Effects of Pesticide Application on Soil Microbial Spectrum: Case Study- Fecolart Demonstration Farm, Owerri-West, Imo State, Nigeria

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***Abstract*– A study was conducted to determine the effects of pesticide application on soil microbial spectrum at different application rates ranging from ½ litre, 1litre with the control soil samples having no pesticide injection. The herbicide, Glysphosphate (the active ingredient in roundup) was used for the study. The fungal and bacterial species were investigated to know their susceptibility to pesticide application. Microbiological analyses were conducted through the use of Nutrient Agar medium. Soil samples were taken at the depth of 0-20cm from college demonstration farm with the aid of auger. The results revealed that pesticide applications caused drastic reduction in microbial population present in the soil when comparing with the control. Also, despite the reductions, some fungal species like Mucor miehei, Mucur hiemalis, Aspergillus fumigates and Aspergillus niger developed tolerance levels, while others like Heruncola grisea and Alternonia terins were extinct due to their susceptibility to Glysphosphate. Also, using paired t-, calculated value 1.34 is < t-table value at 0.01 and 0.05 confidence level which signify that HO is rejected for HA, indicating that there is a great difference between microbial population in treated soil and non-treated soil with pesticide confirming the effects of microbial deduction and extinction due to indiscriminate ways of applying pesticide in the soil.**

***Keywords*– Glysphosphate, Soil Microbial Spectrum and Integrated Pest Management**

I. INTRODUCTION

Pesticides are defined under the Federal Environmental Pesticide Control Act (FEPCA) as "any substance or mixture of substances intended for preventing, destroying, repelling or mitigating any pest (insects, rodents, nematodes, fungus, weeds and other forms of terrestrial or aquatic plant or animal like bacteria or other microorganisms)" (Mishra et al, 2001) or "any substance or mixture of substances intended for use as a plant regulator, defoliant or desiccant" (Mishra et al, 2001). Pesticides are directly toxic to pests having indirect effects to soil invertebrates (Mishra et al, 2001). They may be fungicides (toxic to fungus), insecticides (toxic to insects), nematicides (toxic to nematodes), and herbicides (toxic to herbs). Indirectly fungicides greatly change the numbers and kinds of microorganisms; insecticides influence the numbers of predators and fumigants completely upset the biological balance by destroying a large portion of micro-flora and fauna (Dwivedi et al, 2001). According to Mishra et al, (2001) observed that physicochemical properties of the soil, nature of substrates and environmental degradation determine the persistence of pesticides in nature. And excessive persistent and biological active residues endanger non-target organisms, prove hazardous and make the pest control operational uneconomical.

In recent time there has been a steady increase in the number and amount of residues of pesticides in our food and soil. While pesticides serve useful purposes, concern has been expressed regarding their possible effects on environment. And Edward (1973) gave following four effects of pesticides on living organisms in the soil: i) They may be directly toxic to animal in soil ii) They may affect the soil organisms genetically to produce population resistant to the pesticides iii) They may have sub-lethal effects that result in alterations in behavior or changes in metabolic or reproductive activity. iv) They may be taken into bodies of soil flora or fauna and passes on to the other organisms.

Based on these effects, Metcalf (1980), Dhooria and Mann (2001) observed that, the problem of pests in agricultural practice cannot be solved thorough the continued and exclusive application of broad-spectrum pesticides. Implementation of Integrated Pest Management (IPM) programmes that institute ecologically sound and multi-component suppression on the pest population is the obvious solution.

The soil microorganisms like bacteria, fungi, algae and nematodes play important role in soil nutrition through their role in decay of plant and other organic matter in soil as nitrifiers. Anything that disrupts their activity could be expected to affect the nutritional quality of soils and would thus have serious consequences. Also, microorganisms that live in soil can be killed not only by chemicals applied directly to the soil, but also by those that reach the soil in drift from aerial sprays or washed off foliage, which in turn affect the breakdown of some kinds of dead leaf material into its organic and inorganic constituents and in the incorporation of these material into the soil structure (Mishra et al, 2001).

Above all, in spite of inherent drawbacks of pesticides in terms of toxicity and environmental pollution, their use either on foliage or in soil can not be totally dispensed in the demonstration farm of the Federal College of Land Resources, Owerri. However, continuous use of pesticides requires constant monitoring with respect to their persistence in soil and plants and effects on soil organisms in terms of ill effects and toxic residue. Soil microorganisms have a great contribution towards soil fertility. Any adverse impact of chemical on soil characteristics and microorganism may lead to ultimate loss of soil fertility.

The study then aimed at assessing the effect of pesticides applications on soil microbial spectrum in order to advise on precautionary measures to ensure sustainable agriculture.

