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Effect of Pesticides Application to Soil Health: Benefits and Limitations

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Effect of pesticide on soil health should be included when evaluating soil quality. It is impossible to thoroughly explore the ramifications of all pesticides on soil and environmental quality. Major different biotic processes such as respiration, soil enzyme activity, and carbon-nitrogen transformations are minimally impacted by pesticide application. Crop and soil management practices increase soil organic matter and plant residues. They impart attributes to soil that can impede pesticide movement and enhance degradation, but not hindering pesticide efficacy. Microbial and faunal populations are generally tolerant to pesticide application and exhibit only minor transient perturbations when recommended rates are used.

Introduction

With increased pesticide use, questions on potential effects regarding public health, environment and soil health arising among scientific community. Scientists assuming that pesticides would pollute air, soil and water resources and thus contaminate the food chain and disrupt ecosystem balance. Environmental consequences might also result from pesticide application at rates higher than recommended dose. Thus, assessing soil quality with respect to pesticide management necessitates the defining factors that may affect pesticide dissipation or activity. The ability of a soil to regulate and partition water flow could determine residence time of pesticide in soil or the potential for pesticide movement to non target areas. The capacity of a soil for pesticide sorption and degradation determines its efficacy for buffering their impact. How effectively a soil processes excess or unused to pesticides and mitigates detrimental effects to human and other species helps to determine its value.

Assessment Criteria for Determination

The simplest way for assessment is to categorize pesticides based on similarities in purpose of use and physicochemical properties. One measure of the productivity of agricultural soils is crop yield, and the ability of a soil to sustain yields is a measure of soil quality. Therefore, beneficial aspects of judicial pesticide use in crop production systems must be considered in a discussion of management criteria when assessing pesticide effects on soil quality. The strategy that require minimum quantity of pesticide would be adopt for management measures *e.g.* reduced tillage, site-specific application *etc*. This minimizes potential non-target effects while achieving the needed productivity. Certain organisms being inherently more sensitive, distinction must be made between toxicity to target organisms (pests) and non-target organisms. Several standard parameters to interpret toxicity have been established, e.g. LD_{50} (lethal dose), LC_{50} (lethal concentration), EC_{50} (effective concentration. Sensitive crop species might be used to establish thresholds at which herbicides are impacting growth and production.

Effect of Pesticide on Soil Microbial Populations

The mode of action for sulphonylurea herbicides is inhibition of the enzyme acetolactate synthetase, a component of the biosynthetic pathway of branched amino acids (leucine and isoleucine). This pathway is present in many bacteria; *e.g.*, certain *pseudomonades* are inhibited by sulphonylurea herbicides. The effects of several pesticides on microorganisms in studies ranging from *in vitro* culture studies to field assessments are summarized in table 1.

Table 1: Effect of different pesticide on microorganism

Pesticide	Organism	Effects
2,4-D-iso-octylester	Culturable soil bacteria, fungi and actinomycetes	Reduced soil populations
Captan	Culturable soil bacteria, fungi and actinomycetes	Reduced soil populations
Diazinon	*Azospirillum brasilense*	No effect on growth or N_2 fixation
Fenamiphos	Algae and Cyanobacteria	None
Fenpropimorph	Actinomycetes, *Pseudomonas* sp.	Activity is reduced
Glyphosate	*Bradyrhizobium japonicum*	Inhibition, death
Metsulphuron methyl	*Pseudomonas* sp.	Growth inhibition
Methidathion	*Azospirillum brasilense*	Reduced N_2 fixation and ATP content
Simazine	*Azotobacter chroococcum*	High conc. increased N_2 fixation

Since herbicides are used to kill herbs, a microbial response might be attributed to either direct toxic effects of the compound or to indirect effects such as vegetation loss limiting carbon substrates to soil microflora. Application of a fungicide captan, at normal field application rates (2-10 kg/ha) significantly reduce a numbers of culturable fungi. Overall, with most pesticides studied, deleterious effects on microbial populations were typically transient and below the tolerable level especially when recommended application rates were used.

Microbial Populations Degrading Pesticides

With certain pesticides, repeated applications can promote microbial populations capable of selectively degrading that pesticide. The capability of a soil for accelerated degradation might limit the use of that pesticide or related pesticides to control a particular pest. Accelerated degradation has been demonstrated with the thiocarbamate families of insecticides and herbicides, and the phenoxyacetic acid herbicides.

