RESEARCH

How humic substances help turfgrass grow

Research reveals diverse roles for some little-known products.

R.E. Schmidt, Ph.D.,
and Xunzhong Zhang, Ph.D.

Man has realized for thousands of years that dark-colored soils are more productive than light-colored soils and that this productivity is closely associated with decaying plants, animal residues and microorganism bodies (2).

Such humic substances have long been used as soil conditioners, soil supplements and fertilizers. They hold micronutrient metal ions and the essential macronutrients: nitrogen, phosphorus and potassium.

Over the centuries, agronomists have tried to explain and understand the roles humic substances play in plant growth. Recent studies have shown that humic substances influence mineral nutrition, hormonal activity, antioxidant status and photosynthetic capacity.

KEY POINTS

- Humic substances influence several metabolic processes, such as photosynthesis, respiration, nucleic acid synthesis and ion uptake.
- Humic colloids can form stable bonds with metal ions.
- Humic acid generally enhances turfgrass root development.
- Foliar application of humic acid on turfgrasses significantly enhances the presence of various antioxidants in the leaves.

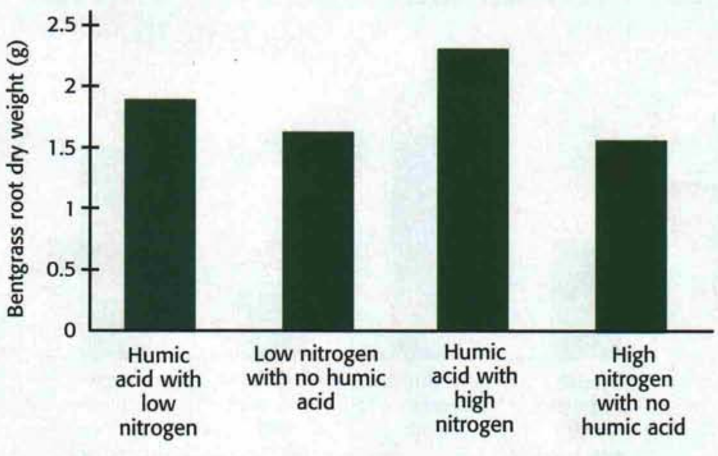
History

In 1872, the "humus theory" stated that humus was a major component of plant nutrition and provided plants with carbon and other nutrients (2), an idea that was later supplanted somewhat by Justus von Liebig's "mineral theory."

By the early 20th century, research suggested that humic substances acted as hormones to influence plant growth

continued

Humic acid and roots



Root development was apparently greater in creeping bentgrass treated with humic acid at Virginia Tech. Low nitrogen treatments equaled 200 grams of nitrogen per 100 square meters per month. High nitrogen treatments equaled 500 grams. Root dry weight in each 10-centimeter plug was determined July 24, 1997, four weeks after foliar application of humic acid solution at 7.5 grams per 100 square meters per month.

continued from p. 65

(2). One scholar noted that humic substances may increase solubilization of some mineral ions, especially iron (8).

As for growth stimulation, research indicates that:

- Humic substances stimulated root initiation of geranium cuttings (7).
- Teak seedlings' uptake of nitrogen, phosphorous, potassium, magnesium, calcium, zinc, iron and copper increased with an application of humic acid (4).
- Humic acid generally enhances turfgrass root development, according to studies at Virginia Tech Turfgrass Research Center.

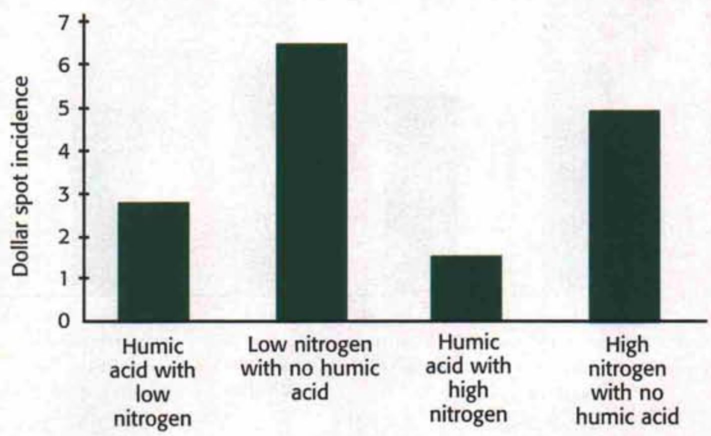
Iron and humic substances

Turfgrass responds to supplemental iron fertilization only in certain environmental conditions, according to observations made at Virginia Tech Turfgrass Research Center. For example, foliar applications of iron improved the color of cool season turfgrass grown on non-calcareous soil only during cool autumn weather (14).

