NITROGEN AND PHOSPHORUS RECALIBRATION FOR SUNFLOWER IN THE NORTHERN GREAT PLAINS

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INTRODUCTION

Sunflower producers in the northern Great Plains states of North Dakota, South Dakota, and Minnesota are presently directed to N and P recommendations that originate from research performed in the late 1960s and early 1970s. These three states alone produce more than 80% of the sunflowers in the United States on a yearly basis (USDA-NASS, 2015). The current general formulas determining N and P fertilizer rate in these top-producing states are equivalent. The N recommendation is represented here by the North Dakota formula (Franzen, 2010): *N-rate = (0.05 x YP (or YG)) – N credits*. This formula uses Yield Potential (YP) or Yield Goal (YG) to calculate total N recommended and subtracts from this N credits of previous crop and soil test nitrate-N from a 2-foot soil core composite. The sunflower fertility recommendation of 0.05 lbs N per 1 lb sunflower yield is the long-time standard and a general rule incorporated in sunflower fertilizer recommendations from Canada to Texas.

Phosphorus recommendation for sunflower uses a sunflower P requirement of 0.02 pound P per 1 pound sunflower yield. The current North Dakota fertilizer recommendation formula (Franzen, 2010), once again representing the formula for South Dakota and Minnesota as well, is: *P-rate = (0.0225 – (0.0014 x STP)) x YP (or YG)*. This formula utilizes the Olsen P test.

The N and P yield-based formulas were appropriate when costs of fertilizer were low and issues of sunflower production revolved around protecting and sustaining obtainable yields rather than increasing yield potentials. Average sunflower yields in the northern Great Plains have increased substantially from the 1970s (Figure 1) and this can be attributed to several factors. Defensive breeding has presented genetics-based solutions provided in herbicide resistance systems, vertical resistance to downy mildew and sunflower rust, and quantitatively inherited Sclerotinia resistance (Hulke and Kleingartner, 2014). Seed treatments have also become commercially available for protection against disease pathogens, insects, and even seed-eating herbivores, prior to emergence.

Improvements of yield from sunflower fertility involve placement methods and split applications which can increase efficient uptake of fertilizers. Also, the potential sunflower uptake of residual N has increased. This potential is greater due to higher fertilizer rates for crops such as corn and wheat in sunflower rotations. This means that with higher rates of N fertilizer applied, due to increased yield potentials of corn and wheat, more N can be left behind. Sunflower has access to this N, plus with a deeper rooting capability than most crops, it can tap into unused residual N below other rotational crops' rooting zones. While sunflower fertility has contributed to greater yields, fertilizer rates determined by above formulas have remained static.

