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PS Chopkar

Post Graduate Student,
Department of Agricultural
Entomology, College of
Agriculture, Dapoli Dr. BSKKV,
Dapoli, Maharashtra, India

RM Samrit

Post Graduate Student,
Agricultural Entomology
Section, College of Agriculture,
Nagpur, Maharashtra, India

RJ Choudhari

Post Graduate Student,
Agricultural Plant Pathology
Section, Post Graduate Institute,
Akola, Maharashtra, India

AL Uparkar

Post Graduate Student,
Agronomy Section, College of
Agriculture, Nagpur,
Maharashtra, India

SB Shelke

Post Graduate Student,
Department of Agricultural
Entomology, College of
Agriculture, Dapoli Dr. BSKKV,
Dapoli, Maharashtra, India

Corresponding Author:**PS Chopkar**

Post Graduate Student,
Department of Agricultural
Entomology, College of
Agriculture, Dapoli Dr. BSKKV,
Dapoli, Maharashtra, India

Population of natural enemies as affected by border crops in Lablab bean (*Lablab purpureus* L.)

PS Chopkar, RM Samrit, RJ Choudhari, AL Uparkar and SB Shelke

Abstract

The research project entitled “Pest management in Lablab bean (*Lablab purpureus* L.) by using border crops” was undertaken at Agronomy Farm, College of Agriculture, Dapoli during *rabi* 2016-17. The natural enemies like black ants, spiders, lady beetles and chrysopids were noticed throughout the cropping period starting from week 1 (1st week of January) till harvest of the crop *i.e.* week 12 (3rd week of March). The average numbers of black ants on lablab bean plants were in the range of 0.00 to 0.09 and maximum 0.09 ± 0.04 black ants were recorded in the treatment Cowpea followed by Safflower (0.05 ± 0.04), Marigold, Coriander and Control (0.04 ± 0.04). The average numbers of black ants on flowering plants were in the range of 0.00 to 0.48 and maximum 0.48 ± 0.16 black ants were recorded in the treatment Cowpea. The average number of spiders observed on lablab bean plant was in the range of 0.26 to 0.47. The maximum spiders (0.47 ± 0.12) were recorded from the treatment Coriander followed by Mustard (0.44 ± 0.12), Sunflower (0.44 ± 0.12), Safflower (0.43 ± 0.12), Sweet corn (0.43 ± 0.12), Marigold (0.41 ± 0.12), Cowpea (0.37 ± 0.12) and Sesame (0.36 ± 0.12). Data on average number of spiders observed on flowering plants was in the range of 0.00 to 0.63. The maximum spiders (0.63 ± 0.22) were recorded from the treatment Sweet corn followed by Marigold (0.44 ± 0.22), Sesame (0.44 ± 0.22), Sunflower (0.44 ± 0.22), Mustard (0.36 ± 0.22), Coriander (0.35 ± 0.22) and Cowpea (0.29 ± 0.22). The average number of lady beetles observed on lablab bean plants was in the range of 0.13 to 0.37. The maximum of 0.37 ± 0.13 lady beetles were recorded in the treatments Sunflower as flowering plant followed by Control (0.21 ± 0.13), Coriander (0.18 ± 0.13), Marigold (0.17 ± 0.13), Safflower (0.17 ± 0.13) and Sweet corn (0.17 ± 0.13). The average number of lady beetles observed on flowering plants was in the range of 0.00 to 2.69. The maximum of 2.69 ± 0.92 lady beetles were recorded in the treatments Sweet corn as flowering plant followed by 1.10 ± 0.92 in Sunflower. The pooled mean number of Chrysopids observed on lablab bean plants was in the range of 0.00 to 0.36. The maximum of 0.36 ± 0.38 Chrysopids were recorded in the treatments Mustard as flowering plant. The pooled mean number of Chrysopids observed on flowering plants was in the range of 0.00 to 0.56. The maximum of 0.56 ± 0.44 Chrysopids were recorded in the treatments Sweet corn as flowering plant followed by 0.47 ± 0.44 in Coriander. The Syrphid flies were noticed from week 6 (1st week of February) till harvest of the crop *i.e.* week 12 (3rd week of March). The pooled mean number of Syrphid flies observed on lablab bean plants was in the range of 0.01 to 0.08. The maximum of 0.08 ± 0.05 Syrphid flies were recorded in the treatments Mustard as flowering plant followed by Safflower (0.07 ± 0.05), Sesame (0.07 ± 0.05), Coriander (0.06 ± 0.05) and Control (0.05 ± 0.05). The pooled mean number of Syrphid flies observed on flowering plants was in the range of 0.00 to 0.42. The maximum of 0.42 ± 0.14 Syrphid flies were recorded in the treatments Safflower as flowering plant.

Keywords: Lablab bean, border crops, natural enemies, Lady bird beetle, Black ants

Introduction

Lablab bean (*Lablab purpureus* L.) belongs to family leguminaceae is an annual herbaceous crop and commonly called as Dolichos bean, Hycinth bean, Indian bean, Country bean, Pavta, Auri, Butter bean, Field bean and Egyptian kidney bean. It is popularly recognized as “Wal” in Maharashtra state. It is one of the oldest vegetable crops grown as pod vegetable in the world and in India particular. It is a native of tropical Asia, probably India and from there it spread to tropical and subtropical countries of the world like China, Sudan, Egypt and other countries.

India is the largest producer of pulse crops under a wide range of agro climatic conditions and is recognized globally as a major contributor of pulses having about 25 percent share in global production and 27 percent of total pulses of the world. The domestic production is often less than the estimated demand *i.e.* 2324 million tonnes. Studies on consumption pattern has revealed that in India only 8-10 million tons of pulses are used directly as a food item (Dal), the remaining 12 million tonnes being indirect actual consumption as processed/value added products such as snacks, fast food for domestic consumption and export.

Thus the average gap of 5 MT is met through imports. In India, the share of pulses to gross cropped area and in total food grains basket is about 12 percent and 6-7 percent, respectively (Anonymous, 2016) [5]. In India, the total area under pulses is 230.98 lakh hectares with an annual production of 17.20 million tonnes with yield 744 kg/hectare (Anonymous, 2015a) [2], while in Maharashtra, the total area under pulses is 2977 thousand hectare with an annual production of 1805.9 thousand tonnes with yield 607 kg/hectare (Anonymous, 2015b) [3]. In *Konkan*, the total area under pulses is 88,000 hectares with an annual production of 37 metric tonnes (Anonymous, 2015c) [4].

As many as 55 species of insects and one mite feeding on the lablab bean crop from seedling stage till the harvest in Karnataka. Among the various pests, pod borer complex comprising of *Helicoverpa armigera* (Hubner), *Adisura atkinsoni* (Moore), *Maruca vitrata* (Geyer), *Etiella zinckenella* (Treitschke), *Exelastis atomosa* (Walshingham), and *Lampides boeticus* (Linnaeus) are of considerable importance causing 80 per cent pod damage. Sucking pests like lablab bug *Coptosoma cribraria* (Fabricius), *Riptortus pedestris* (Fabricius), *Nazara viridula* (Linnaeus) and aphid *Aphis craccivora* Koch. Occurred commonly and observed in large number throughout the cropping period (Govindan, 1974).

Aphids are one of the most serious pests of crops worldwide, causing major yield and economic losses. The management of these noxious pests is primarily based on synthetic insecticides due to their easy availability and applicability and their indiscriminate use has resulted in the development of insecticidal resistance in the pest, environmental pollution, resurgence of minor pests, pollution hazards and disruption on balance of eco-system. Border cropping 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 Bio intensive Pest Management. It is also very good practice for conservation of the natural enemies and pollinators.

Materials and methods

The present investigation entitled "Pest management in Lablab bean (*Lablab purpureus* L.) by using border crops" was undertaken at Agronomy Farm, College of Agriculture, Dapoli during *rabi* 2016-2017 Tal. Dapoli, Dist. Ratnagiri (M.S.). The soil of the experimental site was lateritic, fairly homogeneous with medium drainage. The experimental plot was divided using Randomized Block Design having three replications. Whereas each replication was divided into nine subplots of size 3.6 × 3.6 m. The flat beds were prepared and used for cultivation of lablab bean. The required quantity of F.Y.M. was mixed at the time of field preparation and fertilizers were applied at the time of sowing. The healthy seed of 'Konkan Wal-1' variety of lablab bean was obtained from Department of Agronomy, College of Agriculture,

Dapoli. The recommended seed rate of 30-45 kg ha⁻¹ was used. Farm Yard Manure as organic manure at the rate of 5 tonnes ha⁻¹ was applied in the soil before last harrowing so as to mix it well in the soil. Nitrogen and Phosphorus were applied in the form of straight fertilizers through Urea (46% N) and Single Super Phosphate (16% P₂O₅) to each plot. The recommended dose, 25:50:0 kg NPK ha⁻¹ was applied at the time of sowing.

