The Influence of Soil Surface Temperature and Relative Humidity on 2,4-D Volatilization

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Abstract

2,4-Dichlorophenoxyacetic acid (2,4-D) is the most common and widely used herbicide all over the world. In 2014, the US Department of Agriculture approved a new generation of genetically modified soybean and corn that are resistant to 2,4-D. With new crops available, an increase of 2,4-D usage of 200 to 600% is predicted by 2020, which means the 2,4-D drift concern (Figure 1) will also significantly increase.

The objective of this research project is to determine the influence of soil surface temperature, relative humidity(RH) as well as soil mineral composition on 2,4-D volatilization. The monolayer water content of the smectite is 3.37%, We applied 2,4-D amine to the smectite at a rate of 2.24 kg/ha, ran with the VSA at 25°C, 5%,15%,65% and 95% RH for 24h. 2,4-D was then extracted from the soil using methanol and analyzed on an HPLC. 44.07%,27.31%,19.33% and 27.61% of 2,4-D were volatilized at different RH. We conclude that more 2,4-D was volatilize if the soil water content is below the mono-layer water content in comparison to soil water contends above monolayer water content.

Introduction

Research on 2 ,4-D volatilization was mostly conducted on the field scale. The temperature and RH are very variable and therefore it is hard to accurately determine the effects of a single factor on 2,4-D volatilization. Studying volatilization of herbicides is very challenging because diurnal cycles of soil surface temperature and RH have to be accurately controlled. Schneider et al. (2013) studied volatilization of two herbicides under constant RH conditions (60% and 90%), and under changing conditions. However, few have studied the effect of diurnal variations of soil temperature and RH on herbicide volatilization. A new instrument called a vapor sorption analyzer (VSA) that allows accurate manipulation of RH and temperature is now commercially available (Arthur et al. 2014, and Figure 1). For the first time, it is possible to study vaporization of herbicides as affected by temperature and RH regimes.

Our objective is to improve our understanding of herbicide fate in agroecosystems by determining how soil temperature, RH, soil properties(e.g., texture, mineralogy), and different formulations affect 2,4-D volatilization. Our intent is to mimic realistic environmental (i.e. temperature and humidity) conditions in a lab using VSA technology.

Figure 1. 2,4-D Injury on Soybean.

Figure 2. Vapor Sorption Analyzer (VSA).

Methods and Materials

Table 1. Experimental Materials Used in This Study.

Minerals		location
Kaolinite	KGa-2	Warren County, Georgia
Smectite	ISCz-1	Czechoslovakia
Na rich montmorillinite	SWy-3	Crook County, Wyoming
Ca rich Montmorillinite	STx-1b	Gonzales County, Texas
Cecil soil	Bt2 horizon	Alabama
Dothan soil	Bt2 horizon	Alabama
Orangeburg soil	Bt3 horizon	Alabama

2,-D Amine:
Active ingredient: Dimethyl amine salt of 2,4-Dichlorophenoxyacetic acid.....47.3%
Other ingredient:..... 52.7%

