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Scenario of arthropod diversity in organic farming system

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ABSTRACT

Major reasons of loss of arthropod diversity, species richness, dominance and abundance are due to the application of synthetic pesticides, deforestation for conventional farming and lack of habitat and microclimate, and all these occur under conventional farming system. A detailed review revealed the organic farming system to have an holistic approach in performing better than the conventional farming system as former provided important advantages like harmless chemicals, safety to human and animal health, species richness, abundance of insect predators and the pollinators.

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A rich biodiversity helps preserve natural processes contributing to man's ability to survive, such as natural pest regulation, crop pollination by insects and decomposition of organic matter into humus, thus it encompasses the diversity of life on all levels- species, genetic, habitat and ecosystem diversity.

Lord Northbourne in 1939 made first use of the term "organic farming". The term was derived from his concept of "the farm as organism", which he expounded in his book, "Look to the Land" Northbourne (1940). Influenced by Sir Albert Howard's work, Lady Eve Balfour did first scientific, side-by-side comparison of organic and conventional farming. The concept of organic farming has been reported to be correlated with the concepts of agroecology (Altieri, 1989) and biodynamic agriculture (Koepf, 1976 and Childs, 1995).

Animportant aspect that makes organic farming system different thannon-organicfarming systemis that the former relies on natural principles like biodiversity and composting instead to produce healthy and abundant food while later one applies all the possible chemical interventions to fight pests and weeds and provide plant nutrition. The so-called the "conventional" agricultural model was largely adopted after the green revolution (García, 1991). However, the introduction of green revolution - a chemical intensive and high tech/bio-tech farming approach during the last quarter of the 20th century culminated in the dramatic declines in density and diversity of several beneficial species associated with agricultural crops.

The monoculture expansion has increased the pest problems due to reduced vegetation complexity which is an important landscape component that provides key ecological services including the crop protection (Altieri and Letourneau, 1982).Since, the modern conventional agro systems exhibit difficulties like cyclical outbreaks of pests, water contamination, salinization and soil erosion. Tilman *et al.* (2001) studied and documented the role of conventional farming in the modification of ecosystems has been studied and documented.

Altieri and Nicholls (2000) proposed that an agroecological system including organic crops could produce food using fewer external resources and support the biodiversity conservation and more sustainable food production that would directly benefit the farmers and the environment that supports our production systems. All these facts ultimately demand alternative support systems that are eco-friendly, socio-culturally compatible, sustainable and with less intensive practices that are ecologically and economically beneficial for the overall health of environment, flora, fauna and human race.

Mone *et al.* (2014) analysed the ground insects and fruit eating butterflies on 29 different plantations in Kodagu district of Karnataka which is one of the rich biodiversity zones of the Western Ghats and reported anegative effect on the ground insect species diversity (Shannon index) and evenness (Shannon evenness index) in conventional plantations over the organic plantations. A similar negative effect was observed for butterfly diversity in plantations using pesticides. They corroborated the value of organic plantations in supporting higher levels of biodiversity.

Leksono (2017) based on current research and relevant review studies revealed refugia blocks to increase the arthropod diversity and its composition *viz.*, species diversity, including that of mammals, birds, arthropods, vascular plants and arbuscular mycorrhizal fungi. The arthropod groups they reported were consisted of carabid beetles, butterflies, wasps, predators, and bees.

Organic farming system:

Organic farming benefitting the crops:

The cropsget pollinated by insects and around 20 per cent greater diversity was recorded in organic crops, when compared to conventional farms. Yet no difference was found between farms that had newly converted to organic farming and those that had been organic for longer. Plant diversity benefited immediately from the change in farming system. This was down to ceasing to use herbicides, growing a wider variety of crops on the farms and that the stands of crops were thinner (EPOC, 2012).

Organic farming system benefitting the wild pollinators:

The species diversity of butterflies in one study was 20 per cent higher, and there were 60 per cent more species on the organic farms when compared to conventional farms. The number of butterfly individuals increased with the time since farms converted to organic farming (EPOC, 2012).