Treatment Plots

Tr. No.	Name of the plant	Botanical name	Family
T1	Marigold	<i>Tagetes patula</i> L.	Asteraceae
T2	Safflower	<i>Carthamus tinctorious</i> L.	Asteraceae
T3	Sweet corn	<i>Zea mays</i> L.	Graminae
T4	Sesamum	<i>Sesamum indicum</i> L.	Pedaliaceae
T5	Mustard	<i>Brassica juncea</i> L.	Cruciferae
T6	Coriander	<i>Coriandrum sativum</i> L.	Umbelliferae
T7	Cowpea	<i>Vigna unguiculata</i> L.	Leguminosae
T8	Sunflower	<i>Helianthus annuus</i> L.	Asteraceae
T9	Control	-	-

Date of Sowing: 2nd Dec., 2016 and Date of harvesting: 5th April, 2017

Five plants per plot were selected randomly to record the observations on the incidence of lablab bean pests and for recording the natural enemies in lablab bean ecosystem. Same lablab bean plants were used for recording the presence of different natural enemies. Similarly, five flowering plants on border were randomly selected for recording the natural enemies. The total of nine treatments having eight flowering plants on borders (mentioned in treatments details) and one control (No flowering plants *i.e.* open border) were used around the plot size of 3.6 x 3.6 m. The flowering plants were grown on the borders.

To record the natural enemies on main and border crops

The same five plants selected for recording lablab bean pest infestation and five randomly selected flowering plants on borders were used for recording the number of natural enemies in different plots having different nectar rich flowering plants on the borders. Different natural enemies were recorded at weekly interval. The natural enemies were recorded up to the harvest of the crop. The natural enemies were recorded by necked eyes and by collecting with the help of insect collection net. The recorded natural enemies like lady beetle, spiders, black ants, syrphid fly, and *Chrysoperla carnea* were counted plot wise. Data thus obtained were averaged and analyzed.

Statistical analysis

Data on per cent infestation of lablab bean pests was converted in arc sine transformation and then analyzed, whereas data on number of natural enemies was averaged and the standard deviation was calculated.

Table 1: Number of black ants recorded on lablab bean

Treatments	Number of black ants recorded on lablab bean												Pooled mean of all 12 weeks
	Week1 Jan. 1 st wk	Week2 Jan. 2 nd wk	Week3 Jan. 3 rd wk	Week4 Jan. 4 th wk	Week5 Jan. 5 th wk	Week6 Feb. 1 st wk	Week7 Feb. 2 nd wk	Week8 Feb. 3 rd wk	Week9 Feb. 4 th wk	Week10 March 1 st wk	Week11 March 2 nd wk	Week12 March 3 rd wk	
T1 Marigold	0.07	0.07	0.13	0.07	0.00	0.00	0.07	0.07	0.00	0.07	0.00	0.00	0.04
T2 Safflower	0.00	0.00	0.07	0.00	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.05
T3 Sweet corn	0.07	0.07	0.07	0.07	0.00	0.07	0.00	0.00	0.00	0.07	0.00	0.00	0.03
T4 Sesamum	0.07	0.00	0.07	0.07	0.00	0.00	0.07	0.00	0.07	0.00	0.07	0.00	0.03

T5 Mustard	0.07	0.07	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.07	0.00	0.00	0.02
T6 Coriander	0.07	0.07	0.07	0.00	0.07	0.07	0.00	0.07	0.00	0.07	0.07	0.00	0.04
T7 Cowpea	0.13	0.07	0.07	0.13	0.07	0.07	0.07	0.07	0.13	0.13	0.07	0.07	0.09
T8 Sunflower	0.07	0.00	0.07	0.00	0.07	0.07	0.00	0.00	0.07	0.07	0.00	0.00	0.03
T9 Control	0.00	0.00	0.07	0.13	0.00	0.00	0.07	0.00	0.07	0.07	0.07	0.00	0.04
SD ±	0.04	0.04	0.03	0.06	0.04	0.04	0.03	0.04	0.05	0.03	0.04	0.03	0.04

Table 2: Number of black ants recorded on flowering plants

Treatments	Number of black ants recorded on flowering plants												Pooled mean of all 12 weeks
	Week1 Jan. 1 st wk	Week2 Jan. 2 nd wk	Week3 Jan. 3 rd wk	Week4 Jan. 4 th wk	Week5 Jan. 5 th wk	Week6 Feb. 1 st wk	Week7 Feb. 2 nd wk	Week8 Feb. 3 rd wk	Week9 Feb. 4 th wk	Week10 March 1 st wk	Week11 March 2 nd wk	Week12 March 3 rd wk	
T1 Marigold	0.00	0.07	0.13	0.07	0.00	0.00	0.07	0.00	0.07	0.00	0.00	0.00	0.03
T2 Safflower	0.13	0.27	0.13	0.07	0.07	0.07	0.07	0.20	0.00	0.07	0.07	0.00	0.09
T3 Sweet corn	0.07	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.02
T4 Sesamum	0.00	0.07	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.01
T5 Mustard	0.00	0.00	0.07	0.07	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.02
T6 Coriander	0.00	0.13	0.07	0.07	0.00	0.00	0.00	0.00	0.07	0.07	0.07	0.00	0.04
T7 Cowpea	0.13	0.13	0.47	0.40	0.47	0.73	0.27	0.93	0.93	0.67	0.20	0.40	0.48
T8 Sunflower	0.07	0.13	0.20	0.07	0.00	0.00	0.00	0.07	0.00	0.07	0.00	0.00	0.05
T9 Control	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SD ±	0.06	0.08	0.15	0.12	0.15	0.24	0.08	0.31	0.31	0.21	0.07	0.13	0.16

Table 3: Number of spider recorded on lablab bean

Treatments	Number of spiders recorded on lablab bean												Pooled mean of all 12 weeks
	Week1 Jan. 1 st wk	Week2 Jan. 2 nd wk	Week3 Jan. 3 rd wk	Week4 Jan. 4 th wk	Week5 Jan. 5 th wk	Week6 Feb. 1 st wk	Week7 Feb. 2 nd wk	Week8 Feb. 3 rd wk	Week9 Feb. 4 th wk	Week10 March 1 st wk	Week11 March 2 rd wk	Week12 March 3 th wk	
T1 Marigold	0.40	0.67	0.40	0.53	0.47	0.47	0.40	0.33	0.47	0.40	0.27	0.07	0.41
T2 Safflower	0.47	0.47	0.40	0.60	0.40	0.60	0.53	0.40	0.73	0.27	0.27	0.00	0.43
T3 Sweet corn	0.60	0.60	0.60	0.40	0.47	0.47	0.47	0.40	0.33	0.47	0.27	0.07	0.43
T4 Sesamum	0.47	0.60	0.47	0.27	0.40	0.47	0.47	0.53	0.27	0.27	0.13	0.00	0.36
T5 Mustard	0.53	0.73	0.60	0.47	0.53	0.60	0.53	0.53	0.27	0.27	0.20	0.00	0.44
T6 Coriander	0.67	0.60	0.73	0.60	0.53	0.53	0.60	0.53	0.27	0.40	0.13	0.07	0.47
T7 Cowpea	0.60	0.67	0.67	0.20	0.47	0.47	0.33	0.33	0.27	0.33	0.13	0.00	0.37
T8 Sunflower	0.60	0.47	0.47	0.40	0.73	0.87	0.40	0.40	0.33	0.27	0.20	0.13	0.44
T9 Control	0.40	0.00	0.33	0.33	0.27	0.33	0.33	0.33	0.27	0.27	0.13	0.13	0.26
SD ±	0.10	0.22	0.14	0.14	0.13	0.15	0.09	0.09	0.16	0.08	0.06	0.06	0.12

Table 4: Number of spiders recorded on flowering plants

Treatments	Number of spiders recorded on flowering plants												Pooled mean of all 12 weeks
	Week1 Jan. 1 st wk	Week2 Jan. 2 nd wk	Week3 Jan. 3 rd wk	Week4 Jan. 4 th wk	Week5 Jan. 5 th wk	Week6 Feb. 1 st wk	Week7 Feb. 2 nd wk	Week8 Feb. 3 rd wk	Week9 Feb. 4 th wk	Week10 March 1 st wk	Week11 March 2 nd wk	Week12 March 3 rd wk	
T1 Marigold	0.47	0.40	0.47	0.40	0.40	0.53	0.53	0.60	0.53	0.40	0.27	0.27	0.44
T2 Safflower	0.27	0.33	0.20	0.13	0.07	0.07	0.13	0.20	0.13	0.27	0.13	0.00	0.16
T3 Sweet corn	1.07	1.13	0.80	0.80	0.67	0.73	0.67	0.73	0.27	0.33	0.33	0.07	0.63
T4 Sesamum	0.47	0.60	0.53	0.33	0.27	0.27	0.47	0.80	0.53	0.60	0.27	0.20	0.44
T5 Mustard	0.53	0.67	0.53	0.60	0.47	0.53	0.33	0.20	0.13	0.20	0.07	0.00	0.36
T6 Coriander	0.33	0.53	0.40	0.27	0.60	0.73	0.47	0.27	0.33	0.13	0.13	0.00	0.35
T7 Cowpea	0.27	0.67	0.40	0.27	0.33	0.47	0.27	0.27	0.40	0.13	0.07	0.00	0.29
T8 Sunflower	0.60	0.80	0.33	0.80	0.40	0.40	0.40	0.67	0.47	0.33	0.07	0.00	0.44
T9 Control	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SD ±	0.29	0.32	0.22	0.28	0.22	0.26	0.21	0.29	0.19	0.18	0.11	0.10	0.22

