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Management of maize stem borer, *Chilo partellus* (Swinhoe) in *Kharif* maize with cowpea intercropping

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Abstract
A field study was conducted to evaluate the efficacy of cowpea as an intercrop against maize stem borer, *C. partellus* at Entomological Research Area of CCS Haryana Agricultural University, Regional Research Station, Uchani, Karnal during *Kharif*, 2017. Minimum leaf injury rating [LIR (2.48)] was recorded in treatment with intercropping of maize with cowpea (1:1) which was at par with sole maize + spray of dimethoate 30 EC @ 660 ml/ha at 7-10 days after germination (DAG) (2.62) and maize + cowpea intercrop (2:1) (3.06). Minimum plant infestation (8.1 %) and dead hearts (4.5%) were recorded in treatment with sole maize + spray of dimethoate 30EC @ 660 ml/ha at 7-10 DAG followed by maize + cowpea (1:1) (12.7 and 5.6%) whereas sole maize without spray recorded maximum plant infestation and dead hearts (38.7 and 16.2%, respectively). Highest benefit: cost ratio (1.63) was recorded in treatment with maize + cowpea (1:1) with maize yield 4227 Kg ha^{-1} and cowpea yield, 596 Kg ha^{-1}.

Keywords: *Chilo partellus*, cowpea, leaf injury rating, dimethoate, yield

Introduction
Maize (*Zea mays* L) or corn belonging to family Graminae, is the third most important cereal crop of the world after wheat and rice. It is a major source of human food in developing countries and supplies more than 5 per cent of our dietary energy. Besides serving as human food and livestock feed, maize has its wider applications in milling industries for starch and oil extraction. It is grown in more than 160 countries all over the world, except Antarctica, out of which USA, China, Brazil, France and India are the major producers. Globally, it occupies an area of 186.82 million ha with total annual production of 1078.31 million metric tonnes and productivity of 5.77 metric tonnes per hectare [1]. In India, it occupies an area of 9.63 million hectares having annual production of 25.90 million metric tonnes with average productivity of 2.69 metric tonnes per hectare [2]. The major maize growing states in India are Karnataka, Andhra Pradesh, Maharashtra, Bihar, Punjab, Rajasthan and Haryana. In Haryana, it is grown over an area of 5,000 hectares having production of 17,000 tonnes with average productivity of 3400 kg ha^{-1} [3].

Despite an increase in the area under maize cultivation, its productivity in India is very low in comparison with major maize growing countries of the world. Productivity of India is 2.69 tonnes ha^{-1} against the world average of 5.77 tonnes ha^{-1}. A number of factors are responsible for this low productivity, out of which insect-pests and diseases are among major constraints. In India, about 13.2 per cent economic yield losses have been reported due to insect-pests attack and disease incidence [4]. Among different stem borers infesting maize, maize stem borer or spotted stem borer, *C. partellus* (Swinhoe) (Lepidoptera: Crambidae), is the most serious and ubiquitous pest of maize not only in India but throughout the Asian countries. In north India, it particularly causes more damage during the rainy season. Infestation by this pests starts from 1-2 weeks after germination and continues till harvesting of the crop. The newly emerged larva enters into the whorl of the plant, scraps off the chlorophyll content of the leaves and finally bores into the leaf sheath where it feeds on the growing stem of young plants. In later stages, it bores inside the stem and start tunneling. Leaf scrapping, window formation, pin holes, stunted growth, dead hearts and stem tunneling are the characteristics damaging symptoms produced by this pest. *C. partellus* has been reported to cause 26.7 to 80.4 per cent losses in total yield of maize under different agro-climatic zones of our country [5].

