



Impact of Agronomic Practices on Population and Diversity of Soil Oribatid Mites

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Abstract

The present study evaluated the effects of various agronomic practices, including tillage, irrigation, fertilizer application, and pesticide use, on the population of oribatid mites. Soil samples were collected from different experimental sites across the Navsari Agricultural University campus, South Gujarat. Among the agronomic practices investigated, ploughing, rotavator operation, inter-culturing, puddling, sowing, transplanting, surface irrigation, hand weeding, pesticide applications [imidacloprid 17.8 SL, imidacloprid 30.5 SC, thiamethoxam (12.6%) + lambda-cyhalothrin (9.5%) ZC, diflubenzuron 25 WP, *Bacillus thuringiensis*, cypermethrin 25 EC and azadirachtin 1500 ppm] harvesting and crop rotation exerted significant effects on the population dynamics of oribatid mites.

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1. Introduction

Soil is regarded as one of the most valuable non-renewable natural resources (Marshall *et al.*, 1982) [37] and is fundamental to the productivity and sustainability of terrestrial ecosystems (Lavelle, 1996) [31]. It also represents an immense reservoir of biodiversity (André *et al.*, 2002, Coleman and Whitman, 2005, Ritz *et al.*, 2009) [6, 16, 44] and has been recognized by many ecologists and geneticists as the largest repository of biological diversity on Earth (Feeney *et al.*, 2006, Lescroart, 2009) [24, 35]. Despite its ecological significance, knowledge of soil fauna, particularly soil mites, remains limited due to several biological and methodological constraints (André *et al.*, 1997, Giller *et al.*, 1997) [7, 26]. Among soil fauna, mites constitute an important component of terrestrial ecosystems because they regulate several key ecological processes (Lavelle, 1996, André and Balandreau, 1999, Fitter *et al.*, 2005, Palacio-Vargas *et al.*, 2007, Bardgett, 2008) [31, 8, 25, 41, 9]. Soil microarthropods play a vital role in organic matter decomposition, nutrient cycling, and soil formation, thereby contributing significantly to the functioning of the soil food web (Lavelle and Spain, 2001, Coleman *et al.*, 2004, Walter and Proctor, 2013) [30, 17, 53]. Owing to their limited dispersal ability (Lehmitz *et al.*, 2011, 2012) [33, 34] these organisms are highly vulnerable to environmental disturbances and cannot readily escape unfavorable conditions. Agricultural practices exert considerable influence on soil microarthropod communities. Mechanical disturbances, such as ploughing, harrowing, and trampling, as well as non-mechanical disturbances including crop residue removal and chemical applications, affect soil organisms both directly by causing mortality and indirectly by reducing food availability, physiological resilience, and suitable habitat (Rodrigues *et al.*, 2006) [45]. Among soil microarthropods, oribatid mites (Oribatida) are one of the most abundant and species-rich groups (Coleman *et al.*, 2004, Walter and Proctor, 2013) [17, 53] and are particularly sensitive to agricultural management practices (Behan-Pelletier, 1999, 2003, Cortet *et al.*, 2002a) [12, 13, 18]. Although agricultural intensification frequently leads to a decline in the diversity of oribatid mite communities, the underlying mechanisms responsible for these changes remain poorly understood. Previous experimental studies evaluating the effects of agricultural chemicals on oribatid mites have generally shown that these organisms are more adversely affected by mechanical disturbances than by pesticide applications (Cockfield and Potter, 1983, Krogh, 1991, Al-Assiuty and Khalil, 1995, Schrader and Lingnau, 1997, Cortet *et al.*, 2002a, 2002b, Bedano *et al.*, 2006, Adamsky *et al.*, 2007, 2009, Anbarashan and Gopalswamy, 2013, Al-Assiuty *et al.*, 2014) [15, 29, 4, 48, 18, 18, 11, 1, 2, 5, 3] although contrasting observations have also been reported (Prinzing *et al.*, 2002) [43]. These findings suggest that, at least in the short-

term following a single treatment, mechanical perturbations have a greater impact on oribatid mite communities than pesticide applications. Unlike older classes of insecticides, such as organochlorines, organophosphates, and carbamates, neonicotinoids generally exhibit relatively low mammalian toxicity (but see Berheim *et al.*, 2019, Wu *et al.*, 2020) [14, 55]. Because these insecticides are commonly applied as seed coatings, they were initially considered to pose minimal risks to human health and the environment (Mullins, 1993, Tomizawa and Casida, 2005) [40, 52]. However, subsequent studies have demonstrated that, despite early assurances of environmental safety (Elbert *et al.*, 2008, Jeschke *et al.*, 2011) [22, 28] neonicotinoids can produce significant non-target effects on aquatic ecosystems, pollinators, and natural enemies, similar to those associated with older insecticide classes (Sánchez-Bayo, 2011, Douglas *et al.*, 2015, Douglas and Tooker, 2016, Wood and Goulson, 2017, Hladik *et al.*, 2018) [46, 21, 20, 54, 27]. In contrast, their effects on soil invertebrates, particularly decomposer communities, remain comparatively underexplored (Pisa *et al.*, 2017) [42]. Soil invertebrate decomposers, including earthworms (Lumbricidae), woodlice (Isopoda: Oniscidea), millipedes (Diplopoda), soil mites (Acari, predominantly Oribatida) and springtails (Collembola) play indispensable roles in litter decomposition and nutrient cycling through the comminution, redistribution and microbial inoculation of plant residues (Scheu *et al.*, 2005) [47]. Since these organisms are essential for maintaining soil fertility and ecosystem functioning, understanding their responses to agricultural management practices is of considerable ecological importance. In this context, the present study was undertaken to investigate the effects of routine agronomic practices on soil oribatid mite communities in different agroecosystems of the Navsari Agricultural University campus, South Gujarat. The study aimed to evaluate the influence of various agronomic practices on the distribution, abundance and diversity of soil oribatid mites under field conditions.

2. Materials and Methods

The present study was conducted during 2018–2019 to evaluate the impact of various agronomic practices on the distribution, abundance and diversity of soil oribatid mites in different agroecosystems of the Navsari Agricultural University campus, Gujarat. The agronomic practices investigated included tillage, irrigation, fertilizer application and pesticide application. Soil samples were collected from each study site immediately before and after the implementation of each agronomic practice. The population of soil oribatid mites was recorded before treatment and at 1, 3, 7, and 15 days after each agronomic operation. The collected data were statistically analyzed to determine the percentage change in oribatid mite populations at 1, 3, 7, and 15 days after each treatment or agronomic operation and the overall mean percentage change was subsequently calculated to assess the impact of individual practices on the soil oribatid mite community.

3. Results and Discussion

The impact of various agronomic practices includes tillage, irrigation, fertilizer and pesticides were analyzed to study distribution, abundance and diversity of soil oribatid mites in different agroecosystem of Navsari Agricultural University campus, Gujarat. The oribatid mite's population before and

1, 3, 7, 15 days after each agronomic practice were recorded. The recorded data were analyzed and calculate the per cent differences at 1, 3, 7, 15 days after treatments / applications / operations and calculate the overall mean.

3.1. Impact of Agronomic Practices on Soil Oribatid Mites

3.1.1. Sugarcane

Sugarcane was cultivated following the recommended agronomic practices, including tillage, sowing, irrigation, fertilizer application, pesticide application, inter-culturing and harvesting. The impact of each agronomic practice on soil oribatid mite populations was assessed by estimating the percentage change in their abundance. Among the agronomic practices, tillage operations, particularly ploughing (45.46%) and rotavation (26.35%) caused the greatest reduction in oribatid mite populations by disrupting their habitat during land preparation. Sowing of sugarcane setts also resulted in a moderate reduction (30.09%) in the oribatid population. Surface irrigation reduced the mite population by 22.05% possibly due to temporary changes in soil moisture and disturbance of the soil microhabitat. Seed treatment of sugarcane setts with Carbendazim 50 WP @ 6 g/10 L water and Malathion 50 EC @ 20 ml/10 L water also caused a significant decline in oribatid mite abundance. Inter-culturing operations resulted in a 44.23% reduction in the oribatid mite population primarily due to repeated disturbance of the soil habitat. Harvesting caused a 26.02% reduction, which may be attributed to the removal of crop residues that serve as an important source of food and habitat for oribatid mites. In contrast, the application of chemical fertilizers, biofertilizers, farmyard manure (FYM), biopesticides and most pesticides did not produce any significant positive or negative effect on oribatid mite populations. Although application of Chlorpyrifos 50 EC resulted in a 10.37% reduction in the oribatid mite population, its effect was comparatively small and statistically less pronounced than that of mechanical agronomic operations (Table 1). Overall, the findings indicate that mechanical agronomic practices, particularly tillage and inter-culturing, exerted a substantially greater impact on soil oribatid mite populations than chemical inputs during sugarcane cultivation.

3.1.2. Rice

Rice was cultivated following the recommended agronomic practices including tillage, puddling, transplanting, irrigation, fertilizer application, pesticide application, hand weeding, harvesting and crop rotation. The impact of each agronomic practice on soil oribatid mite populations was assessed by estimating the percentage change in their abundance. Among the tillage operations, ploughing (35.53%) and rotavation (22.08%) caused a considerable reduction in oribatid mite populations by disturbing the soil habitat during land preparation. However, puddling resulted in the greatest decline (87.61%) in oribatid mite abundance owing to the intensive disturbance of the soil structure and the creation of flooded, anaerobic conditions before transplanting. Similarly, transplanting carried out 2–3 days after puddling also recorded a substantial reduction (87.17%) in the oribatid mite population because the soil remained waterlogged and unsuitable for their survival. Surface irrigation further reduced the oribatid mite population by 88.05% indicating that prolonged flooded conditions in paddy fields are highly

unfavorable for these soil-dwelling microarthropods. The higher reduction observed following the basal application of phosphatic fertilizers (88.50%) was primarily associated with the preceding puddling operation rather than with fertilizer application itself, as the extensive soil disturbance and waterlogging were the principal factors influencing oribatid mite abundance. Hand weeding caused a significant reduction (33.71%) in the oribatid mite population due to disturbance of the soil surface. Harvesting (54.06%) and subsequent crop rotation (65.63%) also markedly reduced oribatid mite populations, probably because of the removal of crop residues and changes in soil habitat conditions. In contrast, the application of other chemical fertilizers, biofertilizers, farmyard manure, pesticides and biopesticides did not produce any significant positive or negative effect on oribatid mite populations. Among the pesticides evaluated, Imidacloprid 30.5 SC @ 1 ml/10 L water caused a comparatively greater reduction (73.10%) in the oribatid mite population (Table 2). Overall, the results indicate that agronomic operations causing intensive soil disturbance and prolonged flooding, particularly puddling, transplanting and irrigation, had the greatest adverse effects on soil oribatid mite populations, whereas most fertilizer and biopesticide applications exerted minimal influence.

