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Carbofuran Adsorption, Leaching and Accumulation in Edible Tissues in Three Selected Soils in Tropics

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Abstract: Carbofuran is moderately mobile in soil which could lead to ground water pollution and accumulation in plant tissues. A study was carried out to investigate the adsorption, leaching and accumulation of carbofuran in edible tissues in three soil series of Sri Lanka namely Chankanai, Inuvil and Navatkuli. For the adsorption study, soil samples were shaken with carbofuran having 625µg for 2 hours. Soil suspension was centrifuged at 22000 rpm for 20 minutes and the supernatant was removed and analyzed for carbofuran. A pot experiment using *Amaranthus sp* was also carried out to analyze the carbofuran leaching and accumulation in edible plant tissues. Soils from three series were treated with formulated commercially available carbofuran. All the experiments were conducted in Complete Randomized Design (CRD) with four replicates. Adsorption of carbofuran was highest for Chankanai series soil and lowest for Navatkuli series soil. Percentage adsorption of carbofuran for Chankanai, Inuvil and Navatkuli soil series was 37.6, 19.2 and 5.6, respectively. In the pot experiment, the highest carbofuran leaching was observed in Navatkuli series soil, whereas the lowest leaching was observed in Chankanai series soil. Navatkuli soil significantly differed from rest of the soils; however, there was no significant difference in leaching between Inuvil and Chankanai soils. Amount of carbofuran residue in plant samples varied from 0.011-0.016 mg/100g, however, no significant difference was observed in carbofuran residue in plant tissues amongst these three soils. All samples in pot experiment accumulated less than 0.12mg per 100g carbofuran indicating there is no chance of accumulating carbofuran at risk levels in *Amaranthus* when farmers apply recommended dosages.

Key words: Carbofuran · Leaching · Adsorption · Accumulation

INTRODUCTION

Pesticides play an indispensable role in agriculture considerably reducing the various insect pest infestations. The toxicity of pesticides makes them effective in controlling pests, but this toxicity means that pesticides must be properly applied and managed so that their potential to affect human health and environment is minimized [1]. In Sri Lanka, carbofuran is a widely used nematicide and insecticide for the control of a variety of soil-dwelling and foliar-feeding pests on many fruit and vegetable crops [2]. It has been noted that soil-dwelling pests especially nematodes have been causing problems for many vegetable cultivators and farmers therefore, increasingly apply carbofuran to soil as nematicide.

Though pesticides have been used for many years in Northern region of Sri Lanka, there have been no studies regarding the fate of pesticides in this region. Such studies would give valuable information to adopt better farm management practices and therefore lead to a safer environment to live in for future generations. The adsorption and leaching of pesticides are the major factors affecting the ground water contamination. Moreover, carbofuran is relatively mobile in soil and in surface runoff. Consequently carbofuran has the potential to contaminate groundwater, lakes and streams [3]. Leaching potential of commonly used, highly hazardous pesticides, like carbofuran is of great interest in order to avoid this hazard to ground water. This study therefore was conducted in three soil series in Jaffna Peninsula, Sri Lanka under the following objectives:

To study the soil adsorption, leaching and accumulation of carbofuran in edible tissues using *Amaranthus* sp. as test crop in three soil series of Jaffna Peninsula, Sri Lanka.

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MATERIALS AND METHODS

Soil Sampling: Soil samples were collected from three soil series in Jaffna peninsula namely Chankanai, Inuvil and Navatkuli. Samples were collected up to 20cm. Collected soils were air-dried for one week at room temperature. They were then passed through a 2 mm sieve.

Determination of Soil Properties: Soil pH was determined in a 1:5 / soil: water suspension using pH meter. Ten g soil was mixed with 50ml distilled water and stirred at regular interval for 20 minutes and allowed to settle before the measurement of soil pH. Bulk density of soil was measured by clod method (Blake and Hartge, 1986). Electrical conductivity of soil was determined in a 1: 5 / soil: water medium. Ten g soil was mixed with 50ml distilled water and stirred for 30 minutes and allowed to settle. EC of solution was measured using a conductivity meter. Soil organic matter content was determined by dichromate digestion method [4]. CEC of soil was determined by ionic replacement with 1M ammonium acetate, followed by distillation and titration [5]. Pipette method [6] was used to determine soil texture. The Physical chemical characteristics of three soils under investigation are illustrated in Table 1.

