Managing Nutrients After the Drought
Questions and Answers Log – September 26, 2012

Q: With the drought aggravating soil infiltration and possibly promoting more compaction, how significant will surface salt concentration be. We saw this in the past in some fields where salts concentrated on the soil surface severely impacting crops. How can those salt concentrations be managed?

A: In Kentucky (your email address indicates Kentucky Farm Bureau), we have already received, over much of the state, fall rainfall sufficient to move residual salts out of the soil surface, deeper into the soil. There should be no salt problems, either for wheat planted this fall, or for crops planted in these fields next spring. I hope you have a good season next year. (John Grove)

Q: Would disking or plowing do any good?

A: I do not believe so. The fundamental differences between this year's harvested, but drought damaged, corn fields and the usual harvested, but normal, corn fields are two. First, the amount of residue has been reduced due to stunting of this year's crop - the mass of residue carbon available to drive microbial N immobilization has been reduced. Second, because N uptake occurs more quickly than dry matter accumulation in corn, and because the N rates used this year did not (could not) anticipate the reduced dry matter accumulation, the C:N ratio of these residues is relatively low - similar to that of soybean residue. Finally, tillage tends to speed up the whole immobilization-mineralization turnover process. Combined with the generally lower C:N ratio in this year's corn residues, which also shortens the turnover timeline, net mineralization occurs earlier. If earlier means later this fall - not good. Hence my recommendation to eliminate fall tillage on drought damaged corn fields over moderately well to well-drained/tile-drained soils. I wish you a good season next year. (John Grove)

Q: Will the higher residual N levels in droughty soils influence nitrogen leaching management under the NRCS 590 Standard for nutrient management? For John Grove

A: I will admit to some ignorance here. I am not entirely sure what elements of the NRCS 590 Standard you are exactly referring to. However, with the generally higher residual N levels in many drought damaged corn fields, I would expect nitrogen leaching management to be both qualitatively more important (on the minds of more producers) and quantitatively more important (practices applied to more acres) in the next months. Those 590 practices that reduce N leaching losses will be relatively more important. (John Grove)

Q: Can we grow a decent crop of corn with multiple foliar apps of N if it remains dry into next season?

A: I will give you my thoughts on your question. The other panelists may have some additional ideas, too. In theory, it is possible to grow a crop of corn with foliar N application. There are some practical considerations that would often act to thwart such a strategy for most corn producers. First, the N rate being applied would have to be split into a fairly large number of applications to avoid burning crop foliage. That would cause considerable expense with all the trips through the field. Alternatively, one could use a lot of water as carrier - but, at the limit, this becomes fertigation and there is no dry season to worry about. Second, if untimely heavy rain occurs your N nutrition plan is in danger - the crop could undergo N stress that limits yield potential while you are waiting to get into the field with the next N application - and a water limited yield is further reduced by N limitation. I wish you a good season next year. (John Grove)

Q: Thanks, question is for John, normal practice is to apply N in 3 splits (1/3 at transplant, 1/3 30days after transplant and 1/3 at 50days after transplant), if drought incidence occur, should splits made or we apply N full in one dose?

A: I have limited familiarity with rice, entirely with flooded rice, and none with flooded rice under drought stress. In my experience with flooded rice, water availability was never an issue. However, as a general principle, N management for cereals when drought is a known possibility should be more conservative. Lower cereal yield potential is a greater probability, and split applications allow the producer more flexibility in the total N application rate. When drought occurs, early splits can contain enough N to finish the crop, and the final N application can be reduced or even eliminated. I would not favor a single application under circumstances where drought is a more probable seasonal occurrence. Hope this helps. (John Grove)

Q: One of my clients applied 200 # actual N in southern IL. Corn crop is estimated at 30 bu/ac. The corn is turning greener & greener every day. I think that is from existing un-used N. Question He has not grown wheat for years, would wheat be a good option for this fall?

A: I think the N carryover could challenge your client's wheat management skills. Given mild fall weather, the crop could get a lot of growth on it prior to winter dormancy. The crop would then have to be monitored closely upon greenup in the spring - the lush growth puts pressure on wheat disease resistance; can 'push' early crop growth and development (increases damage if a late frost occurs); encourages lodging (especially if spring N applications are excessive); and raises grain protein (though not always monitored, is generally not desirable in the soft red winter wheat varieties grown in southern Illinois). However, wheat can be followed by double-crop soybean in much of southern Illinois, and this is a very profitable system in many seasons. I wish you and your client a good season to come. (John Grove)

Q: Not sure I fully understand why incorporating surface residue (corn stover) would be a bad thing from a nitrogen standpoint. Would seem to me to immobilize the residual soil nitrogen until it is mineralized again in the spring of 2013.