3.1.3. Pigeon Pea

Pigeon pea was cultivated following the recommended agronomic practices including tillage, sowing, irrigation, fertilizer application, pesticide application, inter-culturing, hand weeding, harvesting and crop rotation. The impact of each agronomic practice on soil oribatid mite populations was assessed by estimating the percentage change in their abundance. As a leguminous crop, pigeon pea enriches soil fertility through biological nitrogen fixation, thereby providing comparatively favorable conditions for soil biota including oribatid mites. Among the agronomic practices, tillage operations, particularly ploughing (35.83%) and rotavation (24.68%) caused a marked reduction in oribatid mite populations by disturbing their soil habitat during land preparation. Sowing of imidacloprid-treated seeds resulted in a significant reduction (46.14%) in the oribatid mite population indicating the influence of seed treatment on soil-dwelling microarthropods. Inter-culturing (38.60%) and hand weeding (42.54%) also caused substantial reductions in oribatid mite abundance due to repeated disturbance of the soil habitat. Harvesting resulted in a 23.70% reduction in the oribatid mite population which may be attributed to the removal of crop residues that serve as an important source of food and shelter for these decomposer organisms. In contrast, the application of chemical fertilizers, irrigation, biofertilizers, farmyard manure, pesticides and biopesticides did not produce any significant positive or negative effect on oribatid mite populations. Crop rotation resulted in a 31.05% reduction in oribatid mite abundance however, its effect was comparatively less pronounced than that of tillage, sowing, inter-culturing and hand weeding (Table 3). Overall, the results indicate that mechanical agronomic operations and imidacloprid seed treatment had a greater influence on soil oribatid mite populations than fertilizer application or irrigation. Despite temporary reductions associated with certain field operations the leguminous nature of pigeon pea is likely to support favorable soil conditions for the recovery and persistence of oribatid mite communities over time.

3.1.4. Lucerne

Lucerne was cultivated following the recommended agronomic practices, including tillage, sowing, irrigation and harvesting. As a perennial fodder crop with minimal soil disturbance during its cultivation, lucerne generally provides a favorable habitat for soil oribatid mite populations. The impact of each agronomic practice on soil oribatid mite populations was assessed by estimating the percentage change in their abundance. Among the agronomic practices, tillage operations, particularly ploughing (35.00%) and rotavation (30.02%) caused a substantial reduction in oribatid mite populations by disrupting their soil habitat during land preparation. In contrast, broadcasting of seeds followed by light irrigation caused little disturbance to the soil environment and therefore had no appreciable effect on oribatid mite abundance. Harvesting or repeated cutting of the fodder crop resulted in the highest reduction (45.90%) in the oribatid mite population, which may be attributed to the removal of above-ground biomass and crop residues, thereby reducing the availability of food resources and suitable microhabitats for these decomposer organisms (Table 4). Overall, the findings indicate that lucerne cultivation is comparatively less disruptive to soil oribatid mite communities than annual cropping systems. Except for land preparation and harvesting, most agronomic operations exerted minimal effects on oribatid mite populations, highlighting the ecological suitability of perennial fodder crops for conserving soil biodiversity.

3.1.5. Castor

Castor was cultivated following the recommended agronomic practices, including tillage, sowing, irrigation, fertilizer application, pesticide application, inter-culturing, harvesting and crop rotation. The impact of each agronomic practice on soil oribatid mite populations was assessed by estimating the percentage change in their abundance. Among the agronomic practices, tillage operations, particularly ploughing (31.67%) and rotavation (21.23%) caused a marked reduction in oribatid mite populations by disturbing their soil habitat during land preparation. Inter-culturing also significantly reduced the oribatid mite population (35.66%) owing to repeated disturbance of the soil surface. Harvesting resulted in the greatest reduction (43.60%) which may be attributed to the removal of crop residues, thereby reducing the availability of food resources and suitable microhabitats for these decomposer organisms. In contrast, the application of chemical fertilizers, irrigation, biofertilizers, farmyard manure, pesticides and biopesticides did not exert any significant positive or negative effect on oribatid mite populations. Crop rotation resulted in a comparatively smaller reduction (27.06%) in the oribatid mite population than the major mechanical operations (Table 5). Overall, the results indicate that mechanical agronomic practices, particularly tillage, inter-culturing and harvesting, had a greater influence on soil oribatid mite populations than chemical inputs. The findings further suggest that habitat disturbance associated with field operations is the principal factor governing changes in oribatid mite abundance during castor cultivation.

3.1.6. Okra

Okra was cultivated following the recommended agronomic practices including tillage, sowing, irrigation, fertilizer

application, pesticide application, inter-culturing and harvesting. The impact of each agronomic practice on soil oribatid mite populations was assessed by estimating the percentage change in their abundance. Among the agronomic practices, tillage operations, particularly ploughing (43.82%) and rotavation (27.45%) caused a substantial reduction in oribatid mite populations by disrupting their soil habitat during land preparation. Sowing with imidacloprid-treated seeds resulted in a marked reduction (81.14%) in oribatid mite abundance, indicating a pronounced effect of seed treatment on soil-dwelling microarthropods. Surface irrigation also caused a considerable reduction (74.76%) in the oribatid mite population, whereas inter-culturing resulted in a comparatively smaller decline (18.62%) due to repeated disturbance of the soil habitat. To protect the crop from insect pests, several insecticides were applied during the cropping period. Among these, Imidacloprid 30.5 SC @ 1 ml/10 L water (71.03%), Diflubenzuron 25 WP @ 3–4 g/10 L water (76.41%) and Cypermethrin 25 EC @ 4 ml/10 L water (84.86%) caused significant reductions in oribatid mite populations indicating that these insecticides adversely affected non-target soil fauna. Harvesting resulted in a 20.00% reduction in oribatid mite abundance, which may be attributed to the removal of crop residues that provide food resources and shelter for these decomposer organisms. In contrast, the application of chemical fertilizers, biofertilizers, farmyard manure and biopesticides did not produce any significant positive or negative effect on oribatid mite populations. Overall, the findings demonstrate that mechanical soil disturbance, imidacloprid seed treatment and the application of certain insecticides had the greatest adverse effects on soil oribatid mite populations during okra cultivation, whereas nutrient management practices exerted minimal influence (Table 6).

3.1.7. Mango

Mango orchards were managed following the recommended agronomic practices including tillage, irrigation, fertilizer application, pesticide application, inter-culturing and orchard sanitation. The impact of each agronomic practice on soil oribatid mite populations was assessed by estimating the percentage change in their abundance. Among the agronomic practices, post-monsoon land preparation using a rotavator for weed management and orchard sanitation caused a substantial reduction (37.32%) in oribatid mite populations by disturbing their soil habitat. Inter-culturing also resulted in a significant decline (42.61%) in oribatid mite abundance owing to repeated soil disturbance. To protect the orchard from insect pests and diseases, several pesticides were applied during the study period. Among these, Imidacloprid 17.8 SL @ 2–4 ml/10 L water per tree caused the highest reduction (85.78%) in the oribatid mite population followed by the combination insecticide Thiamethoxam (12.6%) + Lambda-cyhalothrin (9.5%) ZC @ 4 ml/10 L water, which reduced the population by 76.30%. These results indicate that the application of systemic insecticides had a pronounced adverse effect on non-target soil oribatid mites. In contrast, the application of chemical fertilizers, irrigation, biofertilizers, farmyard manure and biopesticides did not produce any significant positive or negative effect on oribatid mite populations. Overall, the findings demonstrate that mechanical soil disturbance and the application of systemic insecticides were the principal factors responsible for the reduction in oribatid mite populations in mango orchards,

whereas nutrient management practices had little influence on these soil microarthropods (Table 7).

3.1.8. Coconut

Coconut plantations were managed following the recommended agronomic practices including tillage, irrigation, fertilizer application, pesticide application, inter-culturing and orchard sanitation. The impact of each agronomic practice on soil oribatid mite populations was assessed by estimating the percentage change in their abundance. Among the agronomic practices, inter-culturing using a rotavator for weed management and orchard sanitation caused a 19.53% reduction in the oribatid mite population by disturbing the soil habitat. Compared with other cropping systems, this reduction was relatively lower, suggesting that the perennial nature of coconut plantations provides a more stable environment for soil-dwelling microarthropods. To protect the crop from insect pests and diseases, several plant protection measures were adopted. Among these, application of Azadirachtin 1500 ppm @ 50 ml/10 L water resulted in a significant reduction (36.88%) in the oribatid mite population. Although Azadirachtin is a botanical insecticide, the observed reduction indicates that it may exert temporary effects on non-target soil fauna under field conditions. In contrast, the application of chemical fertilizers, irrigation, biofertilizers, farmyard manure and other pesticides and biopesticides did not produce any significant positive or negative effect on oribatid mite populations. Overall, the results suggest that routine nutrient management practices had minimal influence on soil oribatid mites, whereas mechanical soil disturbance and certain plant protection measures were primarily responsible for the observed reductions in their populations (Table 8).