II. MATERIALS AND METHODS

The Study Area

Federal College of Land Resources Technology demonstration farm is located 15 Km south of Owerri-West Local Government Area, Imo State, at latitude 06^0 54' N and longitude 06^0 07' E. Some major characteristics of the study area are given in Table 1:

Table 1: Characteristics of the study area

Characteristics	
Mean annual rainfall (mm)	213.7
Temperature	26^0C minimum, 28^0 C
Humidity	50.5 – 70.5 %
Bio-climate	Rainforest zone
Geology	Sedimentary rock
Soil Type	Sandy-loamy

Soil Sample Collection

Soil samples used in this investigation were collected randomly in demonstration farm with auger from 0 – 20 depth (Susmita and Behera, 2001. Two sample points were selected designated (A) and (B) and soil samples collected were used as control without pesticide application after which Herbicide Glyphosphate (the active ingredient in roundup) ½ litre and 1 litre were applied interval. After two weeks of herbicide application, four other soil samples were collected making a total of six (6) samples where fungi and bacteria were isolated. The samples were taken to the laboratory and stored at temperature of 4^0C until the analyzes were conducted and completed.

Analytical Procedure

Microbiological analyses of the soil samples were made as per the following procedures:

(i) For the enumeration of the micro-fungal and bacterial population dilution plate count technique (DPCT) (Waksman, 1922) was followed. The primary suspension of the soil was prepared from 1 gram of soil which was diluted up to 10^{-9} times using sterile water as diluting fluid. For microfungal population, 1ml of aliquots from 10^{-4} diluted suspension was transferred to 7.5 cm dia petridishes and to it 25 ml of molten agar-rosebengal medium (Martin, 1950) was poured. Petridishes were incubated at room temperature till the development of fungal colonies. Colonies developed on the petridishes were identified following Gilman (1957), Barnett and Hunter (1973)

(ii) For the enumeration of bacterial population 1ml of aliquots from 10^{-8} diluted suspension were transferred to 7.5 m dia petridishes and to 25 ml molten nutrient agar medium was added. After an incubation period of 48 hours, bacterial colonies from the petridishes were counted.

Statistical Technique

Student's paired T-test was used to calculate the relationship between the microbial population in the soil samples without pesticide and soil samples treated with pesticide within the demonstration farm.

III. RESULTS AND DISCUSSION

Table 2 shows the Number of fungi isolates in the soil samples not treated with Herbicide Glyphosphate.

Table 2: Fungi isolates from soil not treated pesticide

S/N	Fungi	Soil Samples not treated		Mean
		A	B	
		Colony Counts	Colony Counts	
1	*Mucor miehei*	16	16	**16**
2	*Mucur hiemalis*	14	15	**21.5**
3	*Rhizopus solonifer*	6	7	**6.5**
4	*Aspergillus fumigates*	17	17	**17**
5	*Fusarium Spp*	3	3	**3**
6	*Emoricella indricans*	3	2	**2.5**
7	*Aspergillus niger*	12	10	**11**
8	*Herumcola grisea*	2	2	**2**
9	*Alternonia terins*	1	1	**1**
	TOTAL	**73.8**	**73**	
	MEAN	**8.2**	**8.1**	

Source: Field work, 2011

Table 2 shows the number of fungi population isolates from the soil not treated with pesticides. All the fungi species listed above are present in the non treated soils in abundant except *Fusarium spp, Emoricella inricans, Herumcola grisea* and *Alternonia terins* which tend to be smaller in quantity. And the fungi species varied from one location to another with soil sample regimes (A) having the total value of 73.8 colony counts with mean value of 8.2 that constitutes 50 % and (B) having total value of 73 colony counts with mean value of 8.1 49.7 % variations. However, there was no appreciable difference in mean value of fungi isolated from sampled soil treated with no pesticides. Also, Table 3 shows the number of fungi isolated in soil samples treated with half litre (½) of pesticides.

From Table 3, it is observed that the number of fungi species present in the sampled soils reduced drastically due to injection of half litre (1/2) of pesticide, *hence Heruncola grisea and Alternonia terins* which are usually present in the soil in little quantity were totally extinct when compare with Table 1 as controlled samples. However, there was no appreciable difference in mean value of fungi isolated from sampled soils treated with ½ pesticides, with 52.7% for sample (A) and 47% for sample (B).

Tolerance nature of *Mucor miehei, Mucur hiemalis, Aspergillus fumigates* and *Aspergillus niger* were suspected to be influenced by adaptability to environmental stress caused by pesticide application. The result is consistent with the findings of Venkatraman and Rajyalakshmi (1971), Susmita and Behera (2001). Table 3 shows the number of fungi isolated from soil samples treated with one (1) litre of pesticide.