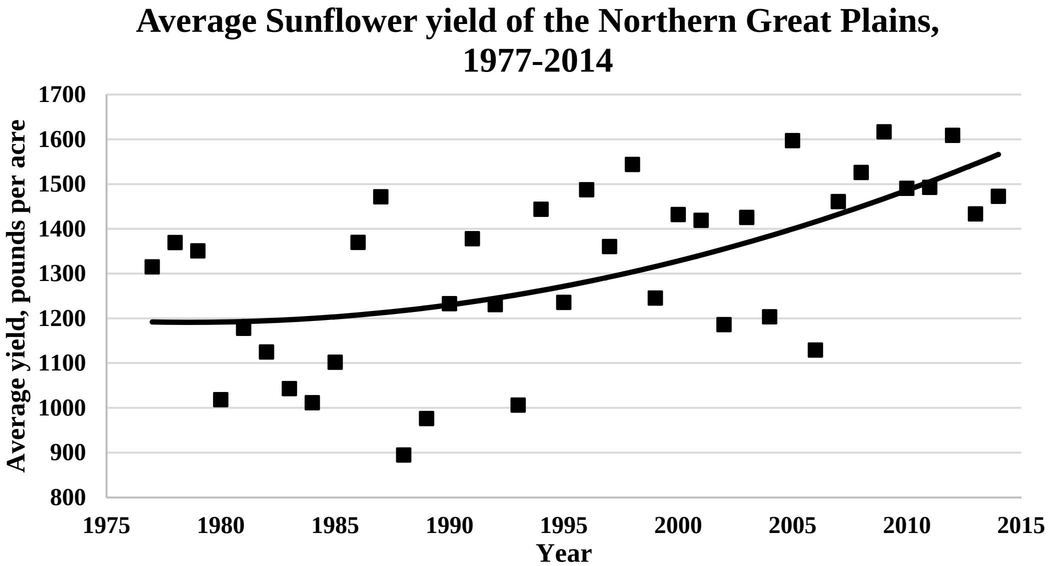

Figure 1. Average sunflower yield for the northern Great Plains states of North Dakota, South Dakota, and Minnesota from 1977-2014 (USDA-NASS, 2015).

Reflected in the current formulas for sunflower are linear responses to fertilizer. However, there is a known curvilinear response to fertilizer in which incremental yield gains with fertilizer application are diminished at higher yields. Much like updated N recommendations for corn (Franzen, 2014) and wheat (Franzen, 2009) in North Dakota, updated sunflower recommendations will take this curvilinear response to fertilizer into account. Responses of yield and oil components of sunflower to N and P will represent the curvilinear response and indicate soil test critical levels.

A total of 30 sites in North Dakota and South Dakota encompass the N and P trials for sunflower in 2014 and 2015. At the time of writing this proceedings paper, the 2015 sunflower sites had yet to be harvested and analyzed.

MATERIALS AND METHODS

The N and P rate trials were conducted on 11 experiment sites in North Dakota and three experiment sites in South Dakota in 2014. The North Dakota sites were established within larger cooperator fields. These sites were planted with the cooperators' hybrid choice, and managed by the cooperator with no additional fertilizer applied other than the treatments. South Dakota State Extension Specialist- Agronomist Christopher Graham and his team planted and managed the South Dakota sites. Experimental design at each site was a randomized complete block with a split plot arrangement and four replications. The main plots were six N treatments (0, 40, 80, 120, 160, and 200 lb N per acre) applied preplant as ammonium nitrate and the sub plots were four P treatments (0, 30, 60, and 90 lb P per acre) applied preplant as triple superphosphate. The experimental units for each site in North Dakota were 30 feet long by 10 feet wide and in South Dakota 30 feet long by five feet wide. One row the length of the plot was harvested for yield determination. Oil analysis was performed using nuclear magnetic resonance. Regression analysis was performed using Microsoft Excel 2010.

RESULTS AND DISCUSSION

After yield analysis of the 2014 sunflower experiments, multiple regression analysis was performed to determine which factors would categorize experiments with stronger relationships. Given the current state of research being from only 2014, comparisons between experiments needed to provide adequate groupings in order to be meaningful. Sunflower has shifted in North Dakota and South Dakota to the western portions of each state, and along with this shift is now grown most commonly in long-term no till (continuous no-till for more than six years) production systems. Although long-term no-till (with high organic matter) has shown a 50 lb N credit in previous North Dakota wheat and corn experiments, with a dataset from only 2014 for sunflower this relationship is difficult to make. Of the 2014 sites, only two were in conventional till and 12 were in long-term no-till. Therefore, focusing on a factor that was expressed over each of the first-year's sites was important. Given the wide range of residual N for the 2014 experiments (28 to 183 lbs N per acre) it seemed logical to use this as a starting point.

The soil nitrate test to 2-feet in depth for residual N has historically been incorporated into N recommendations for all crops in the northern Great Plains, lending reason for investigation into whether its use in sunflower is still relevant. Figure 2 shows the relationship of sunflower yield with applied N treatment rates without any consideration for residual N or previous crop credits. When soil test nitrate to 2-feet in depth is included in the analysis with N treatment rate (represented by total known available N) the response curve is different (Figure 3). The wide range of yields obtained from the check treatments (zero N applied) is removed and can explain the left side of Figure 2 much better. However, the R^2 value is mostly unchanged, 0.037 without soil test nitrate and 0.041 with soil test nitrate. Upon these results it is difficult to justify even the standard soil test for residual N in sunflower. Further analysis was needed to determine if residual N is, in fact, important.

