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IMPACT OF FARMSCAPING IN COWPEA ON THE DIVERSITY OF SAP SUCKING INSECT PESTS

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ABSTRACT

A field experiment study the impact of farmscaping on the seasonal abundance of major sap sucking insect pests of cowpea was carried out during the year 2012 at instructional farm, Rajasthan College of Agriculture, Udaipur. The experiment was conducted in two sets, one comprising treatment with plant oils against insect pests, termed protected condition, and the other without the use of any plant oil, termed natural condition. The major sap sucking insect pests were viz., *Aphis craccivora* Koch, *Empoasca kerri* Pruthi, *Megalurothrips sp., Bemisia tabaci* Gennadius and *Riptortus pedestris* Fabricius. Under both untreated and treated conductions the mean density for all the major sap insect pests was relatively more in sole cowpea than in the other farmscape treatments and minimum when cowpea was famscaped with marigold (cowpea + marigold). The mean atmospheric temperature had a significant positive correlation with the population of aphid and whitefly while a significant negative correlation with the population of jassid. The mean relative humidity and total rainfall showed significant positive correlation with the populations of pod bug.

Key words: *Aphis craccivora, Empoasca kerri*, farmscaping, seasonal abundance

INTRODUCTION

Pulse crops play an important role in Indian agriculture because it is rich in proteins and sustains the productivity of a cropping system. Cowpea, *Vigna unguiculata* (Linn.) Walpers is one of the important pulse crops also known as black eyed bean or Southern pea in English, while *chola* or *choli*, *chavli, lobia* in different languages of India. As many as 21 insect pests of different groups have been recorded damaging the crop from germination to maturity. The avoidable losses in yield due to insect pests have been observed to be 66 to 100 per cent in cowpea (Pandey *et.al.,* 1991). The important insect species attacking cowpea crop include aphid (*Aphis craccivora* Koch)., leafhopper (*Empoasca kerri* Pruthi), thrips (*Megaleurothrips* spp.), whitefly (*Bemisia tabaci*, Genn.), leaf miner (*Acrocercops caerulea* Meyrick), spotted pod borer (*Maruca vitrata* (Fab.)), tobacco caterpillar (*Spodoptera litura* Fab.) and blue butterfly (*Euchrysops cnejus* Cnidus).

Farmscaping is the practice of designing and maintaining habitats that attract and support beneficial organisms, used to improve crop pollination and to control pests species. It is a holistic approach to pest control on farms that focuses on increasing biodiversity as part of an ecological pest management program. The basic principles of farmscaping include increase in plant diversity, increasing plant structural diversity, increasing the time these are available, decrease the distance the beneficials have to travel, building the multiple redundant systems (building guilds- plants and beneficial), ensuring natural enemies for every life stage of the pest, anticipating pest problems and encouraging beneficials when needed to attack the pests (Sreedhar, 2012). Ecological engineering or habitat manipulation, the key element of farmscaping, has emerged as paradigm for considering pest management approaches that are based on cultural practices informed by ecological knowledge of arthropod pest management (Gurr *et al*., 2004). Habitat manipulation aims to provide the natural enemies of pests with resources such as nectar (Baggen and Gurr, 1998), pollen (Hickman and written, 1996), physical refugia (Halaji *et al*., 2000), alternative prey, alternative hosts (Viggiani, 2003) and lekking sites (Sutherland *et al*., 2001). When herbivores (the second trophic level) are suppressed by natural enemies (third trophic level), control is said to be 'top down'. Root (1973) referred to pest suppression resulting from this effect as supporting the' enemies hypothesis'. Importantly, however, within-crop habitat manipulation strategies such as cover crops and green mulches (components of the first trophic level, as is the crop) can also act on pests directly, providing 'bottom-up' control. Root (1973) termed pest suppression resulting from such non- natural enemy effects as 'resources concentration hypothesis' reflecting the fact that the resource (crop) was effectively 'diluted' by cues from other plant species. Farmscaping reduces the need of pesticides, lowering the cost and risks associated with indiscriminate application of pesticides. Ideal farmscape plantings provide food and shelter for beneficial organisms, suppress weeds, and

grow in close proximity to the cash crop without competing for light, water and nutrients.

