IJTA © Serials Publications

National Academy of Agricultural Science (NAAS) Rating : 3.03

Impact of Conservation Agriculture Practices on Arthropod Community in Cotton Intercropping with Groundnut System

[1]Guru, P. N., [2]Patil, R. K. and [3]Asif Hadimani

ABSTRACT: *Arthropod communities were assessed numerically for one year in conservation and conventional agriculture blocks of Main Agriculture Research Station (MARS), Dharwad. Different tillage systems were considered as main variables with broad bed and furrow with mulch (conservation agriculture practices) were alternately referred as secondary variables. Mites and collembolans were the most abundant group collected among the soil arthropods. While, within the tillage systems conservation tillage systems with BBF and mulch harbors relatively more soil arthropods i.e., both meso (45% more) and macro (49% more) and also diversity (Shannon index = 0.601) in contrary to conventional tillage systems without any soil cover (22%, 20% and 0.532 respectively). Defoliators in groundnut and sucking pests in cotton were the pests recorded and found significantly higher numbers in conservation tillage practices. In contrary, natural enemy population was also higher in conservation tillage practices which imply overall conservation agriculture practices have great impact on richness, diversity and abundance of the arthropod community.*

Key words: *soil arthropods, conservation agriculture, Shannon index, tillage system*

INTRODUCTION

Worldwide the cultivation of cotton (*Gossypium* spp.) crop got importance for its fibre i.e., referred as white gold or vegetable wool. But, nearly 162 different insect species and mites are attacking on this wonderful commercial crop and seems no other cultivated crop species is as susceptible as cotton (Agarwal *et al.*, 1984 and Laxman, *et al.*, 2013). By this pest susceptibility, the cost of protection in cotton is necessary. Among these insect pest species many of them can be easily managed by changing the agro ecosystem of the cotton crop by intercropping, mixed cropping or other cropping systems which also changes the habitat of the insect pests which attacking the cotton crop and cause less damage. Secondly, habitat manipulation can also increase the natural enemies of the crop pests which in turn can manage the pests of cotton. Even by using biodiversity (crop diversity) in agroecosystems we can reduce crop losses due to pests (Bianchi, 2003). In cotton, intercrops like groundnut, soybean, peas and green gram are getting popularized now a day since they got harvested as early as the cotton gets established.

With this background of habitat manipulation in cotton ecosystem, a model of sustainable agriculture which involves all these essential components like minimum tillage, soil cover and crop diversification is conservation agriculture (CA) is applicable. All these three main principles have great impact on arthropod community present in that particular ecosystem. The concern towards the arthropods in these systems mainly deals with both below and above ground arthropod diversity. Mainly, soil biota provides essential benefits for the functioning of agro ecosystems which are important for the long term sustainability of agriculture. Without soil organisms, the soil would be a sterile medium that could not sustain crop production. Even, pest populations are higher, more frequent and cause greater crop losses in monocultures than in more diverse stands (Cromartie, 1981). A study showed that out of 50 insect pests studied thirty-five insect species were investigated for their response to plant species diversity. The majority of the insects were in the orders: Lepidoptera, Coleoptera and Homoptera accounting for 42, 32 and 18%, respectively of the total

[1&2] Department of Agricultural Entomology, University of Agricultural Sciences, Dharwad;
[3] Department of Genetics and Plant Breeding, University of Agricultural Sciences, Raichur.

crop pests (Baliddawa, 1985). In present study we mainly concentrating on the effect of these different conservation agriculture practices on the arthropod community in cotton intercropped with groundnut cropping system (since, cotton + groundnut is followed in this zone).

MATERIAL AND METHODS

The experiment entitled "Impact of conservation agriculture practices on arthropod community in cotton intercropping with groundnut system" was carried out at Main Agriculture Research Station (MARS), Dharwad. The experimental area comes under zone-8 of Karnataka state located between 15° 17' North and 76° 46' East longitude at an altitude of 678 meters above Mean Sea Level (MSL). The average rainfall is 751 mm. The soil of the experimental site is medium to deep black (cottony black). All the crop management practices are followed as per standard package of practices by University.

The treatments imposed are, CT 1: Conservation tillage with Broad Bed and Furrow (BBF) and crop residues retained on the surface; CT 2: Conservation tillage with Broad Bed and Furrow (BBF) and incorporation of crop residues; CT 3: Conservation tillage with Flat bed with crop residues retained on the surface; CT 4: Conservation tillage with Flat bed with incorporation of crop residues; CT 5: Conventional tillage with crop residue incorporation and CT 6: Conventional tillage (Flat bed and no crop residue). Each plot was 15 m x 9 m (135 m^2) with 4 replications. The cultivars used were BINDAS (cotton) and GPBD-4 (groundnut).

