Corn Nutrient Uptake and Removal

Agronomic advancements, particularly in breeding and biotechnology, have pushed corn yields to historic levels. Understanding nutrient uptake and removal to best meet the nutrient requirements of modern, high-yielding corn hybrids are critical for matching fertilizer applications with high yield corn production.

There are two major aspects important for fertilizer recommendations:

- *Total Nutrient Uptake* or the amount of a nutrient that needs to be acquired by the plant during the growing season.
- *Nutrient Removed with Grain and Stover* or the amount of a nutrient contained in the grain and stover.

Uptake and Removal

With modern high-yielding corn hybrids, managing the mineral nutrients required for production (i.e., nitrogen (N), phosphorus (P), potassium (K), and sulfur (S)) and those with a high harvest index (percent of nutrient uptake that is removed with the grain/stover) are essential for maintaining yield potential (Figure 1). Nutrient loss from grain and stover removal has a large impact on nutrient availability for the next crop. These losses should be accounted for when developing fertilizer strategies to ensure that adequate nutrients are available for the next crop.

Nutrients that are not removed by harvested grain remains in leaf, stalk, and reproductive tissues and constitutes the stover that is returned to the field. Corn grown for silage production where all aboveground plant parts are harvested can remove additional nutrients that need to be accounted for in fertility programs. A large percentage of the total uptake of N, P, and S is stored in corn grain; whereas, K is mostly stored in the stover.

Research at the University of Illinois correlated the total uptake and removal of major nutrients (N, P, K, S) with modern corn products under high yield conditions.[1] (Table 1).

Figure 1. Ears of corn fully-filled indicate a successful match between nutrients required for production and availability.

Table 1. Total nutrient uptake and removal for corn averaging 230 bushels per acre.[1] Harvest Index (%) is a percentage of total plant uptake removed with the grain.

Nutrient	Total Nutrient Uptake (lb/acre)	Removed with Grain (lb/acre)	Uptake by R1 Growth Stage (%)	Harvest Index (%)
N	256	148	65	58
P205	101	80	44	79
K20	180	59	63	33
S	23	13	48	57

Modified from: [1]Bender, R.R., Haegele, J.W., Ruffo, M.L, and Below, F.E. 2013. Modern corn hybrid's nutrient uptake patterns. Better Crops vol 97(1):7-10

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Uptake Rates and Timing

The highest rate of N uptake in corn occurs from V10 through V14 vegetative growth stages (Figure 2). Of critical importance is supplying N to meet the peak needs of corn for growth and development at this time. The majority of N is taken up during vegetative growth with two-thirds of the uptake completed by R1 or the beginning of reproductive growth. Uptake of N does not cease at R1, with as much as 50 lb N/acre accumulated and partitioned directly into the developing seeds during grain fill. About 60% of the total accumulated N is removed with the grain.

More than 50% of total P uptake occurs after tasseling and silking. Nearly 80% of P is removed with the grain, more than any other nutrient. Much like N, two-thirds of the total uptake of K is completed by VT/R1. However, only 33% of the total accumulated K is removed with the grain. K is retained to a greater percentage in stover. Much like P, more than 50% of total S uptake occurs after tasseling and silking. The percentage of total accumulated S removed with the grain is similar to N.

Research indicates that a season-long supply of P and S is critical for corn nutrition, while the majority of N and K uptake occurs earlier in the season during vegetative growth. As a percentage of total uptake, P is removed more than any other nutrient, suggesting that soils could be rapidly depleted without proper management. At-planting applications such as starter fertilizer applied with the planter can be used to supply N, P, K, S, and needed micronutrients, this is particularly true when any of the nutrients are considered deficient or the cropping system has retained 70% or more residue cover and soils are cool and wet. An application schedule that applies smaller amounts of N early in the season (preplant or starter) followed by later in-season applications of higher amounts is ideal. This schedule can take care of early season N needs and maximizes uptake by applying N during the rapid growth and maximum N requirement period. Side-dressing N around the V4 to V8 growth stages of corn can be used to supply N closer to when the plant needs the nutrient. With irrigated corn that can be fertigated (adding nutrients in irrigation water), N and other nutrient fertilization can be timed more efficiently to match the needs of the plant.

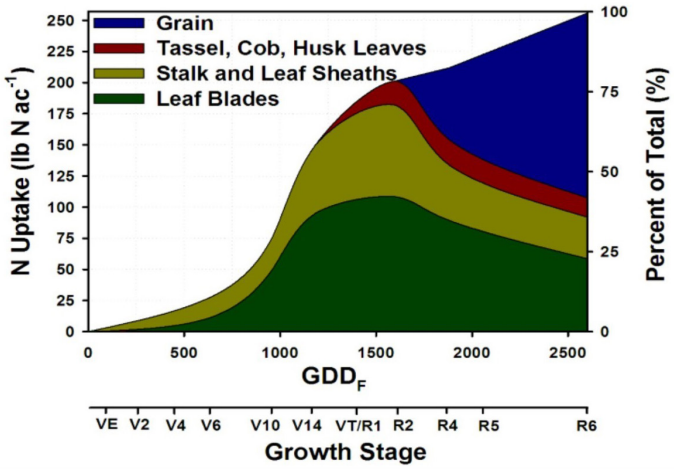

Figure 2. Total corn N uptake and partitioning across four plant stover fractions: leaf, stalk, reproductive, and grain tissue. Each value is a mean of six hybrids across two site-years GGDF = growing degree days.1Figure courtesy of Fred Below, University of Illinois.

Nutrient management in corn is a complex process. However, improving our understanding of nutrient uptake timing and rates, partitioning, and remobilization can help optimize fertilizer rates and application timings.

Sources

[1]Bender, R.R., Haegele, J.W., Ruffo, M.L, and Below, F.E. 2013. Modern corn hybrid's nutrient uptake patterns. Better Crops vol 97(1):7-10

University of Illinois at Urbana-Champaign, Department of Crop Sciences. 2017. Corn nutrient uptake and partitioning. http://cropphysiology.cropsci.illinois.edu/research/nutrient_uptake.html/.

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