A: The fundamental differences between this year's harvested, but drought damaged, corn fields and the usual harvested, but normal, corn fields are three. First, the amount of residue has been reduced due to stunting of this year's crop - the mass of residue carbon available to drive microbial N immobilization has been reduced. Second, because N uptake occurs more quickly than dry matter accumulation in corn, and because the N rates used this year did not (could not) anticipate the reduced dry matter accumulation, the C:N ratio of these residues is relatively low - similar to that of soybean residue. Third, this year's corn crop often contains, in the lower stalk, considerable nitrate-N. Early fall rains will wash that nitrate-N out of the stalk into the soil, likely faster than microbial immobilization can tie that N up. Finally, tillage tends to speed up the whole immobilization-mineralization turnover process. Combined with the generally lower C:N ratio in this year's corn residues, which also shortens the turnover timeline, net mineralization occurs earlier. If earlier means later this fall - not good. Hence my recommendation to eliminate fall tillage on drought damaged corn fields over moderately well to well-drained/tile-drained soils. Thanks for getting me to sharpen up my thoughts on this. (John Grove)

Q: Is there a rule of thumb for adjusting spring applications in years following drought (i.e. a % adjustment for normal recommendations)?

A: I don't know of such a thing as a 'rule of thumb' - the impact of the drought varies from region to region, field to field, and soil to soil. More soil testing and a sound appreciation of the fundamentals are the tools that one brings to bear here. I wish there was a good rule of thumb. (John Grove)

Q: So far the top N management options this fall you have mentioned are cover crops and avoid tillage. Isn't this a good year to work with farmers to do more split applications of N, possibly supported by deep core N soil tests?

A: Split applications of N, the rates of which might be guided by soil N tests, are for the next cereal crop - next spring. Indeed, next year might be the year, depending on the amount of over-winter moisture, where such an approach is of particular benefit. Fall soil N testing is of benefit to next year's crop when done in the drier western portion of the corn belt. However, as Dr. Camberato indicated, soil sampling should be done after the winter - or into the spring/early summer - in the other parts of the corn belt. (John Grove)

Q: What is the difference between protein levels in drought corn and normal corn?

A: A recent Kansas study examined your question. Seven hybrids were examined under three moisture conditions: 1) well-watered, 2) water-restricted during the vegetative phase, and 3) water-restricted during grain fill. Averaged across all maize hybrids, protein content increased slightly under water-restricted conditions. The averages (and ranges) for each of the treatments were:
Water-restricted during the vegetative phase: 10.84% (7.80 – 14.10%)
Water-restricted during grain fill: 10.08% (8.30 – 11.60%)
Well-watered: 9.68% (7.90 – 11.20)

The citation for the study is:
Harrigan, G.G., L.G. Stork, S.G. Riordan, W.P. Ridley, S. MacIsaac, S.C. Halls, R. Orth, D. Rau, R.G. Smith, L. Wen, W.E. Brown, R. Riley, D. Sun, S. Modiano, T. Pester, A. Lund, and D. Nelson. 2007. Metabolite analyses of grain from maize hybrids grown in the United States under drought and watered conditions during the 2002 field season. J. Agric. Food Chem. 55:6169-6176. (Scott Murrell)

Q: Our area has pivot watering with approx. 7.8 ph, higher salts (CA), and sandy loam soils. Yields are lower due to salt build. Crops are cotton, sorghum, and peanuts. Any suggestions to help leach the salts while waiting on more normal rainfall years?

A: I can only suggest that you contact a local expert to guide you through the following exercise: What is the value (crop yield, quality, etc.) of lowering salt levels, to a given depth, considering the cost of delivering the extra water required to accomplish that objective? Is water available, at what cost, outside the crop water need calendar? Can you deliver extra water, to accomplish salt leaching, at what cost, at the same time as you are applying water to meet crop water need? Hope this helps you. (John Grove)

Q: What date would be a good rule of thumb to stop sowing cover crops in KY?