Estimation of soil arthropods

For extraction of soil meso arthropods soil samples of 300g respectively were collected from the respective plots using screw augar and were brought to laboratory for further analysis. The samples were placed in the berlese funnel apparatus for 72 hrs. After the extraction is complete the samples were labeled and kept them for further assessment. The sorting of micro arthropods into their major groups can be done by using the stereo binocular microscope (under 40 x magnification).

Similarly, the soil macro arthropods are sampled by using pitfall traps. The observations were done at 10 days interval. After collection they are grouped into major groups *viz.*, carabids, scarabeids, spiders, ants and all others.

Shannon's index of general diversity (H)

The richness and abundance of the arthropods can be assessed to know the diversity in that particular ecosystem. Similarly, in our case we use shannon's index for the calculation of general diversity (both below and above ground diversity combined). This will give both the evenness and abundance of soil arthropod fauna in different CA practices. The index formula is given below,

$$H = -\Sigma \left\{ \frac{ni}{N} \log \frac{ni}{N} \right\}$$

$$H = -\Sigma \, Pi \log Pi$$

Where,

ni = number of individuals in each species

N = total number of individuals from all the species.

Pi = ni/N, importance probability for each species

Above ground arthropod community

This includes all the other arthropod complexes which present in that particular ecosystem viz., pests and their natural enemies. In general, groundnut was mainly affected by defoliator complex and no other such problem was noticed that's why defoliators (per mrl) were recorded. While, in cotton sucking pests like, leafhoppers (per 3l), thrips (per 3l), aphids (per 3l) and whiteflies (per 3l), mirid bug (per 25 squares) and shoot weevil (% shoot damage) were recorded. In case of natural enemies, general predators like green lace wings (per pl), brown lace wings (per pl), coccinellids (per pl), syrphids (per pl), spiders (per pl) and predatory thrips (per 3l) were recorded at week interval respectively.

RESULTS

Soil meso arthropods

The conservation tillage with broad bed and furrow (BBF) with crop residues retained on the surface (CT1) recorded significantly higher population of all meso arthropods *viz.*, mites (7.30/100 g of soil), collembolans (7.23/100 g of soil), symphyllans (1.78/100 g of soil), diplurans (0.29/100 g of soil) and other micro arthropods (4.96/100 g of soil) followed by conservation tillage with BBF and incorporation of crop residues (CT2). Mites and collembolans are the predominant group recorded. Though the symphylla and diplura numbers are less their population is often encountered. The mites composed majorly of predatory in nature and they are significantly higher in CT1 (7.30/100 g of soil) followed by CT2 (5.45/100 g of soil) and least was recorded in CT6 (1.59/100 g of soil). The population increased gradually from 30 DAS and reached highest at 90 days after sowing (10.67/100 g of soil) and followed by 150 DAS (10/100 g of soil) and 120 DAS (8/100 g of soil) respectively as shown in table 1.

Though the population of collembolan not differed significantly across tillage system their numbers are higher during 180 DAS (13/100 g of soil), 90 DAS (10/100 g of soil) and 150 DAS (10/100 g of soil). The symphyllans and diplurans not differed significantly. The other arthropods (like ants, dipterans, staphylinids, silverfishes *etc.*) were found to be significantly higher in CT1 (4.96/100 g of soil) and CT2 (5.15/100 g of soil) followed by the all other tillage systems. Population reached highest during 120 DAS (10.33/100 g of soil) followed by 180 DAS (7.33/100 g of soil). Overall mean population of soil meso arthropods was significantly higher at 90 DAS (5.27/100 g of soil) and 150 DAS (4.30/100 g of soil) as given in table 1.

Soil macro arthropods

Similar trend was observed with respect to soil macro arthropods where, ground beetle population was higher in CT1 (1.99 per trap) followed by CT2 (1.70 per trap) and least in CT6 (0.79 per trap). Similarly, the scarabeids are higher in CT1 (3.93 per trap) followed by CT2 (3.64 per trap) and least in CT6 (1.69 per trap). However, spiders, ants and other macro arthropods are significantly higher in conservation tillage systems with BBF (CT1: 1.88, 3.45 and 4.30 per trap; CT2: 1.60, 3.21 and 3.69 per trap respectively) and conservation tillage with flat bed systems (CT3: 1.28, 2.56 and 3.41 per trap; CT4: 1.28, 2.12 and 2.93 per trap respectively) as given in table 2.

Insect pests

3.3.1. Groundnut: The insect pest population significantly varied across the different conservation tillage practices. The defoliator complex recorded per meter row length recorded higher population in conventional tillage with flat bed without crop residues (CT6: 3.45/mrl) followed by CT5 (2.67/mrl) and least was observed in CT3 (1.67/mrl) as in table 3.

