PSNT, ISNT, SPAD, etc…What Does It All Mean?

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Abstract

With higher fertilizers prices becoming the norm, scientists and producers alike are looking for alternative (hopefully better) methods of making nitrogen fertilizer rate decisions. Currently there are a number of methodologies promoted, but sometimes the scientific underpinning is lost in the discussion. The objective of this article and corresponding presentation is to provide information on how the methodologies are supposed to be utilized, where they have application, and where they have shortcomings. Various technologies will be discussed including the presidedress nitrate soil test (PSNT), the Illinois soil nitrogen test (ISNT), the use of SPAD meters, and the use of remote sensing.

Presidedress Soil Nitrate Test (PSNT)

The presidedress soil nitrate test (PSNT) was developed with the idea that nitrate levels could be measured prior to corn sidedressing as an indicator of N mineralization or N carryover from the previous year. As soil nitrate levels increase, the need for supplemental fertilizer should decrease. Research has demonstrated that at high levels of nitrate the need for supplemental N does decrease (Figure 1). The question then, is what is the critical level that has to be achieved to ensure that N is not limiting? There are several different statistical approaches that can be employed for determining that critical level. One of the easiest is simple evaluation of the data and selection of the PSNT level where there is a decreased risk of yield loss associated with N deficiency (level where relative yield approached 95%). For the data collected in Ohio over that last 4 years the critical level would be around 30 ppm. Thus soils with PSNT levels above 30 ppm have a decreased risk of N deficiency and would likely not benefit from additional N inputs.

The next question is, can one use PSNT to determine the “optimum” N rate? There is a relationship between PSNT level and optimum N rate, and some universities do make recommendations based upon PSNT level. Evaluation of the relationship for 10 experiments conducted across Ohio does show a relationship, but the relationship is not that great (Figure 2). Notice that for a given PSNT level the optimum N rate can have quite a wide range, thus Ohio State University does not make recommendations based on PSNT levels. One could, however, adjust sidedress rate decisions downward as PSNT level increases — on average this should work.

One thing to note about the use of PSNT is that it is most effective in situations where manure has been applied or where corn is following a leguminous forage crop. In most

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other situations the PSNT level is well below the established critical level and that is an indication that additional N is needed to ensure N sufficiency. Since we suspect that is the case anyway why pay for the analysis?

PSNT is a useful tool for making N rate decisions, but use it where it is most beneficial. It should be used wherever manure has been applied, where corn is following a forage legume, or where N carryover is suspected to be substantial. It can be used for sites that have received preplant N as well, but if the N was banded (like an anhydrous ammonia application or a starter application) there is a significant risk of getting a soil sample that is not representative of actual soil conditions. Do not collect PSNT samples too early in the growing season. This is especially true in manured fields or fields coming out of legume forages. Early collection will usually have lower PSNT levels because the soils have not adequately warmed to allow mineralization to occur.

Illinois Soil Nitrogen Test (ISNT)

This test was first proposed by Mulvaney et al. (2001) based on some research conducted in Illinois. They were evaluating soil organic matter for fractions that were easily mineralizable. Their research led them to the amino sugar-N fraction of soil organic matter. This is a readily metabolizable fraction that they hypothesized could be used for estimating the amount of N mineralization potential based on a lab procedure. Their initial research findings were encouraging as they showed that the ISNT could segregate between N response and non-responsive sites (Mulvaney et al., 2001). They established a critical level between 225 and 235 ppm, so any soil that tested above 235 would be considered unlikely to respond to additional N application (Khan et al., 2001).

Other states began to evaluate the ISNT to determine if the proposed methodology could be adapted to different growing conditions. Iowa State University and the University of Wisconsin were among the first to evaluate the concept (Osterhaus et al., 2008; Laboski et al., 2008; Sawyer and Tabatabai, 2005). There findings were not as positive as the original Illinois work (Figures 3 & 4). Both universities were unable to identify the critical amino sugar-N concentration that Mulvaney and Khan had originally proposed. In fact, the work out of Iowa State and Wisconsin did not show a relationship at all between N responsiveness and amino sugar-N content.