Table 5: Number of lady beetles recorded on lablab bean

Treatments	Number of lady beetles recorded on lablab bean												Pooled mean of all 12 weeks
	Week1 Jan. 1 st wk	Week2 Jan. 2 nd wk	Week3 Jan. 3 rd wk	Week4 Jan. 4 th wk	Week5 Jan. 5 th wk	Week6 Feb. 1 st wk	Week7 Feb. 2 nd wk	Week8 Feb. 3 rd wk	Week9 Feb. 4 th wk	Week10 March 1 st wk	Week11 March 2 nd wk	Week12 March 3 rd wk	
T1 Marigold	0.13	0.13	0.07	0.13	0.07	0.07	0.07	0.27	0.33	0.47	0.27	0.07	0.17
T2 Safflower	0.07	0.07	0.07	0.07	0.07	0.13	0.13	0.33	0.27	0.13	0.73	0.00	0.17
T3 Sweet corn	0.13	0.13	0.33	0.13	0.13	0.13	0.13	0.20	0.27	0.27	0.20	0.00	0.17
T4 Sesamum	0.07	0.13	0.13	0.13	0.07	0.07	0.07	0.27	0.13	0.33	0.13	0.07	0.13
T5 Mustard	0.13	0.07	0.07	0.13	0.13	0.13	0.07	0.27	0.27	0.40	0.20	0.07	0.16
T6 Coriander	0.20	0.07	0.07	0.20	0.07	0.13	0.07	0.40	0.33	0.33	0.27	0.00	0.18

T7 Cowpea	0.13	0.07	0.13	0.13	0.07	0.07	0.07	0.40	0.27	0.13	0.07	0.00	0.13
T8 Sunflower	0.13	0.33	0.20	0.27	0.13	0.20	0.27	0.33	0.20	0.20	0.33	1.80	0.37
T9 Control	0.07	0.07	0.07	0.13	0.07	0.07	0.07	0.27	0.07	0.07	0.27	1.33	0.21
SD ±	0.04	0.09	0.09	0.06	0.03	0.05	0.07	0.07	0.09	0.14	0.19	0.69	0.13

Table 6: Number of lady beetles recorded on flowering plants

Treatments	Number of lady beetles recorded on flowering plants												Pooled mean of all 12 weeks
	Week1 Jan. 1 st wk	Week2 Jan. 2 nd wk	Week3 Jan. 3 rd wk	Week4 Jan. 4 th wk	Week5 Jan. 5 th wk	Week6 Feb. 1 st wk	Week7 Feb. 2 nd wk	Week8 Feb. 3 rd wk	Week9 Feb. 4 th wk	Week10 March 1 st wk	Week11 March 2 nd wk	Week12 March 3 rd wk	
T1 Marigold	0.00	0.13	0.07	0.07	0.13	0.20	0.13	0.20	0.20	0.53	0.27	0.13	0.17
T2 Safflower	0.07	0.07	0.07	0.07	0.07	0.07	0.53	0.87	1.20	1.67	0.93	0.40	0.50
T3 Sweet corn	0.33	0.47	0.33	0.33	3.67	4.93	4.47	5.47	7.33	1.13	1.00	2.87	2.69
T4 Sesamum	0.00	0.00	0.07	0.07	0.13	0.13	0.27	0.20	0.13	0.33	0.07	0.00	0.12
T5 Mustard	0.13	0.20	0.13	0.13	0.07	0.07	0.87	1.47	0.53	0.47	0.07	0.00	0.34
T6 Coriander	0.07	0.13	0.07	0.07	0.07	0.13	1.60	1.27	1.67	0.47	0.07	0.00	0.47
T7 Cowpea	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.13	0.07	0.00	0.00	0.03
T8 Sunflower	0.07	0.20	0.60	0.53	2.13	2.87	2.27	1.93	1.13	1.07	0.40	0.00	1.10
T9 Control	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SD ±	0.10	0.15	0.20	0.18	1.31	1.76	1.47	1.72	2.31	0.55	0.39	0.94	0.92

Table 7: Number of Chrysopids recorded on lablab bean

Treatments	Number of Chrysopids recorded on lablab bean												Pooled mean of all 12 weeks
	Week1 Jan. 1 st wk	Week2 Jan. 2 nd wk	Week3 Jan. 3 rd wk	Week4 Jan. 4 th wk	Week5 Jan. 5 th wk	Week6 Feb. 1 st wk	Week7 Feb. 2 nd wk	Week8 Feb. 3 rd wk	Week9 Feb. 4 th wk	Week10 March 1 st wk	Week11 March 2 nd wk	Week12 March 3 rd wk	
T1 Marigold	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T2 Safflower	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.40	0.00	0.00	0.00	0.00	0.12
T3 Sweet corn	0.00	0.00	0.00	0.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08
T4 Sesamum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.87	0.93	0.00	0.00	0.00	0.15
T5 Mustard	0.00	0.00	1.13	0.00	1.20	0.73	1.27	0.00	0.00	0.00	0.00	0.00	0.36
T6 Coriander	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.73	1.93	0.00	0.31
T7 Cowpea	1.53	0.87	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20
T8 Sunflower	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T9 Control	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SD ±	0.51	0.29	0.38	0.31	0.40	0.24	0.42	0.52	0.31	0.58	0.64	0.00	0.38

Table 8: Number of Chrysopids recorded on flowering plants

Treatments	Number of Chrysopids recorded on flowering plants												Pooled mean of all 12 weeks
	Week1 Jan. 1 st wk	Week2 Jan. 2 nd wk	Week3 Jan. 3 rd wk	Week4 Jan. 4 th wk	Week5 Jan. 5 th wk	Week6 Feb. 1 st wk	Week7 Feb. 2 nd wk	Week8 Feb. 3 rd wk	Week9 Feb. 4 th wk	Week10 March 1 st wk	Week11 March 2 nd wk	Week12 March 3 rd wk	
T1 Marigold	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T2 Safflower	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T3 Sweet corn	1.87	1.27	0.73	0.00	0.00	0.00	0.00	1.07	1.13	0.00	0.60	0.00	0.56
T4 Sesamum	0.00	0.00	0.00	0.00	0.00	1.07	0.00	0.00	0.00	0.00	0.00	0.00	0.09
T5 Mustard	0.00	0.00	0.00	0.87	0.00	0.00	1.07	0.87	0.00	0.93	0.00	0.00	0.31
T6 Coriander	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.20	2.87	1.53	0.00	0.47
T7 Cowpea	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T8 Sunflower	0.00	0.00	0.00	0.00	0.80	1.53	0.00	0.00	0.00	0.00	0.00	0.00	0.19
T9 Control	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SD ±	0.62	0.42	0.24	0.29	0.27	0.58	0.36	0.43	0.51	0.97	0.53	0.00	0.44

Table 9: Number of Syrphid flies recorded on lablab bean

Treatments	Number of Syrphid flies on lablab bean							Pooled mean of all 7 weeks
	Week 6 (Feb. 1 st week)	Week 7 (Feb. 2 nd week)	Week 8 (Feb. 3 rd week)	Week 9 (Feb. 4 th week)	Week 10 (March 1 st week)	Week 11 (March 2 nd week)	Week 12 (March 3 rd week)	
T1 Marigold	0.00	0.00	0.13	0.00	0.00	0.07	0.07	0.04
T2 Safflower	0.00	0.07	0.13	0.07	0.07	0.07	0.07	0.07
T3 Sweet corn	0.00	0.07	0.13	0.00	0.00	0.00	0.00	0.03
T4 Sesamum	0.07	0.07	0.07	0.13	0.07	0.07	0.00	0.07
T5 Mustard	0.07	0.13	0.07	0.07	0.07	0.07	0.07	0.08
T6 Coriander	0.07	0.07	0.13	0.00	0.00	0.13	0.00	0.06
T7 Cowpea	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.01
T8 Sunflower	0.00	0.00	0.00	0.00	0.13	0.00	0.07	0.03

T9 Control	0.07	0.00	0.00	0.07	0.07	0.07	0.07	0.05
SD ±	0.04	0.05	0.06	0.05	0.05	0.04	0.04	0.05

Table 10: Number of Syrphid flies recorded on flowering plants

Treatments	Number of Syrphid flies recorded on flowering plants							Pooled mean of all 7 weeks
	Week6 (Feb. 1 st week)	Week7 (Feb. 2 nd week)	Week8 (Feb. 3 rd week)	Week9 (March 4 th week)	Week10 (March 1 st week)	Week11 (March 2 nd week)	Week12 (March 3 rd week)	
T1 Marigold	0.13	0.07	0.20	0.13	0.27	0.07	0.07	0.13
T2 Safflower	0.13	0.13	0.27	0.67	0.40	0.60	0.73	0.42
T3 Sweet corn	0.00	0.00	0.07	0.00	0.00	0.07	0.00	0.02
T4 Sesamum	0.07	0.07	0.07	0.07	0.00	0.00	0.00	0.04
T5 Mustard	0.07	0.07	0.13	0.13	0.13	0.07	0.00	0.09
T6 Coriander	0.07	0.07	0.07	0.07	0.07	0.07	0.00	0.06
T7 Cowpea	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T8 Sunflower	0.00	0.00	0.13	0.07	0.00	0.00	0.00	0.03
T9 Control	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SD ±	0.06	0.05	0.09	0.21	0.15	0.19	0.24	0.14

Results and Discussion

The rapidly expanding literature on habitat management was reviewed with attention to practice for favoring predators and parasitoids, implementation of habitat management, and the contributions of modelling and ecological theory to this developing area of conservation biological control. The potential to integrate the goals of habitat management for natural enemies and nature conservation is studied in present finding.