3.3.2. Cotton: Mean sucking pest population recorded were not varied significantly across conservation tillage practices while, individually they differ significantly. Overall, population of aphids recorded higher in CT6 (6.14 per 3 leaves) and CT5 (5.04 per 3 leaves). However, leafhoppers recorded highest in CT6 (5.24 per 3 leaves) and CT5 (4.88 per 3 leaves). Thrips recorded higher in CT6 (10.89 per 3 leaves). While, the whitefly population recorded high in CT5 (2.00 per 3 leaves) followed by CT6 (1.70 per 3 leaves). all these sucking pests are lesser in conservation tillage with flat bed and mulch systems.

The other pests like, mirid bug was higher in CT2 (5.83 per 25 bolls) and least in CT6 (1.33 per 25 bolls). However, the least per cent shoot weevil damage was recorded in CT3 (1.66%) followed by CT5 (4.66%) as in table 3.

Natural enemies

3.4.1. Groundnut: The natural enemies like coccinellids, predatory thrips, campoletis and cadavers were recorded. Among them, population of coccinellids and spiders were recorded highest in CT1 (1.32/plant and 1.15/plant respectively) followed by CT2 (1.12/plant and 0.99/plant). Predatory thrips also recorded highest number in CT1 (0.43 per 3 leaves). While, *Campoletis chloridaea* (larval parasitoid on lepidopteran caterpillars like *Helicoverpa, Spodoptera, etc.*) pupae per meter row length per 10 plants did not show any significant difference across the different conservation tillage practices.

Cadavers (caterpillars affected by entomopathogens) recorded per meter row length showed significant difference between conservation tillage practices and higher number noticed in CT1 (2.80/mrl) and was at par with CT2 (2.58/mrl). Least population was recorded in CT6 (0.24/mrl) as shown in table 4.

3.4.2. Cotton: The natural enemies recorded were significantly varied and the population of coccinellids was highest in CT1 (2.60 /pl). Similarly, population of brown lace wing and spiders also recorded highest in CT1 (0.80 and 2.33/pl respectively) and CT2 (0.63 and 1.80/pl respectively). However, population of green lace wing and syrphids did not differ significantly across the tillage practices. But, predatory thrips recorded were higher in CT1 (5.20/3l) and CT2 (4.77/3l). Overall, the population of natural enemy was found to be highest in conservation tillage with BBF systems (CT1 and CT2) followed by conservation tillage with flat bed systems (CT3 and CT4) and least was recorded in conventional tillage systems (CT5 and CT6) as indicated in table 4.

DISCUSSION

Significantly higher number of soil fauna was observed in the conservation tillage and also their abundance and diversity as compared to conventional tillage systems during the experimental period. The

Table 1
Population of soil arthropods across different treatments of conservation agriculture in cotton + groundnut (1:2) cropping system over the experimental period