Since few have been able to replicate what was observed originally in Illinois, most land grant universities in the Midwest do not promote its use. Interestingly, North Carolina State has recently published a manuscript showing that the ISNT has some usefulness in their state for making N rate decisions (Williams et al., 2007).

SPAD Meters and Optical Sensing

Recently some researchers have begun to focus on the plant rather than the soil as an indicator of N release. Remember, N reactions in the soil are primarily biological in nature so the speed and extent of mineralization is not only dictated by the organic material, but also by the weather conditions experienced during the growing season.

Since scientists are unable to accurately predict weather conditions during the growing season, we have been unable to develop models to predict N availability as a result of mineralization. Instead of focusing on the soil and the inherent problems with modeling an idea was born that the plant could be used as an indication of what is going on in the soil during the growing season. We agronomists have used plants in the past to indicate what is going on in the field through the use of tissue analysis, but this methodology is slow, labor intensive, and costly.

These ideas led to the evaluation of optical sensors for determining in-season N response (Mullen et al., 2003, Varvel et al., 1997). The initial work was conducted in wheat with optical sensors and corn with SPAD meters, but optical sensors have been evaluated in corn as well (Figure 5). In-season estimates of crop response can be indicative of responsiveness of the crop to additional N, but the use of a corresponding check strip (0 N) is a better indication of response than using an N rate lower than the reference strip. This was the first step in developing optical sensor based algorithms. There is a caveat to the use of a sensor. You must have an N reference or N-rich strip for comparison. For corn management, this obviously has a time factor. Currently, researchers promote that sidedress decisions be delayed to V6 or later prior to the utilization of this technology. Due to the small numbers of high-clearance sprayers and time constraints, the earlier the reference strip can be measured and used to calibrate N responsiveness the better. Late season readings have been shown to be more indicative of plant response than early season readings. This makes sense considering early season measures have only progressed through a fraction of the growing season after which things can change considerably.

There are multiple algorithms (equations to determine N application rates) being formulated and evaluated. SPAD-based algorithms rely on relative SPAD readings (relative to a reference strip) and crop N response models to determine N application rates. Essentially, SPAD meters are used to replace tissue testing as an indirect measure of tissue N concentration. Similar algorithms are being developed with active sensors as well. Alternative algorithms utilize a prediction of yield potential and N responsiveness. These algorithms depend on yield prediction models developed over many years and locations. The fundamental concept is to project yield potential with and without additional N to determine an N application rate.

So what is the status of these techniques to make N rate decisions? Some land grant universities utilize SPAD meters as improved N management tools (University of Nebraska, Penn State). The drawbacks with SPAD meters are the labor/cost issues and questions about the ability of the algorithms to perform adequately. Optical sensors are more attractive because they can be utilized real-time, but the technology is still quite expensive. Current research shows that in certain regions the sensors can be used with good results (Oklahoma, Missouri, and Virginia). There is still hope that this technology can be transferred to the Tri-State area, but the first real step is the establishment and utilization of reference strips.