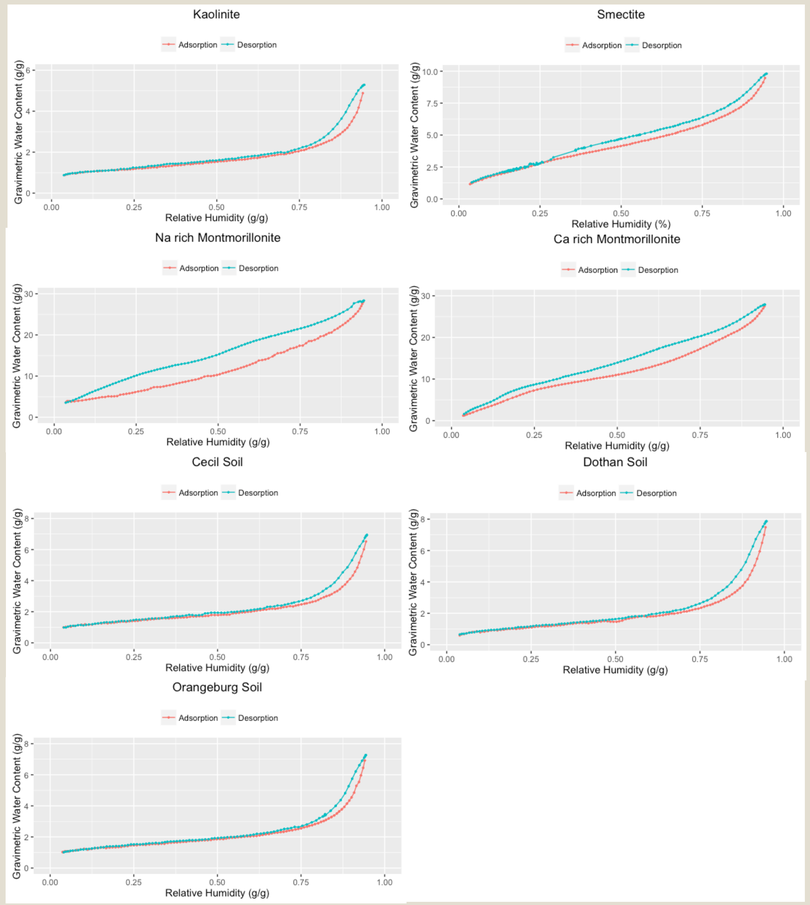

Figure 3. Dynamic Isotherms of Experiment Materials.

Results

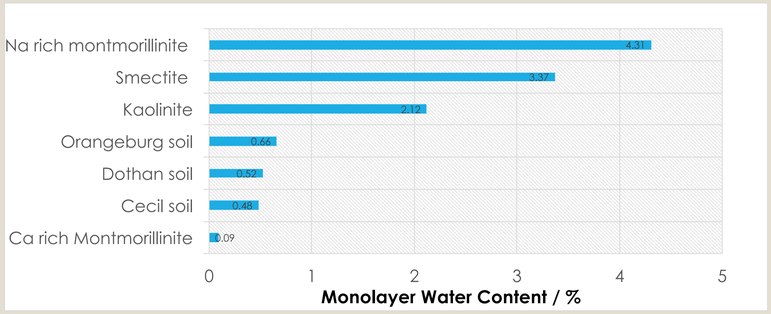

Figure 4. Monolayer Water Content of Experimental Materials.

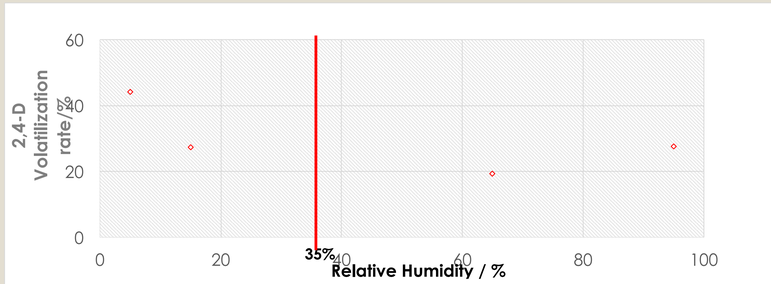

Figure 5. 2,4-D Volatilization Rate of Smectite.

Conclusions

1. The mono-layer water content (ML) differs among individual soil minerals as well as among surface horizons collected from Alabama benchmark soils.
2. There is no clear result shows that more herbicides volatilize if the soil water content is below the mono-layer water content in comparison to soil water contents above ML.
3. Below the ML, volatilization decreases as the increasing of soil water content; Above the ML, volatilization increases as the increasing of soil water content.

Future Research

1. We will conduct more volatilization test on different soil minerals under different RH.
2. We will mimic realistic environmental conditions and determine 2,4-D volatilization in simulated diurnal temperature and relative humidity cycles.

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