3.1.9. Banana

Banana was cultivated following the recommended agronomic practices including tillage, transplanting, irrigation, fertilizer application, pesticide application, inter-culturing, and harvesting. The impact of each agronomic practice on soil oribatid mite populations was assessed by estimating the percentage change in their abundance. Among the agronomic practices, tillage operations, particularly ploughing (41.52%) and rotavation (25.31%) caused a marked reduction in oribatid mite populations by disturbing their soil habitat during land preparation prior to transplanting. Inter-culturing also reduced the oribatid mite population by 21.19% due to repeated disturbance of the soil surface and alteration of the soil microhabitat. In contrast, the application of chemical fertilizers, irrigation, biofertilizers, farmyard manure, pesticides and biopesticides did not exert any significant positive or negative effect on oribatid mite populations. Overall, the findings indicate that mechanical agronomic operations, particularly tillage and inter-culturing were the primary factors influencing soil oribatid mite populations during banana cultivation, whereas nutrient management and plant protection practices had minimal impact under the conditions of the present study (Table 9).

3.1.10. Organic Farm

The organic farm was managed following recommended organic production practices including tillage, sowing, irrigation, application of biofertilizers, biopesticides, inter-culturing and harvesting. The impact of each agronomic practice on soil oribatid mite populations was assessed by

estimating the percentage change in their abundance during the cultivation of organic crops. Among the agronomic practices, tillage operations, particularly ploughing (48.24%) and rotavation (35.80%) caused the greatest reduction in oribatid mite populations by disturbing their soil habitat during land preparation. Sowing with biopesticide-treated seeds also resulted in a significant reduction (34.12%) in the oribatid mite population. Inter-culturing further reduced the oribatid mite population by 30.09% owing to repeated disturbance of the soil habitat. Various biopesticides were applied to protect the crops from insect pests and diseases. Among these, Azadirachtin 1500 ppm @ 50 ml/10 L water caused a significant reduction (34.12%) in the oribatid mite population, followed by *Bacillus thuringiensis* @ 40 g/10 L water, which reduced the population by 22.02%. Although these biopesticides affected oribatid mite abundance, their impact was comparatively lower than that reported for most synthetic insecticides evaluated in conventional cropping systems. Harvesting resulted in a 45.43% reduction in the oribatid mite population, primarily because the removal of crop residues reduced the availability of food resources and suitable microhabitats for these decomposer organisms. In contrast, irrigation, biofertilizers and farmyard manure did not produce any significant effect on oribatid mite populations. Overall, the findings indicate that even under organic farming, mechanical soil disturbance associated with tillage and harvesting exerted a greater influence on soil oribatid mite populations than the application of organic inputs and biopesticides (Table 10).

3.1.11. Turmeric

Turmeric was cultivated following the recommended agronomic practices including tillage, sowing, irrigation, fertilizer application, pesticide application, inter-culturing, harvesting and crop rotation. The impact of each agronomic practice on soil oribatid mite populations was assessed by estimating the percentage change in their abundance. Among the agronomic practices, tillage operations, particularly ploughing (48.44%) and rotavation (29.50%) caused the greatest reduction in oribatid mite populations by disturbing their soil habitat during land preparation. Sowing resulted in a moderate reduction (18.11%) in the oribatid mite population. Inter-culturing also caused a significant decline (32.19%) owing to repeated disturbance of the soil surface. Harvesting reduced the oribatid mite population by 28.68% which may be attributed to the removal of crop residues, thereby reducing the availability of food resources and suitable microhabitats for these decomposer organisms. In contrast, the application of chemical fertilizers, irrigation, biofertilizers, farmyard manure, pesticides and biopesticides did not exert any significant effect on oribatid mite populations. Crop rotation resulted in a 33.63% reduction in oribatid mite abundance however, its impact was comparatively less pronounced than that of tillage operations (Table 11). Overall, the results indicate that mechanical agronomic practices, particularly tillage, inter-culturing and harvesting were the principal factors affecting soil oribatid mite populations during turmeric cultivation, whereas fertilizer application, irrigation and plant protection measures had little or no significant influence under the conditions of the present study.

3.1.12. Aloe Vera

Aloe vera was cultivated following the recommended agronomic practices including tillage, planting, irrigation, fertilizer application, pesticide application, inter-culturing and harvesting. The impact of each agronomic practice on soil oribatid mite populations was assessed by estimating the percentage change in their abundance. Among the agronomic practices, tillage operations, particularly ploughing (54.33%) and rotavation (26.97%) caused the greatest reduction in oribatid mite populations by disturbing their soil habitat during land preparation. Planting resulted in a moderate reduction (17.07%) in the oribatid mite population, while surface irrigation also caused a moderate decline (15.63%) in their abundance. Inter-culturing reduced the oribatid mite population by 22.63% due to repeated disturbance of the soil habitat. Harvesting caused a 36.52% reduction in oribatid mite populations, which may be attributed to the removal of crop residues that serve as important sources of food and shelter for these decomposer organisms. In contrast, the application of chemical fertilizers, irrigation, biofertilizers, farmyard manure, pesticides and biopesticides did not exert any significant effect on oribatid mite populations under the conditions of the present study (Table 12). Overall, the findings indicate that mechanical agronomic practices, particularly tillage, inter-culturing and harvesting had a substantially greater impact on soil oribatid mite populations than nutrient management and plant protection practices during Aloe vera cultivation.

3.1.13. Greenhouse Soil

Greenhouse soil was managed following the recommended agronomic practices including light tillage, sowing, irrigation, fertilizer application, pesticide application, inter-culturing and harvesting. The impact of each agronomic practice on soil oribatid mite populations was assessed by estimating the percentage change in their abundance during the cultivation of greenhouse crops. Among the agronomic practices, pesticide application had the greatest influence on soil oribatid mite populations. Various insecticides were applied to protect greenhouse crops from sucking and chewing insect pests. Among these, Imidacloprid 30.5 SC @ 1 ml/10 L water (76.40%), Cypermethrin 25 EC @ 4 ml/10 L water (76.19%) and Azadirachtin 1500 ppm @ 50 ml/10 L water (58.33%) caused significant reductions in oribatid mite populations, indicating adverse effects on these non-target soil microarthropods. In contrast, the application of chemical fertilizers, irrigation, biofertilizers, farmyard manure and other biopesticides did not exert any significant effect on oribatid mite populations under greenhouse conditions. Overall, the results suggest that pesticide application was the principal factor influencing soil oribatid mite populations in the greenhouse, whereas routine cultural and nutrient management practices had little or no significant effect (Table 13).

3.1.14. Vermicompost Bed

The vermicompost bed was managed using standard vermicomposting practices including irrigation, periodic addition of cow dung slurry and crop residues and harvesting. The impact of these management practices on soil oribatid mite populations was assessed by estimating the percentage change in their abundance during the vermicomposting

process. Among the management practices, harvesting had the most pronounced effect on oribatid mite populations resulting in a 49.48% reduction. Harvesting was carried out by gradually reducing the moisture content of the vermicompost bed, which encouraged earthworms and other decomposer organisms to migrate to the lower layers. The upper layer of vermicompost was then collected, inadvertently removing a substantial proportion of the associated oribatid mite population. In contrast, routine

irrigation and the periodic addition of cow dung slurry and crop residues did not produce any significant effect on oribatid mite abundance (Table 14). Overall, the findings indicate that routine vermicompost management practices are generally favorable for the maintenance of oribatid mite populations. However, the harvesting process temporarily reduced their abundance due to the physical removal of compost containing these soil-dwelling microarthropods.

Table 1: The impact of different agronomic practices on oribatid mite population in sugarcane (January 2018 - December 2019)

Sr. No.	Name of agronomic practices	Before application	After application (Days)				Mean	Differences (%) (Days)				Mean
			1	3	7	15		1	3	7	15	
1	Ploughing	27.00	13.00	12.80	15.60	17.50	14.73	51.85	52.59	42.22	35.19	45.46
2	Rotavator	24.00	15.30	16.20	18.70	20.50	17.68	36.25	32.50	22.08	14.58	26.35
3	Sowing	28.50	17.80	18.90	20.50	22.50	19.93	37.54	33.68	28.07	21.05	30.09
4	Irrigation	17.80	10.50	12.50	15.80	16.70	13.88	41.01	29.78	11.24	6.18	22.05
5	Fertilizer application											
5.1	Nitrogen	26.50	25.30	27.80	28.90	29.00	27.75	4.53	-4.91	-9.06	-9.43	-4.72
5.2	Phosphorus	26.50	26.00	26.20	26.00	26.30	26.13	1.89	1.13	1.89	0.75	1.42
5.3	Potash	26.50	26.30	26.10	26.20	26.30	26.23	0.75	1.51	1.13	0.75	1.04
5.4	FYM	28.00	27.50	28.60	28.90	28.90	28.48	1.79	-2.14	-3.21	-3.21	-1.70
5.5	Vermicompost	28.00	28.30	28.60	29.10	29.50	28.88	-1.07	-2.14	-3.93	-5.36	-3.13
5.6	Acetobacter	28.00	28.30	28.60	29.10	29.50	28.88	-1.07	-2.14	-3.93	-5.36	-3.13
5.7	Phosphate solubilizing bacteria (PSB)	28.00	28.30	28.60	29.10	29.50	28.88	-1.07	-2.14	-3.93	-5.36	-3.13
5.8	Potash mobilizing bacteria (KMB)	28.00	28.30	28.60	29.10	29.50	28.88	-1.07	-2.14	-3.93	-5.36	-3.13
6	Pesticide and biopesticide application											
6.1	Herbicide application											
6.1.1	Metribuzin 70 WP + 2,4-D (80% w/w) @ 1.0 kg a.i./ha	15.30	15.10	15.20	15.30	15.00	15.15	1.31	0.65	0.00	1.96	0.98
6.1.2	Glyphosate 41 SL @ 60 ml/10 lit.	24.00	23.50	23.70	23.90	24.00	23.78	2.08	1.25	0.42	0.00	0.94
6.1.3	Pendimethalin 30 EC @ 60 ml/10 lit.	28.50	27.50	27.90	27.90	28.30	27.90	3.51	2.11	2.11	0.70	2.11
6.2	Insecticide + fungicide application											
6.2.1	Chlorantraniliprole 0.4 GR @ 18.75 kg/ha	13.50	13.20	13.10	13.20	13.50	13.25	2.22	2.96	2.22	0.00	1.85
6.2.2	Carbendazim 50 WP @ 6 gm/10 lit.	28.50	28.00	28.20	28.30	28.20	28.18	1.75	1.05	0.70	1.05	1.14
6.2.3	Malathion 50 EC @ 20 ml/10 lit.	28.50	28.20	28.30	28.20	28.30	28.25	1.05	0.70	1.05	0.70	0.88
6.2.4	Chlorpyrifos 20 EC @ 15 ml/10 lit.	13.50	11.90	11.70	12.30	12.50	12.10	11.85	13.33	8.89	7.41	10.37
6.2.5	Trichoderma viride @ 1 kg a.i./acre	28.00	27.50	28.60	28.90	28.90	28.48	1.79	-2.14	-3.21	-3.21	-1.70
8	Interculturing	6.50	3.00	3.20	3.80	4.50	3.63	53.85	50.77	41.54	30.77	44.23
9	Weeding	12.80	10.00	11.20	11.50	11.60	11.08	21.88	12.50	10.16	9.38	13.48
10	Harvesting	27.00	25.00	21.00	18.60	15.30	19.98	7.41	22.22	31.11	43.33	26.02

