Food and Scientific Reports
ISSN 2582-5437

Detrimental impact of pesticides on beneficial soil dwelling fauna

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ABSTRACT

Pesticides are the chemicals which are used to manage the pest problem in agricultural field. Haphazard use of pesticides invites so many serious problems in environment besides it exerts the deleterious impact on soil inhabiting beneficial organisms. Exposure of pesticides is harmful for nitrogen-fixing bacteria by significantly reducing the activity of Rhizobium sp. and other free-living nitrogen fixers. Earth worm community, Arbuscular Mycorrhiza, soil enzymatic activity all the beneficial soil parameters are affected by the exposure of pesticides at their higher doses. From this standpoint, it should be kept in mind that application of any kind of pesticides should be done judiciously and appropriately to avoid the harmful situation.

Pesticides are the naturally occurring or synthetically produced chemicals normally used to kill, suppress or to manage the unwanted harmful plants and animals in agriculture field or in household. Pesticide is a broad term which includes insecticide (insect), fungicide (fungus), nematicide (nematodes), bactericide (bacteria), herbicide (weeds), rodenticide (rodents or rats), mollusckicide (snails), avicide (birds), piscicide (fishes) (Randall, 2014). Among the total amount of used pesticides throughout the world, 50% comes from Asian countries whereas, China rank first globally in pesticide consumption (FAO, 2019). With the commencement of Green revolution, application of pesticides in agricultural field was increased in several times which lead to heavy deposition of chemicals into the soil causing serious threats to soil inhabiting beneficial arthropods (Wang *et al*., 2006). Outcome of extensive research works revealed that more than 98 % of the total applied insecticides and 95 % of total applied herbicides deposited into the soil ecosystem (Miller, 2004). The huge pesticidal loads on the soil encumber the normal soil biological and ecological process and tear down the soil faunal biodiversity (Lo, 2010).

Impact of Insecticides on beneficial soil fauna

Impact of Insecticides on Nitrogen fixing microorganisms: Nitrogen fixing bacteria play very decisive role in augmentation of soil fertility by existing in the soil symbiotically or free living condition. Indiscriminate use of insecticides in agricultural field has negative impact on the soil borne nitrogen fixing microorganisms. Profenophos and Chlorpyriphos, two popularly known Organo phosphate (OP) insecticides (OP) abridged the number of free living nitrogen fixing bacteria (*Azotobacter chroococcum* and *A. vinelandii*) and significantly reduced nitrogen fixation process in the soil (Martinez *et al*., 1992; Pozo *et al*., 1995). Dimethoate, widely used insecticide against sucking insect pest was reported to reduce the population of symbiotic nitrogen fixing bacteria *Rhizobium* sp. (Castro *et al*., 1997). The deleterious impact of carbamates group of insecticides was reflected by the encumbering the nitrogenase activity in *Azospirillum* sp. (Sannino *et al*., 2001).

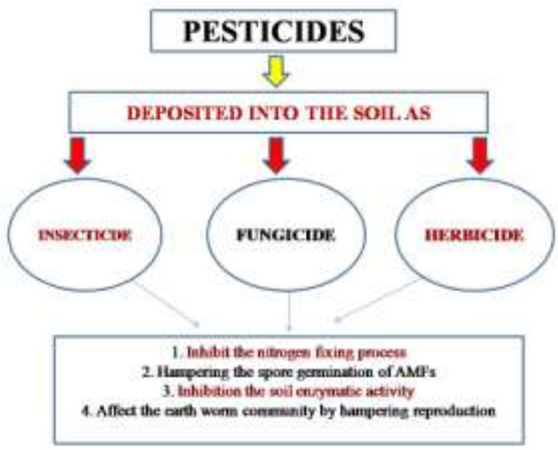

Fig: 1. Pesticides and their impact on soil fauna

Effect of Insecticides on plant growth promoting rhizobacteria (PGPR): The bacteria which colonize in the plant rhizospheric zone promote the plant growth by releasing compounds are known as plant growth promoting rhizobacteria. They also take impart in suppression of harmful soil borne plant pathogens. Application of insecticides has the negative impact on them. Insecticides like chlorpyriphos, endosulfan, imidacloprid, monocrotophos, cypermethrin, carbofuran cause significant variation of their community and their biodiversity (Ahmed and Ahmad, 2006). Among them, Chlorpyriphos was reported most destructive causing huge mortality percentage in *Pseudomonas fluorescences*, *Bacillus subtilis*, *Mycobacterium phlei*, *Trichoderma harzianum*, *Penicillium expansum*, and *Fusarium oxysporum* (Virag *et al*., 2007).

