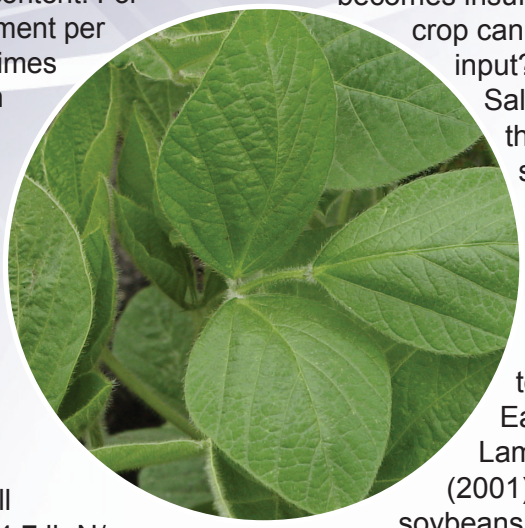
PLANT NUTRITION TODAY

2017 ISSUE 4, NO. 2

NITROGEN AND THE SOYBEAN YIELD GAP

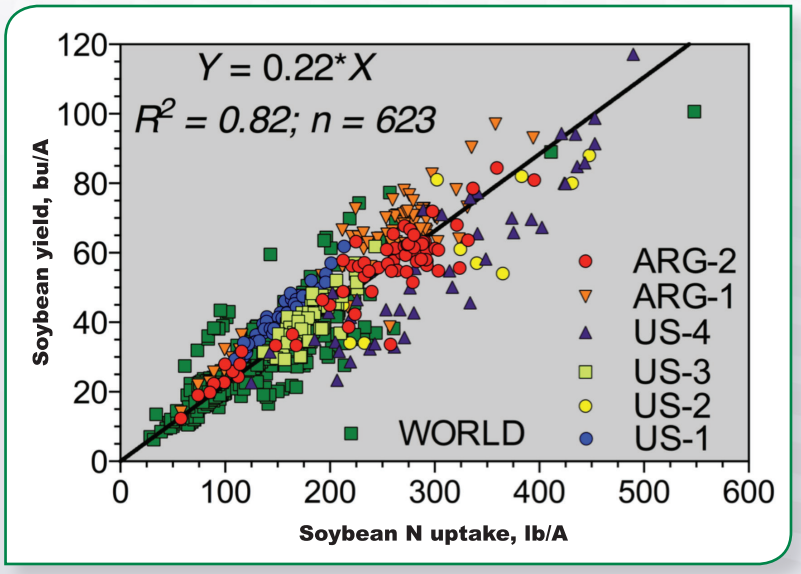
Dr. Mike Stewart
Director, North American Program
mstewart@ipni.net

Soybeans require a lot of nitrogen (N), in fact, most legumes require more N than do other grain crops because of higher seed protein content. For example, the N requirement per unit yield is about four times higher for soybean than for corn. As the figure shows, soybean yield is directly and linearly related to N uptake by the crop.



In a classic paper by Salvagiotti et al. (2008) an analysis of 637 datasets across 17 countries indicated that a soybean crop will take up an average of 4.7 lb N/bu in the aboveground biomass, and that soybean seed contains about 6.3% N. Using these figures, a 70 bu crop will take up about 330 lb N, and will remove about 265 lb N/A from the field at harvest. The same work determined that 50 to 60% of soybean N demand was met by biological fixation, with remainder of the crop's N need supplied by soil reserves. Soybean may generally be considered neutral in relation to its contribution of N to the soil, but at high yields negative N balances can be expected.

It is usually assumed that soybeans do not require N fertilizer input with average production and good nodulation. But what about high yield systems? Is there a yield level above which the contribution of N fixation becomes insufficient and the crop can benefit from N input? The analysis by Salvagiotti concluded that well-nodulated soybean crops managed without constraints and at yields above 67 bu/A are more likely to respond to N fertilization. Earlier work by Lamond and Wesley (2001) on irrigated soybeans in Kansas suggested that when yield potential was greater than 55 bu/A biological N fixation may not be able to supply enough N during peak demand. More recent work by Cafaro La Menza et al. (2017), based on irrigated field experiments conducted in both



Relationship between soybean seed yield and N uptake. Balboa et al. (2017).

PLANT NUTRITION TODAY is a monthly publication of compiled scientific information developed by the International Plant Nutrition Institute (IPNI). Website: http://www.ipni.net/pnt

“Irrigated field experiments conducted in both Argentina and Nebraska, found that yield response to N fertilizer can occur above 37 bu/A. …at least half of the current yield gap for irrigated soybeans in the central U.S. Great Plains may be a result of a seasonal N supply limitation.”

Argentina and Nebraska, found that yield response to N fertilizer can occur above 37 bu/A. This work inferred that at least half of the current yield gap for irrigated soybeans in the central U.S. Great Plains may be a result of a seasonal N supply limitation. Another recent study in Kansas by Tamagno and Ciampitti (2017) estimated biological N fixation for different cultivars with and without N fertilizer and found that a high rate of N fertilizer reduced uptake from fixation.

A. Correndo/IPNI Image

Nodule formation on soybean roots.

The question of whether (and when) to apply N fertilizer to soybeans is likely more complex than a simple yield threshold, and involves other considerations such as weather and soil factors, crop genetics, soil bacteria (different strains of *rhizobium*) and interactions among these factors. Thus, a better understanding of the dynamics of biological N fixation in soybean, and development of tools to that end, has the potential to improve management decisions that foster improved soybean yields.

There are several ways to measure biological N fixation but most come with considerable limitations involving cost, equipment, and complexity, and are therefore not readily adaptable for practical field-level application. However, one method described by Unkovich et al. (2008) has the potential to be practically applied with further development and calibration. Based on the fact that soybean is a ureide transporter (i.e., they export fixed N from the nodule through the stem and petiole as ureides), this method provides an indirect, point-in-time measure of N from biological fixation that is relatively simple and inexpensive. This method is not new, but it has not been well developed for application in temperate regions. Research is currently underway at Kansas State University (IPNI-USA-KS43) to further develop the ureide method for application in the US. The development of a practical, field-level tool to estimate biological N fixation in soybean would help advance the understanding of N balance in specific cropping systems, and its consequences for crop yields, soil organic matter, and potential N losses to the environment.

References

Balboa, G.R. et al. 2017. Crop Sci. https//doi.org/10.2135/cropsci2017.06.0349

Cafaro La Menza, N. et al. 2017. Field Crops Res. 213: 204-212.

Lamond, R.E. and T.L. Wesley. 2001. Better Crops 85(2): 6-11.

Salvagiotti, F. et al. 2008. Field Crops Res. 108: 1-13.

Tamagno, S., and I.A. Ciampitti. 2017. Kansas Agric. Exp. Stat. Res. Rep. 3(6) https://doi.org/10.4148/2378-5977.7436.

Unkovich, M. et al. 2008. Australian Center for International Agricultural Research. http://aciar.gov.au/files/node/10169/mn136_measuring_plant_associated_nitrogen_fixation_19979.pdf

IPNI International Plant Nutrition Institute

3500 Parkway Lane, Suite 550, Peachtree Corners, GA 30092-2844 U.S.
Phone: 770-447-0335 | Fax: 770-448-0439 | www.ipni.net