Iron fertilization improved bermudagrass physiological activity during exposure to chilling temperatures and subsequent recovery (17). Color enhancement, as well as a subsequent increase in shoot and root development, was reported on cool-season grasses from Spain immediately after winter or summer applications of products containing humic substances and iron (9).

Apparently, these seasonal stresses reduced secretion of iron-chelating amino acids from grass roots, so application of iron fertilizer was needed. In conjunction with fertilizing with soluble iron, humic substances may be used to aid in the supply of iron to plants under such stress.

Humic acid and dollar spot



Dollar spot in creeping bentgrass was apparently reduced by humic acid applications at Virginia Tech. Low nitrogen treatments equaled 200 grams of nitrogen per 100 square meters per month. High nitrogen treatments equaled 500 grams. Dollar spot incidence was evaluated July 11, 1997, on a scale of 1 to 9, where 9 indicated highest dollar spot incidence.

Iron availability

Although chelates are the best-known stable structures for presenting iron in an available form to plants, humic colloids can form other stable compounds with metal ions.

Fulvic acid, a humic substance, may take on iron — up to one ferric ion per five atoms of carbon (12). Researchers report this not only enhanced the solubility of iron, but also affected its uptake and translocation from roots to shoot (3).

In addition, surfaces of ferric hydroxides or hydrated oxides will absorb humic acids, resulting in some solubility of iron in the rooting medium (11). The humic matter will be released, become soluble and be taken up by the plant if soil pH rises sufficiently. Some absorbed ferric hydroxide could be absorbed and translocated along with humic substances.

Hormonal activity

Humic acid, fulvic acid and fractions of humic substances inhibit indoleacetic acid (IAA) oxidase, thereby hindering destruction of this plant growth hormone (6). High activity of IAA can promote plant growth. Humic acid extracted from leonardite possesses auxin-like activity and stimulates root initiation of geranium cuttings (7). The humic extract with the highest acidity and smallest molecular size is the only material showing auxin-like activity (10).

Biochemical and physiological process

Humic substances influence several metabolic processes, such as photosynthesis, respiration, nucleic acid synthesis and ion uptake. Humic acid influences the production of RNA, which is essential for many biochemical processes in the cell (15).

Several researchers have indicated that humic acid stimulated the activities of some enzymes (1,2,16).

Enhancement of chlorophyll content with application of humic substances in nutrient solutions or foliar spray has been reported (2,16). Research suggests that humic acids can prevent chlorosis in maize plants by increasing the uptake of Mg^{++} and Fe^{++} ions (5).

Research at Virginia Tech Turfgrass Research Center showed that foliar application of humic acid solution significantly stimulated photosynthetic capacity of creeping bentgrass, particularly during the summer when photosynthetic activity had declined because of environmental stress. Creeping bentgrass treated with humic acid exhibited greener leaves and less dollar spot than the non-treated control, regardless of nitrogen fertilization.

Antioxidant activity

Environmental stress damage to plant cells is correlated with the increase of reactive oxygen species or free radicals, such as superoxide, hydrogen peroxide and hydroxyl radical within the plant.

Studies at Virginia Tech Turfgrass Research Center showed that foliar application of humic acid on turfgrasses significantly enhanced the presence of various antioxidants in leaves. In bentgrass, one antioxidant had a greater increase following humic acid applications, particularly under high nitrogen fertility.