Organic farming- a basis of two principles:

Mondelaers *et al.* (2009) reported the organic farming syatem being founded on two basic principles: the first being to minimize the crop impact on the natural equilibrium of ecosystem and generating high quality residue free food for humans and animals, and second being the implementation of water recycling and management practices. Of the major advantages of organic farming, the one could be the increased biodiversity (Power and Stout, 2011). This crop production system has benefitted the birds, mammals, arthropods and plants besides exhibiting better pest control through maintaining natural enemies and pollinators (Garratt *et al.*, 2011).

Organic farming havinga holistic perspective:

Organic farming has been considered as one of the best alternatives that began in around 1970s due to its safer and sustainable principles for the environment and human societies (Rigby and Cáceres, 2001, IFOAM 2009 a and b). It was considered a holistic perspective as it presents a deep and strong relationship between food production and environment (Cáceres, 2002). As the insects being the most diverse and conspicuous taxonomic group in transformed rural ecosystems, they have been subject to the studies that measure the effects of such transformations on their diversity (Kruess and Tscharntke, 2002). Many authors correlated the advantages of organic farming to the increased taxonomic diversity (Salazar and Except, 2007), functional diversity (Letourneau and Goldstein, 2001) and the generation of a complex pollinator-plant network (Power and Stout, 2011).

Status of species richness in the world:

In France, Hopper *et al.* (1995) reported predatory densities of coccinellid (*Coccinella septempunctata*) as 4-16 per m^2 and the predatory syrphids (*Episyrphus* *balteatus* De ceev., *Metasyrphus corollae* and *Sphaerophoria scripta*) together as 1 per m^2 in wheat fields. Haris (1995) examined four *Dolerus* spp. and thirteen host plants including wheatwhich he reported hadnot own saw fly fauna but derived from surrounding grass cultures. He revealed the females only to move to the wheat and the copulation to occur on grasses. In Denmark, Redderson (1997) looked at the arthropod fauna in 38 matched pairs of fields. Excluding aphids and Collembola, he reported a uniform pattern of higher total arthropod abundance and biomass and of species diversity in organic cereal fields. In England, Feber *et al.* (1997) surveyed the butterfly populations of 18 pairs of organic and conventional farms over two years. They found that the abundance of non-pest butterflies was significantly higher in organic than in conventional systems in both years.

In Sri Lanka, Bambaradeniya *et al.* (1998) documented 77, 45 and 34 species of invertebrates, vertebrates and plants, respectively, on rice ecosystem. Bambaradeniya (2000) reported 280 species of arthropods constituting 90 families and 16 orders in rice ecosystem. There was a significant positive correlation of arthropods diversity with rice plant height and crop age. Rice plant height ascribed for 54 per cent whereas crop age accounted for 75% variation in arthropods diversity. Bambaradeniy *et al.* (2004) observed that of 131 species of phytophagous insects inhabiting rice ecosystem only 55 species act as the rice pests. Among the total recorded arthropod species, 200 are bio-control agents (154 species of predators and 46 species of parasitoids) of insect-pests.

Effects of organic farming on insect biodiversity are most often defined as species richness (Holea *et al*., 2005) and meta-analysis (Bengtsson *et al*., 2005). Bambaradeniya and Edirisinghe (2008) reported 342 species, consisting of 282 of insects (90 families), 17 orders and 60 species of spiders (arachnids) (14 families). They documented eight taxa which were new. Majority of the insects documented were hymenopterans, dominated by bees and ants. Based on feeding habits, majority of arthropods recorded natural enemies (149 species), dominated by spiders. In Japan, Kiritani (2009) reported more than 5000 species of insect pests in the rice agroecosystems. In Vietnam, Giang *et al.* (2009) reported 242 species of arthropods on rice crop at Red River Delta of which, 36 species belonged to pest category and 147 species to natural enemies of these pests. Arthropod quantity in extensive farming was the largest (159 species) and fewest (106) where rice crop was intercropped with other crops.

Several workers have reported organic farming to increase diversity of insects like carabid beetles (Dritschilo and Wanner, 1980; Kromp, 1989 and Pfinner and Niggli, 1996) and birds (Freemark and Kirk, 2001). The enhanced resistance to invasion and other forms of functionality under stress (Wittebolle *et al.*, 2009) was resulted due to higher community evenness in organic farming (Crowder *et al*., 2010). The butterfly population was 20 per cent higher, and there were 60 per cent more species on the organic farming over the conventional farming and it increased with the time since farms converted to the organic farming. Similarly, the bumblebees increase in numbers on organic farms, compared to conventional farms, which to an extent was considered because organic farms had a higher proportion of grassland and more flowering species, which also flower over a longer time period (EPOC, 2012).

