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A portable instrument for determining soil temperatures at various depths

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ABSTRACT. A portable instrument using thermocouples for measuring soil temperatures has been designed and constructed. The instrument as constructed can record temperatures at depths of 5, 10, 15 and 30 cm and also at depths of 10, 15, 20 and 35 or 15, 20, 25 and 40 cm by inserting it into the soil to different points. The instrument can be installed by simply driving it into the soil without materially disturbing the soil packing or the vegetation cover and reliable readings can be obtained within a short time of its insertion unlike in the case of ordinary soil thermometers.

1. Introduction

Soil is the natural environment for the root zone of crop plants. Therefore, the measurement of soil temperature occupies an important place in the scheme of research of the Agricultural Meteorology Division at Poona.

The usual method for measuring soil temperatures is to use mercury in glass thermometers with long stems and bent bulbs, installed in the soil with their bulbs horizontal and at the appropriate depths. Though this is a simple method, its use is restricted, because consequent to the installation of the soil thermometers, the soil takes some time to settle and hence reliable readings can be obtained only after this time, which will be of the order of two or three months. Further, as the soil thermometers become a more or less permanent installation, their use in cropped fields interferes with cultural operations and, therefore, the use of soil thermometer inside cropped fields is rather inconvenient. These thermometers are not therefore suitable for quick determination of soil temperatures especially when it is required to measure soil temperature inside cropped fields.

2. Details of the Instrument

The need for an instrument for measuring soil temperature at different depths which can be easily shifted from place to place has long been felt. Portable instruments using thermocouples to measure temperatures have been constructed by Pasquill (1949) and more recently by Rider (1955). The instrument designed and described in this article is based on the same principle but with some modifications which make it simple to construct and use the instrument.

A sketch of the instrument with its constructional details is given in Fig. 1. Measured lengths of tufnol tube of 1 inch outer diameter and 3/4 inch inner diameter are threaded at the ends and joined together by copper couplings C_1, C_2, C_3 and C_4 of the same outer diameter to form a single tube. A brass spike D is screwed in to the lower end of the tube and the top of the tube is closed by a brass cap which houses a multiswitch. Thermocouples made from 32 S.W.G. constantan wire (silk covered) and 26 S.W.G. copper wire (cotton covered) are soldered to the inner surface of each of the copper couplings C_1, C_2, C_3 and C_4. The constantan leads from these thermo-junctions are taken to terminal A at the top and the copper leads are taken up and connected to the contact points 1, 2, 3 and 4 of the multiswitch, the pole of which is connected to the terminal B. One single reference junction enclosed in a thin glass tube is used with all the four junctions in the instrument.

