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Effect of intercropping system on the incidence of safflower pests and their natural enemies

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Abstract
An Experiment was conducted during the period from November 2017 to April 2018 to study 7 intercropping systems with safflower (*Carthamus tinctorius* L.) on the incidence of aphid and *Helicoverpa armigera* at the department of the Entomology field, Sam Higginbottom University of Agriculture and Technology Science, Allahabad. The study aimed to get the yield advantages and economic gains from the randomized block design including three replication and eight treatments. In this experiment intercropping has been done as treatment; within the base crop of safflower. Eight treatments included in this study *viz.*; T1 Safflower + Mustard, T2 Safflower + Wheat, T3 Safflower + Chickpea, T4 Safflower + Coriander, T5 Safflower + Lentil, T6 Safflower + Sorghum, T7 Safflower + Neemoil 1% and T8 Sole Safflower. Lowest population of aphids was recorded in Safflower + Mustard and it was followed by Safflower + Wheat, Safflower + Sorghum, Safflower + Coriander, Safflower + Chickpea and Safflower + Lentil. Safflower sole was found with highest population. Lowest population and damage by *H. armigera* was recorded in Safflower + Mustard and it was followed by Safflower + Wheat, Safflower + Sorghum, Safflower + Coriander, Safflower + Lentil and Safflower + Chickpea. Lowest infected intercrop was mustard followed by wheat, sorghum and highest infection in lentil and chickpea.

Keywords: *Chrysoperla carnea*, *Coccinella septempunctata*, Damage percentage, *Helicoverpa armigera*, intercrop, Neem oil, safflower, *uroleucon compositae*, yield

1. Introduction
Safflower (*Carthamus tinctorius* L.) is an ancient crop of the family Compositae or Asteraceae and it is originated in the Near East and has been grown for centuries in China, India and North Africa. It is a multi-purpose species with many traditional uses. In India safflower cultivation is being done for centuries for its orange red and yellow dye (Carthamine) extracted from the florets were once used to colour food and clothing and for its oil, rich in poly unsaturated fatty acids which are considered to reduce blood cholesterol and good for heart patients. It is cultivated mainly for its seeds and known for its quality as edible oil, in view of the higher proportion of linoleic acid (78%) content as compared to other vegetable oils. The oil is semi drying in nature and being used in paints, varnishes, textiles and leather industry. Its leaves have been used in ancient and modern medicine. Karnataka is the second largest producer of safflower having 55,038 ha with a production of 45,578 tonnes with the productivity of 872 kg/ha (Anonymous 2011) [3]. The yields of safflower in India are very low with an average productivity of 630 kg/ha as compared to the global average of 893 kg/ha. There are several causes for low productivity in Karnataka among them biotic factors play key role such as aphid, *Uroleucon compositae* (Theobald), capsule borer, *Helicoverpa armigera* (Hub.) and leaf eating caterpillar, *Perigea capensis* (Walker) considered as major pests which cause severe damage to safflower crop and reduces yield up to 30-80 percent (Hanumantharaya *et al.* 2008a) [6]. A total of 101 pests are known to attack safflower at different stages of crop growth and development (Singh *et al.* 1996) [13]. In India Safflower is attacked by 36 species of pests (Bharaj *et al.* 2003) [4], out of these the safflower aphid, *U. compositae* and recently leaf eating caterpillar, *P. capensis* and capsule borer, *H. armigera* are considered to be major pests of the crop. Among different insect pests, safflower aphid, *Uroleucon compositae* alone is one of the most destructive pests (Akashe *et al.* 1999) [1] which reported to cause 35-72 percent yield loss during heavy infestation period (Anonymous 2007) [2]. Seed and oil content losses due to this pest ranges from 20 to 80 percent which has been reported from different parts of the country (Singh *et al.* 2000) [10]. The aphids not only reduce yields of seed and oil content but also attack petals lowering the quality of the value added

product of this part of the plant (Sastry, 1997) [11]. Nymphs as well as adults suck the cell sap from the lower surface of the leaves and tender shoots and impair the vitality of the plants. Besides sucking the sap from the plants, the aphids also excrete honeydew which falls on the upper surface of the lower leaves. It attracts a black sooty mould that adversely affects the photosynthesis. Ultimately reduces the seed yield and oil content losses due to this pest to an extent of 20 to 80 percent have been reported from different parts of the country (Singh *et al.* 2000) [14]. Control of safflower aphid has been achieved only by using different insecticides (Neharkar *et al.* 2003) [10].