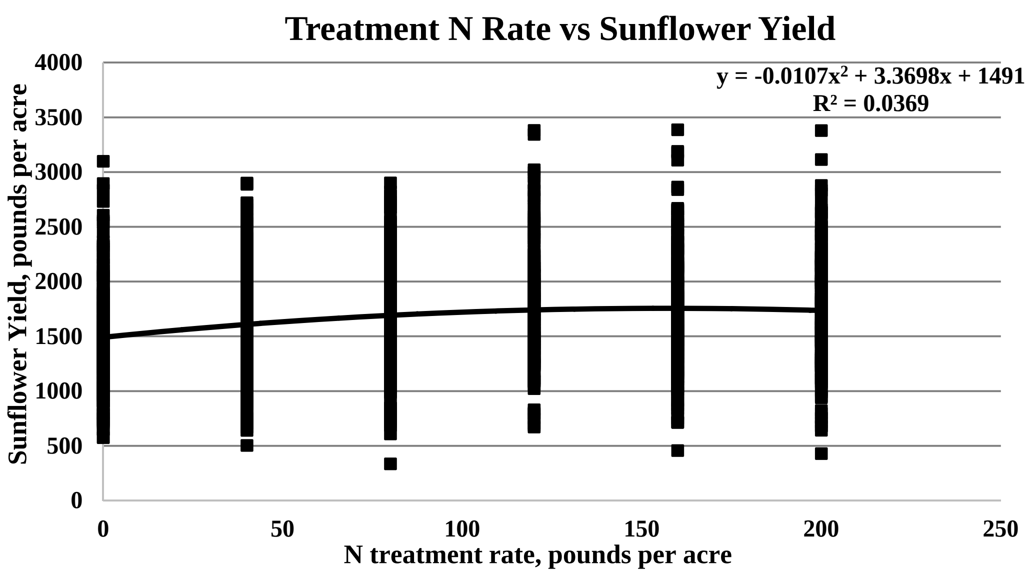

Figure 2. Relationship between N treatment rate and sunflower yield for 11 North Dakota and three South Dakota analyzed experiments.

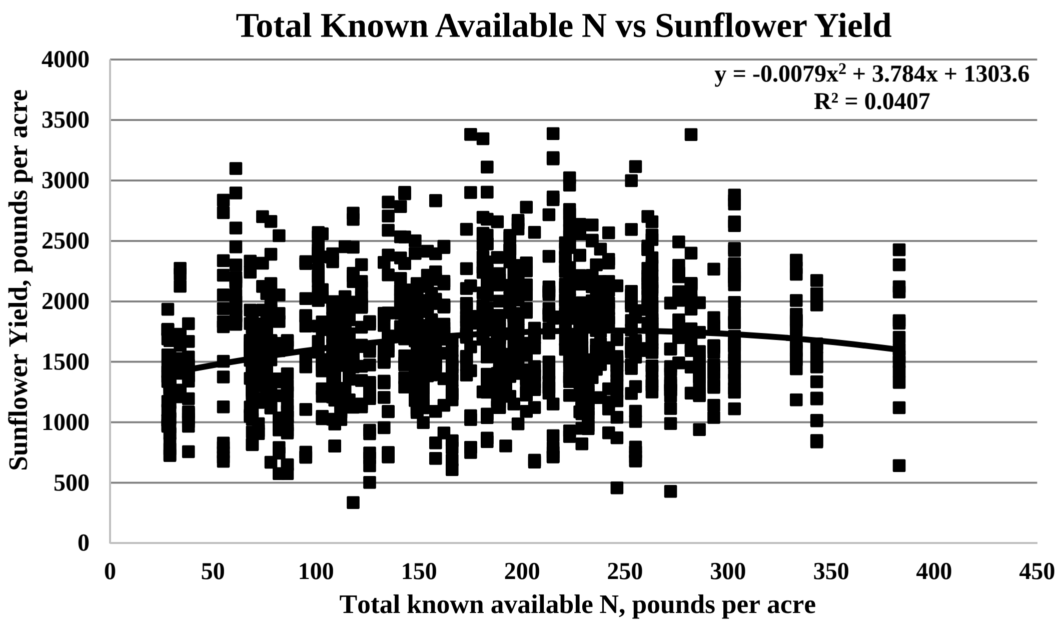

Figure 3. Relationship between total known available N (N treatment rate plus soil test N) and sunflower yield for 11 North Dakota and three South Dakota analyzed experiments.

