STUDIES ON SOIL ARTHROPODS, INSECT PESTS AND THEIR NATURAL ENEMIES IN ORGANIC, INTEGRATED AND CONVENTIONAL FARMING SYSTEMS IN SELECTED CROPS

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BY
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CERTIFICATE

This is to certify that the thesis entitled "STUDIES ON SOIL ARTHROPODS, INSECT PESTS AND THEIR NATURAL ENEMIES IN ORGANIC, INTEGRATED AND CONVENTIONAL FARMING SYSTEMS IN SELECTED CROPS" submitted by Mr. CHETHAN R., for the degree of MASTER OF SCIENCE (Agriculture) in AGRICULTURAL ENTOMOLOGY to the University of Agricultural Sciences, Dharwad is a record of research work done by him during the period of his study in this University under my guidance and supervision and the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar titles.

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With ever regardful memories . . . .

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1. INTRODUCTION

Organic agriculture is a unique production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles and soil biological activity. This is accomplished by using on-farm agronomic, biological and mechanical methods in exclusion of all synthetic off-farm inputs. In ancient times, farming relied on sustainable practices involving use of land races, traditional knowledge in rainfed crops, natural flooding of water, organic manures, dry farming techniques and even the use of rudimentary aquaponic systems. In modern times the term "conventional farming" is defined as any type of agriculture that requires high external energy inputs to achieve higher yields and generally relies upon technological innovation and fossil fuels to supplement the required energy. Many have defined the term conventional farming as being synonymous with in-organic and chemical farming system is typically tied with using of more external inputs.

"The word 'organic' means origin from a living thing and farming with the philosophy of organic is to make production system alive with long life. It is not just to replace fertilizers and pesticides with organic manures and bio control agents, but it is an ongoing dynamic process for making healthy soil, and ultimately a vital living system. Organic farming is similar to the other sustainable farming systems, natural farming, perma culture, eco-farming *etc.* which are based on harmony with nature and ecofriendly" (Sharma, 2001). Organic farming practices reduce the inputs of synthetic pesticides and fertilizers into agro-ecosystems and are ecofriendly than conventional practices; they represent an alternative approach which can help to balance the detrimental effects of intensive agricultural systems (Feber *et al*., 1997; Crowder *et al*., 2010).

Soil biota provides essential favourable environment in the soil for the functioning of agro ecosystems which are important for the long term sustainability of agriculture production. Soil arthropods are essential components of agro-ecosystems making vital contributions to soil functions and soil processes. Without soil organisms, the soil would be a sterile medium that could not sustain crop production. Organic farms support higher levels of biodiversity, they may be better protected against the effects of invasion by alien species through biotic resistance. It has higher biodiversity (in the form of more species of plants, predators, parasitoids and pathogens) may be better protected against novel pests in comparison with their conventional counterparts.

Pest-arthropods and pathogens are the major constraints to agricultural production throughout the world. Synthetic chemical pesticides were introduced in the 1940's and used widely on agricultural crops with the hope that they would manage agricultural pests. Heavy reliance on synthetic pesticides over the last four decades has been a significant factor in the decline of some invertebrate natural enemy populations in agricultural systems (Croft and Brown, 1975). Integrated pest and nutrient management systems and certified organic agriculture can reduces the reliance on agrochemical inputs and makes agriculture environmentally and economically sustainable. It is now clear that, use of synthetic pesticides have some unfortunate consequences, which causes undesirable environmental impacts.

Pests and natural enemies are part of nature. In the ideal system there is a natural balance between predators and pests. If the system is imbalanced then one population can become dominant because it is not being preyed upon by another. The aim of natural control is to restore a natural balance between pest and predator and to keep pests down to an acceptable level. It provides natural habitats to encourage natural enemies for management of crop pests. If pests are still a problem then natural products can be used to manage pests, including sprays made from botanicals, pesticides, bio-pesticides *etc.* The harmful environmental implications of the synthetic chemicals have compelled to search for some alternative methods. This leads to increased development of compounds based on the models of naturally occurring toxins of biological origin, having various biological activities. Bio-pesticides includes broad array of microbial pesticides, biochemicals derived from micro-organisms and other natural sources and processes involving the genetic modification of plants to express genes encoding insecticidal toxins. Use of botanical pesticides for protecting crops from insect pests has assumed greater importance in recent years all over the world.

Earthworms and soil arthropods are major groups involved in soil decomposition processes. Although the interaction between these organisms can influence decomposition rates, little is known about their population dynamics during the decomposition of organic matter. One of the key indicator of soil quality is earthworm activity, which is important for improving and maintaining soil fertility, soil structure and aggregate stability (Edwards and Lofty, 1977). Vermicompost will provide highly nutritive organic fertilizer and more powerful growth promoter over the conventional composts and a protective farm inputs against the destructive chemical fertilizers which has destroyed the soil properties and decreased its natural fertility over the years. Vermicompost is rich in NPK (nitrogen 2-3 per cent, phosphorus 1.55-2.25 per cent and potassium 1.85-2.25 per cent), micronutrients, beneficial soil microbes, plant growth hormones and enzymes. It is scientifically proving as miracle growth promoter and also plant protector. Earthworm biomass and abundance was 1.3-3.2 times higher in organic compared to conventional plots and also average active density of carabids, staphylinids and spiders in the organic plots was almost twice that of the conventional plots (Maeder *et al.*, 2002). In general organic farming system has significantly higher population of soil arthropods compared to integrated and conventional farming systems. The major soil arthropods found were collembolans, diplurans, oribatid mites, predatory mites and pseudoscorpions. Arthropods population in organic system was almost three times more than conventional farming system (Anon, 2011)

Pollination is one of the most important mechanism in maintenance and promotion of biodiversity in general and life on the earth. Many ecosystems depend on pollinator diversity to maintain overall biological diversity. Pollination benefits society by increasing food security and improving the livelihoods. Pollinators are extremely diverse, with more than 20, 000 pollinating bee species and other insect pollinators. Therefore pollinators are essential for diversity in diet and for the maintenance of natural resources.

Approximately 90 per cent of flowering plants are pollinated. In agriculture, nearly a one third of pollination is accomplished by honeybees. Lethal and sub lethal effects of pesticides are one of the many anthropogenic insults threatening to pollinators. Pesticides used in fields, along rights-of-way and in forests tend to reduce the number of flowering plants. This reduces the amount of food available to native pollinators, making their survival more difficult. This affects the food chain, by reducing pollination which leads to reduced fruits on which birds and other creatures depend.

The green revolution model of agriculture introduced in 1960's focused on high yielding varieties (HYVs) and high external inputs, which eventually resulted in monocropping and the chemicalisation of production systems. The high yielding varieties introduced during this period disastrously eroded agricultural biodiversity (Reddy, 2009). Indiscriminate use of chemical fertilizers and pesticides resulted in several harmful effects on soil, water and air causing their pollution. This reduced the productivity of the soil by deteriorating its health in terms of soil physical, chemical and biological properties. This effect led to the entry of harmful compounds into food chain, health hazards on human beings, livestock etc. death of natural enemies, development of resurgence/resistance and outbreak of minor pests. The outbreak of brown plant hopper (BPH), *Nilaparvata lugens* in rice is an example of ecological degradation and effects on natural processes due to over use of chemicals (Wang *et al.,* 1994). It is believed that organic farming can solve many of these problems by maintaining the soil productivity and pest control by enhancing natural processes and cycles in harmony with environment.

The modern agricultural farming practices and irrational use of chemical inputs over the last four decades resulted in loss of natural habitat balance, decreased ground water level, soil salinisation, pollution due to fertilisers and pesticides, genetic erosion, ill effects on environment, reduced food quality and increased cost of cultivation, making the farmer poorer from year to year (Ram, 2003).

In response to rising concern about the sustainability of conventional agriculture, the concept of Integrated Pest Management (IPM) has been promoted by National Centre for Integrated Pest Management (NCIPM) New Delhi. It is an ecological approach to plant protection, which encourages the use of fewer pesticide applications. IPM has no standard definition, but comprises approaches that range from carefully targeted use of chemical pesticides to biological techniques that use natural parasites and predators to control pests (Sorby *et al.*, 2003).

Organic farming is widely regarded as a more sustainable farming system than conventional agriculture as it produces food also conserves soil, water, energy, protect environment and biodiversity (Pimentel *et al.*, 2005).

Thus, increase in the crop diversity provides greater number of opportunities for natural enemies to survive in agricultural ecosystems. Thus, pest outbreaks tend to be less common in polycultures than in monocultures (Root, 1973). 'Push-pull' strategy uses a combination of stimuli to manipulate the behavior of insect pests, natural enemies and to alter their distribution and abundance in Agro-ecosystems (Khan *et al.*, 2001). Organic fields had significantly higher numbers of natural enemies and soil arthropods compared with conventional fields (Berry *et al.*, 1996 and Salavuddin, 2014).

In view of this desirable approach the topic on "Studies on soil arthropods, insect pests and their natural enemies in organic, integrated and conventional farming systems in selected crops" has been taken up with the following objectives:

1. To study the effect of organic, integrated and conventional farming systems on below ground soil arthropod population in selected crops.
2. To study the effect of organic, integrated and conventional farming systems on above ground insects in selected crops.

2. REVIEW OF LITERATURE

In this chapter, literature pertaining to abundance and response of soil meso, macro-arthropods and earthworms in organic, integrated and conventional farming systems are reviewed and the pests with their natural enemy status are also presented in this chapter.

2.1 Effect of organic, integrated and conventional farming systems on below ground soil arthropods population

2.1.1 Population of meso fauna in organic, integrated and conventional farming systems

Application of organic manures on the abundance and incidence of soil meso fauna in agro ecosystems were studied by the several authors among them, application of organic manures or its combination with mineral fertilizer induces higher density of collembola compared to manured or unmanured soil. However, the treatments with different doses of organic manures increased the population of Collembola compared to treatments with fertilizer alone (Bandyopadhyaya, 2002). Application of organic manures and mineral nitrogen induced an increase in collembolan population but the difference between treatments remained insignificant. The abundance of collembola under spring barely (September) was several times higher than under potato (Kanal, 2004). However, studies conducted by Wu *et al.* (2002) found that densities of collembolans and Acarina were higher in the organic than those in the conventional agro ecosystem. Furthermore, they also reported that the subfamilies of Acarina- Mesostigmata and Prostigmata were found greater number in the organic than those in the conventional agro ecosystem because of their habit of omnivores and predators. Whereas, Astigmata and Cryptostigmata were predominant in conventional ecosystem because they are usually fungivores, mycophages or detritivores.

A recent concept of the organic and sustainable agriculture, conservation practices (enriched with organic manures) helped to establish significantly higher soil arthropods abundance compared to recommended or conventional (no manures) method (Srinivasa *et al.,* 1999). With respect to the abundance of the individual groups of the soil meso fauna, collembolans were the most abundant group in cultivation regimes, where as acari in case of uncultivated land. Among the Acari Crypstostigmata were found predominant over Mesostigmata (Shankargouda, 2002).

The large reduction of collembola and pauropod densities in high-input management systems is found because of the mechanical and chemical effects produced by conventional practices. Further, the total abundance of collembolans and species richness was higher in organic field (22 species) than the conventionally farmed fields (20 species) (Schrader *et al.*, 2006). Meanwhile, some of the reports of species diversity in meso-habitats showed higher diversity of organisms in low input among open edge, sub shadow places (under trees), while inside the field was dominant in high input field. The main aspect regarding the declining of macro-invertebrates was less pronounced in organically managed fields (low input) as compared to high input farming (Naureen *et al.*, 2010).

The study in the organically maintained cranberries showed the higher taxa richness, abundance and diversity of the edaphic meso fauna community *(Vaccinium* sp.) in comparison to conventional farms (Santiago *et al*., 2009).

In conventional agricultural management practices there is a reduction of collembolan and pauropod densities in high-input management systems (Jose *et al*., 2006a). Furthermore, the reduction of mites, Oribatida and Mesostigmata observed in high-input management is mainly linked to the mechanical and chemical perturbations produced by conventional (intensive) agricultural management practices and by particular abiotic soil conditions present in the intensively managed sites that are unfavourable for these organisms (Jose *et al*., 2006b).

Relatively higher abundance of collembola, cryptostigmatids, other acari and other invertebrates recorded in higher organic manure applied fields compared to lower doses of organic manure application. In contrary, least abundance of acari and invertebrates was found in recommended fertilizer treatments. This variation in the relative abundance of soil meso fauna may be due to the availability of their food or host and moisture content of food and soil (Abilasha *et al*., 2013b and Narasa Reddy *et al*., 2013).

The effect of pesticides on the soil fauna are observed and got some contrasting results like the significant effect on non target arthropods like Collembolans, Arachinida/ Opiliones, Hymenoptera, Thysonoptera. These were suppressed after pesticides spraying. In contrary, the application of bio-pesticides had no significant effect on non target species; these results indicate that insecticide treatment kept non-target arthropods at low abundance. This implies that, organic farming does not have significant effect on the beneficial non-target arthropods population and biodiversity, whereas preventive insecticide application in conventional fields had significant negative effects on beneficial arthropods (Padmavathy and poyyamoli, 2013).

Collembolans, mites and psuedoscorpions were relatively higher in organic farming as compared to integrated and inorganic farming systems. While, there was no significant difference between all three systems with respect to diplurans (Patil *et al*., 2013a). There was no significant difference between mite population in both organic and integrated farming. However there was significant difference observed between integrated and conventional farming and between organic and conventional farming. Overall, organic farming system was consisting of significantly higher population of soil fauna compared to integrated and conventional cropping systems (Patil *et al*., 2013b).

Organic farming leads to faunal diversity and it also enhances the level of soil organic carbon that may contribute to long term functional approach in an agro-ecosystem (Parwez and Abbas, 2012). Significantly higher population of collembolan, cryptostigmatids, beetles, ants, other mites and total micro arthropods population was recorded in organic than compared to integrated and conventional farming systems (Salavuddin, 2014).

The total abundance of soil fauna in organic and conventionally farmed fields were not differ significantly from each other in community composition, but both differed from integrated fields where the integration of the suitable chemical and traditional methodologies were applied judiciously. *E. multifasciata, Isotomurus* spp., *I. notabilis*, total Arthropleona and total collembola were most abundant under integrated management (Tania *et al*., 2001).

Srinivasa (2002) studied the combination effect of the different organic and inorganic manures, fertilizers and pesticides on the soil fauna in that, significantly more abundance of collembolan was recorded from FYM + Fertilizer + Phorate, FYM + Fertilizer + Chlorpyriphos and FYM + Fertilizer + Phorate + Alachlor treated plots. While, more number of meso-arthropods were recorded in treatment involving crop residue equivalent to 50 per cent recommended dose of fertilizers (RDF) + vermicompost equivalent to 50 per cent RDF. However less number of soil arthropod population were recorded in recommended dose of fertilizer only (Babalad *et al.*, 2013).

Positive significant relationship was found between soil moisture content and the collembolan. The reduction in the abundance and diversity of soil arthropods in the conventionally managed farmlands was due to consistent agricultural activities impact on the soil environment where the soil moisture depleted due to the tillage activities (Agwunobi and Ugwumba, 2013).

A comparative study of soil arthropods and natural enemy showed that, total numbers of micro-arthropods (mites and collembola) and macro arthropod (ground beetles and spiders) populations, were lowest in the conventionally-treatments and highest in no-tillage treatments. The studies on western corn root worm showed that, the beetle density was greater in no-tillage compared with reduced- and conventional tillage treatments. On the contrary Ladybird beetle populations not affected by tillage or insecticide treatments (Stinner *et al.*, 1988).

2.1.1.1 Effect of pesticides on soil fauna

Fertilizers and pesticides are integral part of conventional agriculture in increasing productivity of many agricultural crops all over the world to fight against hunger and the studies related to their impact are well documented. Pesticides like Aldrin and DDT (Edwards and Dennis, 1960), metal pollutants (Sun *et al.*, 2007) have adverse impact on soil fauna, resulted in decreased density, diversity and evenness of soil biota. The micronutrient Zn badly affects the soil fauna (Spurgeon *et al.*, 2008). Air borne pollutants also have a negative effect on soil fauna (Rusek, 2000) and there are some results which showed that the prolonged fertilizer application have negative impact on soil fauna (Lindberg, 2003), lime addition may also reduce the fauna like earthworm and enchytraeid population (Cole *et al.*, 2006). In some cases, Insecticide treatment significantly increased oribatid mite density, but consistently lowered mesostigmatid mite populations.

In Kentucky blue grass turf, chlorpyriphos and isofenphos had the greatest impact on predacious arthropods with some taxa significantly reduced for at least six weeks. Effects of bendiocarb and trichlorfon were generally less severe and more temporary. Oribatid mite populations were apparently unaffected by the insecticides. Bendiocarb increased trap catches of ants for up to two weeks after application (Cockfield and Potter, 1983). An initial, single application of aldicarb affected all soil meso fauna groups quantitatively and qualitatively. After one year, some populations did not recover from the intoxification. For both mites and collembola a negative effect of aldicarb was noticeable (Koehler, 1991).

Application of chlorpyriphos adversely affected the beneficial arthropods was assessed by many (Braman and Pandley, 1993; Rajagopal *et al.*, 1990) on non sminthurid collembolans, ants, spiders and parasitic hymenoptera. Similar result was also obtained by Krogh in 1991 he reported that the single isofenphos application @ 5 kg a.i./ha affected soil meso-arthropod fauna consisting of Acari and Collembola. The least sensitive were euedaphic and epedaphic collembola and Acari. Wernicke and Funke (1995) reported that biopesticides neither Dipel nor BIO 1020 caused severe negative effects on non-target soil arthropods and no significant reduction was observed in mites and collembolan population after the application of *Bacillus thuringiensis* sub sp. *kurstaki* (Dipel) and *Metarhizium anisopliae* (BIO 1020).

The studies are conducted regarding the effect of inorganic fertilizers on the soil fauna and there was a positive effect for enchytraeids, collembolans and mites over 10 years after application of NPK (Franz, 1953). Continuous fertilization over 50 years did not adversely affect the fauna and fertilizers may benefit the fauna in the short term (Edwards and Lofty, 1969).

Sometimes, the other management strategies which are followed in the agro-ecosystem are also having the effect on the soil fauna. Weed management strategies *viz.*, saw dust mulching, repeated spring/ summer cultivation, hand hoeing and 2 herbicides treatments terbumetan plus terbuthylazine (Caragard) @ 5.0 kg a.i/ha and bromocil (Hyvar) @ 1.6 kg a.i./ha in maize and asparagus exerted significant indirect effects on the soil arthropod fauna, probably by modifying the quality of their habitat (Wardle *et al.*, 1993). The pre-emergence application of hexazinone to a sandy loam *alfisols*, results in lower densities of soil micro arthropod densities (Badejo and Adejuyigbe, 1994). Similarly, the application of herbicide triasulfuron, significantly decreased the number of micro-arthropods, acarina and collembolans (Rebecchi *et al.*, 2000).

The granular insecticides applied in the soil for the management of the soil pests are also having negative impacts on the non target soil fauna. The laboratory treated soil with eight newer granular insecticides including controlled release formulations applied to the soil at the time of sowing for the control of groundnut leaf miner showed significant negative effect on non-target soil fauna mainly mites and collembolans. Among the treatments chlorpyriphos 10G (4.0 kg a.i./ha) was more toxic, endosulfan have negative impact on the collembolan population, especially the adult stage (Filser, 1995). In a similar type of study, cypermethrin and pirimicarb were found to be less effective compared with chlorpyriphos, where it is highly toxic to all the species under study (Wiles and Frampton, 1996).

Reduction of the soil fauna like collembolans and mites are also caused by the application of phorate 10G (Rajput *et al.*, 1996) and carbofuran (Alice *et al.*, 1999). While, the collembolan and mite population was not reduced by HCH treatment in banana ecosystem (Alice *et al.*, 1999). In maize field lindane significantly reduced the numbers of spiders, ants and collembolan (Wiktelins *et al.*, 1999). While, in other study chlorpyrifos did not decrease the overall abundance of collembola. However, it had a significant impact on the members of the order Symphypleona, there being significantly lower captures of *Sminthurides spp*. There was no effect on oribatid mites (Michereff *et al.*, 2004). Similarly Fungicide benomyl and the insecticide chlorpyrifos application reduced the number of enchytraeids by 60 per cent and nematodes by 48 per cent. While mites were not affected (Roembke-Joerg, 2009).

Mixture of nicosulfuron + atrazine with chlorpyrifos and the isolated chlorpyrifos reduced the population dynamics of all insect groups on the soil surface compared to the weeded control (Pereira *et al.*, 2005). Mesofauna populations, including Acarina [Acari], Collembolan, Coleopteran and Hymenoptera, were not affected by the use of glyphosate at any concentration, alone or in a mixture with 2, 4-D, although a decrease in the populations was observed due to a period of drought following the treatments (Ferri and Eltz, 2005) and with atrazine and 2, 4-D compared to glyphosate and nicosulfuron caused the most reduction of the collembolans depending on the time of application (Lins *et al.*, 2007)

2.1.2 Population of macro fauna in organic, integrated and conventional farming systems

The population of the soil macro fauna is studied in the different farming systems by several authors and are all compiled briefed here under.

The total biomass of captured fauna includes the carabid beetles that too mainly in biologically managed fields; significantly higher compared to conventionally managed fields throughout the summer (Hokkanen and Holopainen, 1986). The carabid density in biologically managed fields was more abundant soil fauna and other sources of prey because the biologically maintained fields will harbor the food source for the herbivores and detritivores (Pfiffner and Henryk Luka, 2002). Abundance of coleopteran was greatest in organically managed farms compared to conventional (Shah *et al.,* 2003). However, the total predator densities and densities of carabid beetles, staphylinid beetles and linyphiid spiders were highest in Organic (Amanda *et al.*, 2005). Similarly, staphylinids, carabids, spiders and chilopods were also abundant in organic farm. Ground beetles found to be less affected by organic systems (Doring and Kromp*,* 2003). Greater abundance of arthropods was present in the organically maintained systems than in the conventionally managed fields (Cotes *et al.*, 2010).

Both activity-density and species richness of detritivores were higher in the organic fields, activity -density of predators was higher in the conventional fields. Activity-density and species richness of detritivores were positively correlated to crop yield in the conventional but not in the organic fields (Yann *et al.*, 2006). Decomposer diversity was higher in organic fields but reached similar levels in high yielding conventional fields. The main decomposers and detritivores in the soil arthropod community were Scarabaeidae, Tenebrionidae, mites (Acari), springtails (Collembolla), woodlice (Isopoda) and Thysanura (Wurst, 2013).

Decline of soil macro-invertebrates in wheat fields due to high inputs compared with low inputs of chemical fertilizers. Diversity's Index also indicated that the higher diversity is present in the low input system compared to the high input system (Naureen *et al.,* 2010). Biodiversity is particularly affected by intensive farming methods, leading to agroecosystem impoverishment (Biaggini *et al.*, 2007). On the contrary, regulated management systems of low intensity, such as organic farming, appear to favor biodiversity better, e.g. by harboring greater abundance and diversity of arthropods (Attwood *et al.*, 2008).

Organic fields generally having the diversity of the weed fauna which in turn increase the soil fauna richness and diversity. The total biomass was in relation with the weed fauna. So, the organic farming will also contribute for the preservation of soil biodiversity (Carlos *et al.*, 2011)

Higher soil macro faunal abundance was recorded in higher organic manure applied fields (20t FYM/ha) in comparison with the lower doses 10t/ha. While, ants activity was more in recommended crop management practices. The same trend was also observed with the beetle fauna.

Similar case is also with the other soil macro fauna (Abilasha *et al*., 2013a and Shilpa *et al*., 2013). Coleopterans, formicidae, araneae and collembolans were the most abundant taxa. Organic management explained the biggest fraction of arthropod variability (Gkisakis *et al*., 2014).

Significantly higher population of macro-arthropods was observed in organic compared to integrated and conventional farming systems. Because of no usage of chemical fertilizers and pesticides in organic farming system compared to other two farming systems (Salavuddin, 2014 and Guru, 2015). Soil macro faunal population showed significantly higher number in lesser fertilizer applied plots compared with the higher fertilizer dose applied plots (Umadevi *et al*., 2013).

Assessment of both the soil meso and macro faunal population, significantly higher in no tillage system compared with conventional treatment (Stinner *et al*., 1988) and earthworm densities bring an expanded and beneficial involvement for this fauna in crop residue decomposition processes (House and Parmele, 1985). Initial, application of chlorpyriphos adversely affected the beneficial arthropods was assessed by non-sminthurid collembolans, ants (Formicidae), spiders (Araneae) and parasitic Hymenoptera were adversely affected in the short term by insecticide applications (Braman and Pendley, 1993).

Compared with RIA, the CFP regime caused a substantial decline in the abundance and diversity of collembolans in the field. The current farm practice (CFP) represented conventional fungicide, herbicide and applications of organo phosphorus (OP) insecticides, whereas in reduced input approach (RIA) utilized minimum inputs of fungicides and herbicides and excluded any use of insecticides (Frampton, 2002).

2.1.3 Population of Earthworms in organic, integrated and conventional farming systems

Nurhidayati *et al.* (2012) reported that the earthworm population density influences strongly on quality of organic matter (C-organic, N, C/N ratio, lignin, polyphenols, and cellulose content) and prefer low quality organic matter. So input of low quality organic matter with around 10 ton ha-1 is important for maintaining earthworm population and soil health in sugarcane fields.

The fungicides and insecticides are directly toxic to earthworms. The direct toxic effect and accumulation of copper-oxy-chloride in earthworms in vineyards, lead to reduced growth, survival, induced behavior like low burrowing rate and avoidance of copper contaminated soils (Eijsackers *et al*., 2005; Pelosi *et al*., 2014).

According to the studies of many workers (Joschko *et al*., 1989; Nuutinen *et al*., 2001 and Shipitalo *et al*., 2004) the population of *Lumbricus* spp. was influenced by water conductivity and infiltration, the population found to be higher in the organic fields than conventional and the infiltration rate is 3-10 times lower on the conventional fields than on the organic fields (Shipitalo *et al*., 2004). The enhancement of earthworms after conversion from conventional to organic (lasted 2–4 years) the number increased from 0.2 to a maximum of 4.5 ind/m^2 (Ulrich, 2010).

The earthworm biomass and abundance was higher in organic fields compared to conventional fields as reported by many workers (Maeder *et al*., 2002; Hole *et al*., 2005; Curry *et al*., 2002). The enhanced diversity of earthworm is observed when applied with the organic manure compared to the inorganic manures (Ayuke *et al*., 2011). Suthar (2009) reported that the earthworms was maximum at integrated farming (100%) followed by organically managed (70%) and least in conventional (18.9%) agro-ecosystems.

Upon application of herbicide, paraquat to the crop at recommended commercial dose, the significant decrease in the cast formation of earthworms are noticed than compared to glyphosate and untreated control and henceforth conclusion was made to apply herbicides on the soil surface prior to planting, so that the epigeic and anecic species that feed on surface litter may be impacted (Mohasin *et al.*, 2005).

Lal (2004) inferred that by addition of organic matter to the soil, the earthworm density, soil structure and SOM cycling through beneficial earthworm-microbial interactions can be enhanced. The greater soil biological activity positively stimulates the crop growth leading to greater organic matter input from crop residues.

Helling (1998) reported that the higher organic matter will influence the abundant population of the *Aporrectodea caliginosa* (Savigny) in the positive increment (Lowe and Butt, 2002) and similarly for *Lumbricus terrestris* (Linnaeus), but not for *Aporrectodea caliginosa* (Poier and Ritcher, 1992). Sometimes, it is also related with the pH, Ca-content, and organic matter (Irmler, 1999).

Paoletti *et al.,*(1998) reported that the soil biological properties in the conventional management system over 5 years has a negative effect on non-target soil microbial activity compared with an organic management system in orchards. The organic management increased earthworm abundance by about 60 per cent although soil tillage operations for weed control in orchards could reduce earthworm abundance.

Endogeic earthworms are favoured or less impacted by the ploughing as their preference is high for organic matter obtained mainly through burnt crop residues and partial decomposition by soil micro organisms (Wyss and Glasstetter, 1992)

Edwards and Bohlen (1996) reported that the pesticides used in conventional arable and fodder production has negative effects on, for example, reproduction or growth that affect earthworm populations in the long term. Most fungicides have low direct effects, with the exceptions of the carbamate-based fungicides, which all are very toxic to earthworms, and also insecticides such as the organophosphates and most of the carbamate-based compounds.

2.2 Effect of organic, integrated and conventional farming systems on above ground insects

2.2.1 Evaluation of pest status in organic, integrated and conventional farming systems

The different management systems like organic, integrated and conventional have effects on the arthropod fauna (pests) either directly or indirectly. The studies were reviewed hereunder.

In maize crop, the organically managed system will reduce the incidence of *Spodoptera frugiperda* (Smith) (Rossi *et al.*, 1988) also in Italian millet (Fonese *et al.*, 1988). The direct seeding through the crop residue and appropriate crop rotation were avoiding pest and disease survival and also reported that by managing the top soil to create a permanent organic soil cover which can allow growth of organism within the soil. The practice of crop rotation can be used best as insect pests, disease and weed control (Paraschivu *et al.*, 2009).

Phelan *et al.* (1995) reported that Soil-management practices can significantly affect the susceptibility of crops to pests, variation in egg laying of Europian corn borer (ECB) between conventionally managed soil and organic soil. In the organic soils, egg laying of ECB was low compared to conventionally managed soils (18 times more infestation in conventional field compared to organic field). Similarly aphid population growth was slower in organic than conventional farms (Ostman *et al.*, 2001).

There are several reports where the use of organic pest management practices was mainly used to discriminate between the organic and conventional systems. The efficacy of neem oil cake was studied against the okra fruit borer, *Earias vitella* (Feb) and *Earias insulana* (Biosd) (Malik and Lal, 1989). The neem cake applied to the soil, avoid the defoliator *Spodoptera litura* (F) in groundnut (Rajasekaran and Jayaraj, 1990), reduced fruit borer incidence in chilli (Krishnamoorthy and Krishnakumar, 2001). In brinjal reduction of brinjal shoot and fruit borer, *Leucinodes orbonalis* (Guene) (Sudhakar *et al.*, 1998). The use of neem cake to manage fruit borer in brinjal not only found economically feasible in terms of productivity and profitability, but also it is ecofriendly (Sreenivasamurthy *et al.*, 2001). While, the combination of neem cake soil application and root dip treatment with neem oil emulsion was found to be effective against chilli fruit borers, *H. armigera* (Hubner) and *S. litura* (Mallikarjun Rao *et al.*, 1998. Neem cake applied in combination with the recommended dose of fertilizer recorded less incidence of chilli fruit borer, *H. armigera* (Giraddi *et al.*, 2003).

The management of fruit borers in bhendi with the application of organic manures like vermicompost and FYM resulted in effective reduction in the pest population (Surekha and Arjuna Rao, 2000); similarly in chilli (Varma, 1994) and groundnut (Rajasekhara Rao 2003). While, the sucking pests were also reduced by the application of the vermicompost compared to the application of the inorganic fertilizers in cotton (Balakrishnan *et al.*, 2007). Certain organic amendments like biofertilizers in combination with vermicompost are found to reduce the sucking pests in sunflower (Ravi *et al.*, 2006).

The application of organic manures in combination with the inorganic fertilizers also showed significant effect on the pest population. In brinjal the incidence of shoot and fruit borer, *L. orbonalis* was found to be least in neem cake applied plot and is on par with vermicompost, double dose of K_2O and half dose of FYM + half dose of N and P (Godse and Patel, 2003). Foliar spray of neem oil reduces the pest (Singh, 2003). Application of neem and pongamia cake @ 250 kg per ha while planting reduced the brinjal shoot borer (Krishnamoorthy *et al.*, 2001). The integration of organic with inorganic treatments reduced the pest population in brinjal (Chakraborti, 1999).

The application of either organic (composted cow manure) or synthetic (NPK) fertilizers could increase pest populations on tomato (Erdal and Clive, 2003). The lower input organic farming systems with no-tillage and winter legume mulch resulted in less abundance of *Sogatella furcifera* and the much abundance of important predator, sedentary lycosid, in the traditionally managed paddy (Kazumasa, 1997). The regulation of fertilizers reduces the chilli fruit borer. Furthermore, lesser dose of 'N' recorded lower incidence of fruit borer (Venkateshwar Rao *et al.*, 1989). While, the population of sucking pests and pod borer in french been was least in organic amendment treatments (Sridharan *et al.*, 1990).

Cotton plants receiving NPK fertilizers had more infestation of bollworms than those receiving FYM and no fertilizers. The pest population increased with increased fertilizer dosage (Purohit and Deshpande, 1994). The population build up of pod borers in Pigeonpea was minimum in FYM applied plot, followed by FYM + straight fertilizer (50:50) (Dayakar *et al.*, 1995). The increasing organic matter in soil was found to improve the induced pest resistance of crops due to increased beneficiary soil faunal activity, improved nutrient balance and reduced nitrogen content (Altieri and Nicholls, 2004). In groundnut and soybean ecosystem, organic treatment recorded significantly less number of sucking pests and defoliator pests compared to integrated and inorganic treatments (Bharati, 2005).

Ramesh *et al.* (2005) concluded that organic crops are more resistant to insect attack and organic rice is reported to have thicker cell wall and lower levels of free amino acid than conventional rice. Similar observations were also made by Chau and Heong (2005), who reported that organic fertilizers affected the rice plant growth and minimized the outbreak of insect pests and diseases such as brown plant hopper, stem borer, leaf folder, blast and sheath blight in rice ecosystem.

Among fourteen different treatment combinations comprising two organic manures (Farmyard manure and vermicompost), inorganic fertilizers, Azotobacter and PSB containing biofertilizer (Azophos) in different levels. The infestation was recorded at 30 and 45 days after planting after enumerating number of flies per plant basis. The results showed that different sources of nutrient have significant effect on reducing the whitefly population and the treatments containing higher amount of FYM or vermicompost showed better result over sole inorganic fertilizers. However higher amount of vermicompost emerged superior in minimizing the whitefly population in tomato compared to farmyard manure (Ranjit *et al.*, 2013). The application of FYM (10 t ha-1) + 50 per cent RDF found best in reducing the pest population and increasing the yield of cowpea pods. Organic manures also influenced various growth attributing characters like pod length, plant height, 50 per cent flowering (days) and number of pods per plant than compared to use of chemical fertilizers (Patel *et al.,* 2010).

Among the different organic amendments PM+NC followed by FYM+PM and NC were the best treatment combinations with respect to suppressing the sucking pests in Bt cotton among the treatments highest population of natural enemies were noticed in VC, followed by FYM+VC and NC+VC which were the best treatment combinations among the treatments (Naik *et al.*, 2009). Similar observations were also made by Adilakshmi *et al.* (2008), who reported that the population of aphid, leafhopper, whitefly and Fruit borer (*Earias vittella*) in bhendi. Results revealed that significantly lower population was found in 75 per cent Recommended dose of fertilizer (RDF) from neem cake (NC) + 25 per cent RDF from Chemical fertilizer (CF) and 50 per cent RDF from NC + 50 per cent RDF from CF followed by chemical fertilizer alone.

2.2.2 Evaluation of natural enemy status in organic, integrated and conventional farming system

The different management systems like organic, integrated and conventional have effects on the natural enemies either directly or indirectly. The studies were reviewed here under.

Conventional and organic systems could be distinguished based on soil, plant, pest and disease. The diversity indicators suggested that the ecological processes which determine yields and pest levels in both conventional and organic management systems are distinct. In particular, the abundance and diversity of nitrogen mineralization potential, microbial population and natural enemies were higher in organic farms (Drinkwater *et al.*, 1995).

The conventional and organic farms shared a similar range of arthropod damage levels to tomato, whereas herbivore abundance did not differ, higher natural enemy abundance and greater species richness of all functional groups of arthropods (herbivores, predators, parasitoids and others) distinguished organic from conventional tomato (Letourneau and Goldstein, 2001). Organic fields had significantly higher numbers of parasitic hymenoptera (69%), rove beetle (32%) and green lacewings (79%) compared with conventional fields. The mean sequential comparison index (SCI) value was 0.816 for organic fields and 0.648 for conventional ones (Berry *et al*., 1996). Abundance of various predators, including spiders, carabid beetles and parasitoids, can be greater under organic management system (Maeder *et al*., 2002; Hole *et al*., 2005).

Application of herbicides in conventional farming systems may have subsequent deleterious effects on insects and birds, which depend on these plant species. Similarly, the use of pesticides will not only decrease pest insects but also the predators and parasitoids (Chiverton and Sotherton, 1991).

Organic farming is reported to increase diversity in the agricultural landscape, for example, carabid beetles and birds (Dritschilo and Wanner, 1980; Kromp, 1989; Pfiffner and Niggli, 1996; Freemark and Kirk, 2001). Greater abundance and species diversity (16%) of carabid beetles were higher in the organic field compare to conventional (Kromp, 1990).

Organic practices expected to increase conservation biological control. Conservation biological control defined as the maintenance of natural enemies of insect pests through reduced use of broad-spectrum pesticides and enhancement of natural enemies through habitat manipulation (Barbosa, 1998). More number of non-pest butterflies was recorded on organic than on conventional farmland, and more non-pest butterflies were recorded over the uncropped boundary habitat than over the crop edge habitat in both systems (Feber *et al*., 1997).

In conventional agricultural management, synthetic insecticides are used to suppress *Apis gossypii* population, but these insecticides often kill natural enemies and can lead to more severe outbreaks of *A. gossypii* and other pests (Kerns and Gaylor, 1993; Slosser *et al*., 1998; Wilson *et al*., 1999).

Evaluation of some plant products *viz*., *Parthenium hysterophorus* L., *Vitex negundo* L., *Vinca rosea* L., *Calotropis gigantea* L., *Lantana camera* L., *Argemone mexicana* L. and *Tuja occidentalis* L. at two per cent concentration each on different stages of *Chrysoperla carnea* along with polytrin-c and profenophos. They recorded significantly high egg hatchability and less larval and adult mortality of *C. carnea* due to botanicals compared to insecticides (Patil *et al*., 1997). Neem extract and neem oil were harmless to the eggs and larvae of *C. carnea* Steph. and *Coccinella septumpunctata* Thumbrey (Kaethner, 1991). In addition to this oils from *Azadirachta indica* (Jass), *Melia azadirachta* Mthusensua, *M. volkinsii* Gurla, *Citrus aurantium* L. and Gerenium on *C. septumpunctata* in the laboratory. None of the oils affected the survival and behaviour of *C. septumpunctata* and consumption of the aphids (Matter *et al.,* 1993). The ether extracts of neem seed kernel was safer than synthetic insecticide to *C. septumpunctata* (Guddewar *et al*., 1994).

Neem based treatments like spraying of neem oil and NSKE were found safe to natural enemies and were on par with untreated check in chilli ecosystem (Chakraborti, 2000). Schmutter (1990) stated that neem based products were safe to natural enemies due to their weak contact effect on insects and wolf spider, *Lycosa pseudoannulata.*

Natural enemies like syrphids and spiders in all botanical treatments were almost equal to untreated control (2.70 syrphids and 1.87 spiders/5 plants) as compared to monocrotophos (1.66 syrphids and 0.41 spiders/5 plant). These results revealed the safety of botanicals to natural enemies compared to the synthetic insecticides (Rosaiah, 2001a). Among the predatory population in okra ecosystem spiders, chrysopids, *Apanteles* sp. and coccinellids were most dominant and there was no significant difference in the population of these predators in different plant products. This clearly indicates the increased activity of natural enemies in plots treated with botanical insecticides (Rosaiah, 2001b). Neem cake 2 q per ha was safer to coccinellid beetles and predatory mites in chilli ecosystem (Smitha, 2002).

Katti *et al.* (2001) reported that field trial in rice comprising treatments like natural biological control (NBC) with no insecticides application, need based protection (NBP) and schedule based protection (SBP) revealed that NBC resulted in maintaining highest level of parasitism of yellow stem borer (30-50%), gall midge (25%) and leaf folder (11.3-70%) as well as population of predatory spiders (4-16.6/ 25 hills) and mirid bugs (2.4 –1`5.6/ 25 hills) compared to NBP parasitism of yellow stem borer(10-20%), gall midge(16.7%), leaf folder (10-30%) as well as predatory spiders (0-9/ 25 hills) and mirid bugs (0-7.8/ 25 hills) and SBP recorded nil parasitoids of yellow stem borer and Parasitism of gall midge (11.8%), leaf folder (8-10%) and lower number of predatory spider (0-5/ 25 hills) and mirid bugs (0-3/ 25 hills). Though SBP resulted in lowest pest incidence, NBP was superior in terms of higher net returns, higher levels of natural enemy population and found on par with that of natural biological control and superior to that of schedule based protection.

The total population density of predators, carabid beetles, staphylinids and linyphiid spiders were highest in Organic field, whereas soft (selective chemical) and lowest in Hard (broad spectrum chemicals) fields, however densities of these arthropods did not differ between Organic and Soft fields (Amanda *et al*., 2005).

Bengtsson *et al.* (2005) reported the positive effects of organic farming on abundance of organisms and inferred that 50 per cent more organisms were found in organic farming systems than conventional systems. Birds, predatory insects, soil organisms and plants responded positively to organic farming, while non-predatory insects and pests did not.

In groundnut ecosystem, organic treatment recorded less number of pests (aphids, leafhoppers, thrips and defoliators) and higher number natural enemies (coccinellids and syrphids) population compared to integrated and inorganic treatments. Similarly higher number of mycosed larvae due to *N. rileyi* on *S. litura* was noticed in organic field (kavitha, 2009).

Abhilash and Patil (2008) studied the impact of organic amendments and biorationals on the natural enemy complex in soybean ecosystem. Vermicompost @ 2.5 t/ha, combination of vermicompost @ 2.5 t/ha and neem cake @ 250 and 500 kg/ha, combination of farmyard manure @ 5 t/ha and neem cake @ 250 and 500 kg/ha had no impact on the predators like coccinellids and chrysopids. Among the biorationals, vermiwash recorded significantly higher number of predators three days after spraying. However, the combinations of organic amendments and biorationals involving vermiwash were superior compared to other combinations with the highest number of predators.

Sarina *et al.* (2009) found that among 10 replicate pairs of organic and conventional farms with quantitative food webs, the organic farms had significantly more species at three trophic levels (plant, herbivore and natural enemies) and significantly different network structure than compared to conventional farms.

Rakhshani (2010) reported that during a two-year (2004-2005) survey of alfalfa aphids and their natural enemies in Isfahan, the mean per cent of predators and aphid parasitoids in strip-harvested field were higher than those in conventionally-harvested field.