Table 2: The impact of different agronomic practices on oribatid mite population in rice (January 2018 - December 2019)

Sr. No.	Name of agronomic practices	Before application	After application (Days)				Mean	Differences (%) (Days)				Mean
			1	3	7	15		1	3	7	15	
1	Ploughing	9.50	5.30	5.70	6.30	7.20	6.13	44.21	40.00	33.68	24.21	35.53
2	Puddling	11.50	1.00	1.20	1.60	1.90	1.43	91.30	89.57	86.09	83.48	87.61
3	Rotavator	24.00	18.00	18.60	18.90	19.30	18.70	25.00	22.50	21.25	19.58	22.08
4	Transplanting	11.30	1.20	1.20	1.60	1.80	1.45	89.38	89.38	85.84	84.07	87.17
5	Irrigation	11.30	1.20	1.00	1.50	1.70	1.35	89.38	91.15	86.73	84.96	88.05
6	Fertilizer application											
6.1	Nitrogen	1.50	1.30	1.20	1.20	1.30	1.25	13.33	20.00	20.00	13.33	16.67
6.2	Phosphorus	11.30	1.20	1.30	1.20	1.50	1.30	89.38	88.50	89.38	86.73	88.50
6.3	FYM	9.50	10.00	10.50	10.80	11.30	10.65	-5.26	-	-	-	-
6.4	Vermicompost	17.50	12.30	12.50	13.50	13.90	13.05	29.71	28.57	22.86	20.57	25.43
6.5	Azotobacter	17.50	12.30	12.50	13.50	13.90	13.05	29.71	28.57	22.86	20.57	25.43
6.6	Phosphate solubilizing bacteria (PSB)	17.50	12.30	12.50	13.50	13.90	13.05	29.71	28.57	22.86	20.57	25.43
6.7	Potash mobilizing bacteria (KMB)	17.50	12.30	12.50	13.50	13.90	13.05	29.71	28.57	22.86	20.57	25.43
7	Pesticide and biopesticide application											
7.1	Herbicide application											
7.1.1	Pretilachlor 30% + Pyrazosulfuron ethyl 0.75% WG @ 53 gm/10 lit.	1.60	1.45	1.49	1.50	1.50	1.49	9.38	6.88	6.25	6.25	7.19
7.2	Insecticide + fungicide application											
7.2.1	Imidacloprid 30.5 SC @ 1 ml/10 lit.	14.50	3.50	3.70	4.10	4.30	3.90	75.86	74.48	71.72	70.34	73.10
7.2.2	Chlorantraniliprole 0.4 GR @ 10 kg/ha	14.50	14.20	14.30	14.30	14.50	14.33	2.07	1.38	1.38	0.00	1.21
7.2.3	Chlorpyrifos 50 EC @ 8 ml/10 lit.	17.50	15.60	15.90	16.30	16.70	16.13	10.86	9.14	6.86	4.57	7.86
7.2.4	Flubendiamide 39.35 SC @ 1 ml/10 lit.	17.50	15.90	15.70	16.30	16.90	16.20	9.14	10.29	6.86	3.43	7.43
7.2.5	Streptocycline 40 ppm @ 6 gm/10 lit.	14.50	13.70	13.90	14.10	14.30	14.00	5.52	4.14	2.76	1.38	3.45
7.2.6	Propiconazole 25 EC @ 10 ml/10 lit.	24.00	23.70	23.50	23.90	24.00	23.78	1.25	2.08	0.42	0.00	0.94
8	Weeding	17.50	10.50	11.50	11.90	12.50	11.60	40.00	34.29	32.00	28.57	33.71
9	Harvesting	24.00	12.80	11.90	10.50	8.90	11.03	46.67	50.42	56.25	62.92	54.06
10	Crop rotation	24.00	10.00	8.90	7.80	6.30	8.25	58.33	62.92	67.50	73.75	65.63

Table 3: The impact of different agronomic practices on oribatid mite population in Pigeon pea (January 2018 - December 2019)

Sr. No.	Name of agronomic practices	Before application	After application (Days)				Mean	Differences (%) (Days)				Mean
			1	3	7	15		1	3	7	15	
1	Ploughing	18.00	9.00	11.00	12.30	13.90	11.55	50.00	38.89	31.67	22.78	35.83
2	Rotavator	15.60	10.60	11.20	12.30	12.90	11.75	32.05	28.21	21.15	17.31	24.68
3	Sowing	22.00	11.80	11.60	11.90	12.10	11.85	46.36	47.27	45.91	45.00	46.14
4	Irrigation	21.80	18.60	18.90	20.80	20.30	19.65	14.68	13.30	4.59	6.88	9.86
5	Fertilizer application											
5.1	Nitrogen	21.90	20.80	20.90	21.80	21.90	21.35	5.02	4.57	0.46	0.00	2.51
5.2	Phosphorus	21.90	20.80	20.70	20.90	21.90	21.08	5.02	5.48	4.57	0.00	3.77
5.3	FYM	18.00	17.60	17.00	18.90	19.00	18.13	2.22	5.56	-5.00	-5.56	-0.69
6	Pesticide and biopesticide application											
6.1	Herbicide application											
6.1.1	Pendimethalin 30 EC @ 60 ml/10 lit.	21.80	20.70	20.90	21.70	21.70	21.25	5.05	4.13	0.46	0.46	2.52
6.1.2	Glyphosate 41 SL @ 60 ml/10 lit.	18.00	17.30	17.90	17.70	17.90	17.70	3.89	0.56	1.67	0.56	1.67
7	Insecticide + fungicide application											
7.1.1	Emamectin benzoate 5 SG @ 4-5 gm/10 lit.	22.00	11.80	11.60	11.90	12.10	11.85	46.36	47.27	45.91	45.00	46.14
7.1.2	Pendimethalin 30 EC @ 60 ml/10 lit.	30.50	29.80	29.90	29.50	30.00	29.80	2.30	1.97	3.28	1.64	2.30
7.1.3	Spinosad 45 SC @ 1.62 ml/10 lit.	32.50	32.10	30.90	31.50	31.80	31.58	1.23	4.92	3.08	2.15	2.85
8	Interculturing	28.50	17.80	17.50	16.90	17.80	17.50	37.54	38.60	40.70	37.54	38.60
9	Weeding	32.50	16.90	18.60	18.90	20.30	18.68	48.00	42.77	41.85	37.54	42.54
10	Harvesting	11.50	8.50	8.00	9.00	9.60	8.78	26.09	30.43	21.74	16.52	23.70
11	Crop rotation	9.50	6.20	6.30	6.80	6.90	6.55	34.74	33.68	28.42	27.37	31.05

Table 4: The impact of different agronomic practices on oribatid mite population in lucerne (January 2018 - December 2019)

Sr. No.	Name of agronomic practices	Oribatid mite population										
		Before application	After application					Differences (%)				
			1	3	7	15	Mean	1	3	7	15	Mean
1	Ploughing	30.00	18.00	19.60	19.90	20.50	19.50	40.00	34.67	33.67	31.67	35.00
2	Rotavator	28.90	19.60	19.90	20.50	20.90	20.23	32.18	31.14	29.07	27.68	30.02
3	Sowing	32.00	31.50	31.00	31.80	31.90	31.55	1.56	3.13	0.63	0.31	1.41
4	Irrigation	31.50	30.80	28.50	30.60	30.90	30.20	2.22	9.52	2.86	1.90	4.13
5	Harvesting	12.80	6.30	6.90	7.20	7.30	6.93	50.78	46.09	43.75	42.97	45.90

Table 5: The impact of different agronomic practices on oribatid mite population in castor (January 2018 - December 2019)