In southern Brazil, Fritz *et al.* (2011) reported that the arthropod communities in rice fields are composed of a very few families at high frequencies and a much greater number of families each occurring at low abundance. Chen and Bernal (2011) reported a total of 12981 arthropod individuals of which the most numerically dominated species were aquatic beetles *i.e. Microvelia atrolineata* Bergroth (Hemiptera: Veliidae) and *Mesovelia vittigera* Horvath (Hemiptera: Gerridae); these two species accounted for over 30 per cent of the sampled arthropods.

Relatively few studies that have demonstrated the organic farming practices to a positively influence over species richness and abundance of various taxa like plants, insect pests, predatory fauna, pollinators, invertebrates and birds, globally (FIBL, 2012) and especially rarely in India (Mehmood *et al*., 2011, Pandey and Singh, 2012). Zhang *et al.* (2013) in comparison of early and late season arthropod communities and diversity reported a total of 16,902 individuals (135 species of arthropods in 2 classes, 10 orders and 47 families). Early season crop acted as habitat for 114 species while late for 109 species. Also the early season crop had highest spiders and phytophagous pest species while late had more predators and neutral insects.

Poolprasert and Jongjitvimol (2014) recorded 1,928 individuals constituting 27 orders, 11 families and 34 species (11 were pests, 17 beneficial predators and 6 species parasites). Tuck *et al.* (2014) reported the organic farming to increase 30 per cent local biodiversity with a large variation between studies and organism groups. Organic fields being free of synthetic pesticides are 10.5 per cent higher in *species richness* than conventional *fields,* with highest gains (more than 45%) in intensive arable *fields* (Manuel *et al.,* 2014).

In Vietnam, Cuong *et al.* (2016) in a study on *Oryza rufipogon* in the Mekong Delta found a total of 578 arthropod taxa (17 orders and 178 families). The overall community was dominated by predators, followed by detritivores and herbivores. They also reported 45 new taxa of Lepidoptera on rice which were earlier undescribed on this crop. They concluded that wild species of rice like *O. rufipogon* supports higher diversity of arthropod community in rice.

Insecticide free fields:

Pest status in India and world:

In Germany, Basedow *et al.* (1990) compared the population of aphids and their natural enemies (coccinellids, syrphids, aphidiines, carabids, staphylinids and spiders) in six wheat fields at different intensities in 1984-86. An insecticide free winter barley plot since 1981 was infested much less by *Rhopalocephum padi* in 1986 than two other plots having received insecticidal sprays every year until 1985. Besides no insecticidal usage in winter barley in 1986, species number of carabids and staphylinids feeding upon aphids got reduced on the former insecticide plots.

In China, Pang (1993) estimated the Shannon-Wiener index of diversity and the Berger-Parker index of dominance of insect community in wheat crop in Nei Menggu. In the early and middle stages of wheat growth (from May to June) wheat aphids comprised the dominant insect group (dominance index 0.89) while at the later stage (in July) armyworm (*Mythimna separata*) was the dominant species (dominance index 0.70). Similarly, the dominant species of predators was *Adonia variegata* (*Hippodamia variegate*) (dominance index 0.41). During wheat growth and development, the diversity index of insect community was <2 suggesting that it was unstable.

Bhullar and Singh (2008) in their studies on biodiversity of mites associated with various medicinal and aromatic plants in Punjab reported more mite pest diversity, their abundance, species richness under chemical free fields. Agri- ecosystems being rich in insect biodiversity has more resilience to recover readily from biotic and abiotic stresses like drought, environmental degradation, insect- pests, diseases, epidemics, over the conventional and other ones (Wittebolle *et al.,* 2009). The biodiversity conservation facilitates metapopulational processes between habitat patches (Perfecto and Vandermeer, 2010).

A reduced herbicidal usage was considered to have indirect benefit as it increases the food of both herbivores and pollinators, whereas minimized use of insecticides directly reduces both the death from treatments and increases access to prey for predator species (EPOC, 2012).