MATERIALS AND METHODS

The experiment was conducted at the Instructional Farm of Rajasthan College of Agriculture, Udaipur. The trial was laid out in uniformly sized plots measuring 5m x 3m (15 sq. m) in Randomized Block Design containing six treatments [Cowpea Sole, Cowpea + Niger (2 :1), Cowpea + Marigold (2:1), Cowpea + Maize (No border 2:1), Cowpea + Maize + Marigold Border (2:1) and Cowpea + Maize + Niger Border (2:1)] with four replications of each; thus in all, there were 24 plots. The row to row distance and plant to plant spacing for cowpea were 45 cm and 10cm respectively. Sowing of the recommended variety of cowpea (RC-19) and niger (RCR 317) were done in the second week of July, 2012-2013 as sole crop and farmscaping crop combination. The seeds of early flowering Marigold variety Pusa Narangi were sown in well prepared, raised nursery beds. The usual floriculture operations were followed while raising the seedlings. The nursery was raised in the last week of June, mature seedlings of marigold were transplanted in between two rows of cowpea at a distance of 30cm. The experiments were conducted in two sets, one comprising treatment with plant oils against insect pests, termed protected condition (*A. Indica* and *P. pinnata* (3.0%) and the other without the use of any bio-pesticide, termed natural condition. Population of jassids/white flies will be estimated by Vortis suction sampler technique during early hours of the day from 10 plants per replication, selected at random and tagged. Aphids, the nymphs and adults will be counted on the plants directly taking at least a 10cm twig sampling. The observation on pod bug also recorded from 10 plants per replication, selected at random and tagged at weekly interval.

Statistical Analysis

The abiotic factors viz. temperature, relative humidity and rainfall were recorded during the crop season and their simple correlation with the population of insect pests was calculated by the Karl Pearson formula of correlation coefficient:

$$r_{xy} = \frac{\sum XY - \frac{\sum X \sum Y}{n}}{\sqrt{\left[\sum X^2 - \frac{(\sum X)^2}{n}\right]\left[\sum Y^2 - \frac{(\sum Y)^2}{n}\right]}}$$

Where,

r_{xy} = Simple correlation coefficient.

X = Variable i.e. abiotic component

(Average temperature, relative humidity and total rainfall).

Y = Variable i.e. mean number of insect pests per plant.

n = Number of observations.

The correlation coefficient (r) values were subjected to the test of significance using t- test:

$$t = \frac{r}{\sqrt{1 - r^2}} \times \sqrt{n - 2} \sim t_{n-2} \text{ d.f.}$$

The calculated t-value obtained was compared with tabulated t-value at 5% level of significance.

Mean density:

$$\text{Mean density} = \sum \frac{Xi}{N} \times 100$$

Where,

Xi = No. of insects or natural enemies in i^{th} sample

N = Total No. of plant sampled

RESULTS AND DISCUSSION

The seasonal abundance of major insect pests of cowpea in the different farmscapings under untreated conditions showed that the mean density for all the major insect pests was relatively more in sole cowpea than in the other farmscape treatments. The maximum per cent mean density values for the respective major insect pests observed were as follows: aphids (31.16), jassids (11.85), whitefly (5.37), thrips (6.40) and pod bug (2.29). Farmscaping cowpea with marigold resulted in the minimum mean density values for the respective insect pests that were 9.31, 5.27, 2.25, 3.50, and 1.07 per cent [Table 1(a)–5(a)]. Similarly under treated conditions, the maximium per cent mean density for the respective major insect pests observed were as follows: aphids (21.16), jassids (8.79), whitefly (3.58), thrips (5.55), and pod bug (1.83) in sole cowpea; whereas, farmscaping cowpea with marigold resulted in the lowest per cent mean density values for the respective insect pests being 8.19, 4.00, 1.48, 2.70, and 0.73. Under both treated and untreated farmscape treatments, the mean atmospheric temperature had a significant positive correlation with the population of aphid and whitefly; whereas, the mean atmospheric temperature showed significant negative correlation with the population of jassid. The mean relative humidity and total rainfall had a significant positive correlation with the populations of pod bug [Table 1(a) - 5(b)].