il arthropods	*Treatments*	*Time of observation*									*Mean*
		30 days before sowing	*At the time of sowing*	*30 DAS*	*60 DAS*	*90 DAS*	*120 DAS*	*150 DAS*	*180 DAS*	*After harvest*	
Mites	**CT 1**	10.67 (3.34)	5.7 (2.48)	4.00 (2.12)	5.33 (2.42)	10.67 (3.34)	8.00 (2.92)	10.00 (3.24)	6.67 (2.68)	4.67 (2.27)	**7.30 a (2.79)**
	CT 2	7.00 (2.74)	3.7 (2.04)	1.33 (1.35)	3.00 (1.87)	8.67 (3.03)	6.33 (2.61)	8.67 (3.03)	6.00 (2.55)	4.33 (2.20)	**5.45 b (2.44)**
	CT 3	4.67 (2.27)	3.0 (1.87)	1.00 (1.22)	3.33 (1.96)	6.00 (2.55)	4.33 (2.20)	6.67 (2.68)	6.67 (2.68)	4.67 (2.27)	**4.48 b (2.23)**
	CT 4	3.67 (2.04)	3.7 (2.04)	1.00 (1.22)	2.67 (1.78)	4.00 (2.12)	2.67 (1.78)	4.67 (2.27)	4.67 (2.27)	3.67 (2.04)	**3.41 c (1.98)**
	CT 5	3.00 (1.87)	2.0 (1.58)	1.33 (1.35)	2.00 (1.58)	3.00 (1.87)	2.00 (1.58)	3.33 (1.96)	3.67 (2.04)	2.67 (1.78)	**2.56 d (1.75)**
	CT 6	1.67 (1.47)	1.0 (1.22)	1.00 (1.22)	1.33 (1.35)	2.33 (1.68)	1.00 (1.22)	2.00 (1.58)	2.67 (1.78)	1.33 (1.35)	**1.59 e (1.45)**
ollembola	**CT 1**	3.00 (1.87)	2.7 (1.78)	3.00 (1.87)	7.67 (2.86)	12.00 (3.54)	5.00 (2.35)	8.00 (2.92)	13.00 (3.67)	10.67 (3.34)	**7.23 a (2.78)**
	CT 2	0.33 (0.91)	0.7 (1.08)	2.33 (1.68)	9.00 (3.08)	13.33 (3.72)	4.67 (2.27)	6.33 (2.61)	12.33 (3.58)	10.00 (3.24)	**6.56 a (2.66)**
	CT 3	0.33 (0.91)	0.0 (0.71)	1.00 (1.22)	2.33 (1.68)	20.67 (4.60)	11.33 (3.44)	13.67 (3.76)	4.33 (2.20)	2.33 (1.68)	**6.22 a (2.59)**
	CT 4	2.33 (1.68)	1.0 (1.22)	3.33 (1.96)	1.67 (1.47)	13.67 (3.76)	5.33 (2.42)	7.67 (2.86)	10.33 (3.29)	7.67 (2.86)	**5.89 a (2.53)**
	CT 5	0.00 (0.71)	0.7 (1.08)	1.67 (1.47)	3.67 (2.04)	18.00 (4.30)	8.00 (2.92)	11.00 (3.39)	3.67 (2.04)	2.00 (1.58)	**5.41 a (2.43)**
	CT 6	0.00 (0.71)	0.7 (1.08)	1.33 (1.35)	2.00 (1.58)	14.00 (3.81)	6.67 (2.68)	8.00 (2.92)	6.33 (2.61)	4.33 (2.20)	**4.82 a (2.31)**
ymphylla	**CT 1**	12.33 (3.58)	1.0 (1.22)	0.00 (0.71)	0.67 (1.08)	0.67 (1.08)	0.00 (0.71)	0.67 (1.08)	0.33 (0.91)	0.33 (0.91)	**1.78 a (1.51)**
	CT 2	6.33 (2.61)	1.7 (1.47)	1.00 (1.22)	0.00 (0.71)	0.67 (1.08)	0.33 (0.91)	0.33 (0.91)	1.00 (1.22)	0.67 (1.08)	**1.34 a (1.36)**
	CT 3	6.33 (2.61)	0.7 (1.08)	0.33 (0.91)	0.67 (1.08)	0.67 (1.08)	0.00 (0.71)	0.00 (0.71)	1.00 (1.22)	0.33 (0.91)	**1.11 a (1.27)**

Contd.

