International Journal of Psychosocial Rehabilitation, Vol. 23, Issue 05,
2019 ISSN: 1475-7192

Effect of Fertilizers and Pesticides Application On Soil Microbiota

[1]Suchismita Mohanty, [2]Subhaprada Dash

Abstract--- *Soil health management is vital to guarantee production of sustainable agriculture and biodiversity maintenance. Modern farming relies primarily on the extensive use of agrochemicals, including inorganic pesticides and fertilizers. Arbitrary, long-term and over-use of pesticides has serious effects on soil ecology that can lead to changes in or degradation of valuable or crop probiotic soil microbiota. For industrial agriculture, pesticides and fertilizers are a necessary evil. In addition to a number of broadly discussed and well-known harmful effects on the human health and environment of chemical fertilizers and pesticides, they were also held responsible for strongly affecting soil microbial properties. Soil microbiota is a key component of agricultural ecosystems, which not only plays an important role in basic soil processes, but also actively participates in improving the productivity of crop and soil fertility. Pesticides and fertilizers continue to remain in the soil for a long time so they are expected to affect the micobiota of the soil and thus disturbing the health of the soil. This study reviews the effect of long-term use of pesticides and fertilizers on cultivated soil microbiota with respect to fertility and soil health.*

Index Terms--- *Soil microbiota, pesticides, fertilizers, agrochemicals, bio-indicators.*

I. INTRODUCTION

Modern agriculture in the form of fertilizers and pesticides is entirely dependent on chemicals. Soil microbiota, including bacteria, protozoa, fungi, viruses and algae is a vital component of the agro-ecosystem and is responsible for many essential and fundamental functions of soil such as soil fertility, nutrient cycling, increasing crop productivity through decomposition of organic and inorganic matter and increased availability of limited nutrients [1]. The consequences of pesticides and fertilizers may be either direct (short-term and immediate) due to damage to the species that make contact with the chemical, or indirect as a result of alteration caused by the chemical to the atmosphere and/or food source of the microbes [2]. Experimental indication has shown that long use of chemical fertilizers and pesticides has an impact on the functional and structural properties of microbial communities in soil, simultaneously creating nutrient discrepancy in agricultural soils [3]. The direct effect on soil biota of fertilizers can be either short- (apparent in the first season after fertilizer application) or long-term (if repetitive additions are needed to see the effect) [4]. Usually indirect effects are long-term (taking more than one season to grow) due to changes in pH or productivity, levels of organic soil and residual inputs [1], [3]. Such effects become significant in agriculture when the supply of

Department of Agriculture, Siksha 'O' Anusandhan (Deemed to be University), Bhubaneswar, suchismitamohanty@soa.ac.in, subhapradadash@soa.ac.in

Received: 10 Nov 2018 | Revised: 20 Dec 2018 | Accepted: 02 Jan 2019

nutrients is provided to the plants and thus the productivity of crops are modified because of these effects.

The actual deal is that we would all die without a soil microbe. Plants cannot take the nutrients they need from the soil without working in the soil with microbes. Microbes are alive and need nutrition in order to survive, which is derived from the organic matter [5]. Microbes provide foods such as oil, nitrogen, hydrogen, oxygen, potassium, phosphorus and trace minerals for plants while they use the nutrients they need [6]. There are all sorts of microbes such as protozoa, algae, bacteria and fungi waiting to be discovered with many others. Soil organisms also favourably affect the physical properties of soil such as porosity, structure, water infiltration and aeration through soil aggregate formation and stabilization [2], [3]. At the same time, soil microbial group is helpful in promoting environment - friendly practices such as bioremediation of toxin-contaminated soils and toxic components as a result of human activities as well as phytopathogens bio-control. Soil biodiversity is the root of global food security, along with the other aspects of agro-biodiversity, i.e. animal and plant resources [7]. Therefore, if we want to follow the concept of sustainable agriculture and to access the effects of different anthropogenic activities on soil microbial diversity, it is essential to understand the relationship between soil functions and soil biodiversity [8]. Assessment of the various consequences of prolonged application of pesticides and fertilizers on agricultural soil microbiota ecosystems is of crucial importance. Such contaminants have entered soil and water environments as a result of the intensive agricultural use of pesticides [2], [7]. The deprivation of xenobiotic compounds by constituent of the soil microbiota is an essential means by which these compounds are eliminated from the atmosphere, thereby preventing from the problems that occur due to the pollution. During biological cycles, actinomycetes, bacteria and fungi hold a unique position and are necessary for soil fertility and plant growth [9]. A lot of work has been done to understand the complexity of microbial interactions with pesticides in the soil. Microbial communities in soil and rhizosphere environments are more likely to be responsible for the biodegradation of pesticides than single species.