Preliminary Adsorption Study: For comparison of carbofuran adsorption in three soil series, four replicate soil samples containing 5g were shaken with 25 ml of 25 ppm carbofuran for 2 hours in a mechanical shaker at ambient temperature. Analytical grade carbofuran was used. After equilibrium was attained, soil suspension was centrifuged at 22000 rpm for 20 minutes. The supernatant was removed and analyzed for carbofuran colorimetrically [7].

The amount of carbofuran adsorbed by soil was estimated by the calculating the difference between the initial and final concentration of carbofuran in mg of carbofuran adsorbed per 100g of soil.

Table 1: Physical and chemical properties of three soil series

Property	Navatkuli	Inuvil	Chankanai
Bulk density (Kg/m^3)	1.44	1.45	1.26
CEC (cmole/Kg of soil)	3.7	15.85	14.85
EC (µS/cm)	68.9	161.6	82.9
Organic matter (%)	0.62	0.78	1.71
Organic carbon (%)	0.36	0.45	0.99
PH	8.19	8.01	8.14
Texture	Sandy	Sandy clay loam	Sandy loam
Sand	87%	70%	73%
Silt	5%	5%	10%
Clay	8%	25%	17%

Pot Experiment: To understand the fate of carbofuran when it is applied to the crops, a pot experiment was carried out. Soils from three series with four replicates were used. Simultaneously control was kept as blank for each soil and experiment was arranged in complete randomized design (CRD). For each soil formulated commercially available carbofuran was treated at the departmental recommended rate for leafy vegetables, 15 kg/ha. *Amaranthus* seeds were sown in pots. Leachate was collected in the 1st, 2nd and 3rd week after sowing and amount of carbofuran in leachate was analysed colorimetrically [7]. Plants were harvested after one month and the amount of carbofuran in the plant sample was also analysed colorimetrically. The total amount of carbofuran in lechate as well as in plant samples was calculated.

RESULTS AND DISCUSSION

Adsorption Study: In the adsorption study, Chankanai series soil showed highest percentage (37.6%) of adsorption whereas, Navatkuli series soil showed lowest percentage (5.6%) of adsorption. Highest percentage of organic matter content (1.71%) may be the reason for the highest adsorption of Chankanai soil (Fig. 1). This soil had 17% clay content. Amount of adsorption for Chankanai, Inuvil and Navatkuli soil series were 4.70, 2.40, 0.70 mg/100g of soil respectively. The differences in adsorption were significant (Table 2).

In general, adsorption was increased with increasing clay content. Navatkuli series soil has lowest percentage of organic matter content (0.62%) as well as lower percentage of clay content (8%). Intermediate level of adsorption (19.2%) was observed for Inuvil series soil, though it had higher percentage of clay (25%). This intermediate level of adsorption can be explained by intermediate level of organic matter (0.78%). Compared to Navatkuli series, Chankanai and Inuvil series soils had higher clay content as well as higher organic matter content explaining the higher adsorption of both Chankanai and Inuvil soils than Navatkuli series.

Similar results were reported by other workers, where, compost soil showed the maximum adsorption capacity, followed by clayey soil, red soil and sandy soil, respectively [8]. The amount of carbofuran adsorbed was higher for loam soil than sandy loam soil and was related to organic matter content, clay content, CaCO3 content, surface area and cation-exchange capacity of the soils [9]. However, carbofuran adsorption was better correlated with clay content than with organic matter content of soils [9].