The relative efficacy of different border crops was evaluated under field condition for the conservation of natural enemies in lablab bean ecosystem and their impact on lablab bean pests during *rabi* 2016-17 and the data thus obtained is presented below.

Black ants

Number of black ants recorded on lablab bean

The black ants were noticed throughout the cropping period starting from week 1 (1st week of January) till harvest of the crop. *i.e.* week 12 (3rd week of March). Data on number of black ants per five lablab bean plants were recorded at weekly interval and presented in Table 1.

The number of black ants on lablab bean having different border crops as flowering plants recorded in week 1 (1st week of January) was in the range of 0.00 to 0.13. The maximum numbers of black ants 0.13 ± 0.04 were observed in the treatment Cowpea followed by Marigold, Sweet corn, Sesamum, Mustard, Coriander and Sunflower (0.07 ± 0.04). The data recorded on number of black ants in week 2 (2nd week of January) was in the range of 0.00 to 0.07. The maximum numbers of black ants (0.07 ± 0.04) were observed in the treatments Marigold, Sweet corn, Mustard, Coriander and Cowpea while 0.00 black ants were recorded in Safflower, Sunflower, Sesamum and Control. The data of week 3 (3rd week of January) showed that the number of black ants was in the range of 0.00 to 0.13. The maximum numbers of black ants (0.13 ± 0.03) were observed in the treatment Marigold. The maximum numbers of black ants (0.07 ± 0.03) were recorded in the treatments Marigold, Safflower, Sweet corn, Sesamum, Coriander, Cowpea and Sunflower as flowering plant while 0.00 black ants were observed in Mustard. The number of black ants on lablab bean recorded in week 4 (4th week of January) was in the range of 0.0 to 0.13. The maximum numbers of black ants (0.13 ± 0.06) were recorded in Cowpea and control followed by Marigold, Sweet corn and Sesamum (0.07 ± 0.06) while 0.00 black ants were

observed in the treatments Safflower, Mustard, Coriander and Sunflower. In the week 5 (5th week of January) the number of black ants observed was in the range of 0.00 to 0.07. The maximum numbers of black ants (0.07 ± 0.04) was recorded in the treatments Safflower, Coriander, Cowpea and Sunflower while 0.00 black ants was observed in Marigold, Sweet corn, Sesamum, Mustard as a flowering plant and control. The number of black ants on lablab bean plant recorded in week 6 (1st week of February) was in the range of 0.0 to 0.07. The maximum numbers of black ants (0.07 ± 0.04) were recorded in the treatments Safflower, Sweet corn, Coriander, Cowpea and Sunflower. The number of black ants on lablab bean plant recorded in week 7 (2nd week of February) was in the range of 0.0 to 0.07. The maximum numbers of black ants (0.07 ± 0.03) were recorded in the treatments Marigold, Safflower, Sesamum, Mustard, Cowpea and control. In the week 8 (3rd week of February) number of black ants observed was in the range of 0.00 to 0.07. The maximum numbers of black ants (0.07 ± 0.04) were recorded in Marigold, Safflower, Coriander and Cowpea. The data of week 9 (4th week of February) showed that the number of black ants was in the range of 0.00 to 0.13. The maximum number of black ants (0.13 ± 0.05) was observed in the treatment Cowpea followed by 0.07 ± 0.05 in Safflower, Sesamum, Sunflower and control. In the week 10 (1st week of March) number of black ants observed was in the range of 0.00 to 0.13. The maximum numbers of black ants (0.13 ± 0.03) were observed in the treatment Cowpea followed by 0.07 ± 0.03 in Marigold, Safflower, Sweet corn, Mustard, Coriander, Sunflower and Control. The number of black ants on lablab bean plant recorded in week 11 (2nd week of March) was in the range of 0.0 to 0.07. The maximum numbers of black ants (0.07 ± 0.04) were recorded in the treatments Safflower, Sesamum, Coriander, Cowpea and control. In the week 12 (3rd week of March) the number of black ants observed was in the range of 0.00 to 0.07. The maximum numbers of black ants (0.07 ± 0.03) were recorded in the treatment Safflower and Cowpea.

The average number of black ants recorded from week 1 to 12 are presented in Table 1. The average numbers of black ants were in the range of 0.00 to 0.09 and maximum 0.09 ± 0.04 black ants were recorded in the treatment Cowpea. The number of black ants in the other treatments next in the order were Safflower (0.05 ± 0.04), Marigold, Coriander and Control (0.04 ± 0.04) as flowering plants on lablab bean bunds.

The present findings confirm the results of Patro and Behera (1991). They showed that colonies of *Aphis craccivora*, infesting Dolichos lablab [*Lablab purpureus*] were associated with Formicidae.

Number of black ants on flowering plants

Data on number of black ants as natural enemies per five border crops was recorded at weekly interval and presented in Table 2.

The number of black ants recorded in week 1 (1st week of January) were in the range of 0.00 to 0.13. The maximum (0.13) black ants were recorded from the treatments Safflower and Cowpea. The treatments Sweet corn and Sunflower recorded 0.07 ± 0.06 black ants. In the week 2 (2nd week of January) numbers of black ants observed were in the range of 0.00 to 0.27. The maximum (0.27 ± 0.08) black ants were recorded from the treatments Safflower. The numbers of black ants (0.13 ± 0.08) next in the order were in Sweet corn, Coriander, Cowpea and Sunflower. The data of black ants recorded in week 3 (3rd week of January) was in the range of 0.00 to 0.47. The maximum (0.47 ± 0.15) black ants were recorded from the treatment Cowpea. The Sunflower recorded (0.20 ± 0.15) black ants. The number of black ants recorded in week 4 (4th week of January) were in the range of 0.00 to 0.40. The maximum (0.40 ± 0.12) black ants were recorded from the treatments Cowpea followed by Marigold, Safflower, Mustard, Coriander and Sunflower (0.07 ± 0.12). The number of black ants recorded in week 5 (5th week of January) were in the range of 0.00 to 0.47. The maximum (0.47 ± 0.15) black ants were recorded from the treatment Cowpea. The data on black ants recorded in week 6 (1st week of February) revealed that they were in the range of 0.00 to 0.73. The maximum (0.73 ± 0.24) black ants were recorded from the treatment Cowpea. In the week 7 (2nd week of February) numbers of black ants observed were in the range of 0.00 to 0.27. The maximum (0.27 ± 0.08) black ants were recorded from the treatments Cowpea. The number of black ants recorded in week 8 (3rd week of February) were in the range of 0.00 to 0.93. The maximum (0.93 ± 0.31) black ants were recorded from the treatment Cowpea followed by Safflower (0.20 ± 0.31). In the week 9 (4th week of February) number of black ants observed were in the range of 0.00 to 0.93. The maximum (0.93 ± 0.31) black ants were recorded from the treatment Cowpea followed by Marigold and Coriander (0.07 ± 0.31). In week 10 (1st week of March) number of black ants observed were in the range of 0.00 to 0.67. The maximum (0.67 ± 0.21) black ants were recorded from the treatment Cowpea followed by Safflower, Sweet corn, Coriander and Sunflower which recorded 0.07 ± 0.21 black ants. The number of black ants recorded in week 11 (2nd week of March) were in the range of 0.00 to 0.20. The maximum (0.20 ± 0.07) black ants were recorded from the treatment Cowpea while Safflower and Coriander recorded 0.07 ± 0.07 black ants. The number of black ants recorded in week 12 (3rd week of March) were in the range of 0.00 to 0.40. The maximum (0.40 ± 0.13) black ants were recorded from the treatment Cowpea.

The average number of black ants recorded from week 1 to 12 are presented in Table 2. The average numbers of black ants were in the range of 0.00 to 0.48 and maximum 0.48 ± 0.16 black ants were recorded in the treatment Cowpea.

Spiders

Number of spiders on lablab bean

Data on number of spiders per five lablab bean plants were recorded at weekly interval and presented in Table 3.

