Geneva Leaf-Wetness Detector

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ABSTRACT

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An electronic instrument that measures the incidence and duration of leaf wetness, ie, free water on leaf surfaces, needs only a low power supply and may also be used to activate other devices, such as spore traps. Leaf wetness can be recorded on a modified weather-recording instrument, such as a hygrothermograph, or used on-line in a disease-forecasting computer program. The Geneva instrument compared favorably with the deWit detector in measuring leaf wetness in apple orchards and bean fields.

Many important airborne fungal pathogens of foliage depend on free moisture on the host surface for the infection process. Control of these diseases with after-infection fungicides (curative treatments) requires accurate recording of prior host surface wetting. For example, timing of after-infection fungicide sprays to control apple scab, caused by *Venturia inaequalis* (Cooke) Wint., has been based primarily on Mills' periods, which estimate infection periods as a function of leaf-wetness duration and temperature (2). Improvements in scab control by fungicides requires more precise estimates of leaf wetting than is possible by visual observation of the beginning of rain and the ending of leaf wetting. Automatic recording of the duration of leaf wetness by electronic instruments would provide reliable information on leaf wetness for integration into on-line pest management programs.

Commercial instruments are available for recording time and temperature or time and surface wetness, and at least one records all three simultaneously (3). The object of our research was to develop for field use an instrument that is reliable, accurate, simple, small, lightweight, inexpensive, battery-operated, and easy to read and interpret. The option of linking the instrument to a computer for rapid analysis of leaf-wetting periods or to activate other devices such as spore traps was also desired.

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MATERIALS AND METHODS

We evaluated several leaf-wetness measuring instruments, including the deWit 7-day recorder, which utilizes a hemp string as a wetness sensor; a circular glass plate fitted with an indelible pencil that writes on the rotating plate when the surface is wet (4); and some electronic devices of our own design. Electronic instruments met our criteria best, and we studied several variations of sensors, circuitry, power supply, and recorders. The Geneva leaf-wetness detector is the most satisfactory model developed by us to date.

Apparatus. The device records the presence or absence of free moisture on the surface of a simulated leaf sensor. The sensor is placed at the location where leaf wetness is to be monitored and is connected to the detector circuitry, an event recorder, and a 12-V direct-current power supply (Fig. 1). At programmed intervals, current is allowed to flow momentarily to the sensor. If the sensor is wet, the current continues to the event recorder, where a pen arm is activated and wetness is recorded on a chart. If the sensor is dry, current does not flow to the recorder and no wetness is recorded.

The leaf-wetness sensor, which acts as the leaf simulator, consists of a 0.25-mm (0.01-in.) gold-plated printed circuit grid plate (Wong Laboratories, Cincinnati, OH 45209) coated with two thin layers of latex paint. The sensor is similar to that of Davis and Hughes (1). Wet and dry conditions are determined by measuring the resistance across the grid plate. When moisture is absent, resistance is very high and electricity cannot flow across the grid. When moisture is present, resistance drops to a low level, enabling current to pass through to the second half of the circuitry. The installation of a 20,000-ohm variable resistor between the sensor return line and ground enables the on-off actions of the sensor to be recorded at a specific resistance level. Further details about the design of the electronic components (Fig. 2) are available from the authors.

Recording devices. Leaf wetness is recorded on a standard thermograph modified with an additional pen for this purpose. A Bendix-Friez (The Bendix Corp., Baltimore, MD 21204) and Weather Measure (Sacramento, CA 95841) thermograph or hygrothermograph were the easiest to adapt. In addition to providing time, temperature, and humidity data, these units are constructed so that a wetness pen assembly can be mounted. Other types of instruments have limited mounting space or features

