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MICROBIAL ACTIVITY IN DIFFERENT TEA SOILS IN SRI LANKA AS AFFECTED BY SOIL PESTICIDES

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ABSTRACT

Use of soil pesticides is an integral component in modern agriculture to ensure high agricultural yield by controlling pests, diseases and weeds. Nevertheless, soil pesticides cause water and soil pollution, affect non –target organisms in the soils and human health indirectly. Since, the effects of different soil pesticides on microbial activity in tropical soils have been poorly researched; a case study with tea soils was performed. In this study, 10 soil pesticides were tested on different tea soils representing different Agro Ecological Regions (AER) elevations, and organic matter status. They include Deniyaya, Kottawa, Hantana, Passara, Ratnapura and Talawakelle. Rehabilitated soil with Guatemala grass and *Mana* and soil from an undisturbed forest were also used. To investigate the feasibility of ameliorate pesticide treated soils, compost was used in the study.. The soils were exposed to two soil fumigants (Dazomet and Metham Sodium), two insecticides (Cadusafos and Carbofuran) one nematicide (Phenamiphos) and four herbicides (2,4-D, Diuron, Glufosinate Ammonium, Glyphosate and Paraquat) at recommended rates. The CO_2 evolution rate was measured to elucidate changes in soil microbial activity due to application of different pesticides.

Importantly, reduction of soil microbial activity in tea soils due to application of tested pesticides was significant ($P<0.05$) and ranged from 8.2 to 60.1%. Among the soil pesticides tested, Metham Sodium and Glufosinate Ammonium showed greater negative effects. Similar trends were observed with soil rehabilitated with *Mana* and Guatemala and forest soils. Compost treated soils resulted in improving microbial activity in all tea soils by 9.5% and in rehabilitated and forest soils by 11.7%.

Overall, the agrochemicals seemed to interfere with soil microorganisms in the tea ecosystem. Therefore, site specific pesticide applications are proposed to reduce adverse effects on soil biology. Further, conservation of soil biological resources through minimizing agrochemical usage, locally available organic matter incorporation and grass rehabilitation should be promoted. Their bioremedial properties should be harnessed. Also, use of Biochar with added characteristics would help reduce pesticide dosages required by way of reducing the chemical leachates and improving adhesiveness and thereby securing soil micro biology.

Keywords: *soil pesticides, microbial activity, insecticides, nematicides, fumigants, herbicides*

INTRODUCTION

Soil health is an important indicator of long term fertility of agricultural soils in any agro ecosystem (Mohotti, 2002). Agro chemicals, though possessing benefits in nutrient supply and pest control in agriculture, are known to cause negative effects on soil microbial communities. In contrast, maintenance of soil organic matter through incorporation, mulching, green manuring and minimum use of agro chemicals *etc.* enhance soil biology (Goyal *et al.*, 1999, Wolters, 2000).

Tea (*Camellia sinensis* (L.) O. Kuntze) is grown in a range of climates and soils. Hence, the tea plant is subjected to various types of insects, nematodes, diseases and weeds. The use of pesticides forms an integral component of tea cultivation to ensure high agricultural yield in the integrated management of pests

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(http://www.agridept.gov.lk index.php/en/institutes/430). However, the Tea Research Institute of Sri Lanka advocates least priority for pesticide usage and promotes adhering to cultural and biological methods owing to worldwide concerns on health, environment and MRLs. The impact of pesticides on soil, water and environment, however, needs to be addressed as it depends on several factors such as properties of pesticides, properties of soils, condition of the sites and management practices (Misra and Mani, 1994).

Soil microbial activity has not been adequately researched as a determinant of studying the impact of soil pesticides in different agricultural soils. The fate of pesticides used in tea in Sri Lanka and their non target effects were identified as important in view of environmental safety and soil biodiversity. The present study is therefore, evaluated the effects of ten soil pesticides on microbial activity in different tea soils representing different Agro Ecological Regions (AER), elevations and organic matter status.

MATERIALS AND METHODS

Composite soil samples were collected from different Agro Ecological Regions representing different soil types *i.e.* Deniyaya, Kottawa, Hantana, Passara, Ratnapura and Talawakelle for the study. Soils from rehabilitated lands with Mana (*Cymbopogon confertiflorus*) and Guatemala (*Tripsacum laxum*) grass and undisturbed forest also were collected.

Soil pesticides *viz.* Dazomet, Metham Sodium (fumigants), Carbofuran, Cadusafos (insecticide), Phenamiphos (nematicide), 2,4 – D, Diuron, Glufosinate Ammonium, Glyphosate and Paraquat (herbicides) at rates recommended by the Tea Research Institute of Sri Lanka were applied as treatments. Compost and untreated soil were used as control for comparison. Treated soils were incubated *in vitro* at 25 ^{0}C under laboratory conditions for 2 weeks and analyzed for determination of CO_2 evolution rate as the measure of soil microbial activity using Anderson (1982) method. The percentage changes in CO_2 evolution rate in soils after soil pesticide application were calculated in comparison to untreated soils used in the study.

RESULTS AND DISCUSSION

1. Microbial activity of tea soils as affected by different pesticides

Overall, the results revealed a significant ($P<0.05$) effect by soil pesticides on microbial activity of tea soils of different agro ecological regions. The level of impact on soil microbial activity by various pesticides varied with the soil type with different soil organic carbon contents. Pesticides are highly adsorbed by organic matter and clay particles in the soils. Soils with more clay and organic matter tend to hold water and dissolved chemicals longer. Hence, the microbial activity was significantly low in such soils as negative effects on microorganisms by pesticides persisted longer.