The spiders recorded on lablab bean plants in week 1 (1st week of January) were in the range of 0.40 to 0.67. The maximum 0.67 ± 0.10 spiders were recorded in the treatment Coriander followed by 0.60 ± 0.10 in Sweet corn, cowpea and Sunflower. The data during week 2 (2nd week of January) showed that spiders were in the range of 0.47 to 0.73. The maximum spiders (0.73 ± 0.22) was recorded in Mustard which was followed by Marigold (0.67 ± 0.22), Cowpea (0.67 ± 0.22), Sweet corn (0.60 ± 0.22) and Sesamum (0.60 ± 0.22) Coriander (0.60 ± 0.22), Safflower (0.47 ± 0.22) and Sunflower (0.47 ± 0.22). No spider was recorded in control. The numbers of spiders were in the range of 0.33 to 0.73 during week 3 (3rd week of January). The maximum spiders (0.73 ± 0.14) were recorded in Coriander followed by Cowpea (0.67 ± 0.14), Sweet corn (0.60 ± 0.14), Mustard (0.60 ± 0.14), Sesamum (0.47 ± 0.14) and Sunflower (0.47 ± 0.14). The data revealed that spiders were in the range of 0.20 to 0.60 during week 4 (4th week of January). The maximum spiders (0.60 ± 0.14) was recorded in Safflower and Coriander which were followed by marigold (0.53 ± 0.14), Mustard (0.47 ± 0.14), Sweet corn (0.40 ± 0.14), and Sunflower (0.40 ± 0.14). In the week 5 (5th week of January) number of spiders observed were in the range of 0.27 to 0.73. The maximum spiders (0.73 ± 0.13) were recorded from the treatment Sunflower followed by Mustard (0.53 ± 0.13), Coriander (0.53 ± 0.13), Marigold, Sweet corn and Cowpea (0.47 ± 0.13). In the week 6 (1st week of February) numbers of spiders observed were in the range of 0.33 to 0.87. The maximum (0.87 ± 0.15) spiders were recorded from the treatments Sunflower followed by Safflower (0.60 ± 0.015), Mustard (0.60 ± 0.15) Coriander (0.53 ± 0.15), Marigold (0.47 ± 0.15) and Sweet corn (0.47 ± 0.15). The data revealed that spiders were in the range of 0.33 to 0.60 during week 7 (2nd week of February). The maximum spiders (0.60 ± 0.09) was recorded in Coriander which were followed by Safflower (0.53 ± 0.09), Mustard (0.53 ± 0.09), Sweet corn (0.47 ± 0.09), and Sesamum (0.47 ± 0.09). In the week 8 (3rd week of February) number of spiders observed were in the range of 0.33 to 0.53. The maximum spiders (0.53 ± 0.09) were recorded from the treatment Sesamum, Mustard and Coriander followed by Safflower, Sweet corn, Sunflower (0.40 ± 0.09). The data on spiders was in the range of 0.27 to 0.73 during week 9 (4th week of February). The maximum spiders (0.73 ± 0.16) were recorded in Safflower followed by Marigold (0.47 ± 0.16), Sweet corn (0.33 ± 0.16), Sunflower (0.33 ± 0.16) and Sesamum (0.27 ± 0.09). In week 10 (1st week of March) number of spiders observed were in the range of 0.27 to 0.47. The maximum spiders (0.47 ± 0.08) were recorded from the treatment Sweet corn followed by Marigold (0.40 ± 0.08), Coriander (0.40 ± 0.08), Cowpea (0.33 ± 0.08) and Safflower (0.27 ± 0.08). The data reported that spiders were in the range of 0.13 to 0.27 during week 11 (2nd week of March). The maximum spiders (0.27 ± 0.06) was recorded in Safflower, Marigold and Sweet corn followed by Mustard (0.20 ± 0.06), Sunflower (0.20 ± 0.06) and Sesamum (0.13 ± 0.06). In the week 12 (3rd week of March) number of spiders observed were in the range of 0.00 to 0.13. The maximum spiders (0.13 ± 0.06) were recorded from the treatment Sunflower and Control followed by Marigold (0.07 ± 0.06), Sweet corn (0.07 ± 0.06) and Coriander (0.07 ± 0.06).

The data of all twelve weeks was statistically analyzed and pooled mean of the number of spider recorded is presented in Table 3. The number of spiders observed was in the range of 0.26 to 0.47. The maximum spiders (0.47 ± 0.12) were recorded from the treatment Coriander followed by Mustard

(0.44 ± 0.12), Sunflower (0.44 ± 0.12), Safflower (0.43 ± 0.12), Sweet corn (0.43 ± 0.12), Marigold (0.41 ± 0.12), Cowpea (0.37 ± 0.12) and Sesamum (0.36 ± 0.12).

The results of the present findings are more or less in conformity with the finding of Basit *et al.* (2016) [7]. They conducted field experiment during 2008 and 2009 on population fluctuation of insect pests and their predators in sunflower ecosystem. Among natural enemies, spiders were found to be the putative predators with maximum population of 3.5 individuals / plant.

Number of spiders on Flowering plants

Data on number of spiders per five flowering plants were recorded at weekly interval and presented in Table 4.

The data revealed that spiders were in the range of 0.00 to 1.07 during week 1 (1st week of January). The maximum spiders (10.7 ± 0.29) were recorded in Sweet corn which were followed by Sunflower (0.60 ± 0.29), Mustard (0.53 ± 0.29), Marigold (0.47 ± 0.29), Sesamum (0.47 ± 0.29), and Coriander (0.33 ± 0.29). In the week 2 (2nd week of January) number of spiders observed were in the range of 0.00 to 1.13. The maximum spiders (1.13 ± 0.32) were recorded from the treatment Sweet corn followed by sunflower (0.80 ± 0.32), Mustard (0.67 ± 0.32), Cowpea (0.67 ± 0.32), Sesamum (0.60 ± 0.32), Coriander (0.53 ± 0.32), Marigold (0.40 ± 0.32) and Safflower (0.33 ± 0.32). The spiders were in the range of 0.00 to 0.80 during week 3 (3rd week of January). The maximum spiders (0.80 ± 0.22) were recorded in Sweet corn which were followed by Sesamum (0.53 ± 0.22), Mustard (0.53 ± 0.22), Marigold (0.47 ± 0.22), Coriander (0.40 ± 0.22), Cowpea (0.40 ± 0.22), and Sunflower (0.33 ± 0.22). In the week 4 (4th week of January) number of spiders observed were in the range of 0.00 to 0.80. The maximum spiders (0.80 ± 0.28) were recorded from the treatment Sweet corn and Sunflower followed by Mustard (0.60 ± 0.28), Marigold (0.40 ± 0.28) and Sesamum (0.33 ± 0.28). The spiders were in the range of 0.00 to 0.67 during week 5 (5th week of January). The maximum spiders (0.67 ± 0.22) were recorded in Sweet corn which were followed by Coriander (0.60 ± 0.22), Mustard (0.47 ± 0.22), Marigold (0.40 ± 0.22), Sunflower (0.40 ± 0.22), Cowpea (0.33 ± 0.22) and Sesamum (0.27 ± 0.22). In week 6 (1st week of February) number of spiders observed were in the range of 0.00 to 0.73. The maximum spiders (0.73 ± 0.26) were recorded from the treatment Sweet corn and Coriander followed by Marigold (0.53 ± 0.26), Mustard (0.53 ± 0.26) Cowpea (0.47 ± 0.26), Sunflower (0.40 ± 0.26) and Sesamum (0.27 ± 0.26). In the week 7 (2nd week of February) number of spiders observed were in the range of 0.00 to 0.67. The maximum spiders (0.67 ± 0.21) were recorded from the treatment Sweet corn followed by Marigold (0.53 ± 0.21), Sesamum (0.47 ± 0.21), Coriander (0.47 ± 0.21), Sunflower (0.40 ± 0.21), Mustard (0.33 ± 0.21) and Cowpea (0.27 ± 0.21). The data observed that number of spiders were in the range of 0.00 to 0.80 during week 8 (3rd week of February). The maximum spiders (0.80 ± 0.29) were recorded in Sesamum followed by Sweet corn (0.73 ± 0.29), Sunflower (0.67 ± 0.29) and Marigold (0.60 ± 0.29). The data revealed that number of spiders were in the range of 0.00 to 0.53 during week 9 (4th week of February). The maximum spiders (0.53 ± 0.19) were recorded in Marigold and Sesamum which were followed by Sunflower (0.47 ± 0.19), Cowpea (0.40 ± 0.19), Coriander (0.33 ± 0.19) and Sweet corn (0.27 ± 0.19). In the week 10 (1st week of March) number of spiders observed were in the range of 0.00 to 0.60. The maximum

spiders (0.60 ± 0.18) were recorded from the treatment Sesamum followed by Marigold (0.40 ± 0.18), sweet corn (0.33 ± 0.18), Sunflower (0.33 ± 0.18), Safflower (0.27 ± 0.18) and Mustard (0.20 ± 0.18). In week 11 (2nd week of March) number of spiders observed were in the range of 0.00 to 0.33. The maximum (0.33 ± 0.11) spiders were recorded from the treatments Sweet corn which was followed by Marigold (0.27 ± 0.11), Sesamum (0.27 ± 0.11), Safflower (0.13 ± 0.11) and Coriander (0.13 ± 0.11). The data revealed that spiders were in the range of 0.00 to 0.27 during week 12 (3rd week of March). The maximum spiders (0.27 ± 0.10) were recorded in Marigold followed by Sesamum (0.20 ± 0.10).

