Nitrogen key to uptake of other corn nutrients, study shows

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(Phys.org) —A historical analysis of corn research shows that new hybrids are taking up more nitrogen than older plant varieties after the crucial flowering stage, a clue as to how plant scientists will need to adapt plants to increase yields.

Tony Vyn, a professor of agronomy, and Ignacio Ciampitti, a postdoctoral research associate, are studying the timing of nutrient uptake in corn and how that process affects yield. They found that modern hybrids (post-1990) took up 27 percent more total nitrogen from the soil after flowering than pre-1990 corn plants. In fact, nitrogen uptake after flowering in post-1990 hybrids averaged 56 percent of the total grain nitrogen at the end of the season.

Primarily, more grain nitrogen came from new nitrogen uptake from soil during grain filling, as opposed to nitrogen being remobilized from plant leaves and stems. The higher amount and duration of nitrogen uptake contributed to superior grain yields even as actual grain nitrogen concentrations declined.

The timing of nitrogen uptake is also important in understanding how other plant nutrients are affected. Vyn said optimum nitrogen levels increased plants' abilities to absorb phosphorus, potassium and sulfur. Part of the corn plant's response to receiving adequate nitrogen is that progressively higher percentages of total plant phosphorus, potassium and sulfur end up in the grain fraction at harvest.

"You need to think in terms of nutrient balance. If you have a plant with more biomass and more yield, it will be taking up more nutrients in a balanced manner that shifts with plant needs and growth stages," Ciampitti said.

Post-1990 corn hybrids use nitrogen more efficiently, so less is necessary per unit of yield. But as those plants increase nitrogen utilization, they increase their uptake of other nutrients, which affects how much of those nutrients growers need to use and when they need to apply them.

"At some point, they'll need to increase the amount of these other nutrients applied to their fields as yields continue to increase," Vyn said.

Vyn and Ciampitti also found that the timing of nutrient uptake is important for predicting yield and nutrient efficiencies. Vyn said it would be economically beneficial to identify simple, early-stage plant traits that could be measured to predict final yield, but the earliest they could predict yield with even 50 percent certainty was at flowering, much later than hoped.

"It's desirable to estimate yield and nutrient efficiency of new genotypes at an early stage, but you have to wait until flowering time," Vyn said. "You need to wait until flowering stage for most of the total potassium uptake to be present in the plant and recognize that proportionally more phosphorus than nitrogen uptake can occur later in modern corn hybrids. But all nutrient uptake rates are dependent on the specific interactions of hybrids with their environment and management factors like plant density and soil nutrient availability."

Ciampitti said biomass and nutrients were measured for two weeks before, at and two weeks after, flowering in an effort to predict yield. Those periods were crucial because it is the time in which most corn biomass is made in modern hybrids when water is not limiting.

The results of the studies were reported in two journal articles. The review of nitrogen source changes was published in *Crop Science*. Nutrient accumulation and partitioning results were published in *Agronomy Journal*.

More information: Grain Nitrogen Source Changes Over Time in Maize: A Review, Ignacio A. Ciampitti and Tony J. Vyn

ABSTRACT
Understanding the sources of grain N uptake (Grain N) in maize (Zea mays L.) and especially the trade-off between reproductive-stage shoot N remobilization (Remobilized N) and reproductive-stage whole-plant N uptake (Reproductive N) is needed to help guide future improvements in yield and N use efficiency (NUE). Therefore, a literature review was performed to investigate the knowledge gap concerning changes over time in Grain N sources and on N partitioning to the grain and stover plant fractions at maturity. The synthesis–analysis was based on 100 reports, which were divided into two time intervals: (i) research conducted from 1940 to 1990 - "Old Era" - and (ii) research conducted from 1991 to 2011 - "New Era." The most remarkable results were (i) Grain N concentration was the main parameter that has changed over time, (ii) Reproductive N contributed proportionally more to Grain N for the New Era while Reproductive N and Remobilized N contributed equally to Grain N for the Old Era, (iii) Remobilized N was primarily associated with vegetative-stage whole-plant N uptake (Vegetative N), which was constant across eras, although the proportion of the Remobilized N itself seems to be driven by the ear demand, (iv) complex plant regulation processes (source:sink) appeared to influence Reproductive N, and (v) stover N concentration gains mirrored the grain N concentration as the plant N uptake increased at maturity in both eras. This new appreciation for the changes over time may assist directed

selection for yield and NUE improvements.

Maize Nutrient Accumulation and Partitioning in Response to Plant Density and Nitrogen Rate: I Macronutrients, Ignacio A. Ciampitti, Jim J. Camberato, Scott T. Murrell and Tony J. Vyn

ABSTRACT
Understanding nutrient balances in changing cropping systems is critical to appropriately adjust agronomic recommendations and inform breeding efforts to increase nutrient efficiencies. Research to determine the season-long P, K, and S uptake and partitioning dynamics in maize (Zea mays L.) as affected by low, medium, and high plant density (PD) and N rate factors and their interactions was conducted over four site-years in Indiana. Plant nutrient contents at maturity responded predominantly to N rate. Relative nutrient contents at silking compared with those at maturity were 47% for P, 100% for K, and 58% for S. Concentrations of P, K, and S varied less in leaf vs. stem (vegetative stage) and in ear vs. shoot (reproductive stage). Equivalent stoichiometric ratios were documented for N and S partitioning in leaf, stem, and ear components. The PD and N rate treatments did not modify P, K, and S nutrient partitioning to plant components during vegetative or reproductive periods (except for an N rate effect on leaf vs. stem P partitioning). Near silking, relative nutrient partitioning to the ear followed the order P > S > K. This mimicked the nutrient harvest indices observed at maturity, suggesting genetic modulation. Ratios of N to P, K, and S in whole-plant tissues were influenced by N content changes in response to N rate but not by PD. As the season progressed, PD and N rates changed the absolute P, K, and S quantities (primarily reflecting biomass responses) but had little influence on nutrient ratios.

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