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# Impact of Some Selected Insecticides Application on Soil Microbial Respiration

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**Abstract:** The aim of present study was to investigate the impact of selected insecticides used for controlling brinjal shoot and fruit borer on soil microorganisms and to find out the insecticides or nontoxic to soil microorganism the impact of nine selected insecticides on soil microbial respiration was studied in the laboratory. After injection of different insecticides solutions, the soil was incubated in the laboratory at room temperature for 32 days. The amount of $CO_2$ evolved due to soil microbial respiration was determined at 2, 4, 8, 16, 24 and 32 days of incubation. Flubendiamide, nimbicidine, lambda-cyhalothrin, abamectin and thiodicarb had stimulatory effect on microbial respiration during the initial period of incubation. Chlorpyriphos, cartap and carbosulfan had inhibitory effect on microbial respiration and cypermethrin had no remarkable effect during the early stage of incubation. The negative effect of chlorpyriphos, cartap and carbosulfan was temporary, which was disappeared after 4 days of insecticides application. No effect of the selected insecticides on soil microorganisms was observed after 24 or 32 days of incubation.

**Key words:** Insecticides, soil, microorganism, respiration

## INTRODUCTION

Soil is the natural medium in which plants live, multiply and die and thus providing a perennial source of organic matter which could be recycled for plant nutrition. It is composed of five major components, mineral matter, water, air, organic matter and living organisms. The last one makes up appreciably less than 1% of the total soil volume (Purohit, 2003). The soil microorganisms can be categorized into bacteria, actinomycetes, fungi, algae and protozoa (Rao, 1999). The fertility of soil depends on its chemical composition, organic matter content and qualitative and quantitative nature of the soil microorganisms because they have a major role in the metabolism of both organic and inorganic soil constituents for plants (Purohit, 2003). Various groups of soil microorganisms decompose organic matter and most of the carbon is liberated as $CO_2$ during their decomposition. Therefore, the evolution of $CO_2$ serves as a measure of the rate and content of organic matter decomposition by soil microorganisms in soil. The total amount of $CO_2$ liberated depends on the nature of material, the microorganisms concerned and the conditions of the decomposition. Soil respiration is a good index of the activity of microorganisms involved in organic matter decomposition (Komal *et al*., 1999).

Insecticidal compounds are being increasingly used for the control of various insect pests of brinjal and other field crops, which ultimately reach the soil and persist for long periods causing harm to soil microorganisms. There are many reports regarding the favourable effects of insecticides on the growth and activities of microorganisms in soil (Das *et al*., 1995; Bujin and Yongxi, 2000; Das and Mukherjee, 2000; Digrak and Kazanici, 2001). On the other hand, there are some insecticides, which exert adverse effect on the growth of soil microorganisms (Komal *et al*., 1999; Bhuyan *et al*., 1992; Martinez-Toledo *et al*., 1992; Tu, 1980). Bujin and Yongxi (2000) and Komal *et al*. (1999) revealed that the effect of insecticides on soil microbial activities was temporary and it disappeared within short period of time (Bujin and Yongxi, 2000; Komal *et al*., 1999). However, no definite conclusion can be made on the effect of different insecticides on the growth and activities of microorganisms in soil, since different groups of insecticides exhibit manifold variations in toxicity (Das and Mukherjee, 2000; Komal *et al*., 1999). Therefore, the present study was undertaken to investigate the impact of selected insecticides used for controlling brinjal shoot and fruit borer on soil microorganisms and to find out the insecticides less or nontoxic to soil microorganisms.

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## MATERIALS AND METHODS

The experiment was conducted in the Soil Microbiology Laboratory of Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur, Bangladesh, during the period from July to November 2005. The soil (0-15 cm depth) used in the experiment was collected from Entomology Farm of BSMRAU. The soil of the experimental field was clay loom in texture having pH of around 5.8 and poor fertility status. The soil belongs to 'Shallow Red Brown Terrace' soil of Salna series under Madhupur Tract and classified as inseptisols (Haider *et al*., 1991). In the laboratory, soil was dried at room temperature and plant roots, insects, worms and small pieces of organic matter were removed. The soil was then passed through 2 mm mesh sieve. After sieving, the soil was pre-incubated in the laboratory at room temperature (30±1°C) for 10 days, which allowed the soil microbial population to stabilize, minimize the effects of soil handling and preparation (Chowdhury *et al*., 1999). Immediately after pre-incubation, the soil was used for the experiment.

