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Effect of Management Practices (Pesticides Application) on Soil Mesofaunal Population: A Review

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Abstract—*Tremendous benefits have been derived by the use of pesticides in forestry, public health and domestic sphere and of course in agriculture, a major sector upon which the Indian economy is largely dependent. As we know that agriculture is depend on healthy soil. One spoonful of healthy soil has millions of tiny organisms including Bacteria, Fungi, Earthworms, Nematodes, Mites, Beetles, Collembola and Protura etc. Microorganisms play a key role in helping plants utilize soil nutrients needed to grow and thrive. Microorganisms also help soil to store water and nutrients, regulate water flow and filter pollutants. The activity of these soil mesofauna is very significant for the fertility of soil. Fertile soil is that soil which provides essential nutrients for crop, plant growth supports a diverse and active biotic community, exhibit a typical soil structure when soil is disturbed with various soil management practices such as – cropping, tillage and use of pesticides. The heavy treatments of soil with pesticides can cause population of beneficial and allow for an undisturbed decomposition. So, these mesofauna are adversely affected soil mesofauna to decline. Sometimes pesticides have negative impact on the available NPK from soil.*

Introduction:

Improving and maintaining soil quality for enhancing and sustaining agricultural production is of great importance for India's food and nutritional security. Though India is a food surplus nation at present with about 23,150 million tones food grain production per annum, it will require about 4-5 million tons additional food grain each year if the trend in rising population persists. Due to increasing population pressure the demand for food, feed fiber, etc., is rapidly increasing. To overcome this problem of decreasing crop productivity, there is an urgent need for better planning and to improve the crop productivity through improved varieties and to sustain soil fertility. So, sustainability of agricultural system has become an important issue in both developed and developing countries. Globally there has been a tremendous increase in the number of commercial farmer and the total land area practicing the management systems. In the modern agriculture under the management practices, insecticides are frequently applied to the crop field to increase the crop production. Besides combating insects, a significant amount of the insecticide eventually reaches in the soil and is accumulated in the top soil (0-10cm) where the maximum microbiological activities occur (Alexander 1978).

Soil mesofauna

The earliest attempt of study on soil fauna was made by Diem (1903) who surveyed the occurrence of soil fauna in the region of Alps Switzerland. Mc.Atell (1907) successfully counted the sol fauna collected from forest floor and grass meadow. This work was followed by some pedobiologist i.e. Shelford (1913), Adams (1915), Thompson (1924) and ford (1935). Ford (1937) extracted collembolans Acarina, Staphylinides and Spiders from grass tussocks with the aid of improved tullegren funnel. **Joy V.C. et al. (2005)** studied bio-monitoring insecticide pollution using non- target soil microarthropods. He discussed the insecticide pollution with the help of field and laboratory findings on the density, prey-predator ratio and non- target microarthropod fauna. Field experiments were conducted in small plots with mustard, wheat and lady's finger crop with insecticides namely heptachlor 20 EC and Endosulfan 35EC applied at the seedling stage. They concluded on the basis of their study that population response and reproductive sensitivity on non-target soil microarthropod are potential eco toxicological parameters for detecting pesticide pollution in soil and for ecological assessment since the results are based on the bioactivity of toxicants.