Results of further analysis indicated that separating the 2014 sites into those with high residual N (>50 lbs N per acre) and low residual N (<50 lbs N per acre) can explain why the original regression analysis including residual N was ineffective. High residual N sites (Figure 4) have a lacking response to N and a very low R^2 relationship of 0.008. Figure 5 shows the sites with low residual N and has a somewhat poor R^2 value of 0.11, however this is much greater than the R^2 of the high residual N sites and R^2 for all sites including total known available N (Figure 3).

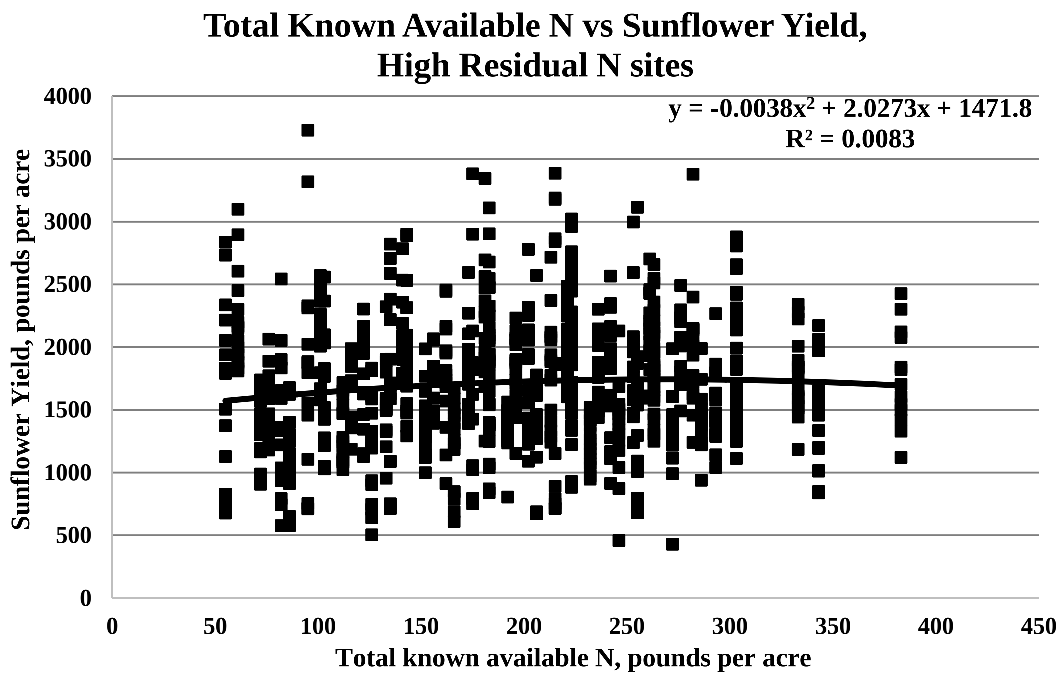

Figure 4. Relationship between total known available N and sunflower yield for analyzed experiments with high residual N (>50 lbs N per acre).