II. MICROORGANISMS IN SOIL:

Living organisms are an important component of the soil, plants and animals. The soil is now considered to be a complex or rather a living environment, comprising a diverse micro-organism population than the uncultivated land, and the soil affluent in organic matter includes much more species than eroded and sandy soil [10]. Microorganisms in the soil are essential to us in the maintenance of soil fertility / productivity, the cycling of nutrient constituents in the biosphere, and the sources of industrial products such as antibiotics, enzymes, vitamins, organic acids, hormones, etc [6]. The soil organisms are widely divided into two groups which are soil fauna and soil flora. Soil microbes (flora and fauna), its growth nutrition and activity depends entirely on the soil. Soil temperature, soil fertility, soil moisture, cultural practices and soil aeration are the main soil factors that influences the microbial population [3], [7].

Others include soil pH, light, food and energy sources, organism matter, nature of microbial and soil alliance [11]. All these factors play a major role in not only deciding the number and type of species, but also their actions. Difference in one or more of these aspects may lead to the alteration in the actions of the organisms that influence the fertility of soil.

Received: 10 Nov 2018 | Revised: 20 Dec 2018 | Accepted: 02 Jan 2019

III. MICROBIOTA OF AGRICULTURE SOIL:

Soil primarily consists of inorganic mineral nutrients and organic matter together with the vast numbers of living organisms thereby, maintaining a balance between chemical, physical, and biological influences. Soil represents the "microbial diversity's black box". For a number of microorganisms, including fungi, bacteria, protozoa, algae and viruses, it is the most abundant and suitable environment. Cultivated soils are richer in terms of microbiota quantity and variety [13]. While bacteria are typically the most abundant microorganisms in soil followed by fungi, actinomycetes, protozoa and algae, variable patterns of fungal bacterial dominance are observed in cultivated soils [2], [3]. However, large variations in bacterial/ fungal biomass ratios were observed in arable soils and this was established to be linked to soil management practices, soil nutrient content, environmental influences as well as methods used to identify the biomass content[3], [7].

The terms soil quality and soil health are often used exchangeable to describe the soil's ability to support plant growth while not degrading itself. This includes chemical parameters such as salinity, pH, content of soil organic matter and physical parameters such as capacity to hold water, texture, and biological parameters such as microbial activity[1]. (Table.1)

Table.1: Parameters of soil health.

Soil health		
Physical parameters	**Biological parameters**	**Chemical parameters**
Texture Water holding capacity	Soil respiration Microbial activity	pH soil organic matter salinity

Similarly, organic soil fertilization results in higher proportions of bacterial/ fungal biomass while inorganic fertilizer inputs experience the reverse effect. It shows that organic fertilization has a positive impact on the soil environment and thus, promotes the idea of sustainable agriculture. Soil parameters such as humidity, pH, temperature, and levels of carbon dioxide in cultivated soils also have variable effects on bacterial/ fungal dominance [6], [7]. Although, it has been well-known that microorganisms form a critical component of soil ecosystems and that 80-90% of soil functions are facilitated by microbes, [14] until recently, most of the biodiversity studies focused only on the animal and plant resources, while the microbial ecology of agricultural soils has received slight attention. Bacteria and fungi are the main organic matter decomposers in soil that regulates the cycle of carbon [3]. Soil microbes convert mineral nutrients into plant-available forms in soil such as zinc, phosphate and supply other nutrients such as nitrogen with symbiotic and non-symbiotic fixation processes [2], [9], [10]. Microorganisms form a crucial part of complex soil food chains at different levels such as parasites; decomposers; saprophytes; pathogens and thus critically mediate nutrient cycling. (Fig. 1)