il arthropods	Treatments	Time of observation									Mean
		30 days before sowing	At the time of sowing	30 DAS	60 DAS	90 DAS	120 DAS	150 DAS	180 DAS	After harvest	
Symphylla	**CT 4**	3.33 (1.96)	1.0 (1.22)	0.67 (1.08)	0.33 (0.91)	0.67 (1.08)	0.00 (0.71)	0.33 (0.91)	0.00 (0.71)	0.33 (0.91)	**0.74 a (1.11)**
	CT 5	2.33 (1.68)	0.7 (1.08)	0.00 (0.71)	0.67 (1.08)	0.00 (0.71)	0.67 (1.08)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.49 a (0.99)**
	CT 6	1.00 (1.22)	0.7 (1.08)	0.00 (0.71)	0.33 (0.91)	0.67 (1.08)	0.67 (1.08)	0.33 (0.91)	0.33 (0.91)	0.00 (0.71)	**0.45 a (0.97)**
Diplura	**CT 1**	0.33 (0.91)	0.3 (0.91)	1.33 (1.35)	1.67 (1.47)	0.33 (0.91)	0.00 (0.71)	0.33 (0.91)	1.33 (1.35)	1.00 (1.22)	**0.74 a (1.11)**
	CT 2	0.00 (0.71)	2.0 (1.58)	1.33 (1.35)	0.33 (0.91)	0.00 (0.71)	0.00 (0.71)	0.33 (0.91)	1.67 (1.47)	0.33 (0.91)	**0.67 a (1.08)**
	CT 3	0.00 (0.71)	0.0 (0.71)	0.00 (0.71)	0.33 (0.91)	2.00 (1.58)	1.67 (1.47)	0.33 (0.91)	0.00 (0.71)	0.67 (1.08)	**0.56 a (1.03)**
	CT 4	0.33 (0.91)	0.3 (0.91)	0.00 (0.71)	1.33 (1.35)	0.67 (1.08)	0.33 (0.91)	0.33 (0.91)	0.00 (0.71)	0.00 (0.71)	**0.37 a (0.93)**
	CT 5	0.00 (0.71)	0.0 (0.71)	0.33 (0.91)	0.33 (0.91)	1.33 (1.35)	0.33 (0.91)	0.33 (0.91)	0.00 (0.71)	0.00 (0.71)	**0.29 a (0.89)**
	CT 6	0.00 (0.71)	0.7 (1.08)	0.33 (0.91)	0.33 (0.91)	0.33 (0.91)	0.00 (0.71)	0.00 (0.71)	0.33 (0.91)	0.00 (0.71)	**0.22 a (0.85)**
Others	**CT 1**	0.00 (0.71)	0.0 (0.71)	4.00 (2.12)	4.33 (2.20)	6.33 (2.61)	10.33 (3.29)	7.00 (2.74)	7.33 (2.80)	5.33 (2.42)	**4.96 a (2.34)**
	CT 2	2.67 (1.78)	0.0 (0.71)	2.33 (1.68)	3.67 (2.04)	6.33 (2.61)	10.33 (3.29)	6.67 (2.68)	8.67 (3.03)	5.67 (2.48)	**5.15 a (2.38)**
	CT 3	0.00 (0.71)	0.0 (0.71)	0.67 (1.08)	3.00 (1.87)	4.33 (2.20)	5.67 (2.48)	4.00 (2.12)	5.67 (2.48)	3.67 (2.04)	**3.00 b (1.87)**
	CT 4	0.33 (0.91)	0.7 (1.08)	2.00 (1.58)	4.33 (2.20)	3.00 (1.87)	4.67 (2.27)	4.67 (2.27)	3.00 (1.87)	4.33 (2.20)	**3.00 b (1.87)**
	CT 5	1.33 (1.35)	0.0 (0.71)	2.00 (1.58)	2.67 (1.78)	1.67 (1.47)	3.00 (1.87)	7.00 (2.74)	3.00 (1.87)	2.67 (1.78)	**2.59 b (1.76)**
	CT 6	1.33 (1.35)	0.7 (1.08)	0.67 (1.08)	3.00 (1.87)	2.00 (1.58)	2.67 (1.78)	6.33 (2.61)	3.00 (1.87)	2.67 (1.78)	**2.49 b (1.73)**
ean number of arthropods		**2.49 (1.73)**	**1.18 (1.30)**	**1.31 (1.35)**	**2.40 (1.70)**	**5.27 (2.40)**	**3.53 (2.01)**	**4.30 (2.19)**	**3.90 (2.10)**	**2.88 (1.84)**	3.03 (1.88)

Note: Figures in the parentheses are √x+0.5 transformed values, in a column, means followed by the same alphabet do not differ significantly (P=0.05) by DMRT. **CT1:** Conservation tillage with Broad Bed and Furrow (BBF) and crop residues retained on the surface; **CT2:** Conservation tillage with Broad Bed and Furrow (BBF) and incorporation of crop residues; **CT3:** Conservation tillage with Flat bed with crop residues retained on the surface; **CT4:** Conservation tillage with Flat bed with incorporation of crop residues; **CT5:** Conventional tillage with crop residue incorporation; **CT6:** Conventional tillage (Flat bed and no crop residue).

Table 2
Population of soil macro arthropods across different treatments of conservation agriculture practices in cotton + groundnut (1:2) and overall diversity

Tillage System	*Macro arthropod population per trap*					*Shannon's index*
	Ground beetles	*Scarabeids*	*Spiders*	*Ants*	*Others*	
CT 1	2.24 (1.65)	3.38 (1.96)	2.43 (1.71)	3.48 (1.99)	4.29 (2.19)	0.601
CT 2	1.90 (1.55)	2.57 (1.75)	1.76 (1.50)	2.76 (1.80)	3.52 (2.00)	0.600
CT 3	1.81 (1.51)	2.19 (1.64)	0.90 (1.18)	2.14 (1.62)	3.19 (1.92)	0.588
CT 4	1.29 (1.33)	1.95 (1.57)	1.52 (1.41)	1.81 (1.52)	3.05 (1.88)	0.566
CT 5	0.76 (1.12)	1.24 (1.31)	0.90 (1.17)	1.19 (1.30)	2.14 (1.63)	0.545
CT 6	1.14 (1.27)	1.24 (1.31)	1.00 (1.22)	1.33 (1.35)	2.14 (1.62)	0.532

Note: figures in the parentheses are subjected to square root transformation.
CT1: Conservation tillage with Broad Bed and Furrow (BBF) and crop residues retained on the surface; **CT2**: Conservation tillage with Broad Bed and Furrow (BBF) and incorporation of crop residues; **CT3**: Conservation tillage with Flat bed with crop residues retained on the surface; **CT4**: Conservation tillage with Flat bed with incorporation of crop residues; **CT5**: Conventional tillage with crop residue incorporation; **CT6**: Conventional tillage (Flat bed and no crop residue).

systems with mulch harbors more arthropods compared to without mulch. This might be due to the shelter created by the straws, hiding places for ground predators and since it conserves moisture it even creates a microclimate which was favorable for their growth and colonization. These findings are also supported by Marasas *et al.* (2001) and Blanchart *et al.* (2006, 2007) who also have reported with their findings of a positive response of arthropods to mulch and minimum/no tillage which inturn enhances biodiversity and abundance of soil fauna.

