

**Table 8.** Elements, their most commonly available forms for plant uptake, and primary functions in turfgrass growth.

	Element	Most Common Form(s)	Function in Plant Growth
<b>Macronutrients</b> Obtained from air and water	Oxygen (O)	CO <sub>2</sub>	Through photosynthesis, these elements are converted to simple carbohydrates and finally into amino acids, proteins, protoplasm, enzymes, and lipids.
	Carbon (C)	CO <sub>2</sub>	
	Hydrogen (H)	H <sub>2</sub> O	
<b>Macronutrients</b> Obtained primarily from fertilization	Nitrogen (N)	NO <sub>3</sub> <sup>-</sup> NH <sub>4</sub> <sup>+</sup>	A mobile element within the plant. Used in the formation of amino acids, enzymes, proteins, nucleic acids, and chlorophyll. Generally increases color and shoot growth. Conversely, N generally reduces heat, cold, and drought hardiness; disease and nematode resistance; wear tolerance; and root growth.
	Phosphorus (P)	H <sub>2</sub> PO <sub>4</sub> <sup>-</sup> HPO <sub>4</sub> <sup>-2</sup>	Involved in a carbohydrate transport system in which energy moves to all parts of the plant to activate growth processes. This function in root development is most vital. P also hastens plant maturity and is needed for glycolysis, amino acid metabolism, fat metabolism, sulfur metabolism, biological oxidation, and photosynthesis. In addition, P influences maturation, establishment, and seed production.
	Potassium (K)	K <sup>+</sup>	Essential for control and regulation of various minerals; adjustment of stomatal movements and water relation; promotion of meristematic tissue and rooting; activation of various enzymes; protein synthesis; and carbohydrate metabolism. Increases heat, cold, and drought hardiness; wear tolerance; and disease and nematode resistance.
<b>Secondary Nutrients</b> Present in some fertilizer formulations; available in most soils, and/or as part of conditioners such as lime, dolomitic lime, and gypsum.	Calcium (Ca)	Ca <sup>+2</sup>	Required for cell division (mitosis); important in cell membrane permeability; activates certain enzymes; provides chromosome stability and structure; and enhances carbohydrate translocation, formation, and production in the protein-containing portions of mitochondria. Influences absorption of other plant nutrients.
	Magnesium (Mg)	Mg <sup>+2</sup>	
	Sulfur (S)	SO <sub>4</sub> <sup>-2</sup>	
<b>Micronutrients</b> Most premium fertilizers contain these.	Iron (Fe)	Fe <sup>+3</sup> Fe <sup>+2</sup>	Necessary for chlorophyll production; an essential component of iron enzymes and carriers. Generally increases color and the growth of shoots and roots.
	Manganese (Mn)	Mn <sup>+2</sup> , organic salts	
	Copper (Cu)	Cu <sup>+2</sup> Cu <sup>+</sup>	
	Chlorine (Cl)	Cl <sup>-</sup>	
	Zinc (Zn)	Zn <sup>+2</sup>	
	Boron (B)	H <sub>3</sub> BO <sub>3</sub> HBO <sub>3</sub> <sup>-2</sup> B <sub>4</sub> O <sub>7</sub> <sup>-2</sup> BO <sub>3</sub> <sup>-3</sup>	
	Molybdenum (Mo)	MoO <sub>4</sub> <sup>-2</sup>	
	Sodium (Na)	Na <sup>+</sup>	