Received: 10 Nov 2018 | Revised: 20 Dec 2018 | Accepted: 02 Jan 2019

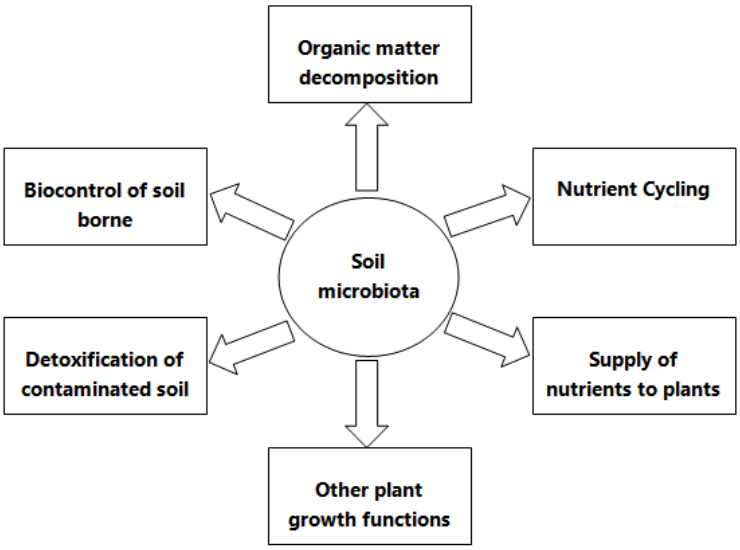

Fig.1. Functions of soil microbiota

IV. PESTICIDES:

In general, pesticides are toxic and xenobiotic in nature and in their presence a large number of microbes are dying. Continuous use of these toxic chemicals in the soil, however, generates stress that leads to resistance development and adaptation among local microbial populations. Pesticides are toxic and are the bioactive substances that affects the quality of agro-ecosystem and soil fertility directly or indirectly. According to the United Nations Food and Agriculture Organization (FAO), pesticides include a broad range of chemicals such as fungicides, insecticides, herbicides, nematicides, rodenticides, plant growth regulators, fruit thinners, defoliants, desiccants, post-harvest chemicals used to prevent loss of crop during transport or storage.

Most of the commonly used pesticides are organic and inorganic chemicals. Pesticide classification may be based on numerous criteria such as chemical composition, target pest, soil persistence (half-life) and activity spectrum, mode of formulation, mode of entry into target pest, active molecule toxicity, and volatilization behavior. Classification based on the chemical composition of an active molecule, however, provides an outline of the pesticide's properties, behavior and nature. Plant diseases are one of the world's most important causes of plant loss and thus pose a major threat to global food security. The world's major crops, i.e. rice, maize, wheat and potato, nearly 10-15% of yield are lost each year due to plant diseases caused by pests.

IV.I. Effects of Pesticides on Soil Microbiota:

Soil microorganisms react differently to different types of chemical pesticides that are used in agricultural soils which are reliant on a number of influences including the soil properties, nature of the pesticide and groups of existing microbes in soil. Most of the pesticides are mainly degraded by microbiological processes in the soil. The significance of the microbiota accountable for this degradation is significant because its activity determines the persistence and hence the agricultural utilization of pesticides. On microbiota, the pesticides act in two means[1].