Management of *C. partellus* is indispensable for successful cultivation of maize. Use of insecticides is not the right choice to control this pest due to its cryptic behaviour of feeding inside the stem. Moreover, extensive use of chemical insecticides directly increases the cost of cultivation and possesses many health hazards. Integrated pest management (IPM) which involves the use of resistant cultivars, biological control agents, intercrops, trap crops etc. sounds to be a better option for management of *C. partellus.* Intercropping is an important cultural practice which increases the ecosystem diversity and affect the microclimate of agro ecosystems producing an unfavourable environment for pests [6, 7] which is favourable for their natural enemies [8-10].

Material and methods: This experiment was conducted during *Kharif*, 2017 at laboratory and research area of CCS Haryana Agricultural University, Regional Research Station, Uchani, Karnal, Haryana. Maize hybrid, HM10 was intercropped with Cowpea variety, CS 88 at the Entomological Research Area of Maize section, RRS, Uchani, Karnal by adopting a spacing of 75 x 20 cm. There were total six treatments and each treatment was replicated four times in a Randomized Block Design. Plot size was twelve rows of 3 m row length. All recommended practices were followed to raise the crop except spray of insecticides in T1-T4 and T6. The detail of treatments is as follows:

	Treatments
T1	1 rows of maize + 1 row of cowpea
T2	2 rows of maize + 1 row of cowpea
T3	3 rows of maize + 1 row of cowpea
T4	4 rows of maize + 1 row of cowpea
T5	Sole maize with single spray with Dimethoate 30EC @ 660ml/ha
T6	Untreated sole maize

Observations were recorded on plant infestation, dead heart formation, LIR and grain yield (Kg ha^{-1}). For recording plant infestation and dead heart formation, 100 plants per replicate were selected randomly and tagged at 5 DAG of crop. Total number of damaged plants and dead hearts were counted at 42 DAG and expressed as per cent infestation and dead hearts. Leaf injury ratings were recorded at 42 DAG in different treatments as per the LIR scale (1-9) given by Reddy *et al.* [11]. Benefit: cost ratio and net economic return from different treatments were also worked out.

Statistical analysis: Data obtained under different heads were subjected to statistical analysis by using Randomized Block Design (RBD) using OPSTAT software. The critical difference was calculated at 5 per cent level of significance. Appropriate transformations were applied on the data obtained during the present studies.

Experimental results and discussion

Plant infestation: Results of the present studies indicated that all the treatments of intercropping *i.e.* maize + cowpea reduced plant infestation to a significant level. Minimum plant infestation (12.7 %) by *C. partellus* was observed in treatment T1 (maize + cowpea in 1:1) (Table 1 and Figure 1a) which differed significantly from all other treatments of intercropping. However, borer infestation in sole maize having one spray of dimethoate 30EC @ 660 ml/ha at 7-10 DAG was recorded to be 8.1 per cent. Whereas untreated control (sole maize without spray) (Figure 1b) reported maximum infestation (38.7 %) which also differed significantly from all other treatments (Table 1). Similar level of reduction in plant infestation by *C. partellus* was reported by Ampong at Kenya when sorghum was intercropped with cowpea [12]. Present results are in accordance with Anuradha *et al.* who reported lowest plant infestation (4.15%) in maize intercropped with cowpea in 2:1 followed by 4.55 per cent in sole maize protected with one spray of endosulfan 35 EC @2ml/l at 12 DAG which were at par with each other [13].

Dead heart formation: Among all treatments of intercropping, minimum dead hearts (5.6 %) were recorded in treatment T1 (maize + cowpea in 1:1) which differed significantly from all intercrop treatments (Table 1). However, dead heart formation in maize + cowpea (1:1) was at par with treatment T5 (sole maize + spray of dimethoate 30EC @ 660 ml/ha at 7-10 DAG) which recorded 4.5 per cent dead heart formation. Maximum dead hearts (16.2%) were reported in sole maize without spray which also differed significantly from all treatments (Table 1). Similar results were reported by Anuradha *et al.* at Rajendarnagar who observed significant reduction in dead heart formation when maize was intercropped with cowpea [13]. They reported lowest dead hearts (0.58%) in maize intercropped with cowpea in 2:1 followed by sole maize with single spray of endosulfan (0.64%). Similarly, minimum number of pinholes and dead hearts were observed when sorghum was intercropped with groundnut followed by sorghum + cowpea at Karnataka [14].

