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A Statistical Analysis of the Effect of Droplet Volume on Water Droplet Penetration Time Results

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The water droplet penetration time (WDPT) test is a commonly used method for determining the degree of soil water repellency. The method involves depositing a droplet of water on the soil surface and then recording the time to infiltration. A number of repellency scales exist to relate WDPT results to a qualitative degree of repellency that can be easily communicated or compared with other studies (Bisdom et al., 1993; Doerr, 1998). While the WDPT method is straightforward, the volume of water droplets used varies between studies, and often these details are not included when reporting results. The aim of this study was to determine the typical distribution of results for WDPT tests on a sandy soil and the effect droplet volume has on the distribution.

Droplets were placed in regularly spaced intervals on trays of naturally repellent sandy soil and the time to infiltration was recorded. Four droplet volumes were tested (15, 20, 80 and 200 μL), and each volume was tested using 4 replicates of 104 droplets.

Results for each droplet volume reasonably fit a normal distribution ($0.8609 < r^2 < 0.9837$), and WDPT is found to decrease with increasing volume. The mean WDPT for 200 μL droplets (281 s) was significantly (α = 0.05) lower than that for 15 μL droplets (461 s) on the same soil. Variability also decreases with increasing volume; the range of 200 μL WDPT results was 305 s with a standard deviation of 47 s. The range for 15 μL droplets was 3438 s, with a standard deviation of 257 s.

WDPTs were also recorded for 20 and 200 μL droplets on 3 soil mixes of wettable and repellent sands, in ratios of 10:90; 25:75; and 50:50. For every mix, mean WDPTs, range and standard deviations were again lower for 200 μL droplets than for 20 μL droplets.

The variability of these results also indicates that, for the sandy soil used in this study, the number of droplets required to estimate the mean WDPT to within $\pm$ 10% are significantly different for different droplet sizes. If 200 μL droplets are used, 11 WDPT measurements would be required; if 15 μL droplets are used, 130 WDPT measurements would be required.

The results of this study suggest that larger droplets provide a more precise measure of WDPT using fewer samples, while smaller droplets more clearly reflect heterogeneity within soil, and therefore require more samples for precise measurement of the mean. The volume and number of droplets used to measure WDPT should therefore be determined according to the context of individual studies.

References:

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