Ahmed Sohail et al. (2006) studied the Effect of insecticides on the total number of soil bacteria under laboratory and field conditions. The laboratory and field studies were conducted to determine the effects of Chlorpyrifos 40EC, Imidacloprid 200SL, Cypermethrin 10EC, Endosulfan 35EC, Carbofuran 20EC, and Cypermethrin 10EC Bifenthrin 10EC at four concentrations (125, 250, 500, and 1000 ppm) and at field application rates respectively on total number of soil bacteria's population. Nutrient Agar medium was used for the count of bacterial populations. Soil samples at 15-20cm depths were taken from agricultural fields, largely under Sugarcane cultivation. Results obtained from both studies revealed that Chlorpyrifos caused significant reduction in number of soil bacteria. However, in the field experiment effect disappeared at 21 day after application. Bifenthrin on the other hand increased the number of bacterial population at 250 (50.97) and 500 (41.69) ppm in the laboratory studies over the control (15.52) while in the field trail, bacteria population was unharmed, with increase (13.97) at day 7 after application over the pre-treatment number (11.30). **Lins V.S. et al. (2007)** pointed out the effect of the glyphosate 2, 4-D atrazine- & nicosulfuron herbicides upon the edaphic Collembola in a no tillage system. In their study, the plots received four types of herbicides: Glyphosate, Atrazine 2AD and Nicosulfuran. A fifth plot did not receive any herbicide (control), for a total of five treatment types. The sub plots were represented by their collection times (10, 20, 30 and 40 days) after the herbicide application. Both the type of herbicide and time of data sampling influenced the collembolan population fluctuation. The treatments with atrazine and 2, 4-D caused the most reduction of the population of collembola depending on the time of application. **Yanmei Xiong et al. (2008)** conducted a short-term pot experiment with treatments of five biocides: Pyridaben, Profenofos, Abamectin, Triflumuron and Naphthalene, and tested their effectiveness and selectivity on soil microarthropods, under the management practices .They found in their results that only Pyridaben and Naphthalene were selective biocides on soil microarthropods when applied at appropriate rates. Although Profenofos significantly decreased soil microarthropod density, it also significantly decreased soil nematode density. Abamectin did not inhibit soil microarthropods but decreased soil nematode density. Profenofos and the highest level of naphthalene application stimulated soil microbial biomass one week after application. Triflumuron showed no negative effect on soil microarthropods, soil nematodes and soil microbial biomass.

Rashmi M.A. et al. monitored in **(2009)** the effect of agro inputs and pesticides on the abundance of macrofauna. They noticed that significantly lower activity of macrofauna in Dicofol which was act par with Neem cake, fertilizer Carbendzim 50 WP and phorate 3G in toxicity to macrofauna. However later two treatments were also on par with Carbofuran 3G and Chloropyriphos 20 EC in toxicity to macrofauna. All the agro inputs recorded significantly lower activity of macrofauna compared to control. At the same time, **Iloba B.N. and Ekrakene T. (2009)** also monitored soil arthropods recovery rates from 5-10 cm depth to ascertain whether the application of Dichlorov (an organo- phosphate) pesticide in varying concentration levels of OL (control), 0.25 L (low) and 0.75L (high) per 25 m^2 would adversely affect the rate of sampling soil arthropods. In their result, they found that there was an initial decrease in the monthly number of sampled soil arthropods in the treated plots from April to May but increased from June to August. The result revealed that, the mean number of sampled soil arthropods was significantly different ($P< 0.05$) on the basis of the amount of dichlorove pesticide concentration used compared with the control with high concentration region being the most toxic to the arthropods. **Iloba and Ekrakene (2010)** worked on soil arthropods recovery rates from 5-10 cm within 5 months period following Endosulfan (an organochlorine pesticide) treatment in designed plots in Benin City, Nigeria. According to them, there was consistent decrease in the mean numbers of soil arthropod sampled from April to June and the decrease was more as concentration of applied endosulfan increased.