Moloud and Mahammad (2012) reported that the pesticide Amitraz caused the reasonable side effects on pupal mortality, fecundity and longevity of the parasitoid wasp *Encarsia formosa* (Gahan) and inferred that it is unsafe for *E. formosa* and it cannot be used for integrated pest management in integration with *E. formosa* to control *Trialeurodes vaporariorum* (Westwood). Application of insecticides diazinon, fenitrothion and chlorpyrifos showed sublethal effect on the functional response of predatory bug, *Andrallus spinidens* Fabricius (Hem: Pentatomidae), caused a decrease in the attack rate and an increase in the handling time of exposed bugs compared with the control. The longest handling time (3.97 ±0.62) and the lowest attack rate (0.023± 0.007) were observed in chlorpyrifos and fenitrothion treatments, respectively (Moloud *et al.*, 2014).

The non-fertilized cabbage plants, seasonal parasitization per cent of *Brevicoryne brassicae* by *Diaeretiella rapae* increased along with the expected lower aphid pressure compared with fertilized plants and reached on average 28.5 per cent. The parasitoid *D. rapae* reduced the population of cabbage aphid by 15.5 per cent in manure fertilized and 12.9 per cent in synthetically fertilized plants. The regression studies showed a positive relationship between the increase of the number of *B. brassicae* and activity of *D. rapae*. No coccinellids were found in aphid colonies on synthetically fertilized plants. It concludes, inorganic fertilization increased the population of cabbage aphid more than its natural enemies and the abundance of natural enemies was too small to provide effective reduction of this pest (Duchovskiene *et al.,* 2012).

Shanker *et al.* (2012) reported that the higher abundance of arthropods found in plots treated with VC and NC with the spider *Tetragnatha* sp. being the dominant species and Simpson's index indicated that the maximum diversity was observed in PM (poultry manure) treated plots (0.022) while the least was in RFD plots (0.183) in rice.

Lu *et al* (2015) reported that the predation by natural enemies in organic fields can achieve the same efficacy in aphid control as pesticides used in conventional fields over the long term and noticed higher peak densities, abundance and longer persistence of predators of *Aphis gossypi* in organic cotton fields, includes coccinellidae (ladybirds), chrysopidae (lacewings), spiders (Linyphiidae and Thomisidae) and Syrphidae (hoverflies). The average annual densities of all predators except chrysopid adults were higher by 200 per cent in organic fields than in conventional fields in all 3 years, of study.

2.2.3 Evaluation of pollinators status in Organic, Integrated and Inorganically treated crops

Morandin and Winston (2005) measured pollination deficit (the difference between potential and actual pollination) and bee abundance in organic, conventional, and herbicide-resistant, genetically modified (GM) canola fields (*Brassica napus and B. rapa*) in northern Alberta, Canada. The resuls indicated no pollination deficit in organic fields, a moderate pollination deficit in conventional fields, and the greatest pollination deficit in GM fields. Bee abundance was greatest in organic fields, followed by conventional fields, and lowest in GM fields. Overall, there was a strong, positive relationship between bee abundance at sampling locations and reduced pollination deficits. Seed set in *B.napus* increased with greater bee abundance. The importance of wild bees to canola production and agroecosystems resulted in greater seed production.

The insect pollinated plants benefit from organic farming. To examine the plant community patterns consistency, the arable weed communities were compared with respect to the type of pollination (*i.e.* insect pollination versus non-insect pollination) in the edges and centres of 20 organic and 20 conventional wheat fields. The plant species number of both pollination types were much higher in organic than in conventional fields and higher in the field edge than in the field centre. The comparison between the proportions of both pollination types to all plant species revealed that the relative number of insect pollinated species was higher in organic than in conventional fields and higher at the field edge than in the field centre, whereas the relative number of non-insect pollinated species was higher in conventional fields and in the field centre. It also showed that insect pollinated plants benefit excessively from organic farming, which appeared to be related to higher pollinator densities in organic fields, whereas in the centres of conventional fields non-insect pollinated plants dominate most probably due to a limitation of pollinators (Doreen Gabriel and Teja Tscharntke, 2006).

The pesticides are potential cause of biodiversity and pollinator decline. The wild bees are insect pollinator group at particular risk from pesticide use by studying about the species richness of wild bees, bumble bees and butterflies by sampling at three spatial scales to assess responses to pesticide application: (i) the ‘field’ scale along pesticide drift gradients; (ii) the ‘landscape’ scale sampling in different crops within the area and (iii) the ‘regional’ scale comparing two river basins with contrasting agricultural intensity. At the field scale, the interaction between the application regime of the insecticide and the point in the season was important for species richness. Wild bee species richness appeared to be unaffected by one insecticide application, but declined after two and three applications. At the landscape scale, the species richness of wild bees declined in vine fields where the insecticide was applied, but did not decline in maize or uncultivated fields. At the regional scale, lower bumblebee and butterfly species richness was found in the more intensively farmed basin with higher pesticide loads (Brittain *et al.*, 2009).

An increase in mortality due to the impact of insecticides may reduce visitation frequency by bees to flowering plants and the number of flower-visiting bees has been shown to be positively associated with plant seed set (Steffan and Tscharntke., 1999). The negative impacts of insecticides on pollinators those visit flowering plant species that are specialist on specific pollinating taxa to set fruits, such as passion fruit that is dependent on carpenter bees or vanilla on specific Euglossinae bees (Klein *et al.*, 2007).

Biesmeijer *et al.* (2006) experimented a trait-based analysis on bees and hoverflies in Britain and the Netherlands found shifts in pollinator communities associated with changes in wild plant communities, with parallel declines in oligolectic pollinator species and plant species reliant on insect pollination.

The landscapes composed of higher proportions of organic crop fields support more bee species at a greater abundances in fallow strips. An increase in organic cropping in surrounding landscape from 5 to 20 per cent enhanced the bee species richness in fallow strips by 50 per cent, density of solitary bees by 60 per cent and bumble bee density by 150 per cent. Thus incorporation of organic crop fields in to conventionally managed agricultural landscapes can provide food resources needed to sustain greater pollinator species in non crop habitats (Andrea *et al.*, 2007).

Gallai *et al.* (2008) estimated the insect pollination economic value (IPEV) as a product of the proportional contribution of biotic pollination to production (Dependence ratio) and the total economic value (EV) of the 100 most important commodity crops used for human food. For all crops, the global IPEV was estimated at € 153 billion per annum, which is equivalent to 9.5 per cent of the value of world agricultural production. Globally, vulnerability was high for fruits (23%), vegetables (12%), nuts (31%), edible oil crops (16%) and stimulants (39%), lower for pulses (4%) and spices (3%) and 0 per cent for cereals, roots and tubers and sugar crops. Whereas staple crops, being primarily wind-pollinated, have low vulnerabilities, those crops providing much of the proteins, vitamins and minerals in human diets are more reliant on biotic pollination.

Georg *et al.* (2012) reported that the pollination success and the proportion of fully pollinated berries were higher on organic fields of strawberry compared to conventional farms. The conversion to organic farming may rapidly increase pollination success and hence benefit the ecosystem service of crop pollination regarding both yield in terms of quantity and quality of strawberry Organic farming was found to provide increased floral resources that attract more pollinating insects and higher pollination success on farms under organic management (Eileen and Jane, 2011).

Siqueira *et al.* (2008) reported that mango flowers in conventional and organic system were visited by 21 species of insects belonging to the orders: Diptera, Hymenoptera, Lepidoptera and Odonata among which, *A. mellifera* was the most frequent accounting for 68.30 per cent of total visits in organic farming and 45.60 per cent in conventional farming. Anjankumar (2014) reported that under organic cashew ecosystem, panicles were visited by twenty seven species of pollinators. Among honey bees, *Apis cerana, A. dorsata* and *A. florea* constituted 34.46, 28.09 and 21.33 per cent of total pollinators, respectively. Whereas the panicles sprayed with conventional insecticides were visited only by sixteen species of pollinators.

Fani *et al.* (2013) studied the negative sublethal effects of the pesticide imidacloprid on honeybees behavioural effects, physiological effects, development of the hypopharyngeal glands (HPGs) (14.5 per cent smaller in diameter in 9-day-old honeybees and 16.3 per cent smaller in 14-day-old honeybees than in the same-aged untreated honeybees), respiratory rhythm and also significantly affected the bursting pattern of abdominal ventilation movements (AVM) by causing 59.4 per cent increase in the inter-burst interval and 56.99 per cent decrease in the mean duration of AVM bursts.

3. MATERIAL AND METHODS

The hypothesis and the objectives considered for investigations on "Studies on soil arthropods, insect pests and their natural enemies in organic, integrated and conventional farming system in selected crops" was carried out both during 2014-15 *kharif* and *rabi* season field and laboratory experiments. The general views of experimental plots are shown in Plate 1 to 3. These studies and observations were made in the fixed site, large size plots laid out experiments under the Network Project on Organic Farming (NPOF) at Main Agricultural Research Station (MARS) and Institute of Organic Farming (IOF), University of Agricultural Sciences (UAS), Dharwad.

Dharwad is situated in Northern Transition Zone (Zone-8) of Karnataka located between $15^{o}17'$ North latitude and 76^{o} 46' East longitude at an altitude of 678 m above mean sea level. The annual overall rainfall is 750 mm confined to monsoon period between June and October with occasional showers during pre-monsoon months of April and May. The soil of the experimental site was medium deep black and clayey soil. In general, the crop growth was good and the incidence of insect pests was moderate to high depending on rainfall. The crop husbandry practices remained uniform for all field experiments during both the seasons and were raised as per the standard both conventional and organic package of practices recommended by the University of Agricultural Sciences, Dharwad for conventional and organically grown crops. The rest of the details pertaining to different experiments have been presented clearly with material details and methodology objective wise here under.

The soil arthropods, pests and their natural enemies were recorded from different crops *viz.,* cowpea (cultivar C-152), pigeonpea (TS-3R), greengram (DGGV-2), cotton (DSH-1062), groundnut (GPBD-4), maize (super 900M Gold), soybean (DSb 21), chickpea (JG-11) and *rabi* sorghum (M-35-1).

3.1 Estimation of soil arthropod population

Field experiments were carried out at Network Project on Organic Farming (NPOF) and Main Agricultural Research Station (MARS), UAS, Dharwad during *Kharif* and *rabi* season, 2015-16 to estimate the soil arthropod population in different farming systems *viz.*, organic, integrated and conventional farming systems on both meso (below ground) and macro (above ground) fauna populations. The details of the sampling, extractions, sorting and preservation techniques fallowed for soil arthropod populations are explained here under.

3.1.1 Estimation of meso-arthropod population

3.1.1.1 Sampling site

The soil samples were collected from different crops *viz.*, cowpea, pigeonpea, cotton intercropped with groundnut, greengram, maize, soybean, *rabi* sorghum and chickpea before sowing and up to harvest of the crops. Crops were raised under organic, integrated and conventional farming systems at fixed sites since 2004-05 at IOF, Dharwad. In these fixed plots, the soil samples were collected. Further, sampling was also done at MARS fields. Soil sampling was started from 1st week of May to till last week of December at 30 days intervals for *kharif* crops. For *rabi* crops sampling was started from 1st week of October to February last week.

Plate 1: Expermental plot view

Plate 2: General view of NPOE experimental plot

Plate 3: Rabi sorghum grown under different farming systems

3.1.1.2 Sampling method

Samples were collected with hole augar, it was placed on the soil surface and pressed gently downwards and turned in clockwise direction to a depth of 10 cm. The 100 g of soil was collected from each spot on dry weight basis. Such collected samples were immediately transferred to plastic bags (15 cm height and 6 cm diameter) and labels were placed into each bag and tied with rubber band. They were brought to the laboratory for further extraction.

3.1.1.3 Extraction technique

The laboratory studies were carried out at the Institute of Organic Farming (IOF), UAS, Dharwad during *Kharif* and *rabi*-2015-16. The meso fauna was extracted from the soil samples by using modified Berleese funnel apparatus. Field collected soil samples were placed in the Berleese funnel apparatus for 72 h. The apparatus consists of the light source situated at the top and the soil containing funnel with 240 mm mesh is fitted at the bottom which directly exposed to the light source. There are series of eight funnels were connected across the circuit with series connection and the 100W incandescent bulbs are used as the light source. At the narrow mouth end of the funnel the container with 70 per cent alcohol is kept which acts as a both preservative and killing agent. Since the soil arthropods are photophobic and hydrophilic in nature, the light generated from the lamp diverted them to drown in to the container.

3.1.1.4 Sorting procedure

Soil faunal composition in terms of number and diversity was recorded for each sampling time (30 days interval). The sorting of meso-arthropods into their major groups was done by using the stereo binocular microscope (under 40 x magnification). The specimens were counted in each sample and separated out into different taxonomical units.

3.1.1.5 Preservation

The collected meso-arthropods in container containing ethyl alcohol were separated after 72 h. The taxonomic groups encountered during the study period were preserved in vials containing 75 per cent alcohol and labeled (date of collection, treatment *etc.*,) for further taxonomic identification.

3.1.1.6 Identification

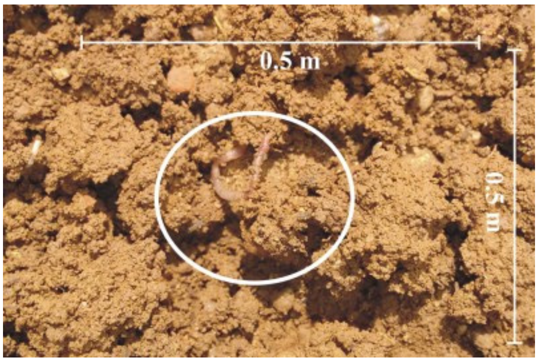
The specimens preserved in 75 per cent alcohol *viz.,* collembolans and diplurans were sent for identification to Dr. Raghuraman. Asst. Professor of Entomology, Banaras Hindu University, Varanasi (UP) and natural enemies were sent for identification to Dr. Ankita Gupta, Scientist, Division of Insect Systematics, NBAIR, Bengaluru.

3.1.2 Estimation of the macro- arthropod population

3.1.2.1 Pit fall traps

Field experiments were carried out under organic, integrated and conventional farming system at Network Project on Organic Farming (NPOF), UAS, Dharwad during *Kharif* and *rabi*- 2015-16 to estimate the macro-arthropod populations through pitfall traps. The pitfall traps was made by plastic cups of 10 cm in diameter and 15 cm in height are those which are used to catch the actively moving surface arthropods as they move and fall inside the installed traps. Pitfall traps were placed in different crops *viz.,* cotton intercropped with groundnut, greengram, pigeonpea, cowpea, soybean, maize, chickpea and *rabi* sorghum under organic, integrated and conventional farming systems.

Berlese funnel setup for extraction of meso arthropods



Earthworm smapling

Pitfall trap collection

Plate 4: Sampling methods used for extraction of earthworms, soil meso and macro arthropods

Each cup was filled with 50 ml of 75 per cent ethyl alcohol as killing agent and water with bit of glycerol was added to avoid quick evaporation. These cups are buried in the ground so as to make sure that their rim is at the soil surface and there is absolutely no difference for a fast mover. Later, the soil or debris was placed over so that the area around pitfall trap matches the surrounding soil surface. Abundance of each group of macro-arthropods population recorded at weekly intervals up to harvest of the crops. Further, these were separated as different taxonomic groups and then preserved for further studies.

3.1.2.2 Estimation of earthworm population

Field experiments are carried out to know the effect of different (organic, integrated and conventional) farming systems on abundance of earthworm population at Network Project on Organic Farming (NPOF), UAS, Dharwad during *kharif* and *rabi*-2015-16. The earthworms counts were made in all the systems, once before sowing and subsequently at 45 days interval up to harvest of the crops. In each plot four quadrants of 0.25 m^2 were dug, up to 30 cm depth and manually counted the earthworms (both juveniles and adults) in the field itself and recorded as numbers per treatment (Plate 4).

3. 1.3 Statistical analysis

The collected data were subjected to square root ($\sqrt{X+0.5}$) transformation and statistically analyzed by adopting analysis of variance technique (Sundararaj *et al.*, 1972).

The data recorded during the course of investigation were compiled and analysed for statistical significance as per the analysis of variance (Two way ANOVA). Fisher's method of analysis of variance (ANOVA) as per method described by Gomez and Gomez (1984) was adopted for the purpose. Standard error of mean and coefficient of variability have been worked out for set of observations under each character.

3.1.3.1 Shannon's index of general diversity (H)

To study the diversity and abundance of organisms in an ecosystem the widely used method is shannon's index since it is dependent of sample size. This will give both the evenness and abundance of soil arthropod fauna in different farming systems as well as crops.

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

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

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

3.2 Effect of organic and conventional farming systems on pests and their natural enemy population in selected crops

3.2.1 Assessment of pest population

i. Assessment of defoliator's complex in cowpea, greengram, groundnut and soybean

Observations on larval population of defoliators were made at three randomly selected spots of one meter row in each treatment leaving border rows. Larval counts were made by shaking the plant gently over a white cloth placed between the rows in cowpea, greengram soybean and groundnut. Average number of caterpillars found per meter row length (mrl) was worked out. At 30, 45 and 60 days after sowing (DAS).

ii. Assessment of sucking pests population in cotton

Observations were made from five randomly selected plants in each treatment. The population of sucking pests were recorded from three leaves per plant *i.e.*, nymphs and adults of leafhoppers, thrips, aphids and whiteflies from one leaf on top, middle and bottom of the plant and expressed as number per three leaves. Observations taken at the intervals of 30, 45, 60, 75, 90, 105 and 120 DAS.

iii. Assessment of shoot weevil in cotton and gall weevil incidence in pigeon pea

The incidence of gall weevil in pigeonpea and shoot weevils in cotton were recorded at 30 and 45 DAS on randomly selected 25 plants based on the galled plants. and recorded and analysed for the per cent incidence as mentioned below:

$$\text{Per cent incidence} = \frac{\text{Number of galls affected plants}}{\text{Total number of plants observed}} \times 100$$

iv. Assessment of pod borer incidence in pigeonpea, greengram, chickpea and cowpea

Observations on pod borer incidence was recorded from ten randomly selected plants in each treatment leaving border rows before harvesting. Number of pods per plant and number of pods damaged by the pod borer were recorded. The data was expressed as per cent pod damage and subjected to arc sin transformation.

$$\text{Per cent pod damage} = = \frac{\text{Number of pods damaged}}{\text{Total number of pods observed}} \times 100$$

v. Assessment of stem borer and aphid incidence in maize and sorghum

Observations were taken on stem borer incidence on 10 randomly selected plants at six spots in each treatment. The number of plants showing pinhole symptoms and dead hearts were recorded. Observations were made on number of larvae from the five infested plants. The per cent infestation was computed using following formula:

$$\text{Per cent infestation} = \frac{\text{Number of infested plants}}{\text{Total number of plants observed}} \times 100$$

Observations were taken on aphid incidence on five randomly selected plants per cm^2 leaf in each treatment. The collected data were subjected to arc sin transformation.

3.2.2 Assessment of natural enemies population

Observations on natural enemies *viz.*, coccinellids, *chrysopa,* syrphids and spiders were made at different crop stages (15 days intervals) from five randomly selected plants in each treatment and expressed as number per plant. For parasitoids *viz.,* braconids, syrphids and *Campoletis chlorideae*. Cadavars observations were made at three randomly selected spots of one meter row length in each treatment leaving border rows in crops like greengram, cowpea, soybean, groundnut and chickpea whereas in crops like maize, sorghum, cotton and pigeonpea five plants in each treatment.

3.2.3 Assessment of pollinator's population

Study was made to assess the pollinator's populations visiting the different crops *viz.*, cotton, soybean, pigeonpea, cowpea and greengram field during peak flowering time for five minutes in each spot of one m^2 area selected from three randomly selected spots at time between 8.30-9.30 AM. However in cotton, five minutes in each spot of five plants selected from three randomly selected spots.

3.2.4 Statistical analysis

The data obtained from the field experiments were suitably analyzed. The per cent values were transformed to corresponding angular transformation for the pests and for the natural enemies and pollinators data were subjected to square roots ($\sqrt{x}$ + 0.5) transformation before analysis.

The data recorded during the course of investigation were compiled and analysed for statistical significance as per t- test between two systems.

3.2.4.1 Shannon's index of general diversity (H)

To study the diversity and abundance of organisms in an ecosystem the widely used method is shannon index since it is dependent of sample size. This will give both the evenness and abundance, of above ground insects and spiders in different farming systems as well as crops.

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

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

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

4. EXPERIMENTAL RESULTS

Field experiments comprising of “Studies on soil arthropods, insect pests and their natural enemies in organic, integrated and conventional farming systems in selected crops” were carried out at Network Project on Organic Farming (NPOF), Main Agricultural Research Station (MARS), Dharwad and laboratory experiments were carried out at the Institute of Organic Farming, UAS, Dharwad. The results of the experiments are presented here under with following headings.

4.1 Effect of organic, integrated and conventional farming systems on below ground arthropods population

The soil arthropods are categorized in to two major groups *viz.*, meso and macro-arthropods and assessed their population by using Berleese funnel and pitfall traps respectively. The soil meso-arthropods like mites, ants, collembolans and other meso-arthropods (beetles, diplurans, symphyllans, pseudoscopion, and dipterans) were recorded. The macro-arthropods *viz.,* beetles, spiders, ants, orthoptera and others (millipedes, centipedes, etc) categories were recorded.

4.1.1 Population of meso-arthropods in different crops and cropping system.

4.1.1a Greengram

Mites and Collembolans are the predominant groups recorded among the soil meso-arthropods across the farming systems. Though the ants and beetles were found in lesser number but noticed in every observation made.

The highest population of meso-arthropods *viz.,* mites, collembolans, ants, beetles and other arthropods was recorded under organic farming (9.27, 3.00, 1.07, 0.73 and 0.93/100g of soil, respectively) followed by integrated farming and least in conventional farming system (3.27, 0.53, 0.27, 0.13 and 0.13/100g of soil, respectively) (Table 1).

Irrespective of dates of collection significant difference in total meso-arthropods population was observed between farming systems. Significantly highest population of total meso-arthropods was recorded in organic farming (15.00) followed by integrated (9.00) and least in conventional farming (4.33). Irrespective of farming systems significant difference in total meso-arthropods were observed between different dates of collection. Significantly highest meso-arthropods were recorded during June (15.22) and least during September (5.00) months.

4.1.1b Soybean

Soybean grown under organic farming recorded higher population of meso-arthropods *viz.,* mites, collembolans, ants, beetles and other arthropods (10.00, 3.20, 1.67, 1.20 and 1.00/100g of soil, respectively) followed by integrated farming and least in conventional farming system (3.47, 0.62, 0.20, 0.40 and 0.53/100g of soil, respectively) (Table 2).

Irrespective of dates of collection of meso-arthropods significant difference in total population was observed between farming systems. Significantly highest population of total meso-arthropods was recorded in organic farming (17.06) followed by integrated (9.07) and least in conventional farming (5.27). Irrespective of farming systems significant difference in total meso-arthropods were observed between different dates of collection. Significantly highest total meso-arthropods were recorded during June (19.67) and least during July (6.00).

Table 1: Population of soil meso-arthropods in greengram under organic, integrated and conventional farming systems during 2015 (100g of soil).

Months / FS	Mites				Collembola				Ants				Beetles				Others				Total			
	OF	**IF**	**CF**	**Mean**	**OF**	**IF**	**CF**	**Mean**	**OF**	**IF**	**CF**	**Mean**	**OF**	**IF**	**CF**	**Mean**	**OF**	**IF**	**CF**	**Mean**	**OF**	**IF**	**CF**	**Mean**
May	9.00 (3.08)	4.67 (2.27)	3.33 (1.96)	**5.67c (2.48)**	4.67 (2.27)	2.33 (1.68)	0.67 (1.08)	**2.56b (1.18)**	1.33 (1.35)	0.00 (0.71)	0.33 (0.91)	**0.55 b (1.03)**	1.67 (1.47)	0.33 (0.91)	0.00 (0.71)	**0.67 a (1.08)**	0.67 (1.08)	0.33 (0.91)	0.00 (0.71)	**0.33a (0.91)**	17.33 (4.22)	7.67 (2.86)	4.33 (2.20)	**9.78b (3.21)**
June	13.67 (3.76)	10.00 (3.24)	4.00 (2.12)	**9.22a (3.12)**	5.33 (2.41)	3.67 (2.04)	1.67 (1.47)	**3.56a (1.55)**	1.67 (1.47)	1.00 (1.22)	0.67 (1.08)	**1.11 a (1.27)**	0.67 (1.08)	0.33 (0.91)	0.33 (0.91)	**0.44ab (0.97)**	1.67 (1.47)	0.67 (1.08)	0.33 (0.91)	**0.89a (1.18)**	23.00 (4.85)	15.67 (4.02)	7.00 (2.74)	**15.22a (3.97)**
July	8.67 (3.03)	6.33 (2.61)	3.00 (1.87)	**6.00c (2.55)**	1.00 (1.22)	0.33 (0.91)	0.00 (0.71)	**0.44d (0.97)**	0.33 (0.91)	0.33 (0.91)	0.00 (0.71)	**0.22b (0.85)**	0.33 (0.91)	0.33 (0.91)	0.00 (0.71)	**0.22ab (0.85)**	1.33 (1.35)	0.33 (0.91)	0.33 (0.91)	**0.66a (1.08)**	11.67 (3.49)	7.67 (2.86)	3.33 (1.96)	**7.56b (2.88)**
August	9.00 (3.08)	6.00 (2.55)	4.67 (2.27)	**6.56b (2.66)**	2.33 (1.68)	2.00 (1.58)	0.33 (0.91)	**1.55c (1.13)**	1.00 (1.22)	0.67 (1.08)	0.33 (0.91)	**0.67 ab (1.08)**	0.67 (1.08)	0.67 (1.08)	0.33 (0.91)	**0.56ab (1.03)**	0.67 (1.08)	0.33 (0.91)	0.00 (0.71)	**0.33a (0.91)**	13.67 (3.76)	9.67 (3.19)	5.67 (2.48)	**9.67b (3.19)**
Septembe r	6.00 (2.55)	3.00 (1.87)	1.33 (1.35)	**3.44d (1.99)**	1.67 (1.47)	0.33 (0.91)	0.00 (0.71)	**0.67d (0.91)**	1.00 (1.22)	0.67 (1.08)	0.00 (0.71)	**0.56 b (1.03)**	0.33 (0.91)	0.00 (0.71)	0.00 (0.71)	**0.11b (0.78)**	0.33 (0.91)	0.33 (0.91)	0.00 (0.71)	**0.22a (0.85)**	9.33 (3.14)	4.33 (2.20)	1.33 (1.35)	**5.00c (2.34)**
Mean	**9.27a (3.13)**	**6.00b (2.55)**	**3.27c (1.94)**	**6.18 (2.58)**	**3.00a (1.87)**	**1.73b (1.49)**	**0.53c (1.02)**	**1.76 (1.50)**	**1.07a (1.25)**	**0.53b (1.02)**	**0.27b (0.88)**	**0.62 (1.06)**	**0.73a (1.11)**	**0.33b (0.91)**	**0.13b (0.79)**	**0.11 (0.71)**	**0.93a (1.20)**	**0.40b (0.95)**	**0.13b (0.79)**	**0.49 (0.99)**	**15.00a (3.93)**	**9.00b (3.08)**	**4.33c (2.20)**	**9.44 (3.15)**

	Mites S.Em.±	Mites CD (P=0.05)	Collembola S.Em.±	Collembola CD (P=0.05)	Ants S.Em.±	Ants CD (P=0.05)	Beetles S.Em.±	Beetles CD (P=0.05)	Others S.Em.±	Others CD (P=0.05)	Total S.Em.±	Total CD (P=0.05)
FS	0.06	0.17	0.07	0.20	0.07	0.19	0.07	0.21	0.08	0.22	0.07	0.20
Month (M)	0.08	0.22	0.09	0.26	0.09	0.25	0.09	0.27	0.10	NA	0.09	0.26
FS X M	0.13	NS	0.15	NS	0.15	NS	0.16	NS	0.17	NS	0.15	NS

OF – Organic farming IF – Integrated farming CF – Conventional farming FS – Farming system

Figures in the parenthesis are √x+0.5 transformed values

In a column or row, means followed by the same alphabet do not differ significantly (P=0.05) by DMRT

Table 2: Population of soil meso-arthropods in soybean under organic, integrated and conventional farming systems during 2015 (100g of soil).

Months	Mites				Collembola				Ants				Beetles				Others				Total			
FS	OF	IF	CF	Mean	OF	IF	CF	Mean	OF	IF	CF	Mean	OF	IF	CF	Mean	OF	IF	CF	Mean	OF	IF	CF	Mean
May	12.00 (3.54)	8.00 (2.92)	5.00 (2.35)	**8.33 b (2.97)**	2.67 (1.78)	1.33 (1.35)	0.00 (0.71)	**1.33 b (1.22)**	1.33 (1.35)	0.00 (0.71)	0.00 (0.71)	**0.44b (0.97)**	0.67 (1.08)	0.00 (0.71)	0.00 (0.71)	**0.22b (0.85)**	1.00 (1.22)	0.33 (0.91)	0.00 (0.71)	**0.44a (0.97)**	17.67 (4.26)	9.66 (3.19)	5.00 (2.35)	**10.78b (3.36)**
June	21.33 (4.67)	11.00 (3.39)	6.67 (2.68)	**13.00 a (3.67)**	5.33 (2.41)	2.33 (1.68)	1.33 (1.27)	**2.92a (1.62)**	2.67 (1.78)	1.00 (1.22)	0.00 (0.71)	**1.22a (1.31)**	2.33 (1.68)	1.00 (1.22)	0.67 (1.08)	**1.33a (1.35)**	1.33 (1.35)	1.00 (1.22)	1.00 (1.22)	**1.11a (1.27)**	33.00 (5.79)	16.33 (4.10)	9.67 (3.19)	**19.67a (4.49)**
July	5.33 (2.41)	4.00 (2.12)	2.00 (1.58)	**3.78 c (2.07)**	1.33 (1.35)	0.67 (0.91)	0.33 (0.91)	**0.66c (0.97)**	1.00 (1.22)	0.67 (1.08)	0.33 (0.91)	**0.67ab (1.08)**	0.33 (0.91)	0.00 (0.71)	0.33 (0.91)	**0.22b (0.85)**	1.00 (1.22)	0.33 (0.91)	0.33 (0.91)	**0.56a (1.03)**	9.00 (3.08)	5.67 (2.46)	3.32 (1.95)	**6.00d (2.55)**
August	7.00 (2.74)	3.00 (1.87)	2.00 (1.58)	**4.00 c (2.12)**	4.67 (2.27)	1.67 (1.47)	1.00 (1.22)	**2.45a (1.51)**	2.00 (1.58)	0.67 (1.08)	0.33 (0.91)	**1.00ab (1.22)**	2.00 (1.58)	1.00 (1.22)	1.00 (1.22)	**1.33a (1.35)**	0.67 (1.08)	1.67 (1.47)	0.67 (1.08)	**1.00a (1.22)**	16.33 (4.10)	8.01 (2.92)	5.00 (2.35)	**9.78bc (3.21)**
September	4.33 (2.20)	3.33 (1.96)	1.67 (1.47)	**3.11 d (1.90)**	2.00 (1.58)	0.33 (0.91)	0.67 (1.08)	**1.00bc (1.03)**	1.33 (1.35)	0.67 (1.08)	0.33 (0.91)	**0.78ab (1.13)**	0.67 (1.08)	0.33 (0.91)	0.00 (0.71)	**0.33b (0.91)**	1.00 (1.22)	1.00 (1.22)	0.67 (1.08)	**0.89a (1.18)**	9.33 (3.14)	5.66 (2.48)	3.34 (1.96)	**6.11cd (2.57)**
Mean	**10.00a (3.24)**	**5.87b (2.52)**	**3.47c (1.99)**	**6.44 (2.64)**	**3.20a (1.92)**	**1.27b (1.33)**	**0.67c (1.08)**	**1.86 (1.54)**	**1.67a (1.47)**	**0.60b (1.05)**	**0.20b (0.84)**	**0.82 (1.15)**	**1.20a (1.30)**	**0.47b (0.98)**	**0.40b (0.95)**	**0.69 (1.09)**	**1.00a (1.22)**	**0.87a (1.17)**	**0.53a (1.02)**	**0.80 (1.14)**	**17.06a (4.19)**	**9.07b (3.07)**	**5.27c (2.40)**	**10.47 (3.31)**

	Mites S.Em.±	Mites CD (P=0.05)	Collembola S.Em.±	Collembola CD (P=0.05)	Ants S.Em.±	Ants CD (P=0.05)	Beetles S.Em.±	Beetles CD (P=0.05)	Others S.Em.±	Others CD (P=0.05)	Total S.Em.±	Total CD (P=0.05)
FS	0.09	0.26	0.08	0.24	0.08	0.23	0.06	0.17	0.10	NS	0.09	0.26
Month (M)	0.11	0.33	0.11	0.31	0.10	0.29	0.07	0.21	0.12	NS	0.12	0.34
FS X M	0.20	NS	0.19	NS	0.18	NS	0.13	NS	0.21	NS	0.20	NS

OF – Organic farming IF – Integrated farming CF – Conventional farming FS – Farming system

Figures in the parenthesis are √x+0.5 transformed values

In a column or row, means followed by the same alphabet do not differ significantly (P=0.05) by DMRT.

4.1.1c Cowpea

The highest population of meso-arthropods *viz.,* mites, collembolans, ants, beetles and other arthropods was recorded under organic farming (9.13, 2.40, 0.60, 1.06 and 1.26/100g of soil, respectively) followed by integrated farming and least in conventional farming (2.87, 0.73, 0.07, 0.20 and 0.13/100g of soil, respectively) (Table 3).

Irrespective of dates of collection significant difference in total meso-arthropods population was observed between farming systems. Significantly highest population of total meso-arthropods was recorded in organic farming (14.46) followed by integrated (7.80) and least in conventional farming (4.00). Irrespective of farming systems significant difference in total meso-arthropods were observed between different dates of collection. Significantly highest total meso-arthropods were recorded during June (13.44) and significantly least during September (3.89).

4.1.1d Maize

The higher population of meso-arthropods *viz.,* mites, collembolans, ants, beetles and other arthropods was noticed in organic farming (11.94, 2.67, 0.67, 0.67 and 0.94/100g of soil, respectively) followed by integrated farming and least in conventional farming (4.77, 0.72, 0.06, 0.17 and 0.28/100g of soil, respectively) system (Table 4).

Irrespective of dates of collection significant difference in total meso-arthropods population was observed between farming systems. Significantly highest population of total meso-arthropods was recorded in organic farming (16.89) followed by integrated (10.28) and least in conventional farming (6.00). Irrespective of farming systems significant difference in total meso-arthropods were observed between different dates of collection. Significantly highest population of total meso-arthropods was recorded during June (18.77) and significantly least during September (4.44).

4.1.1e Pigeonpea

Pigeonpea grown under organic farming was recorded higher population of meso-arthropods *viz.,* mites, collembolans, ants, beetles and other arthropods (12.75, 3.54, 1.04, 0.95 and 0.74/100g of soil, respectively) followed by integrated farming and least in conventional farming (4.83, 0.83, 0.16, 0.16 and 0.33/100g of soil, respectively) system (Table 5).

Irrespective of dates of collection the total meso-arthropods population attained significantly highest in organic farming (19.04) followed by integrated (9.96) and least in conventional farming (6.29). Irrespective of farming systems the total meso-arthropods population attained significantly highest during October (21.67) and minimum during December (6.55). The interaction effect was found significant between different farming systems and dates of collection. Significantly highest meso-arthropods were found in organic farming during October (33.33), whereas significantly least in conventional farming during December (2.67).

4.1.1f Cotton + Groundnut

The highest population of meso-arthropods *viz.,* mites, collembolans, ants, beetles and other arthropods was recorded in organic farming (14.38, 4.12, 1.92, 1.88 and 1.38/100g of soil, respectively) followed by integrated farming and least in conventional farming (5.88, 1.50, 0.71, 0.46 and 0.42/100g of soil, respectively) system (Table 6).

Table 3: Population of soil meso-arthropods in cowpea under organic, integrated and conventional farming systems during 2015 (100g of soil).

Months	Mites				Collembola				Ants				Beetles				Others				Total			
FS	OF	IF	CF	Mean	OF	IF	CF	Mean	OF	IF	CF	Mean	OF	IF	CF	Mean	OF	IF	CF	Mean	OF	IF	CF	Mean
May	9.00 (3.08	5.00 (2.35)	3.67 (2.04)	**5.89b (2.53)**	2.67 (1.78)	1.00 (1.22)	0.67 (1.08)	**1.45b (1.40)**	0.33 (0.91)	0.00 (0.71)	0.33 (0.91)	**0.22a (0.84)**	0.33 (0.91)	0.67 (1.08)	0.00 (0.71)	**0.33a (0.91)**	1.33 (1.35)	1.00 (1.22)	0.00 (0.71)	**0.77a (1.13)**	13.66 (3.76)	7.67 (2.86)	4.67 (2.27)	**8.67b (3.03)**
June	14.33 (3..85)	8.00 (2.92)	5.00 (2.35)	**9.11a (3.10)**	4.00 (2.12)	2.33 (1.68)	2.00 (1.58)	**2.78a (1.81)**	0.67 (1.08)	0.00 (0.71)	0.00 (0.71)	**0.22a (0.85)**	1.00 (1.22)	0.67 (1.08)	0.33 (0.91)	**0.67a (1.08)**	1.67 (1.47)	0.33 (0.91)	0.00 (0.71)	**0.66a (1.08)**	21.67 (4.71)	11.33 (3.44)	7.33 (2.80)	**13.44a (3.73)**
July	10.00 (3.24)	5.33 (2.41)	2.67 (1.78)	**6.00ab (2.51)**	1.33 (1.35)	1.00 (1.22)	0.00 (0.71)	**0.55b (1.03)**	0.67 (1.08)	0.00 (0.71)	0.00 (0.71)	**0.22a (0.85)**	1.33 (1.35)	0.33 (0.91)	0.00 (0.71)	**0.55a (1.03)**	1.33 (1.35)	1.00 (1.22)	0.00 (0.71)	**0.77a (1.13)**	14.66 (3.89)	7.66 (2.86)	2.67 (1.78)	**8.33b (2.97)**
August	8.33 (2.97)	5.00 (2.35)	2.33 (1.68)	**5.22b (2.39)**	2.67 (1.78)	1.66 (1.47)	1.00 (1.22)	**1.78ab (1.51)**	1.00 (1.22)	0.00 (0.71)	0.00 (0.71)	**0.33a (0.97)**	1.67 (1.47)	1.00 (1.22)	0.67 (1.08)	**1.11a (1.27)**	1.33 (1.35)	1.00 (1.22)	0.67 (1.22)	**1.00a (1.22)**	15.00 (3.94)	8.66 (3.03)	4.67 (2.27)	**9.44b (3.15)**
September	4.00 (2.12)	2.00 (1.58)	0.67 (1.08)	**2.22c (1.65)**	1.33 (1.35)	0.33 (0.91)	0.00 (0.71)	**0.55b (1.03)**	0.33 (0.91)	0.33 (0.91)	0.00 (0.71)	**0.22a (0.85)**	1.00 (1.22)	0.33 (0.91)	0.00 (0.71)	**0.44a (0.97)**	0.67 (1.08)	0.67 (1.08)	0.00 (0.71)	**0.44a (0.97)**	7.33 (2.80)	3.66 (2.04)	0.67 (1.08)	**3.89c (2.09)**
Mean	**9.13a (3.10)**	**5.07b (2.36)**	**2.87c (1.84)**	**5.69 (2.49)**	**2.40a (1.70)**	**1.26b (1.33)**	**0.73c (1.11)**	**1.47 (1.40)**	**0.60a (1.05)**	**0.07b (0.75)**	**0.07b (0.75)**	**0.24 (0.86)**	**1.06a (1.25)**	**0.60b (1.05)**	**0.20b (0.84)**	**0.62a (1.06)**	**1.26a (1.33)**	**0.80b (1.14)**	**0.13c (0.80)**	**0.73 (1.11)**	**14.46a (3.87)**	**7.80b (2.88)**	**4.00c (2.12)**	**8.75 (3.04)**

	Mites S.Em.±	Mites CD (P=0.05)	Collembola S.Em.±	Collembola CD (P=0.05)	Ants S.Em.±	Ants CD (P=0.05)	Beetles S.Em.±	Beetles CD (P=0.05)	Others S.Em.±	Others CD (P=0.05)	Total S.Em.±	Total CD (P=0.05)
(FS)	0.06	0.18	0.06	0.19	0.07	0.20	0.08	0.23	0.07	0.19	0.08	0.23
Month (M)	0.08	0.24	0.08	0.24	0.09	NS	0.10	NS	0.09	NS	0.10	0.30
FS X M	0.14	NS	0.14	NS	0.15	NS	0.18	NS	0.15	NS	0.18	NS

OF – Organic farming IF – Integrated farming CF – Conventional farming FS – Farming system

Figures in the parenthesis are √x+0.5 transformed values

In a column or row, means followed by the same alphabet do not differ significantly (P=0.05) by DMRT

Table 4: Population of soil meso-arthropods in maize under organic, integrated and conventional farming systems during 2015 (100g of soil).

