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Effect of border crops on natural enemies of *H. armigera* (Hubner) infesting chickpea

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Abstract
The experiment was carried out on to study the effect of border crops on natural enemies of chickpea pod borer, *H. armigera* (Hubner) infesting chickpea. The activity of Hymenopteran natural enemies started from 4th meteorological week and remained up to 11th meteorological week (0.00-6.58 hymenopteran per five plants). The peak activity was in the 7th meteorological week (2.92-6.58 hymenopteran per five plants) whereas, maximum hymenopteran (6.58 and 4.00 per five plants) was observed in maize and marigold treatments. The activity of Coleopteran natural enemies was started from 4th meteorological week and remained up to 11th meteorological week (1.50-10.00 coleopteran per five plants). During this period lady beetles, *Coccinella septempunctata* and *Cheilomenas sexmaculata* were observed in the experimental plot. The peak activity (2.33-9.17 and 1.67-10.00 coleopteran five plants) was in 10th and 11th meteorological week treatment sorghum recorded maximum coleopteran 9.17 and 10.00 per five plants and was significantly superior over rest of the treatments. The spider population in different border crops during 4th to 11th meteorological week was in the range of 0.58 to 5.33 per five plants. The peak activity (0.83-4.83 and 0.58-5.33) was in 10th and 11th meteorological week where sorghum and maize recorded 4.83, 5.33 and 4.25, 3.50 spider per five plants, respectively.

Keywords: *Helicoverpa armigera*, chickpea, pod borer, trap crop, border crop, *Campoletis chloridae* etc.

Introduction
India is a premier pulse growing country. Gram pod borer, *Helicoverpa armigera* (Hubner) is the serious pest of Indian agriculture. This pest is highly polyphagous and has been reported to damage more than 182 species of host plants. Availability of many alternative hosts and extensive cultivation of this crop in various agro-climatic zones is one of the key reasons for its incidence on the crop (Shivanna *et al*. 2012) [7]. The caterpillar not only defoliates the tender leaves but also makes holes in the pods and feed upon the developing grains. While feeding on the developing seeds the anterior body portion of the caterpillar remains inside the pod and rest half or so hanging outside. When seeds of one pod are finished, it moves to the next. Unless the pest is controlled in the initial stages of infestation it takes the heavy toll of the crop. A single larva has potential to damage up to 30 pods in its lifetime, thereby causing heavy losses to the crop (Sharma, 1978) [6]. The pod damage ranges from 3.3 to 72.8 per cent (Ahmad and Lingappa, 1998) [1]. Worldwide losses due to *H. armigera* have been estimated over US $ 300 million annually (Kaur *et al*. 2007) [3].
The management of this noxious pest is primarily based on synthetic insecticides. Preference of insecticides due to their easy availability and applicability and their excessive and indiscriminate use has resulted in the development of insecticidal resistance in the pest and environmental pollution. Recently, *H. armigera* is reported to have developed resistance to many commonly used insecticides (Phokela *et al*. 1990) [5]. Intercropping is more economical method of pest management and has become popular particularly among the small and marginal farmers and it is very well fitted in Integrated Pest Management. It is also proved very good practice for conservation of the natural enemies. However, the published information about impact of border crops on pest population and their natural enemies is very limited. Looking towards the chickpea plant protection measure, no much work has been reported by the workers and therefore it is necessitated to undertake the present investigation to study the effect of border crops on natural enemies of chickpea pod borer, *Helicoverpa armigera* (Hubner) infesting chickpea.