Conventional farming system:

Arthropodstatus in India:

Ambalaparabil *et al.* (2005) studied the resident spider population and seasonal variations in their diversity in the rice agroecosystem of Kuttanand (Kerala) and reported the spider population in *Rabi* and *Kharif* seasons to exhibit slightly different species abundance and composition. Among 94 species of spiders collected during the study, 70 species of 17 families were recorded in the *Rabi* season and 24 species of 20 families in the *Kharif* season. All the families except Amaurobiidae, Pisauridae and Pholcidae were present in both seasons. A total of 68 species had common occurrence in both crop seasons.

Kandibane *et al.* (2007) in Tamil Nadu studied the inventory, diversity and community structure of acquatic arthropods between weeded and partially weeded rice ecosystems. They reported that a total of 12, 2, 6 and 3 species of Odonata, Ephemeroptera, Hemiptera and Coleoptera acquatic insects, respectively. *Abriocnemus femina famina* Brauer of damselfly, *Pantala flavescens* (Fabricius), *Crocothemis servilla* (Drury) and *Diplocodes trivialis* (Rambur) of dragonflies were the dominant species in both the ecosystems, but were significantly more dominant in partially weeded rice ecosystem.

In West Bengal, Chakraborty *et al.* (2016) reported a total of 49 predators and 7 parasitoid species are found on rice crop and spiders as the most abundant among the predators followed by Coleopterans.

In Punjab, Kaur (2019) reported the highest arthropod diversity during first fortnight of June followed by second fortnight of May and June at Gurdaspur district as compared to Ludhiana in Punjab.

Loss of biodiversity:

Modern agriculture has been reported to cause a great loss of diversity in the agricultural landscape (Fuller *et al.,* 1995; Krebs *et al*., 1999; Stoate *et al.,* 2001 and Benton *et al.,* 2002), and thus, the large-scale conversion of conventional to organic farming could partly ameliorate this loss. Wilby and Thomas (2002) reported intensification to be associated with a substantial loss of biodiversity along with several ecosystem services like crop production, insect pest management, pollination and decomposition processes, and soil properties. In England, Frampton *et al.* (2002) reported lower counts of Collembola species in a rotation of grass and wheat cropping under a conventional regime of pesticide use than under a reduced input regime.

The intensive modern agriculture is not compatible with the biodiversity conservation (Robinson and Sutherland, 2002). Benton *et al.* (2003) revealed that the modern farming practices like use of machinery, mono-culturing, high yielding hybrid or varieties and GM crops when combined with heavy agri-inputs such as chemical fertilizers, pesticides and herbicides have resulted in a great biodiversity loss in agriculture and neighboring localities.

In California, during last one decade, loss of insect biodiversity has occurred worldwideat an unprecedented scale and agricultural intensification has been a major driver of such global change (Kremen *et al.,* 2004). In Europe, Holea *et al.* (2005) reported a dramatic decline in the abundance of several arthropod species associated with farms during the last quarter century.

Climatic and socio-economic issues:

The conventional agriculture has been alarmed as to cause deleterious environmental, economic and social effects of the practices employed in (Céspedes, 2005). A loss of ecosystem services and biodiversity on this scale has fueled the debate over the sustainability of current intensive farming practices that included fears over water contamination and pollution, soil erosion/ quality degradation, landscape quality and food safety (Ericksen *et al*., 2009).

An increasing world's population particularly that of the developing nations has replaced around one billion hectares of natural habitat into conventional farming system that resulted into double or triple inorganic fertilizers usage and threefold demand for water and pesticide consumption with ultimate threatened global biodiversity, food security and human health (Gabriel *et al*., 2010).

Summary:

Based on review of various studies the organic farming system is considered to play an ecofriendly role to conserve environment, arthropod diversity and species richness by enhancing microbial fauna, insect pests, mammals, birds, vascular plants and arbuscular mycorrhizal fungi. In addition, it uses fewer inputs and gives a safest environment to the animal and human health besides benefitting the growers by improving pollination, reduction in soil erosion on arable land, decomposition of dung in pastures and natural pest reduction in soil and crops. The current review is based on biodiversity studies in organic and conventional farming system carried in the world.

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