Sr. No.	Name of agronomic practices	Before application	After application (Days)					Mean	Differences (%) (Days)				Mean
				1	3	7	15		1	3	7	15	
1	Ploughing	19.50	10.80	12.30	14.90	15.30	13.33		44.62	36.92	23.59	21.54	31.67
2	Rotavator	15.90	11.90	12.50	12.80	12.90	12.53		25.16	21.38	19.50	18.87	21.23
3	Sowing	21.00	18.90	19.20	19.50	19.80	19.35		10.00	8.57	7.14	5.71	7.86
4	Irrigation	18.90	16.30	16.80	17.20	17.80	17.03		13.76	11.11	8.99	5.82	9.92
5	Fertilizer application												
5.1	Nitrogen	21.00	22.30	22.80	22.60	22.80	22.63		-6.19	-8.57	-7.62	-8.57	-7.74
5.2	Phosphorus	21.00	20.30	20.60	20.90	20.80	20.65		3.33	1.90	0.48	0.95	1.67
5.3	Potash	21.00	20.30	20.60	20.90	20.80	20.65		3.33	1.90	0.48	0.95	1.67
5.4	FYM	19.50	18.60	18.90	19.60	19.30	19.10		4.62	3.08	-0.51	1.03	2.05
6	Pesticide and biopesticide application												
6.1	Herbicide application												
6.1.1	Pendimethalin 30 EC @ 60 ml/10 lit.	21.00	20.70	20.90	20.90	20.90	20.85		1.43	0.48	0.48	0.48	0.71
6.1.2	Glyphosate 41 SL @ 60 ml/10 lit.	19.50	19.10	19.30	19.50	19.50	19.35		2.05	1.03	0.00	0.00	0.77
6.2	Insecticide + fungicide application												
6.2.1	Emamectin benzoate 5 SG @ 4-5 gm/10 lit.	31.50	30.20	30.60	30.90	30.80	30.63		4.13	2.86	1.90	2.22	2.78
6.2.2	Spinosad 45 SC @ 1.62 ml/10 lit.	33.50	32.50	32.80	32.90	32.60	32.70		2.99	2.09	1.79	2.69	2.39
6.2.3	Trichoderma viride @ 1 kg a.i./acre	19.50	18.60	18.90	19.60	19.30	19.10		4.62	3.08	-0.51	1.03	2.05
6.2.4	Pseudomonas fluorescens @ 10 ml/10 lit.	30.50	29.70	29.90	30.10	30.30	30.00		2.62	1.97	1.31	0.66	1.64
7	Interculturing	30.50	18.60	19.60	19.80	20.50	19.63		39.02	35.74	35.08	32.79	35.66
8	Weeding	21.00	18.60	18.90	18.70	18.90	18.78		11.43	10.00	10.95	10.00	10.60
9	Harvesting	12.50	6.80	6.90	7.30	7.20	7.05		45.60	44.80	41.60	42.40	43.60
10	Crop rotation	8.50	4.30	5.80	6.90	7.80	6.20		49.41	31.76	18.82	8.24	27.06

Table 6: The impact of different agronomic practices on oribatid mite population in okra (January 2018 - December 2019)

Sr. No.	Name of agronomic practices	Before application	After application (Days)					Mean	Differences (%) (Days)				Mean
				3	7	15			3	7	15		
1	Ploughing	8.50	4.60	4.50	4.90	5.10	4.78		45.88	47.06	42.35	40.00	43.82
3	Rotavator	5.10	3.80	3.60	3.50	3.90	3.70		25.49	29.41	31.37	23.53	27.45
4	Sowing	11.00	1.30	1.50	2.60	2.90	2.08		88.18	86.36	76.36	73.64	81.14
5	Irrigation	10.30	1.80	1.90	2.80	3.90	2.60		82.52	81.55	72.82	62.14	74.76
6	Fertilizer application												
6.1	Nitrogen	3.80	3.60	3.70	4.90	5.10	4.33		5.26	2.63	-28.95	-34.21	-13.82
6.2	Phosphorus	3.80	3.60	3.70	3.90	3.90	3.78		5.26	2.63	-2.63	-2.63	0.66
6.3	Potash	3.80	3.60	3.70	3.90	3.90	3.78		5.26	2.63	-2.63	-2.63	0.66
6.4	FYM	8.50	7.60	7.90	8.30	8.90	8.18		10.59	7.06	2.35	-4.71	3.82
7	Pesticide and biopesticide application												
7.1	Herbicide application												
7.1.1	Pendimethalin 30 EC @ 60 ml/10 lit.	10.30	10.10	9.90	9.90	10.10	10.00		1.94	3.88	3.88	1.94	2.91
7.1.2	Glyphosate 41 SL @ 60 ml/10 lit.	10.50	10.10	10.30	10.30	10.50	10.30		3.81	1.90	1.90	0.00	1.90
7.2	Insecticide + fungicide application												
7.2.1	Imidacloprid 30.5 SC @ 1 ml/10 lit.	14.50	3.60	3.80	4.50	4.90	4.20		75.17	73.79	68.97	66.21	71.03

7.2.2	Diafenthiuron 50 WP @ 6 gm/10 lit.	16.00	15.00	15.60	15.80	15.00	15.35	6.25	2.50	1.25	6.25	4.06
7.2.3	Diflubenzuron 25 WP @ 3-4 gm/10 lit.	16.00	3.60	3.50	3.80	4.20	3.78	77.50	78.13	76.25	73.75	76.41
7.2.4	Cypermethrin 25 EC @ 4 ml/10 lit.	17.50	2.30	2.80	2.60	2.90	2.65	86.86	84.00	85.14	83.43	84.86
8	Interculturing	14.50	11.30	11.90	11.70	12.30	11.80	22.07	17.93	19.31	15.17	18.62
9	Weeding	16.00	15.30	15.50	15.70	15.90	15.60	4.38	3.13	1.88	0.63	2.50
10	Harvesting	17.50	13.50	13.90	14.10	14.50	14.00	22.86	20.57	19.43	17.14	20.00

Table 7: The impact of different agronomic practices on oribatid mite population in mango (January 2018 - December 2019)

Sr. No.	Name of agronomic practices	Oribatid mite population										
		Before application	After application					Differences (%)				
			1	3	7	15	Mean	1	3	7	15	Mean
1	Rotavator	6.90	3.90	4.20	4.50	4.70	4.33	43.48	39.13	34.78	31.88	37.32
2	Irrigation	12.50	10.80	10.50	10.90	11.60	10.95	13.60	16.00	12.80	7.20	12.40
3	Fertilizer application											
3.1	Nitrogen	18.50	16.90	17.80	18.90	18.80	18.10	8.65	3.78	-2.16	-1.62	2.16
3.2	Phosphorus	18.50	15.60	16.90	16.80	17.80	16.78	15.68	8.65	9.19	3.78	9.32
3.3	Potash	18.50	15.60	16.90	16.80	17.80	16.78	15.68	8.65	9.19	3.78	9.32
3.4	FYM	7.00	7.20	7.30	7.90	8.30	7.68	-2.86	-4.29	-12.86	-18.57	-9.64
3.5	Novel	12.50	11.90	12.10	12.30	12.50	12.20	4.80	3.20	1.60	0.00	2.40
4	Pesticide and Biopesticide application											
4.1	Herbicide application											
4.1.1	Glyphosate 41 SL @ 60 ml/10 lit.	12.50	11.90	11.90	12.30	12.50	12.15	4.80	4.80	1.60	0.00	2.80
4.2	Insecticide + Fungicide application											
4.2.1	Imidacloprid 17.80 SL @ 2-4 ml/10 lit./tree	41.50	5.80	5.60	5.90	6.30	5.90	86.02	86.51	85.78	84.82	85.78
4.2.2	Thiamethoxam (12.6%) + Lambdacyhalothrin (9.5%) ZC @ 4 ml/10 lit.	46.00	9.80	10.30	11.20	12.30	10.90	78.70	77.61	75.65	73.26	76.30
5	Interculturing	11.50	6.30	6.50	6.70	6.90	6.60	45.22	43.48	41.74	40.00	42.61
6	Weeding	38.50	36.80	36.90	37.80	37.50	37.25	4.42	4.16	1.82	2.60	3.25
7	Harvesting	7.50	6.90	6.80	7.20	7.10	7.00	8.00	9.33	4.00	5.33	6.67

Table 8: The impact of different agronomic practices on oribatid mite population in coconut (January 2018 - December 2019)

Sr. No.	Name of agronomic practices	Oribatid mite population										
		Before application	After application					Differences (%)				
			1	3	7	15	Mean	1	3	7	15	Mean
1	Rotavator	42.50	33.70	33.90	34.50	34.70	34.20	20.71	20.24	18.82	18.35	19.53
2	Irrigation	10.00	9.70	9.50	9.90	10.10	9.80	3.00	5.00	1.00	-1.00	2.00
3	Fertilizer application											
3.1	Nitrogen	21.50	20.60	20.90	21.30	21.90	21.18	4.19	2.79	0.93	-1.86	1.51
3.2	Phosphorus	21.50	21.30	21.20	21.50	21.50	21.38	0.93	1.40	0.00	0.00	0.58
3.3	Potash	21.50	21.30	21.20	21.50	21.50	21.38	0.93	1.40	0.00	0.00	0.58
3.4	FYM	19.00	18.60	18.90	19.30	19.80	19.15	2.11	0.53	-1.58	-4.21	-0.79
4	Pesticide and Biopesticide application											
4.1	Herbicide application											
4.1.1	Glyphosate 41 SL @ 60 ml/10 lit.	38.50	37.90	37.70	38.30	38.50	38.10	1.56	2.08	0.52	0.00	1.04
4.2	Insecticide + Fungicide application											
4.2.1	Azadirachtin 1500 ppm @ 50 ml/10 lit.	32.00	19.30	19.70	20.30	21.50	20.20	39.69	38.44	36.56	32.81	36.88
4.2.2	Copper oxychloride 50 WP @ 60 ml/10 lit.	36.00	35.90	35.80	35.90	36.00	35.90	0.28	0.56	0.28	0.00	0.28
4.2.3	Monocrotophos 36 WSC @ 17.50 ml/10 lit./tree	38.50	37.90	37.80	38.10	38.30	38.03	1.56	1.82	1.04	0.52	1.23
5	Interculturing	42.50	33.70	33.90	34.50	34.70	34.20	20.71	20.24	18.82	18.35	19.53
6	Weeding	42.50	42.10	42.20	41.90	42.30	42.13	0.94	0.71	1.41	0.47	0.88
7	Harvesting	36.00	35.90	35.80	35.60	35.90	35.80	0.28	0.56	1.11	0.28	0.56