2. Materials and Method

The present investigation was undertaken to evaluate "The effect of intercropping system on the incidence of safflower pests and their natural enemies" at the Central Research Farm of Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad, Uttar Pradesh during *Rabi* season 2017-18. The research farm is situated on the right side of Allahabad. Field trial was laid out in randomized block design (RBD) with 3 replications and 8 treatments including untreated control during *rabi* 2017-18 to evaluate the efficacy of six intercrops i.e., mustard, wheat, chickpea, coriander, lentil and sorghum against aphid and *Helicoverpa armigera* on safflower. Crop was raised in plots measuring 2x2 m with a spacing 60x30 cm between rows and plant, respectively. Crop was raised according to all agronomic package of practices under irrigated condition except the plant protection measure. After infestation; observations was taken on 45 and 60 DAS. Specific plant was selected for readings.

2.1 Data collection

2.1.1 Observation on aphids and *Helicoverpa armigera*

Observations on aphids were made on five randomly selected plants in each treatment by counting the number of aphids per 5 cm apical twig and observations on *Helicoverpa armigera* were recorded on number of larvae and damaged capsules on randomly selected five plants in each treatment.

2.1.2 Observation on natural enemies

Observation on predator's viz., coccinellids and *chrysoperla* nymphs and adult was made in the field itself. The total number of predators were counted on five randomly selected plants and the mean of five plants was worked out as the number of coccinellids and *chrysoperla* per plant.

2.2 Percent pod damage

Observations were made on the total number of capsules and the number of damaged capsules by *Helicoverpa armigera*. The percent damaged was worked out at harvest by using the following formula given by Jaba *et al.* (2017) [9].

$$\text{Percent damage} = \frac{\text{Number of damaged capsules}}{\text{Total number of capsules}} \times 100$$

2.3 Equivalent yield

The yields of different intercrops were equated to safflower yield using the following formula and then total equated grain yield of safflower was calculated on hectare basis by adding the safflower main crop and equivalent yield of intercrop given by Verma and Modgel, (1983) [15].

$$\text{Equivalent yield (q/ha)} = \frac{\text{Intercrop yield (q /ha)} \times \text{Market price of inter crop}}{\text{Market price of main crop}}$$

Table 1: Treatment details on the effect of different intercropping systems on the incidence of aphid, *Helicoverpa armigera* and their natural enemies.

Treatments	Treatments	Crop : Intercrop Ratio
T_1	Safflower + Mustard	3:2
T_2	Safflower + Wheat	3:2
T_3	Safflower + Chickpea	3:2
T_4	Safflower + Coriander	3:2
T_5	Safflower + Lentil	3:2
T_6	Safflower + Sorghum	3:2
T_7	Safflower + Neem oil	5
T_8	Sole Safflower	5

3. Results and Discussion

The intercropping is an economical method of pest management and has become popular, particularly among the small and marginal farmers. Intercrops in the study were chosen on the basis of their wide cultivation among small-holder farmers in the region. The possible success of these crops is in ensuring profit and reducing damage by the pests of safflower. The application of chemical insecticides and biological insecticide is the common method of controlling this pest on safflower.

The data present in the table is on 45 DAS (5th February) and 60 DAS (20th February).

