Rethinking potassium fertilization and rooting...

Fertilizer for Thought

Does potassium fertilizer *really* increase roots?

Earlier this year I presented some preliminary results from the soil testing studies I have been conducting at Cornell University to a meeting of the Central NY GCSA. Many in the audience were interested to know how potassium fertilizer applications, or the withholding of potassium fertilizer from the turf, had affected the L-93 creeping bentgrass roots in the study. I did not have any final data to share at that time, but the audience's pointed questions about rooting certainly underscored in my mind the widespread, traditional assumption that potassium plays a critical role in turfgrass rooting.

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In *Turfgrass: Science and Culture* (Beard, 1973), it is clearly stated that higher soil potassium levels yield increased root development and branching. The recently published *Turfgrass Soil Fertility and Chemical Problems* (Carrow et al., 2001) emphasizes the role of potassium in sand rootzones, where potassium encourages "a more extensive fibrous or branched root system." The theory of root stimulation by potassium is propagated and promulgated anew whenever superintendents or turfgrass students are taught about turfgrass nutrition. I recently participated in an online seminar about fall fertility strategies for cool-season grasses, and sure enough, we were reminded by the instructor that a primary plant response to potassium is deeper roots with more branching.

Turfgrass professors tell us that more roots are obtained at higher potassium levels, but plant science researchers tell a different story. The definitive plant nutrition reference is *Mineral Nutrition of Higher Plants* (Marschner, 1995), in which Marschner wrote that mineral nutrient supply can strongly influence root growth, with nitrogen having a particularly marked effect, less so for phosphorus, and usually no effect for other nutrients.

A classic study of the effect of variable ammonium, nitrate, phosphate, and potassium supply on barley roots (Drew, 1975) found that the number and length of lateral roots were stimulated by all nutrients *except for potassium*. In fact, some plants have more roots when no potassium is applied (Cherney et al., 2004), perhaps because the roots explore a larger volume of soil in order to obtain the potassium that they need.

So why, I wondered, are we taught that potassium increases roots, even though the consensus among plant scientists is that potassium has little effect on roots? This property of potassium must have been discovered somewhere, I thought. So I went to the library and read seven papers that Beard cited in 1973 as showing potassium increases root development and branching.

The first of these studies was published in the *Green Section Record* in 1933. In this experiment, creeping bentgrass plants were grown in sand-filled pots and fertilized with various nutrient solutions that were low, medium, or high in certain nutrients. There was an increase in rooting when potassium was applied at the medium and high levels. What is misleading in this study, though, is that the low potassium plants were actually deficient in potassium, exhibiting classic deficiency symptoms including thin yellow leaves. Unfortunately, the author of the study did not describe the actual potassium rates applied, nor were the leaves analyzed for potassium or other nutrient levels. Reading that paper now, in 2004, would lead one to conclude that the *elimination of a potassium deficiency* increases rooting. That is no surprise, for potassium is second only to nitrogen in abundance within plant tissue.

by Micah Woods

Another study, this one from 1944, compared the effect of various N-P-K ratios on bentgrass rooting. Although higher levels of potassium appeared to increase root mass, it was not a statistically significant change. What I found especially interesting in this particular study was the following: a treatment with 10-0-0 fertilizer had equal root weight to a 10-6-8, and the 10-0-0 had more roots than a 10-6-4.

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A study from 1948 showed that potassium deficiency inhibited root growth. Further studies in the 1960s with Kentucky bluegrass and creeping bentgrass found that, when plants were grown in washed sand or in nutrient solutions, the roots were invariably less developed in pots from which potassium was withheld. An increase in roots was obtained with the first increment of potassium fertilizer that was added, but more potassium than the initial increment had either no effect or actually decreased root mass.

In all of these studies, just one thing stands out: potassium deficiency inhibits root growth. One can readily deduce that a positive root response to potassium fertilizer can only be expected when initial soil potassium levels are extremely low. Applications of more potassium, above and beyond that amount required to eliminate the deficiency, can actually reduce roots.

It is difficult to tell for sure, but I believe that many superintendents apply potassium in amounts much greater than that required to prevent a deficiency. For example, Charles Hadwick, superintendent at the Country Club of Lincoln (Nebraska), was quoted in the February 2004 issue of *Grounds Maintenance* as stating "Some superintendents have cut back on nitrogen to below 2 lb. per 1,000 sq. ft. per year. At the same time, we've had to up the potassium level to improve stress tolerance. Where ratios used to be 1-1 or 1-2 N to K, they now may get up to 1-3 or even 1-4 N to K."

Furthermore, the quantities of potassium measured in soil tests are almost always low enough to prompt recommendations for additional potassium applications. What is the basis for these recommendations? As far as I can tell, it is the assumption that more potassium is better for turf, and particularly so for turfgrass roots. And why is more potassium better for roots? I'm not sure that it is. This circular justification for potassium fertilizer applications may be doing more harm than good, and I would encourage golf course superintendents to err on the side of caution by applying less potassium, rather than more.

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Oh, and that data on potassium and rooting that the Central NY superintendents asked me about? I did the lab work this summer, on root samples of different depths collected from my potassium fertilizer study in August and November of 2003, and also in May 2004. It turned out that in the deepest samples, there were actually less roots, by weight, in the research plots that received the highest rates of potassium fertilizer.

References

Beard, J.B. 1973. Turfgrass: Science and Culture. Prentice-Hall, NJ.

Carrow, R.N., D.V. Waddington, and P.E. Rieke. 2001. Turfgrass Soil Fertility and Chemical Problems. John Wiley & Sons, New York.

Cherney, J.H., Ketterings, Q.M., and J.L. Orlorski. 2004. Plant and soil elemental status as influenced by multi-year nitrogen and potassium fertilization. Journal of Plant Nutrition 27(6): 991-1014.

Drew, M.C. 1975. Comparison of the effects of a localized supply of phosphate, nitrate, ammonium and potassium on the growth of the seminal root system, and the shoot, in barley. New Phytologist 75:479-490.

Marschner, H. 1995. Mineral Nutrition of Higher Plants. 2nd Ed. Academic Press, San Diego.

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