Photosynthesis

Studies are investigating practical means for increasing the efficiency of photosynthesis in turfgrass exposed to stresses. Research has shown that materials with hormonal activity, such as humic substances, stimulate production of antioxidants and enhance photosynthetic activity, resulting in greater turfgrass tolerance of abiotic and biotic stresses, including disease infection. Foliar spray of humic substances can boost photosynthesis and improve turfgrass growth and development, especially when applied before stresses increase.

Increased infection and disease development are associated with turfgrass subjected to stress conditions. The greater the level of stress, the greater the fungicide efficacy required to control disease. Therefore, using humic substances that reduce the impact of environmental stresses could be a valuable component of an integrated pest management strategy in turfgrass culture. ■

Literature cited

1. Albuzio, A., G. Ferrari and S. Nardi. 1986. Effects of humic substances on nutrient uptake and assimilation in barley seedlings. *Canadian Journal of Soil Science* 66:731-736.
2. Chen, Y., and T. Aviad. 1990. Effects of humic substances on plant growth. p. 161-186. *In:* MacCarthy (ed.), Humic substances in soil and crop sciences; selected readings. American Society of Agronomy and Soil Science Society of America, Madison, Wis.
3. Dekock, P.C. 1955. The influence of humic acid on plant growth. *Science* 121:473-474.
4. Frabenro, J.A., and A.A. Agboola. 1993. Effects of different levels of humic acid on the growth and nutrient uptake of teak seedlings. *Journal of Plant Nutrition* 16(8):1465-1483.
5. Fernandez, V.H. 1968. The action of humic acids of different sources on the development of plants and their effect on increasing concentration of the nutrient solution. *Pontificiae Academiae Scientiarum Scripta Varia.* 32:805-850.
6. Mato, M.C., L.M. Gonzallez-Alonso and J. Mendy. 1972. Inhibition of enzymatic indoleacetic acid oxidation by fulvic acids. *Soil Biology and Biochemistry* 4:475-478.
7. O'Donnell, R.W. 1973. The auxin-like effects of humic preparations from leonardite. *Soil Science* 116:106-112.
8. Olsen, C. 1930. The influence of humic substances on the growth of green plants in water culture. *Comptes-rendus du laboratoire Carlsberg* 18:1-16.
9. Perez-Sanz, A., E. Eymar and J.J. Lucena. 1996. Effects of foliar sprays on turfgrasses of an extract of peat and kelp amended with iron. *Journal of Plant Nutrition* 19:1179-1188.
10. Piccolo, A., S. Nardi and G. Conchieri. 1992. Structural characteristics of humic substances as related to nitrate uptake and growth regulations in plant systems. *Soil Biology and Biochemistry* 24(4):373-380.
11. Russell, E.W. 1973. Soil conditions and plant growth. Longman, London and New York.
12. Schnitzer, M., and S.I.M. Skinner. 1963. Organo-metallic interaction in soil. 1. Reactions between a number of metal ions and the organic matter of a podzol Bk horizon. *Soil Science* 96:86-93.
13. Stevenson, F.J. 1982. Humus chemistry. Wiley-Interscience, New York.
14. Snyder, V., and R.E. Schmidt. 1974. Nitrogen and iron fertilization of bentgrass. p. 176-185. *In:* E.C. Roberts (eds.), Proceedings of the Second International Turfgrass Research Conference, Blacksburg, Va.
15. Vaughan, D., and R.E. Malcolm. 1979. Effect of humic acid on invertase synthesis in roots of higher plants. *Soil Biology and Biochemistry* 11:247-272.
16. Vaughan, D., and R.E. Malcolm. 1985. Influence of humic substances on growth and physiological processes. p. 37-75. *In:* D. Vaughan and R.E. Malcolm (eds.) Soil organic matter and biological activity. Martinus Nijhoff/Dr. W. Junk Publishing, Dordrecht, The Netherlands.
17. White, R.H. and R.E. Schmidt. 1989. Bermudagrass response to chilling temperatures as influenced by iron and benzyladenine. *Crop Science* 29:768-773.

R.E. Schmidt, Ph.D., is professor of turfgrass ecology at Virginia Tech. Xunzhong Zhang, Ph.D., is a research associate in the department of crop and soil sciences at Virginia Tech, Blacksburg.