A Portable Rainfall-Runoff Simulator-Microscale (PRRS-M) for assessment of Neonicotinoids and Fipronil insecticides transport via surface runoff.

小型移動式降雨流出試験装置を用いたネオニコチノイドおよびフィプロニル殺虫剤の表面流出を介した挙動の評価

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1. Background and objectives

A rainfall simulator is an important tool to study runoff generation and soil loss because it can be used either under laboratory or field conditions (Sangüesa et al., 2009). The general idea behind the rainfall simulation is to allow controlled releases of water to fall onto a confined plot of soil and to measure the runoff and soil loss that occurs as a result. Its application allows a quick, specific and reproducible assessment of the impact of several factors, such as slope, soil type (infiltration, permeability), soil moisture, splash effect of raindrops (aggregate stability), surface structure, vegetation cover and vegetation structure, while allowing very detailed runoff and erosion predictions (Bowyer-Bower and Burt, 1989). Despite differences between natural and simulated rainfall, it is possible to find good correlations between the soil loss observed in an erosion plot under simulated rainfall and what occurs in a watershed (Hamed et al., 2002). It was first developed in the 1930s to measure the erodibility and infiltrability of soil. Since then it has evolved into a complex procedure which can accurately mimic the characteristics of natural rainfall. Accordingly, the present study aimed to evaluate a micro-scale artificial rainfall system for packed soil in the laboratory and for undisturbed soil in field for screening the pesticide concentrations and loads via runoff and sediment transport.

2-Materials and method

A portable rainfall-runoff simulator-Microscale was used to carry out the rainfall-runoff experiments in the laboratory and field. The simulator (Fig.1) is made up of four principle components: (1) the stainless structural frame; (2) Drop former and water reservoir mounted on structural frame that are on the height of 1.46 m above the ground; (3) the water supply system (4); and a pecked soil lysimeter (33 cm wide x 48 cm long x 20 cm high) for in door experiments and a plot frame (33 cm wide x 48 cm long x 20 cm high) for outdoor experiments. A laboratory and field scale studies for investigating imidacloprid, clothianidin and fipronil fate and transport were conducted using lysimeters and plot frames on 5% slope. Pesticides were applied at recommended rates and rainfall events were simulated with 50 mm/hr (SD: ±3mm/hr) intensity for 60 minutes at one day after pesticides

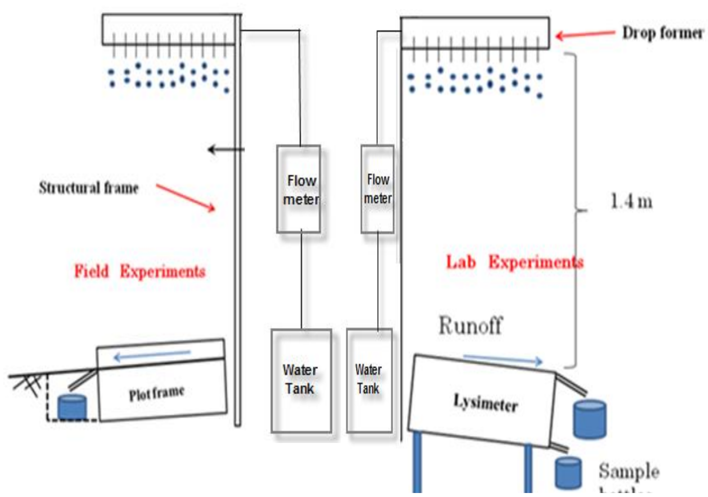

図 1 降雨シミュレータの概略 (PRRS-M)

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application with three replications. The runoff (~10 ml) was sampled at 10 min intervals for 60 minutes from the runoff start during the simulated events in both experiments. Runoff rate (mm/hr) was calculated from the volume of water and the sampling duration. Also, the amount of sediment in the water phase were measured. Sediment concentration (g /L) was calculated from mass of oven dry sediment and mass of water. For pesticide analysis, runoff (800 ml) was collected from the runoff outlets in glass bottles at 10, 20, 30, 40, 50, 60 min after runoff started. These samples were filtered (glass microfiber filters, Grade GF/B 60 mm) to determine pesticides concentrations in the sediment and water phases by HPLC-DAD. The pesticide residues in soil samples collected from the studied plots in lysimeter and in field soil before (1 cm depth) and after (1, 2-5, 5-10 and 11-13 cm depth) rainfall simulation were analyzed in order to determine downward movement of tested pesticides in soil.

3. Results and discussion

The rainfall simulator presented here is a simple and efficient tool to use in field and laboratory measurements. The runoff pattern was similar for all plots at both indoor and outdoor sites. The runoff commenced on average 20 min after start of rainfall for both sites. After initiation of experiments, the runoff increased until it reach a steady state condition. In this study, pesticide concentrations in water and sediment were normalized related to initial applied concentration of pesticides. The highest normalized concentration for all three insecticides were detected in the first runoff samples for both sites simulated. The average dissolved normalized concentration of fipronil, clothianidin and imidacloprid displayed an exponential decline against cumulative rainfall. Unexpectedly, the exports of the three insecticides through water and sediment runoff were negatively correlated with the values of linear soil water partitioning coefficient (Kd) and their water solubility. Whereas, Fipronil was found highest normalized concentration in water and sediment at both simulated sites, despite its highest sorption coefficient. The insecticide losses in runoff samples, as percentage of the amount applied, were 5.7% for fipronil, 1.4 % for clothianidin and 0.9 % for imidacloprid under lysimeter simulation, while it was 6.6% for fipronil, 1.8% for clothianidin and 1.4 % for imidacloprid under field simulation. Fipronil was most susceptible to runoff at both sites. As well as clothianidin and imidacloprid may be transported out of the runoff active zone by leaching in to the soil profile before the initiation of runoff. The data showed that the downward movement of fipronil in soil is very limited as compared to imidacloprid and clothianidin. This is may be due to the strong adsorption of fipronil on soil mineral particles and organic material and also lower solubility in water.

4. Conclusion

In this study, a microscale portable rainfall-runoff simulator system was used for investigating pesticides runoff from upland condition for both indoor and field experiment. The rainfall simulator is simple, easy to maintain and transport. Therefore, it is useful in both laboratory and remote field work. The rainfall simulator is capable of generation reproducible constant intensity rainfall. The lower water solubility and higher Kd of fipronil led to fipronil was most susceptible to runoff at both sites.

References: Bowyer-Bower, T. and Burt, T. (1989). Rainfall simulators for investigating soil response to rainfall. Soil Technol., 2: 1–16.; Hamed, Y., Albergel, J.; Pépin, Y.; Asseline, J.; Nasri, S. and Zante, P. (2002). Comparison between rainfall simulator erosion and observed reservoir sedimentation in an erosion-sensitive semiarid catchment. Catena, 50:1-16. ; Sangüesa, C.; Arumí, J.; Pizarro, R. and Link, O. (2009). A rainfall simulator for the in situ study of superficial runoff and soil erosion. Chil. J. Agr. Res., 70(1):178-182.