handling all sorts of equipment—mowing fairways, tees, greens, raking bunkers, etc. Their ages ranged from 16 to 39 and they were all in uniform. There have been no employment problems and there is a waiting list now with frequent calls wanting to know when employment will be available. Mr. Grant says the women come from many different occupations; waitresses, clerks and even junior college students. They enjoy their work, make good money and have done nothing to put their job in jeopardy, as someone is waiting to take over. I can foresee when this will be a common practice on golf courses in the future. Mr. Grant also tells me that his equipment repairs are not as great since the women have taken over. They won't tinker with the machine but will wait for the mechanic or superintendent to come by with assistance.

Moderator: In this day and age, everyone is cost conscious. I constantly hear about the high cost of golf course maintenance. What are the facts? What really is the relationship between the golf course grounds maintenance budget and the total club budget?

Williams: Grounds maintenance cost is currently running about 16 per cent of the total golf expense dollar to the membership. Continued effort by the course superintendents and the USGA Green Section towards efficiency in maintenance has been responsible for this accomplishment. Most clubs are realizing that their golf course is the prime reason, the prime source of club income and are allocating appropriate funds for its maintenance.

Moderator: That's a good point to close on. Thank you all very much.

Nutrient Application Update

by WILLIAM G. BUCHANAN, Eastern Agronomist, USGA Green Section

Turfgrass management today is a demanding scientific job where great changes are taking place along with the new demands on the superintendent. The terminology is changing as well. Today we say turfgrass management as opposed to "caretaking." Today we say superintendent instead of greenkeeper. Today we say scientific management as opposed to green thumb. Today we say nutrient application instead of fertilizer application. You know there has to be progress being made when the terminology changes from "spread the manure" to "apply the nutrients."

Dr. Jim Watson of Toro Company in a recent talk said, "Fertilization is the process of supplying plant nutrients to supplement the natural supplies of the soil." That pretty well says it all. Before we update the nutrient application too fast, let's look at where we have been and take another look at the plant nutrients.

The actively growing turfgrass plant is made up of water and organic compounds (dry matter). There are 16 elements that combine to make up the organic compounds in the plant and provide the nutrition to the plant necessary to enable it to complete its life cycle. The 16 elements are carbon, hydrogen, oxygen, nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, manganese, zinc, copper, molybdenum, boron and chlorine. These essential elements can be divided into groups—macro-nutrients and micronutrients. Macronutrients are used in larger quantities than the micronutrients; although very small quantities of the micronutrients are required by the plant, generally less than two parts per million in plant tissue, they are just as important to the plant as the macronutrients.

A major portion of the dry matter of the plant is made up from three of the 16 elements—carbon, hydrogen and oxygen. The atmosphere provides the carbon via carbon dioxide. Water is the primary source that supplies the hydrogen after it has been absorbed by the root system. Carbon dioxide and water combine to provide sources for oxygen. Since carbon, hydrogen and oxygen make up a large percentage of the nutrients, they are classified as macronutrients. The remaining six

macronutrients are primarily obtained from the soil and they are nitrogen, phosphorus, potassium, magnesium, calcium and sulfur.

There are many facets of the nutrient story that can be taken under study. The relationship of the individual nutrients with the soil, the effects of each element on the turf, what each element does in the plant, and so on. This paper deals with the practical end of the element's relationship with the plant, how the element acts as a nutrient and what happens if the element is excessive or deficient, and the main sources of the element.

Each essential nutrient has a specific role in plant growth and development. A brief rundown of the essential elements is as follows.

Nitrogen—Nitrogen is applied in the largest amounts in fertilization programs because it is used up more readily by turfgrass. Nitrogen is needed by the plants more than other essential nutrients, with the exception of carbon, hydrogen and oxygen. Nitrogen content in the plant's dry matter is generally between 3 to 6 per cent. Young plants generally have a higher nitrogen content than older plants. Depending on the age and specie of the grass plant, the monthly requirement for actual nitrogen can range from zero to two pounds per 1,000 square feet per growing month.

Nitrogen affects the plant's root growth, color, shoot growth, disease resistance, heat and drought hardiness, and also the plant's ability to resist cold.

Nitrogen nutrition can influence the disease susceptibility of a plant. Work at many universities and research centers have shown that high nitrogen fertility may cause turfgrasses to be more susceptible to *Helminthosporium* leaf spot, brown patch, *Fusarium* patch, *Fusarium* blight and gray leaf spot. Low nitrogen encourages dollar spot, red thread and rust. Therefore we must look for the happy medium between the zero and two pounds of nitrogen per 1,000 square feet per growing month. Also, high nitrogen levels show a tendency to increase the chances of wilting in the summer and desiccation in the winter.

Phosphorus—Every living cell of the growing plant contains some phosphorus. Although nitrogen and potassium are used in much larger quantities by the plant, phosphorus is very important because it plays a part in the reproduction of the grass plant, the establishment of the plant, the rooting and maturation of the plant. Relatively higher phosphorus levels tend to make the plant mature faster. As with nitrogen, different turfgrass species vary in the amounts and absorption rates of phosphorus. Warm-season grasses absorb less phosphorus than the Kentucky bluegrasses.