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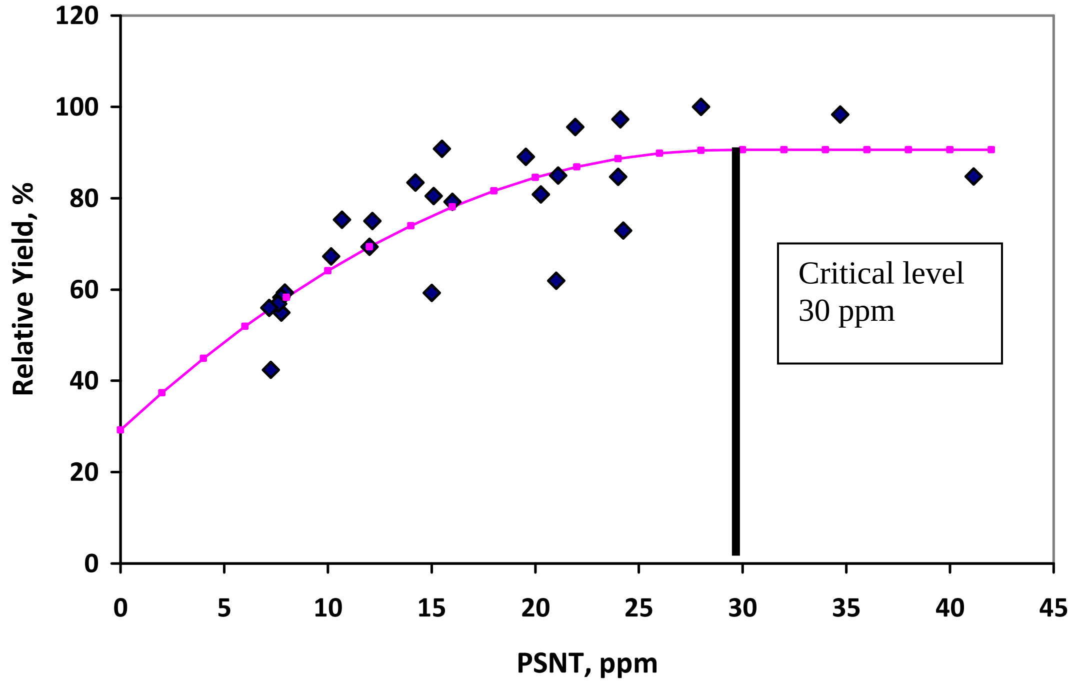

Figure 1. Relationship between PSNT level and relative yield (compared to a fertilized plot) across 10 experiments in Ohio, 2004-2007.

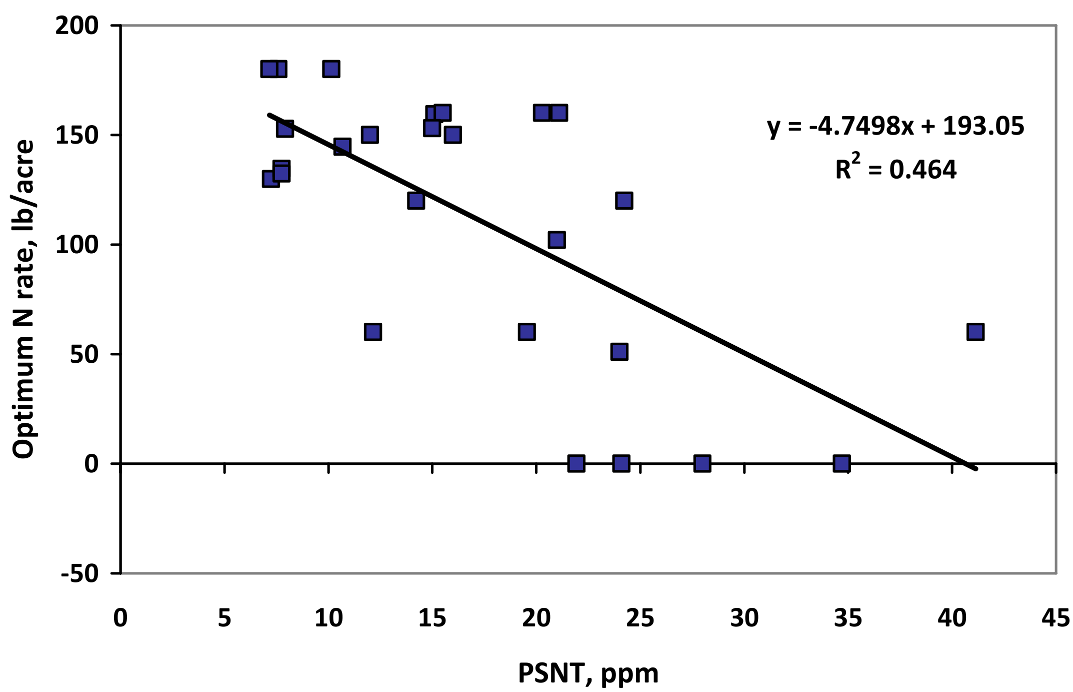

Figure 2. Relationship between PSNT level and optimum N rate across 10 experiments in Ohio, 2004-2007.

