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 microorganisms 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 CO₂ evolved due to soil microbial respiration was determined at 2, 4, 8, 16, 24 and 32 days of incubation. Flubendiamide, nimbicide, lamdb-d-cyhalothrin, abamectin and thiodicarb had stimulatory effect on microbial respiration during the initial period of incubation. Chlorpyrifos, 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 chlorpyrifos, 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 CO₂ during their decomposition. Therefore, the evolution of CO₂ serves as a measure of the rate and content of organic matter decomposition by soil microorganisms in soil. The total amount of CO₂ 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 favorable 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 Kazanci, 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 loam in texture having pH of around 5.8 and poor fertility status. The soil belongs to 'Shallow Red Brown Terrace' soil of Salma series under Madinpur Tract and classified as inceptisols (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 2WG 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 CO₂ 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 CO₂: The amount of CO₂ 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 CO₂ was titrated with standard (0.1N) HCl and pH meter (Horiba pH meter M88L) was used to measure the pH. Amount of CO₂ was expressed as μg CO₂-C evolved g⁻¹ soil.

Data analysis: Data were analyzes 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 CO₂ 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 CO₂ (790.4 μg CO₂ g⁻¹ soil) was recorded from flubendiamide treated soil followed by nimbicidine treated soil (788.4 μg CO₂ g⁻¹ soil) after 2 days of incubation. The lowest amount of CO₂ (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 CO₂ was 115.7 μg CO₂ g⁻¹ soil, which was somewhat higher than cypermethrin treated soil in which the amount of CO₂ was 110.8 μg CO₂ g⁻¹ soil.

Incubation period-4 days: Table 1 further reveals that flubendiamide treated soil released the greatest amount of CO₂ (704.2 μg CO₂ g⁻¹ soil) after 4 days of incubation, which was significantly different from other insecticides treated soils. The amounts of CO₂ recorded from thiodicarb (546.6 μg CO₂ g⁻¹ soil), nimbicidine (544.2 μg CO₂ g⁻¹ soil) and chlorpyriphos (529.4 μg CO₂ g⁻¹ soil) treated soils were almost similar but significantly higher from the control soil. Carbosulfan treated soil released 169.9 μg CO₂ 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 CO₂ (689.4 μg CO₂ g⁻¹ soil) was released from chlorpyriphos treated soil, which was much higher than all other insecticides treated soil (Table 1). The amount of CO₂ released from thiodicarb,
Table 1: Comparative effect of nine selected insecticides on CO₂ evolution (µg g⁻¹ soil) after different exposure of incubation in the laboratory.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>2 days</th>
<th>4 days</th>
<th>8 days</th>
<th>16 days</th>
<th>24 days</th>
<th>32 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nimbicidine</td>
<td>758.4a</td>
<td>544.2b</td>
<td>187.1bc</td>
<td>187.1c</td>
<td>109.3e</td>
<td>98.3c</td>
</tr>
<tr>
<td>Abamectin</td>
<td>433.4d</td>
<td>465.4e</td>
<td>128.0de</td>
<td>120.7e</td>
<td>125.6f</td>
<td>123.1f</td>
</tr>
<tr>
<td>Chlordane</td>
<td>468.8f</td>
<td>529.4g</td>
<td>689.4a</td>
<td>433.4a</td>
<td>1083f</td>
<td>145.3ab</td>
</tr>
<tr>
<td>Cypermethrin</td>
<td>468.8f</td>
<td>169.9e</td>
<td>152.7c</td>
<td>142.8e</td>
<td>152.8bc</td>
<td>125.1a</td>
</tr>
<tr>
<td>Carbosulfan</td>
<td>51.9f</td>
<td>205.2e</td>
<td>184.7bc</td>
<td>213.1f</td>
<td>1083f</td>
<td>125.1b</td>
</tr>
<tr>
<td>Thiodicarb</td>
<td>454.7d</td>
<td>546.6b</td>
<td>135.4de</td>
<td>81.3e</td>
<td>92.6d</td>
<td>143.4ab</td>
</tr>
<tr>
<td>Cypermethrin</td>
<td>110.9e</td>
<td>359.5d</td>
<td>123.1e</td>
<td>152.7d</td>
<td>123.1d</td>
<td>137.9b</td>
</tr>
<tr>
<td>Lambda-cyhalothrin</td>
<td>583.6c</td>
<td>339.8d</td>
<td>130.5de</td>
<td>115.4f</td>
<td>137.9cd</td>
<td>155.1a</td>
</tr>
<tr>
<td>Flubendiamide</td>
<td>790.4a</td>
<td>704.2a</td>
<td>204.4b</td>
<td>211.8b</td>
<td>160.4a</td>
<td>160.4a</td>
</tr>
<tr>
<td>Control</td>
<td>115.7e</td>
<td>163.4g</td>
<td>101.0e</td>
<td>165.0d</td>
<td>128.0cd</td>
<td>130.5b</td>
</tr>
<tr>
<td>S</td>
<td>7.63</td>
<td>6.13</td>
<td>10.00</td>
<td>4.86</td>
<td>6.13</td>
<td>6.08</td>
</tr>
<tr>
<td>CV (%)</td>
<td>3.91</td>
<td>2.00</td>
<td>8.51</td>
<td>4.80</td>
<td>8.14</td>
<td>7.63</td>
</tr>
</tbody>
</table>