Potassium—Potassium is used by the plant in relatively large quantities, second only to nitrogen. Potassium is also found in the cells of the plant. However, as the plant reaches maturity the amounts of potassium are reduced. Potassium increases the thickness of the cell walls, thus making the plant more resistant to heat, cold, and drought conditions, increasing wear tolerance, and encourages rooting. When potassium is applied, it is very unlikely that you will see any visual response of the plant; potassium does not affect things like color and density.

Researchers have noted that high potassium levels reduce the incidence of *Helminthosporium* spp., brown patch, *Fusarium* patch, red thread and dollar spot.

Calcium—The quantity of calcium used by the plant ranks third behind nitrogen and potassium. Calcium is like phosphorus and potassium—found in the cells, mostly in the leaves and stems, rather than in the seeds. It is an important factor in cell division and also serves to neutralize toxic substances that exist within the cell. Calcium becomes permanently fixed in the cell walls, giving leaf tissues a high calcium content.

Red thread and *Pythium* blight are two diseases that are related to calcium deficiencies.

Magnesium—Magnesium directly affects the utilization of phosphorus in the plant. Magnesium is also essential in the plant because it is an integral part of the chlorophyll molecule, and without clorophyll there would be no green plants. Magnesium is not used in very large quantities by the plant because it is very mobile within the plant and is constantly being passed from old cells to newer ones. Extremely high concentrations of magnesium may be toxic to plants.

Sulfur—Sulfur is fairly well distributed within the plant. It is mainly found in amino acids which are required for protein synthesis. Powdery mildew on Kentucky bluegrass has been related to a sulfur deficiency by researchers.

The nine macronutrients have been covered now, so we should take a look at the micronutrients.

Manganese, zinc, copper, iron, boron, chlorine and molybdenum are the seven micronutrients. Generally, soils have adequate supplies of micronutrients for plant life since the plant demands such small quantities of the micronutrients. The reason we have to apply these nutrients is that many times the element is in the soil but is in a form that cannot be used by the plant. Soils that leach very easily, modified soils and sandy soils that are heavily irrigated or soils that become severely compacted are the most likely to have a micronutrient deficiency. The trend today to sandier

soil mixes in putting greens is an example of an area where minor nutrients are required because of the possible leaching and heavier irrigation. As with magnesium, high concentrations of manganese, boron, zinc and copper can be toxic to the turfgrass plant.

Iron and Manganese—Both iron and manganese are important to the color of the turf and both are required for chlorophyll synthesis. Therefore, when either one or both of these elements are deficient there is a discoloration in the turf. Iron is most likely to be deficient in waterlogged, poorly drained soils, or soils with a high content of organic matter. Areas that have heavy thatch layers are likely to be low in iron. Manganese is likely to be deficient in alkaline conditions or heavily leached areas. As noted before, manganese can become toxic with high concentrations. The manganese concentration is highest on poorly aerated soils, compacted soils and acid soils.

Molybdenum—Molybdenum is required in extremely small amounts by the plant. The primary function in plants is associated with nitrate reduction. A deficiency results in poor protein synthesis and nitrate accumulation.

Zinc and Boron—Zinc and boron functions are not well understood. Even though at high concentrations they are toxic, they are essential to the plant. High concentrations have been found only on rare occasions by researchers.

Chlorine—Chlorine is the last of the micronutrients. It is thought to be associated with osmotic pressure and cation balance in the plant. Again, deficiencies have rarely been observed. Research shows no specific role in the plant's metabolism by chlorine.

In these few paragraphs I have tried to explain an update of thoughts behind nutrient application. When we fully understand the complete functions of all the nutrients, then we will be able to fertilize and truly make a nutrient application.

Physiological Responses of Cool and Warm Season Grasses

by **THOMAS L. WATSCHKE,** Assistant Professor, Pennsylvania State University

Over the past 50 years the golf course superintendent has made tremendous advances in improving his status and, particularly during the past decade, has gained the recognition he has long deserved. With this recognition has come rapidly increasing salaries and improved social prominence. But, also with it has come an awareness by the public of the earning power and educational training today's superintendent possesses. Consequently, today's superintendent is going to have considerably more expected of him; both from his club membership and society.

As a result, presentations at conferences of material which do not always directly apply to practical situations will increase. This material is presented to improve and increase the overall knowledge of the turf superintendent about his commodity; turfgrass.

Most superintendents recognize symptoms of physiological breakdown; slowing of growth and wilt from drought and temperature stresses, lesions and chlorosis from diseases, nutrient deficiencies and insect damage. The time has come for superintendents to increase their knowledge of why these symptoms occur beyond knowing that the soil is dry or the temperature is high. Being acquainted with physiological processes and how they are affected by environment and management should be a part of the arsenal of knowledge that today's successful superintendent possesses. For example, a superintendent in the transition zone may be asked by someone why bermudagrass does so well compared to bluegrass in the summer months. If the superintendent merely points out that bermuda is a warm season grass and bluegrass is cool season, he undoubtedly will not be revealing anything the person does not already know. Golf superintendents are considered, and rightfully so, to be the turf experts in their community. People asking questions about turf have the right to expect a knowledgeable answer. Therefore, it is the responsibility of golf course superintendents to attend conferences and meetings to improve and increase their knowledge of how grass grows, and keep abreast of research de-