3.1 Effect of intercrop on the incidence of aphid in safflower

At 45 days after sowing (DAS), the effect of intercrops on the incidence of safflower is presented in Table 2 showed that the aphid *Uroleucon compositae* population ranged from 6.46 to 29.06/5cm apical twig. Safflower intercropped with mustard (T1) recorded significantly minimum aphid population (8.98/5cm apical twig) and was superior to other intercrops viz., wheat (T2) (10.933/5cm apical twig), sorghum (T6) (12.89/5cm apical twig), coriander (T4) (15.756/5cm apical twig), chickpea (T3) (16.573/5cm apical twig) and lentil (T5) (19.606/5cm apical twig), respectively. Whereas, the incidence of aphid was high (29.066/5cm apical twig) when safflower (T8) was grown as sole crop and the least number (6.46/5cm apical twig) recorded in sole safflower protected with neem oil 1% (RPP) (T7). Sole safflower recorded highest aphid of 29.066/5cm apical twig and differed significantly with rest of the intercropping systems (Fig. No.1). However, Hanumantharaya *et al.* (2009) [8] reported that the lower aphid population because natural enemies like *Chrysoperla* and coccinellids were higher killing all the aphids population wherever safflower was intercropped with coriander and sorghum might be due to the availability of pollen, nectar and favorable microclimate to the natural enemies. The similar trend existed at 60 days after sowing (DAS), aphid population ranged from 8.666 to 34.103/5cm apical twig in different intercropping systems. Safflower intercropped with mustard (T1) recorded the minimum aphid population (13.823/5cm apical twig) followed by wheat (T2) (16.230/5cm apical twig), sorghum (T6) (17.470/5cm apical twig), coriander (T4) (19.633/5cm apical twig), chickpea (T3) (21.273/5cm apical twig) and lentil (T5) (25.900/5cm apical twig), respectively. Whereas the incidence of aphid was high (34.103/5cm apical twig) when safflower (T8) was grown as sole crop and least number (8.666/5cm apical twig) was recorded in standard

check i.e., sole safflower protected by spraying with neem oil 1% (T7) (Fig. No.1). Further reported that safflower mixed cropping with coriander also reduces the aphid population on safflower and increases the predatory population which suppresses the pest population (*Chrysoperla* and Coccinellids) Hanumantharaya *et al*. (2008b) [7].

Table 2: Effect of intercrops on the incidence of safflower aphid, *Uroleucon compositae* (Theobald)

Treatment No.	Treatments	Crop: Intercrop Ratio	No. of aphids/5 cm apical twig (On Main crop)		No. of aphids/5 cm apical twig (On Intercrop)	
			45 DAS	60 DAS	45 DAS	60 DAS
T_1	Safflower + Mustard	(3:2)	8.98	13.82	16.71	20.37
T_2	Safflower + Wheat	(3:2)	10.93	16.23	13.59	17.72
T_3	Safflower + Chickpea	(3:2)	16.57	21.27	9.56	11.95
T_4	Safflower + Coriander	(3:2)	15.76	19.63	7.09	10.60
T_5	Safflower + Lentil	(3:2)	19.61	25.90	11.34	14.88
T_6	Safflower + Sorghum	(3:2)	12.89	17.47	14.73	19.64
T_7	Safflower + Neem oil	(5)	6.46	8.67	0	0
T_8	Sole Safflower	(5)	29.07	34.10	0	0
F-Test			**S**	**S**	**S**	**S**
S.Em±			0.71	0.54	0.63	0.41
CD (5%)			2.15	1.63	1.97	1.30
CV (%)			8.17	4.75	8.90	4.49