The abundance and biodiversity of soil macrofauna was also significantly higher under the conservation-till with mulch and BBF system than conventional tillage with flat bed and without any soil cover. The conservation-till with mulch and flat bed system attained an intermediate level of abundance and diversity. Our findings are consistent with those of Andersen (1999) and Wilson-Rummenie *et al.* (1999). Soil cover improves environmental conditions for soil organisms by protecting the habitat against water and wind erosion, drastic variations in humidity and temperature, and by increasing organic matter as a food source, thus providing a more stable environment for soil and litter dwelling invertebrates (Stinner and House, 1990; Kladivko, 2001; Blanchart *et al.,* 2006).

On contrary, the conventional tillage which involves the mechanical disruption of soil strata would reduce the population of beneficial arthropods and sometimes, native arthropods may also emigrate from the fields (Thorbek and Bilde, 2004) due to disruption of their habitat which leads to removal of essential reproduction sites or resources, thus increasing predation risk or reducing prey densities (Robertson *et al.*, 1994 and Marasas *et al.,* 2001).

In our findings mulch resulted significant effect on trophic levels as also founded by House and Parmelee (1985), Brown *et al.* (2002) and Reeleder *et al.* (2006), more detritivores were observed in conservation-tilled than in conventionally tilled soils. The accumulation of organic matter in conservation-till with mulch systems, particularly groundnut intercrop (residues), may provide a resource base for detritivores (Blanchart *et al.*, 2006).

Crop pests recorded in both the crops were also more abundant in mulched and BBF plots than in conventional plots. Similar to this Stinner and House (1990) reported mulch provides a favorable habitat, sometimes this may also triggers the minor pest to a major status (Ratnadass *et al.,* 2006). The overall effects of tillage and mulch-based systems on crop pests can be difficult to predict (in terms of time and location specificity) as ploughing and mulch can respectively kill or serve as refuge for pests and beneficial organisms (Ratnadass *et al.*, 2006). One of the evidence by Stinner and House (1990) who studied the influence of reduced tillage on invertebrate pests and their damage to crops and reported that 43% of the studied species and their damage decreased with

Table 3
Effect of conservation tillage practices on the insect pest population of groundnut and cotton

Tillage system		*Groundnut*	*Cotton*						
		Defoliators/mrl	*Aphids /3l*	*Leafhoppers /3l*	*Thrips /3l*	*Whitefly /3l*	*Mean sucking pest population /3l*	*Mirid bugs/25 bolls*	*Shoot weevil on cotton (%)*
Conservation tillage with Broad Bed and Furrow (BBF) and crop residues retained on the surface	**CT1**	2.00 bc (1.41)	4.23 abc (2.18)	2.97 b (1.86)	5.48 d (2.44)	1.20 c (1.30)	**3.14 a (1.91)**	4.50 b (2.24)	3.66 (11.09)
Conservation tillage with Broad Bed and Furrow (BBF) and incorporation of crop residues	**CT2**	2.00 bc (1.41)	5.03 ab (2.35)	3.01 b (1.87)	6.62 c (2.67)	1.30 bc (1.34)	**3.44 a (1.98)**	5.83 a (2.52)	3.00 (9.98)
Conservation tillage with Flat bed with crop residues retained on the surface	**CT3**	1.67 c (1.28)	2.99 bc (1.87)	3.09 b (1.90)	7.33 c (2.80)	1.10 c (1.26)	**3.11 a (1.90)**	3.00 c (1.87)	1.66 (7.49)
Conservation tillage with Flat bed with incorporation of crop residues	**CT4**	2.56 abc (1.57)	2.69 c (1.79)	3.42 b (1.98)	9.29 b (3.13)	0.93 c (1.20)	**3.50 a (2.00)**	2.17 cd (1.63)	2.00 (8.13)
Conventional tillage with crop residue incorporation	**CT5**	2.67 ab (1.63)	5.04 ab (2.35)	4.88 a (2.32)	10.33 ab (3.29)	2.00 a (1.58)	**4.65 a (2.27)**	1.67 de (1.47)	4.66 (12.52)
Conventional tillage (Flat bed and no crop residue)	**CT6**	3.45 a (1.85)	6.14 a (2.58)	5.24 a (2.40)	10.89 a (3.38)	1.70 ab (1.48)	**4.90 a (2.32)**	1.33 e (1.35)	5.00 (12.92)
			4.35 (2.20)	**3.77 (2.07)**	**8.33 (2.97)**	**1.37 (1.37)**		**3.08 (1.89)**	

Note: Figures in the parentheses are √x+0.5 transformed values, in a column, means followed by the same alphabet do not differ significantly (P=0.05) by DMRT.