**Experimental design and treatments:** The treatments comprised nine insecticides each with a selected dose viz., nimbicidine 0.03EC at the rate of 4.0 ml $L^{-1}$, abamectin 1.8EC at the rate of 1.5 ml $L^{-1}$, chlorpyriphos 20EC at the rate of 2.0 ml $L^{-1}$, cartap 50SP at the rate of 1.2 g $L^{-1}$, carbosulfan 20EC at the rate of 3.0 ml $L^{-1}$, thiodicarb 75WP at the rate of 1.0 g $L^{-1}$, cypermethrin 10EC at the rate of 1.0 ml $L^{-1}$, lambda-cyhalothrin 2.5EC at the rate of 1.0 ml $L^{-1}$ and flubendiamide 24WG at the rate of 0.5 g $L^{-1}$ and a control. Insecticide solutions were prepared by diluting the exact amount of commercial formulation of each insecticide with 1 L distilled water in 1 L volumetric flask. Only 1 L distilled water was taken in a flask for control. Sixty gram oven dry soil was weighed in a 100 mL glass jar and 5 mL of insecticide solution was injected inside the soil of the jar for each treatment except control. Five milliliters of distilled water was added to the control soil to maintain moisture content equivalent to those treated soils. Following insecticide application, glass jars were placed inside the one liter glass bottle. To trap $CO_2$ evolved by soil microorganisms during incubation, 20 mL of 1M NaOH solution was taken in small glass and placed inside the glass bottle. The glass bottles were sealed and incubated for 32 days at room temperature ((30±1°C). Each treatment was replicated three and the glass bottles were arranged in Completely Randomized Design (CRD). To maintain internal humidity of the glass bottle, 10 mL of distilled water was added at the bottom of each incubation bottle.

**Measurement of $CO_2$:** The amount of $CO_2$ evolved due to microbial respiration was determined after 2, 4, 8, 16, 24 and 32 days of incubation. The NaOH was renewed at each sampling. The trapped $CO_2$ was titrated with standard (0.1N) HCl and pH meter (Horiba pH meter M8L) was used to measure the pH. Amount of $CO_2$ was expressed as μg $CO_2$-C evolved $g^{-1}$ soil.

**Data analysis:** Data were analyzed using MSTAT-C software for analysis of variance. ANOVA was made by F variance test and the pair comparisons were performed by Duncan Multiple Range Test (DMRT) (Gomez and Gomez, 1984).

## RESULTS AND DISCUSSION

The impact of nine selected insecticides on soil microorganisms was determined in terms of the amount of $CO_2$ evolution per gram soil during the decomposition of organic matter by soil microorganisms after 2, 4, 8, 16, 24 and 32 days of incubation.

**Incubation period-2 days:** The data (Table 1) indicate that the highest amount of $CO_2$ (790.4 μg $CO_2$ $g^{-1}$ soil) was recorded from flubendiamide treated soil followed by nimbicidine treated soil (758.4 μg $CO_2$ $g^{-1}$ soil) after 2 days of incubation. The lowest amount of $CO_2$ (48.6 μg $g^{-1}$ soil) was recorded from the soil treated with chlorpyriphos and cartap, which was statistically similar to carbosulfan treated soil (51.7 μg $g^{-1}$ soil) but significantly different from other insecticide treated soils. In the control soil, the amount of $CO_2$ was 115.7 μg $CO_2$ $g^{-1}$ soil, which was somewhat higher than cypermethrin treated soil in which the amount of $CO_2$ was 110.8 μg $CO_2$ $g^{-1}$ soil.

**Incubation period-4 days:** Table 1 further reveals that flubendiamide treated soil released the greatest amount of $CO_2$ (704.2 μg $CO_2$ $g^{-1}$ soil) after 4 days of incubation, which was significantly different from other insecticides treated soils. The amounts of $CO_2$ recorded from thiodicarb (546.6 μg $CO_2$ $g^{-1}$ soil), nimbicidine (544.2 μg $CO_2$ $g^{-1}$ soil) and chlorpyriphos (529.4 μg $CO_2$ $g^{-1}$ soil) treated soils were almost similar but significantly higher from the control soil. Carbosulfan treated soil released 169.9 μg $CO_2$ $g^{-1}$ soil, which was also significantly higher than the control soil.