Materials and Methods

The experiment was conducted at ASPEE Agricultural Research and Development Foundation farm, Village- Met, Tal- Wada, Dist- Thane during *rabi* 2012 -2013 and laid out in split plot design with two replication using of chickpea cv. Gujarat-1 with a plot size 1.8 x 1.5 m^2. The spraying of biopesticides *viz*., (T_1) *Bacillus thuringienesis* var. *Kurstaki* 1.5 g l^{-1}, (T_2) *HaNPV* 500 LE ha^{-1}, (T_3) *Beauveria bassiana* 5 g l^{-1}, (T_4) *Metarrhizium anisopliae* 5 g l^{-1}, (T_5) Azadirachtin 50000 ppm (0.8 ml l^{-1}) and (T_6) only water spray was done after initiation of the pest. Another application was done 15 days after first spray. Whereas, border crops *viz*., (S_1) maize, (S_2) marigold, (S_3) sorghum and (S_4) no border (sole chickpea) were sown around the chickpea plot at the time of sowing of chickpea.

The natural enemies attracted towards border crops were recorded from 4 to 11th meteorological week *i.e.* up to harvest of the crop. The natural enemies were recorded by necked eyes and by collecting with the help of insect collection net. Similarly, the infected larvae, pupae from each plot having border crop were collected from the plant and kept in plastic vials in the laboratory for observing the emergence of the natural enemy. The recorded natural enemies were counted plot wise. The unidentified natural enemies were got identified from the Department of Agricultural Entomology, College of Agriculture, Dapoli. The data on number of natural enemies were subjected to $\sqrt{n+1}$ transformation and analyzed statistically.

Results and discussion

Effect of border crops on number of natural enemies at different meteorological weeks

Data on number of natural enemies per five plants at different meteorological weeks was recorded like Hymenoptera, Coleoptera and Spiders.

Effect of border crops on Hymenopteran natural enemies at different meteorological weeks

The data pertaining to the effect of border crops on Hymenopteran natural enemies at different meteorological weeks and results are presented in Table 1. The numbers of Hymenopteran natural enemies were recorded from five plants during 4th to 11th meteorological weeks in *rabi* season of 2012-13. *Campoletis chlorideae* Uchida and *Xanthopimpla punctata* (Hymenoptera) were recorded from the experimental plots. The activity of Hymenopteran natural enemies started from 4thmeteorological week and remained up to 11th meteorological week. The peak activity was in the 7th meteorological week.

Data on number of Hymenopteran natural enemies in 4th meteorological week was statistically significant. The border crop marigold recorded maximum natural enemies of 3.00 followed by maize and sorghum which recorded 2.92 and 2.67 natural enemies per five plants respectively. All the three treatments were at par with each other. In 5th and 6th meteorological week the activity of Hymenopteran natural enemies was in the range of 4.83 to 3.25 in all main plots. In 7th meteorological week, the maximum activity of Hymenopteran natural enemies was in Maize (6.58/5 plants) followed by marigold (4.00/5 plants) and both the border crops were at par with each other. In 8th meteorological week all the main plots recorded equal but good activity of Hymenopteran natural enemies and data was non-significant. The activity of Hymenopteran natural enemies started declining from 9th meteorological week due to maturity of crop.

The present findings confirm the results of Suganthy *et al.* (2000) [8]. They reported that all the IPM strategies were found to be safe to *Campoletis chlorideae* Uchida (Ichenumonidae: Hymenoptera) a larval parasitoid of *H. armigera* in chickpea. The present findings also confirm the results of Gopali *et al*. (2009) [2]. They studied the beneficial role played by natural enemies in chickpea ecosystem at Karnataka. They reported the predatory wasp carrying large numbers of larvae on sunflower plants.

Table 1: Effect of border crops on number of Hymenopteran natural enemies at different meteorological weeks

Treatments	Number of Hymenopteran natural enemies per meteorological week							
	4th	5th	6th	7th	8th	9th	10th	11th
Main plot: Border crop level								
S_1: Maize	2.92 (1.90)*	4.83 (2.31)	4.75 (2.35)	6.58 (2.74)	2.92 (1.87)	2.75 (1.84)	0.00 (1.00)	0.00 (1.00)
S_2: Marigold	3.00 (1.94)	4.00 (2.22)	3.50 (2.06)	4.00 (2.20)	3.58 (2.11)	0.00 (1.00)	0.42 (1.16)	0.00 (1.00)
S_3: Sorghum	2.67 (1.85)	3.25 (1.93)	4.00 (2.16)	2.92 (1.90)	4.08 (2.15)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)
S_4: No border	1.83 (1.64)	3.42 (2.04)	3.33 (2.02)	3.00 (1.99)	2.42 (1.81)	1.25 (1.47)	2.75 (1.88)	1.25 (1.47)
F test	Sig.	NS	NS	Sig.	NS	Sig.	Sig.	Sig.
S.E. ±	0.089	0.263	0.271	0.191	0.273	0.054	0.080	0.019
C.D. at 5%	0.259	-	-	0.558	-	0.158	0.234	0.056