Table 9: The impact of different agronomic practices on oribatid mite population in banana (January 2018 - December 2019)

Sr. No.	Name of agronomic practices	Oribatid mite population										
		Before application	After application					Differences (%)				
			1	3	7	15	Mean	1	3	7	15	Mean
1	Ploughing	11.50	6.30	6.50	6.90	7.20	6.73	45.22	43.48	40.00	37.39	41.52
2	Rotavator	8.00	4.50	5.90	6.30	7.20	5.98	43.75	26.25	21.25	10.00	25.31
3	Sowing	22.00	20.80	20.90	21.60	21.90	21.30	5.45	5.00	1.82	0.45	3.18
4	Irrigation	20.20	19.80	19.90	20.10	20.10	19.98	1.98	1.49	0.50	0.50	1.11
5	Fertilizer application											
5.1	Nitrogen	22.00	19.90	21.90	22.90	22.80	21.88	9.55	0.45	-4.09	-3.64	0.57
5.2	Phosphorus	22.00	19.80	21.90	21.80	22.00	21.38	10.00	0.45	0.91	0.00	2.84
5.3	Potash	22.00	19.80	21.90	21.80	22.00	21.38	10.00	0.45	0.91	0.00	2.84
5.4	FYM	11.50	11.40	11.80	11.90	12.10	11.80	0.87	-2.61	-3.48	-5.22	-2.61
6	Pesticide and Biopesticide application											
6.1	Herbicide application											
6.1.1	Pendimethalin 30 EC @ 60 ml/10 lit,	20.20	19.70	19.90	20.00	20.00	19.90	2.48	1.49	0.99	0.99	1.49
6.1.2	Glyphosate 41 SL @ 60 ml/10 lit.	11.50	11.10	11.30	11.30	11.50	11.30	3.48	1.74	1.74	0.00	1.74
6.2	Insecticide + Fungicide application											
6.2.1	Chlorpyrifos 50 EC @ 8 ml/10 lit.	42.50	42.10	42.20	41.90	41.80	42.00	0.94	0.71	1.41	1.65	1.18
6.2.2	Trichoderma viride @ 1 kg a.i/acre	11.50	11.40	11.80	11.90	12.10	11.80	0.87	-2.61	-3.48	-5.22	-2.61
6.2.3	Pseudomonas fluorescens @ 10ml/10 lit.	33.50	32.70	32.90	33.10	33.30	33.00	2.39	1.79	1.19	0.60	1.49
7	Interculturing	33.50	25.60	26.10	26.80	27.10	26.40	23.58	22.09	20.00	19.10	21.19
8	Weeding	25.00	24.80	24.90	25.00	25.00	24.93	0.80	0.40	0.00	0.00	0.30
9	Harvesting	16.50	15.38	15.90	15.60	15.70	15.65	6.79	3.64	5.45	4.85	5.18

Table 10: The impact of different agronomic practices on oribatid mite population in organic farm (January 2018 - December 2019)

Sr. No.	Name of agronomic practices	Before application	After application (Days)				Mean	Differences (%) (Days)				Mean
			1	3	7	15		1	3	7	15	
1	Ploughing	8.50	4.10	4.30	4.50	4.70	4.40	51.76	49.41	47.06	44.71	48.24
2	Rotavator	12.50	7.80	7.90	8.10	8.30	8.03	37.60	36.80	35.20	33.60	35.80
3	Sowing	8.50	5.30	5.50	5.70	5.90	5.60	37.65	35.29	32.94	30.59	34.12
4	Irrigation	5.30	4.90	5.10	5.30	5.30	5.15	7.55	3.77	0.00	0.00	2.83
5	Fertilizer application											
5.1	FYM	8.50	8.10	8.50	8.70	8.90	8.55	4.71	0.00	-2.35	-4.71	-0.59
5.2	Vermicompost	6.50	5.70	5.90	6.10	6.30	6.00	12.31	9.23	6.15	3.08	7.69
5.3	Azotobacter	6.50	5.70	5.90	6.10	6.30	6.00	12.31	9.23	6.15	3.08	7.69
5.4	Phosphate solubilizing bacteria (PSB)	6.50	5.70	5.90	6.30	6.50	6.10	12.31	9.23	3.08	0.00	6.15
5.5	Potash mobilizing bacteria (KMB)	6.50	5.70	5.90	6.30	6.50	6.10	12.31	9.23	3.08	0.00	6.15
6	Pesticide and biopesticide application											
6.2	Insecticide + fungicide application											
6.2.1	Beauveria bassiana @ 40 gm/10 lit.	38.50	37.60	37.90	36.20	36.30	37.00	2.34	1.56	5.97	5.71	3.90
6.2.2	Metarizium anisopliae @ 40 gm/10 lit.	38.50	37.50	37.90	36.30	36.90	37.15	2.60	1.56	5.71	4.16	3.51
6.2.3	Bacillus thuringensis @ 40 gm/10 lit.	42.00	31.60	31.90	33.60	33.90	32.75	24.76	24.05	20.00	19.29	22.02
6.2.4	Trichoderma viride @ 1 kg a.i./acre	46.00	45.50	45.70	45.90	46.00	45.78	1.09	0.65	0.22	0.00	0.49
6.2.5	Pseudomonas fluorescens @ 10 ml/10 lit.	15.50	14.50	14.80	14.90	15.30	14.88	6.45	4.52	3.87	1.29	4.03
6.2.6	Azadirachtin (1500 ppm)	8.50	5.30	5.50	5.70	5.90	5.60	37.65	35.29	32.94	30.59	34.12
8	Interculturing	29.00	19.60	19.70	20.30	21.50	20.28	32.41	32.07	30.00	25.86	30.09
9	Weeding	12.50	10.50	10.90	11.30	11.90	11.15	16.00	12.80	9.60	4.80	10.80
10	Harvesting	29.00	15.00	15.70	15.90	16.70	15.83	48.28	45.86	45.17	42.41	45.43
11	Crop rotation	18.90	12.70	12.90	13.50	13.70	13.20	32.80	31.75	28.57	27.51	30.16

Table 11: The impact of different agronomic practices on oribatid mite population in turmeric (January 2018 - December 2019)

Sr. No.	Name of agronomic practices	Oribatid mite population										
		Before application	After application					Differences (%)				
			1	3	7	15	Mean	1	3	7	15	Mean
1	Ploughing	8.00	3.60	3.80	4.20	4.90	4.13	55.00	52.50	47.50	38.75	48.44
2	Rotavator	5.00	3.20	3.50	3.50	3.90	3.53	36.00	30.00	30.00	22.00	29.50
3	Sowing	18.50	14.60	14.50	15.60	15.90	15.15	21.08	21.62	15.68	14.05	18.11
4	Irrigation	17.50	16.10	16.20	16.80	16.50	16.40	8.00	7.43	4.00	5.71	6.29
5	Fertilizer application											
5.1	Nitrogen	22.50	22.30	22.50	22.90	22.80	22.63	0.89	0.00	-1.78	-1.33	-0.56
5.2	Phosphorus	22.50	22.30	21.90	21.80	22.30	22.08	0.89	2.67	3.11	0.89	1.89
5.3	Potash	22.50	22.30	21.90	21.80	22.30	22.08	0.89	2.67	3.11	0.89	1.89
5.4	FYM	8.00	6.30	7.90	8.50	8.90	7.90	21.25	1.25	-6.25	-11.25	1.25
6	Pesticide and Biopesticide application											
6.1	Herbicide application											

6.1.1	Pendimethalin 30 EC @ 60 ml/10 lit.	17.50	17.10	16.90	17.30	17.50	17.20	2.29	3.43	1.14	0.00	1.71
6.1.2	Glyphosate 41 SL @ 60 ml/10 lit.	9.50	8.90	8.70	9.10	9.30	9.00	6.32	8.42	4.21	2.11	5.26
6.2	Insecticide + Fungicide application											
	Propiconazole 25 EC @ 10 ml/10 lit.	25.50	24.80	24.90	25.10	25.20	25.00	2.75	2.35	1.57	1.18	1.96
7	Interculturing	28.50	18.50	18.90	19.60	20.30	19.33	35.09	33.68	31.23	28.77	32.19
8	Weeding	28.50	27.90	27.80	28.30	28.20	28.05	2.11	2.46	0.70	1.05	1.58
9	Harvesting	9.50	6.30	6.80	6.90	7.10	6.78	33.68	28.42	27.37	25.26	28.68
10	Crop rotation	36.50	23.70	23.90	24.50	24.80	24.23	35.07	34.52	32.88	32.05	33.63

Table 12: The impact of different agronomic practices on oribatid mite population in Aloe vera (January 2018 - December 2019)

Sr. No.	Name of agronomic practices	Oribatid mite population										
		Before application	After application					Differences (%)				
			1	3	7	15	Mean	1	3	7	15	Mean
1	Ploughing	7.50	3.20	3.30	3.50	3.70	3.43	57.33	56.00	53.33	50.67	54.33
2	Rotavator	16.50	11.20	11.30	12.80	12.90	12.05	32.12	31.52	22.42	21.82	26.97
3	Sowing	20.50	16.60	16.70	17.20	17.50	17.00	19.02	18.54	16.10	14.63	17.07
4	Irrigation	16.80	13.20	13.50	14.90	15.10	14.18	21.43	19.64	11.31	10.12	15.63
5	Fertilizer application											
5.1	Nitrogen	20.50	20.10	20.20	20.80	20.70	20.45	1.95	1.46	-1.46	-0.98	0.24
5.2	FYM	7.50	6.30	6.90	7.50	7.90	7.15	16.00	8.00	0.00	-5.33	4.67
6	Pesticide and Biopesticide application											
6.1	Herbicide application											
6.1.1	Pendimethalin 30 EC @ 60 ml/10 lit.	16.80	16.10	16.30	16.50	16.70	16.40	4.17	2.98	1.79	0.60	2.38
6.1.2	Glyphosate 41 SL @ 60 ml/10 lit.	8.50	7.90	8.10	8.30	8.50	8.20	7.06	4.71	2.35	0.00	3.53
7	Interculturing	28.50	21.30	21.90	22.30	22.70	22.05	25.26	23.16	21.75	20.35	22.63
8	Weeding	31.50	29.60	29.70	30.50	30.90	30.18	6.03	5.71	3.17	1.90	4.21
9	Harvesting	11.50	6.70	7.10	7.90	7.50	7.30	41.74	38.26	31.30	34.78	36.52