**Incubation period-8 days:** After 8 days of incubation, the highest amount of $CO_2$ (689.4 μg $CO_2$ $g^{-1}$ soil) was released from chlorpyriphos treated soil, which was much higher than all other insecticides treated soil (Table 1). The amount of $CO_2$ released from thiodicarb,

Table 1: Comparative effect of nine selected insecticides on $CO_2$ evolution (μg $g^{-1}$ soil) after different exposure of incubation in the laboratory

| | Amount of $CO_2$ released (μg $g^{-1}$ soil) | | | | | |
|---|---|---|---|---|---|---|
| Treatments | 2 days | 4 days | 8 days | 16 days | 24 days | 32 days |
| Nimbicidine | 758.4a | 544.2b | 187.1bc | 187.1c | 169.9a | 98.5c |
| Abamectin | 433.4d | 465.4c | 128.0de | 120.7g | 125.6cde | 123.1b |
| Chlorpyriphos | 46.8f | 529.4b | 689.4a | 433.4a | 108.3ef | 145.3ab |
| Cartap | 46.8f | 169.9e | 152.7cd | 142.8ef | 150.2abc | 162.5a |
| Carbosulfan | 51.7f | 305.3e | 184.7bc | 123.1fg | 108.3ef | 125.6b |
| Thiodicarb | 445.7d | 546.6b | 135.4de | 81.3h | 93.6f | 140.4ab |
| Cypermethrin | 110.8e | 359.5d | 123.1de | 152.7de | 123.1de | 137.9ab |
| Lambda-cyhalothrin | 583.6c | 339.8d | 130.5de | 135.4efg | 137.9bcd | 157.6a |
| Flubendiamide | 790.4a | 704.2a | 204.4b | 211.8b | 160.1ab | 160.0a |
| Control | 115.7e | 103.4g | 101.0e | 165.0d | 128.0cde | 130.5b |
| $S_x$ | 7.63 | 6.13 | 10.00 | 4.86 | 6.13 | 6.08 |
| CV% | 3.91 | 2.00 | 8.51 | 4.80 | 8.14 | 7.63 |

In column, means followed by the same letter are not significantly different ($p < 0.01$, Duncan Multiple Range Test)

lambda-cyhalothrin, abamectin and cypermethrin was 135.4 μg $CO_2$ $g^{-1}$ soil, 130.5 μg $CO_2$ $g^{-1}$ soil, 128.0 μg $CO_2$ $g^{-1}$ soil and 123.1 μg $CO_2$ $g^{-1}$ soil, respectively. Flubendiamide, nimbicidine and carbosulfan treated soils released 204.4, 187.1 and 184.7 μg $CO_2$ $g^{-1}$ soil, respectively, which were significantly higher than control soil. The lowest amount of $CO_2$ (103.4 μg $CO_2$ $g^{-1}$ soil) release was observed in control soil.

**Incubation period-16 days:** The amount of $CO_2$ evolution was 433.4 μg $g^{-1}$ soil from chlorpyriphos treated soil after 16 days of incubation, which was much higher than any other insecticides treated soils as shown in Table 1. Flubendiamide and nimbicidine treated soil released 211.8 and 187.1 μg $CO_2$ $g^{-1}$ soil respectively, which were significantly greater than control soil. The other insecticides, such as abamectin, curtap, carbosulfan, lambda-cyhalothrin and thiodicarb treated soils released lower amount of $CO_2$ than control soil (165.0 μg $CO_2$ $g^{-1}$ soil).

**Incubation period-24 days:** The results presented in the Table 1 show that after 24 days of incubation $CO_2$ evolution was higher in nimbicidine treated soil (169.90 μg $CO_2$ $g^{-1}$ soil) followed by flubendiamide (160.10 μg $CO_2$ $g^{-1}$ soil), cartap (150.20 μg $CO_2$ $g^{-1}$ soil) and control (128.0 μg $CO_2$ $g^{-1}$ soil). Abamectin (125.60 μg $CO_2$ $g^{-1}$ soil), cypermethrin (123.10 μg $CO_2$ $g^{-1}$ soil), carbosulfan (108.30 μg $CO_2$ $g^{-1}$ soil) and chlorpyriphos (108.3 μg $CO_2$ $g^{-1}$ soil) treated soils released lower amount of $CO_2$ than control. The lowest amount (93.6 μg $CO_2$ $g^{-1}$ soil) of $CO_2$ was released from thiodicarb treated soil.

**Incubation period- 32 days:** The highest amount (162.5 μg $CO_2$ $g^{-1}$ soil) of $CO_2$ was evolved from cartap treated soil after 32 days of incubation followed by flubendiamide (160.1 μg $CO_2$ $g^{-1}$ soil) lambda-cyhalothrin (157.6 μg $CO_2$ $g^{-1}$ soil), chlorpyriphos (145.3 μg $CO_2$ $g^{-1}$ soil), thiodicarb (140.4 μg soil) and cypermethrin (137.9 μg soil) treated soil (Table 1). The amount of $CO_2$ released from carbosulfan (125.6 μg $CO_2$ $g^{-1}$ soil) and abamectin (130.5 μg soil) treated soil was similar to that of the control soil (130.5 μg $CO_2$ $g^{-1}$ soil). The lowest amount of $CO_2$ (98.5 μg $CO_2$ $g^{-1}$ soil) was evolved from nimbicidine treated soil, which was significantly lower than control and other insecticide treated soils.