A number of workers have reported that enhanced plant diversity reduced the abundance of pestiferous insects in different crops. Mixed cropping of cowpeas with maize reduced significantly the population density and activity of legume flower bud thrips (*Megalurothrips sjostedti*) compared with sole cowpea crop (Kyamanywa and Ampofo, 1988). Two experiments were conducted in Kenya to establish the relationship between insect suppression by intercropping and grain

Table 1 (a). Seasonal population trend of aphids on untreated cowpea sole and with different farmscapings (FS) during *kharif*, 2012

Dates of observation *kharif*, 2012	Mean Atm. Temp. (C)	Mean RH. (%)	Total Rainfall (mm)	Mean No. / plant					
				Sole cowpea	FS-1	FS-2	FS-3	FS-4	FS-5
07- Aug	26.51	62.21	00.11	22.50	13.30	19.50	08.00	09.20	16.60
14 -Aug	25.02	82.92	15.41	09.60	03.50	06.20	02.60	02.80	03.80
21 -Aug	25.48	76.78	05.77	12.27	06.57	09.87	03.25	04.10	08.25
28 -Aug	25.52	76.28	07.82	20.87	07.47	13.70	04.02	05.12	09.72
05 -Sept	25.63	77.28	08.11	13.25	06.32	09.55	03.62	04.65	07.47
12 -Sept	25.00	89.21	17.97	06.35	03.55	05.70	02.22	02.92	05.67
19 -Sept	25.74	80.14	12.25	11.10	06.35	09.90	04.40	05.10	06.85
26 -Sept	24.10	69.85	00.00	06.82	03.65	06.20	02.35	02.70	04.10
02 -Oct	23.48	59.28	04.85	05.62	03.37	04.65	01.75	02.37	03.95
09 -Oct	26.57	52.56	00.00	16.25	06.35	11.82	05.02	05.45	09.10
Seasonal Mean	25.31	72.65	72.29	12.46	6.04	9.71	3.72	4.44	7.55
Mean Density (%)				31.16	15.11	24.27	9.31	11.10	18.88
Coefficient of correlation (r) for population and Atm. Temp.				0.79*	0.73*	0.79*	0.82*	0.81*	0.77*
Coefficient of correlation (r) for population and RH				-0.30	-0.31	-0.33	-0.39	-0.35	-0.33
Coefficient of correlation (r) for population and Total Rainfall				-0.39	-0.44	-0.45	-0.44	-0.42	-0.43

Legend: FS-1= Cowpea + Niger; FS-2= Cowpea + Maize; FS-3= Cowpea + Marigold; FS-4= Cowpea + Maize + Bordered with Marigold; FS-5= Cowpea + Maize + Bordered with Niger; * Value of 't'- statistically significant at 5%

Table 2 (a). Seasonal population trend of jassids on untreated cowpea sole and with different farmscapings (FS) during *kharif*, 2012

Dates of observation *kharif*, 2012	Mean Atm. Temp. (C)	Mean RH. (%)	Total Rainfall (mm)	Mean No. / plant					
				Sole cowpea	FS-1	FS-2	FS-3	FS-4	FS-5
07- Aug	26.51	62.21	00.11	2.55	1.67	1.52	0.70	0.85	1.85
14 -Aug	25.02	82.92	15.41	3.40	1.75	1.65	0.90	1.27	1.92
21 -Aug	25.48	76.78	05.77	3.15	1.87	1.57	0.85	1.20	2.27
28 -Aug	25.52	76.28	07.82	2.77	1.62	1.57	0.90	1.22	1.95
05 -Sept	25.63	77.28	08.11	3.02	1.85	1.72	1.07	1.32	2.17
12 -Sept	25.00	89.21	17.97	7.45	5.50	4.70	3.50	4.00	6.25
19 -Sept	25.74	80.14	12.25	6.05	4.72	4.50	3.80	4.27	5.00
26 -Sept	24.10	69.85	00.00	6.75	5.20	4.65	3.85	4.22	5.80
02 -Oct	23.48	59.28	04.85	9.22	6.87	6.40	4.72	5.52	7.47
09 -Oct	26.57	52.56	00.00	3.05	2.10	1.50	0.80	1.12	2.35
Seasonal Mean	25.31	72.65	72.29	4.74	3.32	2.98	2.11	2.50	3.70
Mean Density (%)				11.85	8.29	7.45	5.27	6.25	9.26
Coefficient of correlation (r) for population and Atm. Temp.				-0.79*	-0.74*	-0.76*	-0.73*	-0.75*	-0.75*
Coefficient of correlation (r) for population and RH				0.04	0.00	0.02	0.06	0.05	0.02
Coefficient of correlation (r) for population and Total Rainfall				0.19	0.14	0.15	0.15	0.17	0.14