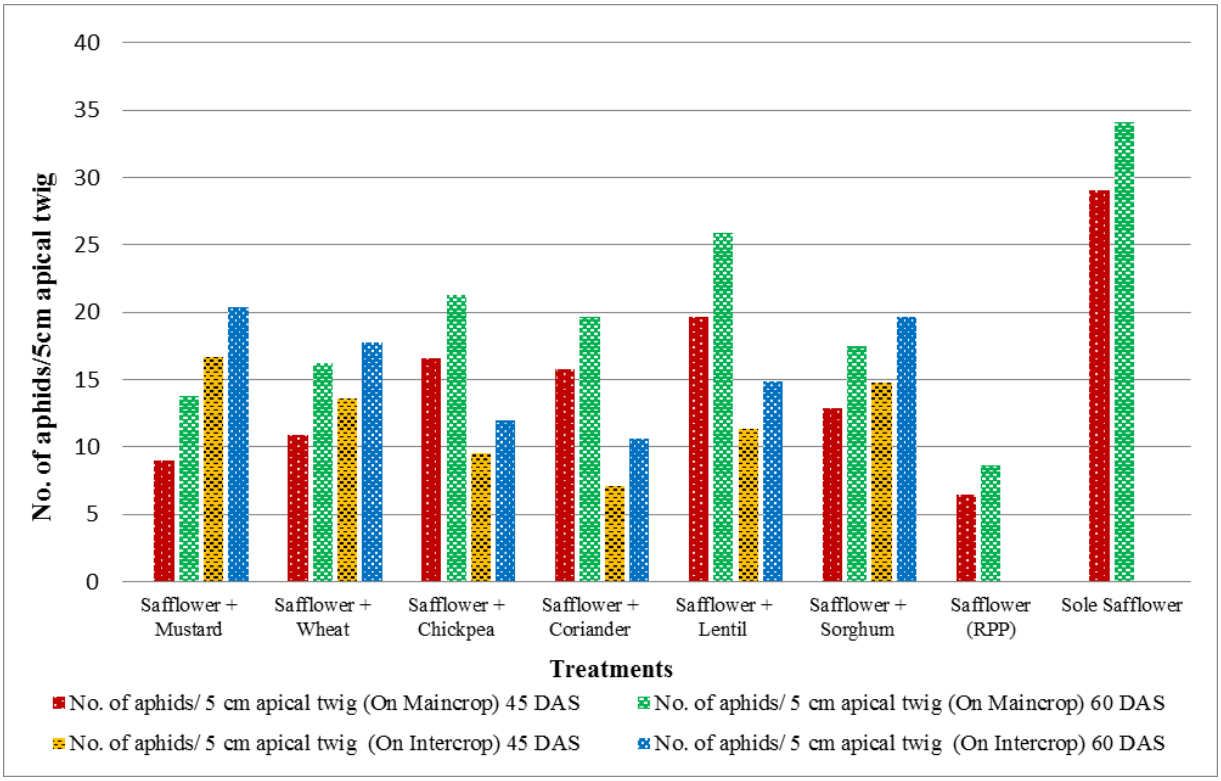

Fig 1: The No. of aphid/5cm (*Uroleucon compositae*) infestation on main crop and on intercrops of safflower

3.2 Effect of intercrop on the incidence of *Helicoverpa armigera* (Hubner)

Effect of intercrops on the incidence of *Helicoverpa armigera* larval population was presented in (Table 3). The lowest larval population 1.090 larvae/plant was recorded on safflower + Mustard (T1) intercropped treatment and it was significantly superior to the rest of the treatments. But this treatment was found on par with RPP (sole safflower when protected with neem oil 1%) (T7), which recorded 0.920 larvae/plant. The next best treatment was safflower + wheat (T2) (1.130 larvae/plant) and found significantly superior over other treatments which was followed by safflower + sorghum (T6) (1.446 larvae/plant), safflower + coriander (T4) (1.683 larvae/plant), safflower + lentil (T5) (1.873 larvae/plant) and safflower + chickpea (T3) (2.200 larvae/plant). However, sole safflower proved its inferiority by recording the higher number of larvae 2.593/plant (T8) (Fig. No.2). Effect of intercrops on the incidence of *Helicoverpa armigera* and percent capsule damage was significant. The fast growing habit of mustard, sorghum and wheat might have acted as barrier crops for the movement of moths and might have reduced the oviposition as reported by the Hanumantharaya *et al*. (2008c) [5].

Among the different intercrops the lowest percent capsule damage was 16.08 percent in safflower + mustard (T1) intercropped treatment (Table 3). This treatment being at par with neem oil 1% (RPP) 12.93 percent (T7) and differed significantly with rest of the treatments. The next best treatment was safflower + wheat (T2) (19.18 percent capsule damage) and found superior over safflower + sorghum (T6) (21.922 percent capsule damage), safflower + coriander (T4) (23.363 percent capsule damage), safflower + lentil (T5)

(24.026 percent capsule damage) followed by safflower + chickpea (T3) (29.50 percent capsule damage). However, sole safflower proved its inferiority by recording maximum capsule damage 42.146% (T8) (Fig. No.2).

The capsule borer population in the different intercrops recorded the maximum number in T6-safflower + sorghum (2.36 larvae/plant) and minimum number in T5-safflower + lentil (0.56 larvae/plant), but there was no infestation in the treatments T2-wheat and T4-coriander. This may be due to the non-host crop as capsule borer does not infest these crops. Shivaleela (2012) [12] reported that chickpea + wheat (3:6) recorded lowest pod borer larvae/meter row length followed by chickpea + safflower (4:2), chickpea + sorghum (1:2), chickpea +sorghum (2:4) and chickpea + sorghum sprinkled, these results are in line were capsule borer larvae recorded more in chickpea as canopy (plant height) of chickpea is lower hence infestation was more in safflower and followed by sorghum, wheat and mustard recorded less infestation as its canopy was higher than safflower.