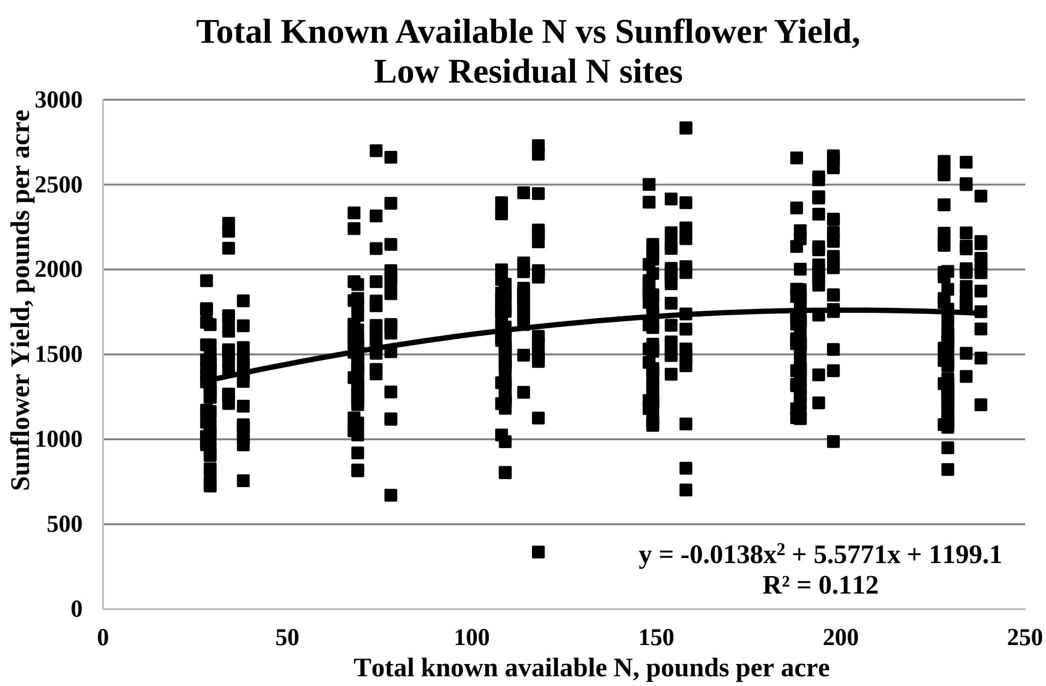

Figure 5. Relationship between total known available N and sunflower yield for analyzed experiments with low residual N (<50 lbs N per acre).

Using the same concepts applied for yield, multiple regression analysis was performed for sunflower oil content from the 11 oilseed sunflower sites. Forty percent oil is the "critical level" where when below this mark there is a dock on price and above this mark a premium is paid. The high-oleic and NuSun® varieties were analyzed together for oil content, as fatty acid content is affected instead of overall oil percent with these differing varieties. The overall trend for oil is to decrease with N (Figure 6). However, the maximum obtained oil according to the trendline is about 39.5 percent. It is also shown that total known available N would have to be somewhere between zero and about 40 lbs per acre to obtain 40 percent oil. The high residual N sites in Figure 7 have a similar trendline, 39.5 percent oil for the lowest N available decreasing steadily with increasing N. Comparatively, the low residual N sites show a response curve increasing oil content and peaking at nearly 40 percent oil then decreasing thereafter (Figure 8). This curve represents the typical oil content response of sunflower, however, like the other relationships between oil and N shown, there is a rather low R^2 value.

Response to P in these trials was minimal. One site testing very low and one site testing very high, according to Olsen-P soil test calibration levels (Franzen, 2010), showed responses to the four P treatment rates. Also, the three sites that responded to P in oil all had soil P levels of 14 ppm and higher placing them in the high and very high soil test levels.