*Figures in parentheses are $\sqrt{n+1}$ transformed values.

Effect of border crops on Coleopteran natural enemies at different meteorological weeks

The data pertaining to the effect of border crops on Coleopteran natural enemies at different meteorological weeks and results are presented in Table 2. The activity of Coleopteran natural enemies was started from 4th meteorological week and remained up to 11th meteorological week. During this period lady beetles, *Coccinella septempunctata* and *Cheilomenas sexmaculata* were observed in the experimental plot. The peak activity was in 10th and 11th meteorological week.

The maximum (2.50/5 plants) number of Coleopteran natural enemies were recorded from Sorghum followed by maize and no border which recorded 2.33 and 2.17 Coleopteran natural enemies per five plants in 4th meteorological week and both the treatments were at par with each other. In 5th meteorological week, the border crop maize recorded highest natural enemies of 6.33 followed by sorghum which recorded

4.50 per Coleopteran natural enemies per five plants and both the treatments were at par with each other. In 6th meteorological week maize and sorghum recorded highest number of natural enemies of 5.58 and 4.58 respectively and both the treatments were at par with each other. In 7th meteorological week the border crop Maize recorded significantly highest number of Coleopteran natural enemies of 6.50 per five plants over all other treatments. The border crop sorghum recorded 4.00 natural enemies per five plants and was the second best border crop. In 8th meteorological week the border crop maize recorded 5.75 natural enemies and found to be the best treatment followed by sorghum and no border which recorded 5.50 and 3.58 natural enemies per five plants. In 9th meteorological week the border crop sorghum recorded highest natural enemies of 7.25 followed by maize (6.50) and both the treatments were at par with each other. In 10th meteorological week the sorghum recorded highest natural enemies of 9.17 per five plants and was significantly superior over rest of the treatments. The next best treatment was maize which recorded 8.00 natural enemies per five plants. In 11th meteorological week the border crop sorghum recorded 10.00 natural enemies and was significantly superior over rest of the border crops. The maize recorded 7.50 natural enemies and found to be second best border crop for attracting Coleopteran natural enemies.

The present findings closely confirm the results of Gopali *et al.* (2009) [2]. They reported that the large numbers of coccinellids were noticed on sunflower plants when it was grown as a inter crop. Similar results found by Pattar *et al.* (2012) [4] and reported that the population of spiders and coccinellids were higher in intercropping system compared to sole chickpea.

Table 2: Effect of border crops on number of Coleopteran natural enemies at different meteorological weeks

Treatments	Number of Coleopteran natural enemies per meteorological week							
	4th	5th	6th	7th	8th	9th	10th	11th
Main plot: Border crop level								
S_1: Maize	2.33 (1.81)*	6.33 (2.69)	5.58 (2.56)	6.50 (2.73)	5.75 (2.58)	6.50 (2.73)	8.00 (2.99)	7.50 (2.90)
S_2: Marigold	1.50 (1.55)	2.42 (1.84)	2.25 (1.76)	2.33 (1.81)	1.67 (1.59)	2.92 (1.97)	3.75 (2.18)	4.17 (2.25)
S_3: Sorghum	2.50 (1.83)	4.50 (2.34)	4.58 (2.35)	4.00 (2.21)	5.50 (2.53)	7.25 (2.86)	9.17 (3.18)	10.00 (3.31)
S_4: No border	2.17 (1.77)	3.33 (2.04)	2.25 (1.77)	2.67 (1.90)	3.58 (2.12)	1.67 (1.60)	2.33 (1.79)	1.67 (1.60)
F test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
S.E. ±	0.073	0.153	0.090	0.032	0.201	0.059	0.021	0.042
C.D. at 5%	0.214	0.447	0.264	0.093	0.586	0.173	0.062	0.123

*Figures in parentheses are $\sqrt{n+1}$ transformed values.