Legend: FS-1= Cowpea + Niger; FS-2= Cowpea + Maize; FS-3= Cowpea + Marigold; FS-4= Cowpea + Maize + Bordered with Marigold; FS-5= Cowpea + Maize + Bordered with Niger; * Value of 't'- statistically significant at 5%

Table 3 (a). Seasonal population trend of whitefly on untreated cowpea sole and with different farmscapings (FS) during *kharif*, 2012

Dates of observation *kharif*, 2012	Mean Atm. Temp. (C)	Mean RH. (%)	Total Rainfall (mm)	Mean No./ plant					
				Sole cowpea	FS-1	FS-2	FS-3	FS-4	FS-5
07- Aug	26.51	62.21	00.11	3.80	2.10	2.95	1.25	1.70	2.45
14 -Aug	25.02	82.92	15.41	1.50	0.85	1.30	0.50	0.70	1.00
21 -Aug	25.48	76.78	05.77	2.82	1.75	2.25	1.15	1.27	2.00
28 -Aug	25.52	76.28	07.82	3.00	1.62	2.45	0.97	1.35	2.07
05 -Sept	25.63	77.28	08.11	1.67	0.95	1.27	0.70	0.90	1.05
12 -Sept	25.00	89.21	17.97	1.35	0.82	1.02	0.60	0.72	0.90
19 -Sept	25.74	80.14	12.25	1.45	1.00	1.27	0.65	0.82	1.15
26 -Sept	24.10	69.85	00.00	1.35	0.82	1.10	0.67	0.75	0.92
02 -Oct	23.48	59.28	04.85	1.12	0.52	0.77	0.35	0.45	0.65
09 -Oct	26.57	52.56	00.00	3.42	2.62	2.97	2.15	2.35	2.77
Seasonal Mean	25.31	72.65	72.29	2.15	1.31	1.74	0.90	1.10	1.50
Mean Density (%)				5.37	3.26	4.34	2.25	2.77	3.74
Coefficient of correlation (r) for population and Atm. Temp.				0.77*	0.81*	0.80*	0.74*	0.81*	0.80*
Coefficient of correlation (r) for population and RH				-0.47	-0.52	-0.47	-0.58	-0.56	-0.49
Coefficient of correlation (r) for population and Total Rainfall			-0.54	-0.53	-0.52	-0.56	-0.55	-0.52	

Legend: FS-1= Cowpea + Niger; FS-2= Cowpea + Maize; FS-3= Cowpea + Marigold; FS-4= Cowpea + Maize + Bordered with Marigold; FS-5= Cowpea + Maize + Bordered with Niger; * Value of 't'- statistically significant at 5%

Table 4 (a). Seasonal population trend of thrips on untreated cowpea sole and with different farmscapings (FS) during *kharif*, 2012

Dates of observation *kharif*, 2012	Mean Atm. Temp. (C)	Mean RH. (%)	Total Rainfall (mm)	Mean No./ plant					
				Sole cowpea	FS-1	FS-2	FS-3	FS-4	FS-5
07- Aug	26.51	62.21	00.11	1.60	1.20	1.45	0.62	0.80	1.35
14 –Aug	25.02	82.92	15.41	1.30	0.80	1.10	0.30	0.45	0.95
21 –Aug	25.48	76.78	05.77	4.10	2.90	3.52	2.40	2.70	3.40
28 –Aug	25.52	76.28	07.82	3.90	3.40	3.80	2.80	3.10	3.30
05 –Sept	25.63	77.28	08.11	3.97	2.77	3.72	2.32	2.55	3.10
12 –Sept	25.00	89.21	17.97	2.10	1.30	1.85	0.57	1.05	1.62
19 –Sept	25.74	80.14	12.25	2.30	1.77	2.10	1.35	1.55	1.87
26 –Sept	24.10	69.85	00.00	2.27	1.60	2.00	1.30	1.50	1.82
02 –Oct	23.48	59.28	04.85	1.95	1.45	1.72	1.10	1.35	1.60
09 –Oct	26.57	52.56	00.00	2.10	1.52	1.85	1.25	1.42	1.72
Seasonal Mean	25.31	72.65	72.29	2.56	1.87	2.31	1.40	1.65	2.07
Mean Density (%)				6.40	4.68	5.78	3.50	4.12	5.18
Coefficient of correlation (r) for population and Atm. Temp.				0.13	0.15	0.14	0.12	0.09	0.14
Coefficient of correlation (r) for population and RH				0.22	0.15	0.22	0.04	0.10	0.18
Coefficient of correlation (r) for population and Total Rainfall				-0.05	-0.10	-0.04	-0.20	-0.14	-0.09