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

Incubation period-16 days: The amount of CO₂ evolution was 433.4 µg g⁻¹ soil from chlordane 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 CO₂ g⁻¹ soil respectively, which were significantly greater than control soil. The other insecticides, such as abamectin, cypermethrin, lambda-cyhalothrin and thiodicarb treated soils released lower amount of CO₂ than control soil (165.0 µg CO₂ g⁻¹ soil).

Incubation period-24 days: The results presented in the Table 1 show that after 24 days of incubation of CO₂ evolution was higher in nimbicidine treated soil (169.9 µg CO₂ g⁻¹ soil) followed by flubendiamide (160.1 µg CO₂ g⁻¹ soil), cypermethrin (123.1 µg CO₂ g⁻¹ soil), carbosulfan (108.3 µg CO₂ g⁻¹ soil) and thiodicarb (108.3 µg CO₂ g⁻¹ soil) treated soils released lower amount of CO₂ than control. The lowest amount (93.6 µg CO₂ g⁻¹ soil) of CO₂ was released from thiodicarb treated soil.

Incubation period-32 days: The highest amount (162.5 µg CO₂ g⁻¹ soil) of CO₂ was evolved from carbosulfan treated soil after 32 days of incubation followed by flubendiamide (160.1 µg CO₂ g⁻¹ soil) lambda-cyhalothrin (157.6 µg CO₂ g⁻¹ soil), chlordane (154.3 µg CO₂ g⁻¹ soil), thiodicarb (140.4 µg soil) and cypermethrin (137.9 µg soil) treated soil (Table 1). The amount of CO₂ released from carbosulfan (125.6 µg CO₂ g⁻¹ soil) and abamectin (130.5 µg soil) treated soil was similar to that of the control soil (130.5 µg CO₂ g⁻¹ soil). The lowest amount of CO₂ (98.5 µg CO₂ 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. Chlordane, cypermethrin, lambda-cyhalothrin and thiodicarb 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, chlorpyrifos, carbosulfan and cartap treated soils had less evolution of CO₂ than control, which indicated inhibitory effect until 4 days of incubation.

Dignak and Kazneci (2001), Iqbal et al. (2001), Bajin and Yongyi (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), Bhagain et al. (1992), Martinez Toledo et al. (1992) and Yu (1980) observed negative or no effect (Iqbal et al., 2001; Konal 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 chloropyriphos treated soils indicated greater activity of soil microorganisms during 4 to 8 days of incubation after chloropyriphos 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. Buji 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 cumulative 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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