From Table 3 the following fungi ,*Mucor miehei, Mucur hiemalis, Aspergillus fumigates* and *Aspergillus niger* still shown the same trend of reduction based on 1 litre pesticide with greater impact than Table 2, with fungi variations of 50.7% for soil sample A and 49% for sample B indicating insignificant variation. The variation of mean value of fungal in soil without pesticide application, ½ litre and 1litre respectively (Fig. 1). On the whole, the number of fungi species was eliminated entirely from the soil due to pesticide infestation which is suspected to be the reason of poor yield on the farm. The result is consistent with the finding of Elain (2001) who observed that if the soil is void of microorganism, the soil is dead. That indiscriminate use of pesticide might work for few years, but after a while, there will be no beneficial soil microorganism to hold on to nutrient.

Table 3: Fungi isolates from soil treated with half (½) litre pesticide

S/N	Fungi	Soil Samples treated ½ litre Pesticide		Mean
		A	B	
		(Colony Counts)	(Colony Counts)	
1	*Mucor miehei*	12	12	12
2	*Mucur hiemalis*	10	9	9.5
3	*Rhizopus solonifer*	5	3	4
4	*Aspergillus fumigates*	14	13	13.5
5	*Fusarium Spp*	1	1	1
6	*Emoricella indricans*	1	1	1
7	*Aspergillus niger*	9	9	9
8	*Herumcola grisea*	0	0	0
9	*Alternonia terins*	0	0	0
	TOTAL	**54**	**48**	
	MEAN	**6**	**5.3**	

Source: Field work, 2011

Table 3: Fungi isolates from soil treated with one (1) litre pesticide

S/N	Fungi	Soil Samples treated with 1 litre Pesticide		Mean
		A	B	
		Colony Counts	Colony Counts	
1	*Mucor miehei*	9	9	8
2	*Mucur hiemalis*	6	6	6
3	*Rhizopus solonifer*	4	4	4
4	*Aspergillus fumigates*	10	9	9.5
5	*Fusarium Spp*	1	1	1
6	*Emoricella indricans*	0	0	0
7	*Aspergillus niger*	5	5	5
8	*Herumcola grisea*	0	0	0
9	*Alternonia terins*	0	0	O
	TOTAL	**35**	**34**	
	MEAN	**3.9**	**3.8**	

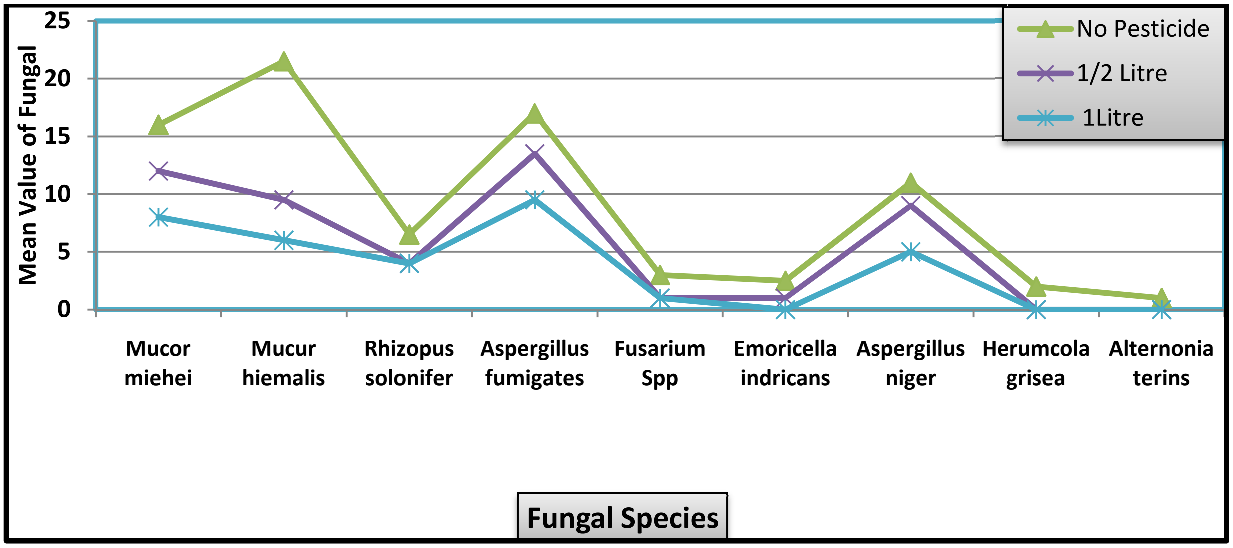

Fig. 1: Variation of Mean Values of Fungal according to soil treatment with and without pesticide

IV. BACTERIAL POPULATION

Table 4 refers to the bacterial population in control where no pesticide is applied to the soil, hence the observed bacterial density that enriches the soil through biodegradation. Also, highest number of bacterial such as *Bacillus spp, Spirilum spp and Nitrobacter spp* were observed in the control indicating that the soil is alive.