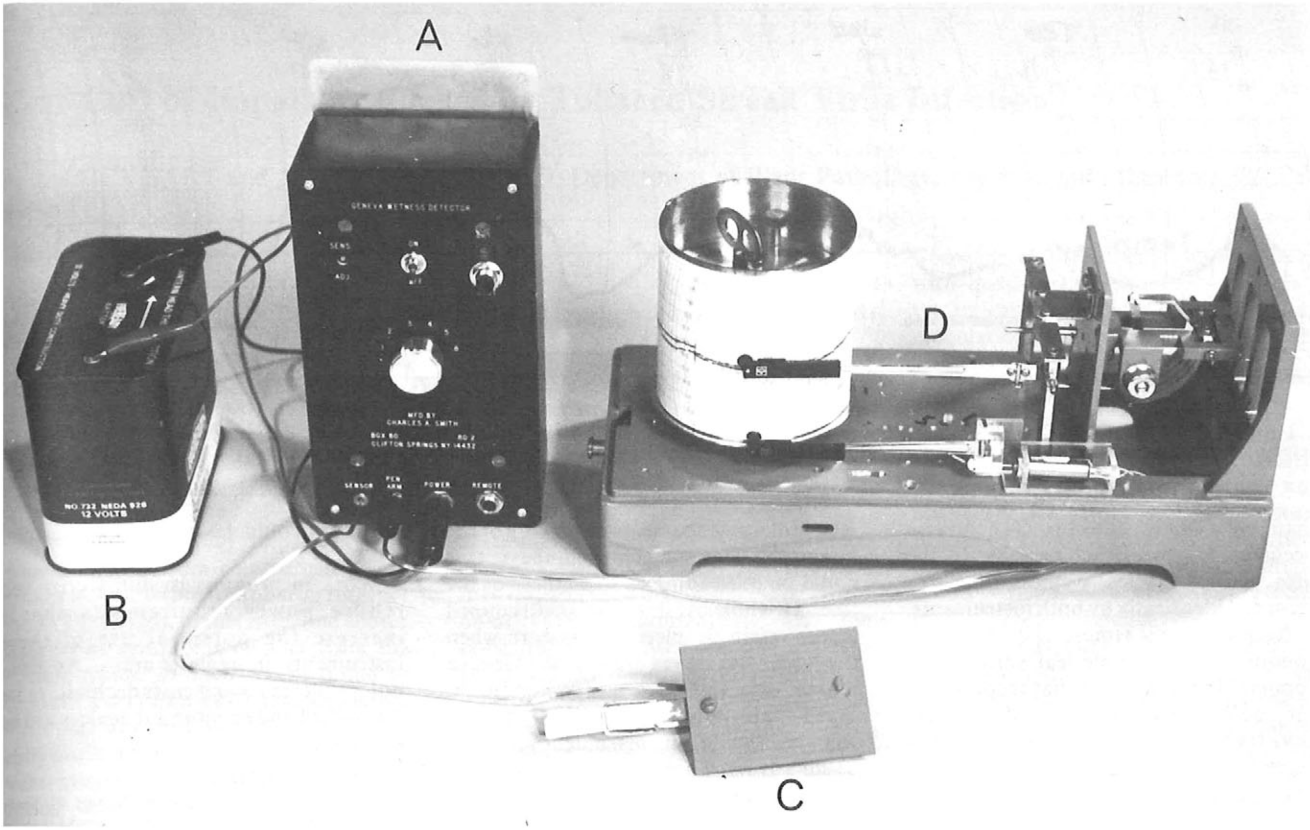

Fig. 1. Geneva leaf-wetness detector **(A)** with battery **(B)**, sensor **(C)**, and recording device **(D)**. Upper pen records temperature, and lower pen records leaf wetness.

preventing installation.

Power supply. The circuitry requires only a small battery for operation, with the power requirements of external devices dictating the size of the power supply needed. A small lantern-type 12-V battery operates the wetness detector and pen solenoid for at least 1 yr. Rechargeable 12-V batteries are recommended if devices such as Rotorods are operated. A 12-V relay with 110-V contacts permits the use of 110-V alternating current.

Variations and cost. Several variations of the basic unit have been tested. The most promising and convenient consists of a 7.5 × 10 cm (3 × 4 in.) printed circuit board with sockets attached for the chips and transistors. The board is mounted in a 11.5 × 18.5 cm plastic box. Provisions are made for external connections for sensor adjustment, power supply, pen arm solenoid wire, and remote device switch. The cycle of the circuitry pulse can be changed to any one of six predetermined time cycles by means of a two-pole, six-position rotary switch, externally controlled. A momentary contact switch plus light provides a means of checking battery power. The components for the basic circuitry for the Geneva wetness detector cost approximately $50, excluding pen and other remote devices, and are available from any electronics supply outlet. Assembly time of the basic unit circuitry is approximately 8 hr. The instrument is commercially available from Seneca Orchards, R.D. #2, Clifton Springs, NY 14432.

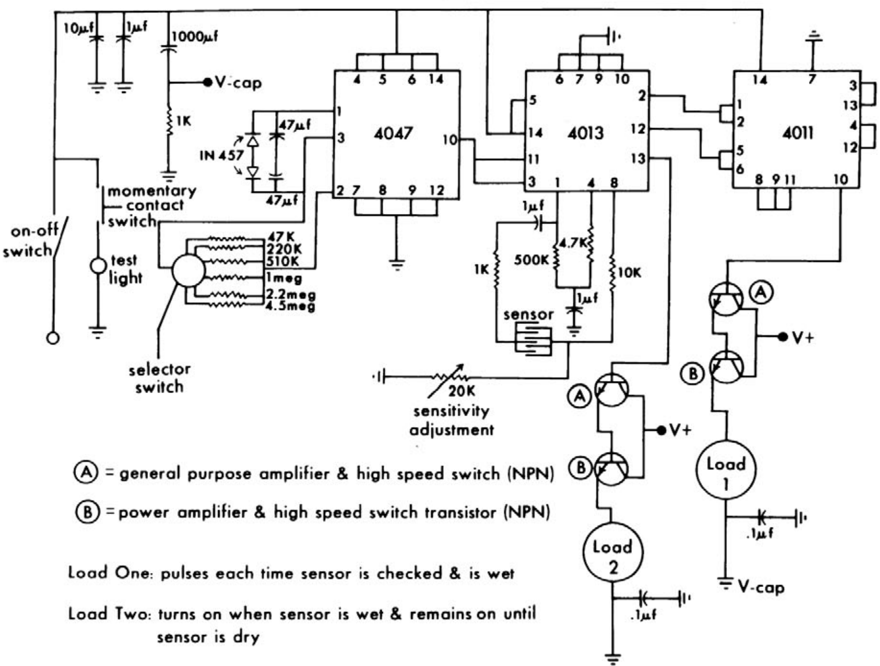

Fig. 2. Schematic diagram of Geneva leaf-wetness detector.