The pooled mean of the number of spider recorded is presented in Table 4. The number of spiders observed was in the range of 0.00 to 0.63. The maximum spiders (0.63 ± 0.22) were recorded from the treatment Sweet corn followed by Marigold (0.44 ± 0.22), Sesamum (0.44 ± 0.22), Sunflower (0.44 ± 0.22), Mustard (0.36 ± 0.22), Coriander (0.35 ± 0.22) and Cowpea (0.29 ± 0.22).

The results of the present findings are more or less in conformity with the finding of Basappa (2011) who reported that in sunflower ecosystem, maximum spider population was found during September and January, coinciding with the maximum population of insect pests.

The results of present findings are corroborative with the results of Niemela *et al.*, (1996). They reported that the diversification increases spider abundance and impact on pests. Heterogeneity at all scales is considered important for the preservation of spider diversity and abundance. Within-crop diversification is reviewed because of its potential to increase spider density during the crop growing season, but they also reviewed landscape diversification because of its significance for the long term and large scale maintenance of diverse and abundant populations of spiders.

Lady beetle

Number of lady beetle recorded on Lablab bean

Lady beetles, (Coccinellids) are one of the attractive insect families to entomologists due to its importance in pest management. Larval and adult stages of predatory lady beetles are active hunters of small insects. Their prey mainly consists of pests such as aphids, scale insects, whiteflies and mealy bugs, which are considered as serious pests of many economically important crops. Studies on lady beetle diversity are considered as important in the context of biological control of agricultural pests. A rich diversity of lady beetles in agro-ecosystems will enhance the natural biological control. The potential to integrate the goals of habitat management for lady beetles and natural conservation was discussed.

Data on number of lady beetle per five lablab bean plants were recorded at weekly interval and presented in Table 5.

In the week 1 (1st week of January) number of lady beetles observed were in the range of 0.07 to 0.20. The maximum numbers of lady beetles (0.20 ± 0.04) were recorded in Coriander as flowering plants on bunds followed by Marigold, Sweet corn, Mustard, Cowpea and Sunflower (0.13 ± 0.04). In week 2 (2nd week of January) number of lady beetles observed were in the range of 0.07 to 0.33. The maximum numbers of lady beetles (0.33 ± 0.09) were recorded in Sunflower as flowering plants on bunds followed by Marigold, Sweet corn and Sesamum (0.13 ± 0.09). In week 3 (3rd week of January) number of lady beetles observed were in the range of 0.07 to 0.33. The maximum lady beetles (0.33

± 0.09) were recorded from the treatment Sweet corn followed by Sunflower (0.20 ± 0.09), Sesamum (0.13 ± 0.09) and Cowpea (0.13 ± 0.09). In week 4 (4th week of January) number of lady beetles observed were in the range of 0.07 to 0.27. The maximum lady beetles (0.27 ± 0.06) were recorded from the treatment Sunflower followed by Coriander (0.20 ± 0.06), Marigold, Sweet corn, Sesamum, Mustard, cowpea and Control (0.13 ± 0.06). In the week 5 (5th week of January) number of lady beetles observed were in the range of 0.07 to 0.13. The maximum lady beetles (0.13 ± 0.03) were recorded from the treatment Sweet corn, Mustard, Sunflower followed by Marigold, Safflower, Sesamum, Coriander, Cowpea and Control (0.07 ± 0.03). The numbers of lady beetles observed were in the range of 0.07 to 0.20 in week 6 (1st week of February). The maximum lady beetles (0.20 ± 0.05) were recorded from the treatment Sunflower followed by Safflower, Sweet corn, Mustard and Coriander (0.13 ± 0.05). In the week 7 (2nd week of February) number of lady beetles observed were in the range of 0.07 to 0.27. The maximum lady beetles (0.27 ± 0.07) were recorded from the treatment Sunflower followed by Safflower (0.13 ± 0.07) and Sweet corn (0.13 ± 0.07). In week 8 (3rd week of February) number of lady beetles observed were in the range of 0.20 to 0.40. The maximum lady beetles (0.40 ± 0.07) were recorded from the treatment Coriander and Cowpea followed by Sunflower and Safflower (0.33 ± 0.07). The numbers of lady beetles observed were in the range of 0.07 to 0.33 in the week 9 (4th week of February). The maximum lady beetles (0.33 ± 0.09) were recorded from the treatment Marigold and Coriander followed by Sweet corn, Mustard, Cowpea and Safflower (0.27 ± 0.09). In week 10 (1st week of March) number of lady beetles observed were in the range of 0.07 to 0.47. The maximum lady beetles (0.47 ± 0.14) were recorded from the treatment Marigold followed by Mustard (0.40 ± 0.14), Sesamum (0.33 ± 0.14), Coriander (0.33 ± 0.14) and Sweet corn (0.27 ± 0.14). In the week 11 (2nd week of March) number of lady beetles observed were in the range of 0.07 to 0.73. The maximum lady beetles (0.73 ± 0.19) were recorded from the treatment Safflower followed by Sunflower (0.33 ± 0.19), Marigold, Coriander and Control (0.27 ± 0.19). In week 12 (3rd week of March) number of lady beetles observed were in the range of 0.00 to 1.80. The maximum lady beetles (1.80 ± 0.69) were recorded from the treatment Sunflower.

The pooled mean number of lady beetles observed in twelve weeks is presented in Table 5. The number of lady beetles observed was in the range of 0.13 to 0.37. The maximum of 0.37 ± 0.13 lady beetles were recorded in the treatments Sunflower as flowering plant followed by Control (0.21 ± 0.13), Coriander (0.18 ± 0.13), Marigold (0.17 ± 0.13), Safflower (0.17 ± 0.13) and Sweet corn (0.17 ± 0.13).

The results of present findings are corroborative with the results of Rachappa *et al.* (2014) [12]. They reported that significantly highest number of Coccinellid population was recorded on chickpea + safflower (4:1) intercropping sequence (0.00 to 2.00) Coccinellid per ten plants both on main crop and intercrops.

Number of lady beetles recorded flowering plants.

The lady beetles were noticed throughout the cropping period starting from first week of January till harvest of the crop. *i.e.* week 12 (3rd week of March).

In the week 1 (1st week of January) number of lady beetles observed was in the range of 0.00 to 0.33. The maximum lady

beetles (0.33 ± 0.10) were recorded from the treatment Sweet Corn followed by Mustard (0.13 ± 0.10). The numbers of lady beetles recorded in week 2 (2nd week of January) were in the range of 0.00 to 0.47. The maximum (0.47 ± 0.15) lady beetles were recorded from the treatment Sweet corn as a border crop followed by Mustard and Sunflower (0.20 ± 0.15). The numbers of lady beetles recorded in week 3 (3rd week of February) were in the range of 0.00 to 0.60. The maximum number (0.60 ± 0.20) of lady beetles were recorded from the treatment Sunflower followed by Sweet corn (0.33 ± 0.20). In the week 4 (4th week of January) number of lady beetles observed was in the range of 0.00 to 0.53. The maximum lady beetles (0.53 ± 0.18) were recorded from the treatment Sunflower followed by Sweet corn (0.33 ± 0.18). In week 5 (5th week of January) number of lady beetles observed was in the range of 0.00 to 3.67. The maximum lady beetles (3.67 ± 1.31) were recorded from the treatment Sweet corn followed by Sunflower (2.13 ± 1.31). The number of lady beetles observed was in the range of 0.00 to 4.93 in the week 6 (1st week of February). The maximum lady beetles (4.93 ± 1.76) were recorded from the treatment Sweet corn followed by Sunflower (2.87 ± 1.76). In the week 7 (2nd week of February) number of lady beetles observed was in the range of 0.00 to 4.47. The maximum lady beetles (4.47 ± 1.47) were recorded from the treatment Sweet corn followed by Sunflower (2.27 ± 1.47) and Coriander (1.60 ± 1.47). In week 8 (3rd week of February) number of lady beetles observed was in the range of 0.00 to 5.47. The maximum lady beetles (5.47 ± 1.72) were recorded from the treatment Sweet corn followed by Sunflower (1.93 ± 1.72). The number of lady beetles observed was in the range of 0.00 to 7.33 in the week 9 (4th week of February). The maximum lady beetles (7.33 ± 2.31) were recorded from the treatment Sweet corn. In the week 10 (1st week of March) number of lady beetles observed was in the range of 0.00 to 1.67. The maximum lady beetles (1.67 ± 0.55) were recorded from the treatment Safflower followed by Sweet corn (1.13 ± 0.55) and Sunflower (1.07 ± 0.55). In week 11 (2nd week of March) number of lady beetles observed was in the range of 0.00 to 1.00. The maximum lady beetles (1.00 ± 0.39) were recorded from the treatment Sweet corn followed by Safflower (0.93 ± 0.39) and Sunflower (0.40 ± 0.39). In the week 12 (3rd week of March) number of lady beetles observed was in the range of 0.00 to 2.87. The maximum lady beetles (2.87 ± 0.94) were recorded from the treatment Sweet corn.