A: I refer you to one of our extension publications, url below, for that information. The latest seeding date will differ with your chosen cover crop. The latest date is associated with cereal rye, I believe. http://www.ca.uky.edu/agc/pubs/id/id113/id113.htm (John Grove)

Q: What would you recommend for a grower who likes to do all field work in the fall and plant into a stale seedbed in order to reduce oxidation without changing their whole operation?

A: This is a real challenge. I admit, at the outset, to a bias against tillage – and especially fall tillage. However, I know that fall tillage is important to many producers. So ---- First, evaluate your individual field situations. Then, avoid tillage on fields that meet both of two criterion: a) field N removal was low in relation to N applied=likely considerable carryover N; and b) soils in the field will leach nitrate because they are either well-drained or tile drained. My producers tell me that tillage is especially important on fields with poorly drained soils, where there is an expectation that spring planting dates will be appreciably delayed by the need to do spring tillage. Poorly drained soils that are tilled in the fall will generate nitrate, but much of that nitrate will not be lost to leaching. Rather, that nitrate will more likely be lost to denitrification on these soils.

Second, consider making your planting operation more flexible, making one or more of your planters no-till "possible". This allows you to consider a wider range of fall to spring tillage/planting options -- establish a cover crop on some of these fields, eliminate tillage on some of your soybean fields rotating to corn, etc. (John Grove)

Q: Will applications of "carbon type" commercial products this fall help keep nitrate n immobile?

A: Applications of carbon might be useful, but the needed rates, for the "carbon type" products, would likely be prohibitively expensive. To immobilize 50 pounds of N would require about 500 to 600 pounds of C (this assumes a microbial biomass C:N ratio of 10:1 to 12:1). Not only that, but some of the applied C would be oxidized to the atmosphere during that biological activity – perhaps another 500 to 600 pounds of C. That's a lot of added C. (John Grove)

Q: What are your thoughts on Humic?

A: From the few peer-reviewed published studies available, it appears that humic acids have the greatest chances of providing benefits when plants are grown hydroponically or when they are grown in soils with very little organic matter. Field trials have provided mixed results, but application during planting appears to be most effective. Horticultural crops have been the most heavily studied. Type "humic" in the search box at the following site: http://extension.agron.iastate.edu/compendium/index.aspx (Scott Murrell)

Q: All of these issues would make it seem more logical to place nutrients in a band near crops next year to avoid making major over/underapplication errors. Would you agree?

A: Your question may relate to the K issues. Yes perhaps from the perspective of being sure K don't limit yield, but you still need soil-testing and knowledge of removal for a better management over time. Also, in low-testing soils I would not apply K only in a band because of the high rate needed (possible salt effects), and to avoid restricting root growth to or near the band zone. (Antonio Mallarino)

Q: If cover cropping is a great way to manage nutrients and build soil health, why is it just becoming a recommendation by conventional agromomy in a challenging year? Will it be around on a mainstream recommendation in good years to come?

A: This year provided a great educational opportunity to talk about cover crops. They are gaining traction in large part because many states are using the Environmental Quality Incentives Program (EQIP) to provide economic incentives for farmers to incorporate them into their cropping practices. There are many logistical and financial issues with cover crops, as there are with any management practice. The financial incentives help overcome one of the barriers to adoption. Other barriers have and will continue to be addressed through education and on-farm trials. Mainstream agriculture is becoming increasingly aware that nitrogen rate adjustments alone will not reduce nitrate losses enough in many areas. Cover crops reduce nitrate loads substantially, and the combination of the right N rate and the right combination of cover crop species can provide benefits beyond either practice alone. (Scott Murrell)

Q: Not knowing there would be a drought, how did various N additives respond?

A: N additives provide economic and agronomic benefits when conditions are present that they were designed to work under. Moist soils are necessary for most of these products to work. Although we had a drought, the spring started out with moist soils in many areas, so many of these products could have worked early, but their effects became overwhelmed by the lack of water later in the season.

Links to information about the various types of additives are provided below:
http://www.extension.iastate.edu/Publications/NCH55.pdf
http://extension.agron.iastate.edu/compendium/compendiumpdfs/sf1581.pdf
http://extension.agron.iastate.edu/compendium/compendiumpdfs/evaluationnutrisphere-n.pdf
http://extension.agron.iastate.edu/compendium/compendiumpdfs/ncsfc%202011%20goos%20p5.pdf (Scott Murrell)

Q: What is the soil difference between soil types between case 1 and case 2 in exchangeable?