Chelinho Sonia et al. (2011) described the Carbofuran effects in soil nematode communities: using trait and taxonomic based approaches. This work intends to implement the use of native soil nematode communities in ecotoxicological tests using a model pesticide and two geographically nematode communities (Mediterranean and sub-tropical) in order to obtain new perspectives on the evaluation of the toxic potential of chemical substances. The environmental condition of the nematode communities was described using a trait-based approach (grouping the organisms according to their feeding traits) and a traditional taxonomic method (identification upto family level). Effects on total nematode abundance, number of families and abundance of nematode feeding groups as well as potential shifts in both trophic and family structure were assessed. Their results showed that using such a trait-based approach may increase the ecological relevance of toxicity data, by establishing communalities in the response to a chemical from two different taxonomic communities, although with potential loss of information on biodiversity of the communities. Philip J. White et al. (2012) studied the soil management for sustainable agriculture. They noted that the adoption of appropriate agro forestry systems can reduce soil losses, increase SOM, improve soil physical properties and preserve water resources. In addition management techniques such zero or minimum tillage, mulching, cultivating cover crops, can be used to increase SOM and sustain soil health. In their opinion, good management of soil ensures that elements do not become deficient or toxic to plants and the appropriate mineral elements enter the food chain. Soil management is important both directly and indirectly to crop productivity, environmental sustainability, and human health. Maha Aliand Abdel Latif (2013) studied the ecological role of animal diversity in soil system at Sudan. They observed that the impacts of agricultural managements on populations and communities of soil fauna and their interactions confirm that high input, intensively managed systems tend to promote low diversity while lower input systems conserve diversity. Animal diversity contributes to soil ecology and functioning such as breakdown and cycling of nutrients in the soil. They concluded that these animals were essential to the proper function of the soil ecosystem in different environments. In arid environment, the role of soil Collembola , Mites and Nematodes in decomposing plant litter was assessed and compared in El-Rawakeeb Dry land Research Station, (latitudes 15" - 2° and 15"- 36° N and longitudes 32" -0° and 32" – 10° E) as affected by application of organic manure (bovine manure) or pesticide (Neem leaf powder) over one year. Thirty litter bags each one contain 10 gm. oven dried litter of *Cajanus-Cajan* were buried into the treated and control plots. Six bags per plot along with their respective soil were retrieved four times the year. Mean mass loss in litter was correlated to population density of Collembola, Mites and Nematodes. Some soil properties eg. Temperature, Moisture, Particle size distribution and organic matter contents were correlated to litter mass loss. Results showed that manuring enhanced role of decomposers in decomposing plant litter, while Neem application mostly retarded it. Jiwan Kim et al. (2014) published the paper in the conference Entomological Society of America entitled "Effect of agricultural management on the biodiversity of soil microarthropod communities in apple orchards". They concluded that in agriculture systems, the activity of insect fauna is influenced by management practices through change in the orchard environment from cultivation, the application of synthetic fertilizers and pesticides. Abundance of soil microarthropods relative to functional groups, predator and detritivore groups were significantly different between orchard management systems. The abundance of soil microarthropods were correlated to the soil conditions. The abundance of oribatid mites was positively correlated with soil moisture content, organic matters and nitrogen but negatively to soil pH. Collembolan was positively correlated with soil moisture content, organic matters. Also, Gamasid mites were positively correlated with their potential preys, Oribatid mites and Collembolans. Francesca Cotrufoa M. et al. also in (2014) studied Naphthalene addition to soil surfaces: A feasible method to reduce soil micro-arthropods with negligible direct effects on soil C dynamics. The addition of naphthalene, a polycyclic aromatic hydrocarbon (C10H8), to suppress soil fauna has been used for decades in decomposition experiments, but its efficacy remains questioned. In fact, they lack a rigorous field assessment of the efficacy of naphthalene additions for soil fauna suppression and potential non target effects on the soil microbial community and carbon cycling. They added naphthalene at a high rate (477 g m−2) monthly for 23 months on the bare soil surface of a tall grass prairie. They determined the effect of such additions on the abundance of nematodes and micro-arthropods along the soil profile to a depth of 20 cm at 11, 16 and 23 months after initiating naphthalene application. They used the variation in the natural 13C abundance of the naphthalene (13C – 25.5%) as compared to the native soil (13C −17%) to quantify naphthalene contribution to soil CO2 efflux and microbial biomarkers (PLFA). They found in their results that Naphthalene addition significantly reduced the abundance of Oribatid mites (45%), predatory mites (52%) and springtails (49%), but did not affect nematode abundance. The 13C abundance of a few Gram-negative (cy17:0, 18:17c, 16:17c), Gram-positive (a15:0, i15:0) and Actinobacteria (10Me- 16:0, 10Me-18:0) PLFA markers decreased significantly in naphthalene treated plots, indicating bacterial utilization of naphthalene-derived C. Mixing models showed this contribution to be highly variable, with the highest naphthalene-C incorporation for Gram negative bacteria. Naphthalene-C was not incorporated in fungal PLFAs. This microbial utilization did not affect overall microbial abundance, community structure or activity, estimated as soil respiration. This experiment proves that naphthalene addition is a feasible method to reduce soil micro-arthropods in the field, with negligible direct effects on soil nematodes, microbial abundance and C dynamics.