RESULTS AND DISCUSSION

In 1978 and 1979, the deWit and Geneva wetness detectors were compared for measuring apple leaf wetness. Sensors for both detectors were placed side by side approximately 1.5 m from the ground within the canopy of a full-sized apple tree on seedling rootstock. Figure 3 shows wetness period recordings for both devices for a 1-wk period in 1978. Five leaf-wetness periods were recorded. On two occasions the deWit detector recorded leaf wetness for an hour longer

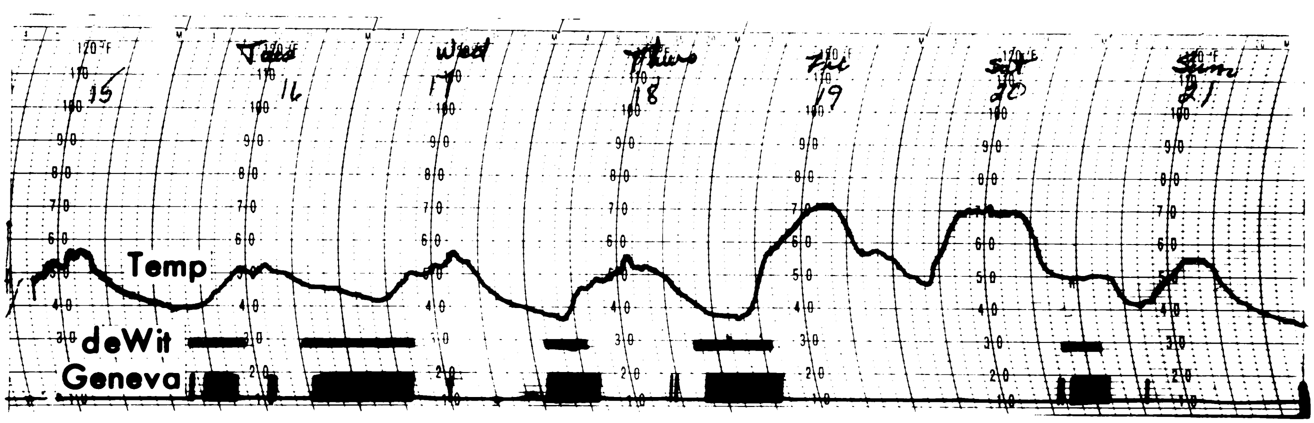

Fig. 3. Leaf-wetness periods recorded simultaneously by the deWit and Geneva detectors for the week of May 15–21, 1978. Data from the deWit detector were transferred to the thermograph recording chart of the Geneva leaf-wetness detector for this comparison.

than the Geneva detector. The reverse occurred for two other periods. In the fifth period, the leaf-wetness time was recorded identically by both instruments.

At numerous times, the moisture condition of the apple leaf surface was compared visually with that recorded by the deWit and Geneva detectors. Invariably, these visual observations agreed with the recorded readings. Visual observations indicated that the Geneva sensing system responds to light misty rainfall sooner than the deWit detector does. The deWit instrument must absorb moisture into a string and create sufficient tension to mechanically move a pen. The same principle applies in an inverse manner during a drying period accompanied by light winds. Air moving through apple trees shakes off water and/or hastens its evaporation from the leaf surface. The latex paint on the surface of the Geneva sensor allows close simulation of the evaporation process. In the early part of the apple-growing season when foliage is sparse, rapid drying of the larger flat leaf surfaces and the sensor could be misleading as to wetness of the tree as a whole. At this time, small cupped leaves retain droplets of moisture when the larger flat leaves are dry; the Geneva sensor also indicates a dry condition. With calm conditions during leaf wetness, the deWit instrument seems to be slightly more accurate than the Geneva device. In spite of these minor variations, both instruments are satisfactory for recording leaf-wetness duration when calculating Mills' apple scab infection periods.

Eight Geneva leaf-wetness detectors were also utilized to monitor leaf wetness of snap beans throughout western New York State during the 1978 growing season. A deWit detector was installed for 1-wk periods in some fields for comparative studies. An analysis of charts showed that the deWit and Geneva instruments recorded similar wetting of bean leaves. In addition, all Geneva detectors could be adjusted to perform alike.

Work in progress to miniaturize and reduce power requirements should increase the potential use of these instruments in remote areas. As technology increases and costs decrease, more diversified and economical devices will be possible.

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