Table 2: Carbofuran adsorption

Soil series	mg/100g soil
Chankanai	4.71
Inulil	2.40
Navatkuli	0.70
LSD	1.40

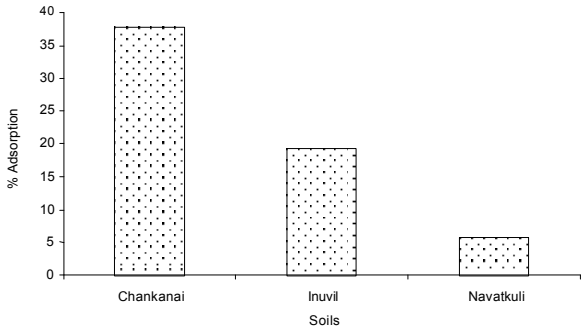

Fig. 1: Percentage adsorption of three soil series

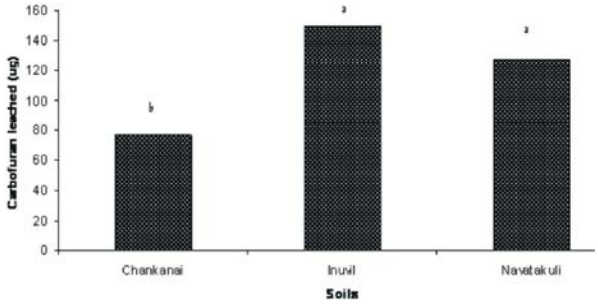

Fig. 2: Amount of carbofuran leached in three soils in the first week

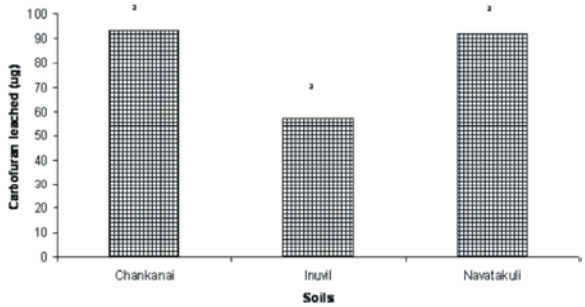

Fig. 3: Amount of carbofuran leached in three soils in the second week

Carbofuran Leaching in Pot Experiment: Figure 2, 3 and 4 illustrated that the amount of carbofuran leached during the first, second and third week in three soils respectively. The highest and lowest leaching was observed in Inuvil and Chankanai soil respectively during first week. However, there was no significant difference observed between Inuvil and Navatkuli soils. Chankanai soil showed significantly higher leaching than other two soils. Amount of leaching in the first week varied from 76.8-149.6 µg.

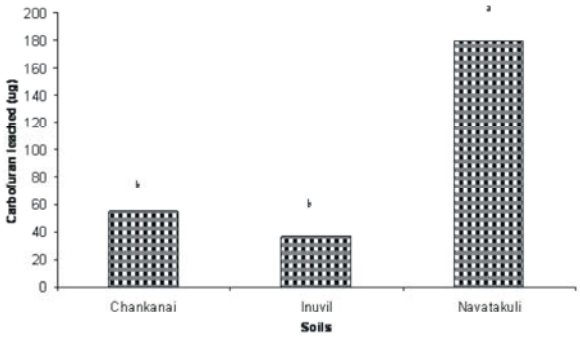

Fig. 4: Amount of carbofuran leached in three soils in the third week

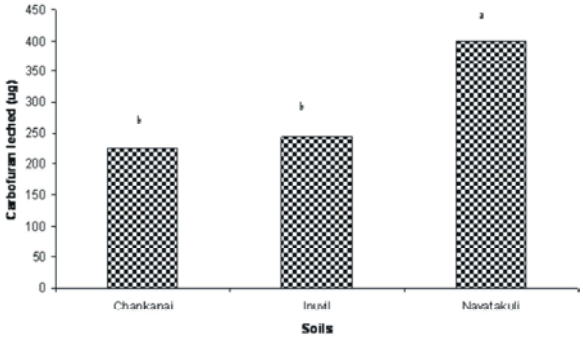

Fig. 5: Total amount of carbofuran leached in three soils

During the second week amount of carbofuran leached varied from 57.4-93.3µg. However, amount of leaching was not significantly differed among three soils. During the third week the highest and lowest leaching was observed in Navatkuli and Inuvil soil respectively. Navatkuli soil significantly differed from other two soils, however, Inuvil and Chankanai soils showed no significant difference. Amount of carbofuran leached during the third week varied from 36.8-179.7µg.

