A Closer Look at Corn Nutrient Demand

By Alan Olness and G.R. Benoit

Fertility management programs for today's high yielding crops must satisfy nutrient requirements at all stages of the growing season. Recent research has helped clarify nutrient accumulation patterns and relationships for corn.

GETTING THE MOST out of fertilizer investment requires matching plant nutrient demand with soil nutrient supply. While benefits of fertilization have been recognized for centuries, scientists have only recently begun to take a closer look at relative rates and times of nutrient availability and accumulation. Early studies of nutrient uptake by corn were concerned more with total uptake than with relative rates and periods of uptake.

Corn has **two** intense periods of nutrient uptake. The first uptake period occurs during vegetative growth; the second during reproductive growth or ear development (**Figure 1**). Potassium (K) uptake shows a different pattern from that of nitrogen (N) and phosphorus (P). Net K uptake seems restricted mainly to the vegetative growth period. Usually, uptake rates for N, P and K are much less during tasseling and silking than during the two growth periods.

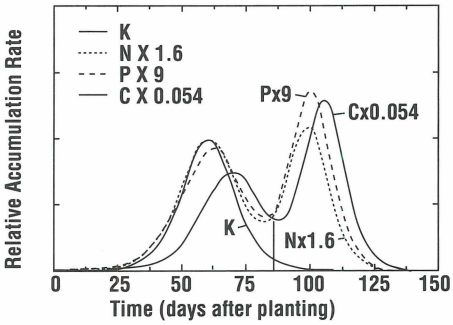

Figure 1. Accumulation of N, P, K and carbon (C) by corn planted in early May in Minnesota. The vertical line represents the date of 50% tasseling and silking. The amount of N accumulated was multiplied by 1.6, P by 9 and C by 0.054 so that the uptake could be shown on the same graph.

During vegetative growth, N and K are synchronized both in time and amount of uptake (**Figure 2**). The amount of N accumulated ranges from about 0.55 to 0.85 times the amount of K accumulated during leaf and stalk development. The close relationship between N and K accumulation is probably related to ammonium-N (NH_4^+-N) uptake. Corn takes up N in both nitrate-N (NO_3^--N) and NH_4^+-N forms.

The form in which N is accumulated requires adjustment for ionic charge both within the plant and externally to the root. Uptake of NH_4^+-N tends to acidify the root environment and inhibit K ion (K^+) accumulation. As a result, today's corn hybrids seem to grow best when the ratio of NO_3^--N to NH_4^+-N is about 2 to 3. At these ratios, K^+ uptake is capable of balancing some of the charge of NO_3^--N and the rest

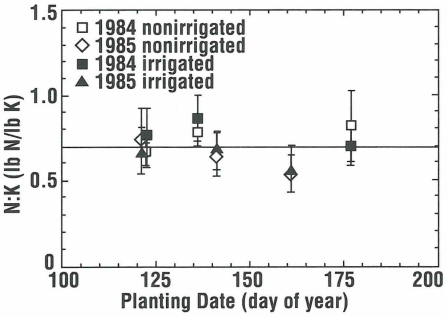

Figure 2. Relative amounts of N and K uptake by corn planted at different dates.

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can be balanced by NH_4^+-N uptake. While corn accommodates different ratios of N forms and availabilities of K, it seems to do so by sacrificing growth and grain yield potentials. Thus, balances in forms and amounts of N with K are important for optimal growth during the vegetative stage. Some loss of K from leaves and stalk during grain filling occurs, but the exact reason for this loss is unknown.

Regardless of planting date or climatic condition, the maximal vegetative accumulation rate for both N and K occurs at the same time (**Figure 3**). At maximal

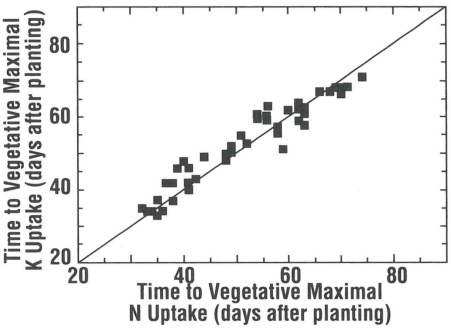

Figure 3. Time of maximal uptake rate for N and K during vegetative growth. The diagonal line represents a perfect relationship.

rates of accumulation, a stand density of 25,000 plants per acre can remove about 1.9 to 4.2 lb of N and 3.4 to 4.9 lb of K each day. These rates vary and are strongly affected by soil temperature. Soil temperature affects the rate of root growth which, in turn, affects the volume of soil accessed by roots.