Insectidal impact on earth-worm community: Earth worm is the best mediator for augmenting the soil fertility level. Exposures to toxic insecticides hamper their normal physiological process and reduce the soil health as well as quality. Researchers have proved that exposure of Chlorpyriphos @ 5mg / kg adversely affects the fecundity of earth worms (Zhou *et al*., 2007). Cypermethrin, another important widely used synthetic pyrithroid insecticide hamper the reproduction of earth worm @ 20 mg / kg and juvenile stage is more susceptible to infestation than adult stage (Zhou *et al*., 2008). Insecticides fall under the group of N-Acetyl Carbamic acid or carbamate group cause the abnormalities in sperm production in earth worm at very low dose 0.125 mg / kg (Gupta and Saxena, 2003).

Fungicidal impacts on beneficial soil fauna

Fungus are the most destructive plant pathogens survive mainly in soil, seed, other planting materials and can be disseminate through air. Fungicides are the natural or synthetically produced chemicals which mainly used to curb the fungal pathogens in plant.

Fungicides, nitrogen fixing bacteria and nitrification process: Carbendazim or Bavistin, popularly known as seed treatment fungicide was reported as very toxic to nodule forming bacteria (Kaur *et al*., 2007). Fungicides containing Copper (Cu) like thiram or captan, metalaxyl showed the deleterious impact on nodulation process of *Rhizobium* sp. (Kyei-Boahen *et al*., 2001). Nitrification and Denitrification process are disturbed by the indiscriminate use of mancozeb and chlorothalonil (Kinney *et al*., 2005). Dinocap, Dimethomorph inhibit the activity of ammonifying bacteria (*Bacillus ramosus* and *Bacillus vulgaris*) and subsequently hinder the soil fertility level (Cernohlávková *et al*., 2009).

Effect of fungicides on PGPR: Indiscriminate and non judicious use of triarimol and captan fungicides show the negative impact on the abundance of *Aspergillus* sp. which is very much responsible for promoting the plant growth and development. *Pseudomonas fluorescens* and *Bacillus subtilis* were reported as moderately susceptible to Carbendazim while *Trichoderma harzianum*, *Trichoderma viridae* were reported as highly susceptible (Virag *et al*., 2007). Triadimefon, widely used fungicide in corn, cotton, oat, sorghum, rye, pine apple, banana was reported as inhibitory substance against beneficial soil bacteria (Yen *et al*., 2009).

Earthworm and fungicides: Implication of fungicides has severe impact on earthworm community. Fungicides like Benomyl, Thiophanate methyl, Thiram, Ethazole are very harmful and resulted deleterious impact on earthworm, *Eisenia fetida* (Rorak and Dale, 1979).

Impact of fungicides on soil enzymatic activity: Soil enzyme is the aggravator of many soil biochemical processes like decomposition, mineralization, solubilization etc. Activities of phosphomonoesterase and urease enzymes are subdued by application of captan, trifloxystrobin, and thiram fungicides in soil (Marfo *et al*., 2015). Fungicides benomyl, mancozeb, and tridemorph inhibit the activity of dehydrogenase, urease and phosphatase enzymes in soil environment (Shukla, 2000).

Arbuscular mycorrhizal fungi (AMF) and fungicides: Intimate association between AMF and plant roots is the well studied mutualistic relationship through which plant can easily access the immobilized phosphorus from soil system. Exposure of fungicide to AMFs' is detrimental for the existence of mycorrhizal fungi (*Glomus* sp.). Benomyl show the toxicity to the hyphal growth and development of mycorrhizal fungi (Cycon, 2006).

Herbicides and its impact on soil beneficial fauna

Herbicides are commonly used to manage the weed problem in agriculture field. However, indiscriminate and non-judicious application leads to harm of the many soil inhabiting beneficial microorganisms.

Herbicides and nitrogen fixing bacteria: Herbicides like 2,4-D, 2,4,5-T strictly inhibit the process of nodulation by *Rhizobium* sp. and nitrification process by *Nitrosomonas* sp. and *Nitrobacter* sp. (Fox *et al*., 2001). The activity of *Azotobacter* sp. is suppressed by the application of Glyphosate (Santos and Flores, 1995).

Herbicides and Arbuscular mycorrhizal fungi (AMF): Mycorrhiza is characterized by the close symbiotic associations between fungi and plant roots which normally increase the capacity of up taking of plant nutrients, especially P, nitrate and ammonium and improve the soil aggregate stability for long term prospect (Smith and Read, 2008). Herbicides like metribuzin, oryzalin, trifluralin, oxadiazon significantly reduce the AMFs' population in the soil by killing their spore and other germination procedures (Pasaribu *et al*., 2013). Non selective herbicide Glyphosate reduces the chance of spore germination of mycorrhizal fungi (Druille *et al*., 2013).

Concluding remarks

To curb the pest population in agricultural crop field, dependency on the pesticide is requisite manner but non judicious application invites so many harmful issues to the environment. Application in over dose destroys many soil borne beneficial organisms besides it can create an imbalance in ecological balance and diversity. Blind application of pesticides leads to destruction of natural enemies and deposition in soil as well as in environment leads to causing severe problems. Keeping the all essentialities in mind, it can be suggested to use the pesticides at proper dose and appropriate time and in judicious way to protect our soil health for long term perspective.

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