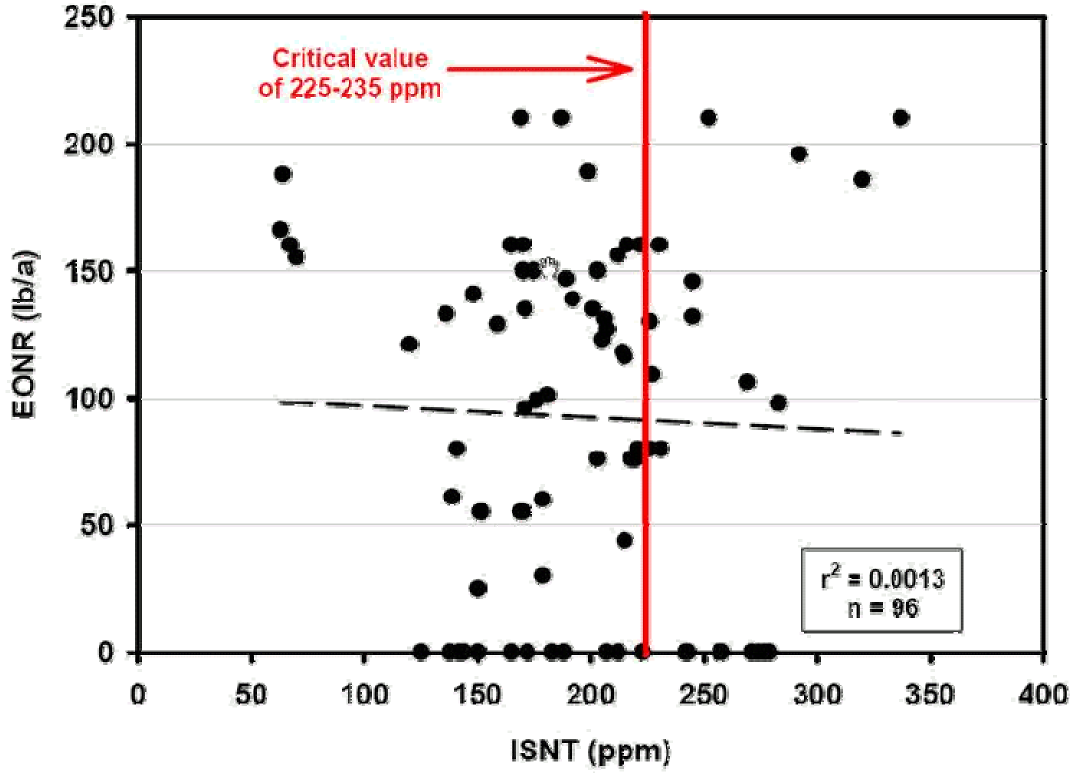

Figure 3. Relationship between ISNT and economically optimal N rate (EONR) across 96 experiments conducted in Wisconsin (Osterhaus et al., 2008).