A: Those are Iowa sites with different soil series, rainfall, and yield levels but approximately similar clay mineralogy; and are part of ongoing research. I showed those as examples of the range of responses of exchangeable (soil-test K) and the so called non-exchangeable K to cropping (removal) and fertilization. I am not completely sure yet of the reasons, we are studying data at this time, but I suspect the difference mainly is due to the different hydrologic regime of the soils. We see greater short-term "changes" of non-exchangeable K in poorly drained soils, but still with changes between moist and dry conditions, which in Iowa sometimes have finer texture and organic matter than others but not always. (Antonio Mallarino)

Q: In spring of 2011 we had a flood which kept soil underwater until Nov. of 2011. 2012 had been very dry. Can this kind of thing change carbonate levels in the soil? Soil test is showing 5-7% higher

A: Many of the Midwest streams carry significant amounts of carbonate and would deposit them on the soil increasing soil pH. If you are in the southeast this usually is not an issue. (James Camberato)

Q: It appears, based on the report in the Christian Scientist Monitor, that improvements in plant genetics since 1988 have improved plant resistance to drought. Do your estimates of nutrient carryover account for these new drought resistant varieties? Richard Mertens reported yesterday at The Christian Science Monitor Online that, "Across the Corn Belt, farmers have expressed surprise that their corn endured drought as well as it did – much better, they say, than the varieties they planted just a decade or two ago. In Illinois, for example, one estimate suggests that corn farmers will lose one-quarter less of their crop than they did during the 1988 drought – in large part because of the seeds they planted.

"Farmers are benefiting from decades of research in plant breeding combined with a growing interest in crops that can better tolerate drought and other stress. Indeed, research has shown that vulnerability to drought is one of the chief limits to crop production around the world. Meanwhile, gene mapping and other innovations have enabled scientists to develop new varieties with much greater speed and precision than before."

A: The estimates of carryover were solely examples to illustrate the concept that nutrient removal changes both with yield and with alterations to the plant organs harvested. A review of corn genetic changes over time was conducted by Duvick and Cassman (1999) and they concluded that the most significant change in corn has been improved stress resistance (many types of stresses). They also noted that protein content in grain has been decreasing over time while starch content has been increasing. IPNI used to publish corn removal of 0.9 lb N/bu but more recent data indicate it is now closer to 0.7 lb N/bu. So there have been and will continue to be significant changes in stress tolerance and nutrient content. The key is to conduct on-farm measurements of these changes through grain testing. The complete reference is:
Duvick, D.N. and K.G. Cassman. 1999. Post-green revolution trends in yield potential of temperate maize in the North-Central United States. Crop Sci. 39:1622-1630. (Scott Murrell)

Q: Antonio -- please say a little bit about what happens to the potential for N leaching or losses next year if we don't ge the K levels right? Is it correct that if we don't get K levles right that the crop will use less N than anticipated, leading to greater chance of N losses next year?

A: Good point and question: Often there is a positive interaction NxK in corn (but not always for some reason), which means the yield increase from N application is maximized and and the optimum N rate increases if K is adequate compared with deficient K. Therefore, the most efficient way of utilizing N and K is to be sure both are adequate. This interaction results in more efficient use of water expressed per bu of yield, but still increases the water use due to increases biomass yield. Therefore, perhaps you are right, and the combination of higher water and N uptake may result in less N leaching loss. Now, I should say, I have not seen that a soil-test K level or a higher than normal optimum is needed for this better use of N to happen. (Antonio Mallarino)

Q: Have Scott M recount his data regarding Effect of soil moisture on soil test K results

A: In other presentations, I did highlight data showing that as soils dry, soil test K levels tend to go down and as soils rewet, the K levels climb back up. The changes can be on the order of tens of ppm. These data came from several sources, and unfortunately, many of these are not published in peer-reviewed literature. A study that shows this effect is:

Stucki, J.W. 1996. Potassium in the soil: Is it there or isn't it? Some new findings that may explain its behavior. Better Crops 80(4):16-19. (Scott Murrell)

Q: Could it make sense to skip a soybean rotation (going back to corn) assuming the drought creates a N credit of sorts?

A: There are probably many viewpoints that exist for your question. Even though carbon to nitrogen ratios of corn stover are expected to be lower this season and could possibly approach those of soybean, I still advocate keeping soybeans in the rotation. My bias is based on the following concepts that are applicable to the Midwest and northern corn growing areas.