Table 5 shows the number of bacterial isolated from the soil treated with half (1/2) of pesticide.

From Table 5, during the initial application of ½ litre of pesticide, the bacteria population showed a decreasing trend indicating the effect of pesticide on bacterial in the soil samples A and B, and the decrease was in uniform in the two soil samples.

From Table 6 , the result shown that the initial decline in bacterial population was worsened by application of 1litre of pesticide which further stressed the soil by further reducing the bacterial species present in the soil which will invariable reduce the action of bacteria in the soil that might lead to decline in soil fertility in the farmland. And pesticides that persist in the soil for long usually affect soil bacterial resulting to chemical degradation of the soil (Kamrin, 1997; Gupta, 2001).

Based on the hypothesis formulation that there is no significance different existing between treated soil with pesticide and non treated soil. It is then observed that, with a paired t-test, the calculated values which is t= 1.34 is less than the table value at 0.05 and 0.01 level of significant. This then indicated that HO is rejected for HA, Signifying that pesticide application on soil has helped in the reduction of microbial population which may likely lead to biomagnifications in soil ecosystems.

Table 4: Bacteria isolates from soil samples not treated pesticide

S/N	Bacteria	Soil Samples not treated with Pesticide	
		A	B
1	*Bacillus spp*	10×16^5	10×16^5
2	*Spirilum spp*	10×12^3	10×12^3
3	*Micrococcus varians*	10×6^2	10×6^2
4	*Nitrobacter spp*	10×12^4	10×12^4

Source: Fieldwork, 2011

Table 5: Bacteria isolates from soil samples treated with ½ pesticide

S/N	Bacteria	Soil Samples treated with half (½) litre Pesticide	
		A	B
1	*Bacillus spp*	10×10^3	10×10^3
2	*Spirilum spp*	10×7^4	10×7^4
3	*Micrococcus varians*	10×4^2	10×4^2
4	*Nitrobacter spp*	10×8^4	10×8^4

Source: Fieldwork, 2011

Table 6: Bacteria isolates from soil samples treated with one (1) litre pesticide

S/N	Bacteria	Soil Samples treated with one (1) litre Pesticide	
		A	B
1	*Bacillus spp*	10 x 6^3	10 x 6^3
2	*Spirilum spp*	10 x 4^5	10 x 4^3
3	*Micrococcus varians*	10 x 2^2	10 x 2^2
4	*Nitrobacter spp*	10 x 5^3	10 x 5^3

Source : Fieldwork, 2011

V. CONCLUSION AND RECOMMENDATIONS

In agriculture and in control of diseases, man used a grater number of different chemicals. Also, pesticides are the major soil, water and air pollutant, There is growing concern throughout the world at the way, man is damaging his environment by injudicious use of pesticides to overcome problem of controlling insects, diseases etc**.**

Effect of pesticide application on soil microbial spectrum was studies, and the result indicated that comparative analysis of the fungal population shown a decrease due to application of ½ litre and 1 litre applications of pesticide in the soil samples, and some fungal species like *Mucor miehei, Mucur hiemalis, Aspergillus fumigates* and *Aspergillus niger* shown tolerance levels which indicates the adaptability to harsh environment, and others were suppressed due to glysphospte application to the soil samples. There was also a sharp decrease in bacterial population.

It is then concluded that in spite the importance of pesticide used in agriculture, indiscriminate use of pesticide can lead to soil degradation. Thus, although in tropical soil, persistence of pesticide in soil and their effect on density and non-target soil organisms is minimum at a normal agricultural dose, their effect is obvious at population metabolism, with change in physiological and biochemical responses (Behera and Mishra, 2001)). This implies that at doses, higher than prescribed dose, would alter the balance of the soil sub-system. Under this mineralization and humufication processes will be very low leading to low nutritional values , hence poor crop yield that may lead to hunger and starvation.

Based on the conclusion, to minimize damage due to pesticide application to soil ecosystems, the following precautionary measures should be adopted:

(i) To select pesticides and methods that are least hazardous and to apply them at a minimum effective dosage

(ii) To avoid excessive drift and improper use of pesticides as much as possible and limit the applications to the target area

(iii) Should not exceed recommended application rates

(iv) Farmers should be properly guided on the use of pesticides in agriculture.

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