Legend: FS-1= Cowpea + Niger; FS-2= Cowpea + Maize; FS-3= Cowpea + Marigold; FS-4= Cowpea + Maize + Bordered with Marigold; FS-5= Cowpea + Maize + Bordered with Niger

Table 5 (a). Seasonal population trend of pod bug on untreated cowpea sole and with different farmscapings (FS) during *kharif*, 2012

Dates of observation *kharif*, 2012	Mean Atm. Temp. (C)	Mean RH. (%)	Total Rainfall (mm)	Mean No./ plant					
				Sole cowpea	FS-1	FS-2	FS-3	FS-4	FS-5
07- Aug	26.51	62.21	00.11	0.00	0.00	0.00	0.00	0.00	0.00
14 –Aug	25.02	82.92	15.41	0.00	0.00	0.00	0.00	0.00	0.00
21 –Aug	25.48	76.78	05.77	0.00	0.00	0.00	0.00	0.00	0.00
28 –Aug	25.52	76.28	07.82	0.00	0.00	0.00	0.00	0.00	0.00
05 –Sept	25.63	77.28	08.11	0.77	0.60	0.72	0.45	0.50	0.65
12 –Sept	25.00	89.21	17.97	1.37	0.87	1.15	0.67	0.72	1.00
19 –Sept	25.74	80.14	12.25	1.20	0.75	1.00	0.60	0.65	0.85
26 –Sept	24.10	69.85	00.00	0.90	0.60	0.80	0.40	0.45	0.70
02 –Oct	23.48	59.28	04.85	0.75	0.45	0.70	0.30	0.35	0.60
09 –Oct	26.57	52.56	00.00	0.50	0.25	0.45	0.15	0.20	0.35
Seasonal Mean	25.31	72.65	72.29	0.92	0.59	0.80	0.43	0.48	0.69
Mean Density (%)				2.29	1.47	2.01	1.07	1.20	1.73
Coefficient of correlation (r) for population and Atm. Temp.				-0.15	-0.16	-0.22	-0.07	-0.07	-0.25
Coefficient of correlation (r) for population and RH				0.90*	0.97*	0.91*	0.98*	0.98*	0.93*
Coefficient of correlation (r) for population and Total Rainfall				0.86*	0.84*	0.86*	0.88*	0.88*	0.85*

Legend: FS-1= Cowpea + Niger; FS-2= Cowpea + Maize; FS-3= Cowpea + Marigold; FS-4= Cowpea + Maize + Bordered with Marigold; FS-5= Cowpea + Maize + Bordered with Niger; * Value of 't'- statistically significant at 5%

Table 1 (b). Seasonal population trend of aphids on plant oil treated cowpea sole and with different farmscapings (FS) during *kharif*, 2012

Dates of observation *kharif*, 2012	Mean Atm. Temp. (C)	Mean RH. (%)	Total Rainfall (mm)	Mean No./ plant					
				Sole cowpea	FS-1	FS-2	FS-3	FS-4	FS-5
07- Aug	26.51	62.21	00.11	20.37	13.12	18.47	08.20	09.40	15.70
14 - Aug	25.02	82.92	15.41	08.60	03.42	06.35	02.40	02.85	03.60
21 - Aug	25.48	76.78	05.77	06.60	02.80	04.40	02.20	02.40	03.20
28 - Aug	25.52	76.28	07.82	09.90	05.35	07.75	03.75	04.15	06.12
05 - Sept	25.63	77.28	08.11	11.65	05.60	07.80	03.65	04.20	06.70
12 - Sept	25.00	89.21	17.97	03.75	02.05	03.32	01.30	01.90	02.30
19 - Sept	25.74	80.14	12.25	08.55	05.50	07.40	03.50	04.95	05.60
26 - Sept	24.10	69.85	00.00	04.02	03.25	03.65	01.85	02.27	03.45
02 – Oct	23.48	59.28	04.85	02.55	01.45	02.17	01.25	01.37	01.60
09 - Oct	26.57	52.56	00.00	10.45	06.02	08.30	04.65	05.07	07.27
Seasonal Mean	25.31	72.65	72.29	8.64	4.86	6.96	3.28	3.86	5.55
Mean Density (%)				21.16	12.14	17.40	8.19	9.64	13.89
Coefficient of correlation (r) for population and Atm. Temp.				0.79*	0.73*	0.75*	0.78*	0.78*	0.73*
Coefficient of correlation (r) for population and RH				-0.26	-0.35	-0.30	-0.42	-0.34	-0.38
Coefficient of correlation (r) for population and Total Rainfall				-0.32	-0.43	-0.35	-0.46	-0.38	-0.45