Table 4
Effect of conservation tillage practices on the natural enemy population in groundnut and cotton under cotton + groundnut (1:2) intercropping system

Tillage systems	*Groundnut*					*Cotton*					
	Coccinellids/ plant	*Spiders/ plant*	*Predatory thrips/ 3 leaves*	*Campoletis chlorideae (pupae/mrl)*	*Cadavars/mrl*	*Green lace wing /pl*	*Brown lace wing /pl*	*Syrphids /pl*	*Coccinellids /pl*	*Spiders /pl*	*Predatory thrips /3l*
CT1	1.32 a (1.35)	1.15 a (1.28)	0.43 a (0.97)	2.20 a (1.64)	2.80 a (1.82)	0.27 a (0.88)	0.80 a (1.14)	0.53 a (1.02)	2.60 a (1.76)	2.33 a (1.68)	5.20 a (2.39)
CT2	1.12 b (1.27)	0.99 b (1.22)	0.38 a (0.94)	1.20 a (1.30)	2.58 a (1.75)	0.13 a (0.80)	0.63 b (1.06)	0.27 a (0.88)	2.13 b (1.62)	1.80 b (1.52)	4.77 a (2.29)
CT3	0.90 c (1.18)	0.76 c (1.12)	0.25 b (0.87)	1.87 a (1.54)	1.58 b (1.44)	0.20 a (0.84)	0.47 c (0.98)	0.27 a (0.88)	1.83 b (1.53)	1.60 c (1.45)	3.67 b (2.04)
CT4	0.64 d (1.07)	0.60 d (1.05)	0.19 b (0.83)	0.87 a (1.17)	1.58 b (1.44)	0.07 a (0.75)	0.37 c (0.93)	0.10 a (0.77)	1.37 c (1.37)	1.40 d (1.38)	3.20 bc (1.92)
CT5	0.42 e (0.96)	0.44 e (0.97)	0.08 c (0.76)	0.53 a (1.02)	1.24 c (1.32)	0.07 a (0.75)	0.23 d (0.86)	0.20 a (0.84)	1.17 cd (1.29)	1.30 d (1.34)	2.67 cd (1.78)
CT6	0.25 f (0.87)	0.24 f (0.86)	0.03 d (0.72)	0.63 a (1.06)	0.24 d (0.86)	0.13 a (0.80)	0.20 d (0.84)	0.23 a (0.86)	1.00 d (1.22)	1.17 e (1.29)	2.07 d (1.60)

Note: Figures in the parentheses are √x+0.5 transformed values, in a column, means followed by the same alphabet do not differ significantly (P=0.05) by DMRT. **CT1:** Conservation tillage with Broad Bed and Furrow (BBF) and crop residues retained on the surface; **CT2**: Conservation tillage with Broad Bed and Furrow (BBF) and incorporation of crop residues; **CT3**: Conservation tillage with Flat bed with crop residues retained on the surface; **CT4**: Conservation tillage with Flat bed with incorporation of crop residues; **CT5**: Conventional tillage with crop residue incorporation; **CT6**: Conventional tillage (Flat bed and no crop residue).

decreasing tillage, 29% were not significantly influenced by tillage and 28% increased with decreasing tillage.

In general the most predominant groups generally observed in the conservation tillage systems are soil- and litter-inhabiting predatory arthropods, especially ground beetles (Carabidae) and spiders (diverse Aranae) (Robertson *et al.,* 1994; Pullaro *et al*., 2004), in our study also they are the most abundant groups often recorded with the diverse variation. Our study also confirmed that these ground predators were encountered in greater abundance especially in conservation-tillage with mulch and BBF. In cotton systems, removal of soil-dwelling predators from both conventional and conservation tillage systems significantly increased the emergence rate of adult Heliothis moths (Gaylor *et al.,* 1984). Though the reports regarding the response of natural enemies to these type of practices is meager, from our study we found that the conservation agriculture practices like mulch (soil cover) and minimum tillage have great impact on abundance and distribution of natural enemies in the crop system in response to the pest density.

CONCLUSION

The studied arthropod complexes have greater diversity and activity under conservation-tillage with mulch and BBF systems are of great interest to those in the field of soil health. Compared to conventional tillage, conservation tillage and direct seeding with other CA components favoured the colonization and growth of detritivores (collembolans and ants) and predators (spiders and carabids). More detailed studies are needed regarding taxonomic categorization and identification of organisms (down to genera or species), and to link this diversity beneficial purposes to agriculture. Furthermore, it is of great importance to study regarding the entomological issues in conservation agriculture and long term experimentations to get valid results.

