NESTING MULTIPLE CONTROLLED ENVIRONMENTS FOR INDEPENDENT MANIPULATION OF SHOOT AND ROOT TEMPERATURES

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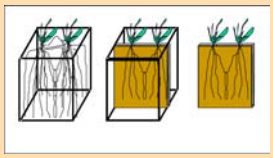
Introduction

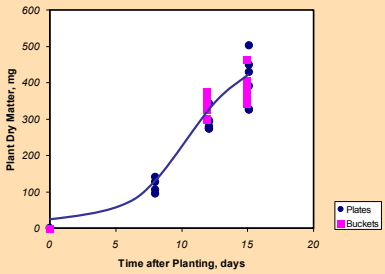
In nature, the roots and shoots of many crops are frequently exposed to greatly differing temperatures. To study such effects we combined three environmental control systems to allow independent manipulation of shoot and root temperature for maize seedlings. The apparatus was housed in two PGW-36 Conviron growth chambers which controlled humidity, CO_2, light intensity, and provided a constant external temperature for the apparatus.

Cuvettes

Roots are usually hidden in soil and cannot be easily measured without destructive harvest. Rather than growing plants "naturally" in a 3-D soil mass (buckets), plants were grown in 2-D between clear acrylic plates (cuvettes). This made some of the roots visible so that non destructive quantitative measurements were possible..



Comparisons showed that total root length, plant dry weight etc, were comparable between plants grown in buckets and cuvettes



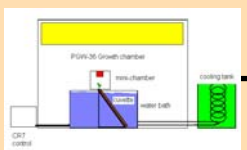
Rationale

Problem:
Interdependent factors are governing shoot and root biomass production, root proliferation within soil layers, and root penetration into successive soil layers. These cannot be studied in the field, and root growth cannot be predicted at the moment.

Solution:
A model system (cuvettes) is used to quantify shoot and root growth under a variety of environmental conditions, from which a computer simulation model will be developed to describe and predict shoot and root growth

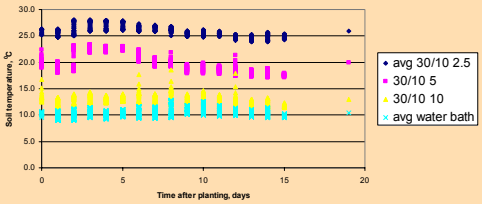
Apparatus

Two water baths (55 x 103 x 50 cm) were placed in each of two PGW-36 chambers. Each cuvette was filled with soil and then wrapped in three, 3 mm, polyethylene bags. Four cuvettes were stacked in each tank, totaling sixteen cuvettes. A mini-chamber (31 x 61 x 55 cm) was placed over each group of four cuvettes.



Experimental control

The temperature in a mini-chamber was controlled by an electric-plate heater and a fan to circulate the air. Water was circulated from the water baths and chilled in an ethyl-glycol tank. Temperatures were controlled by adjusting the temperature of the ethyl glycol in the tank using a laboratory chiller. The PGW-36 chamber temperature was set below the water bath temperature to compensate for the heat load from the MH and HPS lamps (16 lamps x 400 W). Soil temperatures were measured at 2.5 cm, 5 cm and 10cm depths.



Average water bath and soil temperatures at 2.5, 5 and 10 cm below the surface during an experiment with air and water temperatures at 30°C and 10°C respectively.

Results

A number of experiments were conducted, in which the shoots and roots of juvenile maize (Pioneer 3325) were subjected to different temperatures. The water baths were held at constant temperatures of 10, 15 and 20°C. Above the baths, shoots were subjected to constant temperatures between 10°C and 40°C.

Conclusions

By nesting smaller controlled spaces within a growth chamber we were able to separately control root and shoot temperatures, enabling a series of studies subjecting roots and shoots to constant temperature differences as great as 30°C.

Problems encountered were:

- Achieving a stable temperature gradient in the soil profile. This required frequent adjustment of water cooling control, and chamber temperature settings. Cycling of water bath temperature was caused by temperature fluctuations of the unconditioned building space in which the cooling tank was housed.
- Keeping the soil in the cuvettes dry. Wrapping each cuvette in three or more polyethylene garbage bags was effective but awkward and time consuming.

Contacts

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