E. Gagnarli et al. (2015) studied the microarthropod communities in Italy to assess soil quality in different managed vineyards. In the area of Langhe (Piedmont, Italy), eight vineyards characterized for physical and chemical properties (soil texture, soil pH, total organic carbon, total nitrogen, calcium carbonate) were selected. They evaluated the effect of two types of crop management, organic and integrated pest management (IPM), on abundance and biodiversity of microarthropods living at the soil surface. The mesofauna abundance was affected by both the type of management and sampling time. On the whole, a higher abundance was in organic vineyards (N =1981) than in IPM ones (N=1062). The analysis performed by ecological indexes showed quite a high level of biodiversity in this environment. **Johann G. Zalle et al. in 2016** studied that soil organisms would be particularly susceptible to pesticide as they get in direct contact with these chemicals. Using microcosms with field soil we investigated, whether seeds treated either with neonicotinoid insecticides or fungicides influence the activity and interaction of earthworms, collembola, protozoa and microorganisms. Using microcosms with field soil we investigated, whether seeds treated either with neonicotinoid insecticides or fungicides influence the activity and interaction of earthworms, collembola, protozoa and microorganisms. The full-factorial design consisted of the factor Seed dressing (control vs. insecticide vs. fungicide), Earthworm (no earthworms vs. addition Lumbricus terrestris L.) and collembola (no collembola vs. addition Sinella curviseta Brook). They concluded that non-target effects of seed dressings and their interactions with soil organisms are remarkable because they were observed after a one-time application of only 18 pesticide treated seeds per experimental pot. Because of the increasing use of seed dressing in agriculture and the fundamental role of soil organisms in agroecosystems these ecological interactions should receive more attention.

Pesticides are used to kill the pests and insects which attack on crops and harm them. Pesticides benefit the crops; however, they also impose a serious negative impact on the environment. Excessive use of pesticides may lead to the destruction of biodiversity. All this discussed in the review of **Isra Mahmood et al (2016). Cristina Menta et al**. in **2017** monitored the soil fauna under agriculture management. They analyzed soil arthropods community in several agricultural managements (arable land, grassland, vineyard and orchard) located in the Emilia-Romagna region (Italy), whose land se has an impact on soil state and functioning. Soil fauna diversity is a validated tool to assess soil quality, in relation to crop types and management. The computation of the biological soil quality index QBS- revealed lower values in arable lands, easily due to management practices applied. **Lesley W. Atwood (2018)** Studied to show the evidence for multi-trophic effects of pesticide seed treatments on non-targeted soil fauna. They found the effects of seed treatment on the soil faunal community varied in direction and magnitude by year and feeding guild and were most apparent in the predator and detritivore guilds. Guild-level effects tended to be strongest soon after planting but remained apparent throughout the crop growing season, particularly in the predator and mixed feeding guilds. We found no evidence that pesticide seed treatment affected the herbivore guild intended target of the seed treatment, or nitrogen mineralization, surface litter decomposition or grain yields. Collectively, these data suggest that pesticide seed treatments can alter the abundance, richness, and diversity of all non-targeted soil faunal guilds. Recently, **Abhijit Ghosal and Anusweta Hati (2019)** determined the impact of some new generation insecticides on soil arthropods in rice maize cropping system. They applied several insecticides in field to manage different borer insects and get deposited in soil. In their results, no appreciable toxic effect was noticed by the insecticides on the basis of mean population count over control. They also conclude that Collembola population was less sensitive toward rynaxypyr, cartap hydrochloride, fipronil, and chlorpyrifos. Imidacloprid, chlorpyrifos, and phorate showed negative impact on earthworm.

Conclusion:

Soil mesofauna cooperate and compete, and they interact with other soil communities to form an integrated system which functions in a manner as to affect the breakdown of organic material. In this way the recycling of plant nutrients in promoted. The majority of soil animals are microscopic in size and their diversity is quite remarkable. The soil fauna are active partners of the soil flora. In the decomposition of plant tissues when dead leaves fall on moist soil, they are immediately attacked by mites who perforate and fragment dead plant bodies, thus facilitating microbial entry and offering a larger surface area of microbial action. Any disturbance in this cycle like the spray of pesticides, tillage etc. has a direct effect on the soil mesofanal population. To protect the soil biodiversity, management practices such as-use of chemical fertilizer, pesticides should be done judiciously. The occasional spreading of pesticides does not affect significantly the soil fauna. However frequent exposure can cause several fold decrease in the abundance of soil mesofaunal population.

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