Table 3: Effect of intercrops on the incidence of *Helicoverpa armigera* (Hubner) in safflower.

Treatment No.	Treatments	Crop: Intercrop Ratio	No. of *Helicoverpa armigera* larvae/plant		Damage Percentage	
			Main crop	Intercrop	Main crop	Intercrop
T_1	Safflower + Mustard	(3:2)	1.090	1.23	16.09	10.79
T_2	Safflower + Wheat	(3:2)	1.130	0	19.18	0
T_3	Safflower + Chickpea	(3:2)	2.200	1.82	29.50	14.61
T_4	Safflower + Coriander	(3:2)	1.683	0	23.36	0
T_5	Safflower + Lentil	(3:2)	1.873	0.56	24.02	9.08
T_6	Safflower + Sorghum	(3:2)	1.446	2.36	21.92	24.50
T_7	Safflower + Neem oil	(5)	0.920	0	12.93	0
T_8	Sole Safflower	(5)	2.593	0	42.14	0
F-Test			S	S	S	S
S.Em±			0.17	0.11	1.18	0.19
CD (5%)			0.51	0.35	3.59	3.22
CV (%)			18.12	19.33	8.67	18.01

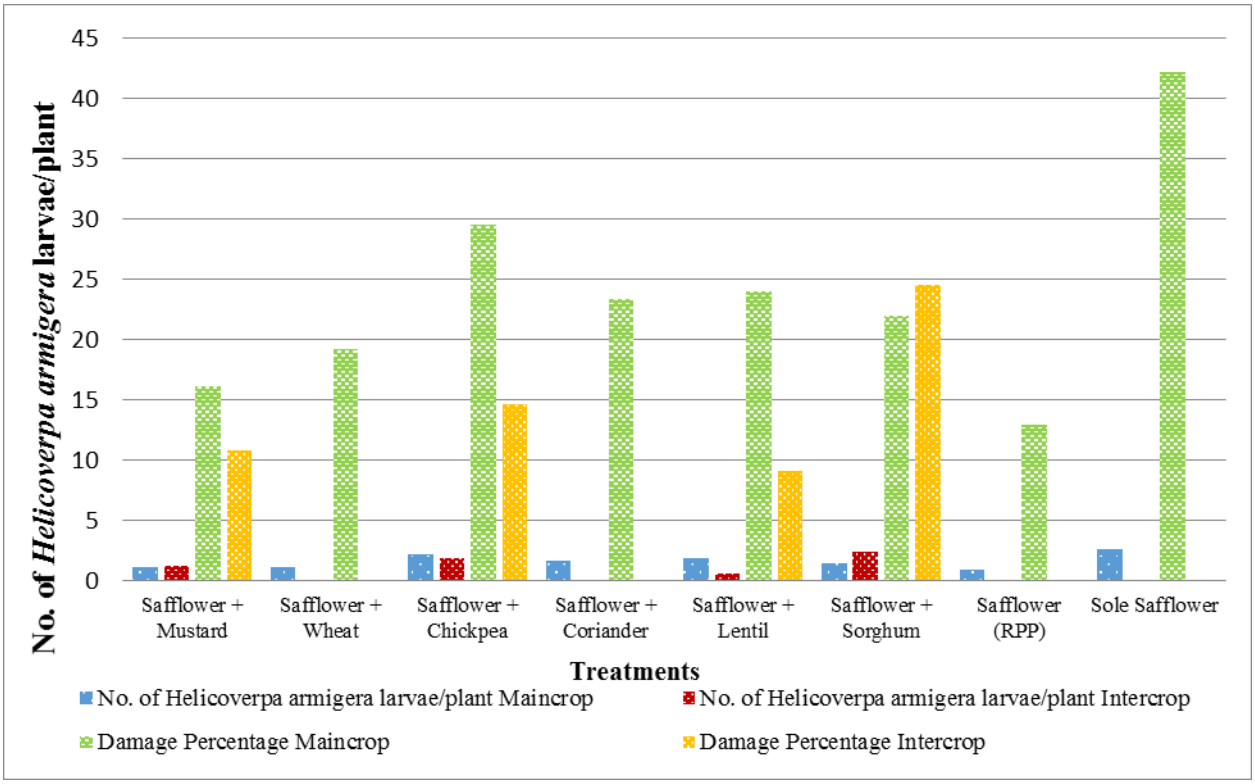

Fig 2: The No. of *Helicoverpa armigera*/plant infestation on main crop and on intercrops of safflower