Metham Sodium, Dazomet, Carbofuran, Cadusafos, Phenamiphos and Glufosinate Ammonium showed significant effects on soil microbial biomass while the effects due to Diuron, Glyphosate, 2,4- D and Paraquat being not significant (Table 1). On the contrary, compost treated soil showed the highest microbial activity probably due to higher microbial biomass and considerably high organic matter. Therefore, in situations with lower soil microbial activity in soils affected due to contamination of pesticides, incorporation of compost seems to have a bioremedial action. Table1 shows the percentage changes in microbial activity of tea soils due to various pesticide applications.

Type of pesticides	Pesticide	Talawakele	Kottawa	Deniyaya	Ratnapura	Hanatana	Passara	Mean	SD
Soil Fumigants	Dazomet	-26.5	-40.0	-29.7	-22.2	-34.8	-2.5	-30.6	13.1
	M.Sodium	-73.5	-53.3	-67.6	-58.3	-47.8	-47.5	-60.1	10.7
Insecticides	Carbofuran	-17.6	-35.6	-18.9	-16.7	-32.6	-27.5	-24.3	8.2
Nematicides	Cadusafos	-17.6	-35.6	-21.6	-11.1	-28.3	-22.5	-22.8	8.5
	Phenamiphos	-20.6	-33.3	-2.7	-25.0	-21.7	-25.0	-20.7	10.2
Herbicides	2,4-D	-2.9	-24.4	-16.2	-2.8	-8.7	-2.5	-11.0	9.0
	Diuron	-4.4	-15.6	-16.2	-8.3	-8.7	-2.5	-10.6	5.6
	G Ammonium	-2.9	-15.6	-5.4	-4.2	-13.0	0.0	-8.2	6.1
	Glyphosate	-5.9	-11.1	1.4	1.4	-32.6	-12.5	-9.4	12.6
	Paraquat	-2.9	-24.4	-16.2	-5.6	-28.3	-8.8	-15.5	10.4
Compost		14.7	6.7	10.8	11.1	4.3	6.3	9.5	3.9

2. Microbial activity of forest and grass rehabilitated soils as affected by different pesticides

The rehabilitated tea soils with Guatemala grass and *Mana* and undisturbed forest soils are expected to be comparatively rich in organic carbon and resultantly a greater soil microbial activity. Results indicated a significant effect on such soils by soil pesticides (Table1). The importance in improving the soil microbial activity through rehabilitation was highlighted in view of bioremediation of contaminated tea lands. Data also revealed an apparent possibility in reaching soil microbial activity of an undisturbed forest.

Table 2 shows the percentage changes in microbial activity after soil pesticide application in rehabilitated and forest soils. Metham Sodium treated soil showed significantly lowest microbial activity while compost treated soil showed the highest.

Table 2 : Percentage changes in microbial activity in rehabilitated and forest soils after soil pesticide application

Type of pesticides	Pesticide	Forest Soil	Mana Soil	Guatemala Soil	Mean	SD
Soil Fumigants	Dazomet	-38.1	-36.4	-29.4	-34.6	4.6
	M. Sodium	-62.9	-86.4	-55.9	-68.4	16
Insecticides	Carbofuran	-35.1	-31.8	-21.6	-29.5	7
Nematicides	Cadusafos	-36.1	-34.1	-25.5	-31.9	5.6
	Phenamiphos	-19.6	-18.2	-17.6	-18.5	1
Herbicides	2,4-D	-19.6	-18.2	-11.8	-16.5	4.2
	Diuron	-23.7	-11.4	-7.8	-14.3	8.3
	G. Ammonium	-11.3	-11.4	-9.8	-10.8	0.9
	Glyphosate	-34	-18.2	-7.8	-20	13.2
	Paraquat	-27.8	-12.5	-21.6	-20.6	7.7
Compost		13.4	8	13.7	11.7	3.2

CONCLUSIONS

The fate of different soil pesticides in different tea soils from agro-ecological zones with varying levels of organic matter was demonstrated in this study. The non target effects of soil pesticides were clear on soil microbes irrespective of the active ingredient of the pesticide. Observations were similar to findings of Goyal *et al.* (1999) and Misra and Mani (1994). Hence, compared to the existing blanket recommendations, a location specific and more rational pesticide recommendation based on soil type was made clear in this study. This would serve as a precision agricultural practice with concerns on leaching and retention capacity of pesticides and effects on soil health.

Also, the bioremedial properties (Amarasena, 2005) by important Good Agricultural Practices (GAPs) such as soil rehabilitation with Guatemala or *Mana* grass and incorporation of organic amendments in rectifying affected tea lands were shown. Adherence to such cultural practices shall accomplish improved soil microbial activity and overall soil productivity and also reach biological status of undisturbed forests.

FUTURE PROSPECTS

Despite tea ecosystem being maintained as a mini forest with humid microclimatic conditions, agrochemicals seemed to interfere with inherent soil biological organisms. Therefore, site specific pesticide applications will aid to reduce inverse effects on soil biology. Further, conservation of soil biological resources through minimizing agrochemical usage, locally available organic matter incorporation and grass rehabilitation should be promoted.

In addition to Pre Harvest Interval (PHI), Maximum Residue Level (MRL) and Restricted Entry Interval (REI) in connection with pesticide use, non target effects on plant soil and water environments are of paramount importance in reserving the biological wealth in tea soils. Adherence to such requisites would ensure product quality standards for customer needs as well as environmental, social and ethical certifications. Also, the bioremedial properties should be harnessed by adopting important Good Agricultural Practices (GAPs) such as soil rehabilitation. Planting of species with phytoremediation properties would further assist in lowering the pesticide residues in soils and thereby minimizing the effects to soil microbes. Use of Biochar would be another avenue to reduce pesticide dosages required by way of reducing the chemical leachates and improving adhesiveness.

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