Soybeans in rotation do two important things in regard to nitrogen: 1) they scavenge residual nitrate from the previous corn crop and 2) they increase an easily mineralizeable organic N pool in soils while corn decreases this pool. Corn following soybean has this pool of organic N to draw from while corn following corn does not. This pool reduces the amount of N needed by the following corn crop and also allows some room for error in getting the N rate right. Ideally, the corn/soybean rotation should be expanded to a corn/cover crop/soybean/cover crop rotation to do the best job of managing the N cycle in soils. There are many logistical, environmental, agronomic, and economic factors to juggle as we strive for this ideal, but I think it is a good target. (Scott Murrell)

Q: Is the assumption that the data points are statistically significant?

A: Given where your question was in the queue, I'm assuming you were referring to the slide that showed corn response to nitrogen following: 1) corn, 2) non-nodulated soybean, and 3) nodulated soybean. I've pasted in the quote from the research paper I referenced so you can see what the authors themselves said about these figures and their statistical significance (figure and table numbers refer to those in the original paper):

"The presence of a non-nodulated rather than a nodulated soybean as a previous crop impaired the yield performance of the subsequent maize crop in the more favorable environment of 1999, while a similar tendency (P = 0. 12) was also observed in 2000 (Figure 4, Table 1). In 2000, the yield response to N was quadratic (Table 2) with 159 kg N ha^{-1} maximizing yield of maize after nodulated soybean, 233 kg N ha^{-1} for maize after non-nodulated soybean, and 295 kg N ha^{-1} for maize after maize. Conversely, in 1999, the yield responses to N were linear and the highest N rate evaluated always resulted in the highest yields."

Reference:
Bergerou, J.A., L.E. Gentry, M.B. David, and F.E. Below. 2004. Role of N_2 fixation in the soybean N credit in maize production. Plant Soil 262:383-394. (Scott Murrell)

Q: is there a possibility that PSNT will underestimate the N available next year for corn?

A: Research with the PSNT test found few errors associated with overestimation but a near 40% chance for underestimation (http://www.agry.purdue.edu/ext/pubs/AY-314-W.pdf). Unfortunately, I am not sure these error rates apply to this year's situation. The PSNT is usually recommended for situations where manure is applied or a legume (clover, alfalfa, etc. – not soybean) is incorporated into the soil. The nitrate-N found is considered an index of the N to become available to the crop from the organic N pool, and is not the total amount of N available. Except for some N temporarily incorporated into residue and microbial biomass the nitrate-N we find leftover from fertilizer applied to this year's corn crop is all we are going to get. So, if we use our previous guidelines based on the N found being an indicator of more N to be released we will be overestimating the true supply, not underestimating. (James Camberato)

Q: Will applications of "carbon type" commercial products this fall help keep nitrate n immobile?

A: Each carbon product will have its own chemical properties that dictate how it affects nitrogen cycling when applied to soils. I'll focus on biochar and charcoal, both of which appear to have similar properties.

Based on current knowledge, which is sparse, the only way these compounds would affect nitrate is in the initial stages of nitrification – before nitrate has formed. Biochar's and charcoal's reactive surfaces adsorb ammonium from the soil solution, keeping a portion of it from nitrifying. Once nitrogen is already in the nitrate form, these carbon compounds would not be expected to immobilize it.

A couple of reviews on these compounds are:
Clough, T.J. and L.M. Condron. 2010. Biochar and the nitrogen cycle: Introduction. J. Environ. Qual. 39:1218-1223.
Glaser, B., J. Lehman, and W. Zech. 2002. Ameliorating physical and chemical properties of highly weathered soils in the tropics with charcoal – a review. Biol. Fertil. Soils 35:219-230. (Scott Murrell)

Q: Since we had later water this year in Indiana and more late nodulation will we have a greater N leftover N % this season following soybeans?

A: It's hard to find studies that answer this question directly. A greenhouse study in China showed nicely that drought decreased shoot biomass production but increased N concentration (Jin et al. ,2011); however, overall accumulation of N in the above-ground portion of the soybean plant decreases with drought. Combining this information with another study that demonstrated no increase in root biomass with drought (Hoogenboom et al., 1987), it seems reasonable to conclude that overall plant biomass (roots plus above-ground biomass) decreases under a drought and so does nitrogen accumulation. I conjecture that there will be less N contribution to the soil from the soybean plant itself.