Effect of Pesticide Addition on Microbial Biomass

Microbial biomass is a standardized component of ecotoxicity assessment in OECD guidelines for pesticide registration, but not required in USEPA assessments. Field application of glyphosate increase microbial biomass carbon and microbial biomass nitrogen. Application of rimsulfuron under field condition has no effect on biomass carbon, but under lab condition it elicited reduced soil biomass.

Effect of Pesticide Addition on Soil Fauna

Toxicity of a given pesticide to earthworms is a component of standardized ecotoxicity tests in pesticide registration by both the OECD and USEPA. Applications of benomyl have no significant effect on herbivores, but significantly reduce certain fungal feeders and predatory nematodes. Protozoa may also be affected by several herbicides. Fipronyl has the greatest toxicity to microarthropods, significantly reducing numbers of *Oribatida*. Besides, field application of 2,4-DB and glyphosate herbicides and dimethoate insecticide has no effect on survival and growth of several earthworm species. Various groups of protozoa are affected by field application rates of the fungicide fenpropimorph.

Effect of Pesticide Addition on Soil Enzymatic Activity

Soil enzymatic activities are useful indicators of soil health and have been used to determine whether adversely effects of a management practices affect soil biochemical functions. Enzyme status in soil, extracellular and bound to clay or humic acid, or as a component of viable organisms, can determine how pesticides affect enzymatic activities. Pesticide effects on enzyme activities depend on soil conditions and the pesticide application rate. A dehydrogenase enzyme assay is used to assess pesticide soil toxicity in German pesticide registration. Bromoxynil herbicide and profeniphos insecticide inhibited cellulose activity. Substituted phenylurea (monuron, diuron and linuron) herbicides inhibit urea hydrolysis in soil.

Effect of Pesticide Addition on Nitrogen Fixation

Fungicides and herbicides may either directly affect colonization of rhizobial symbionts, or indirectly influence performance or either the plant or the nitrogen fixing bacteria in *planta*. Several studies have addressed the effects of specific pesticides on non-symbiotic nitrogen fixation. The fungicide captan significantly reduce population of aerobic nitrogen fixing bacteria and nitrogen fixing activity. Applications of carboxin, captan and thiram to seed reduce the survival of *Bradyrhizobium japonicum* and *Rhizobium phaseoli*. The soybean symbiont *B. japonicum* possesses glyphosate-sensitive EPSE and *B. japonicum* growth is inhibited by glyphosate resulting in death.

Effect of Pesticide Addition on Mycorrhizal Growth

Chloropicrin and methyl bromide completely inhibit *Glomus mossae* and *G. fasiculatum* on citrus. Evaluation of herbicides like bromacil, diuron or trifluralin on mycorrhizal infection of citrus had no effect on citrus growth or *Glomus etunicatum* chlamydospores in soil. Only high rates of simazine reduce citrus infection by *G. etunicatum* indicating minor effects of herbicides on mycorrhizal symbiosis. Cotton mycorrhizal infection is stimulated by nematicides 1, 3-dichloropropane and dibromochloropropane in soils highly productive in for cotton.

Carbon and Nitrogen Mineralization

Assessing pesticide effects on carbon and nitrogen mineralization is a standardized component of testing pesticides for non-target effects. Examining cumulative CO_2 evolution in pesticide-treated soil is one approach to evaluating pesticide effects on mineralization. Nitrogen mineralization and nitrification rate increased by benomyl, captan and chlorothalonil. Captan increase NH_4-N, whereas benomyl or chlorothalonil has little impact. Bensulfuron application at normal field rate has no effect on nitrification, whereas cinosulfuron transiently inhibit nitrification.

Conclusion

Based on the current stage of knowledge, we summarized a group of diagnostic tests that may be performed to assess pesticide impact on soil health and the ability of a soil to process pesticides or limit negative effects. Thus it is necessary to establish testing criteria for measuring pesticide impacts on soil quality. We have to develop and adopt standard protocols for cost-benefit analysis and risk management assessments. Plan, coordinate and implement a series of multi-location, holistic studies to provide appropriate databases for refinement and modeling is necessary.

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