Months / FS	Mites				Collembola				Ants				Beetles				Others				Total			
	OF	IF	CF	Mean	OF	IF	CF	Mean	OF	IF	CF	Mean	OF	IF	CF	Mean	OF	IF	CF	Mean	OF	IF	CF	Mean
May	11.33 (3.44)	7.67 (2.86)	3.33 (1.96)	**7.44d** **(2.82)**	2.33 (1.68)	1.00 (1.22)	0.67 (1.08)	**1.33bc** **(1.35)**	0.00 (0.71)	0.33 (0.91)	0.00 (0.71)	**0.11a** **(0.78)**	0.33 (0.91)	0.00 (0.71)	0.00 (0.71)	**0.11a** **(0.78)**	0.33 (0.91)	0.00 (0.71)	0.00 (0.71)	**0.11a** **(0.78)**	14.32 (3.85)	9.00 (3.08)	4.00 (2.12)	**9.11c** **(3.10)**
June	16.00 (4.06)	13.00 (3.67)	8.00 (2.92)	**12.33a** **(4.43)**	7.33 (2.80)	5.00 (2.35)	1.67 (1.47)	**4.67a** **(2.27)**	1.33 (1.35)	0.33 (0.91)	0.00 (0.71)	**0.56a** **(1.03)**	1.00 (1.22)	0.33 (0.91)	0.00 (0.71)	**0.44a** **(0.97)**	1.33 (1.35)	0.67 (1.08)	0.33 (0.91)	**0.78a** **(1.13)**	26.99 (5.24)	19.33 (5.05)	10.00 (3.94)	**18.77a** **(4.39)**
July	11.33 (3.44)	8.00 (2.92)	5.00 (2.35)	**8.11c** **(2.93)**	1.00 (1.22)	0.33 (0.91)	0.00 (0.71)	**0.44c** **(0.97)**	1.00 (1.22)	0.33 (0.91)	0.00 (0.71)	**0.44a** **(0.97)**	0.33 (0.91)	0.00 (0.71)	0.00 (0.71)	**0.11a** **(0.78)**	0.33 (0.91)	0.33 (0.91)	0.67 (1.08)	**0.44a** **(0.97)**	14.00 (3.81)	9.00 (3.08)	5.67 (2.48)	**9.55c** **(3.17)**
August	12.00 (3.54)	7.00 (2.74)	4.67 (2.27)	**7.89c** **(2.90)**	2.67 (1.78)	1.67 (1.47)	1.33 (1.35)	**1.89b** **(1.55)**	0.33 (0.91)	0.00 (0.71)	0.00 (0.71)	**0.11a** **(0.78)**	0.67 (1.08)	0.67 (1.08)	1.00 (1.22)	**0.78a** **(1.13)**	1.00 (1.22)	0.67 (1.08)	0.33 (0.91)	**0.67a** **(1.08)**	16.67 (4.14)	10.00 (3.24)	7.33 (2.80)	**11.34bc** **(3.44)**
September	5.00 (2.35)	1.67 (1.47)	0.67 (1.08)	**2.45e** **(1.72)**	1.00 (1.22)	0.33 (0.91)	0.33 (0.91)	**0.56bc** **(1.03)**	0.67 (1.08)	0.67 (1.08)	0.33 (0.91)	**0.56a** **(1.03)**	0.67 (1.08)	0.33 (0.91)	0.00 (0.71)	**0.33a** **(0.91)**	1.33 (1.35)	0.33 (0.91)	0.00 (0.71)	**0.56a** **(1.03)**	8.67 (3.03)	3.33 (1.96)	1.33 (1.35)	**4.44d** **(2.22)**
October	16.00 (4.06)	9.00 (3.08)	7.00 (2.74)	**10.67b** **(3.34)**	1.67 (1.47)	1.00 (1.22)	0.33 (0.91)	**1.00bc** **(1.22)**	0.67 (1.08)	0.33 (0.91)	0.00 (0.71)	**0.33a** **(0.91)**	1.00 (1.22)	0.33 (0.91)	0.00 (0.71)	**0.44a** **(0.97)**	1.33 (1.35)	0.33 (0.91)	0.33 (0.91)	**0.67a** **(1.08)**	20.67 (4.60)	11.00 (3.39)	7.67 (2.86)	**13.11b** **(3.69)**
Mean	**11.94a** **(3.53)**	**7.72b** **(2.87)**	**4.77c** **(2.30)**	**9.11** **(3.10)**	**2.67a** **(1.78)**	**1.56b** **(1.43)**	**0.72c** **(1.11)**	**1.65** **(1.47)**	**0.67a** **(1.08)**	**0.33b** **(0.91)**	**0.06c** **(0.75)**	**0.35** **(0.92)**	**0.67a** **(1.08)**	**0.28b** **(0.88)**	**0.17b** **(0.82)**	**0.37** **(0.93)**	**0.94a** **(1.20)**	**0.39b** **(0.94)**	**0.28b** **(0.88)**	**0.54** **(1.02)**	**16.89a** **(4.17)**	**10.28b** **(3.28)**	**6.00c** **(2.55)**	**11.05** **(3.40)**

	Mites S.Em.±	Mites CD (P=0.05)	Collembola S.Em.±	Collembola CD (P=0.05)	Ants S.Em.±	Ants CD (P=0.05)	Beetles S.Em.±	Beetles CD (P=0.05)	Others S.Em.±	Others CD (P=0.05)	Total S.Em.±	Total CD (P=0.05)
FS	0.05	0.15	0.07	0.19	0.06	0.16	0.06	0.17	0.06	0.17	0.06	0.17
Month (M)	0.08	0.22	0.09	0.27	0.08	NS	0.08	NS	0.08	NS	0.08	0.24
FS X M	0.13	NS	0.16	NS	0.14	NS	0.14	NS	0.14	NS	0.14	NS

OF – Organic farming IF – Integrated farming CF – Conventional farming FS – Farming system

Figures in the parenthesis are √x+0.5 transformed values

In a column or row, means followed by the same alphabet do not differ significantly (P=0.05) by DMRT

Table 5: Population of soil meso-arthropods in pigeonpea under organic, integrated and conventional farming systems during 2015 (100g of soil).

Months	Mites				Collembola				Ants				Beetles				Others				Total			
FS	OF	IF	CF	Mean	OF	IF	CF	Mean	OF	IF	CF	Mean	OF	IF	CF	Mean	OF	IF	CF	Mean	OF	IF	CF	Mean
May	12.33 (3.58)	6.00 (2.55)	4.33 (2.20)	**7.55bc (2.84)**	3.00 (1.87)	1.00 (1.22)	0.67 (1.08)	**1.56ab (1.43)**	0.67 (1.08)	0.00 (0.71)	0.67 (1.08)	**0.45a (0.97)**	1.00 (1.22)	0.00 (0.71)	0.00 (0.71)	**0.33a (0.91)**	0.33 (0.91)	0.00 (0.71)	0.00 (0.71)	**0.11b (0.78)**	17.33 (4.22)	7.00 (2.74)	5.67 (2.48)	**10.00bc (3.24)**
June	20.00 (4.53)	10.00 (3.24)	7.00 (2.74)	**12.33a (3.58)**	5.67 (2.48)	2.33 (1.68)	1.67 (1.47)	**3.22a (1.93)**	0.67 (1.08)	0.33 (0.91)	0.00 (0.71)	**0.33a (0.91)**	2.00 (1.58)	0.67 (1.08)	0.33 (0.91)	**1.00a (1.22)**	1.00 (1.22)	0.33 (0.91)	0.33 (0.91)	**0.55ab (1.02)**	29.33 (5.46)	13.66 (3.76)	9.33 (3.14)	**17.44a (4.24)**
July	10.00 (3.29)	5.67 (2.48)	4.00 (2.12)	**6.55bcd (2.66)**	2.67 (1.78)	1.00 (1.22)	0.00 (0.71)	**1.22ab (1.31)**	1.00 (1.22)	0.00 (0.71)	0.00 (0.71)	**0.33a (0.91)**	0.33 (0.91)	0.00 (0.71)	0.00 (0.71)	**0.11a (0.78)**	0.33 (0.91)	0.00 (0.71)	0.00 (0.71)	**0.11b (0.78)**	14.33 (3.85)	6.67 (2.68)	4.00 (2.12)	**8.33bc (2.99)**
August	9.67 (3.19)	7.00 (2.74)	4.00 (2.12)	**6.89bc (2.72)**	5.67 (2.48)	1.33 (1.35)	0.33 (0.91)	**2.44a (1.72)**	0.33 (0.91)	0.00 (0.71)	0.00 (0.71)	**0.11a (0.78)**	0.67 (1.08)	0.33 (0.91)	0.00 (0.71)	**0.33a (0.91)**	0.33 (0.91)	0.33 (0.91)	0.00 (0.71)	**0.22ab (0.85)**	16.67 (4.14)	8.99 (3.08)	4.33 (2.20)	**10.00bc (3.24)**
September	6.00 (2.55)	4.67 (2.27)	2.67 (1.78)	**4.44d (2.22)**	2.33 (1.68)	2.00 (1.58)	1.33 (1.35)	**1.89ab (1.54)**	2.00 (1.58)	0.67 (1.08)	0.67 (1.08)	**1.11a (1.27)**	0.67 (1.08)	0.33 (0.91)	0.00 (0.71)	**0.33a (0.91)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00b (0.71)**	11.00 (3.39)	7.67 (2.86)	4.67 (2.27)	**7.78c (2.88)**
October	22.67 (4.81)	14.00 (3.81)	9.67 (3.19)	**15.44a (3.99)**	6.00 (2.55)	2.33 (1.68)	2.00 (1.58)	**3.44a (1.99)**	1.67 (1.47)	0.67 (1.08)	0.00 (0.71)	**0.78a (1.13)**	2.00 (1.58)	0.33 (0.91)	1.00 (1.22)	**1.11a (1.27)**	1.00 (1.22)	0.67 (1.08)	1.00 (1.22)	**0.89ab (1.18)**	33.33 (5.82)	18.00 (4.30)	13.67 (3.76)	**21.67a (4.71)**
November	13.00 (3.67)	8.33 (2.97)	4.67 (2.27)	**8.66b (3.03)**	2.33 (1.68)	1.33 (1.35)	0.67 (1.08)	**1.44ab (1.39)**	1.33 (1.35)	1.00 (1.22)	0.00 (0.71)	**0.78a (1.13)**	0.33 (0.91)	0.33 (0.91)	0.00 (0.71)	**0.22a (0.85)**	2.00 (1.58)	1.00 (1.22)	0.67 (1.08)	**1.22a (1.31)**	19.00 (4.42)	12.00 (3.54)	6.00 (2.55)	**12.33b (3.58)**
December	8.33 (2.97)	4.67 (2.27)	2.33 (1.68)	**5.11cd (2.37)**	0.67 (1.08)	0.33 (0.91)	0.00 (0.71)	**0.33b (0.91)**	0.67 (1.08)	0.00 (0.71)	0.00 (0.71)	**0.22b (0.85)**	0.67 (1.08)	0.33 (0.91)	0.00 (0.71)	**0.33a (0.91)**	1.00 (1.22)	0.33 (0.91)	0.33 (0.91)	**0.55ab (1.02)**	11.33 (3.44)	5.67 (2.48)	2.67 (1.78)	**6.55c (2.66)**
Mean	**12.75a (3.64)**	**7.54b (2.84)**	**4.83c (2.31)**	**8.37 (2.98)**	**3.54a (2.01)**	**1.46b (1.40)**	**0.83c (1.15)**	**1.94 (1.52)**	**1.04a (1.24)**	**0.33b (0.91)**	**0.16b (0.82)**	**0.51 (1.01)**	**0.95a (1.20)**	**0.29b (0.89)**	**0.16b (0.81)**	**0.47 (0.98)**	**0.74a (1.11)**	**0.33b (0.91)**	**0.29b (0.89)**	**0.45 (0.97)**	**19.04a (4.42)**	**9.96b (3.23)**	**6.29c (2.61)**	**11.76 (3.50)**

	Mites		Collembola		Ants		Beetles		Others		Total	
	S.Em.±	**CD (P=0.05)**	**S.Em.±**	**CD (P=0.05)**	**S.Em.±**	**CD (P=0.05)**	**S.Em.±**	**CD (P=0.05)**	**S.Em.±**	**CD (P=0.05)**	**S.Em.±**	**CD (P=0.05)**
FS	0.05	0.15	0.05	0.16	0.05	0.14	0.06	0.16	0.05	0.15	0.06	0.17
Month (M)	0.09	0.25	0.09	0.25	0.08	0.23	0.09	NS	0.09	0.25	0.10	0.27
FS X M	0.15	0.44	0.15	0.44	0.14	NS	0.16	NS	0.15	NS	0.17	0.47

OF – Organic farming IF – Integrated farming CF – Conventional farming FS – Farming system

Figures in the parenthesis are $\sqrt{x+0.5}$ transformed values

In a column or row, means followed by the same alphabet do not differ significantly (P=0.05) by DMRT

Table 6: Population of soil meso-arthropods in cotton intercropped with groundnut under organic, integrated and conventional farming systems during 2015 (100g of soil).

Months / FS	Mites				Collembola				Ants				Beetles				Others				Total			
	OF	IF	CF	Mean	OF	IF	CF	Mean	OF	IF	CF	Mean	OF	IF	CF	Mean	OF	IF	CF	Mean	OF	IF	CF	Mean
May	13.00	9.67	8.00	**10.22c**	4.00	3.67	3.00	**3.56c**	1.67	0.67	0.67	**1.00cd**	1.33	0.67	0.33	**0.78cd**	1.33	1.00	0.67	**1.00b**	21.33	15.67	12.67	**16.56bc**
	(3.67)	(3.19)	(2.92)	**(3.27)**	(2.12)	(2.04)	(1.87)	**(2.01)**	(1.47)	(1.08)	(1.08)	**(1.22)**	(1.35)	(1.08)	(0.91)	**(1.13)**	(1.35)	(1.22)	(1.08)	**(1.22)**	(4.67)	(4.02)	(3.63)	**(4.13)**
June	17.00	12.00	8.67	**12.56b**	7.33	3.67	2.00	**4.33b**	1.67	1.33	1.00	**1.33c**	2.33	1.00	0.33	**1.22bc**	2.33	0.67	0.00	**1.00b**	30.66	18.67	12.00	**20.44b**
	(4.18)	(3.54)	(3.03)	**(3.61)**	(2.80)	(2.04)	(1.58)	**(2.20)**	(1.47)	(1.35)	(1.22)	**(1.35)**	(1.68)	(1.22)	(0.91)	**(1.31)**	(1.68)	(1.08)	(0.71)	**(1.22)**	(5.58)	(4.38)	(3.54)	**(4.58)**
July	12.00	7.00	5.33	**8.11e**	2.67	0.33	0.67	**1.22e**	2.33	1.00	0.33	**1.22c**	2.00	0.67	0.00	**0.89bcd**	0.67	1.00	0.67	**0.78bc**	19.67	10.00	7.00	**12.22d**
	(3.54)	(2.74)	(2.41)	**(2.93)**	(1.78)	(0.91)	(1.08)	**(1.31)**	(1.68)	(1.22)	(0.91)	**(1.31)**	(1.58)	(1.08)	(0.7)	**(1.18)**	(1.08)	(1.22)	(1.08)	**(1.13)**	(4.49)	(3.24)	(2.74)	**(3.57)**
August	16.00	8.00	5.00	**9.67d**	2.33	1.67	0.33	**1.44e**	0.33	0.33	0.67	**0.44de**	1.67	1.00	1.00	**1.22bc**	0.67	0.33	0.00	**0.33cd**	21.00	11.33	7.00	**13.11cd**
	(4.06)	(2.92)	(2.35)	**(3.19)**	(1.68)	(1.47)	(0.91)	**(1.39)**	(0.91)	(0.91)	(1.08)	**(0.97)**	(1.47)	(1.22)	(1.22)	**(1.31)**	(1.08)	(0.91)	(0.71)	**(0.91)**	(4.64)	(3.44)	(2.74)	**(3.68)**
September	9.00	8.00	3.00	**6.67f**	2.33	1.33	0.33	**1.33e**	2.67	1.67	1.33	**1.89b**	2.00	1.67	0.33	**1.33b**	0.33	1.00	0.33	**0.55bcd**	16.33	13.67	5.33	**11.78d**
	(3.08)	(2.92)	(1.87)	**(2.68)**	(1.68)	(1.35)	(0.91)	**(1.35)**	(1.78)	(1.47)	(1.35)	**(1.55)**	(1.58)	(1.47)	(0.91)	**(1.35)**	(0.91)	(1.22)	(0.91)	**(1.03)**	(4.10)	(3.76)	(2.42)	**(3.50)**
October	26.00	13.67	10.00	**16.56a**	9.00	5.67	4.33	**6.33a**	4.33	2.67	1.33	**2.78a**	3.33	1.67	1.33	**2.11a**	3.67	1.67	1.67	**2.34a**	46.33	25.33	18.67	**30.11a**
	(5.15)	(3.76)	(3.24)	**(4.13)**	(3.08)	(2.48)	(2.20)	**(2.61)**	(2.20)	(1.78)	(1.35)	**(1.81)**	(1.96)	(1.47)	(1.35)	**(1.62)**	(2.04)	(1.47)	(1.47)	**(1.68)**	(6.84)	(5.08)	(4.38)	**(5.53)**
November	15.00	8.00	6.00	**9.67d**	4.00	2.67	1.33	**2.67d**	2.00	0.67	0.33	**1.00cd**	1.67	0.33	0.00	**0.67d**	1.67	0.67	0.00	**0.78bc**	24.33	12.33	7.67	**14.78cd**
	(3.94)	(2.92)	(2.55)	**(3.19)**	(2.12)	(1.78)	(1.35)	**(1.78)**	(1.58)	(1.08)	(0.91)	**(1.22)**	(1.47)	(0.91)	(0.71)	**(1.08)**	(1.47)	(1.08)	(0.71)	**(1.13)**	(4.98)	(3.58)	(2.86)	**(3.91)**
December	7.00	2.67	1.00	**3.56g**	1.33	0.33	0.00	**0.55f**	0.33	0.00	0.00	**0.11e**	0.67	0.67	0.33	**0.56d**	0.33	0.33	0.00	**0.22d**	9.66	4.00	1.33	**5.00e**
	(2.74)	(1.78)	(1.22)	**(2.01)**	(1.35)	(0.91)	(0.71)	**(1.03)**	(0.91)	(0.71)	(0.71)	**(0.78)**	(1.08)	(1.08)	(0.91)	**(1.03)**	(0.91)	(0.91)	(0.71)	**(0.85)**	(3.19)	(2.12)	(1.35)	**(2.34)**
Mean	**14.38a**	**8.63b**	**5.88c**	**9.63**	**4.12a**	**2.42b**	**1.50c**	**2.68**	**1.92a**	**1.04b**	**0.71b**	**1.22**	**1.88a**	**0.96b**	**0.46b**	**1.10**	**1.38a**	**0.83b**	**0.42b**	**0.88**	**23.67a**	**13.88b**	**8.96c**	**15.50**
	(3.86)	**(3.02)**	**(2.52)**	**(3.18)**	**(2.15)**	**(1.71)**	**(1.41)**	**(1.78)**	**(1.55)**	**(1.24)**	**(1.10)**	**(1.31)**	**(1.54)**	**(1.21)**	**(0.98)**	**(1.26)**	**(1.37)**	**(1.15)**	**(0.96)**	**(1.17)**	**(4.92)**	**(3.80)**	**(3.07)**	**(4.00)**

	Mites S.Em.±	Mites CD (P=0.05)	Collembola S.Em.±	Collembola CD (P=0.05)	Ants S.Em.±	Ants CD (P=0.05)	Beetles S.Em.±	Beetles CD (P=0.05)	Others S.Em.±	Others CD (P=0.05)	Total S.Em.±	Total CD (P=0.05)
FS	0.06	0.17	0.05	0.15	0.07	0.19	0.06	0.17	0.06	0.16	0.06	0.18
Month (M)	0.10	0.27	0.09	0.25	0.11	0.31	0.10	0.27	0.09	0.26	0.10	0.29
FS X M	0.17	0.47	0.15	NS	0.19	NS	0.17	NS	0.16	NS	0.18	0.50

OF – Organic farming IF – Integrated farming CF – Conventional farming FS – Farming system

Figures in the parenthesis are √x+0.5 transformed values

In a column or row, means followed by the same alphabet do not differ significantly (P=0.05) by DMRT

Irrespective of dates of collection the total meso-arthropods population attained significantly highest in organic farming (23.67) followed by integrated (13.88) and least in conventional farming (8.96). Irrespective of farming systems the total meso-arthropods population attained significantly highest during October (30.11) and least during December (5.33). The interaction effect was found significant between different farming systems and dates of collection. Significantly highest meso-arthropods were found in organically grown cotton field during October (46.33), whereas significantly least in conventionally grown cotton field during December (1.33).

4.1.1g Chickpea

Chickpea grown under organic farming was recorded higher population of meso-arthropods *viz.,* mites, collembolans, ants, beetles and other arthropods (9.40, 0.60, 0.26, 0.33 and 0.66/100g of soil, respectively) followed by integrated farming and least in conventional farming system (2.66, 0.13, 0.00, 0.00 and 0.13/100g of soil, respectively) (Table 7).

Irrespective of dates of collection significant difference in total meso-arthropods population was observed between farming systems. Significantly highest population of total meso-arthropods was recorded in organic farming (11.25) followed by integrated (4.84) and least in conventional farming (2.92). Irrespective of farming systems significant difference in total meso-arthropods were observed between different dates of collection. Significantly highest population of total meso-arthropods was recorded during October (13.11) and least during February (0.99).

4.1.1h *Rabi* sorghum

The higher population of meso-arthropods *viz.,* mites, collembolans, ants, beetles and other arthropods was noticed in organically grown sorghum plot (10.33, 0.94, 1.66, 0.49 and 1.00/100g of soil, respectively) followed by integrated and least in conventionally grown sorghum plot (3.83, 0.27, 0.11, 0.17 and 0.44/100g of soil, respectively)(Table 8).

Irrespective of dates of collection significant difference in total meso-arthropods population was observed between farming systems. Significantly highest population of total meso-arthropods was recorded in organically grown sorghum plot (14.42) followed by integrated (8.18) and least in conventionally grown sorghum plot (4.79). Irrespective of farming systems significant difference in total meso-arthropods were observed between different dates of collection. Significantly highest population of total meso-arthropods was recorded during October (21.11) and least during February (2.89).

4.1.1i Total population of meso-arthropods in different crops under organic, integrated and conventional farming systems during 2015-16 (100 g of soil)

Overall, significantly higher population of total arthropods was recorded in organic farming (16.47/100g of soil) followed by integrated farming (9.13/100g of soil) and least in conventional farming (5.32/100g of soil) (Table 9).

Across the different crops, soybean recorded more population (10.47/100 g of soil) of total arthropods compared to greengram (9.44/100g of soil) and cowpea (8.75/100g of soil) among short duration crops. Among long duration crops, cotton intercropped with groundnut recorded highest (15.50/100g of soil) compared to pigeonpea (11.76/100g of soil). In *rabi* crops *rabi* sorghum recorded more population (9.13/100g of soil) of total arthropods compared to chickpea (6.34/100g of soil). Overall cotton intercropped with groundnut recorded more population (15.50/100g of soil) followed by pigeonpea (11.76/100g of soil) and least in chickpea (6.34/100g of soil) (Plate 5).

Table 7: Population of soil meso-arthropods in chickpea under organic, integrated and conventional farming systems during 2015-16 (100g of soil).

Months	Mites				Collembola				Ants				Beetles				Others				Total			
FS	OF	IF	CF	Mean	OF	IF	CF	Mean	OF	IF	CF	Mean	OF	IF	CF	Mean	OF	IF	CF	Mean	OF	IF	CF	Mean
October	16.00 (4.06)	9.00 (3.08)	7.00 (2.74)	**10.60a (3.33)**	1.67 (1.47)	1.00 (1.22)	0.33 (0.91)	**1.00a (1.22)**	0.67 (1.08)	0.33 (0.91)	0.00 (0.71)	**0.33a (0.91)**	1.00 (1.22)	0.33 (0.91)	0.00 (0.71)	**0.44a (0.97)**	1.33 (1.35)	0.33 (0.91)	0.33 (0.91)	**0.66a (1.08)**	20.67 (4.60)	11.00 (3.39)	7.67 (2.86)	**13.11a (3.69)**
November	12.67 (3.63)	5.00 (2.35)	3.33 (1.96)	**7.00b (2.74)**	0.67 (1.08)	0.00 (0.71)	0.00 (0.71)	**0.22ab (0.85)**	0.00 (0.71)	0.33 (0.91)	0.00 (0.71)	**0.11a (0.78)**	0.33 (0.91)	0.00 (0.71)	0.00 (0.71)	**0.11ab (0.78)**	1.00 (1.22)	0.33 (0.91)	0.33 (0.91)	**0.55a (1.02)**	14.67 (3.89)	5.67 (2.48)	3.67 (2.04)	**8.00b (2.92)**
December	9.00 (3.08)	4.67 (2.27)	2.33 (1.68)	**5.33b (2.41)**	0.33 (0.91)	0.33 (0.91)	0.33 (0.91)	**0.33ab (0.91)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00a (0.71)**	0.33 (0.91)	0.00 (0.71)	0.00 (0.71)	**0.11ab (0.78)**	0.67 (1.08)	0.00 (0.71)	0.00 (0.71)	**0.22a (0.85)**	10.33 (3.29)	5.00 (2.35)	2.67 (1.78)	**6.00bc (2.55)**
January	7.00 (2.74)	2.00 (1.58)	0.33 (0.91)	**3.11c (1.90)**	0.33 (0.91)	0.00 (0.71)	0.00 (0.71)	**0.11b (0.78)**	0.67 (1.08)	0.00 (0.71)	0.00 (0.71)	**0.22a (0.85)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00b (0.71)**	0.33 (0.91)	0.33 (0.91)	0.00 (0.71)	**0.22a (0.85)**	8.33 (2.97)	2.33 (1.68)	0.33 (0.91)	**3.66c (2.04)**
February	2.33 (1.68)	0.33 (0.91)	0.33 (0.91)	**0.99d (1.22)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00b (0.71)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00a (0.71)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00b (0.71)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00a (0.71)**	2.33 (1.68)	0.33 (0.91)	0.33 (0.91)	**0.99d (1.22)**
Mean	**9.40a (3.15)**	**4.20b (2.17)**	**2.66c (1.78)**	**5.40 (2.43)**	**0.60a (1.05)**	**0.26b (0.87)**	**0.13b (0.79)**	**0.33 (0.91)**	**0.26a (0.87)**	**0.13ab (0.79)**	**0.00b (0.71)**	**0.13 (0.79)**	**0.33a (0.91)**	**0.06b (0.75)**	**0.00b (0.71)**	**0.13 (0.79)**	**0.66a (1.08)**	**0.19b (0.83)**	**0.13b (0.79)**	**0.33 (0.91)**	**11.25a (3.43)**	**4.84b (2.31)**	**2.92c (1.85)**	**6.34 (2.61)**

	S.Em.±	CD (P=0.05)	S.Em.±	CD (P=0.05)	S.Em.±	CD (P=0.05)	S.Em.±	CD (P=0.05)	S.Em.±	CD (P=0.05)	S.Em.±	CD (P=0.05)
FS	0.07	0.20	0.06	0.17	0.05	0.14	0.03	0.10	0.06	0.16	0.08	0.23
Month (M)	0.09	0.25	0.08	0.22	0.06	NS	0.04	0.13	0.07	0.21	0.10	0.30
FS X M	0.15	NS	0.13	NS	0.11	NS	0.08	NS	0.12	NS	0.18	NS

OF – Organic farming IF – Integrated farming CF – Conventional farming FS – Farming system

Figures in the parenthesis are √x+0.5 transformed values

In a column or row, means followed by the same alphabet do not differ significantly (P=0.05) by DMRT

Table 8: Population of soil meso-arthropods in *rabi* sorghum under organic, integrated and conventional farming systems during 2015-16 (100g of soil).

Months / FS	Mites				Collembola				Ants				Beetles				Others				Total			
	OF	IF	CF	Mean	OF	IF	CF	Mean	OF	IF	CF	Mean	OF	IF	CF	Mean	OF	IF	CF	Mean	OF	IF	CF	Mean
September	8.00 (2.92)	3.67 (2.04)	1.33 (1.35)	**4.33d (2.20)**	0.67 (1.08)	0.00 (0.71)	0.00 (0.71)	**0.22b (0.85)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00b (0.71)**	0.33 (0.91)	0.00 (0.71)	0.00 (0.71)	**0.11b (0.78)**	0.33 (0.91)	0.33 (0.91)	0.00 (0.71)	**0.22b (0.85)**	9.33 (3.14)	4.00 (2.12)	1.33 (1.35)	**4.89d (2.32)**
October	18.00 (4.3)	13.00 (3.67)	9.67 (3.19)	**13.55a (3.75)**	2.00 (1.58)	2.00 (1.58)	1.00 (1.22)	**1.60a (1.45)**	8.67 (3.03)	1.67 (1.47)	0.33 (0.91)	**3.55a (2.01)**	0.66 (1.08)	0.33 (0.91)	0.00 (0.91)	**0.33b (0.91)**	3.67 (2.04)	1.00 (1.22)	1.33 (1.35)	**2.00a (1.58)**	33.00 (5.79)	18.00 (4.30)	12.33 (3.58)	**21.11a (4.65)**
November	13.00 (3.67)	9.00 (3.08)	7.00 (2.74)	**9.66a (3.18)**	1.33 (1.35)	1.67 (1.47)	0.67 (1.08)	**1.22a (1.31)**	1.00 (1.22)	0.00 (0.71)	0.00 (0.71)	**0.33b (0.91)**	1.66 (1.47)	1.00 (1.22)	1.00 (1.22)	**1.22a (1.31)**	0.67 (1.08)	0.67 (1.08)	0.67 (1.08)	**0.67b (1.08)**	17.66 (4.26)	12.34 (3.58)	9.34 (3.14)	**13.11b (3.69)**
December	11.00 (3.39)	7.00 (2.74)	3.67 (2.04)	**7.22b (3.19)**	0.67 (1.08)	0.33 (0.91)	0.00 (0.71)	**0.33b (0.91)**	0.00 (0.71)	0.33 (0.91)	0.00 (0.71)	**0.11b (0.78)**	0.33 (0.91)	0.00 (0.71)	0.00 (0.71)	**0.11b (0.78)**	1.00 (1.22)	0.67 (1.08)	0.33 (0.91)	**0.66b (1.08)**	13.00 (3.67)	8.33 (2.97)	4.00 (2.12)	**8.44c (2.99)**
January	7.00 (2.74)	3.67 (2.04)	1.00 (1.22)	**3.89c (2.78)**	0.67 (1.08)	0.00 (0.71)	0.00 (0.71)	**0.22b (0.85)**	0.33 (0.91)	0.00 (0.71)	0.33 (0.91)	**0.22b (0.85)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00b (0.71)**	0.33 (0.91)	0.33 (0.91)	0.00 (0.91)	**0.22b (0.85)**	8.33 (2.97)	4.00 (2.12)	1.33 (1.35)	**4.55de (2.25)**
February	5.00 (2.35)	2.67 (1.78)	0.33 (0.91)	**2.66d (2.10)**	0.33 (0.91)	0.00 (0.71)	0.00 (0.71)	**0.11b (0.78)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00b (0.71)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00b (0.71)**	0.00 (0.71)	0.00 (0.71)	0.33 (0.91)	**0.11b (0.78)**	5.33 (2.42)	2.67 (1.78)	0.67 (1.08)	**2.89e (1.84)**
Mean	**10.33a (3.29)**	**6.50b (2.65)**	**3.83c (2.08)**	**6.88 (2.72)**	**0.94a (1.20)**	**0.66b (1.08)**	**0.27c (0.88)**	**0.63 (1.06)**	**1.66a (1.47)**	**0.33b (0.91)**	**0.11c (0.78)**	**0.71 (1.10)**	**0.49a (1.00)**	**0.22b (0.85)**	**0.17b (0.82)**	**0.30 (0.89)**	**1.00a (1.22)**	**0.50b (1.00)**	**0.44a (0.97)**	**0.64 (1.07)**	**14.42a (3.87)**	**8.18b (2.95)**	**4.79c (2.30)**	**9.13 (3.10)**

	S.Em.±	CD (P=0.05)	S.Em.±	CD (P=0.05)	S.Em.±	CD (P=0.05)	S.Em.±	CD (P=0.05)	S.Em.±	CD (P=0.05)	S.Em.±	D (P=0.05)
FS	0.06	0.17	0.04	0.12	0.04	0.11	0.05	0.14	0.06	0.16	0.06	0.18
Month (M)	0.09	0.24	0.06	0.17	0.06	0.16	0.07	0.19	0.08	0.23	0.09	0.26
FS X M	0.15	NS	0.10	NS	0.10	0.28	0.12	NS	0.14	NS	0.16	NS

OF – Organic farming IF – Integrated farming CF – Conventional farming FS – Farming system

Figures in the parenthesis are $\sqrt{x+0.5}$ transformed values

In a column or row, means followed by the same alphabet do not differ significantly (P=0.05) by DMRT

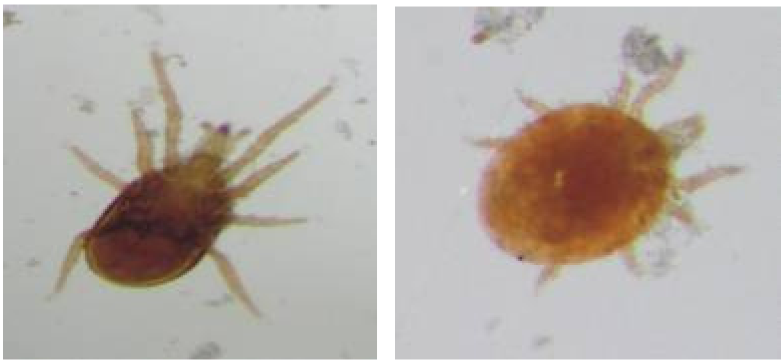
Table 9: Total population of meso-arthropods in different crops under organic, integrated and conventional farming systems during 2015-16.

Meso-arthropods/100 g of soil				
Crops	**Organic**	**Integrated**	**Conventional**	**Mean**
Greengram	15.00 (3.93)	9.00 (3.08)	4.33 (2.20)	**9.44** **(3.15)**
Soybean	17.06 (4.19)	9.07 (3.07)	5.27 (2.40)	**10.47** **(3.31)**
Cowpea	14.46 (3.87)	7.80 (2.88)	4.00 (2.12)	**8.75** **(3.04)**
Maize	16.89 (4.17)	10.28 (3.28)	6.00 (2.55)	**11.05** **(3.40)**
Pigeonpea	19.04 (4.42)	9.96 (3.23)	6.29 (2.61)	**11.76** **(3.50)**
Cotton + Groundnut	23.67 (4.92)	13.88 (3.80)	8.96 (3.07)	**15.50** **(4.00)**
Chickpea	11.25 (3.43)	4.84 (2.31)	2.92 (1.85)	**6.34** **(2.61)**
***Rabi* sorghum**	14.42 (3.87)	8.18 (2.95)	4.79 (2.30)	**9.13** **(3.10)**
Mean	**16.47a** **(4.12)**	**9.13b** **(3.10)**	**5.32c** **(2.41)**	

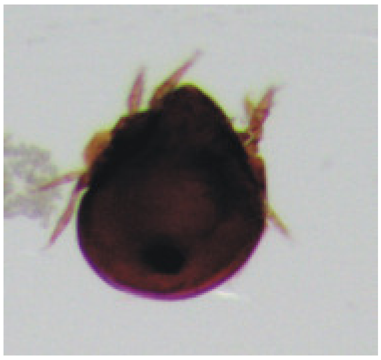
Figures in the parenthesis are $\sqrt{x+0.5}$ transformed values.

Pseudoscorpions

Carabid



Predatory Mites



Cryptostigmatid mite

Spider

Ant

Staphylinid

Symphylla

Diptera

Centipede

4.1.2 Population of macro-arthropods in different crops and cropping system

4.1.2a Greengram

The higher population of macro-arthropods *viz.,* scarabids, spiders, ants, orthoptera and other arthropods was noticed in organic farming (9.40, 0.53, 0.26, 0.33 and 0.86/pitfall trap, respectively) followed by integrated farming and least in conventional farming system (3.83, 0.06, 0.00, 0.00 and 0.46/pitfall trap, respectively) (Table 10).

Irrespective of dates of collection the total macro-arthropods population attained significantly highest in organic farming (11.40) followed by integrated (6.53) and least in conventional farming (4.53). Irrespective of farming systems the total macro arthropod population collected per pitfall trap was significantly highest during first week of August (12.33) and gradually decreasing from first week of August to last week of August and attained lowest population (1.55) during last week of August. The interaction effect was found significant between different farming systems and dates of collection. Significantly highest macro-arthropods were found in organic farming during first week of august (18.00), whereas, no arthropods were found in both integrated and conventional farming during last week of August.

4.1.2b Soybean

The higher population of macro-arthropods per trap was found in organic frming *viz.,* scarabids, spiders, ants, orthoptera and other arthropods (12.19, 0.66, 0.57, 0.23 and 0.85 respectively) followed by integrated farming and least in conventional farming (6.38, 0.04, 0.04, 0.09 and 0.19, respectively) system (Table 11).

Irrespective of dates of collection the total macro-arthropods population attained significantly highest in organic farming (14.52) followed by integrated (8.80) and least in conventional farming (6.76). Irrespective of farming systems the total macro arthropod population attained significantly highest during first week of August (14.22) and significantly lowest during second week of September (4.11). The interaction effect was found significant between different farming systems and dates of collection. Significantly highest macro-arthropods were found in organic farming during first week of August (18.67), whereas, least in conventional farming during second week of September (2.00).

4.1.2c Cowpea

Cowpea grown under organic farming was recorded higher population of macro-arthropods *viz.,* scarabids, spiders, ants, orthoptera and other arthropods (11.29, 0.48, 0.62, 0.38 and 0.38/trap, respectively) followed by integrated farming and least in conventional farming (4.67, 0.14, 0.09, 0.14 and 0.05/trap, respectively) (Table 12).

Irrespective of dates of collection the total macro-arthropods population attained significantly highest in organic farming (13.14) followed by integrated (7.71) and least in conventional farming (5.09). Irrespective of farming systems the total macro arthropod population attained significantly highest during first week of August (13.11) and lowest during second week of September (2.00). The interaction effect was found significant between different farming systems and dates of collection. Significantly highest macro-arthropods were found in organic farming during first week of August (19.33), whereas, least in conventional farming during second week of September (1.00).

Table 10: Population of soil macro-arthropods in greengram under organic, integrated and conventional farming systems during 2015 (per pitfall trap).

Observation period	Scarabids				Spiders				Ants				Orthoptera				Others				Total			
FS	OF	IF	CF	Mean	OF	IF	CF	Mean	OF	IF	CF	Mean	OF	IF	CF	Mean	OF	IF	CF	Mean	OF	IF	CF	Mean
4th week July	12.67	8.33	6.00	**9.00ab**	0.33	0.67	0.00	**0.33a**	1.00	0.00	0.00	**0.33a**	0.67	0.33	0.00	**0.33a**	0.67	0.00	1.00	**0.55a**	15.33	9.33	7.00	**10.55ab**
	(3.63)	(2.97)	(2.55)	**(3.08)**	(0.91)	(1.08)	(0.71)	**(0.91)**	(1.22)	(0.71)	(0.71)	**(0.91)**	(1.08)	(0.91)	(0.71)	**(0.91)**	(1.08)	(0.71)	(1.22)	**(1.02)**	(3.98)	(3.14)	(2.74)	**(3.32)**
1st week August	14.67	10.67	7.67	**11.00a**	1.67	0.33	0.00	**0.66b**	0.00	0.00	0.00	**0.00a**	0.33	0.00	0.00	**0.11a**	1.33	0.33	0.00	**0.55a**	18.00	11.33	7.67	**12.33a**
	(3.89)	(3.34)	(2.86)	**(3.39)**	(1.47)	(0.91)	(0.71)	**(1.08)**	(0.71)	(0.71)	(0.71)	**(0.71)**	(0.91)	(0.71)	(0.71)	**(0.78)**	(1.35)	(0.91)	(0.71)	**(1.02)**	(4.30)	(3.44)	(2.86)	**(3.58)**
2nd week August	9.67	6.00	5.00	**6.89b**	0.67	0.00	0.33	**0.33a**	0.33	0.33	0.00	**0.22a**	0.33	0.00	0.00	**0.11a**	0.67	0.67	1.33	**0.89a**	11.67	7.00	6.67	**8.44b**
	(3.19)	(2.55)	(2.35)	**(2.72)**	(1.08)	(0.71)	(0.91)	**(0.91)**	(0.91)	(0.91)	(0.71)	**(0.85)**	(0.91)	(0.71)	(0.71)	**(0.78)**	(1.08)	(1.08)	(1.35)	**(1.18)**	(3.49)	(2.74)	(2.68)	**(2.99)**
3rd week August	5.67	4.33	1.33	**3.70c**	0.00	0.00	0.00	**0.00a**	0.00	0.00	0.00	**0.00a**	0.33	0.00	0.00	**0.11a**	1.33	0.67	0.00	**0.66a**	7.33	5.00	1.33	**4.50c**
	(2.48)	(2.20)	(1.35)	**(2.05)**	(0.71)	(0.71)	(0.71)	**(0.71)**	(0.71)	(0.71)	(0.71)	**(0.71)**	(0.91)	(0.71)	(0.71)	**(0.78)**	(1.35)	(1.08)	(0.71)	**(1.08)**	(2.80)	(2.35)	(1.35)	**(2.24)**
4th week August	4.33	0.00	0.00	**1.44d**	0.00	0.00	0.00	**0.00a**	0.00	0.00	0.00	**0.00a**	0.00	0.00	0.00	**0.00a**	0.33	0.00	0.00	**0.11a**	4.67	0.00	0.00	**1.55d**
	(2.20)	(0.71)	(0.71)	**(1.39)**	(0.71)	(0.71)	(0.71)	**(0.71)**	(0.71)	(0.71)	(0.71)	**(0.71)**	(0.71)	(0.71)	(0.71)	**(0.71)**	(0.91)	(0.71)	(0.71)	**(0.78)**	(2.27)	(0.71)	(0.71)	**(1.43)**
Mean	**9.40a**	**5.86b**	**4.00c**	**6.40**	**0.53a**	**0.20b**	**0.06b**	**0.26**	**0.27a**	**0.07b**	**0.00b**	**0.11**	**0.33a**	**0.07b**	**0.00b**	**0.19**	**0.86a**	**0.33b**	**0.46ab**	**0.55**	**11.40a**	**6.53b**	**4.53c**	**7.47**
	(3.15)	**(2.52)**	**(2.12)**	**(2.63)**	**(1.01)**	**(0.84)**	**(0.75)**	**(0.87)**	**(0.87)**	**(0.75)**	**(0.71)**	**(0.78)**	**(0.91)**	**(0.75)**	**(0.71)**	**(0.83)**	**(1.17)**	**(0.91)**	**(0.98)**	**(1.02)**	**(3.45)**	**(2.65)**	**(2.24)**	**(2.82)**
	S.Em.±		**CD (P=0.05)**		**S.Em.±**		**CD (P=0.05)**		**S.Em.±**		**CD (P=0.05)**		**S.Em.±**		**CD (P=0.05)**		**S.Em.±**		**CD (P=0.05)**		**S.Em.±**		**CD (P=0.05)**	
FS	0.06		0.17		0.05		0.14		0.04		0.12		0.04		0.12		0.06		0.16		0.06		0.17	
Month (M)	0.08		0.22		0.16		0.18		0.05		NS		0.05		NS		0.07		0.21		0.08		0.22	
FS X M	0.13		0.38		0.17		0.49		0.09		NS		0.09		NS		0.12		0.36		0.13		0.38	

OF – Organic farming IF – Integrated farming CF – Conventional farming FS – Farming system

Figures in the parenthesis are √x+0.5 transformed values

In a column or row, means followed by the same alphabet do not differ significantly (P=0.05) by DMRT

Table 11: Population of soil macro-arthropods in soybean under organic, integrated and conventional farming systems during 2015 (per pitfall trap).