Figure 5 shows the total amount of carbofuran leached in three soils. The highest amount of carbofuran leaching was observed in Navatkuli series soil, whereas the lowest amount of leaching was observed in Chankanai series soil. Navatkuli soil significantly differed from other two soils; however, there was no significant difference between Inuvil and Chankanai soils. Lowest leaching of Chankanai soil can be explained by highest adsorption in the preliminary adsorption study. Likewise, highest leaching of Navatkuli soil can be explained by lowest adsorption indicating a negative correlation between leaching and adsorption. Total amount of leaching varied from 225.4-399.6µg.

Carbofuran Residues in the Plant Samples: Results of *Amaranthus* tissue analysis of pot experiment revealed that highest and lowest residue was observed in Inuvil

Table 3: Amount of carbofuran accumulation in plant samples from three soils

Soil series	mg/100g sample
Chankanai	0.011
Inulil	0.016
Navatkuli	0.012
LSD	NS

and Chankanai soils, respectively. Amount of residue in plant samples varied between 0.011-0.016 mg/100 g samples (Table 3). This range is less than the range of residue (0.03- 0.08 mg/100g) in market *Amaranthus* sample that we tested. In addition, insignificant difference was observed in the carbofuran residue in plant tissue amongst these three soils. Furthermore, all plant samples in pot experiment accumulated less than 0.12mg (per 100g). Hence, there is no risk associated with *Amaranthus* in relation to carbofuran toxicity when an adult consume less than 100g *Amaranthus* per day. Thus, it could be concluded that there is no chance of accumulating carbofuran in plant when farmers apply recommended dosage of carbofuran.

CONCLUSION

Percentage adsorption of carbofuran in Chankanai, Inuvil and Navatkuli soil series was 37.6, 19.2 and 5.6 respectively. A positive trend between adsorption and organic matter content was observed. On the other hand leaching was highest in Navatkuli soil series and lowest in Chankanai series. However, no significant differences in carbofuran accumulation in edible tissues were observed among soils. The study reveals that there is no risk associated with *Amaranthus* in relation to carbofuran toxicity when farmers apply recommended dosage of carbofuran.

REFERENCES

1. Smith, L.H., J.A. Liyanage, R.C. Watawala, A.G.P. Aravinna and R.S. Kookana, 2006. Degradation of the pesticides carbofuran and diazinon in tropical soils from Sri Lanka. CSIRO Land and Water Science Report, 67/06.
2. DOA, 1997. Pesticide recommendation. Department of Agriculture, Peradeniya, Sri Lanka.
3. Singh, D., 2000. Co-solvent effects on the adsorption of carbofuran by two Indian soils. Pest Management Science, 56(2): 195-201.
4. Walkley, A. and I.A. Black, 1934. An examination of the degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. Soil Science, 37: 29-38.
5. Chapman, H.D., 1965. Cation exchange capacity. In: Physical and mineralogical methods, Method of soil analysis, C.A. Black, *et al*., (eds.). Part 1, American Society of Agronomy, Inc, Madison, Wisconsin, Agronomy, 9: 891-901.
6. Day, P.R., 1965. Particle fractionation and particle size analysis. In: Physical and mineralogical methods, Methods of soil analysis, C.A. Black, *et al*., (Eds.), Part 1, American Society of Agronomy, Inc, Madison, Wisconsin, Agronomy, 9: 545-567.
7. Zhelev, I.Z., V.G. Vrabcheva and M.T.V. Yotsev, 2004. Spectrophotometric determination of the carbamate insecticide carbofuran in biological samples. Bulgarian Journal of Veterinary Medicine, 7(3): 189-193.
8. Rama, K.K. and L. Philip, 2008. Adsorption and desorption characteristics of lindane, carbofuran and methyl parathion on various Indian soils. Journal of Hazardous Materials, 160: 559-567.
9. Singh, R.P., K. Kumari and D. Singh, 1994. Influence of different factors on the adsorption of carbofuran (2, 3-dihydro-2,2-dimethyl-7-benzofuranyl-N-methyl carbamate) on soils. Ecotoxicology and Environmental Safety, 29(1): 70-79.