The pooled mean number of lady beetles observed in twelve weeks is presented in Table 6. The number of lady beetles observed was in the range of 0.00 to 2.69. The maximum of 2.69 ± 0.92 lady beetles were recorded in the treatments Sweet corn as flowering plant followed by 1.10 ± 0.92 in Sunflower.

The results of present findings are corroborative with the results of Sedlacek *et al.* (2012). They determined the effect of habitat management/border plantings on beneficial insect diversity and abundance in agricultural crops. They reported that pink lady beetle, *Coleomegilla maculata* (De Geer); Asian lady beetle, *Harmonia axyridis* (Pallas) and seven spotted lady beetle, *Coccinella septempunctata* L. were caught. The pink lady beetle was the most abundant species overall in all three borders and in the sweet corn plots with 79 per cent and 94 per cent, respectively.

Basit *et al.* (2016) [7] observed that among natural enemies, lady beetles were found to be the putative predators with maximum population of 3.9 individuals/plant.

Merriam (1988) and Pogue and Schnell (2001) reported that agricultural production practices are modernized by mechanization and chemical pesticides and agricultural landscapes are simplified. These changes negatively affect the diversity of lady beetles. Mixed cropping ecosystems are more favourable to ladybird beetles than monocropping ecosystems to establish their populations. Lady beetles can be conserved in the agro ecosystems through manipulation of agro ecosystems by growing intercrops and/or border crops. Border crops and intercrops may provide microclimate, breeding grounds and pollen to predatory lady beetles and will serve to maintain a good number of these biocontrol agents for conservation biological control. The present study clearly indicated that sweet corn and mustard are suitable crops to support different species of lady beetles.

Chrysopids

Number of Chrysopids recorded on Lablab bean

Data on number of Chrysopids per five lablab bean plants were recorded at weekly interval and presented in Table 7.

In week 1 (1st week of January) number of Chrysopids observed was in the range of 0.00 to 1.53. The maximum Chrysopids (1.53 ± 0.51) were recorded from the treatment Cowpea. In week 2 (2nd week of January) number of Chrysopids observed were in the range of 0.00 to 0.87. The maximum Chrysopids (0.87 ± 0.29) were recorded from the treatment Cowpea. In week 3 (3rd week of January) number of Chrysopids observed were in the range of 0.00 to 1.13. The maximum Chrysopids (1.13 ± 0.38) were recorded from the treatment Mustard. In week 4 (4th week of January) number of Chrysopids observed were in the range of 0.00 to 0.93. The maximum Chrysopids (0.93 ± 0.31) were recorded from the treatment Sweet corn. In week 5 (5th week of January) number of Chrysopids observed were in the range of 0.00 to 1.20. The maximum Chrysopids (1.20 ± 0.40) were recorded from the treatment Mustard. In week 6 (1st week of February) number of Chrysopids observed were in the range of 0.00 to 0.73. The maximum Chrysopids (0.73 ± 0.24) were recorded from the treatment Mustard. In the week 7 (2nd week of February) number of Chrysopids observed were in the range of 0.00 to 1.27. The maximum Chrysopids (1.27 ± 0.42) were recorded from the treatment Mustard. In the week 8 (3rd week of February) number of Chrysopids observed were in the range of 0.00 to 1.40. The maximum Chrysopids (1.40 ± 0.52) were recorded from the treatment Safflower followed by Sesamum (0.87 ± 0.52). In the week 9 (4th week of February) number of Chrysopids observed were in the range of 0.00 to 0.93. The maximum Chrysopids (0.93 ± 0.31) were recorded from the treatment Sesamum. In the week 10 (1st week of March) number of Chrysopids observed were in the range of 0.00 to 1.73. The maximum Chrysopids (1.73 ± 0.58) were recorded from the treatment Coriander. In the week 11 (2nd week of March) number of Chrysopids observed were in the range of 0.00 to 1.93. The maximum Chrysopids (1.93 ± 0.64) were recorded from the treatment Coriander. In the week 12 (3rd week of March) no Chrysopids were recorded.

The pooled mean number of Chrysopids observed in twelve weeks is presented in Table 7. The pooled mean number of Chrysopids observed was in the range of 0.00 to 0.36. The maximum of 0.36 ± 0.38 Chrysopids were recorded in the treatments Mustard as flowering plant.

The results of the present findings are corroborative with the findings of Paul and Rijn (2012). The lacewings are among the most common natural enemies of pests in arable fields

whereas the larvae are voracious predators of aphids and other insects. In this study the suitability of flowers of 16 plant species was examined as food source for the common *Chrysoperla carnea*. The results indicated that only umbellifers and other flowers with well exposed nectaries are suitable as sugar sources.

Virk (2009) tested three modules of habitat management (intercropped with cowpea, marigold and border rows of sorghum and release of bio control agents), bio intensive pest management (BIPM-border row of maize and release of bio control agents) and insecticidal control to assess the effect of habitat management in cotton on population/incidence of insect pests and natural enemies. The natural enemies *Chrysoperla* spp. population was significantly higher in habitat management.

Number of Chrysopids recorded on flowering plants

Data on number of Chrysopids per five flowering plants were recorded at weekly interval and presented in Table 8.

In week 1 (1st week of January) number of Chrysopids observed was in the range of 0.00 to 1.87. The maximum Chrysopids (1.87 ± 0.62) were recorded from the treatment Sweet Corn. In week 2 (2nd week of January) number of Chrysopids observed were in the range of 0.00 to 1.27. The maximum Chrysopids (1.27 ± 0.42) were recorded from the treatment Sweet Corn. In week 3 (3rd week of January) number of Chrysopids observed were in the range of 0.00 to 0.73. The maximum Chrysopids (0.73 ± 0.24) were recorded from the treatment Sweet Corn. In week 4 (4th week of January) number of Chrysopids observed were in the range of 0.00 to 0.87. The maximum Chrysopids (0.87 ± 0.29) were recorded from the treatment Mustard. In week 5 (5th week of January) number of Chrysopids observed were in the range of 0.00 to 0.80. The maximum Chrysopids (0.80 ± 0.27) were recorded from the treatment Sunflower. In week 6 (1st week of February) number of Chrysopids observed were in the range of 0.00 to 1.53. The maximum Chrysopids (1.53 ± 0.58) were recorded from the treatment Sunflower followed by treatments Sesamum (1.07 ± 0.58). In the week 7 (2nd week of February) number of Chrysopids observed were in the range of 0.00 to 1.07. The maximum Chrysopids (1.07 ± 0.36) were recorded from the treatment Mustard. In the week 8 (3rd week of February) number of Chrysopids observed were in the range of 0.00 to 1.07. The maximum Chrysopids (1.07 ± 0.43) were recorded from the treatment Sweet corn followed by Mustard (0.87 ± 0.43). In the week 9 (4th week of February) number of Chrysopids observed were in the range of 0.00 to 1.20. The maximum Chrysopids (1.20 ± 0.51) were recorded from the treatment Coriander followed by Sweet corn (1.13 ± 0.51). In the week 10 (1st week of March) number of Chrysopids observed were in the range of 0.00 to 2.87. The maximum Chrysopids (2.87 ± 0.97) were recorded from the treatment Coriander. In the week 11 (2nd week of March) number of Chrysopids observed were in the range of 0.00 to 1.53. The maximum Chrysopids (1.53 ± 0.53) were recorded from the treatment Coriander. In the week 12 (3rd week of March) no Chrysopids were recorded.

The pooled mean number of Chrysopids observed in twelve weeks is presented in Table 8. The pooled mean number of Chrysopids observed was in the range of 0.00 to 0.56.

The maximum of 0.56 ± 0.44 Chrysopids were recorded in the treatments Sweet corn as flowering plant followed by 0.47 ± 0.44 in Coriander.

The results of the present findings are corroborative with the

findings of Swaminathan *et al.* (1999)^[13]. They reported that cotton (*Gossypium hirsutum* L.) intercropped with sunflower and cowpea in paired row system was favourable for the conservation of *Chrysoperla carnea* (Stephens), Cotton alone was comparatively less favourable to the multiplication of *C. carnea* which correspondingly recorded more population of insect pests.

Syrphid fly

Number of Syrphid flies recorded on Lablab bean

The Syrphid flies were noticed from week 6 (1st week of February) till harvest of the crop *i.e.* week 12 (3rd week of March).