REFERENCES

Agarwal , R. A., Gupta, G. P. and Grag. D. O., (1984), *Cotton pest management in India*. Research Publication, Azad Nagar, Delhi, pp. 1-191.

Andersen, A., (1999), Plant protection in spring cereal production with reduced tillage. II. Effects on pests and beneficial insects. Crop Prot. 18, 651–657.

Baliddawa, C. W., (1985), Plant species diversity and crop pest control- an analytical review. *Insect Sci. Applic.* 6(4): 479-487.

Bianchi, F.J.J.A. (2003), Usefulness of spatially explicit population models in conservation biological control: an example. *International Organisation for Biological Control WPRS Bulletin* 26: 13–18.

Blanchart, E., Bernoux, M., Sarda, X., Siqueira Neto, M., Cerri, C.C., Piccolo, M., Douzet, J.M., Scopel, E., Feller, C., (2007), Effect of direct seeding mulch-based systems on soil carbon storage and macrofauna in central Brazil. Agric. Conspec. Sci. 72, 81–87.

Blanchart, E., Villenave, C., Viallatoux, A., Barthe's, B., Girardin, C., Azontonde, A., Fellera, C., (2006), Long-term effect of a legume cover crop (Mucuna pruriens var. utilis) on the communities of soil macrofauna and nematofauna, under maize cultivation, in southern Benin. Appl. Soil Ecol. 42, 136–144.

Brown, G., Pasini, A., Benito, N.P., Aquino, A.M., Correia, E., (2001), Diversity and functional role of soil macrofauna communities in Brazilian no tillage agroecosytems. In: Lal, R. (Ed.), International Symposium on Managing Biodiversity in Agricultural Ecosystems, Montreal, Canada, p. 19.

Cromartie, W. J., (1981), The environmental control of insects using crop diversity. In: CRC Handbook of Pest Management of Agriculture, pp. 223-246. (ed. by D. Pimentel). Boca Raton, Florida: CRC Press.

Gaylor, M.J., Foster, M.A., (1987), Cotton pest management in the southeastern United States as influenced by conservation tillage practices. In: House, G.J., Stinner, B.R. (Eds.), Arthropods in Conservation Tillage Systems, ESA Misc. Publ. No. 65. Entomol. Soc. Am., College Park, pp. 29–34.

House, G.J., Parmelee, R.W., (1985), Comparison of soil arthropods and earthworms from conventional and no-tillage agroecosystems. Soil Till. Res. 5, 351–360.

Kladivko, E.J., (2001), Tillage systems and soil ecology. Soil Till. Res. 61, 61–76.

Laxman, P., Ch. Samantha and Ch. Sammaiah., (2013), Sucking pests on *Bt* and Non-*Bt* cotton. *Indian Journal of Entomology.,* 75(2):167- 179.

Marasas, M.E., Sarandon, S.J., Cicchino, A.C., (2001), Changes in soil arthropod functional group in a wheat crop under conventional and no tillage systems in Argentina. Appl. Soil Ecol. 18, 61–68.

Pullaro, T.C., Marino, P.C., Jackson, D.M., Harrison, H.F., Keinath, A.P., (2004), Effects of killed cover crop mulch on weeds, weed seeds, and herbivores. Agric. Ecosyst. Environ. 115, 97–104.

Ratnadass, A., Michellon, R., Randriamanantsoa, R., Se´guy, L., (2006), Effects of soil and plant management on crop pests and diseases. In: Biological Approaches to Sustainable Soil Systems, CRC Press, pp. 589–602.

Reeleder, R.D., Miller, J.J., Ball Coelho, B.R., Roy, R.C., (2006), Impacts of tillage cover crop, and nitrogen on populations of earthworms, mircoarthropods, and soil fungi in a cultivated fragile soil. Appl. Soil Ecol. 33, 243–257.

Robertson, L.N., Kettle, B.A., Simpson, G.B., (1994), The influence of tillage practices on soil macrofauna in a semi-arid agroecosystem in northeastern Australia. Agric. Ecosyst. Environ. 48, 149–156.

Stinner, B.R., House, G.J., (1990), Arthropods and other invertebrates in conservation-tillage agriculture. Ann. Rev. Entomol. 35, 299–318.

Thorbek, P., Bilde, T., (2004), Reduced numbers of generalist arthropod predators after crop management. J. Appl. Ecol. 41, 526–538.

Wilson-Rummenie, A.C., Radford, B.J., Robertson, L.N., Simpson, G.B., Bell, K.L., (1999), Reduced tillage increases population density of soil macrofauna in a semi-arid environment in central Queensland. Environ. Entomol. 28, 163–172.