Observation period FS	Scarabids				Spiders				Ants				Orthoptera				Others				Total			
	OF	IF	CF	Mean	OF	IF	CF	Mean	OF	IF	CF	Mean	OF	IF	CF	Mean	OF	IF	CF	Mean	OF	IF	CF	Mean
4th week July	14.00 (3.81)	9.33 (3.14)	8.67 (3.03)	**10.60a (3.33)**	0.33 (0.91)	0.33 (0.91)	0.00 (0.71)	**0.22a (0.85)**	0.67 (1.08)	2.00 (1.58)	0.33 (0.91)	**1.00a (1.22)**	0.33 (0.91)	0.33 (0.91)	0.33 (0.91)	**0.33a (0.91)**	1.33 (1.35)	0.00 (0.71)	1.00 (1.22)	**0.77a (1.13)**	16.67 (4.14)	12.00 (3.54)	10.33 (3.29)	**13.00a (3.67)**
1st week August	15.33 (3.98)	9.67 (3.19)	10.67 (3.34)	**11.89a (3.52)**	1.33 (1.35)	2.00 (1.58)	0.00 (0.71)	**1.11a (1.27)**	0.33 (0.91)	0.33 (0.91)	0.00 (0.71)	**0.22b (0.85)**	0.67 (1.08)	0.33 (0.91)	0.00 (0.71)	**0.33a (0.91)**	1.00 (1.22)	0.67 (1.08)	0.33 (0.91)	**0.66a (1.08)**	18.67 (4.38)	13.00 (3.67)	11.00 (3.39)	**14.22a (3.84)**
2nd week August	14.00 (3.81)	10.00 (3.24)	5.67 (2.48)	**9.89a (3.22)**	1.00 (1.22)	0.67 (1.08)	0.33 (0.91)	**0.66a (1.08)**	0.33 (0.91)	0.00 (0.71)	0.00 (0.71)	**0.11b (0.78)**	0.33 (0.91)	0.33 (0.91)	0.00 (0.71)	**0.22a (0.85)**	1.33 (1.35)	0.00 (0.71)	0.00 (0.71)	**0.44ab (0.97)**	17.00 (4.18)	11.00 (3.39)	6.00 (2.55)	**11.30a (3.44)**
3rd week August	10.00 (3.24)	6.00 (2.55)	5.33 (2.42)	**7.11b (2.76)**	0.67 (1.08)	0.67 (1.08)	0.00 (0.71)	**0.44a (0.97)**	0.33 (0.91)	0.33 (0.91)	0.00 (0.71)	**0.22b (0.85)**	0.33 (0.91)	0.00 (0.71)	0.00 (0.71)	**0.11a (0.78)**	1.33 (1.35)	1.00 (1.22)	0.00 (0.71)	**0.77a (1.13)**	12.67 (3.63)	8.00 (2.92)	5.33 (2.92)	**8.66b (3.03)**
4th week August	15.00 (3.94)	8.00 (2.92)	7.00 (2.74)	**10.00a (3.24)**	0.33 (0.91)	0.00 (0.71)	0.00 (0.71)	**0.11a (0.78)**	2.00 (1.58)	0.00 (0.71)	0.00 (0.71)	**0.66c (1.08)**	0.00 (0.71)	0.33 (0.91)	0.33 (0.91)	**0.22a (0.85)**	1.00 (1.22)	0.00 (0.71)	0.00 (0.71)	**0.33ab (0.91)**	18.33 (4.34)	8.33 (2.97)	7.33 (2.80)	**11.33a (3.44)**
1st week September	10.00 (3.24)	6.00 (2.55)	5.33 (2.42)	**7.11b (2.76)**	0.67 (1.08)	0.33 (0.91)	0.00 (0.71)	**0.33a (0.91)**	0.33 (0.91)	0.00 (0.71)	0.00 (0.71)	**0.11b (0.78)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00a (0.71)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00b (0.71)**	11.00 (3.39)	6.33 (2.61)	5.33 (2.42)	**7.55b (2.84)**
2nd week September	7.00 (2.74)	3.00 (1.87)	2.00 (1.58)	**4.00c (2.12)**	0.33 (0.91)	0.00 (0.71)	0.00 (0.71)	**0.11a (0.78)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00b (0.71)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00a (0.71)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00b (0.71)**	7.33 (2.80)	3.00 (1.87)	2.00 (1.58)	**4.11c (2.15)**
Mean	**12.19a (3.56)**	**7.42b (2.81)**	**6.38c (2.62)**	**8.65 (3.02)**	**0.66a (1.08)**	**0.57ab (1.03)**	**0.05b (0.73)**	**0.42 (0.96)**	**0.57a (1.03)**	**0.38ab (0.94)**	**0.05b (0.73)**	**0.33 (0.91)**	**0.23a (0.85)**	**0.19a (0.83)**	**0.09a (0.77)**	**0.17 (0.82)**	**0.85a (1.16)**	**0.24b (0.86)**	**0.19b (0.83)**	**0.42 (0.96)**	**14.52a (3.88)**	**8.80b (3.05)**	**6.76c (2.69)**	**10.02 (3.24)**

	Scarabids S.Em.±	Scarabids CD (P=0.05)	Spiders S.Em.±	Spiders CD (P=0.05)	Ants S.Em.±	Ants CD (P=0.05)	Orthoptera S.Em.±	Orthoptera CD (P=0.05)	Others S.Em.±	Others CD (P=0.05)	Total S.Em.±	Total CD (P=0.05)
FS	0.04	0.11	0.06	0.16	0.04	0.12	0.05	NS	0.04	0.12	0.05	0.14
Month (M)	0.06	0.16	0.09	0.25	0.07	0.19	0.07	NS	0.06	0.18	0.08	0.22
FS X M	0.10	0.28	0.15	NS	0.12	0.33	0.12	NS	0.11	0.31	0.13	0.37

OF – Organic farming IF – Integrated farming CF – Conventional farming FS – Farming system

Figures in the parenthesis are √x+0.5 transformed values

In a column or row, means followed by the same alphabet do not differ significantly (P=0.05) by DMRT

4.1.2d Maize

The higher population of macro-arthropods per trap *viz.,* scarabids, spiders, ants, orthoptera and other arthropods was recorded under organic farming (27.93, 0.93, 1.81, 0.42 and 0.48, respectively) fallowed by integrated farming and least in conventional farming system (14.52, 0.26, 0.85, 0.37 and 0.18, respectively) (Table 13).

Irrespective of dates of collection the total macro-arthropods population attained significantly highest in organic farming (31.56) followed by integrated (21.60) and least in conventional farming (16.18). Irrespective of farming systems the total macro arthropod population attained significantly highest during first week of August (41.33) and attained lowest during fourth week of September (5.33). The interaction effect was found significant between different farming systems and dates of collection. Significantly highest macro-arthropods were found in organic farming during first week of August (53.33), whereas, least in conventional farming during fourth week of September (1.00).

4.1.2e Pigeonpea

Pigeonpea grown under organic farming was recorded higher population of macro-arthropods *viz.,* scarabids, spiders, ants, orthoptera and other arthropods (21.87, 0.40, 0.31, 0.40 and 0.24/trap, respectively) followed by integrated farming and least in conventional farming (9.67, 0.20, 0.11, 0.13 and 0.07/trap, respectively) system (Table 14).

Irrespective of dates of collection significant difference in total macro-arthropods population was observed between farming systems. Significantly highest population of total macro-arthropods was recorded in organic farming (23.20) followed by integrated (15.56) and least in conventional farming (10.18). Irrespective of farming systems significant difference in total macro-arthropods were observed between different dates of collection. Significantly highest macro-arthropods were recorded during first week of October (30.67), whereas, least during second week of November (3.00).

4.1.2f Cotton + Groundnut

The higher population of macro-arthropods *viz.,* scarabids, spiders, ants, orthoptera and other arthropods was recorded in organic farming (58.82, 0.69, 0.51, 0.56 and 0.22/trap, respectively) followed by integrated farming and least in conventional farming system (27.40, 0.18, 0.22, 0.11 and 0.04/trap, respectively) (Table 15).

Irrespective of dates of collection the total macro-arthropods population attained significantly highest in organic farming (60.80) followed by integrated (35.02) and least in conventional farming (27.95). Irrespective of farming systems the total macro arthropod population attained significantly highest during first week of October (67.33) and attained lowest during second week of November (11.33). The interaction effect was found significant between different farming systems and dates of collection. Significantly highest macro-arthropods found in organic farming during first week of October (112.33), whereas, least in conventional farming during second week of November (6.67).

4.1.2g Chickpea

Chickpea cultivated under organic farming recorded higher population of macro-arthropods *viz.,* scarabids, spiders, ants, orthoptera and other arthropods (5.27, 0.30, 0.13, 0.17 and 0.23/trap, respectively) followed by integrated farming and least in conventional farming (1.43, 0.10, 0.07, 0.03 and 0.03/trap, respectively) (Table 16).

Table 12: Population of soil macro-arthropods in cowpea under organic, integrated and conventional farming systems during 2015 (per pitfall trap).

Observation period / FS	Scarabids				Spiders				Ants				Orthoptera				Others				Total			
	OF	IF	CF	Mean	OF	IF	CF	Mean	OF	IF	CF	Mean	OF	IF	CF	Mean	OF	IF	CF	Mean	OF	IF	CF	Mean
4th week July	16.33 (4.10)	9.00 (3.08)	6.33 (2.61)	**10.55b (3.32)**	0.67 (1.08)	0.33 (0.91)	0.00 (0.71)	**0.33ab (0.91)**	0.67 (1.08)	0.67 (1.08)	0.33 (0.91)	**0.56ab (1.03)**	0.33 (0.91)	0.67 (1.08)	0.33 (0.91)	**0.44ab (0.97)**	0.67 (1.08)	0.33 (0.91)	0.00 (0.71)	**0.33a (0.91)**	18.67 (4.38)	11.00 (3.39)	7.00 (2.74)	**12.22a (3.57)**
1st week August	16.67 (4.14)	10.67 (3.34)	7.67 (2.86)	**11.67a (3.49)**	1.00 (1.22)	0.67 (1.08)	0.33 (0.91)	**0.67a (1.08)**	1.00 (1.22)	0.33 (0.91)	0.00 (0.71)	**0.44ab (0.97)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00c (0.71)**	0.67 (1.08)	0.33 (0.91)	0.00 (0.71)	**0.33a (0.91)**	19.33 (4.45)	12.00 (3.54)	8.00 (2.92)	**13.11a (3.69)**
2nd week August	13.00 (3.67)	7.67 (2.86)	5.67 (2.48)	**8.78c (3.05)**	0.33 (0.91)	0.33 (0.91)	0.00 (0.71)	**0.22ab (0.85)**	1.33 (13.5)	0.33 (0.91)	0.33 (0.91)	**0.66a (1.08)**	1.00 (1.22)	0.33 (0.91)	0.33 (0.91)	**0.55a (1.03)**	0.33 (0.91)	0.00 (0.71)	0.00 (0.71)	**0.11a (0.78)**	16.00 (4.06)	8.67 (3.03)	6.33 (2.61)	**10.33ab (3.29)**
3rd week August	10.67 (3.34)	5.33 (2.41)	5.00 (2.35)	**7.00d (2.74)**	0.33 (0.91)	0.33 (0.91)	0.33 (0.91)	**0.33ab (0.91)**	0.33 (0.91)	0.00 (0.71)	0.00 (0.71)	**0.11ab (0.78)**	1.33 (1.35)	0.67 (1.08)	0.33 (0.91)	**0.78a (1.13)**	0.33 (0.91)	0.67 (1.08)	0.33 (0.91)	**0.44a (0.97)**	13.00 (3.67)	7.00 (2.74)	6.00 (2.55)	**8.66b (3.03)**
4th week August	13.00 (3.67)	8.00 (2.92)	5.33 (2.41)	**8.78c (3.05)**	0.67 (1.08)	0.00 (0.71)	0.33 (0.91)	**0.33ab (0.91)**	0.67 (1.08)	0.33 (0.91)	0.00 (0.71)	**0.33ab (0.91)**	0.00 (0.71)	0.33 (0.91)	0.00 (0.71)	**0.11bc (0.78)**	0.33 (0.91)	0.33 (0.91)	0.00 (0.71)	**0.22a (0.85)**	14.67 (3.89)	9.00 (3.08)	5.67 (2.48)	**9.78ab (3.21)**
1st week September	5.67 (2.48)	4.67 (2.27)	1.67 (1.47)	**4.00e (2.12)**	0.33 (0.91)	0.00 (0.71)	0.00 (0.71)	**0.11b (0.78)**	0.33 (0.91)	0.33 (0.91)	0.00 (0.71)	**0.22ab (0.85)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00c (0.71)**	0.33 (0.91)	0.00 (0.71)	0.00 (0.71)	**0.11a (0.78)**	6.67 (2.68)	5.00 (2.35)	1.67 (1.47)	**4.44c (2.22)**
2nd week September	3.67 (2.04)	1.33 (1.35)	1.00 (1.22)	**2.00f (1.58)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00b (0.71)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00b (0.71)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00c (0.71)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00a (0.71)**	3.67 (2.04)	1.33 (1.35)	1.00 (1.22)	**2.00d (1.58)**
Mean	**11.29a (3.43)**	**6.67b (2.68)**	**4.67c (2.27)**	**7.54 (2.84)**	**0.48a (0.99)**	**0.24ab (0.86)**	**0.14b (0.80)**	**0.28 (0.89)**	**0.62a (1.06)**	**0.28ab (0.89)**	**0.09b (0.77)**	**0.33 (0.91)**	**0.38a (0.94)**	**0.29a (0.89)**	**0.14a (0.80)**	**0.27 (0.88)**	**0.38a (0.94)**	**0.24ab (0.86)**	**0.05b (0.74)**	**0.22 (0.85)**	**13.14a (3.69)**	**7.71b (2.87)**	**5.09c (2.37)**	**8.65 (3.02)**

	Scarabids S.Em.±	Scarabids CD (P=0.05)	Spiders S.Em.±	Spiders CD (P=0.05)	Ants S.Em.±	Ants CD (P=0.05)	Orthoptera S.Em.±	Orthoptera CD (P=0.05)	Others S.Em.±	Others CD (P=0.05)	Total S.Em.±	Total CD (P=0.05)
FS	0.05	0.15	0.06	0.16	0.07	0.19	0.05	NS	0.05	0.13	0.06	0.17
Month (M)	0.08	0.23	0.09	NS	0.10	NS	0.08	0.23	0.07	NS	0.09	0.27
FS X M	0.14	NS	0.15	NS	0.17	NS	0.14	NS	0.12	NS	0.16	0.46

OF – Organic farming IF – Integrated farming CF – Conventional farming FS – Farming system
Figures in the parenthesis are $\sqrt{x+0.5}$ transformed values
In a column or row, means followed by the same alphabet do not differ significantly (P=0.05) by DMRT

Table 13: Population of soil macro-arthropods in maize under organic, integrated and conventional farming systems during 2015 (per pitfall trap).

Observation period / FS	Scarabids				Spiders				Ants				Orthoptera				Others				Total			
	OF	IF	CF	Mean	OF	IF	CF	Mean	OF	IF	CF	Mean	OF	IF	CF	Mean	OF	IF	CF	Mean	OF	IF	CF	Mean
4th week July	41.00 (6.44)	27.00 (5.24)	18.67 (4.38)	**28.89b (5.42)**	2.67 (1.78)	2.00 (1.58)	0.67 (1.08)	**1.78a (1.51)**	4.33 (2.20)	1.67 (1.47)	2.00 (1.58)	**2.67b (1.78)**	0.33 (0.91)	0.67 (1.08)	0.00 (0.71)	**0.33b (0.91)**	0.33 (0.91)	0.00 (0.71)	0.00 (0.71)	**0.11b (0.78)**	48.66 (7.01)	31.34 (5.64)	21.33 (4.67)	**33.78b (5.85)**
1st week August	48.33 (6.99)	35.00 (5.96)	29.33 (5.46)	**37.55a (6.17)**	1.33 (1.35)	1.00 (1.22)	0.67 (1.08)	**1.00ab (1.22)**	1.33 (1.35)	0.67 (1.08)	0.00 (0.71)	**0.67c (1.08)**	1.00 (1.22)	1.00 (1.22)	2.33 (1.68)	**1.44a (1.39)**	1.33 (1.35)	0.67 (1.08)	0.00 (0.71)	**0.67ab (1.08)**	53.33 (7.34)	38.33 (6.32)	32.33 (5.73)	**41.33a (6.47)**
2nd week August	37.67 (6.18)	29.00 (5.43)	22.33 (4.78)	**29.67b (5.49)**	0.33 (0.91)	0.67 (1.08)	0.00 (0.71)	**0.33bc (0.91)**	1.33 (1.35)	2.33 (1.68)	5.33 (2.42)	**3.00b (1.87)**	1.00 (1.22)	0.33 (0.91)	0.33 (0.91)	**0.55ab (1.03)**	0.33 (0.91)	0.00 (0.71)	0.00 (0.71)	**0.11b (0.78)**	40.67 (6.42)	32.33 (5.73)	28.00 (5.34)	**33.67b (5.85)**
3rd week August	25.00 (5.05)	17.67 (4.26)	15.00 (3.94)	**19.22c (4.44)**	1.33 (1.35)	0.67 (1.08)	1.00 (1.22)	**1.00ab (1.22)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00d (0.71)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00b (0.71)**	0.67 (1.08)	1.00 (1.22)	1.33 (1.35)	**1.00a (1.22)**	27.00 (5.24)	19.33 (4.45)	17.33 (4.22)	**21.22c (4.66)**
4th week August	36.00 (6.04)	25.67 (5.12)	20.33 (4.56)	**27.33b (5.28)**	0.33 (0.91)	0.00 (0.71)	0.00 (0.71)	**0.11bc (0.78)**	9.00 (3.08)	6.00 (2.55)	0.00 (0.71)	**5.00a (2.35)**	1.00 (1.22)	0.33 (0.91)	0.33 (0.91)	**0.59ab (1.04)**	0.33 (0.91)	0.00 (0.71)	0.00 (0.71)	**0.11b (0.78)**	46.67 (6.87)	32.00 (5.70)	20.67 (4.60)	**33.11b (5.80)**
1st week September	21.00 (4.64)	14.00 (3.81)	10.00 (3.24)	**15.00d (3.94)**	1.67 (1.47)	0.67 (1.08)	0.00 (0.71)	**0.78abc (1.13)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00d (0.71)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00b (0.71)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00b (0.71)**	23.00 (4.85)	14.67 (3.89)	10.00 (3.24)	**15.78d (4.03)**
2nd week September	21.67 (4.71)	15.00 (3.94)	11.67 (3.49)	**16.11cd (4.08)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00c (0.71)**	0.00 (0.71)	0.67 (1.08)	0.33 (0.91)	**0.33cd (0.91)**	0.33 (0.91)	0.00 (0.71)	0.00 (0.71)	**0.11b (0.78)**	1.00 (1.22)	0.67 (1.08)	0.00 (0.71)	**0.56ab (1.03)**	23.67 (4.92)	16.34 (4.10)	12.00 (3.54)	**17.11cd (4.20)**
3rd week September	10.33 (3.29)	6.00 (2.55)	2.33 (1.68)	**6.22e (2.59)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00c (0.71)**	0.33 (0.91)	0.00 (0.71)	0.00 (0.71)	**0.11d (0.78)**	0.00 (0.71)	0.00 (0.71)	0.33 (0.91)	**0.11b (0.78)**	0.33 (0.91)	0.00 (0.71)	0.33 (0.91)	**0.22ab (0.85)**	10.00 (3.39)	6.00 (2.55)	3.00 (1.87)	**6.66e (2.68)**
4th week September	10.33 (3.29)	3.67 (2.04)	1.00 (1.22)	**5.00ee (2.35)**	0.67 (1.08)	0.00 (0.71)	0.00 (0.71)	**0.22 bc (0.85)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00d (0.71)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00b (0.71)**	0.00 (0.71_	0.33 (0.91)	0.00 (0.71)	**0.11b (0.78)**	11.00 (3.39)	4.00 (2.12)	1.00 (1.22)	**5.33f (2.42)**
Mean	**27.93a (5.33)**	**19.22b (4.44)**	**14.52c (3.88)**	**20.56 (4.59)**	**0.93a (1.19)**	**0.56b (1.03)**	**0.26c (0.87)**	**0.58 (1.04)**	**1.81a (1.52)**	**1.26b (1.32)**	**0.85c (1.16)**	**1.30 (1.34)**	**0.42a (0.96)**	**0.26a (0.87)**	**0.37a (0.93)**	**0.35 (0.92)**	**0.48a (0.99)**	**0.30b (0.89)**	**0.18c (0.83)**	**0.32 (0.91)**	**31.56a (5.66)**	**21.60b (4.70)**	**16.18c (4.08)**	**23.11 (4.86)**

	Scarabids		Spiders		Ants		Orthoptera		Others		Total	
	S.Em.±	CD (P=0.05)	S.Em.±	CD (P=0.05)	S.Em.±	CD (P=0.05)	S.Em.±	CD (P=0.05)	S.Em.±	CD (P=0.05)	S.Em.±	CD (P=0.05)
FS	0.05	0.15	0.05	0.15	0.03	0.09	0.04	NS	0.04	0.13	0.06	0.16
Month (M)	0.09	0.26	0.09	0.25	0.05	0.15	0.07	0.21	0.08	0.22	0.10	0.28
FS X M	0.16	NS	0.15	NS	0.09	0.26	0.13	NS	0.13	NS	0.17	0.48

OF – Organic farming IF – Integrated farming CF – Conventional farming FS – Farming system

Figures in the parenthesis are √x+0.5 transformed values

In a column or row, means followed by the same alphabet do not differ significantly (P=0.05) by DMRT

Table 14: Population of soil macro-arthropods in pigeonpea under organic, integrated and conventional farming systems during 2015 (per pitfall trap).

Observation period FS	Scarabids				Spiders				Ants				Orthoptera				Others				Total			
	OF	IF	CF	Mean	OF	IF	CF	Mean	OF	IF	CF	Mean	OF	IF	CF	Mean	OF	IF	CF	Mean	OF	IF	CF	Mean
4th week July	27.33 (5.28)	24.00 (4.95)	12.33 (3.58)	**21.22d (4.66)**	1.00 (1.22)	1.00 (1.22)	1.332 (1.35)	**1.11a (1.27)**	1.00 (1.22)	0.00 (0.71)	0.00 (0.71)	**0.33a (0.91)**	2.00 (1.58)	0.67 (1.08)	0.00 (0.71)	**0.89a (1.18)**	1.33 (1.35)	0.00 (0.71)	0.00 (0.71)	**0.44ab (0.97)**	32.67 (5.76)	25.67 (5.12)	13.67 (3.76)	**24.00c (4.95)**
1st week August	35.00 (5.96)	24.67 (5.02)	19.67 (4.49)	**26.44b (5.19)**	1.00 (1.22)	1.00 (1.22)	0.67 (1.08)	**0.89ab (1.18)**	0.67 (1.08)	0.00 (0.71)	0.33 (0.91)	**0.33a (0.91)**	1.33 (1.35)	1.33 (1.35)	0.00 (0.71)	**0.89a (1.18)**	0.00 (0.71)	0.67 (1.08)	0.00 (0.71)	**0.22ab (0.85)**	38.00 (6.20)	27.67 (5.37)	20.67 (4.60)	**28.78b (5.41)**
2nd week August	24.00 (4.95)	17.33 (4.22)	12.33 (3.58)	**17.89e (4.29)**	0.67 (1.08)	0.00 (0.71)	0.00 (0.71)	**0.22bc (0.85)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00a (0.71)**	0.33 (0.91)	0.00 (0.71)	0.67 (1.08)	**0.33ab (0.91)**	0.67 (1.08)	0.00 (0.71)	0.00 (0.71)	**0.22ab (0.85)**	25.67 (5.12)	17.33 (4.22)	13.00 (3.67)	**18.67e (4.38)**
3rd week August	21.00 (4.64)	18.00 (4.30)	12.33 (3.58)	**17.11f (4.20)**	0.67 (1.08)	0.67 (1.08)	0.33 (0.91)	**0.56abc (1.03)**	0.67 (1.08)	0.67 (1.08)	0.00 ()0.71	**0.44a (0.97)**	0.33 (0.91)	0.33 (0.91)	0.00 (0.71)	**0.22ab (0.85)**	1.00 (1.22)	1.00 (1.22)	0.67 (1.08)	**0.89a (1.18)**	23.67 (4.92)	20.00 (4.53)	13.33 (3.72)	**19.00e (4.42)**
4th week August	31.00 (5.61)	21.00 (4.64)	14.33 (3.85)	**22.11c (4.76)**	1.00 (1.22)	0.00 (0.71)	0.67 (1.08)	**0.56abc (1.03)**	1.00 (1.22)	0.33 (0.91)	0.33 (0.91)	**0.55a (1.03)**	0.00 (0.71)	0.00 (0.71)	0.67 (1.08)	**0.22ab (0.85)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00b (0.71)**	33.00 (5.79)	21.33 (4.67)	16.00 (4.06)	**23.44c (4.89)**
1st week September	19.00 (4.42)	12.33 (3.58)	7.33 (2.80)	**12.89h (3.66)**	0.33 (0.91)	0.33 (0.91)	0.00 (0.71)	**0.22bc (0.85)**	0.00 (0.71)	0.00 (0.71)	0.33 (0.91)	**0.11a (0.78)**	1.00 (1.22)	0.00 (0.71)	0.00 (0.71)	**0.33ab (0.91)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00b (0.71)**	20.33 (4.56)	12.67 (3.63)	7.67 (2.86)	**13.56g (3.75)**
2nd week September	22.33 (4.78)	13.33 (3.72)	10.00 (3.24)	**15.22g (3.96)**	0.33 (0.91)	0.00 (0.71)	0.00 (0.71)	**0.11c (0.78)**	0.00 (0.71)	0.33 (0.91)	0.33 (0.91)	**0.22a (0.85)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00b (0.71)**	0.67 (1.08)	0.00 (0.71)	0.00 (0.71)	**0.22ab (0.85)**	23.33 (4.88)	13.67 (3.76)	10.33 (3.29)	**15.78f (4.03)**
3rd week September	18.00 (4.30)	10.33 (3.29)	6.67 (2.68)	**11.67i (3.49)**	0.33 (0.91)	0.33 (0.91)	0.00 (0.71)	**0.22bc (0.85)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00a (0.71)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00b (0.71)**	0.00 (0.71)	0.67 (1.08)	0.00 (0.71)	**0.22ab (0.85)**	18.33 (4.34)	11.33 (3.44)	6.67 (2.68)	**12.11h (3.55)**
4th week September	12.67 (3.63)	9.67 (3.19)	4.00 (2.12)	**8.78k (3.05)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00c (0.71)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00a (0.71)**	0.33 (0.91)	0.00 (0.71)	0.33 (0.91)	**0.22ab (0.85)**	0.00 (0.71)	0.00 (0.71)	0.33 (0.91)	**0.11b (0.78)**	13.00 (3.67)	9.67 (3.19)	4.67 (2.27)	**9.11j (3.10)**
1st week October	41.33 (6.47)	30.00 (4.52)	19.00 (4.42)	**30.11a (5.53)**	0.67 (1.08)	0.00 (0.71)	0.00 (0.71)	**0.22bc (0.85)**	0.33 (0.91)	0.67 (1.08)	0.00 (0.71)	**0.33a (0.91)**	0.00 (0.71)	0.33 (0.91)	0.00 (0.71)	**0.11b (0.78)**	0.00 (0.71)	0.33 (0.91)	0.00 (0.71)	**0.11b (0.78)**	42.33 (6.54)	30.67 (5.58)	19.00 (4.42)	**30.67a (5.58)**
2nd week October	30.00 (5.52)	19.33 (4.45)	16.67 (4.14)	**22.00c (4.74)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00c (0.71)**	0.67 (1.08)	0.00 (0.71)	0.33 (0.91)	**0.33a (0.91)**	0.00 (0.71)	0.33 (0.91)	0.00 (0.71)	**0.11b (0.78)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00b (0.71)**	30.67 (5.58)	19.67 (4.49)	17.00 (4.18)	**22.44d (4.79)**
3rd week October	17.67 (4.26)	9.00 (3.08)	4.00 (2.12)	**10.22j (3.27)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00c (0.71)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00a (0.71)**	0.67 (1.08)	0.00 (0.71)	0.33 (0.91)	**0.33ab (0.91)**	0.00 (0.71)	0.67 (1.08)	0.00 (0.71)	**0.22ab (0.85)**	18.33 (4.34)	9.67 (3.19)	4.33 (2.20)	**10.78i (3.36)**
4th week October	13.00 (3.67)	8.67 (3.03)	5.00 (2.35)	**8.89k (3.06)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00c (0.71)**	0.33 (0.91)	0.00 (0.71)	0.00 (0.71)	**0.11a (0.78)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00b (0.71)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00b (0.71)**	13.33 (3.72)	8.67 (3.03)	5.00 (2.35)	**9.00j (3.08)**
1st week of November	9.33 (3.14)	3.00 (1.87)	1.00 (1.22)	**4.44l (2.22)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00c (0.71)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00a (0.71)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00b (0.71)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00b (0.71)**	9.00 (3.14)	3.00 (1.87)	1.00 (1.22)	**4.44k (2.22)**
2nd week of November	6.33 (2.61)	2.33 (1.68)	0.33 (0.91)	**3.00m (1.87)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00c (0.71)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00a (0.71)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00b (0.71)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00b (0.71)**	6.33 (2.61)	2.33 (1.68)	0.33 (0.91)	**3.00l (1.87)**
Mean	**21.87a (4.73)**	**14.87b (3.92)**	**9.67c (3.19)**	**15.47 (4.00)**	**0.40a (0.95)**	**0.22b (0.85)**	**0.20b (0.84)**	**0.27 (0.88)**	**0.31a (0.90)**	**0.13b (0.80)**	**0.11b (0.78)**	**0.16 (0.81)**	**0.40a (0.95)**	**0.20b (0.84)**	**0.13b (0.80)**	**0.24 (0.86)**	**0.24a (0.86)**	**0.22a (0.85)**	**0.07b (0.75)**	**0.18 (0.82)**	**23.20a (4.87)**	**15.56b (4.01)**	**10.18c (3.27)**	**16.31 (4.10)**

	Scarabids S.Em.±	Scarabids CD (P=0.05)	Spiders S.Em.±	Spiders CD (P=0.05)	Ants S.Em.±	Ants CD (P=0.05)	Orthoptera S.Em.±	Orthoptera CD (P=0.05)	Others S.Em.±	Others CD (P=0.05)	Total S.Em.±	Total CD (P=0.05)
FS	0.06	0.17	0.03	0.09	0.03	0.08	0.03	0.09	0.03	0.08	0.06	0.17
Month (M)	0.13	0.37	0.07	0.19	0.06	NS	0.07	0.20	0.07	0.19	0.14	0.38
FSXM	0.23	NS	0.12	NS	0.11	NS	0.12	0.34	0.12	NS	0.24	NS

OF – Organic farming IF – Integrated farming CF – Conventional farming FS – Farming system

Figures in the parenthesis are √x+0.5 transformed values

In a column or row, means followed by the same alphabet do not differ significantly (P=0.05) by DMRT

Table 15: Population of soil macro-arthropods in cotton intercropped with groundnut under organic, integrated and conventional farming systems during 2015 (per pitfall trap).

Observation period / FS	Scarabids				Spiders				Ants				Orthoptera				Others				Total			
	OF	IF	CF	Mean	OF	IF	CF	Mean	OF	IF	CF	Mean	OF	IF	CF	Mean	OF	IF	CF	Mean	OF	IF	CF	Mean
4th week July	60.00 (7.78)	51.67 (7.22)	33.33 (5.52)	**48.33bcde (6.99)**	3.67 (2.04)	1.67 (1.47)	1.00 (1.22)	**2.11a (1.62)**	1.00 (1.22)	1.67 (1.47)	2.33 (1.68)	**1.67a (1.47)**	0.33 (0.91)	0.00 (0.71)	0.33 (0.91)	**0.33a (0.91)**	0.33 (0.91)	0.00 (0.71)	0.00 (0.71)	**0.11a (0.78)**	65.33 (8.11)	55.00 (7.45)	37.00 (6.12)	**52.44bc (7.28)**
1st week August	70.00 (8.40)	53.00 (7.31)	31.67 (5.67)	**51.56bc (7.22)**	1.67 (1.47)	1.00 (1.22)	0.33 (0.91)	**1.00b (1.22)**	0.33 (0.91)	0.00 (0.71)	0.00 (0.71)	**0.11c (0.78)**	0.67 (1.08)	0.33 (0.91)	0.00 (0.71)	**0.33a (0.91)**	0.33 (0.91)	0.00 (0.71)	0.33 (0.91)	**0.22a (0.85)**	73.00 (8.57)	54.33 (7.40)	32.33 (5.73)	**53.22abc (7.33)**
2nd week August	46.67 (6.87)	35.00 (5.96)	26.67 (5.21)	**36.11ef (6.05)**	**1.00** (1.22)	0.33 (0.71)	0.00 (0.71)	**0.44bc (0.97)**	0.00 (0.71)	1.00 (1.22)	0.00 (0.71)	**0.33bc (0.91)**	1.00 (1.72)	0.33 (0.91)	0.00 (0.71)	**0.44a (0.97)**	0.33 (0.91)	0.00 (0.71)	0.00 (0.71)	**0.11a (0.78)**	49.00 (7.04)	36.33 (6.07)	26.67 (5.21)	**37.33ef (6.15)**
3rd week August	43.33 (6.62)	35.00 (5.96)	33.33 (5.82)	**37.22def (6.14)**	0.33 (0.91)	0.00 (0.71)	0.00 (0.71)	**0.11bc (0.78)**	2.33 (1.68)	0.00 (0.71)	0.33 (0.91)	**0.89ab (1.18)**	0.33 (0.91)	0.00 (0.71)	0.00 (0.71)	**0.11a (0.78)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00a (0.71)**	46.33 (6.84)	35.00 (5.96)	33.67 (5.85)	**38.33def (6.23)**
4th week August	83.33 (9.16)	42.33 (6.54)	36.67 (6.10)	**54.11ab (7.39)**	1.33 (1.35)	0.67 (1.08)	0.33 (0.91)	**0.78bc (1.13)**	1.00 (1.22)	0.00 (0.71)	0.33 (0.91)	**0.44bc (0.97)**	1.33 (1.35)	0.67 (1.08)	0.33 (0.91)	**0.78a (1.13)**	1.00 (1.22)	0.67 (1.08)	0.00 (0.71)	**0.56a (1.03)**	88.00 (9.41)	44.33 (6.70)	37.67 (6.18)	**56.67ab (7.56)**
1st week September	68.33 (8.3)	38.33 (6.23)	31.67 (5.67)	**46.11bcde (6.83)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00c (0.71)**	0.00 (0.71)	0.33 (0.91)	0.00 (0.71)	**0.11c (0.78)**	0.33 (0.91)	0.67 (1.08)	0.33 (0.91)	**0.44a (0.97)**	0.33 (0.91)	0.33 (0.91)	0.00 (0.71)	**0.22a (0.85)**	69.00 (8.34)	**40.00** (6.36)	32.00 (5.70)	**47.00bcde (6.89)**
2nd week September	73.33 (8.59)	35.00 (5.96)	38.33 (6.23)	**48.89bcd (7.03)**	0.67 (1.08)	0.33 (0.91)	0.00 (0.71)	**0.33bc (0.91)**	1.67 (1.47)	1.00 (1.22)	0.00 (0.71)	**0.89ab (1.18)**	0.67 (1.08)	0.33 (0.91)	0.00 (0.71)	**0.33a (0.91)**	0.33 (0.91)	0.33 (0.91)	0.00 (0.71)	**0.22a (0.85)**	76.67 (8.78)	37.00 (6.12)	38.33 (6.23)	**50.67bcd (7.15)**
3rd week September	66.67 (8.20)	30.00 (5.52)	21.67 (5.21)	**39.45cdef (6.32)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00c (0.71)**	0.67 (1.08)	0.33 (0.91)	0.00 (0.71)	**0.33bc (0.91)**	0.67 (1.08)	0.00 (0.71)	0.00 (0.71)	**0.22a (0.85)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00a (0.71)**	68.00 (8.28)	30.33 (5.55)	21.67 (4.71)	40.00cdef **(6.36)**
4th week September	45.00 (6.75)	26.67 (5.21)	23.33 (4.88)	**31.67fg (5.67)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00c (0.71)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00c (0.71)**	0.33 (0.91)	0.00 (0.71)	0.33 (0.91)	**0.22a (0.85)**	0.00 (0.71)	0.00 (0.71)	0.33 (0.91)	**0.11a (0.78)**	45.33 (6.77)	26.67 (4.71)	24.00 (4.95)	**32.00f (5.70)**
1st week October	110.00 (10.51)	50.00 (7.11)	38.33 (6.23)	**66.11a (8.16)**	1.00 (1.22)	0.33 (0.91)	0.33 (0.91)	**0.55bc (1.03)**	0.33 (0.91)	0.00 (0.71)	0.00 (0.71)	**0.11c (0.78)**	1.00 (1.22)	0.33 (0.91)	0.00 (0.71)	**0.44a (0.97)**	0.00 (0.71)	0.33 (0.91)	0.00 (0.71)	**0.11a (0.78)**	112.33 (10.62)	51.00 (7.18)	38.67 (6.26)	**67.33a (8.24)**
2nd week October	78.33 (8.88)	40.00 (6.36)	36.67 (5.76)	**51.67bc (7.22)**	0.00 (0.71)	0.33 (0.91)	0.00 (0.71)	**0.11bc (0.78)**	0.00 (0.71)	0.00 (0.71)	0.33 (0.91)	**0.11c (0.78)**	0.00 (0.71)	0.33 (0.91)	0.00 (0.71)	**0.11a (0.78)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00a (0.71)**	78.33 (8.88)	40.67 (6.42)	37.00 (6.12)	**52.00bcd (7.25)**
3rd week October	46.67 (6.87)	20.00 (4.53)	**26.67** (5.21)	**31.11fg (5.62)**	0.00 (0.71)	0.00 (0.71)	0.33 (0.91)	**0.11bc (0.78)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00c (0.71)**	0.67 (1.08)	0.00 (0.71)	0.33 (0.91)	**0.33a (0.91)**	0.67 (1.08)	0.67 (1.08)	0.00 (0.71)	**0.45a (0.97)**	48.00 (6.96)	20.67 (4.60)	27.33 (5.28)	**32.00f (5.70)**
4th week October	48.33 (6.99)	29.33 (5.46)	15.00 (3.94)	**30.89g (5.06)**	0.33 (0.91)	0.33 (0.91)	0.00 (0.71)	**0.22bc (0.85)**	0.33 (0.91)	0.00 (0.71)	0.00 (0.71)	**0.11c (0.78)**	0.67 (1.08)	0.00 (0.71)	0.00 (0.71)	**0.22a (0.85)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00a (0.71)**	49.67 (7.08)	29.67 (5.49)	15.00 (3.94)	**31.45f (5.65)**
1st week of November	22.33 (4.78)	16.67 (4.14)	11.00 (3.39)	**16.67h (4.14)**	0.33 (0.91)	0.33 (0.91)	0.33 (0.91)	**0.33bc (0.91)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00c (0.71)**	0.33 (0.91)	0.00 (0.71)	0.00 (0.71)	**0.00a (0.71)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.11a (0.78)**	23.00 (4.85)	17.00 (4.18)	11.33 (3.44)	**17.11g (4.20)**
2nd week of November	20.00 (4.53)	7.33 (2.80)	6.67 (2.68)	**11.33h (3.43)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00c (0.71)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00c (0.71)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00a (0.71)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.11a (0.78)**	20.00 (4.53)	7.33 (2.80)	6.67 (2.68)	**11.33g (3.44)**
Mean	**58.82a (7.70)**	**34.02b (5.88)**	**27.40c (5.28)**	**40.08 (6.37)**	**0.69a (1.09)**	**0.35b (0.92)**	**0.18c (0.82)**	**0.41 (0.95)**	**0.51a (1.01)**	**0.29b (0.89)**	**0.22b (0.85)**	**0.34 (0.92)**	**0.56a (1.03)**	**0.21b (0.85)**	**0.11b (0.78)**	**0.30 (0.89)**	**0.22a (0.85)**	**0.16ab (0.81)**	**0.04c (0.74)**	**0.41 (0.80)**	**60.80a (7.83)**	**35.02b (5.96)**	**27.95c (5.33)**	**41.26 (6.46)**

	Scarabids S.Em.±	Scarabids CD (P=0.05)	Spiders S.Em.±	Spiders CD (P=0.05)	Ants S.Em.±	Ants CD (P=0.05)	Orthoptera S.Em.±	Orthoptera CD (P=0.05)	Others S.Em.±	Others CD (P=0.05)	Total S.Em.±	Total CD (P=0.05)
FS	0.08	0.22	0.03	0.10	0.03	0.09	0.04	0.10	0.03	0.08	0.08	0.22
Month (M)	0.17	0.49	0.08	0.22	0.07	0.20	0.08	NS	0.06	0.17	0.18	0.50
FSXM	0.30	0.84	0.14	NS	0.12	0.35	0.14	NS	0.10	NA	0.31	0.87

OF – Organic farming IF – Integrated farming CF – Conventional farming FS – Farming system

Figures in the parenthesis are √x+0.5 transformed values

In a column or row, means followed by the same alphabet do not differ significantly (P=0.05) by DMRT

Irrespective of dates of collection the total macro-arthropods population attained significantly highest in organic farming (6.13) followed by integrated (3.40) and least in conventional farming (1.63). Irrespective of farming systems the total macro arthropod population attained significantly highest during first week of October (10.33) and attained lowest during fourth week of December (0.11). The interaction effect was found significant between different farming systems and dates of collection. Significantly highest macro-arthropods found in organic farming during first week of October (15.33), whereas, no macro-arthropods recorded in conventional farming during third and fourth week of December.

4.1.2h *Rabi* sorghum

The higher population of macro-arthropods *viz.,* scarabids, spiders, ants, orthoptera and other arthropods (6.09, 0.27, 0.45, 0.12 and 0.24 respectively) was recorded in organic farming fallowed by integrated farming and least population of scarabids, spiders, ants, orthoptera and other arthropods was noticed in conventional farming (2.09, 0.09, 0.15, 0.00 and 0.036 respectively) system (Table 17).

Irrespective of dates of collection the total macro-arthropods population attained significantly highest in organic farming (7.18) followed by integrated (4.15) and least in conventional farming (2.39). Irrespective of farming systems the total macro arthropod population attained significantly highest during first week of October (11.67) and attained lowest during fourth week of December (0.44). The interaction effect was found significant between different farming systems and dates of collection. Significantly highest macro-arthropods found in organic farming during first week of October (18.67), whereas, no macro-arthropods recorded in conventional farming during third week of December.

4.1.2i Total population of macro-arthropods in different crops under organic, integrated and conventional farming systems during 2015-16 (per trap)

Significantly higher population of total macro-arthropods was recorded in organic farming (20.99/trap) followed by integrated (12.85/trap) and least in conventional farming (9.34/trap) (Table 18).

