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Role of Antitranspirants in Agriculture

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INTRODUCTION

Antitranspirants are substances applied to the plants for the purpose of reducing transpiration (water loss) without causing a significant effect on other plant processes, such as photosynthesis & growth. Antitranspirants can act as either physical or physiological barriers to water loss. The most popularly used antitranspirants are spray emulsions of latex, wax, or acrylic that form a film over the leaf surface and reduce water loss. Other physical barriers are solar reflectants, which reduce internal leaf temperature and thereby depress evapotranspiration. Physiological barriers are those chemicals that act as plant growth regulators and may close stomata or inhibit plant growth. Applying these substances to plant leaves can have a significant impact on normal physiological function. Film-forming antitranspirants prevent evaporation by covering and clogging leaf stomata – the tiny pores on leaf surfaces. These pores have two functions: they create a gradient for water movement throughout the plant and they allow gas exchange between the plant and the atmosphere. Each of these physiological functions is vital to a plant's survival. The transpiration stream not only transports water through the plant, but root-produced growth regulators and soil minerals as well. Furthermore, water transpiration from the leaf surface aids in evaporative cooling of the leaves. Interfering with this normal and necessary process is harmful to the plant; the increase in internal leaf temperature has been documented to kill some plants.

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The second vital function performed by stomates is gas exchange. In the daytime, carbon dioxide enters the leaf and oxygen exits; in the evening, the reverse occurs. This is erroneously referred to as "breathing" but the mental image of the effect on the plant is useful. Without carbon dioxide uptake, photosynthetic rate is depressed. Regardless of what advertisers claim, it is impossible to prevent water vapor movement through the stomates without impairing gas exchange.

How they reduce Transpiration (water loss)

Antitranspirants may reduce transpiration in three different ways:

1. By reducing the absorption of solar energy and thereby reducing leaf temperatures and transpiration rates.
2. By forming thin transparent films which hinder the escape of water vapors from the leaves.
3. By promoting closure of stomata (by affecting the guard cells around the stomatal pore), thus decreasing the loss of water vapors from the leaf.

Possible Effects on Plants of Reducing Transpiration:

The significance of transpiration have varied over the past decades from considering that it is essential for such processes as leaf cooling and mineral uptake and transport.

Effects on Field Crops and Plants:

An increase in yield of an annual crop was observed after the application of antitranspirants. Fuahring (1973) sprayed stomata inhibiting or film-forming antitranspirants on field-grown sorghum under limited irrigation conditions, he found that grain yield increases 5 to 17% and application of antitranspirant just before the boot stage was more effective than later sprays.

Transpiration and ion uptake and transport:

There is no question that transpiration expedites ion transport within the plant. There appears to be some effect of transpiration rate on ion uptake, but this varies according to the type of the plant and the specific ion involved, and there is usually no proportionality between uptake and transpiration rates. The reduction of transpiration by an antitranspirant was found to reduce, to a significant extent, the uptake of rubidium by sugar beet and the transport of rubidium within bean plants and sugar beets during a 100-hr period. Another way in which the transpiration stream may possibly affect plant-mineral nutrition is to expedite movement of mobile ions in the soil towards the rhizosphere. As yet there is little evidence that this would be important under normal field conditions when roots are growing constantly. It appears, therefore, that a very large reduction in transpiration may, under extreme circumstances, affect the plant's mineral balance.

Materials causing stomatal closure:

The stomata closing type of antitranspirant should be of low mobility within the plant and ideally should be confined to the leaf epidermis to avoid toxic side effects to other systems. PMA is generally of low mobility, although Shimshi found some toxicity to sunflowers. Unfortunately, none of the inhibitors yet tested has remained effective for longer than about 16 days. However, this may be adequate for certain applications and the very low cost of this type of antitranspirant may make repeated applications worthwhile.

Materials forming thin films:

Considerable attention has been given in recent years to the reduction of reservoir evaporation by the application of higher alcohols to the surface of the water. The hydrophilic ends of the highly polar alcohol molecules are attracted to the water and the hydrophobic ends are repulsed, so that Van de Waal forces cause a tightly and symmetrically arranged monomolecular layer to form, which is highly impermeable to water vapor. It has been considered possible that such materials, if made to form a film on the mesophyll surface of plants, would constitute effective antitranspirants.

Materials forming relatively thick films:

The purpose of this type of antitranspirant is to cover the stomata with a film whose resistance to water vapor transmission is greater than its resistance to CO_2 and O_2.

Other approaches to reducing transpiration:

Certain growth retardants such as 2, 4-dichlorobenzyl-tributyl-phosphonium-chloride (Phosphon) have been reported to reduce plant water stress and also the transpiration/growth ratio. However, more recent work revealed that the transpiration/ growth ratio either increased or remained unaffected although drought susceptibility was sometimes reduced, probably because of a lower top/root ratio. Under daytime conditions, most of the energy input to the plant is from solar radiation which is often at superoptimal intensities at the top of the plant canopy. This energy input may be reduced by increasing the plant reflectivity by the application of reflective materials, either alone or mixed with other antitranspirants. It may be possible to use materials which reflect in those portions of the spectrum least used by the plants, such as the infrared, which is absorbed by water in the plant. Such a treatment would lower transpiration by reducing transpirations.

CONCLUSION

In the present state of antitranspirant research, the main practical problem is the development of improved antitranspirants. Longer retention and greater specificity are required for antitranspirants of the stomata-closing type, and greater selectivity to gases and vapors for the film-forming type. With the development of such materials, physiologists must then look at their effects, direct and indirect, on processes such as mineral nutrition and photosynthesis. These measurements should be made under a variety of controlled and well-defined environmental conditions.

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