Effect of border crops on Spiders at different meteorological weeks

The data pertaining to the effect of border crops on Spiders at different meteorological weeks and results are presented in Table 3. The spider population in different border crops during 4th to 11th meteorological week was in the range of 0.58 to 4.83 per five plants. The peak activity was in 10th and 11th meteorological week. Data on effect of border crops on spider population during 4th meteorological week revealed that the border crop maize recorded highest spider population of 3.67 and was significantly superior over rest of the border crops. In 5th meteorological week the border crop sorghum recoded 2.67 spiders per five plants followed by maize and marigold which recoded 2.42 and 0.92 spiders and all these three border crops were at par with each other. In 6th meteorological week maize recorded maximum number of spiders of 2.67 and was significantly superior over rest of the border crops. It was followed by sorghum (1.50). In 7th meteorological week the border crop maize recorded 4.08 spider populations and was found to be best border crop followed by marigold and sorghum which recorded 0.92 and 0.75 spider population per five plants respectively. In 8th meteorological week the border crop maize recorded highest number of spider population (2.58/5 plants) and found to be significantly superior border crop. It was followed by Sorghum which recorded 1.83 spiders per five plants. In 9th meteorological week sorghum recorded highest number of spiders of 3.75 and found to be best treatment. The next best border crop was maize which recorded 3.00 spiders per five plants. The same trend was observed in 10th and 11th meteorological week where sorghum and maize recorded 4.83, 5.33 and 4.25, 3.50 spiders per five plants, respectively.

The present findings also corroborate the results of Pattar *et al.* (2012) [4]. They reported that the population of spiders and coccinellids were higher in intercropping system compared to sole chickpea.

The number of birds like cattle egret, house sparrows and pigeons were observed during experimental period. These birds were commonly observed at morning, noon and evening hours. The border crop was served as bird perches for them. They were picking the *H. armigera* larva from the plot and feeding them by sitting on these border crops.

Table 3: Effect of border crops on number Spiders at different meteorological weeks

Treatments	Number of Spiders per meteorological week							
	4th	5th	6th	7th	8th	9th	10th	11th
Main plot: Border crop level								
S1: Maize	3.67 (2.04)*	2.42 (1.78)	2.67 (1.88)	4.08 (2.24)	2.58 (1.85)	3.00 (1.98)	4.25 (2.29)	3.50 (2.10)
S2: Marigold	0.58 (1.23)	0.92 (1.35)	0.58 (1.24)	0.92 (1.32)	0.67 (1.24)	1.33 (1.48)	2.17 (1.77)	2.33 (1.81)
S3: Sorghum	0.75 (1.24)	2.67 (1.88)	1.50 (1.52)	0.75 (1.27)	1.83 (1.63)	3.75 (2.16)	4.83 (2.41)	5.33 (2.50)
S4: No border	0.92 (1.35)	0.67 (1.24)	0.92 (1.34)	0.58 (1.23)	0.67 (1.26)	0.58 (1.23)	0.83 (1.32)	0.58 (1.23)
F test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
S.E. ±	0.204	0.189	0.040	0.021	0.154	0.053	0.025	0.050
C.D. at 5%	0.595	0.550	0.117	0.061	0.449	0.154	0.072	0.145

*Figures in parentheses are $\sqrt{n+1}$ transformed values.

Conclusion

The present investigation findings proved that border crops play vital role in conserve natural enemies. In chickpea ecosystem farmers using of border cropping system *viz*., maize, sorghum, marigold crops not only for suppressing pod borer population in field but also get incremental yield from those crops.

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