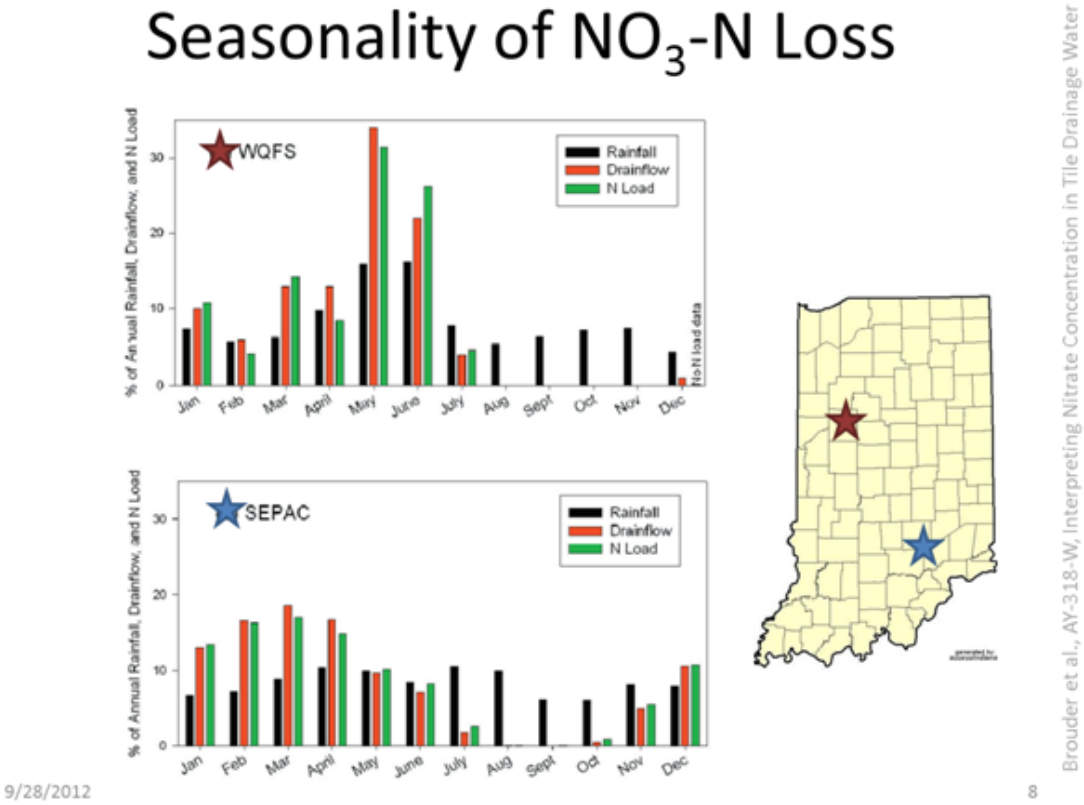
Another factor is that with reduced total uptake of N, it is likely that there will be higher quantities of residual soil nitrate left after this year's soybean crop (Bundy et al., 1993). Soybean typically scavenges a lot of the residual nitrate left after corn, but this year, I'm assuming it will be less.

References:
Bundy, L.G., T.W. Andraski, and R.P. Wolkowski. 1993. Nitrogen credits in soybean-corn crop sequences on three soils. Agron. J. 85:1061-1067.
Hoogenboom, G., M.G. Huck, and C.M. Peterson. 1987. Root growth rate of soybean as affected by drought stress. Agron. J. 79:607-614.
Jin, J., G. Wang, X. Liu, X. Pan, S.J. Herbert, and C. Tang. 2011. Interaction between phosphorus nutrition and drought on grain yield, and assimilation of phosphorus and nitrogen in two soybean cultivars differing in protein concentration. J. Plant Nutr. 29:1433-1449. (Scott Murrell)

A: Scott Murrell pointed out how complicated the impact of soybean was on corn yield and N requirement. I really don't think we can make any adjustments to N rates in a corn-soybean rotation based on this year's situation. Our current recommendations should be a good basis for fertilization of corn after soybean (http://www.agry.purdue.edu/ext/corn/news/timeless/NitrogenMgmt.pdf). If we have a dry winter the big adjustment will be for corn after corn (in fields that yielded poorly). (James Camberato)

Q: So in Indiana you are not recommending a preseason Nitrate test next year? Only a sidedress test?