Received: 10 Nov 2018 | Revised: 20 Dec 2018 | Accepted: 02 Jan 2019

On the one hand, due to its physiological activity, it can influence the micro-organisms responsible for its degradation. This action may also affect the organisms that are involved in degradation of other constituents. The pesticides, on the other hand, also act as a soil microbiota substrate. As a matter of the fact, its degradation may provide the carbon and energy needed for their growth to the organisms is particularly nitrogen. In any case, in relation to pesticide degradation, the most important consequences of these two aspects appear [11]. The microorganisms that make up the extremely diverse microbiota involve bacteria, fungi and actinomycetes. Depending primarily on the nature, i.e. potential and toxicity of the pesticide as a nutrient or energy source, the total number of fungi, algae, bacteria, and protozoa may increase or decrease. Under the influence of applied chemical pesticide, soil appears to become dominated by only a few functional groups, thereby influencing the overall community structure and hence, specific soil biological processes. Even if there are no significant pesticide effects on soil functional microbial diversity or microbial biomass, the complete functional structure of soil bacteria will surely get changed.

Several studies have confirmed that the type of pesticide is an important factor for affecting the actions of soil microbial communities. It can therefore, be concluded that although variable patterns have been observed in terms of population size and structure with regard to the dosage, type of pesticide and number of applications, as well as the class of microorganisms and soil quality (nutrient content and physical parameters), it is clear that chemical inputs present in soil in the form of any pesticide class have a significant impact on microbiota of soil and its other biotic properties.

V. FERTILIZERS:

A fertilizer is a chemical-based natural or synthetic material used to promote the growth and fertility of plants. Fertilizers can also increase water retention and remove any excess liquid, thereby increasing the productivity of the soil. Fertilizers generally offer main macronutrients such as phosphorus, potassium and nitrogen. Over a long period of time, organic fertilizers create a well environment for the soil, while inorganic fertilizers work very rapidly, but fail to form a sustainable environment. Organic fertilizers are made up of natural plant and animal materials. Examples include manure and sections of a mixture such as hulls of peanut and leaves. On the other hand, inorganic fertilizer is made from minerals or synthetic chemicals. Both organic and inorganic fertilizers add nutrients to the soil and feed plants. Nitrogen, potassium and phosphorus are referred to as primary nutrients because they are required in the highest quantities by the plants. Chemical fertilizers, primarily nitrogen (N), potassium (K) and phosphorus (P) fertilizers were the most common method adopted by man to provide the nutrients in cultivated soils. Soil science society of America defined fertilizer as “any organic or inorganic material of natural or synthetic origin, other than liming materials that is added to the soil to supply one or more plant nutrients essential to the growth of plants”. The supply of chemical fertilizers has been steadily increasing with time along with the rising food production.

V.I. **Effects of Fertilizers on Soil Microbiota**:

Since 1930s, chemical fertilizers have helped farmers grow crops. While chemical fertilizers have a position in adverse weather conditions to increase crop nutrients or in periods when plants require additional nutrients, chemical fertilizers also have several harmful effects. Some of the harmful chemical fertilizers can cause chemical burning crops,

Received: 10 Nov 2018 | Revised: 20 Dec 2018 | Accepted: 02 Jan 2019

waterway pollution, increasing air pollution, mineral depletion of the soil and acidification of the soil. It has been well established that the soil microbial community's functional diversity is primarily regulated by the availability of resources (N, P, and C). It clearly suggests that the category and composition of the fertilizer applied would certainly affect contagious communal structure of the cultivated lands.

Several studies have recorded significantly higher levels of organic carbon content, microbial communities and activities in organic manure-treated soils as compared to those treated with inorganic fertilizers in crops such as mustard, tobacco, wheat and maize-wheat rotation. In addition, the population of gram-negative bacteria that includes many environment-friendly groups such as Pseudomonas is adversely affected by the long-term use of chemical fertilizers, while organic modifications result in the establishment of bacterial populations closer to those of untreated soils in crops such as wheat and rice.

Another significant part of organic fertilization is a reduction in the bioavailability of pollutants such as soil pesticides and heavy metals. In addition to increasing the amount of organic matter in soil, organic manures often tend to form complexes with such contaminants and thus reduce their bioavailability. In agricultural habitats supplemented with organic inputs, higher and more functionally diversified microbial communities are observed relative to those with lasting treatments with inorganic fertilizers in a diversity of crops.