Across the different crops, soybean recorded more population (10.02/trap) of total macro-arthropods compared to cowpea (8.65/trap) and greengram (7.47/trap) in short duration crops. Among long duration crops, cotton intercropped with groundnut recorded highest (41.26/trap) compared to pigeonpea (16.31/trap). In *rabi* crops *rabi* sorghum recorded more population (4.57/trap) of total macro-arthropods compared to chickpea (3.75/trap). Overall cotton intercropped with groundnut recorded more population (41.26/trap) followed by maize (23.11/trap), pigeonpea (16.31/trap) and least in chickpea (3.75/trap).

4.1.2j Assessment of Shannon's diversity index of the soil arthropods (meso and macro) in different crops under organic, integrated and conventional farming systems during 2015-16.

Shannon's weaver index of general diversity was calculated and analysed for soil arthropod diversity. Among the farming systems, organic farming has recorded the higher diversity index (0.68) followed by integrated (0.62) and conventional farming (0.52). Among the different crops grown under organic farming system *viz*., greengram, soybean, cowpea, maize pigeonpea, cotton + groungnut, chickpea and *rabi* sorghum recorded diversity index (0.79, 0.80, 0.75, 0.63, 0.62, 0.59, 0.53 and 0.69, respectively) followed by integrated and least diversity index in conventional farming (0.57, 0.58, 0.54, 0.50, 0.50, 0.51, 0.43 and 0.56, respectively) (Table 19).

Table 16: Population of soil macro-arthropods in chickpea under organic, integrated and conventional farming systems during 2015-16 (per pitfall trap).

Observation period FS	Scarabids				Spiders				Ants				Orthoptera				Others				Total			
	OF	IF	CF	Mean	OF	IF	CF	Mean	OF	IF	CF	Mean	OF	IF	CF	Mean	OF	IF	CF	Mean	OF	IF	CF	Mean
3rd week October	13.00 (3.67)	8.33 (2.97)	4.00 (2.12)	**8.44a (2.99)**	0.67 (1.08)	0.33 (0.91)	0.67 (1.08)	**0.56a (1.03)**	0.67 (1.08)	1.00 (1.22)	0.00 (0.71)	**0.56a (1.03)**	1.00 (1.22)	0.67 (1.08)	0.00 (0.71)	**0.56a (1.03)**	0.00 (0.71)	0.67 (1.08)	0.00 (0.71)	**0.22a (0.85)**	15.33 (3.98)	11.00 (3.39)	4.67 (2.27)	**10.33a (3.29)**
4th week October	10.33 (3.29)	8.00 (2.92)	5.00 (2.35)	**7.78a (2.88)**	1.00 (1.22)	0.33 (0.91)	0.00 (0.71)	**0.44a (0.97)**	0.00 (0.71)	0.00 (0.71)	0.33 (0.91)	**0.11a (0.78)**	0.33 (0.91)	0.00 (0.71)	0.00 (0.71)	**0.11a (0.78)**	1.00 (1.22)	0.33 (0.91)	0.00 (0.71)	**0.44a (0.97)**	12.67 (3.63)	8.67 (3.03)	5.33 (2.42)	**8.89a (3.06)**
1st week November	8.00 (2.92)	3.00 (1.87)	2.33 (1.68)	**4.44b (2.22)**	0.67 (1.08)	0.33 (0.91)	0.00 (0.71)	**0.33a (0.91)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00a (0.71)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00a (0.71)**	0.33 (0.91)	0.67 (1.08)	0.00 (0.71)	**0.33a (0.91)**	9.00 (3.08)	4.00 (2.12)	2.33 (1.68)	**5.11b (2.37)**
2nd week November	5.00 (2.35)	2.33 (1.68)	0.33 (0.91)	**2.55c (1.75)**	0.00 (0.71)	0.00 (0.71)	0.33 (0.91)	**0.11a (0.78)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00a (0.71)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00a (0.71)**	0.67 (1.08)	0.00 (0.71)	0.00 (0.71)	**0.22a (0.85)**	5.67 (2.48)	2.33 (1.68)	0.67 (1.08)	**2.89bcd (1.84)**
3rd week November	5.00 (2.35)	2.00 (1.58)	0.33 (0.91)	**2.44c (1.72)**	0.33 (0.91)	0.00 (0.71)	0.00 (0.71)	**0.11a (0.78)**	0.33 (0.91)	0.00 (0.71)	0.00 (0.71)	**0.11a (0.78)**	0.00 (0.71)	0.33 (0.91)	0.00 (0.71)	**0.11a (0.78)**	0.33 (0.91)	0.00 (0.71)	0.33 (0.91)	**0.22a (0.85)**	6.00 (2.55)	2.33 (1.68)	0.67 (1.08)	**3.00bc (1.87)**
4th week November	4.67 (2.27)	1.67 (1.47)	0.67 (1.08)	**2.34c (1.68)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00a (0.71)**	0.00 (0.71)	0.00 (0.71)	0.33 (0.91)	**0.11a (0.78)**	0.33 (0.91)	0.00 (0.71)	0.00 (0.71)	**0.11a (0.78)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00a (0.70)**	5.00 (2.35)	1.67 (1.47)	1.00 (1.22)	**2.56cde (1.75)**
1st week December	3.33 (1.96)	2.00 (1.58)	0.67 (1.08)	**2.00c (1.58)**	0.33 (0.91)	0.67 (1.08)	0.00 (0.71)	**0.33a (0.91)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00a (0.71)**	0.00 (0.71)	0.33 (0.91)	0.00 (0.71)	**0.11a (0.78)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00a (0.71)**	3.67 (2.04)	3.00 (1.87)	0.67 (1.08)	**2.45def (1.72)**
2nd week December	1.00 (1.22)	0.00 (0.71)	0.67 (1.08)	**0.56de (1.03)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00a (0.71)**	0.33 (0.91)	0.00 (0.71)	0.00 (0.71)	**0.11a (0.78)**	0.00 (0.71)	0.00 (0.71)	0.33 (0.91)	**0.11a (0.78)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00a (0.71)**	1.33 (1.35)	0.00 (0.71)	1.00 (1.22)	0.78def (1.13)
3rd week December	2.33 (1.68)	1.00 (1.22)	0.00 (0.71)	**1.11cd (1.27)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00a (0.71)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00a (0.71)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00a (0.71)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00a (0.71)**	2.33 (1.68)	1.00 (1.22)	0.00 (0.71)	**1.11f (1.27)**
4th week December	0.00 (0.71)	0.00 (0.71)	0.33 (0.91)	**0.11e (0.78)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00a (0.71)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00a (0.71)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00a (0.71)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00a (0.71)**	0.33 (0.91)	0.00 (0.71)	0.00 (0.71)	**0.11ef (0.78)**
Mean	**5.27a (2.40)**	**2.83b (1.83)**	**1.43c (1.39)**	**3.18 (1.92)**	**0.30a (0.89)**	**0.16ab (0.82)**	**0.10b (0.77)**	**0.18 (0.83)**	**0.13a (0.80)**	**0.10a (0.77)**	**0.07a (0.75)**	**0.10 (0.77)**	**0.17a (0.82)**	**0.13a (0.80)**	**0.03b (0.73)**	**0.11 (0.78)**	**0.23a (0.86)**	**0.17a (0.82)**	**0.03b (0.73)**	**0.14 (0.80)**	**6.13a (2.58)**	**3.40b (1.97)**	**1.63c (1.46)**	**3.75 (2.05)**

	Scarabids S.Em.±	Scarabids CD (P=0.05)	Spiders S.Em.±	Spiders CD (P=0.05)	Ants S.Em.±	Ants CD (P=0.05)	Orthoptera S.Em.±	Orthoptera CD (P=0.05)	Others S.Em.±	Others CD (P=0.05)	Total S.Em.±	Total CD (P=0.05)
FS	0.05	0.14	0.04	0.12	0.02	NS	0.03	0.08	0.04	0.10	0.05	0.15
Month (M)	0.09	0.26	0.08	NS	0.04	NS	0.05	NS	0.06	NS	0.10	0.27
FS X M	0.16	0.45	0.14	NS	0.07	NS	0.09	NS	0.11	NS	0.17	0.47

OF – Organic farming IF – Integrated farming CF – Conventional farming FS – Farming system

Figures in the parenthesis are $\sqrt{x+0.5}$ transformed values

In a column or row, means followed by the same alphabet do not differ significantly (P=0.05) by DMRT

Table 17: Population of soil macro-arthropods in *rabi* sorghum under organic, integrated and conventional farming systems during 2015-16 (per pitfall trap).

Observation period FS	Scarabids				Spiders				Ants				Orthoptera				Others				Total			
	OF	IF	CF	Mean	OF	IF	CF	Mean	OF	IF	CF	Mean	OF	IF	CF	Mean	OF	IF	CF	Mean	OF	IF	CF	Mean
3rd week October	16.33 (4.10)	9.67 (3.19)	5.00 (2.35)	**10.33 (3.29)**	0.67 (1.08)	0.33 (0.91)	0.67 (1.08)	**0.56a (1.03)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00a (0.71)**	1.00 (1.22)	0.67 (1.08)	0.00 (0.71)	**0.56a (1.03)**	0.67 (1.08)	0.00 (0.71)	0.00 (0.71)	**0.22a (0.85)**	18.67 (4.38)	10.67 (3.34)	5.67 (2.48)	**11.67a (3.49)**
4th week October	14.67 (3.89)	8.67 (3.03)	5.67 (2.48)	**9.67 (3.19)**	1.00 (1.22)	0.33 (0.91)	0.00 (0.71)	**0.44a (0.97)**	0.33 (0.91)	0.00 (0.71)	0.00 (0.71)	**0.11a (0.78)**	0.33 (0.91)	0.00 (0.71)	0.00 (0.71)	**0.11b (0.78)**	0.33 (0.91)	0.67 (1.08)	0.00 (0.71)	**0.33a (0.91)**	16.67 (4.14)	9.67 (3.19)	5.67 (2.48)	**10.67a (3.34)**
1st week November	12.00 (3.54)	8.00 (2.92)	7.33 (2.80)	**9.11 (3.10)**	0.67 (1.08)	0.33 (0.91)	0.00 (0.71)	**0.33a (0.91)**	0.67 (1.08)	0.33 (0.91)	0.00 (0.71)	**0.33a (0.91)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00b (0.71)**	0.67 (1.08)	0.00 (0.71)	0.00 (0.71)	**0.22a (0.85)**	14.01 (3.81)	8.66 (3.03)	7.33 (2.80)	**10.00a (3.24)**
2nd week November	9.00 (3.08)	4.33 (2.20)	2.00 (1.58)	**5.11 (2.37)**	0.00 (0.71)	0.00 (0.71)	0.33 (0.91)	**0.11a (0.78)**	1.00 (1.22)	1.33 (1.35)	0.00 (0.71)	**0.77a (1.13)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00b (0.71)**	0.00 (0.71)	0.67 (1.08)	0.33 (0.91)	**0.33a (0.91)**	10.00 (3.24)	6.33 (2.61)	2.67 (1.78)	**6.34b (2.61)**
3rd week November	5.67 (2.48)	2.67 (1.78)	0.67 (1.08)	**3.00 (1.87)**	0.33 (0.91)	0.00 (0.71)	0.00 (0.71)	**0.11a (0.78)**	1.00 (1.22)	0.00 (0.71)	0.67 (1.08)	**0.55a (1.03)**	0.00 (0.71)	0.33 (0.91)	0.00 (0.71)	**0.11b (0.78)**	0.33 (0.91)	0.33 (0.91)	0.33 (0.91)	**0.33a (0.91)**	7.33 (2.80)	3.33 (1.96)	1.67 (1.47)	**4.11bc (2.15)**
4th week November	4.00 (2.12)	2.00 (1.58)	0.67 (1.08)	**2.22 (1.65)**	0.00 (0.71)	0.33 (0.91)	0.00 (0.71)	**0.11a (0.78)**	0.33 (0.91)	0.00 (0.71)	1.00 (1.22)	**0.44a (0.97)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00b (0.71)**	0.00 (0.71)	0.33 (0.91)	0.00 (0.71)	**0.11a (0.78)**	4.33 (2.20)	2.66 (1.78)	1.67 (1.47)	**2.89cd (1.18)**
1st week December	1.00 (1.22)	0.00 (0.71)	0.67 (1.08)	**0.56 (1.03)**	0.33 (0.91)	0.67 (1.08)	0.00 (0.71)	**0.33a (0.91)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00a (0.71)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00b (0.71)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00a (0.71)**	1.33 (1.35)	0.67 (1.08)	0.67 (1.08)	**0.89de (1.18)**
2nd week December	2.33 (1.68)	1.00 (1.20)	0.00 (0.71)	**1.11 (1.27)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00a (0.71)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00a (0.71)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00b (0.71)**	0.33 (0.91)	0.00 (0.71)	0.00 (0.71)	**0.11a (0.78)**	2.66 (1.78)	1.00 (1.22)	0.00 (0.71)	**1.22de (1.31)**
3rd week December	1.00 (1.22)	1.67 (1.47)	0.33 (0.91)	**1.00 (1.22)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00a (0.71)**	0.67 (1.08)	0.33 (0.91)	0.00 (0.71)	**0.33a (0.91)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00b (0.71)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00a (0.71)**	1.67 (1.47)	2.00 (1.58)	0.33 (0.91)	**1.33de (1.35)**
4th week December	0.67 (1.08)	0.00 (0.71)	0.33 (0.91)	**0.33 (0.91)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00a (0.71)**	1.00 (1.22)	0.33 (0.91)	0.00 (0.71)	**0.44a (0.97)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00b (0.71)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00a (0.71)**	1.67 (1.47)	0.33 (0.91)	0.33 (0.91)	**0.78e (1.13)**
1st week January	0.33 (0.91)	0.00 (0.71)	0.33 (0.91)	**0.22 (0.85)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00a (0.71)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00a (0.71)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00b (0.71)**	0.33 (0.91)	0.33 (0.91)	0.00 (0.71)	**0.22a (0.85)**	**0.67 (1.08)**	0.33 (0.91)	0.33 (0.91)	**0.44e (0.97)**
Mean	**6.09a (2.57)**	**3.46b (1.99)**	**2.09c (1.61)**	**3.87 (2.09)**	**0.27a (0.88)**	**0.18ab (0.83)**	**0.09b (0.77)**	**0.18 (0.83)**	**0.45a (0.98)**	**0.21b (0.84)**	**0.15b (0.81)**	**0.26 (0.87)**	**0.12a (0.79)**	**0.09a (0.77)**	**0.00b (0.71)**	**0.07 (0.76)**	**0.24a (0.86)**	**0.21a (0.84)**	**0.06b (0.75)**	**0.17 (0.82)**	**7.18a (2.77)**	**4.15b (2.16)**	**2.39c (1.70)**	**4.57 (2.25)**

	Scarabids S.Em.±	Scarabids CD (P=0.05)	Spiders S.Em.±	Spiders CD (P=0.05)	Ants S.Em.±	Ants CD (P=0.05)	Orthoptera S.Em.±	Orthoptera CD (P=0.05)	Others S.Em.±	Others CD (P=0.05)	Total S.Em.±	Total CD (P=0.05)
FS	0.05	0.15	0.04	NS	0.04	0.12	0.02	0.07	0.03	0.10	0.06	0.18
Month (M)	0.10	0.28	0.08	NS	0.08	0.23	0.04	0.12	0.07	NS	0.12	0.35
FS X M	0.17	0.49	0.13	NS	0.14	NS	0.08	NS	0.12	NS	0.21	0.60

OF – Organic farming IF – Integrated farming CF – Conventional farming FS – Farming system

Figures in the parenthesis are √x+0.5 transformed values

In a column or row, means followed by the same alphabet do not differ significantly (P=0.05) by DMRT

Table 18: Total population of macro-arthropods in different crops under organic, integrated and conventional farming systems during 2015-16.

Macro-arthropods/pitfall trap				
Crops	**Organic**	**Integrated**	**Conventional**	**Mean**
Greengram	11.40 (3.45)	6.53 (2.65)	4.53 (2.24)	**7.47 (2.82)**
Soybean	14.52 (3.88)	8.80 (3.05)	6.76 (2.69)	**10.02 (3.24)**
Cowpea	13.14 (3.69)	7.71 (2.87)	5.09 (2.37)	**8.65 (3.02)**
Maize	31.56 (5.66)	21.60 (4.70)	16.18 (4.08)	**23.11 (4.86)**
Pigeonpea	23.20 (4.87)	15.56 (4.01)	10.18 (3.27)	**16.31 (4.10)**
Cotton+ Groundnut	60.80 (7.83)	35.02 (5.96)	27.95 (5.33)	**41.26 (6.46)**
Chickpea	6.13 (2.58)	3.40 (1.97)	1.63 (1.46)	**3.75 (2.05)**
***Rabi* sorghum**	7.18 (2.77)	4.15 (2.16)	2.39 (1.70)	**4.57 (2.25)**
Mean	**20.99a (4.64)**	**12.85b (3.65)**	**9.34c (3.14)**	

Figures in the parenthesis are $\sqrt{x+0.5}$ transformed values.

Table 19: Shannon's diversity index of the soil arthropods (meso and macro) in different crops under organic, integrated and conventional farming systems during 2015-16.

Crops	Organic	Integrated	Conventional	Mean
Greengram	0.79	0.64	0.57	**0.67**
Soybean	0.80	0.75	0.58	**0.71**
Cowpea	0.75	0.70	0.54	**0.66**
Maize	0.63	0.56	0.50	**0.56**
Pigeonpea	0.62	0.57	0.50	**0.56**
Cotton+ Groundnut	0.59	0.56	0.51	**0.55**
Chickpea	0.53	0.52	0.43	**0.49**
***Rabi* sorghum**	0.69	0.62	0.56	**0.62**
Mean	**0.68**	**0.62**	**0.52**	

Across the crops, soybean has recorded the higher mean diversity index of 0.71 followed by greengram (0.67), which is at par with cowpea (0.66) and least in chickpea (0.49).

4.1.3 Population of earthworm in different crops and cropping system (0.25 m^2)

4.1.3a *Kharif* crops (Greengram, Soybean, Cowpea and Maize)

In greengram, significantly higher earthworm population was observed in organically grown greengram (2.22/0.25 m^2) or (80, 800/ha) followed by integrated (1.56/0.25 m^2) or (62, 400/ha) and least in conventionally grown greengram (0.78/0.25 m^2) or (31, 200/ha). Significant difference was found in earthworm population between organic and conventional farming and between integrated and conventional farming. Irrespective farming systems the earthworm population was highest at the time of sowing (3.78/0.25 m^2) and least after harvesting (0.33/0.25 m^2) (Table 20).

In soybean, significantly higher earthworm population per unit area was observed in organic farming (3.11/0.25 m^2) or (1, 24, 400/ha) followed by integrated (1.44/0.25 m^2) or (57, 600/ha) and least in conventional farming system (0.89/0.25 m^2) or (35, 600/ha). Significant difference was found between organic and conventional farming, however integrated farming found on par with conventional farming. Irrespective of farming systems the earthworm population was highest at the time of sowing (4.78/0.25 m^2). However, at 45 DAS and after harvesting recorded least population (0.33/0.25 m^2) of earthworms (Table 20).

In cowpea, significantly higher earthworm population was observed in organic farming (2.00/0.25 m^2) or (80, 000/ha) followed by integrated (1.44/0.25 m^2) or (57, 600/ha) and least in conventional farming system (0.67/0.25 m^2) or (26, 800/0.25 m^2). Significant difference in earthworm population was found between organic and conventional farming, however integrated farming was on par with organic farming. Irrespective farming systems the earthworm population was highest at the time of sowing (3.78/0.25 m^2) and least after harvesting (0.11/0.25 m^2) (Table 20).

In maize, significantly increased earthworm population was observed in organically grown maize (2.83/0.25 m^2) or (1, 13, 200/ha) followed by integrated (0.92/0.25 m^2) or (36, 800/ha) and least in conventionally grown maize (0.75/0.25 m^2) or (30, 000). Significant difference was found between organic and conventional farming. However integrated farming found on par with both organic and conventional farming. Irrespective farming systems the earthworm population was highest at the time of sowing (4.00/0.25 m^2) followed by after harvesting (2.33/0.25 m^2) (Table 21).

4.1.3b *Rabi* crops (Chickpea and *rabi* sorghum)

In chickpea, significantly higher earthworm population was noticed in organic farming (1.17/0.25 m^2) or (46, 800/ha) followed by integrated (0.58/0.25 m^2) or (23, 200/ha) and least in conventional farming system (0.33/0.25 m^2) or (13, 200). Significant difference was noticed between organic and conventional farming. However integrated farming system found on par with both organic and conventional farming systems. Irrespective farming systems the earthworm population was highest at the time of sowing (2.33/0.25 m^2) and least at after harvesting (0.00/0.25 m^2) (Table 21).

In *rabi* sorghum, Significantly higher earthworm population was noticed in organically grown *rabi* sorghum (1.25/0.25 m^2) or (50, 000/ha) followed by integrated (0.67/0.25 m^2) or (26, 800/ha) and least in conventionally grown *rabi* sorghum (0.42/0.25 m^2) or (16, 800). Significant difference in earthworm population was noticed between organic and conventional farming. However integrated farming found on par with both organic and conventional farming. Irrespective farming systems the earthworm population was highest at the time of sowing (2.33/0.25 m^2) (Table 21).

Table 20: Population of earthworms in soybean, cowpea and greengram, under organic, integrated and conventional farming systems (per 0.25m^2) during 2015

Farming systems	Soybean					Cowpea					Greengram				
	Earthworm/0.25m^2				Earthworm / ha	Earthworm/0.25m^2				Earthworm / ha	Earthworm/0.25m^2				Earthworm / ha
	At the time of sowing	45 DAS	After harvesting	Mean		At the time of sowing	45 DAS	After harvesting	Mean		At the time of sowing	45 DAS	After harvesting	Mean	
Organic (A)	8.00 (2.92)	0.67 (1.08)	0.67 (1.08)	**3.11 (1.90)**	**1,24,400**	5.33 (2.42)	0.33 (0.91)	0.33 (0.88)	**2.00 (1.58)**	**80,000**	5.00 (2.35)	1.00 (1.22)	0.67 (1.08)	**2.22 (1.65)**	**80,800**
Integrated (B)	4.00 (2.12)	0.33 (0.91)	0.00 (0.71)	**1.44 (1.39)**	**57,600**	4.00 (2.12)	0.33 (0.88)	0.00 (0.71)	**1.44 (1.39)**	**57,600**	4.33 (2.20)	0.33 (0.91)	0.00 (0.71)	**1.56 (1.43)**	**62,400**
Conventional (C)	2.33 (1.68)	0.00 (0.71)	0.33 (0.91)	**0.89 (1.18)**	**35,600**	2.00 (1.58)	0.00 (0.71)	0.00 (0.71)	**0.67 (1.08)**	**26,800**	2.00 (1.58)	0.00 (0.71)	0.33 (0.91)	**0.78 (1.13)**	**31,200**
Mean	**4.78 (2.30)**	**0.33 (0.91)**	**0.33 (0.91)**	**1.81 (1.52)**	**72,400**	**3.78 (1.84)**	**0.22 (0.85)**	**0.11 (0.78)**	**1.37 (1.37)**	**54,800**	**3.78 (2.07)**	**0.44 (0.97)**	**0.33 (0.91)**	**1.52 (1.42)**	**60,800**
A and B	*					NS					NS				
B and C	NS					*					*				
A and C	**					**					*				

Note: Figures in the parenthesis are subjected to $\sqrt{X+0.5}$ transformation.
* indicates significance at P = 0.05.
** significance at P = 0.01.
NS: Non-significance t value

Table 21: Population of earthworms in maize, chickpea and *rabi* sorghum under organic, integrated and conventional farming systems (per 0.25m^2) during 2015-16.

Farming systems	Maize						Chickpea						*Rabi* sorghum					
	Earthworm/0.25m^2					Earthworm / ha	Earthworm/0.25m^2					Earthworm / ha	Earthworm/0.25m^2					Earthworm / ha
	At the time of sowing	45 DAS	90 DAS	After harvesting	Mean		At the time of sowing	45 DAS	90 DAS	After harvesting	Mean		At the time of sowing	45 DAS	90 DAS	After harvesting	Mean	
Organic (A)	7.33 (2.80)	0.00 (0.71)	0.33 (0.88)	3.67 (2.04)	**2.83 (1.83)**	**1,13,200**	3.67 (2.04)	0.67 (1.00)	0.33 (0.88)	0.00 (0.71)	**1.17 (1.29)**	**46,800**	3.33 (1.96)	1.00 (1.22)	0.33 (0.91)	0.31 (0.91)	**1.25 (1.32)**	**50,000**
Integrated (B)	3.00 (1.81)	0.00 (0.71)	0.33 (0.91)	2.00 (1.58)	**1.33 (1.35)**	**53,200**	2.00 (1.58)	0.00 (0.71)	0.33 (0.88)	0.00 (0.71)	**0.58 (1.04)**	**23,200**	2.33 (1.68)	0.33 (0.88)	0.00 (0.71)	0.00 (0.71)	**0.67 (1.08)**	**26,800**
Conventional (C)	1.67 (1.44)	0.00 (0.71)	0.00 (0.71)	1.33 (1.35)	**0.75 (1.12)**	**30,000**	1.33 (1.35)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.33 (0.91)**	**13,200**	1.33 (1.35)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.42 (0.96)**	**16,800**
Mean	**4.00 (2.12)**	**0.00 (0.71)**	**0.22 (0.85)**	**2.33 (1.68)**	**1.64 (1.46)**	**65,600**	**2.33 (1.68)**	**0.22 (0.85)**	**0.22 (0.85)**	**0.00 (0.71)**	**0.69 (1.09)**	**27,600**	**2.33 (1.68)**	**0.55 (1.03)**	**0.11 (0.78)**	**0.11 (0.78)**	**0.78 (1.13)**	**31,200**
A and B	NS						NS						NS					
B and C	NS						NS						NS					
A and C	**						*						* *					

Note: Figures in the parenthesis are subjected to √X+0.5 transformation.
* indicates significance at P = 0.05.
** significance at P = 0.01.
NS: Non-significance t value.

4.1.3c Pigeonpea and Cotton + Groundnut

In pigeonpea, significantly higher earthworm population was noticed in organic farming (3.00/0.25 m^2) or (1, 20, 000/ha) followed by integrated (1.73/0.25 m^2) or (69, 200/ha) and least in conventional farming system (1.00/0.25 m^2) or (40, 000). Irrespective farming systems the earthworm population was highest at 120 DAS (4.45/0.25 m^2) followed by at the time of sowing (3.67) and least at 45 DAS (0.22/0.25 m^2) (Table 22).

In cotton + groungnut, significantly increased earthworm population was noticed in organic farming (3.00/0.25 m^2) or (120, 000/ha) followed by integrated (1.73/0.25 m^2) or (69, 200/ha) and least in conventional farming system (0.80/0.25 m^2) or (32, 000). Significant difference in earthworm population was recorded between organic and conventional farming system. However integrated farming system found on par with conventional farming. Irrespective farming systems the earthworm population was highest at 120 DAS (4.44/0.25 m^2) followed by at the time of sowing (3.22/0.25 m^2) and least at 45 DAS (0.22/0.25 m^2) (Table 22).

4.1.3d Total population of earthworms/ha in different crops under organic, integrated and conventional farming systems during 2015-16.

Significantly higher population of total earthworms was recorded in organic farming (91,900/ha) followed by integrated (52,400/ha) and least in conventional farming (28,200/ha) (Table 23).

Across the different crops, soybean recorded more population (72,400/ha) of total earthworms compared to greengram (60,800/ha) and cowpea (54,800/ha) in short duration crops. Among long duration crops, pigeonpea recorded highest (76,400/ha) compared to cotton intercropped with groundnut (73,600/ha). In *rabi* crops *rabi* sorghum recorded more population (31,200/ha) of total earthworms compared to chickpea (27,600/ha). Overall pigeonpea recorded more population of earthworms (76,600/ha) followed by cotton intercropped with groundnut (73,600), soybean (72,400/ha) and least in chickpea (27,600/ha).

4.2 Effect of organic, integrated and conventional farming systems on above ground insects population

The experimental results on influence of organic, integrated and conventional farming systems on pests and their natural enemy complex in different crops recorded during 2015-16 at Main Agricultural Research Station, Dharwad are elucidated here under.

4.2.1 Pests and their natural enemies status in different crops and cropping system

4.2.1a Greengram

The data pertaining to different insect pests and their natural enemies occurring in greengram during *kharif* 2015, season in organic, integrated and conventional farming systems are presented here (Table 24).

Pest population

Defoliators

A significant difference in defoliator's population was observed between organic and conventional farming. However integrated farming system defoliators population to urd on par with both organic and conventional farming systems. Significantly less defoliators population was observed in organic (3.22/mrl) followed by integrated (3.67/mrl) and higher in conventional farming (4.11/mrl) system.

Table 22: Population of earthworms in pigeonpea and cotton + groundnut under organic, integrated and conventional farming systems (per 0.25m^2) during 2015

Farming systems	Pigeonpea							Cotton+ Groundnut						
	Earthworm/0.25m^2						Earthworm / ha	Earthworm/0.25m^2						Earthworm / ha
	At the time of sowing	45 DAS	90 DAS	120 DAS	At harvesting	Mean		At the time of sowing	45 DAS	90 DAS	120 DAS	At harvesting	Mean	
Organic (A)	5.67 (2.48)	0.33 (0.91)	1.00 (1.22)	6.33 (2.61)	1.67 (1.47)	**3.00 (1.87)**	**1,20,000**	5.67 (2.48)	0.33 (0.91)	1.33 (1.35)	7.00 (2.74)	0.67 (1.08)	**3.00 (1.87)**	**1,20,000**
Integrated (B)	4.00 (2.12)	0.00 (0.71)	0.33 (0.91)	4.00 (2.12)	0.33 (0.91)	**1.73 (1.49)**	**69,200**	3.00 (1.87)	0.33 (0.91)	0.67 (1.08)	4.33 (2.20)	0.33 (0.91)	**1.73 (1.49)**	**69,200**
Conventional (C)	1.67 (1.47)	0.33 (0.91)	0.00 (0.71)	2.67 (178)	0.33 (0.91)	**1.00 (1.22)**	**40,000**	1.00 (1.22)	0.00 (0.71)	0.67 (1.08)	2.00 (1.58)	0.33 (0.91)	**0.80 (1.14)**	**32,000**
Mean	**3.78 (2.07)**	**0.22 (0.85)**	**0.44 (0.97)**	**4.33 (2.20)**	**0.78 (1.13)**	**1.91 (1.55)**	**76,400**	**3.22 (1.93)**	**0.22 (0.85)**	**0.89 (1.18)**	**4.44 (2.22)**	**0.44 (0.97)**	**1.84 (1.53)**	**73,600**
A and B	*							*						
B and C	*							NS						
A and C	**							**						

Note: Figures in the parenthesis are subjected to $\sqrt{X+0.5}$ transformation.
* indicates significance at P = 0.05.
** significance at P = 0.01.
NS: Non-significance t value.

Table 23: Total population of earthworms /ha in different crops under organic, integrated and conventional farming systems during 2015-16.

Earthworm/ha				
Crops	**Organic**	**Integrated**	**Conventional**	**Mean**
Greengram	80,000	62,400	31,200	**60,800**
Soybean	1,24,400	57,600	35,600	**72,400**
Cowpea	80,000	57,600	26,800	**54,800**
Maize	1,13,200	53,200	30,000	**65,600**
Pigeonpea	1,20,000	69,200	40,000	**76,400**
Cotton+ Groundnut	1,20,000	69,200	32,000	**73,600**
Chickpea	46,800	23,200	13,200	**27,600**
***Rabi* sorghum**	50,000	26,800	16,800	**31,200**
Mean	**91,900a**	**52,400b**	**28,200c**	

Table 24: Pest and natural enemies status in greengram under organic, integrated and conventional farming systems at MARS Dharwad during *kharif* 2015

Farming system	Pests		Natural enemies		
	Defoliators /mrl	Pod borer (%)	Braconids /mrl	*Illeis cincta* / mrl	Other coccinellids /mrl
Organic (A)	3.22 (1.93)	33.54 (35.39)	3.33 (1.96)	5.17 (2.38)	0.58 (1.04)
Integrated (B)	3.67 (2.04)	34.44 (35.93)	2.08 (1.61)	3.00 (1.87)	0.33 (0.91)
Conventional (C)	4.11 (2.15)	36.49 (37.16)	1.50 (1.41)	1.50 (1.41)	0.33 (0.91)
A and B	NS	NS	NS	*	NS
B and C	NS	NS	NS	NS	NS
A and C	*	NS	**	**	NS

Note: Figures in the parenthesis are subjected to $\sqrt{X+0.5}$ transformation.
* indicates significance at P = 0.05.
** significance at P = 0.01.
NS: Non-significance t value.

Pod borer

No significant difference in pod borer population was observed between all the three farming systems. However, numerically higher population of pod borer was observed in conventional farming (36.49%) followed by integrated (34.44%) and least in organic farming system (33.54%).

Natural enemies

Braconids

Significant difference in braconids population was observed between organic and conventional farming. However integrated farming system found on par with both organic and conventional farming systems. Higher braconids population was observed in organic (3.33/mrl) followed by integrated (2.08/mrl) and least in conventional farming system (1.50/mrl).

Illeis cincta (Mycophagous coccinellid)

Significant difference in *Illeis cincta* population was observed between organic and conventional farming and integrated farming system found on par with conventional farming. Significantly higher *Illeis cincta* population was observed in organic (5.17/mrl) followed by integrated (3.00/mrl) and least in conventional farming system (1.50/mrl).

Coccinellids

No significant difference in coccinellid population was observed in all the three farming systems. However, numerically higher population of coccinellid was found in organic farming (0.58/mrl) followed by integrated (0.33/mrl) and conventional farming systems (0.33/mrl).

In general organic farming recorded numerically lower population of pests and higher population of natural enemies compared to integrated and conventional farming systems.

4.2.1b Soybean

The data pertaining to different insect pests and their natural enemies occurring in soybean during *kharif* 2015, season in organic, integrated and conventional farming systems are presented here (Table 25).

Pest population

Defoliators

In general, less defoliator population was found in soybean grown under organic farming system (3.56/mrl) followed by integrated (4.00/mrl) and conventional farming systems (4.56/mrl). However significant difference in defoliator population of soybean was observed between organic and conventional farming systems and integrated was on par with both organic and conventional farming systems.

Pod borer

Significant difference in pod borer population was observed between organic and conventional farming and integrated was on par with both organic and conventional farming. Significantly less per cent pod borer (61.67%) damage was observed in organic farming followed by integrated (75.00%) and conventional (84.33%) farming systems.

Natural enemies

Braconids

Significant difference in braconids population was observed between all the three farming systems. Significantly higher braconids population was observed in organic (6.00/mrl) followed by integrated (3.75/mrl) and least in conventional farming (2.42/mrl).

Table 25: Pest and natural enemies status in soybean under organic, integrated and conventional farming systems at MARS Dharwad during *kharif* 2015

Farming system	Pests		Natural enemies		
	Defoliators/ mrl	Pod borer (%)	Braconids /mrl	*N. rileyi* (mycosed larvae/m.row)	Coccinellids /mrl
Organic (A)	3.56 (2.01)	61.67 (51.75)	6.00 (2.55)	2.83 (1.83)	1.58 (1.44)
Integrated (B)	4.00 (2.12)	75.00 (60.00)	3.75 (2.06)	1.17 (1.29)	1.08 (1.26)
Conventional (C)	4.56 (2.25)	84.33 (66.68)	2.42 (1.71)	0.67 (1.08)	0.42 (0.96)
A and B	NS	NS	**	**	NS
B and C	NS	NS	*	NS	*
A and C	*	*	**	**	**

Note: Figures in the parenthesis are subjected to $\sqrt{X+0.5}$ transformation.
* indicates significance at P = 0.05.
** significance at P = 0.01.
NS: Non-significance t value

N. rileyi (mycosed larvae)

Significant difference in *N. rileyi* infected (mycosed) larvae was observed between organic and conventional farming systems. However in integrated farming system mycosed larval population was on par with conventional farming. Significantly higher *N. rileyi* infected larvae was observed in organic (2.83/mrl) followed by integrated (1.17/mrl) and significantly least in conventional farming (0.67/mrl).

Coccinellids

Significant difference in coccinellid population was observed between organic and conventional and integrated was on par with organic farming. Significantly higher population of coccinellids (1.58/mrl) was observed in organic farming followed by integrated (1.08/mrl) and least in conventional farming system (0.42/mrl).

4.2.1c Cowpea

The data pertaining to different insect pests and their natural enemies occurring in cowpea during *kharif* 2015, season in organic, integrated and conventional farming systems are presented here (Table 26).

Pest population

Defoliators

There was no significant difference in defoliator population between organic and conventional farming systems. However, numerically less defoliator population was observed in organic (2.22/mrl) followed by integrated (2.33/mrl) and conventional farming (2.56/mrl) systems.

Pod borer

Significant difference in pod borer infestation was observed between all the three farming systems. Significantly higher per cent pod borer damage (85.67%) was observed in conventional farming followed by integrated (70.33%) and significantly least in organic farming system (43.66%).

Natural enemies

Braconids

Significant difference in braconids population was observed between organic and conventional farming systems. However integrated farming system found on par with both organic and conventional farming systems. Significantly higher braconids were observed in organic (2.38/mrl) followed by integrated (1.92/mrl) and significantly least in conventional farming (1.42/mrl).

Illeis cincta (Mycophagous coccinellid)

Significant difference in *Illeis cincta* population was found between organic and conventional farming systems. However integrated farming system found on par with organic farming system. Significantly higher *Illeis cincta* population was observed in organic (2.67/mrl) followed by integrated (1.17/mrl) and significantly least in conventional farming system (0.75/mrl).

Coccinellids

No significant difference in coccinellid population was observed between all the three farming systems. However, numerically higher population of coccinellids was observed in organic farming (0.50/mrl) followed by conventional farming system (0.33/mrl).

Table 26: Pest and natural enemies status in cowpea under organic, integrated and conventional farming systems at MARS Dharwad during *kharif* 2015

Farming system	Pests		Natural enemies		
	Defoliators	Pod borer (%)	Braconids /mrl	*Illeis cincta* / mrl	Other coccinellids /mrl
Organic (A)	2.22 (1.65)	43.66 (41.36)	2.38 (1.83)	2.67 (1.78)	0.50 (1.00)
Integrated (B)	2.33 (1.68)	70.33 (57.00)	1.92 (1.55)	1.17 (1.29)	0.50 (1.00)
Conventional (C)	2.56 (1.75)	85.67 (67.75)	1.42 (1.38)	0.75 (1.12)	0.33 (0.91)
A and B	NS	**	NS	*	NS
B and C	NS	*	NS	NS	NS
A and C	NS	**	*	**	NS

Note: Figures in the parenthesis are subjected to $\sqrt{X+0.5}$ transformation.
* indicates significance at P = 0.05.
** significance at P = 0.01.
NS: Non-significance t value

4.2.1d Maize

The data pertaining to different insect pests and their natural enemies occurring in maize during *kharif* 2015, season in organic, integrated and conventional farming systems are presented here (Table 27).

Pest population

Stem borer

Significant difference in stem borer population was observed between organic and conventional farming systems. However integrated farming systems found on par with both organic and conventional farming systems. Significantly less stem borers was observed in organic farming (20%) followed by integrated (25%) and significantly more in conventional farming system (33.33%).

Aphids

There was no significant difference in aphid population was observed between all the three farming systems. However, numerically higher population of aphids was observed in conventional (10.75/cm^2 leaf) followed by integrated (10.50/cm^2 leaf) and organic farming (9.08/cm^2 leaf).

Natural enemies

Coccinellids

Significant difference in coccinellids population was observed between organic and conventional farming and integrated was on par with organic farming. Significantly higher coccinellids were observed in organic farming (2.58/plant) followed by integrated (1.80/plant) and least in conventional farming (0.80/plant).

Syrphids

Significant difference in syrphid populations was observed in between organic and conventional farming system. However integrated farming system syrphid population found on par with conventional farming system. Significantly higher population of syrphids (2.00/plant) was observed in organic farming system followed by integrated (1.25/plant) and least in conventional farming system (0.83/plant).

4.2.1e Cotton

The data pertaining to different insect pests and their natural enemies occurring in cotton during *kharif* 2015, season in organic, integrated and conventional farming systems are presented here (Table 28).

Pest population

Sucking pests

Aphids

Significant difference in aphids population was observed between organic and conventional farming system. Significantly less aphids were observed in organic (1.26/3 leaves) followed by integrated (2.3/3 leaves) and higher in conventional farming (3.5/3 leaves).

Table 27: Pest and natural enemies status in maize under organic, integrated and conventional farming systems at MARS Dharwad during *kharif* 2015

Farming system	Pests		Natural enemies	
	Stem borer (%)	Aphids / cm^2	Coccinellids/ plant	Syrphids/plant
Organic (A)	20.00 (26.54)	9.08 (3.10)	2.58 (1.76)	2.00 (1.58)
Integrated (B)	25.00 (29.92)	10.50 (3.32)	1.80 (1.52)	1.25 (1.32)
Conventional (C)	33.33 (35.16)	10.75 (3.35)	0.80 (1.14)	0.83 (1.15)
A and B	NS	NS	NS	*
B and C	NS	NS	*	NS
A and C	*	NS	**	**

Note: Figures in the parenthesis are subjected to $\sqrt{X+0.5}$ transformation.
* indicates significance at P = 0.05.
** significance at P = 0.01.
NS: Non-significance t value

Table 28: Incidence of sucking pests and their natural enemies in cotton intercropped with groundnut under organic, integrated and conventional farming systems at MARS Dharwad during *kharif* 2015

Systems	Sucking pests/ 3 leaves					Predators/ plant			
	Aphids	Thrips	Leafhoppers	Whiteflies	Mean	Coccinellids	Spiders	Green lace wings	Mean
Organic (A)	1.26 (1.33)	1.43 (1.39)	0.73 (1.11)	0.64 (1.07)	**1.02 (1.23)**	1.03 (1.24)	1.58 (1.44)	1.17 (1.29)	**1.26 (1.33)**
Integrated (B)	2.3 (1.67)	2.94 (1.85)	0.92 (1.19)	0.77 (1.13)	**1.73 (1.49)**	0.60 (1.05)	1.14 (1.28)	0.83 (1.15)	**0.86 (1.16)**
Conventional (C)	3.5 (2.00)	4.94 (2.33)	1.67 (1.47)	0.99 (1.22)	**2.78 (1.81)**	0.30 (0.89)	0.21 (0.84)	0.33 (0.91)	**0.28 (0.88)**
Mean	**2.35 (1.69)**	**3.10 (1.90)**	**1.11 (1.27)**	**0.80 (1.14)**		**0.64 (1.07)**	**0.98 (1.22)**	**0.78 (1.13)**	**0.80 (1.14)**
A and B	*	NS	NS	NS	t critical=2.18	NS	NS	NS	t critical=2.18
B and C	NS	NS	NS	NS		NS	NS	*	
A and C	*	*	NS	NS		*	*	*	

Note: Figures in the parenthesis are subjected to √X+0.5 transformation.
* indicates significance at P = 0.05.
** significance at P = 0.01.
NS: Non-significance t value.