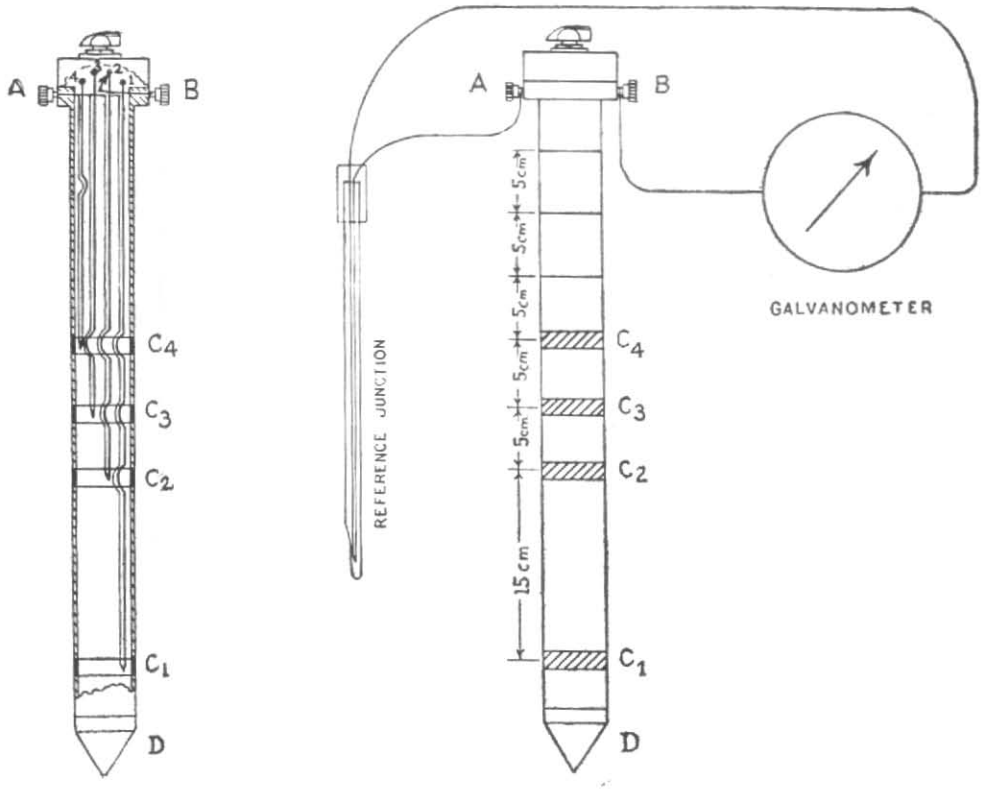

Fig. 1

When in use, the reference junction is kept immersed in water at constant temperature contained in a thermosflask and the constantan lead from it is connected to the terminal A of the instrument and the copper lead is connected to terminal B through a sensitive galvanometer. The sensitive galvanometer used is manufactured by M/s Laboratory Apparatus Works, Poona and has an internal resistance of 10 ohms giving a full scale deflection of 25 divisions for a temperature difference of 10°F between the reference junction and any of the junctions inside the tube. An external resistance was used in the circuit when the range of temperature expected was of a higher order. The galvanometer is thus very sensitive, showing a change of about 2·5 divisions for a temperature change of 1°F. It can be read correct to tenth of a division giving the temperatures correct to 0°. 1 F.

The instrument was constructed to record soil temperatures at depths of 5, 10, 15 and 30 cm. It can also be used for recording temperatures at depths of 10, 15, 20 and 35 cm or 15, 20, 25 and 40 cm by inserting it into the soil to different marks. The instrument can also be constructed so as to record the temperatures at any other depths.

The use of the instrument is very simple. It can be just driven into the soil without materially disturbing the soil. When the soil is hard, an iron rod of the same diameter and ending in a similar spike as that of the instrument, is first hammered into the soil to the required depth. It is then slowly removed and the instrument is inserted in its place. Accurate readings of soil temperature can be obtained within half an hour of the insertion of the instrument into the soil. Once the instrument is inserted into the soil, temperatures at all the four depths can be recorded one after another by working the switch at the top. If the instrument is kept inserted in the ground, when the switch is turned on, the galvanometer gives a steady reading within about 30 seconds. This shows that the instrument has very little lag.

TABLE 1

Comparative observations between (A) temperature readings as recorded by the mercury soil thermometers and (B) those as recorded by the portable thermocouple instrument

Depths (cm)	No. of obervations n	Mean difference $m = A - B$ (°F)	Standard error of mean σ_m	$t = \frac{m}{\sigma_m}$
5	43	0	1·1	0
10	46	— 0·2	1·2	0·2
15	50	— 0·6	1·0	0·6
30	49	— 0·9	0·8	0·9

The calibration of the instrument is done using stirred water baths of different temperatures. It has been found that the same calibration curve holds good for all the four thermocouples.

3. Comparative readings

Comparative readings of the instrument were taken with those of soil thermometers for depth of 5, 10, 15 and 30 cm by inserting the instrument into the soil adjacent to the soil thermometer plot at the Central Agricultural Meteorological Observatory, Poona. A set of soil thermometers were also installed in another plot and comparative readings taken. It took about two months for the soil to settle after the installation of the soil thermometers before the readings given by them were comparable with those indicated by the portable thermocouple instrument. Later, the readings agreed to within 2°F. This difference may be due to the fact that the portable instrument is more sensitive and has less of lag when compared to the mercury thermometers.

A statistical examination of the comparative readings obtained from the soil thermometers and the portable thermocouple instrument for the various depths is given

in Table 1. It will be seen from the data given in the table that the differences are not significant.

The portable instrument as constructed will be very useful especially for determining soil temperatures under crops where it is not possible to install the ordinary soil thermometers.

4. Acknowledgement

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