In addition, organic fertilizers are a more desirable and soil-friendly option as compared to chemical fertilizers to increase the nutrient content of agricultural soils. In some cases, it has been reported that long-term chemical fertilization application does not result in any important changes in the microbial features of agricultural soils. It was also noted that functional variety tends to increase with an improvement in the fertilization dose i.e. double or triple fertilizer therapy. It was also observed that if applied individually or in combination with organic inputs, inorganic fertilization could yield variable results. It can therefore be determined that variable effects are observed in agricultural fields for long-term applications of chemical fertilizers depending on the factors varying from soil to plant variety. However, under all conditions, the overall performance of organic fertilizers is always greater than that of chemical fertilizers.

VI. CONCLUSION

There is a clear indication that non-target soil biota is affected by the fertilizers and pesticides, but the effects are wide ranging – some are stimulating, others are extremely inhibitory. Fertilizers generally increase the production of plants, thereby raising the levels of organic matter in the soil. As food sources are increased, this is generally beneficial for soil biota. Maintaining fertility and soil quality is therefore most important to meet the demands for nutrition worldwide. Chemical fertilizers and pesticides affect properties of soil in terms of predominant soil species, nutrient content, structural and functional microbial population’s diversity, soil-enzymes activities and several others. The effects can range from temporary and short-term fluctuations to long-term and irreversible changes in both cases. Soil quality and fertility are closely related to agricultural land's microbial biodiversity. Therefore, any changes in properties and composition of soil microbiota may pose a threat to global food security in the long run. This can therefore, be concluded that prolonged and extreme use of chemical fertilizers and pesticides has a number of adverse effects on the

Received: 10 Nov 2018 | Revised: 20 Dec 2018 | Accepted: 02 Jan 2019

agricultural ecosystem's soil microbiota. In order to better understand the relationships between soil biology and plant management, work on the indications of soil biology agricultural management needs to maintain.

REFERENCES:

[1] G. Imfeld and S. Vuilleumier, "Measuring the effects of pesticides on bacterial communities in soil: A critical review," Eur. J. Soil Biol., 2012.
[2] A. Kalia and S. K. Gosal, "Effect of pesticide application on soil microorganisms," Archives of Agronomy and Soil Science. 2011.
[3] P. Prashar and S. Shah, "Impact of Fertilizers and Pesticides on Soil Microflora in Agriculture," 2016.
[4] E. J. B. N. Cardoso et al., "Soil health: Looking for suitable indicators. What should be considered to assess the effects of use and management on soil health?," Scientia Agricola. 2013.
[5] J. Laishram, K. G. Saxena, R. K. Maikhuri, and K. S. Rao, "Soil Quality and Soil Health : A Review," Int. J. Ecol. Environ. Sci., 2012.
[6] B. Muñoz-Leoz, C. Garbisu, I. Antigüedad, and E. Ruiz-Romera, "Fertilization can modify the non-target effects of pesticides on soil microbial communities," Soil Biol. Biochem., 2012.
[7] N. Sharma and R. Singhvi, "Effects of Chemical Fertilizers and Pesticides on Human Health and Environment: A Review," Int. J. Agric. Environ. Biotechnol., 2017.
[8] L. Henneron et al., "Fourteen years of evidence for positive effects of conservation agriculture and organic farming on soil life," Agron. Sustain. Dev., 2014.
[9] Alternative Farming Systems, Biotechnology, Drought Stress and Ecological Fertilisation. 2011.
[10] F. Isbell et al., "Benefits of increasing plant diversity in sustainable agroecosystems," Journal of Ecology. 2017.
[11] J. M. Chaparro, A. M. Sheflin, D. K. Manter, and J. M. Vivanco, "Manipulating the soil microbiome to increase soil health and plant fertility," Biology and Fertility of Soils. 2012.

Received: 10 Nov 2018 | Revised: 20 Dec 2018 | Accepted: 02 Jan 2019