3.3 Effect of different intercropping systems on seed yield of safflower

Among the intercropping systems safflower + mustard (T1) recorded significantly highest crop yield of safflower (0.857 q/ha). The next best treatments were safflower + sorghum (T6) (0.75 q/ha), followed by safflower + chickpea (T3) (0.725 q/ha), safflower + wheat (T2) (0.692 q/ha), safflower + coriander (T4) (0.619 q/ha) and safflower + lentil (T5) (0.586 q/ha). As compared to intercrops the sole safflower (RPP) (T7) when protected with neem oil 1% proved its supremacy by recording maximum yield of 2.14 q/ha. Whereas untreated check recorded lowest yield of 0.4 q/ha (Table 4).

Table 4: Effect of different intercropping systems on seed yield of safflower

Treatment No.	Treatments	Crop: Intercrop Ratio	Main crop yield (q/ha)	Intercrop yield (q/ha)	Equivalent yield (q/ha)	Total yield (q/ha)
T_1	Safflower + Mustard	(3:2)	0.420	0.355	0.437	0.857
T_2	Safflower + Wheat	(3:2)	0.470	0.370	0.222	0.692
T_3	Safflower + Chickpea	(3:2)	0.325	0.297	0.400	0.725
T_4	Safflower + Coriander	(3:2)	0.465	0.107	0.154	0.619
T_5	Safflower + Lentil	(3:2)	0.385	0.155	0.201	0.586
T_6	Safflower + Sorghum	(3:2)	0.457	0.440	0.293	0.75
T_7	Safflower + Neem oil	(5)	2.14	0	2.14	2.14
T_8	Sole Safflower	(5)	0.4	0	0.4	0.4

3.4 Effect of intercropping on *Chrysoperla carnea* and *Coccinella septempunctata*

Effect of different intercrops on the population of *Chrysoperla carnea* is presented in Table 5. The *Chrysoperla* population at 45 DAS ranged from 0.35 to 2.60/ plant. However, the safflower intercropped with wheat (T2) recorded the highest number of *Chrysoperla* (2.45 adults/plant), followed by coriander (T4) (2.19 adults/plant), mustard (T1) (2.13 adults/plant), sorghum (T6) (1.82 adults/plant), lentil (T5) (1.31 adults/plant) and chickpea (T3) (0.91 adults/plant), respectively. The least number of *Chrysoperla* (0.35 adults/plant) was recorded in sole safflower protected with neem oil 1% (RPP) (T7) and the highest number in untreated check (2.60 adults/plant) (T8), respectively. The *Chrysoperla* population at 60 DAS ranged from 0.81 to 3.27/ plant. The safflower intercropped with wheat (T2) recorded the highest number of *Chrysoperla* 3.20 adults/plant, followed by coriander (T4) (2.87 adults/plant), mustard (T1) (2.83 adults/plant), sorghum (T6) (2.36 adults/plant), lentil (T5) (1.88 adults/plant) and chickpea (T3) (1.46 adults/plant), respectively. The least number of *chrysoperla* (0.81 adults/plant) was recorded in sole safflower protected with neem oil 1% (T7) and that of highest number was in untreated plot (3.27 adults/plant)(T8).