Table 13: The impact of different agronomic practices on oribatid mite population in Greenhouse soil (January 2018 - December 2019)

Sr. No.	Name of agronomic practices	Oribatid mite population										
		Before application	After application					Differences (%)				
			1	3	7	15	Mean	1	3	7	15	Mean
1	Sowing	12.50	11.30	11.90	12.30	12.50	12.00	9.60	4.80	1.60	0.00	4.00
2	Irrigation	11.90	11.70	11.80	11.90	11.90	11.83	1.68	0.84	0.00	0.00	0.63
3	Fertilizer application											
3.1	Nitrogen	11.90	11.70	11.90	12.10	12.20	11.98	1.68	0.00	-1.68	-2.52	-0.63
3.2	Phosphorus	11.90	11.70	11.80	11.90	11.90	11.83	1.68	0.84	0.00	0.00	0.63
3.3	Potash	11.90	11.70	11.80	11.90	11.90	11.83	1.68	0.84	0.00	0.00	0.63
4	Pesticide and Biopesticide application											
4.1	Herbicide application											
4.1.1	Glyphosate 41 SL @ 60 ml/10 lit.	9.00	8.30	8.50	8.90	9.00	8.68	7.78	5.56	1.11	0.00	3.61
4.2	Insecticide + Fungicide application											
4.2.1	Imidacloprid 30.5 SC @ 1 ml/10 lit.	12.50	2.50	2.70	3.10	3.50	2.95	80.00	78.40	75.20	72.00	76.40
4.2.2	Spiromesifen 22.90 SC @ 8 ml/10 lit.	18.50	16.70	16.90	16.70	18.30	17.15	9.73	8.65	9.73	1.08	7.30
4.2.3	Azadirachtin 1500 ppm @ 50 ml/10 lit.	16.50	6.50	6.80	6.90	7.30	6.88	60.61	58.79	58.18	55.76	58.33
4.2.4	Cypermethrin 25 EC @ 4 ml/10 lit.	10.50	2.10	2.30	2.70	2.90	2.50	80.00	78.10	74.29	72.38	76.19
5	Weeding	14.50	13.50	13.70	13.90	14.00	13.78	6.90	5.52	4.14	3.45	5.00
6	Harvesting	10.50	9.30	9.70	9.90	10.50	9.85	11.43	7.62	5.71	0.00	6.19

Table 14: The impact of different agronomic practices on oribatid mite population in vermicompost bed (January 2018 - December 2019)

Sr. No.	Name of agronomic practices	Oribatid mite population										
		Before application	After application					Differences (%)				
			1	3	7	15	Mean	1	3	7	15	Mean
1	Irrigation	28.00	26.70	26.90	27.30	27.90	27.20	4.64	3.93	2.50	0.36	2.86
2	Fertilizer application											
2.1	Cow dung slurry + crop residue	22.00	21.70	21.90	22.70	22.80	22.28	1.36	0.45	-3.18	-3.64	-1.25
3	Harvesting	38.50	18.70	18.90	19.50	20.70	19.45	51.43	50.91	49.35	46.23	49.48

An overall assessment of various agronomic practices across different disturbed agroecosystems was conducted to evaluate their effects on soil oribatid mite populations. The tillage operations investigated included ploughing, rotavation, inter-culturing and puddling. Changes in oribatid mite populations were recorded at 1, 3, 7 and 15 days after each operation and expressed as percentage differences. Among the tillage operations, ploughing caused the greatest

reduction in oribatid mite populations in *Aloe vera* (54.33%) whereas the lowest reduction was recorded in castor (31.67%). Similarly, rotavation resulted in the highest reduction in mango orchards (37.32%) and the lowest in coconut plantations (19.53%). Inter-culturing also adversely affected oribatid mite populations with the highest reduction observed in sugarcane (44.23%) and the lowest in okra (18.62%). Among all tillage-related operations, puddling in

rice fields caused the greatest reduction (87.61%) in oribatid mite populations indicating that intensive soil disturbance coupled with prolonged flooding creates highly unfavorable conditions for these soil-dwelling microarthropods.

The present findings are in agreement with those of Lee (1986) who reported that long-term intensive agricultural practices significantly reduced the distribution and diversity of oribatid mites. Statistical analyses revealed that oribatid heterogeneity at the generic level was significantly lower in cultivated plots than in adjacent woodland areas. Similarly, Taylor and Wolters (1998) investigated the effects of three tillage practices-ploughing, chisel ploughing and spring cultivation-on soil mite communities and reported that tillage reduced acarine populations by more than 50%. They further observed that the adverse effects of spring cultivation were less pronounced in deeper soil layers than those of ploughing and chisel ploughing. Moreover, different groups of acari responded differently to tillage with oribatid mites being particularly sensitive to ploughing whereas gamasid mites were more affected by chisel ploughing. These findings strongly support the present study, demonstrating that mechanical soil disturbance is one of the principal factors regulating the abundance and diversity of soil oribatid mites in agricultural ecosystems.

Sowing operations in the different agroecosystems included broadcasting, seed drilling and transplanting. The effect of these sowing methods on soil oribatid mite populations varied depending on the crop and the associated field conditions. Broadcasting of lucerne seed resulted in only a marginal reduction (1.41%) in the oribatid mite population, indicating minimal disturbance to the soil habitat. In contrast, transplanting in rice caused a substantial reduction (87.17%) in oribatid mite abundance, primarily because it was performed immediately after puddling under flooded field conditions which are highly unfavorable for soil-dwelling oribatid mites. Seed drilling also had a marked effect on oribatid mite populations in crops where seeds were treated with systemic insecticides. In okra, sowing with imidacloprid-treated seeds resulted in an 81.14% reduction in the oribatid mite population, whereas pigeon pea recorded a 46.14% reduction following seed treatment with Imidacloprid 17.8 SL. These findings suggest that, although the sowing operation itself causes relatively little disturbance, the associated use of insecticide-treated seeds can significantly reduce oribatid mite populations by exposing these non-target soil microarthropods to systemic insecticides.

Irrigation practices evaluated in the present study included surface irrigation in different crop ecosystems and flooded irrigation in rice. The impact of irrigation on soil oribatid mite populations varied considerably depending on the irrigation method and the associated soil moisture conditions. Among the crops receiving surface irrigation, the highest reduction in oribatid mite populations was observed in okra (74.76%) followed by sugarcane (22.05%). In contrast, flooded irrigation in rice caused the greatest reduction (88.05%) in oribatid mite abundance, indicating that prolonged waterlogged and anaerobic soil conditions are highly unfavorable for these soil-dwelling microarthropods. Conversely, irrigation had only a marginal effect on oribatid mite populations in perennial cropping systems, with the lowest reductions recorded in banana (1.11%) and coconut

(2.00%). The comparatively lower impact in these crops may be attributed to the absence of prolonged flooding and the relatively stable soil environment maintained under perennial cultivation. Overall, the findings indicate that the effect of irrigation on soil oribatid mite populations is largely determined by the intensity and duration of soil saturation with flooded irrigation exerting substantially greater adverse effects than surface irrigation.

Hand weeding had variable effects on soil oribatid mite populations across different crop ecosystems. The highest reduction in oribatid mite populations following hand weeding was recorded in pigeon pea (42.54%) followed by rice (33.71%) whereas the lowest reductions were observed in banana (0.30%) and coconut (0.88%). The reduction in mite populations following hand weeding may be attributed to disturbance of the soil surface and alteration of the microhabitat during weed removal.

Both pre- and post-emergence herbicides were evaluated in different crop ecosystems. The herbicides used included Metribuzin 70 WP+2,4-D (80% W/W) @ 1.0 kg a.i. ha⁻¹, Glyphosate 41 SL @ 60 ml/10 L water, Pendimethalin 30 EC @ 60 ml/10 L water and Pretilachlor (30%) + Pyrazosulfuron-ethyl (0.75%) WG @ 53 g/10 L water. None of these herbicides produced any significant positive or negative effect on soil oribatid mite populations under field conditions indicating that the recommended herbicide applications were comparatively safe for these non-target soil microarthropods.

The present findings are consistent with those of Mohammed *et al.* (2017) who evaluated the effects of Glyphosate and Multazine on the abundance and diversity of soil microarthropods. Although the highest abundance of soil microarthropods was recorded in the untreated control, populations in the low and recommended doses of Glyphosate did not differ significantly from the control. In contrast, all application rates of Multazine significantly reduced soil microarthropod populations compared with Glyphosate. These observations support the present findings that Glyphosate when applied at recommended doses, exerts minimal adverse effects on soil oribatid mite populations.