Legend: FS-1= Cowpea + Niger; FS-2= Cowpea + Maize; FS-3= Cowpea + Marigold; FS-4= Cowpea + Maize + Bordered with Marigold; FS-5= Cowpea + Maize + Bordered with Niger; * Value of 't'- statistically significant at 5%

Table 2 (b). Seasonal population trend of jassids on plant oil treated cowpea sole and with different farmscapings (FS) during *kharif*, 2012

Dates of observation *kharif*, 2012	Mean Atm. Temp. (C)	Mean RH. (%)	Total Rainfall (mm)	Mean No./ plant					
				Sole cowpea	FS-1	FS-2	FS-3	FS-4	FS-5
07- Aug	26.51	62.21	00.11	2.45	1.57	1.52	0.62	0.80	1.67
14 - Aug	25.02	82.92	15.41	3.42	1.70	1.62	0.87	1.30	2.12
21 - Aug	25.48	76.78	05.77	2.10	1.32	1.20	0.67	0.92	1.42
28 - Aug	25.52	76.28	07.82	2.12	1.45	1.22	0.80	1.02	1.57
05 - Sept	25.63	77.28	08.11	4.65	3.47	3.20	2.60	2.90	3.75
12 - Sept	25.00	89.21	17.97	4.67	4.15	3.62	2.97	3.35	4.65
19 - Sept	25.74	80.14	12.25	2.05	1.35	1.08	0.90	1.15	1.52
26 - Sept	24.10	69.85	00.00	4.60	3.52	2.95	2.40	2.72	3.97
02 – Oct	23.48	59.28	04.85	7.55	5.70	4.72	3.60	4.32	5.92
09 - Oct	26.57	52.56	00.00	1.55	1.17	0.85	0.55	0.75	1.20
Seasonal Mean	25.31	72.65	72.29	3.52	2.54	2.20	1.60	1.92	2.78
Mean Density (%)				8.79	6.35	5.50	4.00	4.81	6.95
Coefficient of correlation (r) for population and Atm. Temp.				-0.84*	-0.79*	-0.77*	-0.76*	-0.79*	-0.81*
Coefficient of correlation (r) for population and RH				-0.03	-0.02	0.03	0.08	0.07	0.04
Coefficient of correlation (r) for population and Total Rainfall				0.10	0.10	0.13	0.16	0.18	0.14

Legend: FS-1= Cowpea + Niger; FS-2= Cowpea + Maize; FS-3= Cowpea + Marigold; FS-4= Cowpea + Maize + Bordered with Marigold; FS-5= Cowpea + Maize + Bordered with Niger; * Value of 't'- statistically significant at 5%

Table 3 (b). Seasonal population trend of whitefly on plant oil treated cowpea sole and with different farmscapings (FS) during *kharif*, 2012

