About the Author of the Article on the Facing Page.

Dr. James R. Love is one of a group of agricultural scientists devoting their time to the nation's number one crop — turf. He received his Bachelor of Science degree at North Dakota State University, and both his Master of Science and Doctor of Philosophy degrees in Soils at the University of Wisconsin.

Intent on teaching Dr. Love took supplementary courses in education. This enabled him to teach science and mathematics before completing his graduate studies. Dr. Love is Associate Professor of Soils at Wisconsin. He teaches the beginning course in soils and carries on research in lime as well as turfgrasses. He was instrumental in reactivating the annual Wisconsin Turf Conference and served as its first general chairman two years ago.

don Alves . . . Course is on farm famed for its apple and peach orchards . . . Has tee markers shaped like apples . . . Open first nine of Driftwood G&CC near Mobile, Ala. . . . Green Cover Springs, Fla., takes over as municipal course nine hole naval station layout recently closed.

Third Haig & Haig Scotch mixed foursome tourney to be played in Sebring and Avon Park, Fla., Dec. 13-16 . . . Prize money will total $30,000 with Dave Ragan and Mickey Wright being the defending champions . . . New Jersey State GA never awarded a trophy in the 42 years its Open has been played . . . But that has been corrected . . . Ballantine Brewing people are filling the void with a 30-inch sterling silver cup . . . Third Lucky International Open to be played at Harding Park in San Francisco, Jan. 21-27, 1963 . . . New England GCSA held clambake in Rehoboth, Mass. in Aug. for Mario Finizia, retired supt. of Wannamosett CC

Bergen County, N. J., to receive funds from state for building Norwood course as an item of the state's Green Acres Program for conservation and recreation . . . Building 18 for Big Cypress G&CC north of Naples, Fla., . . . Suffolk County (L.-I., N. Y.) Board of Supervisors buying Bergen Point land on which two courses will be built. . . . Victor Electronics, Inc.,

(*Continued on page 79*)

MINERAL DEFICIENCY SYMPTOMS IN TURFGRASS

By Dr. James R. Love • Associate Professor of Soils, University of Wisconsin

The foliar deficiency symptoms of major and minor nutrient elements for many agricultural and horticultural plants have been described and illustrated in the excellent publications listed at the end of this article. However, no mention of the nutrient deficiency symptoms in turfgrasses is given.

The purpose of this study, sponsored by the O. J. Noer Research Foundation, was to determine the foliar deficiency symptoms of the three major nutrient elements: nitrogen, phosphorus, and potassium; and of the three secondary elements: calcium, magnesium, and sulfur. Three cool-season grasses were used as the indicator plants: Seaside creeping bent, Merion Kentucky bluegrass, and Pennlawn creeping red fescue.

A similar study of the minor nutrient elements (iron, manganese, copper, boron, zinc and molybdenum) is under way and will be reported in Golfdom when completed. Bermuda grass will also be included in these investigations.

The grasses were grown from seed in sand cultures, using a complete nutrient solution until all plants were well established. It was found that unless the initial solution was complete the small seeded bent and bluegrass died from starvation while they were too small to clearly show any deficiency symptoms or else they failed to develop the signs that characterize the deficiency in the more mature stages of growth. The nutrient element under study was then removed from the feeding solution and the deficiency symptoms noted as they appeared. Each treatment was duplicated. The deficiency symptoms were produced three times to eliminate all mistakes. This was done by adding the deficient element to the nutrient solution and permitting the grass to recover its normal growth pattern. The element was again withheld until the deficiency symptoms reappeared. In every instance the visual symptoms were reproduced.

The symptoms were found to vary somewhat depending upon the extent of the shortage and the stage of growth at which the deficiency manifested itself. Calcium is a good example of the latter. When it was not added initially the roots of the young plant were stunted, black in color, and very gelatinous. None of these symptoms was observed in the calcium deficient grass after having been first established with the complete nutrient solution. The deficiency of calcium became so acute that one of the duplicates in the bluegrass series failed to recover after calcium was added to make the nutrient solution contain every one of the essential nutrient elements.

The following descriptions of the nutrient deficiency symptoms reveal a close similarity between those seen in Seaside bentgrass and Pennlawn fescue. Where differences exist in Merion bluegrass they have been noted.

A chemical analysis of the leaves revealed that those grown on deficient nutrient solutions contained from 50 to 75 per cent less of the element in question than leaves from healthy plants. This is based on an average of the three grasses. This is shown in the following table that lists the percentage of each element present in leaves of healthy and deficient grass plants.

	(% in leaf)		(% in leaf)
Nitrogen		Calcium	
Complete	.73	Complete	.75
Deficient	.38	Deficient	.21
Phosphorus		Magnesium	
Complete	.11	Complete	.17
Deficient	.05	Deficient	.06
Potassium		Sulfur	
Complete	1.18	Complete	.15
Deficient	.25	Deficient	.06

Since any description is a matter of individual judgment, the illustrations in the accompanying color plates should be studied carefully and used in making the final diagnosis along with a chemical test of the soil, a leaf tissue analysis, or both.