Various chemical pesticides and biopesticides were evaluated for their impact on soil oribatid mite populations under different crop ecosystems. The chemical pesticides included Imidacloprid 17.8 SL @ 2-4 ml/10 L water, Imidacloprid 30.5 SC @ 1 ml/10 L water, Spiromesifen 22.9 SC @ 8 ml/10 L water, Cypermethrin 25 EC @ 4 ml/10 L water, Propiconazole 25 EC @ 10 ml/10 L water, Chlorpyrifos 50 EC @ 8 ml/10 L water, Copper oxychloride 50 WP @ 60 g/10 L water, Monocrotophos 36 WSC @ 17.5 ml/10 L water, Thiamethoxam (12.6%) + Lambda-cyhalothrin (9.5%) ZC @ 4 ml/10 L water, Diflubenzuron 25 WP @ 3-4 g/10 L water, Diafenthiuron 50 WP @ 6 g/10 L water, Spinosad 45 SC @ 1.62 ml/10 L water, Emamectin benzoate 5 SG @ 4-5 g/10 L water, Streptocycline 40 ppm @ 1 g/10 L water, Flubendiamide 39.35 SC @ 1 ml/10 L water, Chlorantraniliprole 0.4 GR @ 10 kg ha⁻¹, Malathion 50 EC @ 20 ml/10 L water and Carbendazim 50 WP @ 6 g/10 L water. The biopesticides evaluated included Azadirachtin 1500 ppm @ 50 ml/10 L water, *Beauveria bassiana* @ 40 g/10 L water, *Metarhizium anisopliae* @ 40 g/10 L water, *Bacillus thuringiensis* @ 40 g/10 L water, *Trichoderma viride* @ 1.0 kg acre⁻¹ and *Pseudomonas fluorescens* @ 10

ml/10 L water. These plant protection products were applied according to the recommended doses to protect different crops against a wide range of sucking and chewing insect pests as well as plant diseases. The effects of these pesticides and biopesticides on soil oribatid mite populations were subsequently assessed under field conditions. Imidacloprid 17.80SL and Imidacloprid 30.5SC showed significant effects on oribatid mite population. Highest per cent difference was found in mango (85.78%) followed by Greenhouse ecosystems (76.40%), rice (73.10%), okra (71.03%) and pigeon pea as seed treatment (46.14%). Thiamethoxam (12.6%) + Lambda cyhalothrin (9.5%) ZC showed per cent differences in mango (76.30%). Present findings more or less similar to earlier findings by El-Naggar and Zidan (2013) investigated the effect of insecticides on soil fauna. The reduction was more significant between plants than under plants. The most influenced micro-arthropod was oribatida. The results also revealed that imidacloprid had more adverse effects on soil fauna than thiamethoxam.

Diffubenzuron 25 WP exhibited a significant adverse effect on soil oribatid mite populations, causing a 76.41% reduction in okra. In contrast, the biopesticide *B. thuringiensis* caused a comparatively moderate reduction (22.02%) in oribatid mite abundance, indicating that its impact on non-target soil microarthropods was considerably lower than that of diffubenzuron.

The present findings are in agreement with those of Beck *et al.* (2004) who investigated the effects of diffubenzuron (Dimilin® 25 WP) and *B. thuringiensis* var. *kurstaki* (B.t.k.; Dipel ES®) on the soil fauna of a deciduous forest in the Upper Rhine Valley. Their study demonstrated that diffubenzuron applied at 25 g ha⁻¹ affected all arthropod groups investigated, causing reductions in the abundance and dominance of several mite species, while increasing the dominance of others and inducing the migration of some species from the litter layer to deeper soil horizons. Although arthropod populations gradually recovered following the degradation of diffubenzuron, its initial impact on soil fauna was substantial. In contrast, *B. thuringiensis* var. *kurstaki* had only a limited effect, reducing the dominance of *Veigaia nemorensis* (C.L. Koch, 1892) (Gamasida) without causing major changes in the overall soil arthropod community. These observations support the present study, indicating that diffubenzuron is considerably more detrimental to soil oribatid mite populations than *B. thuringiensis* under field conditions.

Cypermethrin 25 EC, a synthetic pyrethroid insecticide, exerted a significant adverse effect on soil oribatid mite populations causing reductions of 84.86% in okra and 76.19% under greenhouse conditions. Among the biopesticides evaluated, Azadirachtin (1500 ppm) also significantly reduced oribatid mite populations with the highest reduction observed in greenhouse crops (58.33%) followed by coconut plantations (36.88%) and the organic farming system (34.12%). Although Azadirachtin affected oribatid mite abundance, its impact was generally less pronounced than that of the synthetic pyrethroid cypermethrin.

The present findings are consistent with earlier reports. Stark (1992) demonstrated that neem seed-kernel extracts and the neem-based insecticide Margosan-O® (containing 3.0 g L⁻¹ azadirachtin) were effective against several insect pests while

exhibiting lower toxicity than chlorpyrifos to most beneficial invertebrates. However, the study also reported that oribatid mites were more sensitive to the neem-based formulation than to chlorpyrifos, indicating that botanical insecticides may also affect certain non-target soil arthropods. Similarly, Tigga *et al.* (2018) evaluated the *in vitro* efficacy of neem and karanj extracts alone and in combination with cypermethrin, against arthropod intermediate hosts including ticks, oribatid mites, lice and ants. Their results showed that mixtures of cypermethrin with neem or karanj achieved 100% mortality of oribatid mites, lice and ants within one hour of treatment, while providing 84% and 100% efficacy against ticks after 48 hours, respectively. These findings support the present investigation by demonstrating that cypermethrin possesses high toxicity to oribatid mites, whereas Azadirachtin although comparatively less harmful than synthetic pyrethroids can still adversely affect non-target soil microarthropods under certain conditions.

Chlorpyrifos 50 EC exerted only a slight to moderate effect on soil oribatid mite populations causing reductions of 10.37% in sugarcane, 7.86% in rice and 1.18% in banana. These relatively low reductions indicate that chlorpyrifos was comparatively safe for soil oribatid mites under the field conditions of the present investigation. Similarly, several other plant protection chemicals, including Spiromesifen 22.9 SC, Triazophos 40 EC, Propiconazole 25 EC, Copper oxychloride 50 WP, Monocrotophos 36 WSC, Dichlorvos 76 EC, Diafenthiuron 50 WP, Spinosad 45 SC, Emamectin benzoate 5 SG, Streptocycline (500 ppm), Flubendiamide 39.35 SC, Chlorantraniliprole 0.4 GR, Malathion 50 EC and Carbendazim 50 WP did not produce any significant adverse effect on oribatid mite populations. The present findings are consistent with those of Michereff-Filho *et al.* (2004) who evaluated the side effects of chlorpyrifos on springtails, ants and oribatid mites associated with the soil surface of no-tillage maize fields in Brazil. Their principal component analysis detected no negative effect of chlorpyrifos on the soil arthropod assemblage, and no significant impact was observed on oribatid mites. The authors concluded that the effects of chlorpyrifos on soil arthropods under tropical field conditions were less severe than previously anticipated. Similarly, Mandal and Riso (2016) evaluated the effects of soil-applied granular insecticides, namely Rynaxypyr 0.4 G, Fipronil 0.3 G, Carbofuran 3 G, Cartap hydrochloride 4 G and sprayable Chlorpyrifos 20 EC on soil fauna. Their study demonstrated that Rynaxypyr was safe to both collembolans and soil oribatid mites, whereas Chlorpyrifos was safe to oribatid mites but not to collembolans. In contrast, Fipronil, Carbofuran and Cartap hydrochloride significantly reduced the populations of collembolans and oribatid mites up to seven days after application while their effects on other soil mesofauna including pseudoscorpions and minute staphylinid beetles, were not significant. Overall, the present study, together with previous reports, indicates that chlorpyrifos and several commonly used fungicides and insecticides have relatively low adverse effects on soil oribatid mite populations under recommended field application rates. These findings suggest that the impact of plant protection chemicals on oribatid mites depends on the active ingredient, formulation and mode of action with certain insecticides being considerably less harmful than systemic neonicotinoids and synthetic pyrethroids.

Harvesting and crop rotation significantly reduced soil oribatid mite populations by disturbing their habitat and reducing the availability of food resources. Harvesting caused considerable reductions in oribatid mite populations across different agroecosystems with the highest reduction recorded in rice (54.06%), followed by vermicompost beds (49.48%), lucerne (45.90%), organic farming systems (45.43%) and castor (43.60%). In contrast, the lowest reduction following harvesting was observed in coconut plantations (0.56%) where the perennial cropping system provides a relatively stable soil environment and continuous organic matter input. Crop rotation also adversely affected oribatid mite populations with the greatest reduction recorded in rice (65.63%) and the lowest in castor (27.06%). The pronounced decline observed in rice may be attributed to intensive soil disturbance, removal of crop residues and changes in soil moisture and habitat conditions associated with the transition between cropping cycles. In comparison, the relatively smaller reduction observed in castor suggests that crop rotation under less intensive management exerts a comparatively lower impact on soil-dwelling microarthropods. Overall, the findings indicate that harvesting and crop rotation are important agronomic practices influencing soil oribatid mite populations. The removal of crop residues and the consequent loss of food resources and favorable microhabitats, together with soil disturbance during post-harvest field operations are likely to be the primary factors responsible for the observed reductions in oribatid mite abundance across different agroecosystems. Fertilizer applications evaluated in the present study included chemical fertilizers, organic manures and biofertilizers. The chemical fertilizers comprised nitrogenous, phosphatic, and potassic fertilizers whereas the organic nutrient sources included farmyard manure and vermicompost. The biofertilizers used were *Azotobacter*, *Acetobacter*, phosphate-solubilizing bacteria (PSB) and potassium-mobilizing bacteria (KMB). Overall, the application of these nutrient sources did not produce any significant effect on soil oribatid mite populations. Although nitrogenous fertilizers appeared to favor oribatid mite abundance by promoting plant growth and increasing the availability of organic residues, the observed increase was not statistically significant. Similarly, the application of FYM, cow dung slurry, vermicompost and crop residues enhanced the availability of organic matter thereby providing a favorable food source and habitat for oribatid mites. However, these inputs did not result in a significant increase in mite populations during the study period. This may be attributed to the relatively slow life cycle, low reproductive rate and gradual population response of oribatid mites, which require a longer period to exhibit measurable changes in abundance. Overall, the results indicate that fertilizer application, irrespective of its source had little direct influence on soil oribatid mite populations under field conditions. Compared with mechanical agronomic operations, nutrient management practices were relatively benign, suggesting that habitat disturbance rather than fertilizer application is the primary factor governing changes in soil oribatid mite abundance across different agroecosystems.

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