Thrips

Significant differences in thrips population were observed between organic and conventional farming system and integrated was on par with both organic and conventional farming. Significantly less thrips per 3 leaves was observed in organic (1.43/3 leaves) followed by integrated (2.94/3 leaves) and conventional farming (4.94/3 leaves) system.

Leafhoppers

No significant difference in leafhoppers population was observed in all the three systems. However, numerically less population of leafhoppers was observed in organic (0.73/3 leaves) followed by integrated (0.92/3 leaves) and higher in conventional farming system (1.67/3 leaves).

Whiteflies

No significant difference in whiteflies population was observed in all the three systems. However, numerically higher population of whiteflies per 3 leaves was observed in conventional farming (0.99/3 leaves) followed by integrated (0.77/3 leaves) and least in organic farming system (0.64/3 leaves).

Shoot weevil

At 30 DAS, No significant difference in shoot weevil population was observed between all the three farming systems. However, numerically lesser shoot weevil damaged plants were observed in organic (28%) followed by integrated (34%) and conventional farming (34%) system (Table 28).

In general shoot weevil incidence was more during 45 DAS compared to 30 DAS.

But at 45 DAS, significant difference in shoot weevil damage was observed between organic and conventional farming system. However integrated farming system found on par with conventional farming system. Significantly lesser shoot weevils were observed in organic (56%) followed by integrated (75.67%) and higher in conventional farming (84.67%).

Natural enemies

Coccinellids

Significant difference in coccinellid population was observed between organic and conventional farming system. However integrated farming system found on par with both organic and conventional farming systems. Significantly higher coccinellids were observed in organic (1.03/plant) followed by integrated (0.60/plant) and least in conventional farming (0.30/plant).

Spiders

Significant difference in spiders population was observed between organic and conventional farming systems. However integrated farming system found on par with both organic and conventional farming systems. Significantly higher spiders were observed in organic (1.58/plant) followed by integrated (1.14/plant) and least in conventional farming (0.21/plant) system.

Green lace wings

Significant difference in lace wings population was observed between organic and conventional farming. However in integrated farming green lace wings population was at par with organic farming system. Significantly higher population of lace wings (1.17/plant) was observed in organic farming followed by integrated (0.83/plant) and least in conventional (0.33/plant) system.

4.2.1f Groundnut

The data pertaining to different insect pests and their natural enemies found in groundnut during *kharif* 2015, season in organic, integrated and conventional farming systems are presented here (Table 29).

Pest population

Defoliators

Significant difference in defoliator population was observed between organic and conventional farming systems. However integrated farming system found on par with both organic farming and conventional farming systems. Significantly least defoliator was recorded in organic (2.76/mrl) followed by integrated (3.45/mrl) and higher in conventional farming (4.11/mrl).

Natural enemies: *Campoletis chlorideae*

Significant difference in *Campoletis chlorideae* pupae population was noticed between organic and conventional farming systems. However integrated farming system found on par with both organic farming and conventional farming systems. Significantly higher *Campoletis chlorideae* pupae were noticed in organic (2.22/mrl) followed by integrated (1.67/mrl) and least in conventional farming system (1.00/mrl).

4.2.1f Pigeonpea

The data pertaining to different insect pests and natural enemies found in pigeonpea during *kharif* 2015, season in organic, integrated and conventional farming systems are presented here (Table 30).

Pest population

Gall weevil

Significant difference in gall weevil incidence was observed between all the three farming systems. Significantly increased gall weevil was observed in organic (44%) followed by integrated (39.67%) and least in conventional farming (27%).

Pod borer

No significant difference in pod borer damage was observed between all the three farming systems. However, numerically higher population of pod borer damage was observed in conventional (27%) followed by integrated (26.67%) and lesser in organic farming system (24.67%). But on the contrary seed damage shown significant difference between organic and conventional farming. Significantly higher seed damage (25%) was observed in conventional farming followed by integrated (19.33%) and least in organic farming (17.67%) (Plate 6).

Natural enemies

Illeis cincta

Significant difference in *Illeis cincta* population was observed between all the three farming systems. Significantly higher *Illeis cincta* population was observed in organic (3.81/plant) followed by integrated (2.81/plant) and least in conventional farming system (2.00/plant).

Spiders

Table 29: Shoot weevil status in cotton and pest and natural enemies status in groundnut under organic, integrated and conventional farming systems at MARS Dharwad during *kharif* 2015

Systems	Cotton			Groundnut	
	Shoot weevil damage (%)			Defoliators /mrl	***Campoletis chlorideae*** (pupae/mrl)
	30 DAS	45 DAS	Mean		
Organic (A)	28 (31.95)	56 (48.45)	42.00 (40.40)	2.76 (1.81)	2.22 (1.65)
Integrated (B)	34 (35.67)	75.67 (60.44)	54.84 (47.77)	3.45 (1.99)	1.67 (1.46)
Conventional (C)	34 (35.67)	84.67 (66.95)	59.34 (50.38)	4.11 (2.15)	1.00 (1.22)
A and B	NS	*	t critical=2.77	NS	NS
B and C	NS	NS		NS	NS
A and C	NS	**		*	*

Note: Figures in the parenthesis are subjected to √X+0.5 transformation.
* indicates significance at P = 0.05.
** significance at P = 0.01.
NS: Non-significance t value.

Table 30: Pest and natural enemies status in pigeonpea under organic, integrated and conventional farming systems at MARS Dharwad during *kharif* 2015

Tillage system	Pests			Natural enemies		
	Gall weevil (%)	Pod borer (%)		*Illeis cincta* / plant	Spiders/ plant	Green lace wings /plant
		Pod damage	Seed damage			
Organic (A)	44.00 (41.55)	24.67 (29.78)	17.67 (24.85)	3.81 (2.08)	2.00 (1.58)	1.48 (1.41)
Integrated (B)	39.67 (39.04)	26.67 (31.09)	19.33 (26.08)	2.81 (1.82)	1.29 (1.34)	1.00 (1.22)
Conventional (C)	27.00 (31.31)	27.00 (31.31)	25.00 (29.33)	2.00 (1.58)	0.91 (1.19)	0.76 (1.12)
A and B	*	NS	NS	**	*	*
B and C	**	NS	NS	*	*	NS
A and C	**	NS	*	**	**	*

Note: Figures in the parenthesis are subjected to $\sqrt{X+0.5}$ transformation.
* indicates significance at P = 0.05.
** significance at P = 0.01.
NS: Non-significance t value.

Significant difference in spiders population was observed in between all the three farming systems. Significantly higher population of spiders (2.00/plant) was observed in organic farming followed by integrated (1.29/plant) and least in conventional farming (0.91/plant) system.

Green lace wing

Significant difference in lace wing population was observed in between organic and conventional farming systems. However integrated farming system found on par with conventional farming system. Significantly higher population of lace wing was observed in organic farming (1.48/plant) followed by integrated (1.00/plant) and least conventional (0.76/plant).

4.2.1g Chickpea and *rabi* sorghum

The data pertaining to different insect pests and natural enemies occurring in chickpea and *rabi* sorghum during *rabi* season in organic, integrated and conventional farming systems are presented here (Table 31).

i. Chickpea

Pest population: Pod borer

No significant difference in pod borer damage was observed between all the three farming systems. However, numerically lesser population of pod borer damage was observed in organic farming.

Natural enemies

Campoletis chlorideae

No significant difference in *Campoletis chlorideae* population was observed between all the three farming systems. However, numerically increased population of *Campoletis chlorideae* pupae (0.56/mrl) was recorded in organic farming followed by integrated (0.44/mrl) and conventional farming system (0.44/mrl).

ii. *Rabi* sorghum

Pest population: stem borer

No significant difference in stem borer incidence was observed between all the three farming systems. However, numerically increased stem borers incidence was observed in conventional farming (4.83%) followed by organic (4.33%) and least in integrated farming (4.00%).

Natural enemies: spiders

Significant difference in spider population was observed between organic and conventional farming systems. However integrated farming system found on par with both organic and conventional farming systems. Significantly increased population of spiders was observed in organic farming (2.11/plant) followed by integrated (1.33/plant) and least in conventional farming (0.89/plant) (Plate 7).

4.2.2 Pollinators status in different crops

4.2.2a Greengram

Bees and lepidopterans are the predominant groups recorded among the pollinators across the farming systems.

The higher population of honey bees, lepidopterans (butterflies), dipterans and others pollinators were noticed in organic farming (6.00, 4.00, 1.33 and 2.55/m$^{2/}$5 mts, respectively) followed by integrated and least in conventional farming (3.17, 1.33, 0.50 and 0.67/m$^{2/}$5 mts, respectively) (Table 32).

Gall weevil

Pigeonpea pod borer

Soybean pod borer

Chickpea pod borer (*Helicoverpa armigera*)

Maize stem borer

Plate 6: Insect pests recorded in different crops

Table 31: Pest and natural enemies status in chickpea and *rabi* sorghum under organic, integrated and conventional farming systems at MARS Dharwad during *rabi* 2015-16

Farming system	Chickpea		*Rabi* sorghum	
	Pod borer (%)	*Campoletis chlorideae* (pupae/mrl)	Stem borer (%)	Spiders/plant
Organic (A)	2.33 (8.79)	0.56 (1.00)	4.33 (12.01)	2.11 (1.62)
Integrated (B)	2.67 (9.40)	0.44 (0.96)	4.00 (11.54)	1.33 (1.35)
Conventional (C)	2.67 (9.40)	0.44 (0.96)	4.83 (12.70)	0.89 (1.18)
A and B	NS	NS	NS	NS
B and C	NS	NS	NS	NS
A and C	NS	NS	NS	*

Note: Figures in the parenthesis are subjected to √X+0.5 transformation.
* indicates significance at P = 0.05
** significance at P = 0.01
NS: Non-significance t value

Green lace wings

Helicoverpa larva parasitoid with braconid

Oothica of mantid in greengram

N. rileyi (mycosed larva)

Syrphid larva

Brown lace wing

Predatory bug

Syrphid pupa

Spider

Coccinellid

Reduvid bug

Plate 7: Natural enemies observed in different crops

Table 32: Pollinators status in greengram under organic, integrated and conventional farming systems at MARS Dharwad during *kharif* 2015

Farming systems	Bees			Lepidopterans			Dipterans			Others			Total pollinators visited during flowering time per m^2 area in 5 min
	45 DAS	55 DAS	Mean	45 DAS	55 DAS	Mean	45 DAS	55 DAS	Mean	45 DAS	55 DAS	Mean	
Organic (A)	10.67 (3.34)	1.33 (1.35)	**6.00 (2.55)**	4.67 (2.27)	3.33 (1.96)	**4.00 (2.12)**	2.00 (1.58)	0.67 (1.08)	**1.33 (1.35)**	2.67 (1.78)	2.33 (1.68)	**2.50 (1.73)**	**13.83 (3.78)**
Integrated (B)	10.00 (3.24)	1.00 (1.22)	**5.50 (2.45)**	2.33 (1.68)	1.67 (1.47)	**2.00 (1.58)**	1.00 (1.22)	0.33 (0.91)	**0.67 (1.08)**	2.33 (1.68)	1.33 (1.35)	**1.83 (1.53)**	**10.00 (3.24)**
Conventional (C)	6.00 (2.55)	0.33 (0.91)	**3.17 (1.92)**	1.67 (1.47)	1.00 (1.22)	**1.33 (1.35)**	0.33 (0.91)	0.67 (1.08)	**0.50 (1.00)**	1.00 (0.22)	0.33 (0.91)	**0.67 (1.08)**	**5.67 (2.48)**
Mean	**8.89 (3.06)**	**0.89 (1.18)**	**4.89 (2.32)**	**2.89 (1.84)**	**2.00 (1.58)**	**2.44 (1.72)**	**1.11 (1.27)**	**0.56 (1.03)**	**0.83 (1.15)**	**2.00 (1.58)**	**1.33 (1.35)**	**1.67 (1.47)**	**9.87 (3.21)**
A and B	NS			NS			NS			NS			
B and C	*			NS			NS			NS			
A and C	**			*			NS			*			

Note: Figures in the parenthesis are subjected to $\sqrt{X+0.5}$ transformation.
* indicates significance at P = 0.05.
** significance at P = 0.01.
NS: Non-significance t value.

Table 33: Pollinators status in cowpea under organic, integrated and conventional farming systems at MARS Dharwad during *kharif* 2015

Farming systems	Bees			Lepidopterans			Dipterans			Others			Total pollinators visited per m^2 area in 5 min
	50 DAS	60 DAS	Mean	50 DAS	60 DAS	Mean	50 DAS	60 DAS	Mean	50 DAS	60 DAS	Mean	
Organic (A)	2.00 (1.58)	2.67 (1.78)	**2.33 (1.68)**	5.33 (2.41)	10.00 (3.24)	**7.67 (2.86)**	2.00 (1.58)	1.00 (1.22)	**1.50 (1.41)**	2.67 (1.58)	1.33 (1.35)	**2.00 (1.58)**	**13.50 (3.74)**
Integrated (B)	1.33 (1.35)	1.67 (1.47)	**1.50 (1.41)**	4.00 (2.12)	6.67 (2.68)	**5.33 (2.41)**	1.33 (1.35)	0.67 (1.08)	**1.00 (1.22)**	1.67 (1.47)	0.67 (1.08)	**1.17 (1.29)**	**9.00 (3.08)**
Conventional (C)	0.67 (1.08)	1.33 (1.35)	**1.00 (1.22)**	2.67 (1.78)	3.37 (1.96)	**3.02 (1.87)**	0.33 (0.91)	0.00 (0.71)	**0.17 (0.82)**	1.00 (1.22)	0.33 (0.91)	**0.67 (1.08)**	**4.86 (2.31)**
Mean	**1.33 (1.35)**	**1.89 (1.55)**	**1.61 (1.45)**	**4.00 (2.12)**	**6.68 (2.68)**	**5.34 (2.42)**	**1.22 (1.31)**	**0.56 (1.03)**	**0.89 (1.18)**	**1.78 (1.51)**	**0.78 (1.13)**	**1.28 (1.33)**	**9.12 (3.10)**
A and B	NS			NS			NS			NS			
B and C	NS			*			NS			NS			
A and C	*			*			NS			*			

Note: Figures in the parenthesis are subjected to $\sqrt{X+0.5}$ transformation.
* indicates significance at P = 0.05.
** significance at P = 0.01.
NS: Non-significance t value.

Table 34: Pollinators status in soybean under organic, integrated and conventional farming systems at MARS Dharwad during *kharif* 2015

Farming systems	Bees			Lepidopterans			Dipterans			Others			Total pollinators visited per m^2 plants in 5 min
	50 DAS	60 DAS	Mean	50 DAS	60 DAS	Mean	50 DAS	60 DAS	Mean	50 DAS	60 DAS	Mean	
Organic (A)	2.00 (1.58)	3.00 (1.87)	**2.50 (1.73)**	1.67 (1.47)	2.33 (1.68)	**2.00 (1.58)**	1.67 (1.47)	2.67 (1.78)	**2.17 (1.63)**	1.33 (1.35)	2.33 (1.68)	**1.83 (1.53)**	**8.50 (3.00)**
Integrated (B)	1.33 (1.35)	1.67 (1.47)	**1.50 (1.41)**	1.33 (1.35)	1.67 (1.47)	**1.50 (1.41)**	1.33 (1.35)	2.00 (1.58)	**1.67 (1.47)**	1.00 (1.22)	1.33 (1.35)	**1.17 (1.29)**	**5.84 (2.52)**
Conventional (C)	0.33 (0.91)	1.00 (1.22)	**0.67 (1.08)**	1.00 (1.22)	0.67 (1.08)	**0.83 (1.15)**	0.33 (0.91)	0.67 (1.08)	**0.50 (1.00)**	0.67 (1.08)	1.00 (1.22)	**0.83 (1.15)**	**2.83 (1.82)**
Mean	**1.22 (1.31)**	**1.89 (1.55)**	**1.56 (1.43)**	**1.33 (1.35)**	**1.56 (1.43)**	**1.44 (1.39)**	**1.11 (1.27)**	**1.78 (1.51)**	**1.45 (1.40)**	**1.00 (1.22)**	**1.55 (1.43)**	**1.28 (1.33)**	**5.72 (2.49)**
A and B	NS			NS			NS			NS			
B and C	NS			NS			*			NS			
A and C	*			*			*			*			

Note: Figures in the parenthesis are subjected to $\sqrt{X+0.5}$ transformation.
* indicates significance at P = 0.05.
** significance at P = 0.01.
NS: Non-significance t value.

Significantly higher population of pollinators visit was observed in organic farming (13.83/m$^{2/}$5 mts) followed by integrated (on par with organic) (10.00/m$^{2/}$5 mts) and significantly least in conventional farming (5.67/m^2/5 mts).

4.2.2b Cowpea

The higher population of honey bees, lepidopterans (butterflies), dipterans, and others pollinators was found in organic farming (2.33, 7.67, 1.50 and 2.00/m^2 area/5 mts, respectively) followed by integrated farming and least in conventional farming (1.00, 3.02, 0.17 and 0.67/m^2 area/5 mts, respectively) (Table 33).

Significantly higher population of pollinators fauna was observed in organic (13.50/m^2 area/5 mts) followed by integrated (9.00/m^2 area/5 mts) and significantly least in conventional farming (4.86/m^2 area/5 mts). Lepidopterans (butterflies) population was more compared to honey bees in all the farming systems.

4.2.2c Soybean

The higher population of honey bees, lepidopterans (butterflies), dipterans, and others pollinators was noticed in organic farming (2.50, 2.00, 2.17 and 1.83/m^2 area/5 mts, respectively) followed by integrated farming and least in conventional farming (0.67, 0.83, 0.50 and 0.83/m^2 area/5 mts, respectively) (Table 34).

Significantly higher population of pollinators fauna was observed in organic farming system (8.50/m^2 area/5 mts) followed by integrated (5.84/m^2 area/5 mts) and least in conventional farming (2.83/m^2 area/5 mts).

4.2.2d Cotton + Groundnut

The higher population of honey bees, lepidopterans (butterflies), dipterans and others pollinators was noticed in organic farming (7.50, 0.67, 1.50 and 0.50/5 plants/5 mts, respectively) followed by integrated farming and least in conventional farming (2.67, 0.50, 117 and 0.17/5 plants/5 mts, respectively) (Table 35).

Significantly higher population of total pollinators visited was observed in organic (10.17/5 plants/5 mts) followed by integrated (4.34/5 plants/5 mts) and least in conventional farming (4.51/5 plants/5 mts). Among the different pollinators honey bees were dominating (7.50/5 plants/5 mts) followed by dipterans (1.50/5 plants/5 mts) in all the farming systems.

4.2.2e Pigeonpea

The higher population of bees (honey bees and bumble bees), lepidopterans (butterflies), dipterans and others pollinators was observed in organic farming system (9.17, 2.50, 2.00, and 1.83/m^2 area/5 mts, respectively) followed by integrated farming and least in conventional farming (3.67, 0.83, 0.83 and 0.17/m^2 area/5 mts, respectively) (Table 36).

Significantly higher population of total pollinators visited was observed in organic (15.20/m^2 area/5 mts) followed by integrated (10.17/m^2 area/5 mts) and significantly least in conventional farming (5.50/m^2 area/5 mts). Among the different pollinators bees were dominating (9.17/m^2 area/5 mts) (Plate 8).

4.1.2f Assessment of Shannon's diversity index of above ground insects (pests, natural enemies and pollinators) in different crops under organic, integrated and conventional farming systems during 2015-16

Shannon's weaver index of general biodiversity of insects and spiders were calculated and analysed for above ground insects diversity. Among the farming systems, organic farming has recorded the higher diversity index (0.38) followed by integrated (0.32) and less in conventional farming (0.27). In all the crops, *viz.*, greengram, soybean, cowpea, maize, pigeonpea, cotton, groundnut, chickpea and *rabi* sorghum, highest diversity index was observed in organic farming (0.45, 0.42, 0.37, 0.45, 0.51, 0.46, 0.30, 0.21 and 0.27, respectively) followed by integrated and least diversity index was recorded in conventional farming (0.35, 0.22, 0.18, 0.31, 0.46, 0.38, 0.21, 0.15 and 0.19, respectively) (Table 37).

Across the crops, pigeonpea has recorded the higher diversity index of 0.48 followed by cotton (0.41), greengram (0.40) and least in chickpea (0.18).

4.1.2g Identification report of soil arthropods (collembolans and diplurans) and natural enemies observed under organic, integrated and conventional farming systems

The collembolans and diplurans collected from experimental field were identified by Dr. Raghuraman. Asst. Professor of Entomology from Banaras Hindu University, Varanasi. The collembolans specimen collected belongs to 3 families *viz.*, Isotomidae, Cyphoderidae, Entomobryidae. In Isotomidae, three species belongs to three genera were identified as *viz., Isotoma trispinata, Isotomurus antennalis, Proisotoma ripicola.* In Cyphoderidae, three species belongs to genera *viz.*, *Cyphoderus albinus, Cyphoderus grassei, Cyphoderus* sp. In case of Entomobryidae, eight species belongs to six genera were identified as *viz.*, *Seira* spp., *Entomobrya* sp., *Lepidocyrtus* spp., *Orchesellides* sp. *Willowsia* sp., *Heteromurus* sp. Among all the families identified under collembolan, Entomobryidae was found to be dominating one in Dharwad. Over all 14 species of collembolan belongs to 10 genera distributed in three families were recorded from this region. In diplura specimens collected during study period belonging to 3 families *viz.,* Japygidae, Anajapygidae, Compodeidae and it includes three genera *viz.*, *Japyx, Anajapyx, Compodea* (Plate 9).

Natural enemies were sent for identification to Dr Ankita Gupta from NBAIR, Bengaluru. Natural enemies belonging to 4 families *viz.* (Encyrtidae, Braconidae, Chalcididae, Platygastridae). In Encyrtidae, two genera and two species, one is *Copidosoma floridanum* on Thysanoplusia larvae (host) another one is *Aenasius aurizonensis* on Cotton mealy bug. In Braconidae, two genera and three species *viz., Glyptapanteles spodopterae* on Spodoptera larvae, *Glyptapanteles* sp. on *Helicoverpa armigera* larvae and *Apanteles* sp. on Thysanoplusia larvae. In Chalcididae, identified upto generic level, where as in case of Platygastridae identified upto family level (Table 38) (Plate 10).

Table 35: Pollinators status in cotton under organic, integrated and conventional farming systems at MARS Dharwad during *kharif* 2015

Farming systems	Bees			Lepidopterans			Dipterans			Others			Total pollinators visited per 5 plants in 5 min
	80 DAS	90 DAS	Mean	80 DAS	90 DAS	Mean	80 DAS	90 DAS	Mean	80 DAS	90 DAS	Mean	
Organic (A)	8.00 (2.92)	7.00 (2.74)	**7.50 (2.83)**	0.67 (1.08)	0.67 (1.08)	**0.67 (1.08)**	2.00 (1.58)	1.00 (1.22)	**1.50 (1.41)**	0.67 (1.08)	0.33 (0.91)	**0.50 (1.00)**	**10.17 (3.27)**
Integrated (B)	4.00 (2.12)	2.67 (1.78)	**3.33 (1.96)**	0.33 (0.91)	0.00 (0.71)	**0.17 (0.82)**	1.00 (1.22)	0.67 (1.08)	**0.83 (1.15)**	0.00 (0.71)	0.33 (0.91)	**0.17 (0.82)**	**4.34 (2.20)**
Conventional (C)	2.33 (1.68)	3.00 (1.87)	**2.67 (1.78)**	0.67 (1.08)	0.33 (0.91)	**0.50 (1.00)**	1.33 (1.35)	1.00 (1.22)	**1.17 (1.29)**	0.33 (0.91)	0.00 (0.71)	**0.17 (0.82)**	**4.51 (2.24)**
Mean	**4.78 (2.30)**	**4.22 (2.17)**	**4.50 (2.24)**	**0.56 (1.03)**	**0.33 (0.91)**	**0.45 (0.97)**	**1.44 (1.39)**	**0.89 (1.18)**	**1.17 (1.29)**	**0.33 (0.91)**	**0.22 (0.85)**	**0.28 (0.88)**	**6.34 (2.62)**
A and B	*			NS			NS			NS			
B and C	NS			NS			NS			NS			
A and C	*			NS			NS			NS			

Note: Figures in the parenthesis are subjected to $\sqrt{X+0.5}$ transformation.
* indicates significance at P = 0.05.
** significance at P = 0.01.
NS: Non-significance t value.

Table 36: Pollinators status in pigeonpea under organic, integrated and conventional farming systems at MARS Dharwad during *kharif* 2015

Farming systems	Bees			Lepidopterans			Dipterans			Others			Total pollinators visited per m^2 plants in 5 min
	90 DAS	100 DAS	Mean	90 DAS	100 DAS	Mean	90 DAS	100 DAS	Mean	90 DAS	100 DAS	Mean	
Organic (A)	10.33 (3.29)	8.00 (2.92)	**9.17 (3.11)**	3.00 (1.87)	2.00 (1.58)	**2.50 (1.73)**	2.33 (1.68)	1.67 (1.47)	**2.00 (1.58)**	2.00 (1.58)	1.67 (1.47)	**1.83 (1.53)**	**15.50 (4.00)**
Integrated (B)	6.67 (2.68)	6.33 (2.61)	**6.50 (2.65)**	1.67 (1.47)	1.00 (1.22)	**1.33 (1.35)**	1.67 (1.47)	0.67 (1.08)	**1.17 (1.29)**	1.00 (1.22)	1.33 (1.35)	**1.17 (1.29)**	**10.17 (3.27)**
Conventional (C)	4.33 (2.20)	3.00 (1.87)	**3.67 (2.04)**	1.33 (1.35)	0.33 (0.91)	**0.83 (1.15)**	1.00 (1.22)	0.67 (1.08)	**0.83 (1.15)**	0.00 (0.71)	0.33 (0.91)	**0.17 (0.82)**	**5.50 (2.45)**
Mean	7.11 (2.76)	5.78 (2.51)	**6.45 (2.63)**	2.00 (1.58)	1.11 (1.27)	**1.55 (1.43)**	1.67 (1.47)	1.00 (1.22)	**1.33 (1.35)**	1.00 (1.22)	1.11 (1.27)	**1.06 (1.24)**	**10.39 (3.30)**
A and B	NS			NS			NS			NS			
B and C	NS			NS			NS			NS			
A and C	**			*			*			*			

Note: Figures in the parenthesis are subjected to $\sqrt{X+0.5}$ transformation.
* indicates significance at P = 0.05.
** significance at P = 0.01.
NS: Non-significance t value.

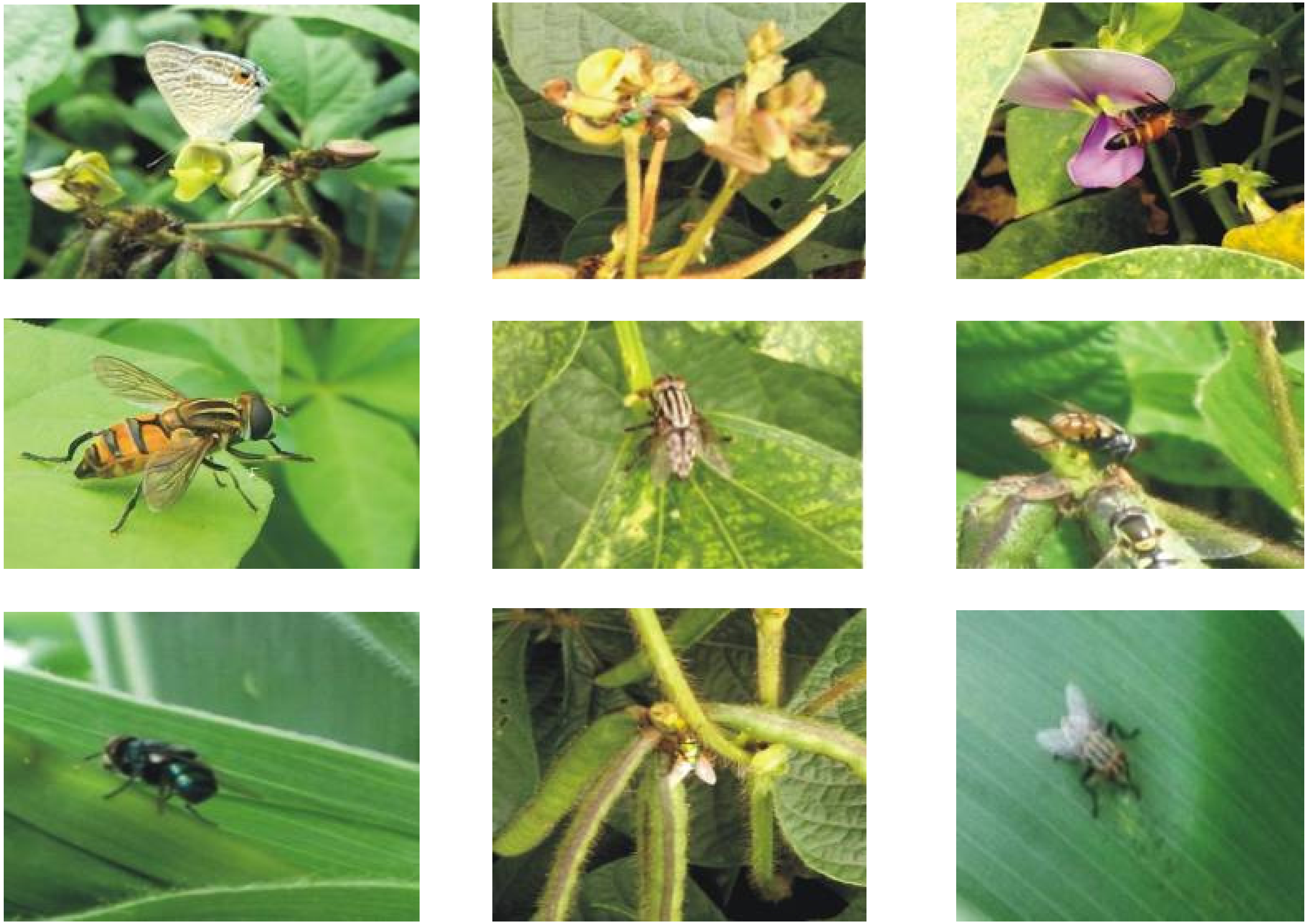


Plate 8: Pollinators recorded in different crops

Table 37: Assessment of Shannon's diversity index of above ground insects (pests, natural enemies and pollinators) in different crops under organic, integrated and conventional farming systems during 2015-16

Crops	Organic	Integrated	Conventional	Mean
Green gram	0.45	0.41	0.35	**0.40**
Soybean	0.42	0.31	0.22	**0.32**
Cowpea	0.37	0.26	0.18	**0.27**
Maize	0.45	0.39	0.31	**0.38**
Pigeonpea	0.51	0.48	0.46	**0.48**
Cotton+ Groundnut	0.46	0.38	0.38	**0.41**
Groundnut	0.30	0.27	0.21	**0.26**
Chickpea	0.21	0.18	0.15	**0.18**
***Rabi* sorghum**	0.27	0.24	0.19	**0.24**
Mean	**0.38**	**0.32**	**0.27**	**0.33**

Proisotoma ripicola

Cyphoderus albinus

Cyphoderus grassei

Isotoma ripicola

Isotomurus antennalis

Seira sp.

Heteromurus sp.

Orchesellides sp.

Willowsia sp.

Anajapyx sp.

Japyx sp.

Compodea sp.

Plate 9: Collembola and Dipluran species found in MARS, UAS, Dharwad during study period (2015-16)

Table 38: Identification report of soil arthropods (collembolans and diplurans) and natural enemies observed under organic, integrated and conventional farming systems at MARS Dharwad during 2015-16.

Collembola			Diplurans		
Family	**Genera**	**species**	**Family**	**Genera**	**species**
Isotomidae	*1. Isotoma (Desoria)*	*trispinata*	Japygidae	*1. Japyx*	sp.
	2. Isotomurus	*antennalis*			
	3. Proisotoma	*ripicola*			
Cyphoderidae	*1. Cyphoderus*	*albinus* *grassei* sp.	Anajapygidae	*2. Anajapyx*	sp.
Entomobryidae	*1. Seira*	spp.	Compodeidae	*3. Compodea*	sp.
	2. Entomobrya	sp.			
	3. Lepidocyrtus	spp.			
	4. Orchesellides	sp.			
	5. Willowsia	sp.			
	6. Heteromurus	sp.			

Natural enemies

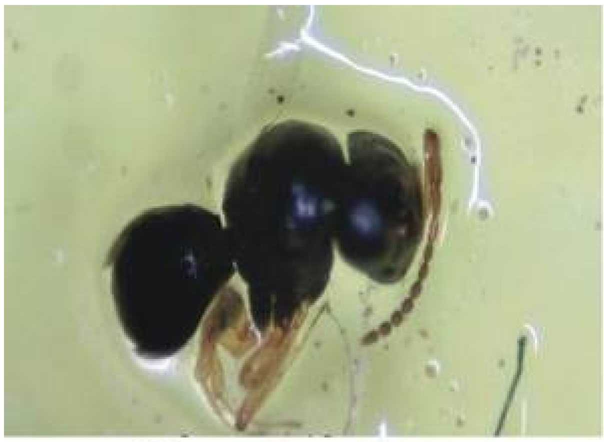
Host	**Family**	**Sceintific name**
Thysanoplusia (Semilooper) larvae	1. Encyrtidae	*Copidosoma floridanum*
	2. Braconidae	*Apanteles* sp.
Cotton mealy bug	Encyrtidae	*Aenasius aurizonensis*
Spodoptera larvae	Braconidae	*Glyptapanteles spodopterae*
Helicoverpa larvae	Braconidae	*Glyptapanteles* sp.
Helicoverpa pupae	3. Chalcididae	*Brachymeria* sp.
Bug eggs	4. Platygastridae	

Copidosoma floridanum on semilooper larva

Bracon sp. on *Thysonoplusia* larva

Apanteles sp. on semilooper larva

Gnyptapanteles sp. on *Helicoverpa* larva



Platygastridae on bug eggs

Plate 10: Parasitoids recorded on different hosts

5. DISCUSSION

Organic farming works in harmony with nature rather than against it. This involves best practices and techniques to achieve good crop yields without harming the natural environment or the people who live and work in it. Organic farming uses almost exclusively biological and natural materials and processes to produce food. The practice aims to protect human health and conserve, maintain or enhance natural resources, with the goal to preserve the quality of the environment for future generations while being economically sustainable. Organic farming has grown rapidly throughout the world in recent years. One of the most valuable benefits of organic farming is the improvement in soil quality, which can be expressed in terms of chemical, physical and biological properties and their interactions.

The species richness of soil fauna may represent as much as 23 per cent of all described organisms, or about 360, 000 species, with soil arthropods comprising 85 per cent of that number. They comprise a huge proportion of the meso and macro fauna of the soil. Within the litter/humus soil system, four groups are chiefly represented: Isopoda, Myriapoda, Insecta and Acari. Mites and Collembolans are the most abundant and diverse. Soil arthropods act as ecosystem engineers they modify soil structure, its physical condition, mineral and organic matter composition and hydrology. Burrowing by arthropods, particularly the subterranean network of tunnels and galleries that comprise termite and ant nests, improves soil porosity to provide adequate aeration, improves infiltration of water and water-holding capacity below ground, facilitate root penetration and prevent surface crusting and erosion of top soil. Also, the movement of particles from lower horizons to the surface by ants and termites aids in mixing the organic and mineral fractions of the soil. The faeces of arthropods are the basis for the formation of soil aggregates and humus, which physically stabilize the soil and increase its capacity to store nutrients. Micro arthropods as soil mites (Acari) and springtails (Collembolans) play important role in soil fertility maintainenace through their regulatory activities in decomposition and nutrient turn over (Culliney, 2013).

Long-term and large number of soil inorganic fertilizer applications can affect negatively on soil fertility, soil biodiversity and crop products quality (Gruzdeva *et al.*, 2007). So, considering the increasing importance of organic agriculture, soil organic manure applications are desirable and recommended. The effect deriving from organic manure applications includes numerous benefits resulting in an improvement of physical and chemical soil properties, *i.e.* porosity, aggregates stability, water exchange and fertility (Tester, 1990).

There is currently world-wide concern regarding the impact of modern farming practices on soil physical and biological fertility due to loss of below ground biodiversity and water quality. Alternative management system mainly organic farming is being promoted on the basis that it is more environmentally benign and specifically enhance soil and water quality relative to conventional practices. Organic farming often increases abundance and diversity of soil fauna and soil fertility. Organic farming typically adds large amounts of organic matter and soil amendments, which, in turn, increases the biological activity in soil and availability of all nutrients.

5.1 Effect of organic, integrated and conventional farming systems on below ground diversity of soil arthropods population

5.1.1 Population of meso-arthropods in different crops and cropping system under organic, integrated and conventional farming systems

Soil meso-arthropods population was assessed in organic, integrated and conventional farming systems with seven crops (greengram, cowpea, soybean, maize, pigeonpea, chickpea and *rabi* sorghum and one intercropping system (cotton + groundnut). In general organic farming leads to more faunal abundance and diversity because of usage of organic manures, green manures, crop residue, inter cropping and no usage of chemical fertilizers and pesticides, whereas in integrated and conventional farming systems decline in soil fauna due to usage of fertilizers and synthetic chemical pesticides. In the present investigation significantly more population of total meso-arthropods was recorded in organic farming with different crops *viz.,* greengram, soybean, cowpea, maize, pigeonpea, cotton intercropped with groundnut, chickpea and *rabi* sorghum (16.47/100 g of soil) as compared to integrated farming system (9.13/100 g of soil,) and least in conventional farming system (5.32/100 g of soil) (Fig. 9). Results shows that irrespective of cropping systems, organic farming recorded more population followed by integrated farming and least in conventional farming system. It may be due to higher organic matter content which is at different stages of decomposition found in organic farming may favour the faunal population. In organic farming agrochemical consumables are being replaced by other crop residue and organic matter added to the soil, which encourages soil arthropods, micro organisms which utilise as food source and energy source or energy alternatives allowing a greater inward movement of different soil fauna in search of food thus increasing biodiversity and accumulation of organic material in organic farming releases nutrients and maintains appropriate soil structure. This stability, results in taxa richness which would be represented by those groups which adopt to organic management (Santiago *et al.*, 2009). Organic farming fields are rich in soil arthropods is mainly due to high organic and nutrient content which improved soil quality. Absence of chemicals, no or low levels of soil disturbance and eco friendly management techniques in organic fields which completely or partially absent in conventionally managed fields, resulted in the buildup of beneficial arthropods (Mader *et al.*, 2002; Nakhro and Dkhar, 2010). It may be due to non usage of chemical pesticides and fertilizers in organic farming and more usage in conventional farming system which has deleterious effect on these organisms (Salavuddin, 2014). In integrated farming less population of micro arthropods was recorded compared to organic farming. It may be due to usage of chemicals in an integrated system, which might have effected soil fauna to certain extent and resulted in the reduction of soil fauna. This variation in the relative abundance of soil meso fauna may be due to the availability of their food or host and moisture content of food and soil. Similar results in relatively higher abundance of collembolan, cryptostigmatids, other acari and other invertebrates was recorded in 20 tons of FYM/ha applied treatment compare to recommended fertilizer alone reported by Abilasha *et al.*, 2013b and Narasa Reddy *et al.*, 2013. In conventional farming less population of micro arthropods was recorded. It may be due to intensive agriculture and excessive uses of agrochemicals have resulted in an impoverished bio-life especially reduced arthropod diversity and density in agriculture ecosystem. Because of high input of chemical fertilizers and pesticides, a severe decline of biological diversity has been observed (Letourneau and Bothwell, 2008). Mechanical and chemical perturbations produced by conventional agricultural management practices and by particular abiotic soil conditions present in the intensively managed sites that are unfavourable for collembolans, pauropods and mites densities (Jose *et al.*, 2006a and Jose *et al.*, 2006b).

Irrespective of farming systems in cotton intercropped with groundnut recorded more population of meso-arthropods (15.50/100 g of soil) followed by pigeonpea (11.76/100 g of soil) and least in chickpea (6.34/100 g of soil). It may be because of groundnut crop acted as cover crop which prevented excessive evaporation of moisture from soil and blocked sunshine reaching the soil, thus helped in maintaining the favourable micro climate for the survival, food availability for growth and development of soil meso-arthropods. The intercropping practices are to increase vegetation cover in time and space and to increase the structural and species diversity of cropping systems, thereby affecting habitat for invertebrates. These practices can have significant influences on herbivorous, predacious and decomposer invertebrates and pigeonpea act as legume crop rich in protein, heavy litter fall that going to add nutrients to soil, sunshine will not reach the soil and act as mulch so, soil meso-arthropods population might have increased. The present findings are supported by the work of Kumar Rao *et al.* (1996) who reported that pigeonpea litter mass ranged from 2.7 to 7.6 t/ha. Total N (kg/ha) supply expected from litter fall based on litter biomass and nitrogen concentration (per cent N) ranged from 56 to 132 kg N/ha in the leaves that fall during the growth of pigeonpea. This in turn provides the favourable condition for development of soil fauna. In chickpea least population of meso-arthropods was recorded. It may be due to less moisture in the soil, rainfall received during *rabi* season is very less resulted in less moisture in soil in turn less population of meso-arthropods. The present findings are supported by Banasco (1993) determined the number, composition and distribution of collembolans population was 2.3 times higher in rainy season than in dry season. The results are also similar with Maareg and Saleh (1989) who have studied the fluctuations of invertebrate fauna. Highest population of mites and total fauna were recorded in autumn, whereas lowest population occurred in winter.

Among *kharif* crops (soybean, cowpea and greengram), soybean recorded increased population (10.47/100 g of soil) followed by greengram (9.44/100 g of soil). Soybean and greengram crop act as cover crop, both are belong to the leguminosae family and they are nitrogen fixers in turn will be the source of nutrients for many of these soil arthropods. Conservation of soil moisture is comparatively high in these crops and the falling leaf litter acts as mulch to retain moisture, reduce soil temperature as well as organic food source for the soil arthropods which supports their food chain in order to feed and reproduce consistently and maintain their population at higher side. Kumar Rao and Dart, 1987 opined that the soybean residue degrades quickly because of its high N content and soybean may be the only one that meets the standard of 30 per cent surface residue cover. In case of long duration crops, cotton intercropped with groundnut recorded higher population (15.50/100g of soil) compared to pigeonpea (11.76/100g of soil) it may be due to groundnut crop act as cover crop, which prevented excessive evaporation of moisture from soil and blocked sunshine reaching the soil. Thus helped in maintaining the favourable micro climate for the survival, reproduction and food availability to soil meso-arthropods so, their population increased. But in pigeonpea eventhough there was huge litter fall meso-arthropods population is less it may be due to wider spacing, initial stage of the crop there is no litter fall and there is no cover crop to reduce soil moisture. In case of *rabi* crops, *rabi* sorghum recorded more meso-arthropods population (9.13/ 100 g of soil) compared to chickpea (6.34/100 g of soil). Because of more canopy cover which blocked sunshine reaching the soil.