Nitrogen: The plants of bent and fescue are thin and erect, with almost no tillering. Leaves are short and small. In the early stages the color is a pale green. As starvation progresses the older leaves take on a yellow hue until the entire blade becomes yellow-green. This is followed by a tanned or fired effect starting at the tip of the older leaves. The firing or premature yellowing progresses down the leaf in a horizontal pattern.

Merion bluegrass is similar except that there is less of the (reddish) copper hue to the firing.

Phosphorus: The first sign of phosphorus deficiency in Seaside bent and Pennlawn fescue is the appearance of a dark green coloration in the leaves. While the plants tend to be spindly, the shoots are not as short and thin as in plants lacking nitrogen. As the deficiency progresses, the leaves become a dull blue-green in color with purple discolorations appearing along the entire margin of the blade and in the main veins near the base. Gradually these colors give way to dull reddish tints, appearing first near the leaf tips and progressing down the blade. At the climax the entire leaf appears scorched and the leaf tip withered.

Initial symptoms are the same for Merion Kentucky bluegrass. But Merion does not pass through the dull blue-green to purplish stage. The dark green gives way to a tanned condition which appears first at the tip of the older leaves and progresses slowly down the blade. At this stage phosphorus resembles nitrogen deficiency. The difference can be distinguished in several ways. In the case of no nitrogen, the color of the blade below the tanning is very pale green to yellowish-green. In the case of no phosphorus, the color is dark green. Also, the tanning is more intense in the case of no phosphorus.

Potassium: In the early stages of development, potassium deficiency in Seaside bent and Pennlawn fescue is characterized by a drooping appearance of the leaves and a soft feel. Blades are horizontally inclined. The tendency is toward excessive tillering. There is moderate chlorosis (yellowing) in the areas between the veins, particularly in older leaves, followed by rolling and withering of the leaf tips which retain blotches of green coloring. In more advanced stages the chlorotic area extends to the mid-vein which still remains green while the leaf margins become scorched and the tips severely withered.

Symptoms are similar for Merion bluegrass except for the early loss of chlorophyll in the leaf tips and the delayed firing of the tip and marginal scorching of the blades.

Calcium: Symptoms are the same for all three grasses. As noted earlier, the symptoms in young plants are quite different from older ones.

The first signs of calcium deficiency in older plants is the appearance of a reddish-brown discoloration in the tissue between the veins along the margin of the blade in the young (upper) leaves, extending gradually to the mid-vein. Colors fade to lighter shades of red, predominantly rose red. The tips take on a withered or fired condition.

Magnesium: The symptoms are similar for all three grasses and resemble those for calcium. To the casual observer, the deficiencies of calcium and magnesium appear to be identical. In contrast to calcium deficiency symptoms, however, those for magnesium usually appear first in the older (lower) leaves and the initial discoloration is more cherry red. Also, in approximately 30 to 50 per cent of the affected leaves the coloring is blotchy, giving rise to a banded appearance which never occurs in the calcium deficient plants.

Sulfur: Seaside and Pennlawn deficiency symptoms were similar. Like calcium and magnesium, symptoms of sulfur deficiency are late developing and, as a consequence, have only a slight effect on growth.

The initial symptom is the general paling of the leaves. As it progresses, the blades take on a pale yellow-green cast. Accompanying this is the appearance of a faint scorching at the tip of the blade that ad-


SEASIDE BENT GRASS
All Elements
No Nitrogen
No Phosphorus
No Potassium
No Calcium
No Magnesium
No Sulfur
All Elements
MERION BLUE GRASS
All Elements
No Nitrogen
No Phosphorus
No Potassium
No Calcium
No Magnesium
No Sulfur
All Elements
PENNLAWN RED FESCUE
All Elements
No Nitrogen
No Phosphorus
No Potassium
No Calcium
No Magnesium
All Elements
Each group of unhealthy leaves show progressive stages of deficiency symptoms

Photo shows no calcium in the culture solution resulted in no growth in the seedling fescue.

vances toward the leaf base in a thin line along each margin. The border enlarges gradually until finally the entire leaf blade becomes fired and withered.

In Merion bluegrass the shortage of sulfur manifests itself in two ways. As the chlorotic condition develops, the veins, especially the mid-vein, remain green, giving the leaf a striped appearance. Eventually the mid-vein loses its color and the entire blade fires. The other characteristic sign, noted time and again, is the greater susceptibility of these plants to powdery mildew.

Editor's comment about practical application.

An example of magnesium deficiency was observed this spring on a tee in the Montreal district which would have been baffling except for this study. The leaves were exactly like magnesium deficient ones of Merion Kentucky bluegrass. To confirm this diagnosis, a soil sample was collected. It was strongly acid and exceedingly low in magnesium. As a result, dolomitic lime has been used liberally on this and other tees with striking results in overcoming the deficiency.

Another deficiency was noted at Nassau in the Bahamas in St. Augustine grass. This and others that have been observed are being checked out.

The failure of initial root development in the no-calcium nutrient solution has been striking, as noted above. Calcium may play a part in the formation and the stimulation of root growth on new grassland seedings. The marked effect of superphosphate applications on new turfgrass seedings has been stressed frequently. It may be due to the calcium as well as the phosphorus in superphosphate, especially on strongly acid soil, low in available calcium. It is assumed that the other needed elements are in plentiful supply.

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