Dates of observation *kharif*, 2012	Mean Atm. Temp. (C)	Mean RH. (%)	Total Rainfall (mm)	Mean No./ plant					
				Sole cowpea	FS-1	FS-2	FS-3	FS-4	FS-5
07- Aug	26.51	62.21	00.11	3.52	1.95	2.92	1.20	1.67	2.47
14 - Aug	25.02	82.92	15.41	1.30	0.70	1.10	0.52	0.60	0.95
21 - Aug	25.48	76.78	05.77	1.45	0.77	1.25	0.55	0.67	1.12
28 - Aug	25.52	76.28	07.82	1.32	0.67	1.12	0.45	0.57	0.87
05 - Sept	25.63	77.28	08.11	1.22	0.55	0.97	0.35	0.45	0.65
12 - Sept	25.00	89.21	17.97	0.77	0.42	0.67	0.27	0.35	0.52
19 - Sept	25.74	80.14	12.25	0.97	0.77	0.87	0.45	0.65	0.80
26 - Sept	24.10	69.85	00.00	0.75	0.50	0.65	0.40	0.45	0.55
02 – Oct	23.48	59.28	04.85	0.45	0.30	0.40	0.20	0.25	0.35
09 - Oct	26.57	52.56	00.00	2.55	1.77	2.27	1.52	1.62	1.92
Seasonal Mean	25.31	72.65	72.29	1.43	0.84	1.22	0.59	0.73	1.02
Mean Density (%)				3.58	2.10	3.06	1.48	1.82	2.55
Coefficient of correlation (r) for population and Atm. Temp.				0.80*	0.80*	0.81*	0.76*	0.79*	0.79*
Coefficient of correlation (r) for population and RH				-0.48	-0.57	-0.50	-0.64	-0.60	-0.51
Coefficient of correlation (r) for population and Total Rainfall				-0.49	-0.53	-0.50	-0.56	-0.54	-0.50

Legend: FS-1= Cowpea + Niger; FS-2= Cowpea + Maize; FS-3= Cowpea + Marigold; FS-4= Cowpea + Maize + Bordered with Marigold; FS-5= Cowpea + Maize + Bordered with Niger; * Value of 't'- statistically significant at 5%

Table 4 (b). Seasonal population trend of thrips on plant oil treated cowpea sole and with different farmscapings (FS) during *kharif*, 2012

Dates of observation *kharif*, 2012	Mean Atm. Temp. (C)	Mean RH. (%)	Total Rainfall (mm)	Mean No./ plant					
				Sole cowpea	FS-1	FS-2	FS-3	FS-4	FS-5
07- Aug	26.51	62.21	00.11	1.72	1.12	1.50	0.70	0.90	1.30
14 - Aug	25.02	82.92	15.41	1.40	0.70	1.20	0.35	0.50	1.00
21 - Aug	25.48	76.78	05.77	3.80	2.80	3.45	2.22	2.40	3.10
28 - Aug	25.52	76.28	07.82	3.52	2.67	3.32	2.12	2.32	2.92
05 - Sept	25.63	77.28	08.11	3.60	2.42	3.32	2.00	2.20	2.72
12 - Sept	25.00	89.21	17.97	1.70	0.95	1.50	0.25	0.40	1.10
19 - Sept	25.74	80.14	12.25	1.82	1.30	1.60	0.95	1.10	1.45
26 - Sept	24.10	69.85	00.00	1.62	1.10	1.42	0.80	1.00	1.30
02 – Oct	23.48	59.28	04.85	1.42	0.75	1.20	0.45	0.60	0.95
09 - Oct	26.57	52.56	00.00	1.60	1.25	1.50	0.95	1.10	1.37
Seasonal Mean	25.31	72.65	72.29	2.22	1.51	2.00	1.08	1.25	1.72
Mean Density (%)				5.55	3.77	5.00	2.70	3.13	4.30
Coefficient of correlation (r) for population and Atm. Temp.				0.23	0.31	0.25	0.30	0.30	0.28
Coefficient of correlation (r) for population and RH				0.27	0.18	0.25	0.08	0.08	0.21
Coefficient of correlation (r) for population and Total Rainfall				-0.01	-0.10	-0.02	-0.20	-0.21	-0.08

Legend: FS-1= Cowpea + Niger; FS-2= Cowpea + Maize; FS-3= Cowpea + Marigold; FS-4= Cowpea + Maize + Bordered with Marigold; FS-5= Cowpea + Maize + Bordered with Niger

Table 5 (b). Seasonal population trend of pod bug on plant oil treated cowpea sole and with different farmscapings (FS) during *kharif*, 2012