Total meso-arthropods include pseudoscorpions, diplurans, ants and others. Most of these are predatory in habit as they are density dependent they are dependent on other micro arthropods like collembolans, mites, *etc.*, among the total meso-arthropods more number of mites and collembolans were recorded in organic farming system compared to other two farming systems. It may be due to more organic matter in the soil where collembolans and mites helps in the degradation of organic matter rapidly than in conventional cultivated areas. Microbial grazing of collembolans affects the growth and metabolic activities of microbes thus regulating decomposition rate. Mites and collembolans enhance microbial activity, accelerate decomposition and mediate transport processes in the soil. Even when they do not transform ingested material significantly they breakdown, moisten it and make it available for micro organisms to decompose (Berg and Pawluk, 1984). Greengram under organic farming recorded 3.46 fold more number of total meso-arthropods (15.00/100 g of soil) compared to conventional farming (4.33/100 g of soil). Whereas, in greengram under integrated farming (9.00/100 g of soil) recorded 2.08 fold increase in total meso-arthropods compared to conventional farming. Soybean grown under organic and integrated farming (17.06 and 9.07 total meso-arthropods were recorded/100 g of soil, respectively) recorded 3.23 and 1.72 folds, respectively increase in meso-arthropods compared to conventional farming system (5.27/100 g of soil). Cowpea grown under organic and integrated farming recorded relatively more number of meso-arthropods (14.46 and 7.80/100 g of soil, respectively), which was 3.61 and 1.95 folds, respectively increase in meso-arthropods compared to conventional farming system (4.00/100 g of soil). Maize grown under organic farming recorded more number of meso-arthropods (16.89 and 10.28/100 g of soil, respectively) which was 2.81 and 1.71 folds, respectively increase in meso-arthropods population over conventional farming system (6.00/100 g of soil) because of more organic material in these two systems compared to conventional farming. These meso-arthropods as well as microbes decomposed the organic matter and helped in improving soil fertility and availability of nutrients to plants. In case of long duration crops like cotton and pigeonpea grown under organic farming recorded comparatively more number of meso-arthropods (23.67 and 19.04/100 g of soil) which was 2.64 and 3.03 folds, respectively increase in meso-arthropods population over conventional farming system (8.96 and 6.29/100 g of soil, respectively). Whereas cotton and pigeonpea under integrated farming recorded (13.88 and 9.96/100 g of soil) more number of meso-arthropods, which was 1.55 and 1.58 folds, respectively increase over conventional farming system. In case of *rabi* crops like *rabi* sorghum and chickpea grown under organic farming recorded more number of meso-arthropods (14.42 and 11.25/100 g of soil) which was 3.01 and 3.80 folds, respectively increase over conventional farming (4.79 and 2.92/100 g of soil, respectively). Whereas *rabi* sorghum and chickpea under integrated farming recorded (8.18 and 4.84/100 g of soil) more number of meso-arthropods, which was 1.71 and 1.63 folds, respectively increase over conventional farming systems. The present findings are in line with Padmavathy and poyyamoli (2013), Wernicke and Funke (1995) they concluded that pesticide application in conventional fields had significant negative effect on non target arthropods like Collembolans, Mites, Hymenoptera and Thysanoptera. In contrary, the application of bio-pesticides in organic fields had no significant effect on non targeted species; these results indicate that insecticide treatment kept non-target arthropods at low abundance. This implies that, organic farming does not have significant effect on the beneficial arthropods population and biodiversity. The results were also in line with the Patil *et al.* (2013a) and Salavuddin (2014) concluded that organic farming system was consisting of significantly higher population of soil fauna compared to integrated and conventional farming systems. It may due to less usage of chemical pesticides and fertilizers in organic farming more usage in conventional and integrated farming systems. The same results were also found by many workers (Wu *et al.*, 2002, Ayuke *et al.*, 2004, Santiago *et al.*, 2009, Parwez and Abbas, 2012, Narasa Reddy *et al.*, 2013). According to Jose *et al.*, 2006a and Jose *et al.*, 2006b the reduction of soil arthropods density in conventional farming system is largely explained by the mechanical and chemical perturbations produced by conventional farming system.

5.1.1.1 Population dynamics of meso-arthropods in different crops and cropping systems under organic, integrated and conventional farming systems during 2015-16

The climatic conditions as well as crop growth period largely influence the abundance as well as activity of soil arthropods. There was a fluctuation of total meso-arthropods population during cropping season. The Population dynamics of meso-arthropods evaluated under organic, integrated and conventional farming systems in seven crops (greengram, cowpea, soybean, maize, pigeonpea, chickpea and *rabi* sorghum) and one intercropping system (cotton intercropped with groundnut) during 2015-16 showed that there was fluctuation of meso-arthropods population during cropping season. In *kharif* crops, the peak population of meso-arthropods were recorded during June under organic (5.23/100g of soil), integrated (3.13/100g of soil) and conventional (1.70/100g of soil) farming systems and minimum during September under organic (1.73/100g of soil), integrated (0.85/100g of soil) and conventional (0.33/100g of soil) farming systems (Fig. 1). In long duration crops like cotton and pigeonpea, the peak population of meso-arthropods were recorded during October under organic (7.97/100g of soil), integrated (4.34/100g of soil) and conventional (3.23/100g of soil) farming systems and minimum during December under organic (2.10/100g of soil), integrated (0.97/100g of soil) and conventional (0.40/100g of soil) farming systems (Fig. 2). In case of *rabi* crops like *rabi* sorghum and chickpea crops the peak population of meso-arthropods occurred in October under organic (4.77/100g of soil), integrated (2.37/100g of soil) and conventional (1.60/100g of soil) farming systems and minimum during January under organic (1.07/100g of soil), integrated (0.43/100g of soil) and conventional (0.17/100g of soil) farming systems (Fig. 3). The peak population of meso-arthropods occurred in June and October month may be due to sufficient soil moisture because of rainfall during June and October months and it may due to soil cover by the crops during their peak growth periods. Which resulted in high soil moisture in turn, increase the soil meso-arthropods population which is positively interrelated with food availability, lower soil temperature and crop shade during June and October month. In *kharif* crops (greengram, cowpea and maize) from June onwards population decreased because of drastic reduction in the rainfall, less moisture content in soil and reached minimum population in the month of September.

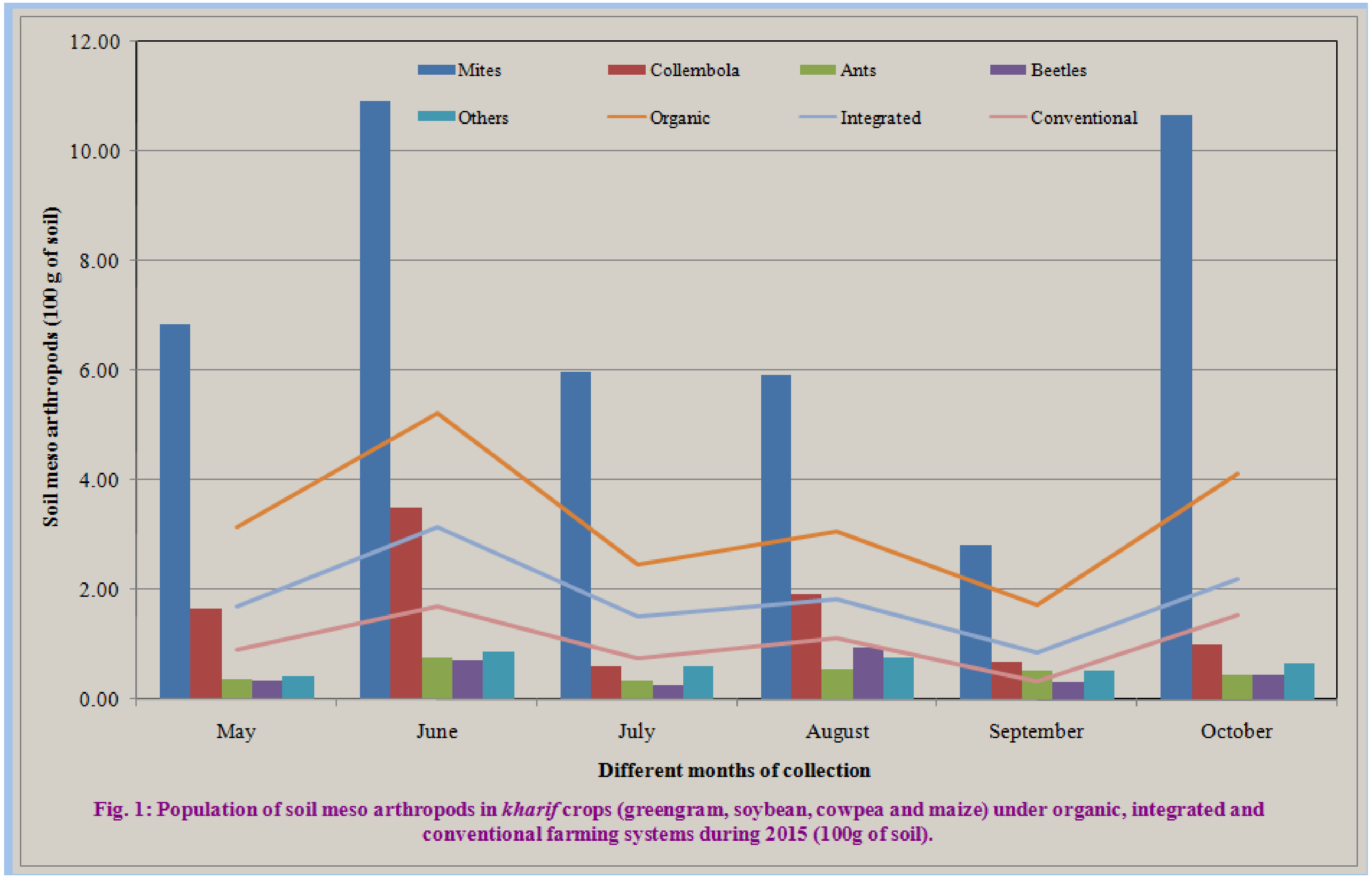


Fig. 1: Population of soil meso arthropods in *kharif* crops (greengram, soybean, cowpea and maize) under organic, integrated and conventional farming systems during 2015 (100g of soil).

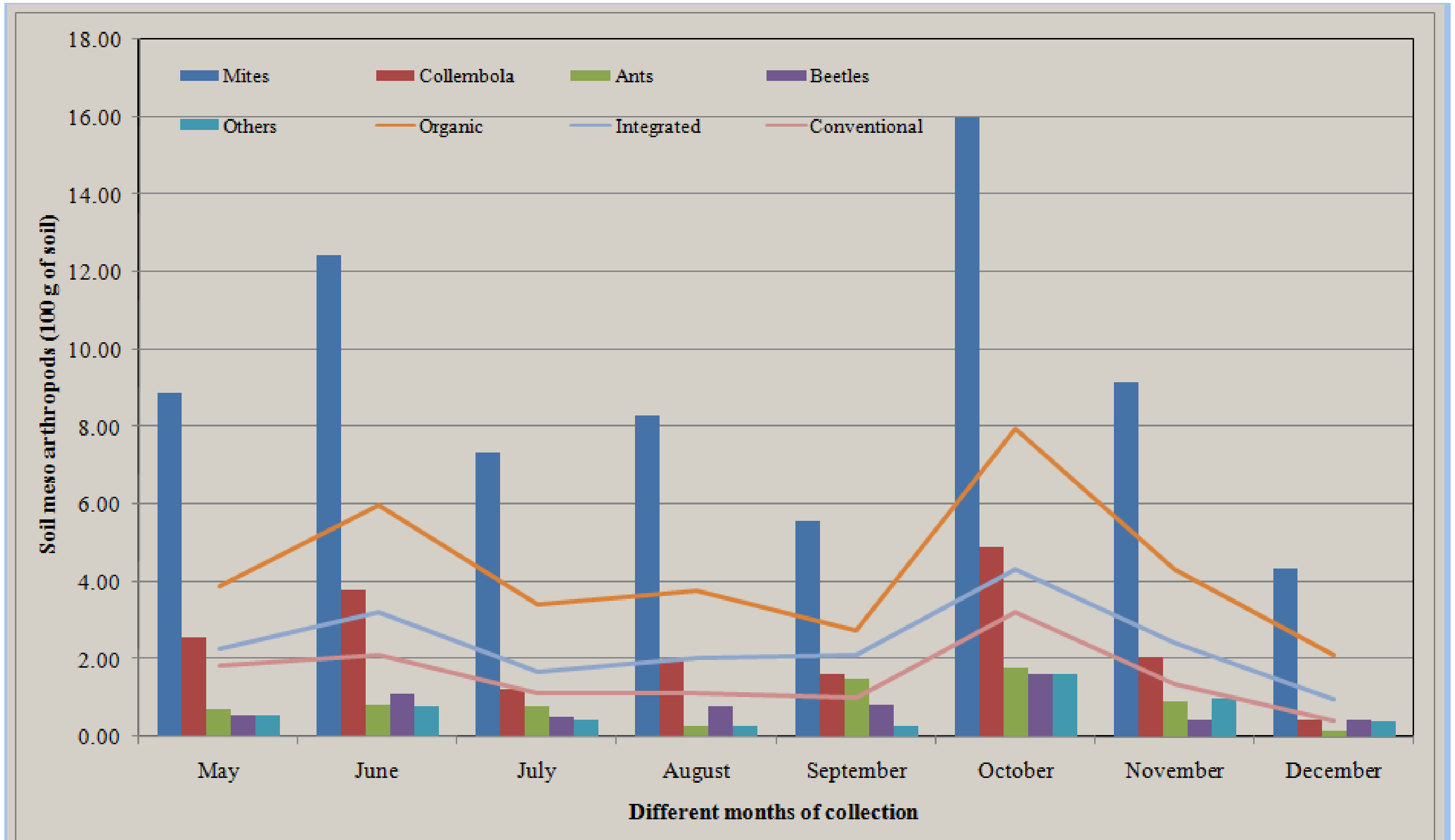


Fig. 2: Population of soil meso arthropods in long duration crops (cotton and pigeonpea) under organic, integrated and conventional farming systems during 2015 (100g of soil)

Fig. 2: Population of soil meso arthropods in long duration crops (cotton and pigeonpea) under organic, integrated and conventional farming systems during 2015 (100g of soil)

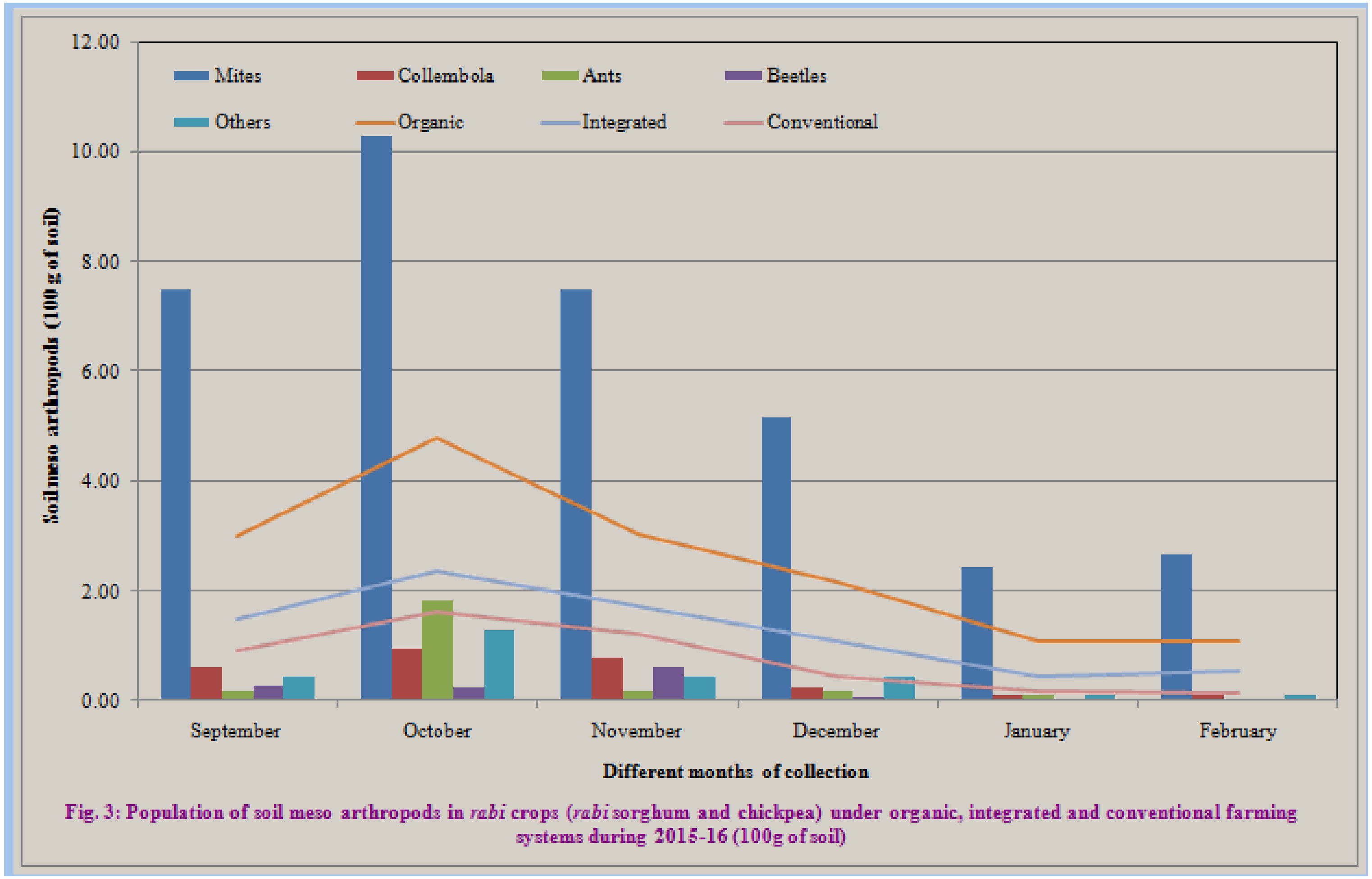


Fig. 3: Population of soil meso arthropods in *rabi* crops (*rabi* sorghum and chickpea) under organic, integrated and conventional farming systems during 2015-16 (100g of soil)

In long duration crops (cotton intercropped with groundnut and pigeonpea) maximum population of meso-arthropods during in October because heavy rainfall occurred in this month and after October drastic reduction in the rainfall, less moisture content in soil and reached minimum population in the month of December. In *rabi* crops moisture content gradually decreased so the population of meso-arthropods also declined from October onwards and reached minimum population in the month of February. The soil meso-arthropods population was found higher in rich nutrient habitat along with moist and suitable environment. Harsh climatic conditions could lead to gradual loss of meso-arthropods. Present findings are in line with Adis *et al.* (1989) who determined Acari and Collembola represented more than 75 per cent of the total catch. Decreasing population was significantly correlated with lower soil temperature and soil humidity at greater soil depth and also by Narasa Reddy *et al.* (2013) reported that there was a significant negative relationship existed between the abundance of soil mesofauna and maximum temperature of the atmosphere, soil temperature and insitu soil temperature. Negative correlation was observed with sunshine hours and minimum temperature. However, maximum relative humidity, minimum relative humidity, total rainfall and soil moisture had positive correlation. In-situ soil temperature had significant negative impact on abundance of soil mesofauna compared to other abiotic factors. William *et al.* (2012) reviewed that the reduced litter temperatures increases litter micro arthropod populations and increased soil moisture has little effect. The results also similar with the Rashmi *et al.,*(2013), Palacios *et al.,*(2007), Narula *et al.,*(1996). On contrary to present investigation, several findings like Sanyal (1996), Gondim *et al.* (2010), Abilasha *et al.* (2013a), Salavuddin (2014), Guru (2015) who reported arthropod peak population in the months of August and September. But present finding shows peak population during the months of June and October because 2015 was the drought year, which received uneven rainfall and very less rain fall during July, August and September compared to previous years as well as mean of sixty four years in Dharwad region. Present year, 2015 August and September rainfall recorded was very less (34.4mm and 22.4mm, respectively), which was 2.98 and 4.97 folds lower than the mean of sixty four years (August, 102.34mm and September, 109.32mm respectively). During 2015, good rainfall received during June (160.2mm) October (179.8mm), which was 1.50 and 1.42 folds higher in rainfall compared to previous mean sixty four years, June and October rainfall (106.60mm and 126.50mm, respectively). Hence during current year, August and September months soil arthropods population was less.

5.1.2 Population of macro-arthropods in different crops and cropping system under organic, integrated and conventional farming systems during 2015-16

Soil macro-arthropods population was evaluated in organic, integrated and conventional farming systems with seven crops (green gram, cowpea, soybean, maize, pigeon pea, chickpea and *rabi* sorghum) and one intercropping systems (cotton intercropped with groundnut). In this study significantly higher population of total macro-arthropods were recorded in organic farming with different crops *viz.,* greengram, soybean, cowpea, maize, pigeonpea, cotton intercropped with groundnut, chickpea and *rabi* sorghum (20.99/trap) as compared to integrated farming system (12.85/trap) and least in conventional farming system (9.34/trap) (Fig. 9). In *kharif* crops like soybean, greengram, cowpea and maize under organic farming (14.52, 11.40, 13.14 and 31.56/trap, respectively) recorded 2.14, 2.51, 2.58 and 1.95 folds, respectively increase in number of total macro-arthropods compared to conventional farming. Whereas, in soybean, greengram, cowpea and maize under integrated farming recorded 1.30, 1.44, 1.51 and 1.34 folds, respectively increase in number of total macro-arthropods compared to conventional farming. Among long duration crops like pigeonpea and cotton under organic farming (23.20 and 60.80/trap, respectively) recorded 2.27 and 2.17 folds, respectively increase in number of total macro-arthropods compared to conventional farming (10.18 and 27.95/trap, respectively) Whereas, in pigeonpea and cotton under integrated farming (13.56 and 35.02/trap, respectively) recorded 1.53 and 1.25 folds, more number of total macro-arthropods over conventional farming respectively. Among *rabi* crops like *rabi* sorghum and chickpea under organic farming (7.18 and 6.13/trap, respectively) recorded 3.00 and 3.76 fold, more number of total macro-arthropods compared to conventional farming (2.39 and 1.63/trap, respectively). Whereas, *rabi* sorghum and chickpea under integrated farming (4.15 and 3.40/trap, respectively) recorded 1.73 and 2.08 folds, more number of total macro-arthropods over conventional farming respectively. Irrespective of crops total soil macro fauna recorded was relatively more in organic farming followed by integrated and least in conventional farming.

The major soil macro fauna comprised of scarabids, spiders, ants, orthoptera and others (millipeds, centipeds, cockroach etc). Most of the soil macro fauna are predatory in habit. As these predators are density dependent when the meso-arthropods population is more automatically that will help to increase the soil macro-arthropods also. It may be also due to the abundance of organic matter, microbial biomass, optimum moisture, soil temperature and food availability. Present findings are corroborating with Abilasha *et al.* (2013a) and Shilpa *et al.* (2013), they have also recorded higher macro fauna in plots applied with 20t of FYM per hectare. Minarro *et al.* (2009) they also reported that ground beetles (Ca*rabi*ds), rove beetles (Staphylinidae), ants (Formicidae) and spiders (Araneae) sampled monthly with pitfall traps in the apple orchard a total of 4978 individuals collected. Ca*rabi*ds (56.8 per cent of the total catches) were the most abundant taxonomic group, followed by spiders (20.7%), ants (14.8%) and rove beetles (7.7%). Present findings are also in line with Braman and Pendley (1993), Gkisakis *et al.* (2014) they reported that application of insecticides adversely affected the beneficial arthropods like ants (Formicidae), spiders (Araneae) and parasitic Hymenoptera. Similarly by Doring and Kromp (2003) opined that staphylinids, ca*rabi*ds, spiders and chilopods were more abundant in organic farm. Naureen *et al.* (2010) also concluded that declining of macro-invertebrates was less pronounced in organically managed fields (low input) as compared to high input farming.

Irrespective of farming systems among *kharif* crops (soybean, cowpea, green gram and maize) maize recorded more population (23.11 macro-arthropods/trap) followed by soybean (10.02/trap) and cowpea (8.65/trap). In case of long duration crops, cotton intercropped with groundnut (41.26/100g of soil) recorded more population compared to pigeon pea (16.31/trap). In case of *rabi* crops, sorghum (4.57/trap) recorded more population compare to chickpea (3.75/trap).

5.1.2.1 Population dynamics of macro-arthropods in different crops and cropping systems under organic, integrated and conventional farming systems during 2015-16

Population dynamics of macro-arthropods evaluated under organic, integrated and conventional farming systems with above mentioned crops during 2015-16 showed that there was fluctuation of total macro-arthropods population during the cropping season. In *kharif* crops, the peak population of macro-arthropods were recorded during first week of August under organic (6.07/trap), integrated (4.11/trap) and conventional (3.21/trap) farming systems and gradually declined and attained minimum during fourth week of September under organic (2.20/trap), integrated (0.80/trap) and conventional (0.20/trap) farming systems (Fig. 4). In long duration crops like pigeonpea and cotton, the peak population of macro-arthropods was recorded during first week of October under organic (15.47/trap), integrated (8.23/trap) and conventional (5.77/trap) farming systems and gradually declined and attained minimum during second week of November under organic (2.63/trap), integrated (0.97/trap) and conventional (0.70/trap) farming systems (Fig. 5). In case of *rabi* crops like *rabi* sorghum and chickpea the peak population of macro-arthropods occurred during third week of October under organic (3.40/trap), integrated (2.17/trap) and conventional (1.03/trap) farming systems and gradually declined and attained minimum during first week of January under organic (0.13/trap), integrated (0.07/trap) and conventional (0.07/trap) farming systems (Fig. 6). The peak population occurred during October because of sufficient rainfall, food availability with optimum soil moisture and soil temperature, cropping period and also it may be due to the availability of suitable food (prey, vegetation *etc*). The present findings are in close agreement with the observations of Shilpa *et al.* (2013) reported treatments with application of FYM supported higher macro fauna and Umadevi *et al.* (2013) reported higher macro faunal activity was observed on 45 DAG (53.99/trap). The present findings corroborate with the findings of Minati and Kakati (2013) who reported that maximum abundance was exhibited during rainy season followed by winter and summer. The peak population density recorded during August. Similarly by Sanyal (1996), Tripathi *et al.* (2007) who recorded peak population of soil arthropods during the month of August.

5.1.3 Population dynamics of earthworms in different crops and cropping system under organic, integrated and conventional farming systems during 2015-16

The population of earthworms are assessed in the above mentioned crops and cropping systems. In this study significantly higher population of earthworm was recorded in organic farming with different crops *viz.,* greengram, soybean, cowpea, maize, pigeonpea, cotton intercropped with groundnut, chickpea and *rabi* sorghum (2.32/0.25 m^2 or 92, 800/ha) as compared to integrated farming (1.31/0.25 m^2 or 52, 400/ha) and least in conventional farming (0.71/0.25 m^2 or 28, 400/ha) (Fig. 9).

Irrespective of crops, earthworm population was relatively more in organic farming followed by integrated and least in conventional farming. Among all these systems in organic plots the population was higher compared to conventional plots it might be because of crop residue retention, no chemical interventions, better aeration, organic matter and more moisture retention which in turn helped for the development of worms and contributed to the higher densities of earthworms under organic farming.

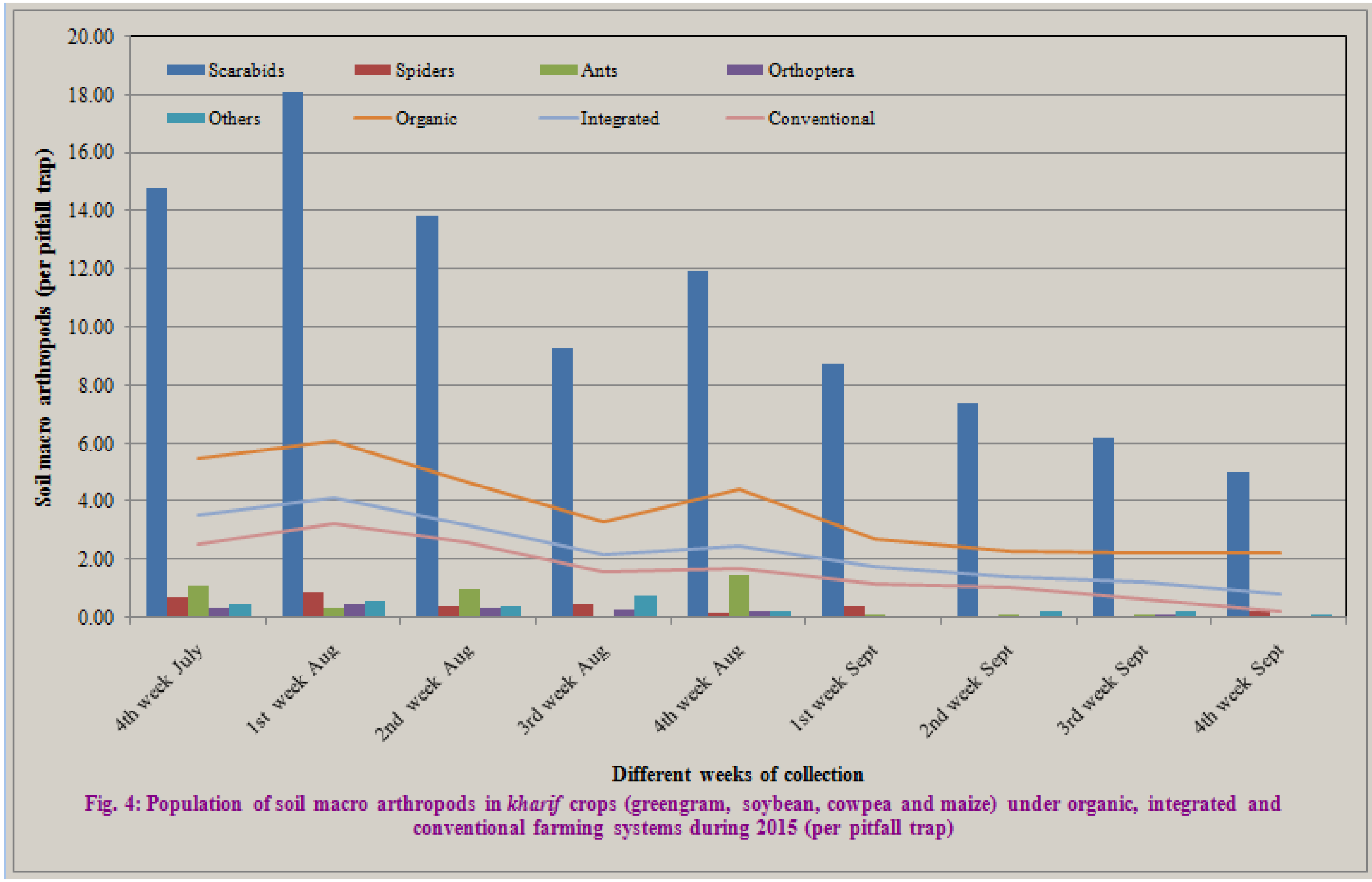


Fig. 4: Population of soil macro arthropods in *kharif* crops (greengram, soybean, cowpea and maize) under organic, integrated and conventional farming systems during 2015 (per pitfall trap)

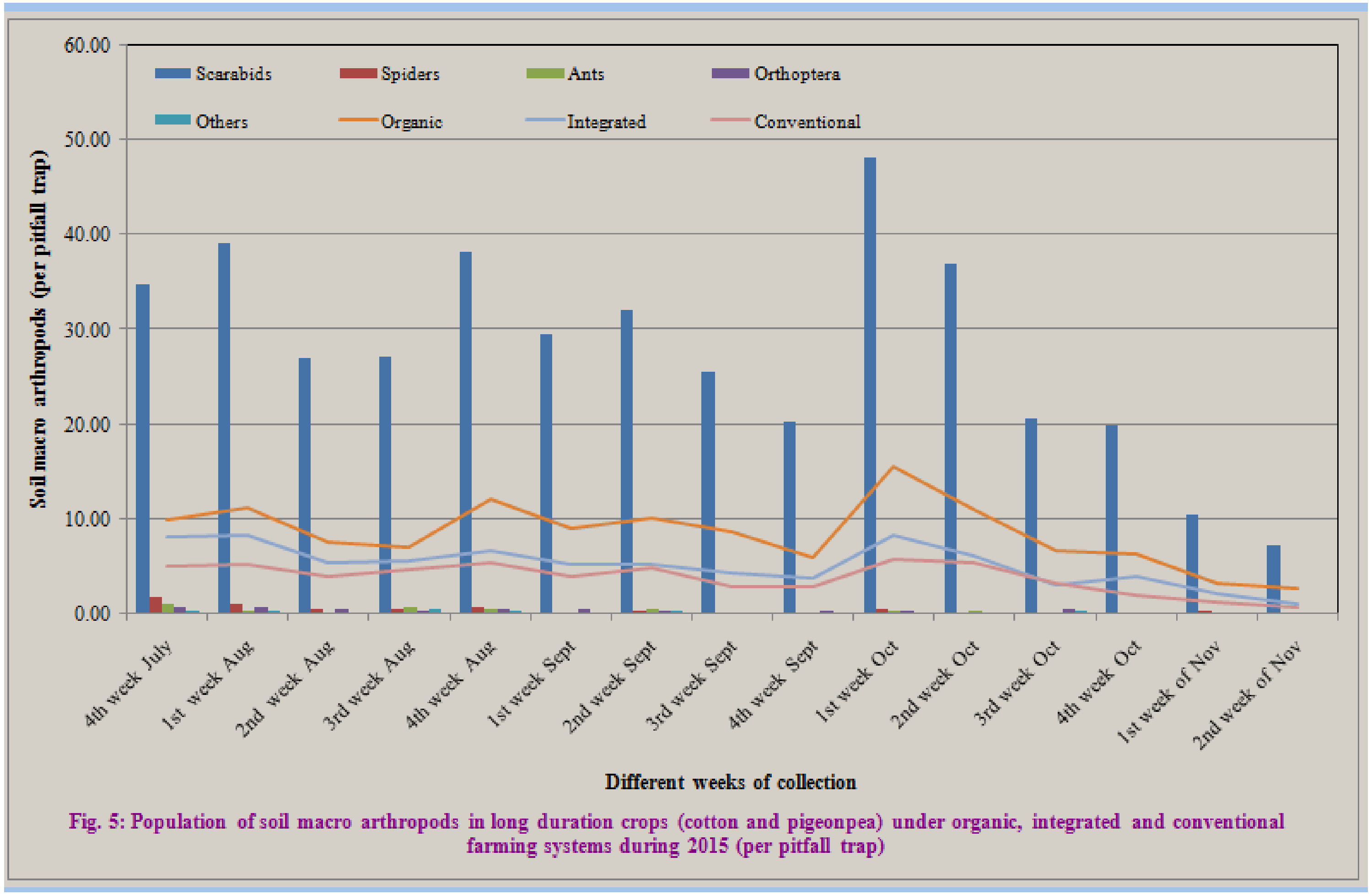


Fig. 5: Population of soil macro arthropods in long duration crops (cotton and pigeonpea) under organic, integrated and conventional farming systems during 2015 (per pitfall trap)

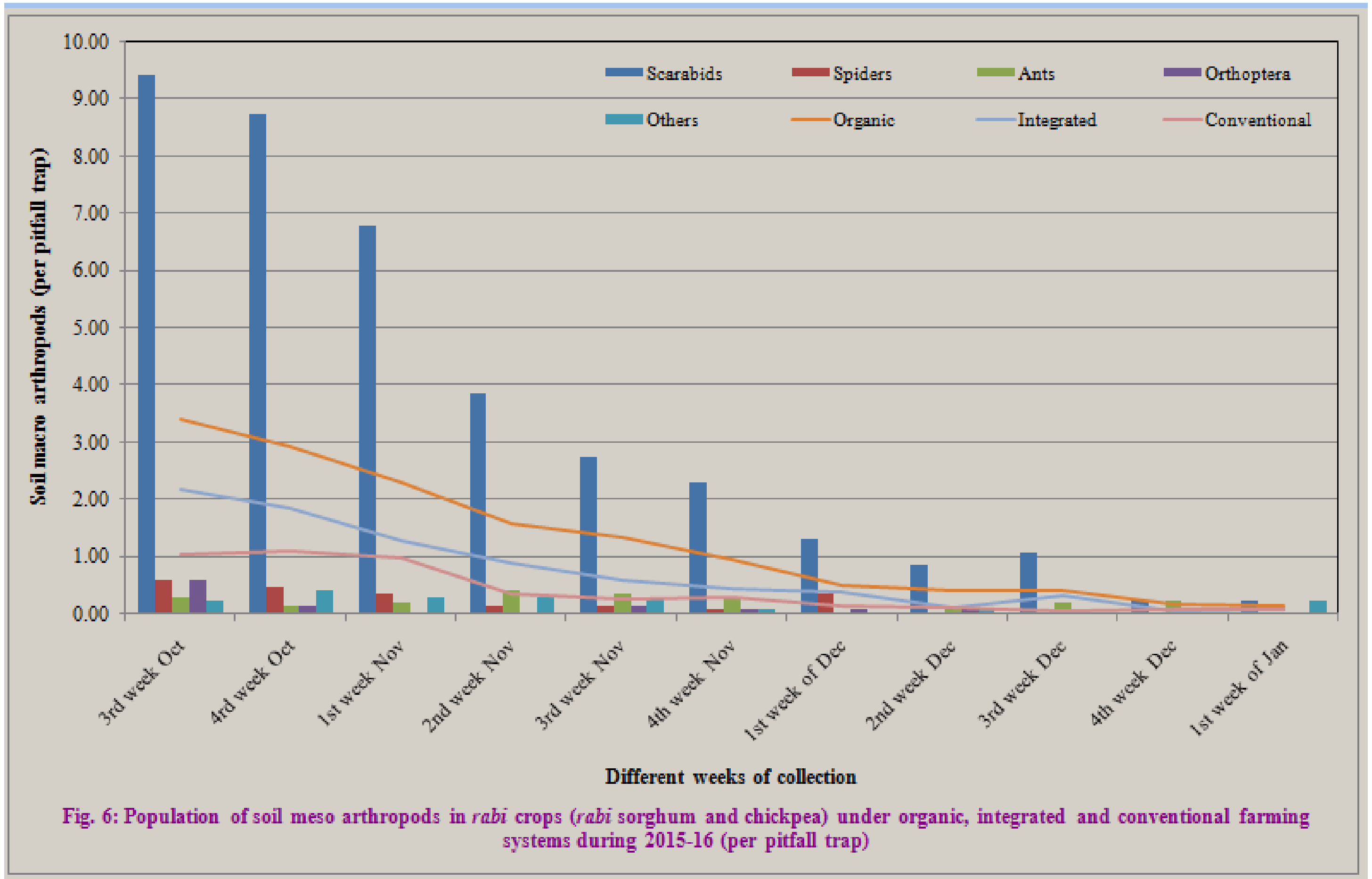


Fig. 6: Population of soil meso arthropods in *rabi* crops (*rabi* sorghum and chickpea) under organic, integrated and conventional farming systems during 2015-16 (per pitfall trap)

Present findings are corroborating with many workers, they reported that the earthworm biomass and abundance was higher in organic fields compared to conventional fields (Maeder *et al.*, 2002; Hole *et al.*, 2005; Curry *et al.*, 2002; Lal, 2004 and Helling, 1998). Similarly Ayuke *et al.* (2011) reported that, enhanced diversity of earthworm is observed when applied with the organic manure compared to the inorganic manures. Present finding showed that the earthworm abundance in organic field was about 69.4 per cent more as compared to conventional fields. This investigation is supported by Paoletti *et al.,*(1998) as the soil biological properties in the conventional management system over 5 years had a negative effect on non-target soil microbial activity compared to organic management system in orchards. The organic management increased earthworm abundance by 60 per cent although, soil tillage operations for weed control in orchards could reduce earthworm abundance. Many workers (Joschko *et al.*, 1989; Nuutinen *et al.*, 2001 and Shipitalo *et al.*, 2004) reported that the population of *Lumbricus* spp. was influenced by water conductivity and infiltration, the population found to be higher in the organic fields than conventional and the infiltration rate is 3-10 times lower on the conventional fields than on the organic fields. Pelosi *et al.* (2014) reported that pesticides are directly toxic to earthworms. The direct toxic effect lead to reduced growth, survival, induced behavior like low burrowing rate. Similar reports by Edwards and Bohlen (1996) and Mohasin *et al.* (2005).

Overall irrespective of farming systems earthworms population was highest in pigeonpea (1.91/0.25 m^2 or 76.400/ha) followed by cotton intercropped with groundnut (1.84/0.25 m^2 or 73, 600/ha) and soybean (1.81/0.25 m^2 or 72, 400/ha) because, pigeonpea and soybean act as cover crops, legume crops rich in protein, heavy litter fall that going to add nutrients to soil and act as mulch, conserve the moisture so, earthworms population might have increased. The present findings are supported by the work of Kumar Rao *et al.* (1996) who reported that pigeonpea litter mass ranged from 2.7 to 7.6 t/ha. Total N (kg/ha) supply expected from litter fall based on litter biomass and nitrogen concentration (per cent N) ranged from 56 to 132 kg N/ha in the leaves that fall during the growth of pigeon pea. In cotton intercropped system, groundnut crop act as cover crop which prevented excessive evaporation of moisture from soil and blocked sunshine reaching the soil. Thus helped in maintaining the favourable micro climate for the survival, food availability for growth and development of earthworms.

In present investigation, the mites and collembolan were the abundant group recorded in meso-arthropods and in macro arthropod category scarabeids, were the most dominant group noticed. The main decomposers and detritivores in the soil arthropod community are Scarabaeidae, Tenebrionidae, mites (Acari), springtails (Collembolla), woodlice (Isopoda) and Thysanura (Wurst, 2013). In general, arthropod communities are affected by mechanical alteration of soil, modification of quantity and location of plant residues and alterations to weed communities (Stinner and House, 1990).