As planting date is delayed, soil and air temperatures increase and the warmer environment causes growth to accelerate. The increased growth rate creates an increased demand for nutrients. Time required to reach maximal uptake rates for N and K shortens as planting date is delayed (**Figure 4** vs. **Figure 1**). When this happens, daily amounts of N and K removed from the soil increase but the period of uptake shortens. Under these conditions nutrient management becomes even more important.

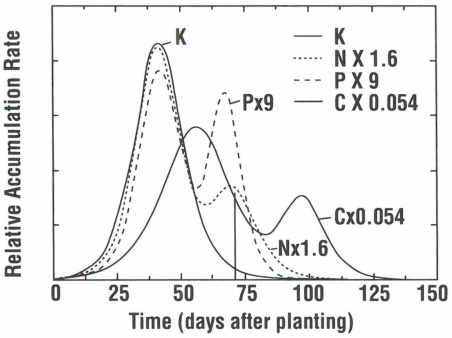

Figure 4. The effect of delayed planting on the time and relative rate of nutrient uptake by corn. This corn was planted in late May on a Hamerly clay loam. The vertical line represents 50% tasseling and silking.

Accumulation of P is critical for transforming, storing and moving energy in the plant; so it is no surprise that corn growth is closely related to the amount of P accumulated in each stage. Corn clearly shows a two-stage pattern of P uptake. During vegetative growth, the maximal rate of P accumulation usually occurs about 3 days after that of N and K. When planting is delayed later than early May, P uptake during grain fill decreases and grain yield declines (**Figure 5**).

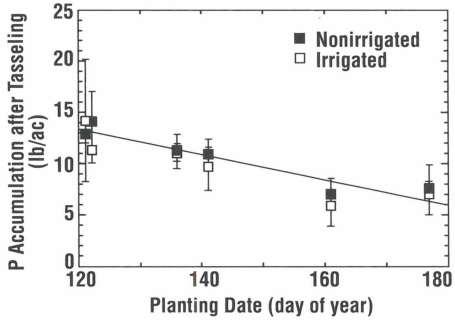

Figure 5. The change in uptake of P during grain fill as a function of planting date.

In a recent study in Minnesota, P uptake averaged about 12.7 lb/A before tasseling and about 13.0 lb/A during grain fill; grain yields averaged about 150 bu/A. For every day planting was delayed, P uptake during grain fill decreased at the rate of about 0.12 lb/A and grain yield decreased by about 2.3 bu/A.

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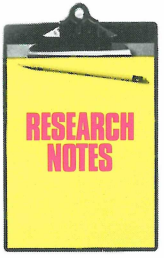
Summary

Corn takes up nutrients in a well defined pattern. Nitrogen and K are accumulated synchronously during vegetative growth. Net accumulation of K ceases at or near tasseling. Maximum rates of P accumulation occur about 3 days after those of N during the vegetative period. A close relationship exists between N and P uptake during reproductive growth and grain fill. Both N and P accumulation rates peak once during vegetative growth and a second time during grain fill. Soil fertility must be managed to satisfy both peak demands to realize full yield potential. ■



Missouri

Phosphate Interaction with Uptake and Leaf Concentration of Magnesium, Calcium and Potassium in Winter Wheat Seedlings

LOW tissue concentrations of magnesium (Mg) and calcium (Ca) in cool-season grasses in late fall and early spring are primary causes of grass tetany and wheat pasture poisoning in grazing cattle. The objective of this study was to determine the interaction between phosphate and leaf concentrations of Mg, Ca and potassium (K) in winter wheat.

Seedlings were grown hydroponically or in perlite with nutrient solution concentrations similar to those found in a typical midwestern Alfisol. As solution phosphorus (P) was increased, Mg and Ca concentrations in the leaf increased while K decreased. The K/(Ca + Mg) ratios were lowered from 1.8 to 1.0 in one greenhouse study; from 1.7 to 1.2 in another. ■

Source: T. M. Reinbott and D. G. Blevins. 1991. Agron. J. 83:1043-1046.