Water and Plant Growth

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INTRODUCTION

It is well known that maximum plant growth is dependent on an optimum water supply. Large amounts of water are passing through a plant, most of which is used for temperature regulation. It is generally accepted that 97% of the water taken up is transpired. This leaves 3% for other uses, and nearly all of this water is used in the growth process, whereas extremely little is utilized in chemical processes. The total amount of water used may be 350 litre (100 gal) per kg (2 lb) dry matter produced. Of the 350 litres of water, only 10 liters is used for growth, leaving 340 litres to be transpired. Small restrictions of water flow to the plant over a short time period would be harmless, if it only affected the water transpired. However, a decreased water supply quickly affects growth rate. Several factors are known to influence water availability.

Humidity. Under most growing conditions, the forces pulling water out of the leaf are so strong that transpiration has first priority causing even small levels of water depletion to affect plant growth more than expected. Each time a water molecule is transpired, a new molecule has to replace it to prevent water stress from occurring. Leaf growth decreases dramatically when well-watered plants are transferred from humid to arid conditions (i.e., a decrease in humidity from 85% to 50%) (Nagarajah and Schulze, 1983). Therefore, transpiration may limit growth even if the root system is well watered.

Water availability. Most of the water is taken up by the very tip of the root in the root hair zone. Just a few millimeters further up the root, and the ability of water to penetrate the root surface becomes difficult. Only a growing root is continuously making new cells where water uptake takes place. The implication of this is that, when a root experiences drought, the capability for water uptake diminishes, making it even more difficult for the plant to maintain its growth rate.

Temperature. When the temperature decreases, the viscosity of a liquid increases. This is also true not only for soil water, but also for the lipids in the cell membranes. When plants acclimatize to cooler temperatures, cell membranes change to minimize the effect on transport of ions, etc. through the membrane. However, in subtropical species, such as citrus, these membrane changes are not as pronounced as in subalpine species such as Engelmann spruce (*Picea engelmannii*) (Kaufmann, 1975). The consequence of this is that, at low soil temperatures, water uptake is restricted by high resistance in the roots and the resistance is higher in subtropical species.

Nutrition. The existence of a close relationship between plant growth and the nutritional status in the growing media is a well established fact. However, it is more surprising that there also may be a direct relationship between phosphorus levels and root resistance to water uptake. Radin and Edinboch (1984) have demonstrated such a relationship in young cotton plants. Under water stress conditions water flow through the roots of phosphorus-deficient plants was only one-third of control plants.

MATERIAL AND METHOD

Hibiscus cuttings (*Hibiscus rosa-sinensis*) were rooted hydroponically, and grown for an additional month in a full nutrient solution as described by Bertram (1991). The plants were grown at 20C. When plant roots were about 15 cm long, the apical 10 cm was cut off and placed in a Clark-type oxygen electrode and respiratory oxygen uptake determined at temperatures ranging from 5 to 35C. Fresh weight of the root was determined after the experiment was conducted.

RESULTS

Root respiration is strongly dependent on the temperature. At 30C, 0.3 ml oxygen per g fresh wt per hour was taken up, whereas at 5C this value had decreased to 1/10 (Fig. 1). The decreased respiratory oxygen uptake at 35C is most likely caused by a heat shock effect.

DISCUSSION

To ensure optimal plant growth, it is commonly accepted that growing media must have optimal air/water properties. However, this alone may not secure a good water uptake by the roots. When a drought situation has occurred, either because of natural causes in the field or by a failure in the watering system, excess watering