5.2 Effect of organic, integrated and conventional farming systems on above ground diversity of insect population

Nearly all non-crops, naturally occurring species observed in comparative farm land practice studies show a preference for organic farming both by abundance and diversity. An average of 30 per cent more species inhabits organic farms. Lack of pesticides improves biodiversity fitness and population density. Many weed species attract beneficial insects that improve soil qualities and forage on weed pests. Soil-bound organisms often benefit because of increased bacterial populations due to natural fertilizer such as manure and earthworm population while experiencing reduced intake of pesticides. Increased biodiversity, especially from beneficial soil microbes and mycorrhizae have been proposed as an explanation for the high yields experienced by some organic plots (Anon, 2011).

Overuse of pesticides in conventional farming has led to the outbreak of pests because of destruction of natural enemies. It has also led to development of resistance, environmental pollution, operational hazards followed by substantial erosion in net income. Further, farmers have failed to get appreciable increase in yield between sprayed and unsprayed plots. This indicates the failure of insecticide sprays and increase in natural enemy population in unsprayed plots, which add to the total cost of the production and affect the environment adversely (Wightman and Ranga Rao, 1994). In recent years with increased awareness about the harmful effects of pesticides, organic farming has attracted attention of scientists, environmentalists and farmers for sustainable production. This is true when marginal and sub marginal farmers, who cannot afford to take up control measures because of increased cost of cultivation, to grow the crop. Hence, studies were undertaken to know the influence of organics on pest and natural enemy complex.

Generally, it is observed that populations of several crop insect pest species are depressed under conditions of plant species diversity. The factors responsible for this depression are: natural enemies, masking, repellency, less colonization, resource concentration, unfavourable microclimate, physical obstruction by trap cropping, intercropping *etc.* Natural enemies account for more than half of the cases where the pest population was claimed to be regulated in the weed-diversity systems.

Pest-control measures in organic farming such as crop diversity and fostering natural insect predators, as well as naturally-sourced pesticides are employed, while it excludes or strictly limits the use of synthetic pesticides, the conservation of natural resources and biodiversity is a core principle of organic production. Three broad management practices (prohibition/reduced use of pesticides; sympathetic management of non-cropped habitats; and preservation of mixed farming) that are largely intrinsic (but not exclusive) to organic farming are particularly beneficial for faunal and wildlife activities. Using practices that attract or introduce beneficial insects, provide habitat for birds and mammals, and provide conditions that increase soil biotic diversity serve to supply vital ecological services to organic production systems. Advantages to organic operations that implement these types of production practices include: decreased dependence on outside fertility inputs; reduced pest management costs; more reliable sources of clean water and better pollination.

5.2.1 Pest status in different crops under organic, integrated and conventional farming systems during 2015-16

The present investigation is also support to the above said statements and in nine different crops, cropping system and different farming systems the pests and natural enemies were assessed and discussed here under.

Soybean grown under conventional farming recorded significantly more number of defoliators and pod borer incidence, which were 1.28 and 1.36 folds, respectively increase over organic farming. Whereas soybean under integrated farming recorded more number of defoliators and pod borer incidence, which was 1.20 and 1.21 folds, respectively decrease compared to conventional farming system. In greengram grown under conventional farming recorded more number of defoliators and pod borer incidence, which was 1.27 and 1.08 folds, respectively increase over organic farming. Whereas greengram under integrated farming recorded less number of defoliators and pod borer incidence, which was 1.13 and 1.02 folds, respectively decrease compared to conventional farming. In cowpea grown under conventional farming recorded significantly more number of defoliators and pod borer incidence which was 1.15 and 1.96 folds, respectively increase over organic farming. Whereas cowpea under integrated farming system recorded less number of defoliators and pod borer incidence, which was 1.04 and 1.61 folds, respectively decrease compared to conventional farming system (Fig. 7). In groundnut grown under organic and integrated farming systems recorded less number of defoliators, which was 1.49 and 1.20 folds, decrease in defoliators incidence compared to conventional farming system.

In general crops grown in organic system recorded fewer incidences of defoliators and pod borer compared to conventional fields because of more natural enemies presence, which will take care of pests and using of botanicals will not affects the natural enemies in organic system. These findings are supported by Bharathi (2005) and Kavita (2009) reported lowest population of defoliators in organically grown soyabean compared to integrated and conventional crop and also supported by Rajashekara Rao (2003) showed that the organically grown groundnut recorded lowest pest population of defoliators (*S. litura)* compared conventional grown. The low pest incidence in organically grown crops treated with neem cake was due to insecticidal, repellent and associated actions of neem, Azadiractin after being translocated into the plant system it acts as growth disruptant to many insect species and reduce food conversion efficiency by interfering with their digestive processes (Rajashekaran and Jayaraj, 1990).

Pigeonpea

The per cent gall weevil incidence was significantly higher in organic field (44%) which was 1.67 and 1.10 folds increase over integrated (39.67%) and conventional fields (27%) respectively. In case of pod borer damage, no significance difference between farming systems. Interestingly seed damage shows significant difference it was highest in conventional and least in organic field. According to present investigation gall weevil incidence is more in sole organic field it may be due to there was no control measure taken initially for gall weevil in organic field, but control measures were taken up in conventional system. But pod borer damage less in organic field because of more natural enemies population. The present findings are supported by Dayakar *et al.* (1995) who reported the population build up of pod borers on Pigeonpea was minimum in organic followed by integrated and conventional fields.

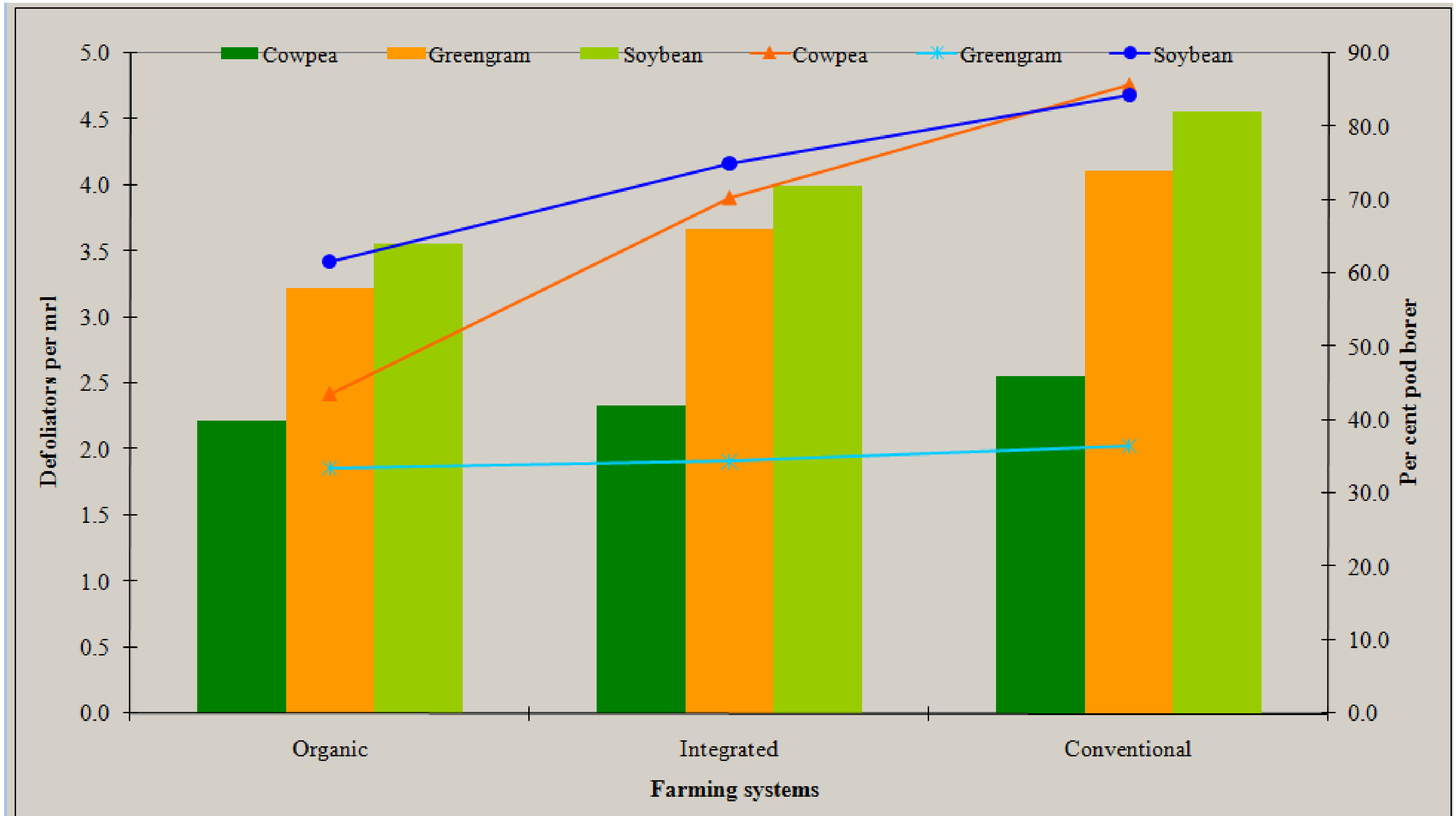


Fig. 7: Defoliators and pod borer incidence in greengram, cowpea and soybean under organic, integrated and conventional farming systems

Fig. 7: Defoliators and pod borer incidence in greengram, cowpea and soybean under organic, integrated and conventional farming systems

Cotton

In general, the sucking pest damage was highest in conventional cotton (2.78/3 leaves), which was 1.60 and 2.72 folds increase over integrated (1.73/3 leaves) and organic cotton (1.02/3 leaves) respectively. The increased incidence of these sucking pests in conventionally grown crops, due to increased auxin content of plants under heavy nitrogenous manuring. The inorganic fertilizers increased the plant growth and provided nutrients to the plants in larger proportion in shorter period, leading to heavy insect population. These findings are supported by kavita (2009) and Balakrishna *et al.* (2007) who also reported lowest population of sucking pests *viz.,* aphids, leafhoppers, thrips and whiteflies in organic fields cotton compared to conventional.

The shoot weevil, damage was highest in conventional cotton (56%), which was 1.11 and 1.51 folds increase over integrated (75.67%) and organic cotton (56%) respectively. This may be due to organic amendments which increased the total phenols in the plant and also activities of enzymes *viz.*, polyphenol oxidase and peroxidase which might be responsible for reducing pest incidence.

Maize

In maize it is evident from the results that the crop grown in conventional field recorded more incidence of stem borer (33.33%), which was 1.33 and 1.66 folds increase over integrated (25%) and organic field (20%) respectively. Stem borer incidence was less in organic field it may due to low and slow release of N content in the plants due to organic manure leads to increased phenols, tannins and lignin that contribute to leaf toughness and production of more cell wall related structural compounds which are not desirable for herbivores (Scriber and Slansky, 1981) hence insects are unable to ingest sufficient quantity of nutrients. With the concept it may be possible to create a partial nitrogen stress up to a certain period through organic manures and thus induced resistance through intrinsic production of defence compounds, which deter the pest attack but nitrogenous fertilizers application in conventional maize it leads N content is more, succulent and vigorous growth so stem borers prefers more. These findings are supported by Anon.(2011) who reported that organic plant protection consisting of Ha NPV, *N. rileyi*, *Verticillum lecanii*, NSKE and *Trichogramma* release for 3-4 times found effective in management of stem borer, cob borer and aphids in maize. Natural enemies *viz.*, coccinellids, syrphids were found abundantly feeding on aphids. *Apanteles sp, Nomuraea, Tachinids* found on stem borer and *H. armigera*. Organic plant protection measures also provide good protecton to crop compared to conventional management strategies. The present findings also draw the support of the findings of Rossi *et al.* (1988) against *S. frugiperda* in Maize. Results from the present investigation on pest population in groundnut and other crops vividly showed that organically grown crop recorded least incidence of pests compared to integrated and conventional crop.

Chickpea

In chickpea, numerically lesser per cent pod borer incidence was observed in organic (2.33%) farming because of more natural enemies like *C. chlorideae* and predatory bird cattle egret. The present findings are supported by Kavitha (2009) she reported that organically grown chickpea crop treated with organic manures, biodynamic and biopesticide sprays recorded least incidence of *H. armigera* compared with conventional system.

Rabi sorghum

In *rabi* sorghum the per cent stem borer incidence was non significant among the three systems. The present findings also draws the support of the findings of Phelan *et al.* (1995) reported that soil management practices can significantly affect the susceptibility of crops to pests.

5.2.2 Natural enemies status in different crops under organic, integrated and conventional farming systems during 2015-16

Results from the present investigation on natural enemy population clearly showed that organically grown crops recorded significantly higher number of natural enemies. Soybean grown under organic farming recorded more number of braconids, *N. rileyi* infected larvae and coccinellids, which was 2.47, 4.22 and 3.76 folds and 1.60, 2.42 and 1.46 folds higher, respectively over conventional and integrated farming systems respectively. Greengram grown under organic farming recorded more number of braconids, *Illeis cincta* and coccinellids (3.33, 5.17 and 0.58/mrl, respectively) which is 2.22, 3.44 and 1.75 folds, and 1.60, 1.72 and 1.76 folds, respectively increase over conventional and integrated farming respectively. Cowpea grown under organic farming recorded more number of braconids, *Illeis cincta* and coccinellids (2.38, 2.67 and 0.50/mrl respectively), which was 1.67, 3.56 and 1.51 folds, respectively and 1.23, 2.28 and 1.00 folds, increase over conventional and integrated farming systems. In maize grown under organic farming recorded more number of coccinellids and syrphids (2.58 and 2.00/plant, respectively) which was 3.22 and 2.41 folds and 1.43 and 1.60 folds, increase over conventional and integrated farming systems respectively. In cotton grown under organic farming recorded more number of coccinellids, spiders and green lace wings (1.03, 1.58 and 1.17/plant, respectively) which was 3.43, 7.52 and 3.54 folds and 1.72, 1.38 and 1.41 folds increase over conventional and integrated farming system respectively. In pigeonpea grown under organic farming recorded more number of *Illeis cincta*, spiders and green lace wings (3.81, 2.00 and 1.48/plant, respectively) which was 1.90, 2.19 and 1.95 folds and 1.35, 1.55 and 1.48 folds increase over conventional and integrated farming respectively. In groundnut and chickpea grown under organic farming recorded more number of *Campoletis chlorideae* pupae (2.22 and 0.56/mrl respectively) which was 2.22 and 1.27 folds and 1.32, and 1.27 folds increase over conventional farming and integrated farming system respectively. In *rabi* sorghum grown under organic farming recorded more number of spiders (2.11/plant) which was 2.37 folds and 1.58 folds higher, respectively over conventional and integrated farming system.

In general organic crops have higher population of natural enemies compared to integrated and conventional crops. Its due to in organically grown crops was applied with natural products like soil application of FYM, neem cake, vermicompost, green leaf manure and spraying with panchagavya, NSKE (5%), biodynamic and *N. rileyi* were found safer to natural enemies. The present findings are supported by Katti *et al.* (2001) who reported highest level of parasitism of yellow stem borer, gall midge, leaf folder and predatory spiders and mirid bugs in natural biological control compared to need based protection and schedule based protection. It is evident from the results of the findings that use of organic amendments and indigenous sprays spared the natural enemies which are their in the ecosystem to take care of pest population without affecting the environment. Similarly Kavita (2009) reported that in groundnut ecosystem, organic treatment recorded less number of pests (aphids, leafhoppers, thrips and defoliators) and higher number natural enemies (coccinellids and syrphids) population compared to integrated and inorganic treatments. Similarly higher number of mycosed larvae due to *N. rileyi* on *S. litura* was noticed in organic field. Present investigation was also supported by Letourneau and Goldstein (2001) who concludes that conventional and organic farms shared a similar range of arthropod damage levels to tomato, whereas herbivore abundance did not differ, higher natural enemy abundance and greater species richness of all functional groups of arthropods (herbivores, predators, parasitoids and others) distinguished organic from conventional tomato. Organic fields had significantly higher numbers of parasitic hymenoptera (69%), rove beetle (32%) and green lacewings (79%) compared with conventional fields in carrot crop (Berry *et al*., 1996). Abundance of various predators, including spiders, ca*rabi*d beetles and parasitoids, can be greater under organic management system (Maeder *et al*., 2002; Hole *et al*., 2005). In conventional agricultural management, synthetic insecticides are used to suppress *Apis gossypii* population, but these insecticides often kill natural enemies and can lead to more severe outbreaks of *A. gossypii* and other pests (Kerns and Gaylor, 1993; Slosser *et al*., 1998; Wilson *et al*., 1999).

5.2.3 Pollinators status in different crops under organic, integrated and conventional farming systems during 2015-16

Pollination is an important phenomenon in agricultural systems especially in growing fruits and seed production which depend greatly on bees visiting during blossom. The major pollinator dependent crops are fruit and vegetable crops, spices and plantation crops, pulses, oilseeds *etc.* (Gallai *et al*., 2008). Organic versus conventional farming has always been a matter of heated debate. While some point out that conventional agriculture is a big environmental threat that undercuts biodiversity and water resources, along with releasing greenhouse gases, others argue that large-scale organic farming would take up more land and make food unaffordable for most of the world's poor and hungry. Although organic techniques may not be able to do the job alone, they do have an important role to play in feeding a growing global population while minimizing environmental damage. In countries like India, where a population in excess of a billion souls has to be fed, food production is a crucial aspect. Since bees are the small and hard-working insects who actually make it possible for many of our favorite foods to reach our table, it is our responsibility to protect them from declining. Every third bite of food we take, we must be thankful to bees or other pollinators and without them the whole mankind is going to doom. May it be organic or conventional, our main motto must be hooked on protecting these pollinators. Thus focus may be shifted to integrating the best methods of pest management which are bee friendly and at the same time yield enhancing.

Present investigation on pollinators activity in different farming systems evidently showed that organically grown crops greengram, cowpea, soybean, pigeonpea, cotton intercropped with groundnut recorded significantly more number of pollinators (13.83, 13.50, 8.50, 15.50/m^2/5 min and 10.17/5pl/5 min, respectively) as compared to integrated farming and least in conventional farming system (Fig. 8). Overall, organically grown above crops recorded significantly more number of pollinators (10.25/m^2/5 min), which was 1.56 and 2.63 folds, higher in pollinators compared to integrated farming (6.56/m^2/5 min) and conventional farming system (3.89/m^2/5 min) (Fig. 9).

Present investigation was supported by Morandin and Winston (2005) reported that bee abundance was greatest in organic fields, compared to conventional fields and GM fields. The pesticides are potential cause of biodiversity and pollinator decline. The wild bees are insect pollinator group at particular risk from pesticide use. Siqueira *et al.* (2008) reported that mango flowers in conventional and organic system were visited by 21 species of insects belonging to the orders: Diptera, Hymenoptera, Lepidoptera and Odonata among which, *A. mellifera* was the most frequent accounting for 68.30 per cent of total visits in organic farming and 45.60 per cent in conventional farming. Anjankumar (2014) reported that under organic cashew ecosystem, panicles were visited by twenty seven species of pollinators. Among honey bees, *Apis cerana, A. dorsata* and *A. florea* constituted 34.46, 28.09 and 21.33 per cent of total pollinators, respectively. Whereas the panicles sprayed with conventional insecticides were visited only by sixteen species of pollinators. According to Brittain *et al.* (2009) lower bumblebee and butterfly species richness was found in the more intensively farmed basin with higher pesticide loads. The negative impacts of insecticides on pollinators those visit flowering plant species that are specialist on specific pollinating taxa to set fruits, such as passion fruit that is dependent on carpenter bees or vanilla on specific Euglossinae bees (Klein *et al.*, 2007). Organic farming was found to provide increased floral resources that attract more pollinating insects and higher pollination success on farms under organic management (Eileen and Jane, 2011).

5.2.4 Shannon's weaver biodiversity index in different crops and cropping system under organic, integrated and conventional farming systems during 2015-16

Shannon's weaver index of general biodiversity of below ground arthropods were found higher in organic farming (0.68) followed by integrated (0.62) and least in conventional farming (0.52). The present results were supported by many workers they have stated that in organically maintained fields showed higher taxa richness, abundance and diversity of the meso faunal community. In turn it also enhances the level of soil organic carbon that may contribute to long term functional approach in an agro-ecosystem (Schrader *et al.*, 2006; Santigo *et al.*, 2009; Naureen *et al.*, 2010; Carlos *et al.*, 2011; Parwez and Abbas, 2012; Wurst, 2013). Irrespective of different crops, arthropods respond well for the organic farming in positive way in turn proved by their abundance in organic farming systems and negative relation towards the conventional farming, where less abundance of arthropods was observed.

Across the different crops in below ground arthropods, soybean recorded higher biodiversity index (0.71) followed by greengram (0.67) and least in chickpea (0.49) because of soybean and green gram crop act as cover crop, and they are nitrogen fixers in turn will be the source of nutrients for many of these soil arthropods. Conservation of soil moisture is comparatively high in these crops and the falling leaf litter acts as mulch to retain moisture, reduce soil temperature as well as organic food source for the soil arthropods which supports their food chain in order to feed and reproduce consistently and maintain their population at higher side (Fig. 10).

Shannon's weaver index of general biodiversity of above ground insects and spiders were found higher in organic farming (0.38) followed by integrated (0.32) and least in conventional (0.27). Present investigation was supported by Berry *et al.* (1996) who reported that mean diversity index of natural enemies were higher in (0.816) organic fields compared to conventional (0.648) fields. Similarly by Drinkwater *et al.* (1995), Liat *et al.* (2004)*,* Yann *et al.* (2006).

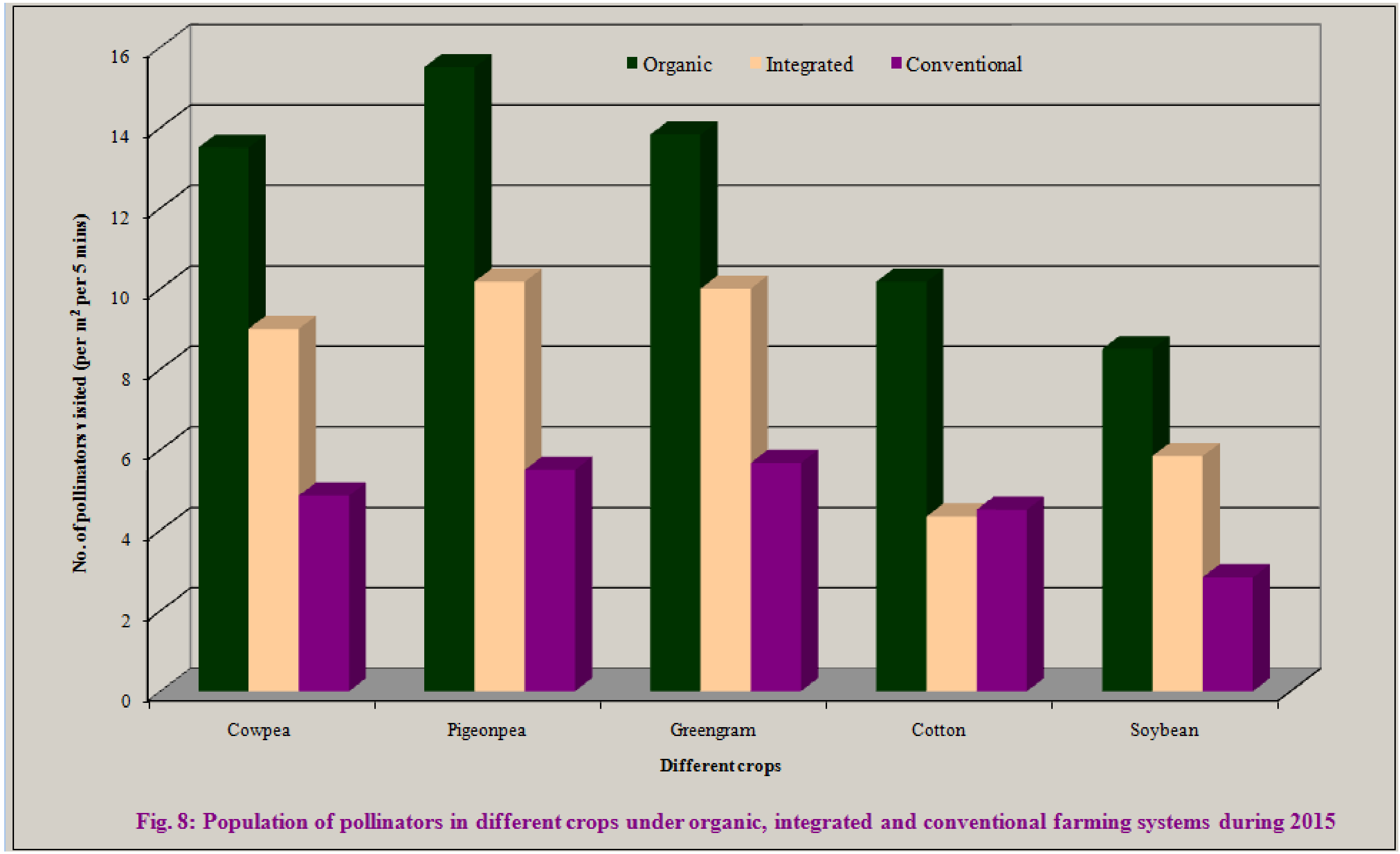


Fig. 8: Population of pollinators in different crops under organic, integrated and conventional farming systems during 2015

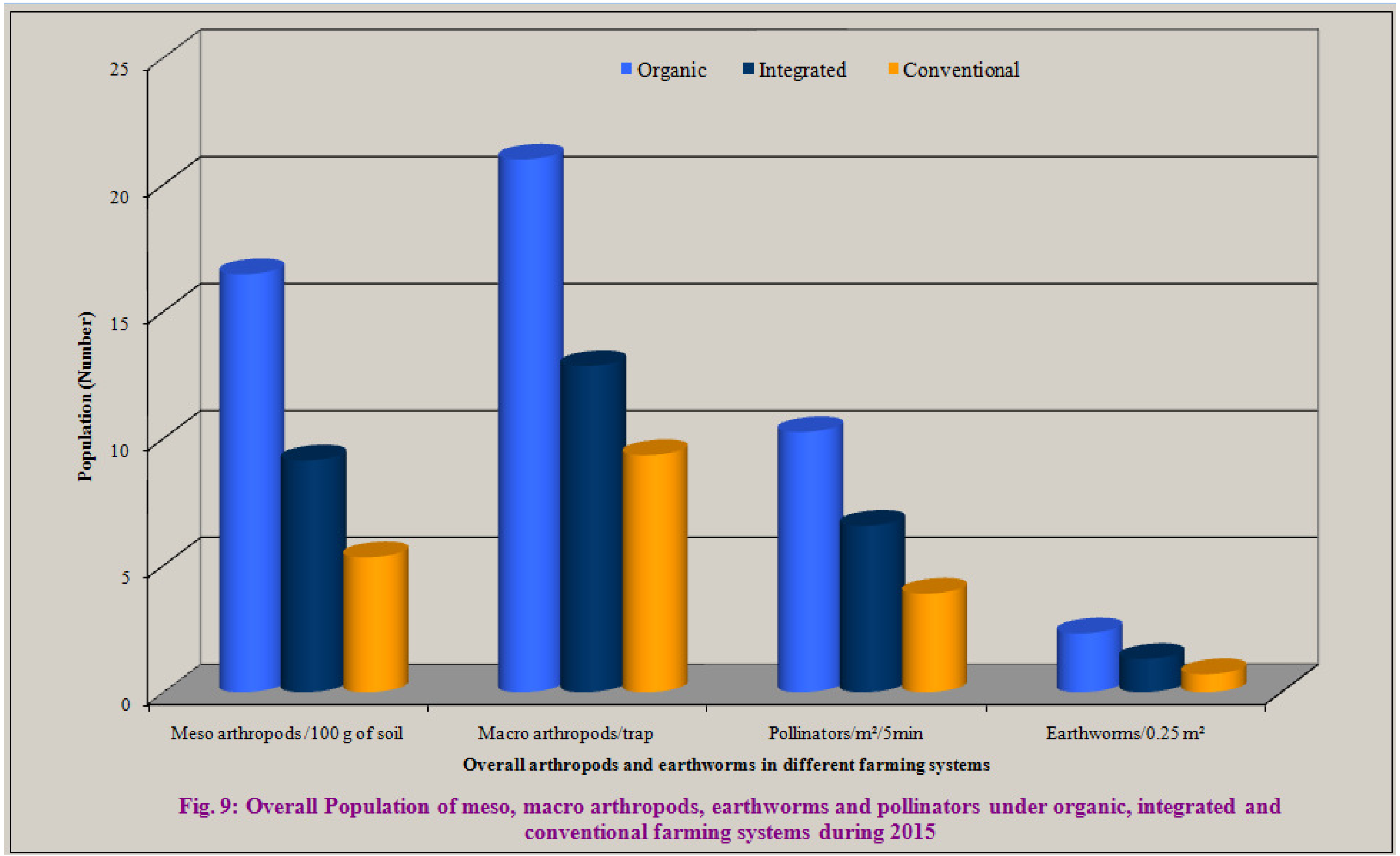


Fig. 9: Overall Population of meso, macro arthropods, earthworms and pollinators under organic, integrated and conventional farming systems during 2015

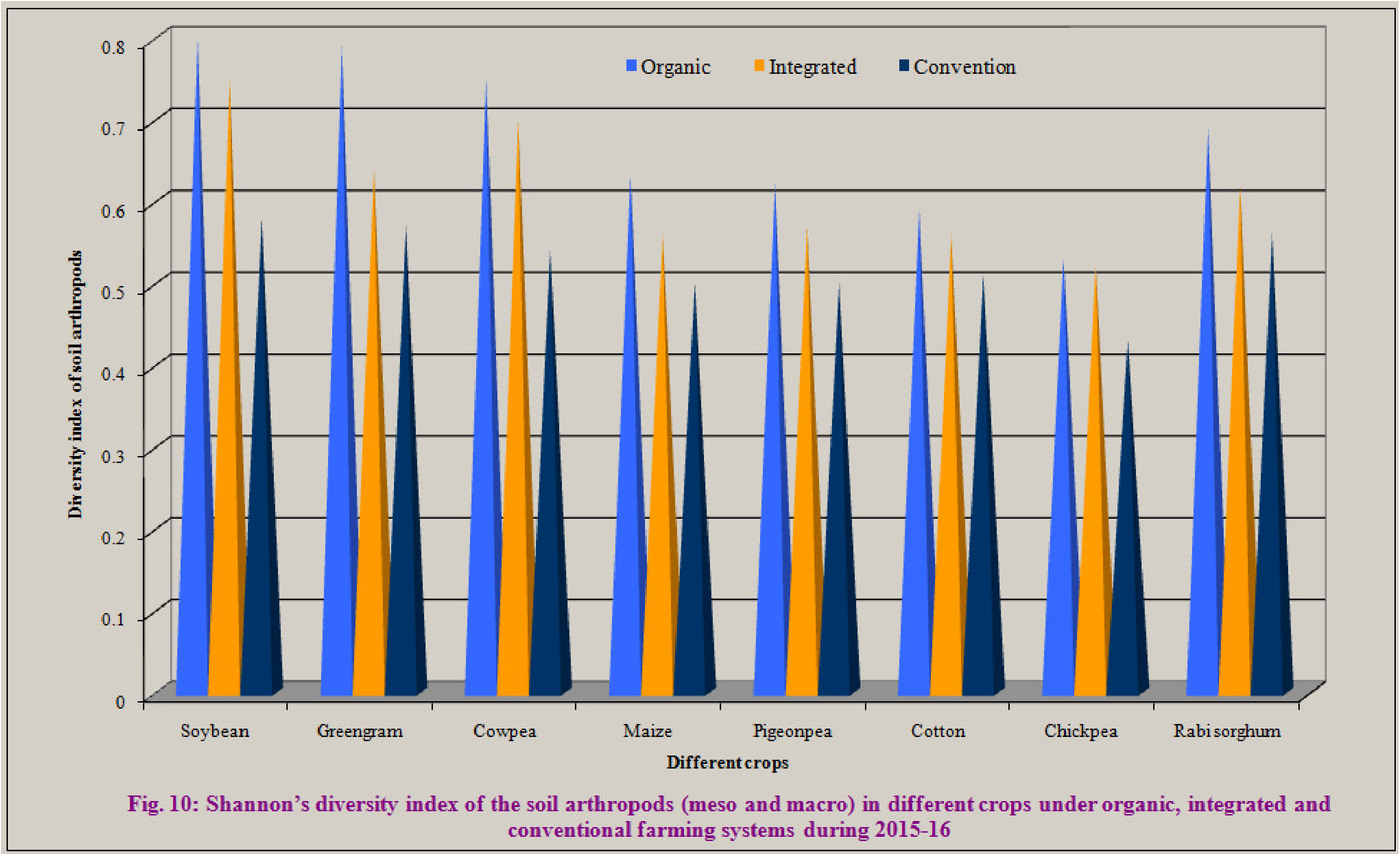


Fig. 10: Shannon's diversity index of the soil arthropods (meso and macro) in different crops under organic, integrated and conventional farming systems during 2015-16

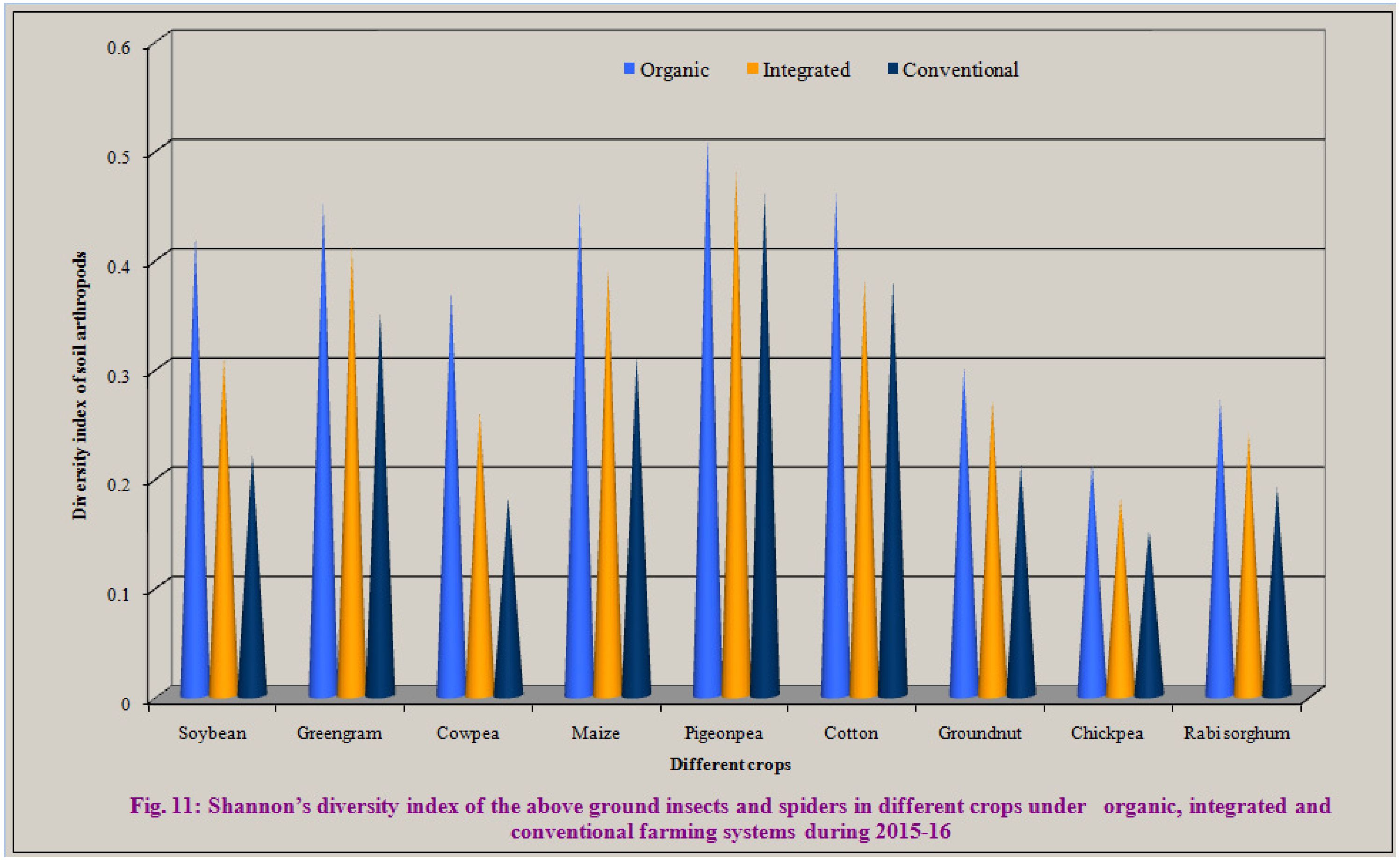


Fig. 11: Shannon's diversity index of the above ground insects and spiders in different crops under organic, integrated and conventional farming systems during 2015-16

In case of above ground insects and spiders biodiversity index were found higher in pigeonpea (0.48) followed by cotton (0.41) and greengram (0.40) and least in chickpea (0.18). Because, in pigeonpea even distribution of pests and natural enemies and gall weevil incidence was more this year and maximum pollinators recorded in pigeonpea and in cotton more population of pests and natural enemies present, so biodiversity was higher in these crops. In case of chickpea biodiversity index was very less due to less pests and natural enemies (Fig. 11).

6. SUMMARY AND CONCLUSIONS

The investigation on “Studies on soil arthropods, insect pests and their natural enemies in organic, integrated and conventional farming systems in selected crops” was carried out at Network Project on Organic Farming (NPOF), Main Agricultural Research Station (MARS) and Institute of Organic Farming (IOF), University of Agricultural Sciences (UAS), Dharwad during *Kharif* and *rabi* season of 2015-16. Population of different soil arthropods *viz.,* meso and macro-arthropods, pest and natural enemies were assessed in seven crops (greengram, cowpea, soybean, maize, pigeonpea, chickpea and *rabi* sorghum and one cropping system, cotton intercropped with groundnut. Soil meso-arthropods were extracted through berlese funnel and macro-arthropods were recorded through pitfall traps. The pests and their natural enemy population were recorded on the standard counting procedure followed for different major pests of crops studied.

The results indicated that organic farming has recorded the significantly higher number of soil arthropods (both meso and macro) and earthworms followed by integrated and least in conventional farming systems irrespective of the crops. In *kharif* crops, peak soil meso and macro-arthropods population was recorded during June and first week of August respectively. In long duration and *rabi* crops, highest soil meso and macro-arthropods were recorded during October and first week of October respectively. Across the different crops, soybean recorded more population of soil arthropods and earthworm compared to greengram and cowpea in *kharif* crops. Among long duration crops, cotton intercropped with groundnut recorded highest population of total soil arthropods compared to pigeonpea. In *rabi* crops *viz., rabi* sorghum recorded more population of total arthropods and earthworm compared to chickpea. Overall cotton intercropped with groundnut recorded more population of soil arthropods and earthworm followed by pigeonpea and least in chickpea.

The collembolans and diplurans collected from experimental field were identified by Dr. Raghuraman. Asst. Professor of Entomology from Banaras Hindu University, Varanasi. Over all 14 species of collembolan belongs to 10 genera distributed in three families were recorded from this region and diplurans belongs to three genera distributed in three families. Natural enemies were sent for identification to Dr Ankita Gupta from NBAIR, Bengaluru. Over all natural enemies belonging to six genera distributed in four families.

Shannon’s weaver index of general biodiversity of below ground arthropods were found higher in organic farming (0.68) followed by integrated (0.62) and least in conventional (0.52). Across the different crops in below ground arthropods, soybean recorded higher biodiversity index (0.71) followed by greengram (0.67) and least in chickpea (0.49). Biodiversity index of above ground insects and spiders were found higher in organic farming (0.38) followed by integrated (0.32) and least in conventional (0.27). In case of above ground insects and spiders biodiversity index were found higher in pigeonpea (0.48) followed by cotton (0.41) and greengram (0.40) and least in chickpea (0.18).

Organic farming system recorded higher population of both below ground arthropods (meso and macro) including earthworms population and above ground insects (natural enemies and pollinators) followed by integrated and least in conventional farming systems.

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Appendix I: Meteorological data for the year 2015-16 at Main Agricultural Research Station, Dharwad

Months	Rainfall (mm)		Rainydays	Temperature (^0C)		Relative Humidity (%)
	2015	1950-2014		Max	Min	
January	0.2	0.80	-	28.6	13.3	52
February	0.0	11.34	-	31.8	14.6	40
March	105.2	2.16	3	33.2	19.3	55
April	13.2	48.86	1	35.1	20.3	51
May	129.4	21.67	7	34.7	21.9	63
June	160.2	106.60	11	28.8	21.2	80
July	42.8	155.92	6	28.7	21.0	79
August	34.4	102.34	5	28.7	20.6	79
September	22.4	109.32	3	29.9	20.6	78
October	179.8	126.50	5	31.2	19.6	65
November	28.6	32.13	2	30.0	18.0	70
December	0.0	5.10	0	30.6	15.7	56
Total	**716.2**	**722.73**	**43**	**-**	**-**	**-**

STUDIES ON SOIL ARTHROPODS, INSECT PESTS AND THEIR NATURAL ENEMIES IN ORGANIC, INTEGRATED AND CONVENTIONAL FARMING SYSTEMS IN SELECTED CROPS

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ABSTRACT

The experiment was conducted to study the response of organic, integrated and conventional farming systems on soil arthropods, earthworms, insect pests and their natural enemies in different crops *viz.,* Greengram, Cowpea, Soybean, Pigeonpea, Cotton + Groundnut, Maize, *Rabi* Sorghum and Chickpea at MARS, UAS, Dharwad during *kharif* and *rabi* season 2015-16.

Among the different farming systems, organic farming system has recorded significantly higher population of meso, macro-arthropods and earthworms (16.47 /100 g of soil, 20.99 /pitfall trap and 91,900 / ha, respectively) followed by integrated (9.13 /100 g of soil, 12.85 /pitfall trap and 52,400 / ha, respectively) whereas, least population was recorded in conventional farming (5.32 /100 g of soil, 9.34 / pitfall trap and 28,200/ ha, respectively). Significantly higher soil arthropods population was observed during June and October months.

The cotton inter cropped with groundnut has recorded significantly higher population of soil meso and macro-arthropods (15.50 /100 g of soil and 41.26 / pitfall trap respectively). However, significantly higher earthworms population was recorded in sole pigeonpea (76,400 /ha).

The above ground arthropods population *viz*., insect pests, natural enemies and honeybees were observed in different farming systems in different crops. In general the lower pest population was recorded in organic farming system with higher natural enemies populations, whereas least natural enemy population found in conventional farming system. Significantly higher pollinators' activity was found in soybean, greengram, cowpea, maize and cotton + groundnut in organic farming systems. On contrary less pollinators activity was found in conventional farming system.

Assessment of biodiversity of below and above ground arthropods in different farming system indicated higher Shannon's index in organic farming (0.68 and 0.38, respectively) followed by integrated system (0.62 and 0.32 respectively) whereas, least Shannon's index (0.52 and 0.27 respectively) in conventional farming system.