LIR: Minimum LIR (2.48) was recorded in treatment T1 (intercropping of maize with cowpea in 1:1) which was at par with T5 (sole maize + spray of dimethoate 30 EC @ 660 ml/ha at 7-10 DAG) (2.62) and treatment T2 (maize + cowpea intercropped in 2:1) (3.06). Treatment T6 (sole maize without spray) recorded maximum LIR (5.12) which was at par with treatment T4 (maize + cowpea in 4:1) which recorded LIR 4.68 (Table 1). Results of present investigations are in close association with Kaur *et al.* who reported minimum LIR when cowpea was intercropped with maize (1.09) as compared with sole maize treated with endosulfan spray (1.36) [15].

Table 1: Effect of cowpea as an intercrop for management of *C. partellus* in maize during *Kharif*, 2017

	Treatments	Plants infested (%)	Dead hearts (%)	LIR	Maize Yield (kg ha^{-1})	Cowpea grain yield (kg ha^{-1})
T1	Maize + Cowpea (1:1)	12.7(20.82)*	5.6(13.73)*	2.48	4227	596
T2	Maize + Cowpea (2:1)	16.0 (23.56)	7.9 (16.28)	3.06	4655	347
T3	Maize + Cowpea (3:1)	25.2 (30.08)	11.1(19.40)	4.32	4624	297
T4	Maize + Cowpea (4:1)	28.9 (32.51)	13.3(21.37)	4.68	4803	198
T5	Sole maize + spray Dimethoate @ 660 ml/ha at 7-10 DAG**	8.1 (16.48)	4.5(12.26)	2.62	6545	-
T6	Sole Maize without spray	38.7 (38.42)	16.2(23.68)	5.12	4854	-
	C.D at P=0.05	(2.62)	(1.63)	0.82	381.52	93.60

*Figures in parenthesis are angular transformed values

**Dimethoate 30 EC was sprayed @ 660 ml in 500 L water per hectare

Yield of maize and cowpea: The adoption of intercropping with maize resulted in substantial increase in the yield during crop season. The data pertaining to yield of maize and cowpea is given in Table 1. However, maize yield was highest in treatment T5 (sole maize + spray with dimethoate 30EC @ 660 ml/ha) (6545 kg ha^{-1}) whereas lowest maize yield was recorded in treatment T1 (maize + cowpea 1:1) (4227 kg ha^{-1}). It was due to the fact that cowpea was intercropped in maize by replacement intercropping (rows of maize were removed for sowing cowpea). But when cowpea was intercropped with maize in different ratio, maximum yield of cowpea (596 kg ha^{-1}) was recorded in T1 (maize + cowpea in 1:1) followed by treatment T2 (maize + cowpea in 2:1) (347 kg ha^{-1}) and treatment T3 (maize + cowpea in 3:1) (297 kg ha^{-1}). Minimum cowpea yield (198 kg ha^{-1}) was recorded in treatment T4 (maize + cowpea in 4:1). Anuradha *et al.* also reported increase in yield when maize was intercropped with cowpea [13]. They reported higher grain yield in maize + cowpea plot (2:1) (9.67 kg/8 rows of 4 m row length) as compared to sole maize (8.29 kg/8 rows of 4 m row length) which gives support to present findings [13].