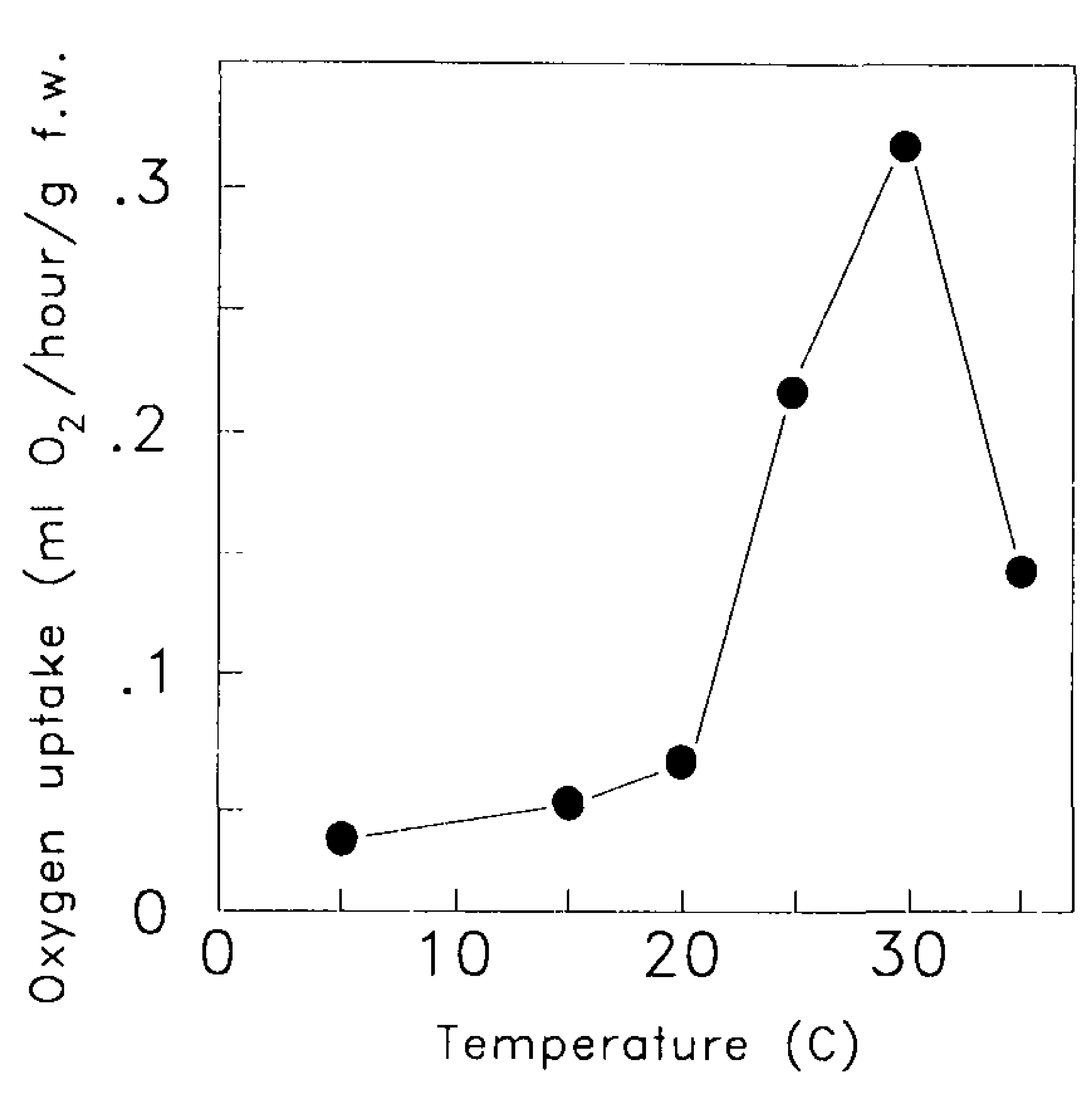

Figure 1. Temperature-dependent oxygen uptake in roots of*Hibiscus rosa-sinensis*. The plants were grown hydroponically at 20C until used for measurements.

is commonly observed afterwards. The plants therefore first experiences a drought which is followed by a flooding situation. On a smaller scale, this is also what occurs in greenhouse production, where ebb and flow tables are used. Under such conditions suffocation of the roots might be a possibility. In Denmark these conditions may be experienced during fall in the field. Under poor drainage conditions, the respiring roots will use up all the oxygen, and anaerobic conditions occur. This situation occurs 10 times faster at 30C compared to 5C. If uncontrolled watering occurs after a drought period, not only is the capability to take up water diminished, but anaerobic conditions may occur causing the young root tips to die, further constricting the water-uptake capability of the plant.

CONCLUSION

Water uptake of a plant is affected by a range of factors. To ensure optimal water conditions in the plant, it is not enough just to examine the water relations in the growing media, because factors such as a previously experienced drought, relative humidity soil temperature, and phosphate level greatly influence the ability of the plant to take up water.

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