The results thus demonstrate that all the insecticides had impact on the soil microbial activity vis-a-vis population but such impact was significantly influenced by the incubation period. Some insecticides were very quickly decomposed while the others required relatively longer period for microbial stimulation because of their long persistence, although the whole process is very complex and depends on several factors. Therefore, application of flubendiamide, nimbicidine, lambda-cyhalothrin, abamectin and thiodicarb enhanced the population of soil microorganisms immediately after application and retained their stimulating effect even after 32 days. Chlorpyriphos, cartap, carbosulfan and cypermethrin had no effect on microbial population until 4 days of incubation, which attained the highest value after 8 days of incubation and then gradually decreased but still retained the effect even after 32 days of incubation. On the other hand, chlorpyriphos, carbosulfan and cartap treated soils had less evolution of $CO_2$ than control, which indicated inhibitory effect until 4 days of incubation.

Digrak and Kaznici (2001), Iqbal *et al.* (2001) Bajin and Yongxi (2000), Das and Mukherjee (2000) and Das *et al.* (1999) reported the positive effect of different groups of insecticides during early stage of incubation. On the other hand, Kamal *et al.* (1999), Bhugan *et al.* (1992), Martinez Toledo *et al.* (1992) and Tu (1980) observed negative or no effect (Iqbal *et al.*, 2001; Komal *et al.*, 1999) of insecticides on soil microorganisms.

Komal *et al.* (1999) observed that bacterial population in the soil treated with dimethoate was significantly lower compared to control after 2 days of incubation. Poor metabolism of chloropyriphos by soil microorganism and its negative impacts on non-target soil microorganisms at early stage was observed by Pozo *et al.* (1995) and Susan *et al.* (2004).

On the other hand, Mallek *et al.* (1994) observed the adverse effect on fungi after 2, 4 and 6 weeks of treatments. While, Ahtiainen *et al.* (2003) revealed that dimethoate and primicarb inhibited microbial respiration at high concentrations. The results, however, may differ from that of the other researchers but logical because the microbial respiration is mostly dependent upon the physiological condition of the active microorganisms, the nature and concentration of the chemical as well as the environmental conditions such as temperature, light etc. (Komal *et al*., 1999).

The amount of $CO_2$ evolution is higher in all insecticides treated soils than control soil after 4-8 days of incubation, which indicated the stimulatory effect of all insecticides on soil microorganisms during this period. Moreover, the increased amount of $CO_2$ evolution in chlorpyriphos treated soils indicated greater activity of soil microorganisms during 4 to 8 days of incubation after chlorpyriphos application. A decrease in numbers of the bacteria during the first week after insecticide applications followed by rapid increase in the second week and then reversed to normal was observed by Komal *et al.* (1999). Similar interpretation may be applicable for the less evolution of $CO_2$ vis-a-vis reduction in microbial population after chlorpyriphos and cartap and then increase with time. Bujin and Yongxi (2000) also reported that the effect of insecticides on soil microorganisms disappeared within 4, 8, or 16 days after treatment depending on the dose applied. Gonzalez-Lopez *et al.* (1992) revealed that nitrifying bacteria decreased initially but recovered rapidly to levels similar to those in the control soil without the insecticides.

The amount of $CO_2$ evolution gradually decreased in some cases and became similar to or less than that of the control during the later stage (24 to 32 days) of incubation. Microbial decomposition of insecticides decreased its amount as well as source of carbon for the active microorganism in soil. As a result, the amount of $CO_2$ evolution was gradually reduced and became similar to that of the control. Therefore, the effect of these insecticides disappeared after 4th week of incubation. The findings, thus, obtained in this study was similar to that of results obtained by Gonzalez-Lopez *et al.* (1992). Short persistency of phorate carbofuran and fenvalerate was reported by Das and Mukherjee (2000). Komal *et al.* (1999) found temporary effect of insecticides on the microbes and their activities which disappeared before the next insecticide treatment. Therefore, the results in the present study are in agreement with the previous reports provided by many researchers.

Thus it is revealed that all the insecticides tested in the present study were useful in terms of microbial activity vis-a-vis microbial population. Flubendiamide had consistently higher positive stimulatory effect starting right from its application and continuing even beyond 32 days of incubation. Similar but slightly less positive effect than flubendiamide was observed in case of abamectin another effective insecticide identified. Carbosulfan, another effective insecticide identified as effective in the previous experiment, had negative effect on microbial activity initially, which gained positive stimulation with time but was always less stimulative than flubendiamide.

After application of insecticides at recommended dose, both inhibitory and stimulatory effects on microbial respiration were observed, which were in general being very weak and transient.

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