Dates of observation *kharif*, 2012	Mean Atm. Temp. (C)	Mean RH. (%)	Total Rainfall (mm)	Mean No./ plant					
				Sole cowpea	FS-1	FS-2	FS-3	FS-4	FS-5
07- Aug	26.51	62.21	00.11	0.00	0.00	0.00	0.00	0.00	0.00
14 - Aug	25.02	82.92	15.41	0.00	0.00	0.00	0.00	0.00	0.00
21 - Aug	25.48	76.78	05.77	0.00	0.00	0.00	0.00	0.00	0.00
28 - Aug	25.52	76.28	07.82	0.00	0.00	0.00	0.00	0.00	0.00
05 - Sept	25.63	77.28	08.11	0.60	0.40	0.52	0.30	0.35	0.45
12 - Sept	25.00	89.21	17.97	1.10	0.70	0.90	0.45	0.50	0.75
19 - Sept	25.74	80.14	12.25	1.00	0.55	0.80	0.40	0.45	0.70
26 - Sept	24.10	69.85	00.00	0.70	0.40	0.60	0.30	0.35	0.45
02 – Oct	23.48	59.28	04.85	0.65	0.30	0.55	0.20	0.25	0.40
09 - Oct	26.57	52.56	00.00	0.35	0.17	0.30	0.10	0.15	0.22
Seasonal Mean	25.31	72.65	72.29	0.73	0.42	0.61	0.29	0.34	0.50
Mean Density (%)				1.83	1.05	1.53	0.73	0.85	1.24
Coefficient of correlation (r) for population and Atm. Temp.				-0.21	-0.10	-0.25	-0.11	-0.11	-0.11
Coefficient of correlation (r) for population and RH				0.87*	0.96*	0.88*	0.97*	0.97*	0.92*
Coefficient of correlation (r) for population and Total Rainfall				0.86*	0.89*	0.85*	0.84*	0.84*	0.89*

Legend: FS-1= Cowpea + Niger; FS-2= Cowpea + Maize; FS-3= Cowpea + Marigold; FS-4= Cowpea + Maize + Bordered with Marigold; FS-5= Cowpea + Maize + Bordered with Niger; * Value of 't'- statistically significant at 5%

yield in sorghum and cowpea. Treatments consisted of monocrops and intercrops of sorghum and cowpea, and an additional pair of monocultures and mixtures protected by insecticides. Intercropping reduced the numbers of *Chilo partellus* in sorghum and *Megalurothrips sjostedti* in cowpea (Ampong, 1994). Rekha Das Dutta (1996) observed that intercropping *Vigna radiata* with maize resulted in reduced populations of the pests *viz*., *Monolepta signata*, *Aphis craccivora*, *Nacolea vulgaris*, *Nezara viridula* and *Riptortus linearis* on *V. radiata* than when intercropped with other legumes like *Vigna umbellata* (rice bean), *Glycine max* (soybean), *Vigna mungo* (blackgram) and *Arachis hypogea* (groundnut). Soundararajan and Chitra (2012) observed that the sucking pests, *B. tabaci* and *E. kerri* population was low in the intercropped blackgram when compared to sole crop. Legume pod borer and other pod borer damage were low in the sorghum intercropped blackgram. Cereals intercropped with blackgram had lower pest incidence as well as higher coccinellid population. Lower pest pressure on cowpea crop, higher abundance of predators and higher cowpea yields were observed to be associated with cowpea/greengram cropping systems; therefore, cowpea/greengram should be promoted among other biological control conservation strategies, aiming at enhancing natural enemies in cowpea systems, through habitat manipulation (Munyulia *et al.,* 2006). Sule Hassan (2009) reported that population of aphids (*Aphis craccivora* Koch.) and thrips (*Megalarothrips sjostedi* Trybom) were significantly (P>0.05) lower in cowpea + sorghum intercrop in 2006 and 2007 cropping season than sole cowpea crop. Similarly in 2007 cropping season population of pod borer (*Maruca vitrata*) was significantly (P>0.05) lower in cowpea + sorghum intercrop than sole crop of cowpea.

With regard to the impact of abiotic factors of the environment on the insect pests; earlier, Poonia (2005) reported that high temperature and decrease in the relative humidity after mid august decreased the population of jassid on cowpea, as they prefer moderate temperature and high humidity on cowpea in *kharif*. Yadav *et al* (2012) reported that the population of jassids on groundnut had a negative correlation with mean temperature. Jagadish *et al* (2003) reported that maximum and average temperatures were significantly and positively correlated with the total aphid population. The population of whitefly had a significant positive correlation with maximum temperature, sunshine and evaporation (Yadav and Singh, 2006; Kumar *et al*., 2004; Kumar *et al*., 2007). Yadav and Singh (2013) reported that population of blister beetle and pod bug showed mild positive correlation with the maximum, minimum and mean temperature on greengram. Jain *et al* (2013) observed that the population of blister beetle on greengram showed positive correlation with the mean atmospheric temperature.

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