A: A pre-season test will possibly be useful but unfortunately in our climate there is still a high probability of losing N during the late spring. The further south you are the N loss is distributed throughout winter but more north there is a strong peak in both May and June. Waiting till after planting gives the best chance of determining plant available N for that season. If one chooses to sample earlier in the season and we have a dry spring I don't see a problem, but if one samples earlier and then gets normal or above-normal rainfall another test would be warranted. (James Camberato)



Q: What percent of corn acres receive split N application? Was the onset of the drought early enough that the second N application was not completed?

A: In Indiana almost all the corn was fully fertilized. Normally we have a fairly even distribution of rainfall throughout the season so there was no reason to expect the drought to continue for so long.

This year was interesting because the corn that had fall-applied or spring pre-plant N used the N much better early in the season than the corn to which N was applied after planting. In some cases the corn that was sidedressed was N deficient because the soil was too dry for the plant to take up the N. We had several research experiments that fortuitously compared at-plant N to sidedressed N. Only one has been harvested and there was no yield difference between the timings.

The last two years there has been a large yield benefit to sidedressed N due to excessive early season N loss from abundant rainfall. (James Camberato)

Q: What about nitrogen availability for a wheat crop this fall? is the unused N available for wheat to use now? east central Missouri

A: Wheat has a better chance of recovering the leftover N than corn or soybean next year. Not only will it take up some N this fall, but it will have a fairly deep root system in the spring and be ready to accumulate more N earlier in the season and deeper in the profile. I don't believe one need apply the customary fall N application (and I think most others will agree with me). How to adjust next year's N application for the carryover is the hard part. I suggest you discuss with Peter Scharf (copied above) the potential of soil or tissue testing in the spring to make an informed adjustment. (James Camberato)

A: I think the N carryover would generally be available to a wheat crop this fall, but could challenge wheat management skills. Given mild fall weather, the crop could get a lot of growth on it prior to winter dormancy. The crop would then have to be monitored closely upon greenup in the spring - the lush growth puts pressure on wheat disease resistance; can 'push' early crop growth and development (increases damage if a late frost occurs); encourages lodging (especially if spring N applications are excessive); and raises grain protein (though not always monitored, is generally not desirable in the soft red winter wheat varieties grown in east central Missouri). However, wheat might be followed by double-crop soybean in some of your region, and this is a very profitable system in many seasons. I wish you a good season to come. (John Grove)

Q: Does soybean add any nitrogen to the soil every year after harvest? What are the dynamics in drought vs normal year?

A: The root exudates of soybean add nitrogen to the organic-N pool. In an Iowa study (Martens et al., 2006), soybean produced increases in amino sugar-N, amino acid-N, and ammonium-N. Ammonium is the product of mineralization of organic residues. The ammonium is plant-available and organic forms are mineralized during a time frame that corresponds well with the next season's corn uptake in the central and northern parts of the U.S. Corn Belt.

In a drought year, soybeans have fewer nodules on their roots and less nodule mass overall (Serraj and Sinclair, 1998). Additionally, overall soybean root mass doesn't appear to change during a drought (Hoogenboom et al., 1987). Both of these pieces of information point to a reduction in soybean's contribution to the organic-N pool under drought conditions.

Soybean also is a good scavenger of soil nitrate. Reductions in soil nitrate levels have been observed after soybean compared to corn (Bundy et al., 1993). With reduced growth and nutrient uptake, it is likely that soybeans will not take up as much nitrate in a drought year.

So to conclude, I hypothesize that in a drought year after soybeans, the size of the organic-N pool decreases and the size of the nitrate-N pool remains higher.

References:
Bundy, L.G., T.W. Andraski, and R.P. Wolkowski. 1993. Nitrogen credits in soybean-corn crop sequences on three soils. Agron. J. 85:1061-1067.
Hoogenboom, G., M.G. Huck, and C.M. Peterson. 1987. Root growth rate of soybean as affected by drought stress. Agron. J. 79:607-614.
Martens, D.A., D.B. Jaynes, T.S. Colvin, T.C. Kaspar, and D.L. Karlen. 2006. Soil organic nitrogen enrichment following soybean in an Iowa corn-soybean rotation. Agron. J. 70:382-392.
Serraj, R. and T.R. Sinclair. 1998. Soybean cultivar variability for nodule formation and growth under drought. Plant Soil 202:159-166. (Scott Murrell)