatments	Dose	Yield (kg/ha)		
	(kg/ha)	2018-19	2019-20	Mean
Bacillus thuringiensis var. *kurstaki* 0.5 WP (DOR Bt-1)	1.5 kg	1073	925	999
Bacillus thuringiensis var. *kurstaki* 0.5 WP (DOR Bt-1)	1.75 kg	1126	1003	1065
Bacillus thuringiensis var. *kurstaki* 0.5 WP (DOR Bt-1)	2.0 kg	1317	1233	1275
Untreated control	-	903	857	880
LSD (p=0.05)		126	149	

supported present findings. Similarly, the research findings by Taggar *et al.* (2014) in Punjab regarding the low pod damage (25.57%) by *H. armigera* in Bt-1 @ 1.5 kg/ha over untreated control (39.45%) in pigeonpea are in accordance with present studies. The present work is in agreement with Allahyari *et al.* (2020) who reported 9.03 and 27.32 per cent pod damage in chickpea by *H. armigera* after 14 days of *Bt* treatment.

Yield

In 2018-19, DOR Bt-1 @2.0 kg/ha registered significantly highest grain yield (1317 kg/ha) than its lower dosages of 1.75 kg/ha (1126 kg/ha) and 1.75 kg/ha (1073 kg/ha) over untreated control (903 kg/ha) (Table 3). In 2019-20, similar trend was observed with higher yield in DOR Bt-1 @ 2.00 kg/ha (1233 kg/ha) than its lower dosage of 1.75 kg/ha (1003 kg/ha) and 1.50 kg /ha (925 kg/ha) over the untreated control (857 kg/ha). On overall mean basis for two years, DOR Bt-1 @2.00 kg /ha performed better due to highest yield (1275 kg/ha) than lower dosage of 1.75 kg/ha (1065 kg/ha) and 1.5 kg/ha (999 kg/ha) over the untreated control (880 kg/ha). Similarly, the present investigations for higher yield in chickpea in the studies for management of gram caterpillar on chickpea crop are in agreement to those of Ahmed and Khalique (2012) and Taggar *et al.* (2014) who also reported highest yield of pigeonpea in *Bt* treated plots over the untreated plots. The present work is in agreement with Allahyari *et al.* (2020) who in their studies for management of *H. armigera* with *Bt* formulation also recorded higher yield in *Bt* treated plots (786.42 kg/ha) over the untreated plots (627.49 kg/ha).

CONCLUSION

The non-judicious use of chemical pesticides created various issues like development of pest resistance, resurgence and residue effects on soil, water and environment besides ill effects on human and animal. The task of resistance development is more frequent in *Helicoverpa armigera* (Hubner) in comparison to other insect pests. Furthermore, untimely and excessive pesticidal applications can lead to the residual problems in *H. armigera* on chickpea. The detection of different ecofriendly pest management strategy is the only solution to the earlier mentioned problems. In view of that *Bt* formulation was tested against *H.armigera* on chickpea crop under organic conditions in the present investigation. The finding of present work revealed low larval counts of *H. armigera* larvae, pod damage, highest per cent larval reduction and more crop yield in *Bt* treated chickpea plots (DOR Bt-1 @2.0 kg/ha) over untreated ones. Therefore, the tested *Bt* formulation was observed to have high potential for the management of *H. armigera* in chickpea crop under organic conditions.

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Conflict of interest: None.

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