In the week 6 (1st week of February) number of Syrphid flies observed was in the range of 0.00 to 0.07. The maximum Syrphid flies (0.07± 0.04) were recorded from the treatment Sesamum, Mustard, Coriander and control. In the week 7 (2nd week of February) number of Syrphid flies observed was in the range of 0.00 to 0.13. The maximum Syrphid flies (0.13 ± 0.05) were recorded from the treatment Mustard followed by Safflower, Sweet corn, Sesamum and Coriander (0.07 ± 0.05). In the week 8 (3rd week of February) number of Syrphid flies observed was in the range of 0.00 to 0.13. The maximum Syrphid flies (0.13 ± 0.06) were recorded from the treatment Sweet corn, Marigold, Safflower and Coriander followed by Sesamum and Mustard (0.07 ± 0.06). In the week 9 (4th week of February) number of Syrphid flies observed was in the range of 0.00 to 0.13. The maximum Syrphid flies (0.13 ± 0.05) were recorded from the treatment Sesamum followed by Safflower, Mustard and Cowpea (0.07±0.05). In the week 10 (1st week of March) number of Syrphid flies observed was in the range of 0.00 to 0.13. The maximum Syrphid flies (0.13 ± 0.05) were recorded from the treatment Sunflower followed by safflower, Sesamum, Mustard and control (0.07 ± 0.05). In the week 11 (2nd week of March) number of Syrphid flies observed was in the range of 0.00 to 0.13. The maximum Syrphid flies (0.13± 0.04) were recorded from the treatment Coriander followed by Marigold, Safflower, Sesamum, Mustard and Control (0.07 ± 0.04). In the week 12 (3rd week of March) number of Syrphid flies observed was in the range of 0.00 to 0.07. The maximum Syrphid flies (0.07 ± 0.04) were recorded from the treatment Marigold, Safflower, Mustard, Sunflower and Control (0.07±0.04).

The pooled mean number of Syrphid flies observed in seven weeks is presented in Table 9. The pooled mean number of Chrysopids observed was in the range of 0.01 to 0.08. The maximum of 0.08 ± 0.05 Syrphid flies were recorded in the treatments Mustard as flowering plant followed by Safflower (0.07 ± 0.05), Sesamum (0.07 ± 0.05), Coriander (0.06 ± 0.05) and Control (0.05 ± 0.05).

The results of the present findings are corroborative with the findings of Pineda and Marcos-Garcia (2008). They noticed that the addition of floral resources in a crop is the most commonly used conservation biological control strategy. The influence of additional floral resources on the abundance of aphidophagous syrphids has been studied in Mediterranean sweet-pepper greenhouses. Sweet alyssum and coriander were the plant species used as flowering plants. More hoverfly adults were observed in the plots where flowers had been introduced than in the control. The three most abundant syrphid species found were *Eupeodes corollae*, *Episyrphus balteatus* and *Sphaerophoria rueppellii*.

Number of Syrphid flies recorded on flowering plants

Data on number of Syrphid flies per five flowering plants were recorded at weekly interval from week 6 (1st week of

February) to week 12 (3rd week of March) and presented in Table 10.

In the week 6 (1st week of February) number of Syrphid flies observed were in the range of 0.00 to 0.13. The maximum Syrphid flies (0.13± 0.06) were recorded from the treatment Marigold and Safflower. In the week 7 (2nd week of February) numbers of Syrphid flies observed were in the range of 0.07 to 0.13. The maximum Syrphid flies (0.13 ± 0.05) were recorded from the treatment Safflower followed by Marigold, Sesamum, Mustard and Coriander (0.07 ± 0.05). In the week 8 (3rd week of February) number of Syrphid flies observed were in the range of 0.20 to 0.27. The maximum Syrphid flies (0.27 ± 0.09) were recorded from the treatment Safflower followed by Marigold (0.20±0.09) and Mustard (0.13 ± 0.09). In the week 9 (4th week of February) number of Syrphid flies observed were in the range of 0.07 to 0.67. The maximum Syrphid flies (0.67 ± 0.21) were recorded from the treatment Safflower. In the week 10 (1st week of March) number of Syrphid flies observed were in the range of 0.07 to 0.40. The maximum Syrphid flies (0.40 ± 0.15) were recorded from the treatment Safflower followed by Marigold (0.27±0.15). In the week 11 (2nd week of March) numbers of Syrphid flies observed were in the range of 0.07 to 0.60. The maximum Syrphid flies (0.60 ± 0.19) were recorded from the treatment Safflower. In the week 12 (3rd week of March) number of Syrphid flies observed were in the range of 0.00 to 0.73. The maximum Syrphid flies (0.73 ± 0.24) were recorded from the treatment safflower.

The pooled mean number of Syrphid flies observed in seven weeks is presented in Table 10. The pooled mean number of Chrysopids observed was in the range of 0.00 to 0.42. The maximum of 0.42 ± 0.14 Syrphid flies were recorded in the treatments Safflower as flowering plant.

The results of the present findings are corroborative with the findings of Martinez-Una *et al.* (2013)^[11]. Six plant species were selected from preliminary work for their potential attractiveness to four common aphidophagous hoverflies species. *Sphaerophoria scripta* L. and *Sphaerophoria rueppellii* (Wiedeman) were the dominant hoverflies present throughout the sampling period whereas *Eupeodes corollae* (F.) and *Episyrphus balteatus* (DeGeer) visits were less abundant and appeared only in the early season. *Calendula arvensis* L. and *Coriandrum sativum* L. were the most visited species. The visits to *C. sativum* were concentrated in a short blooming period.

Conclusion

The black ants were noticed throughout the cropping period starting from week 1 (1st week of January) till harvest of the crop. *i.e.* week 12 (3rd week of March). The average numbers of black ants on lablab bean plant were in the range of 0.00 to 0.09 and maximum 0.09 ± 0.04 black ants were recorded in the treatment Cowpea followed by Safflower (0.05 ± 0.04), Marigold, Coriander and Control (0.04 ± 0.04) as flowering plants on lablab bean bunds. The average numbers of black ants on flowering plants were in the range of 0.00 to 0.48 and maximum 0.48 ± 0.16 black ants were recorded on Cowpea.

The spiders were noticed throughout the cropping period starting from week 1 (1st week of January) till harvest of the crop *i.e.* week 12 (3rd week of March). The average number of spiders on lablab bean plant observed was in the range of 0.26 to 0.47. The maximum spiders (0.47 ± 0.12) were recorded from the treatment Coriander followed by Mustard (0.44± 0.12), Sunflower (0.44 ± 0.12), Safflower (0.43 ± 0.12), Sweet corn (0.43 ± 0.12), Marigold (0.41 ± 0.12), Cowpea

(0.37 ± 0.12) and Sesamum (0.36 ± 0.12). The average numbers of spiders on flowering plants observed were in the range of 0.00 to 0.63. The maximum spiders (0.63 ± 0.22) were recorded from the treatment Sweet corn followed by Marigold (0.44 ± 0.22), Sesamum (0.44 ± 0.22), Sunflower (0.44 ± 0.22), Mustard (0.36 ± 0.22), Coriander (0.35 ± 0.22) and Cowpea (0.29 ± 0.22).

The lady beetles were noticed throughout the cropping period starting from first week of January till harvest of the crop. *i.e.* week 12 (3rd week of March). The average number of lady beetles observed on lablab bean plant was in the range of 0.13 to 0.37. The maximum of 0.37 ± 0.13 lady beetles were recorded in the treatments Sunflower as flowering plant followed by Control (0.21 ± 0.13), Coriander (0.18 ± 0.13), Marigold (0.17 ± 0.13), Safflower (0.17 ± 0.13) and Sweet corn (0.17 ± 0.13). The average number of lady beetles observed on flowering plants was in the range of 0.00 to 2.69. The maximum of 2.69 ± 0.92 lady beetles were recorded in the treatments Sweet corn as flowering plant followed by 1.10 ± 0.92 in Sunflower.

The Chrysopids were noticed throughout the cropping period starting from first week of January till harvest of the crop. *i.e.* week 12 (3rd week of March). The pooled mean number of Chrysopids observed on lablab bean plants was in the range of 0.00 to 0.36. The maximum of 0.36 ± 0.38 Chrysopids were recorded in the treatments Mustard as flowering plant. The pooled mean number of Chrysopids observed on flowering plants was in the range of 0.00 to 0.56. The maximum of 0.56 ± 0.44 Chrysopids were recorded in the treatments Sweet corn as flowering plant followed by 0.47 ± 0.44 in Coriander.

The Syrphid flies were noticed from week 6 (1st week of February) till harvest of the crop *i.e.* week 12 (3rd week of March). The pooled mean number of Syrphid flies observed on lablab bean plants was in the range of 0.01 to 0.08. The maximum of 0.08 ± 0.05 Syrphid flies were recorded in the treatments Mustard as flowering plant followed by Safflower (0.07 ± 0.05), Sesamum (0.07 ± 0.05), Coriander (0.06 ± 0.05) and Control (0.05 ± 0.05). The pooled mean number of Syrphid flies observed on flowering plants was in the range of 0.00 to 0.42. The maximum of 0.42 ± 0.14 Syrphid flies were recorded in the treatments Safflower.

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