Some Factors Affecting Seed Germination and Seedling Growth©

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Poor uniformity of seed germination and early seedling growth rates are major obstacles in conventional propagation. This paper combines some principles of propagation with climate control and may help growers better understand and then control seedlings environmental factors.

The physical environment affects seedling physiology (photosynthesis, transpiration, and respiration), with factors interacting to control growth rate and uniformity. A strategy for controlling environmental factors will benefit seedling etiolation, hardiness, and disease control.

ENVIRONMENTAL FACTORS AFFECTING SEED GERMINATION

Optimum temperature and moisture for seed germination fall within a range where the largest percentages of seedlings are produced at the highest rate. The maximum water vapor in the air at a particular temperature can be determined in a Mollier diagram (Kamp and Timmerman, 2002). Fluctuating temperatures in a seed bed and in a greenhouse cause relative humidity changes that affect uniform germination. Automated computer control from temperature sensors in propagation compartments can provide the optimum relative humidity necessary for germination uniformity.

For example: At dawn, the greenhouse temperature is 17 °C and the seedbed temperature is 22 °C. The air inside the greenhouse absorbs heat from the seedbed by evaporating water from the medium. This phenomenon usually happens in early morning.

At mid-day, the greenhouse temperature is 27 °C and the seedbed temperature is 20 °C. Heat will be transferred to the medium as water evaporates, taking heat from the greenhouse air.

In addition to temperature, moisture is vital for germination. For example: In two greenhouse seedbeds (24 °C with RH = 100% and 25 °C with RH = 70%), a Mollier diagram (Kamp and Timmerman, 2002) indicates a water vapor pressure in the medium of 3 kpa and in the atmosphere 2.25 kpa. This vapor pressure difference is 0.75 kpa so water will evaporate from the seedbed into the air until eliminating the deficit. The heat required for this evaporation is taken from the greenhouse air and maybe from the seedbed so absolute humidity in the medium will decrease. A computer can measuring the humidity deficit in the seedbed and calculate the target value (target value = set value + adjustment).

ENVIRONMENTAL FACTORS AFFECTING SEEDLING PHYSIOLOGY

Each crop has its own demands on the environment. The basic principles that influence all crops are photosynthesis, transpiration, and respiration.

Optimum photosynthesis requires light, CO_2, temperature, and water. The most restrictive factor determines the rate of photosynthesis. Many settings in the environment control computer program are used; however, the best is light intensity.

Transpiration increases when the water vapor pressure differences between the inside stomatal cavity and air is greater, the transpiration rate is more, and the guard cell's resistance is less. The water vapor pressure in turn depends on the difference between air and plant temperature. For example: when the plant temperature is 24 °C and the greenhouse temperature is 26 °C with a RH of 80%, the water vapor pressure [based on a Mollier diagram (Kamp and Timmerman, 2002)] is 3 kpa and in the greenhouse is 1.9 kpa. The plant will transpire if the resistance of the stomata is less than 1.1 kpa (3 - 1.9 = 1.1). In this example, there would be a little transpiration.

Respiration means providing energy as carbohydrate for the plant's current and new cells. Respiration is strongly influenced by temperature.

ENVIRONMENTAL FACTORS AFFECTING POST-GERMINATION

Shading and decreasing light intensity are vital to decrease seedling epicotyl temperature. Appropriate substrate temperature and adequate oxygen levels stimulate more respiration in the hypocotyl for root development prior to the emergence of the foliage.

Seedlings need adequate water. Cell pressure in the seedling depends on the activity of root cells. For example: at a greenhouse temperature of 20 °C with a RH = 95%, a Mollier diagram (Kamp and Timmerman, 2002) indicates that the water vapor will be (AH = 14 $g{\cdot}kg^{-1}$). With the medium temperature at 22 °C with a RH = 85% (AH = $g{\cdot}kg^{-1}$), the water vapor pressure in a seeded flat and in the surrounding air are the same (2.25 kpa). As a result, there will be altered carbohydrate in the hypocotyl due to the higher rate of respiration which will benefit the formation of roots prior to leaf formation.

Under the low light conditions of heavy shading, high temperatures would be undesirable, increasing respiration and subsequently etiolation.

Good hardiness and disease control require strategies that optimize temperature and relative humidity to ensure cell tension.

A good root system prior to the emergence of the foliage is necessary for optimum water and nutrient absorption.

CONCLUSION

- Environmental factors and the plant's physiology go hand-in-hand
- A computer-controlled greenhouse simplifies environmental control to optimize the plant's physiology
- Obtaining changes in a plant's physiological triangle (photosynthesis, transpiration and respiration) can be calculated and controlled by software to set new values

REFERENCE

Kamp, P.G.H., and **G.J. Timmerman.** 1996. Computerized environmental control in greenhouses. A Step by Step Approach. Ede, Netherlands.