Fig 1: (a) Better crop stand and healthy plants in maize + cowpea (1:1) intercropping system and (b) more infested sole maize

Benefit: cost ratio: The economics of different treatments involving maize cowpea interaction was worked out. The data regarding B:C ratio and net economic return of different treatments is presented in Table 2 and Figure 2. Highest B:C ratio (1.63) was recorded in treatment T1 (maize + cowpea in 1:1) followed by treatment T2 (maize + cowpea in 2:1) (1.48) and treatment T5 (maize + spray with dimethoate 30EC @ 660 ml/ha) (1.47). Lowest B:C (1.10) was observed in T6 (sole maize without spray), which is reported to be least profitable. Similarly, Hedge *et al.* recorded highest monetary returns from maize and cowpea intercropping system when evaluated against *C. partellus.* They recorded highest cost:benefit ratio (1:3.31) when maize intercropped with cowpea as compared to sole maize (1:2.42) [16].

Table 2: Net economic return from different treatments of maize: cowpea intercropping.

	Treatments	Maize yield (Kg ha^{-1})	Return from maize (Rs. ha^{-1})	Cowpea yield (Kg ha^{-1})	Return from cowpea (Rs. ha^{-1})	Return from by Products (Rs. ha^{-1})	Gross return (Rs. ha^{-1})	Total variable cost (Rs. ha^{-1})	Net return (Rs. ha^{-1})	Benefit cost Ratio (B:C)
T1	Maize + Cowpea (1:1)	4227	64250	596	23989	1800	90039	55313	34726	1.63
T2	Maize + Cowpea (2:1)	4655	70756	347	13967	1200	85923	57998	27924	1.48
T3	Maize + Cowpea (3:1)	4624	70285	297	11954	1000	83239	60910	22329	1.37
T4	Maize + Cowpea (4:1)	4803	73006	198	7970	1500	82475	61720	20755	1.34
T5	Sole maize + spray dimethoate @ 660 ml/ha at 7-10 Dag*	6545	99484	-	-	1500	100984	68858	32126	1.47
T6	Sole Maize without spray	4854	73781	-	-	1000	74781	67693	7088	1.10
	C.D. at P=0.05	381.52		93.60						

Market price of maize: Rs. 1520/qt; Market price of cowpea: Rs. 4025/qt; Total variable cost (Rs. ha^{-1}): variable cost + transportation cost+ management cost; Gross return (Rs. ha^{-1}): return from maize + return from cowpea + return from selling of by-products; Net return (Rs. ha^{-1}): Gross return – total variable cost

*Dimethoate 30 EC was sprayed @ 660 ml in 500 L water per hectare

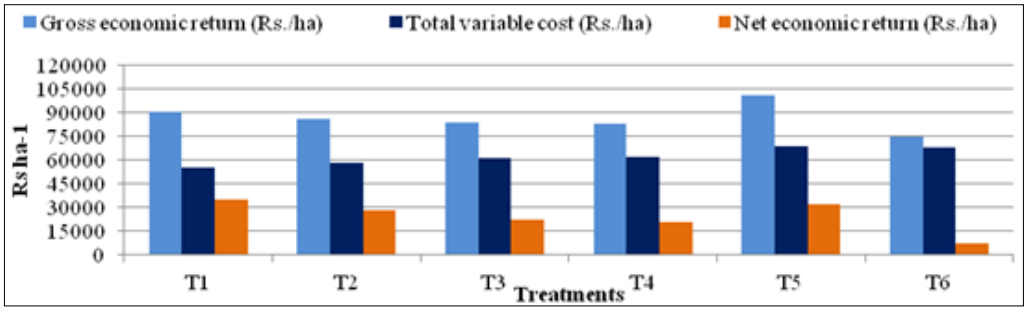

Fig 2: Net economic return from different treatments of maize cowpea intercropping.

Conclusion

From the results of above study it was concluded that maize-cowpea intercropping in 1:1 was most effective in reducing plant infestation and dead heart formation by *C. partellus* larvae followed by maize protected with single spray of dimethoate @ 660 ml/ha and maize-cowpea (2:1) intercropping. Highest monetary returns (Rs. 34726 ha^{-1}) and highest B:C (1.63) ratio were also recorded in maize-cowpea (1:1) intercropping.

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