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EXTENDED ABSTRACTS BOOK

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METODOLOGY TO MEASURE THERMAL DIFFUSIVITY IN INTACT SEED IN SOIL COLUMN BY LOW RESOLUTION NMR

Maria G. A. Carosio[a*]; Luis A. Colnago[b]
[a]*INSTITUTO DE QUÍMICA DE SÃO CARLOS*, [b]*EMBRAPA INSTRUMENTAÇÃO AGROPECUÁRIA* **carosio@iqsc.usp.br*

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Soil temperature varies in time and space, depending on soil types, land use, vegetation, time of year, and climate. It is an important parameter to understand atmospheric, drought and others climate events. Soil temperature is related to fauna, flora and microbiological activities. It is also important in agriculture and affects directly the seed germination, water's evaporation and plant growth. In cold climates, it is necessary to wait the soil temperature to reach a minimum value for a specific crop. In the tropics, the problem is related to the high soil temperatures. Some seeds may survive in high temperature environment for days, but the seedling may die in few hours. The temperature on soil surface is directly influenced by solar radiation. The heat transferred to lower soil level is a function of the temperature gradient and the soil thermal properties. The thermal diffusivity (λ) of the soil depends on its structure as well as on its moisture content. This parameter is calculated according to the theory of heat transfer and it is related with thermal conductivity (k), specific heat (Cp) and density (ρ), according with the equation (λ=k/Cp.ρ). This property shows how heat can be carried into the soil.

The current methods to measure soil temperature in function of dept are based on conventional thermometry. Here we are showing that we can use low resolution NMR to measure soil thermal properties using oilseeds as a sensor. The measurement is based on the T_2 dependence of oil viscosity and temperature.

The T_2 measurements were carried out in a SLK-100 Spin Lock spectrometer, (Córdoba, Argentine), model SL.IM.01. The spectrometer uses a 0.23T permanent magnet and a 33mm probe. The CPMG pulse sequence used in T_2 measurements uses for $\pi/2$ and π pulses were 5.8μs and 10.28 μs, respectively; tau=2000μs and 400 echoes, acquisition time 10.6 μs and four scan with repetition time 15000ms. The calibration of seed temperature in the soils samples were checked using an infrared thermometer. The soil temperature and thermal diffusivity were obtained in two soil samples (sandy and clayey soil) using spherical oilseed, *Macadamia integrifolia*. For the measurement of temperature in function of time, the samples (soil and seed) were heated up to 80°C.

Figure 1 shows the variation of T_2 as a function of oil in oilseed temperature, that fit with an exponential function $y = 83{,}397 - 76{,}505.e^{-(x/0{,}3632)}$ where y is temperature and x is the T_2.

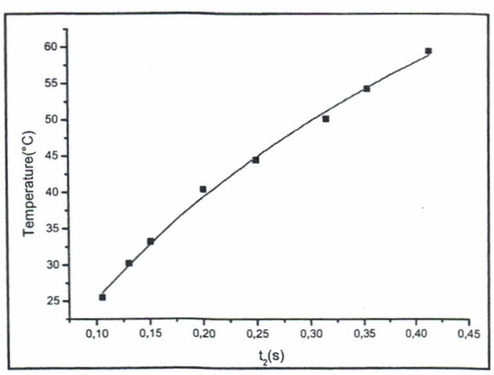

Figure 1 – Variation of T_2 as a function of oil in oilseed temperature

With this equation and T_2 values we obtain the variation of temperature in function of time for sandy and clayey soils shown in figure 2.

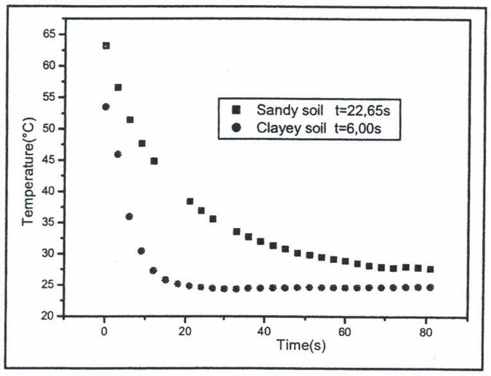

Figure 2 – Variation on temperature in function of time in sandy and clayey soils.

With this information, it was calculated soils thermal diffusivity value. The sample were spheres and the equation of diffusion is

$$\frac{\Theta(r,t)-\theta_0}{\theta_b-\theta_0} = 1+2\sum_{n=1}^{\infty}(-1)^n e(-n^2\lambda\pi^2 t/a^2)\frac{sen(\pi n r/a)}{\pi n r/a}$$

equation 1

where $\Theta(r,t)$ - θ_0/ θ_b - θ_0 is the variation of temperature, *n* is the direction of heat, λ is thermal diffusivity, *t* is the constant obtained from the figure 2, *a*, is the diameter of sphere and r is the radius of the sphere.

Neglecting the sine component and n=1, we can estimate the value of thermal diffusivity, according the equation 2

$$\lambda = (a / \pi)^2 . 1 / t$$

equation 2

Therefore to sandy soil with t=22,65 s and a=0,02 m, the thermal diffusivity (λ) was $7.15.10^{-6}$ m^2/s, to clayey soil with t=6,00 s and a=0,02 m, the thermal diffusivity was $2.70.10^{-5}$ m^2/s. These values agree with literature, which estimate the thermal diffusivity in $4.6.10^{-6}$ m^2/s. The differences in the values of the two samples is related with porosity, moisture, substances like organic matter and iron, compaction and other characteristics that influences the thermal diffusivity.

We can note that small values of diffusivity show small depth of penetration. So, the heat diffuses better in the clayey soil than the sandy soil; and confirming that the sandy soil does not keep the heat like the clayey soil.

This study show that with the information of T_2 and theory of heat transfer is possible find values of thermal diffusivity and the non-invasive nature of the measurement makes it possible to obtain information in vivo and quickly, compared with other techniques.

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