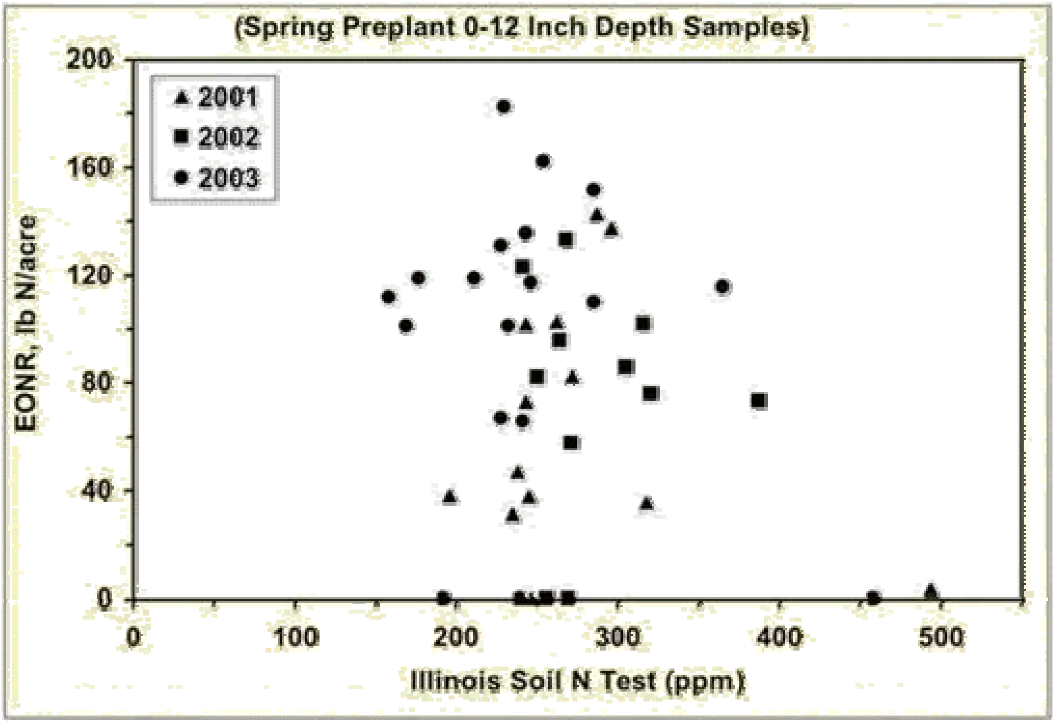

Figure 4. Relationship between ISNT and economically optimum N rate (EONR) across 43 on-farm trials in Iowa (adapted from Sawyer and Tabatabai, 2005).

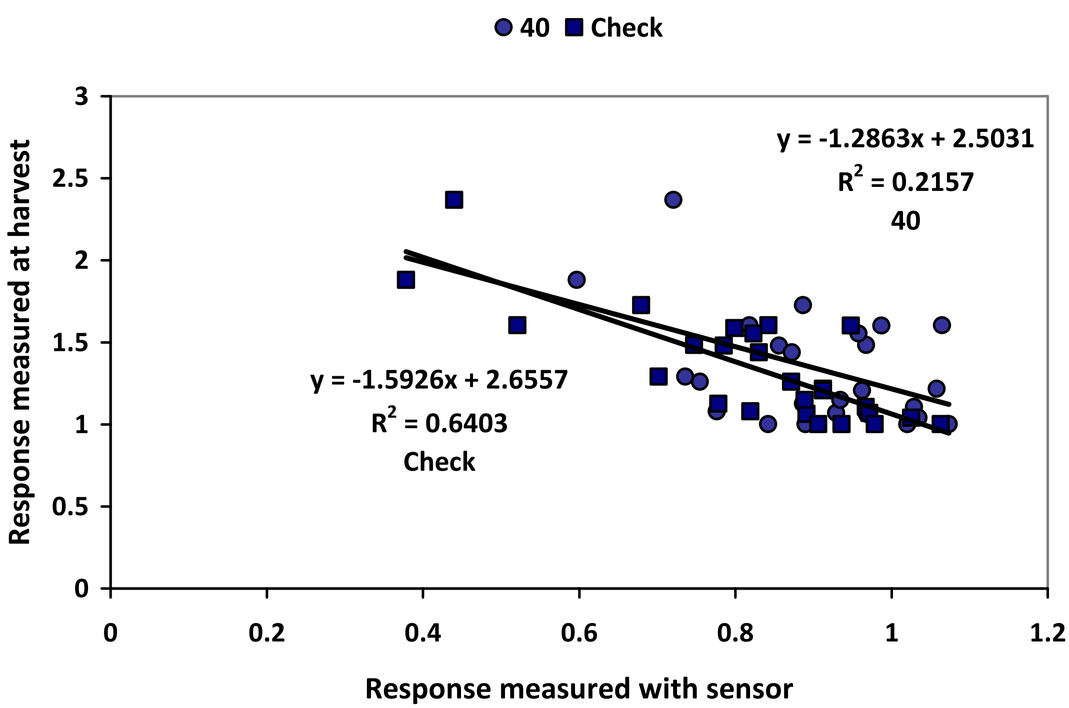

Figure 5. Relationship between response measured in-season with an optical sensor around V6-V10 and response measured at harvest across 26 experimental locations, 2004-2007.