Effect of different intercrops on the population of *Coccinella septempunctata* is presented in Table 5. There was significant difference of coccinellids population among the treatments at 45 DAS. However, safflower + wheat (T2) intercropping system recorded numerically higher number of coccinellids (0.58 adults/plant), followed by lentil (T5) (0.57 adults/plant), sorghum (T6) (0.55 adults/plant), mustard (T1) (0.53 adults/plant), coriander (T4) (0.50 adults/plant) and Chickpea (T3) (0.38 adults/plant) *Coccinellla septempunctata* per plant respectively. Least number of coccinellid (0.12 adults/plant) was found in sole safflower protected with neem oil 1% (T7) and highest number observed in untreated plot (0.68 adults/plant) (T8). At 60 DAS the highest and significant coccinellids population was noticed on safflower under intercropping system with compared to RPP. However, among intercrops safflower + wheat (T2) recorded coccinellids 0.95 adults/plant, lentil (T5) (0.95 adults/plant), sorghum (T6) (0.92 adults/plant), mustard (T1) (0.89 adults/plant), coriander (T4) (0.85 adults/plant) and Chickpea (T3) (0.56 adults/plant). Least number of coccinellids (0.23 adults/plant) population were found in sole safflower protected with neem oil 1% (T7) and that of higher was in untreated plot (1.02 adults/plant) (T8). This might be due to the availability of pollen, nectar and favorable microclimate to the predatory population in coriander, mustard and wheat intercropping ecosystem as reported by Hanumantharaya *et al*. (2009) [8]. The *Chrysoperla carnea* and *Coccinella septempunctata* were numerically lower in intercropped situation as compared to sole safflower crop, these results are in line with reports placed on records by Hanumantharaya *et al*. (2008b) [7]. However, among the intercrops safflower intercropped with coriander (4:2 to 4:6) and sorghum (2:8 to 3:8) harbored more natural enemies as reported by Hanumantharaya *et al*. (2008b) [7].

Table 5: Effect of different intercrops on the incidence of *Chrysoperla carnea* in safflower

Treatment	Crop: Intercrop Ratio	No. of *Chrysoperla*/plant				No. of Coccinellids/plant			
		Main crop		Intercrop		Main crop		Intercrop	
		45 DAS	60 DAS	45 DAS	60 DAS	45 DAS	60 DAS	45 DAS	60 DAS
T_1	(3:2)	2.13	2.83	0.89	1.23	0.53	0.89	0.88	1.04
T_2	(3:2)	2.45	3.20	1.69	1.89	0.58	0.95	1.11	1.31
T_3	(3:2)	0.91	1.46	0.73	1.10	0.38	0.56	0.73	0.91
T_4	(3:2)	2.19	2.87	2.37	2.72	0.50	0.85	1.36	1.86
T_5	(3:2)	1.31	1.88	1.50	1.70	0.57	0.95	0.57	0.74
T_6	(3:2)	1.82	2.36	2.18	2.37	0.55	0.92	1.27	1.64
T_7	(5)	0.35	0.81	0	0	0.12	0.23	0	0
T_8	(5)	2.60	3.27	0	0	0.68	1.02	0	0
F-Test		S	S	S	S	S	S	S	S
S.Em±		0.09	0.15	0.19	0.13	0.08	0.13	0.16	0.18
CD (5%)		0.26	0.46	0.61	0.40	0.23	0.39	0.50	0.56
CV (%)		8.95	11.67	21.42	12.00	27.25	28.33	26.15	24.62

4. Conclusion

Among the different intercropping systems safflower intercropped with mustard recorded minimum aphid population at 45 DAS and at 60 DAS (8.98 and 13.82 aphids/5cm apical twig) respectively, whereas maximum aphid population (19.61 and 25.90 aphids/5cm apical twig) was recorded in safflower + lentil. Higher incidence of aphid (29.07 and 34.10 aphids/5cm apical twig) was recorded in sole safflower. The minimum capsule borer (*H. armigera*) population (1.090 larvae/plant) was noticed on safflower + mustard intercropping system, whereas maximum capsule borer of (2.20 larvae/plant) in safflower + chickpea

intercropping system. Higher incidence of capsule borer (2.593 larvae/plant) was recorded in sole safflower. Lower percent capsule damage (16.09%) was recorded in safflower + mustard intercropping system, whereas maximum (29.50%) in safflower + chickpea intercropping system. Higher incidence of capsule damage (42.15 percent) was recorded in sole safflower. Significantly highest yield was obtained in safflower intercropped with wheat (0.87 q/ha) and lowest in safflower intercropped with lentil (0.586 q/ha). Highest mean number of coccinellids (*Coccinella septempunctata* Linn.) and *Chrysoperla carnea* at 45 and 60 DAS was recorded in safflower + wheat (0.58 and 0.95 adults/plant) and safflower + wheat (2.45 and 3.20 adults/plant) respectively, whereas lowest mean number of coccinellids (*Coccinella septempunctata*) and *Chrysoperla carnea* at 45 and 60 DAS was recorded in safflower + chickpea (0.91 and 1.46 adults/plant) and safflower + chickpea (0.38 and 0.56 adults/plant), respectively.

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