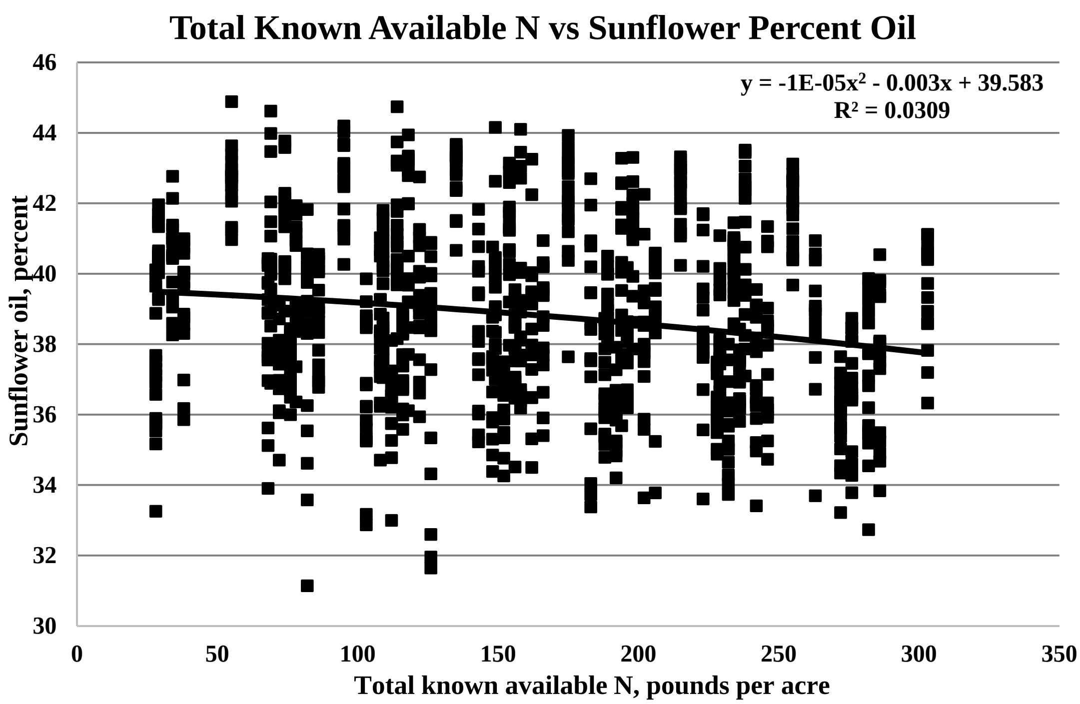

Figure 6. Relationship between total known available N and sunflower percent oil content.

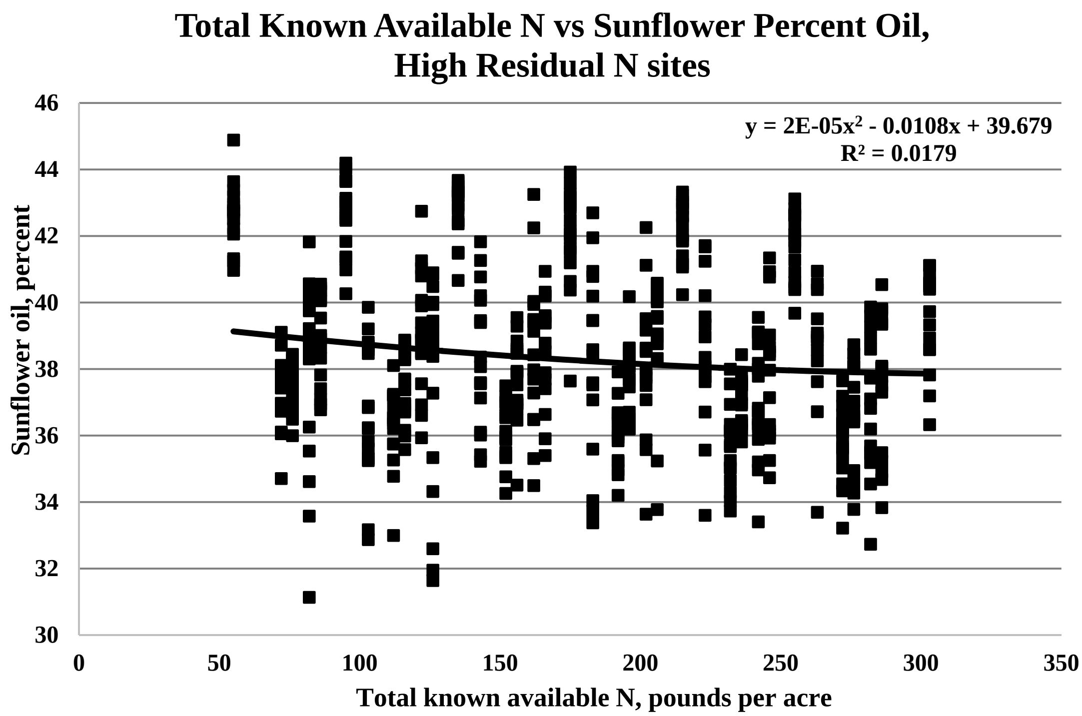

Figure 7. Relationship between total known available N and sunflower percent oil content for high residual N sites (>50 lbs residual N per acre).

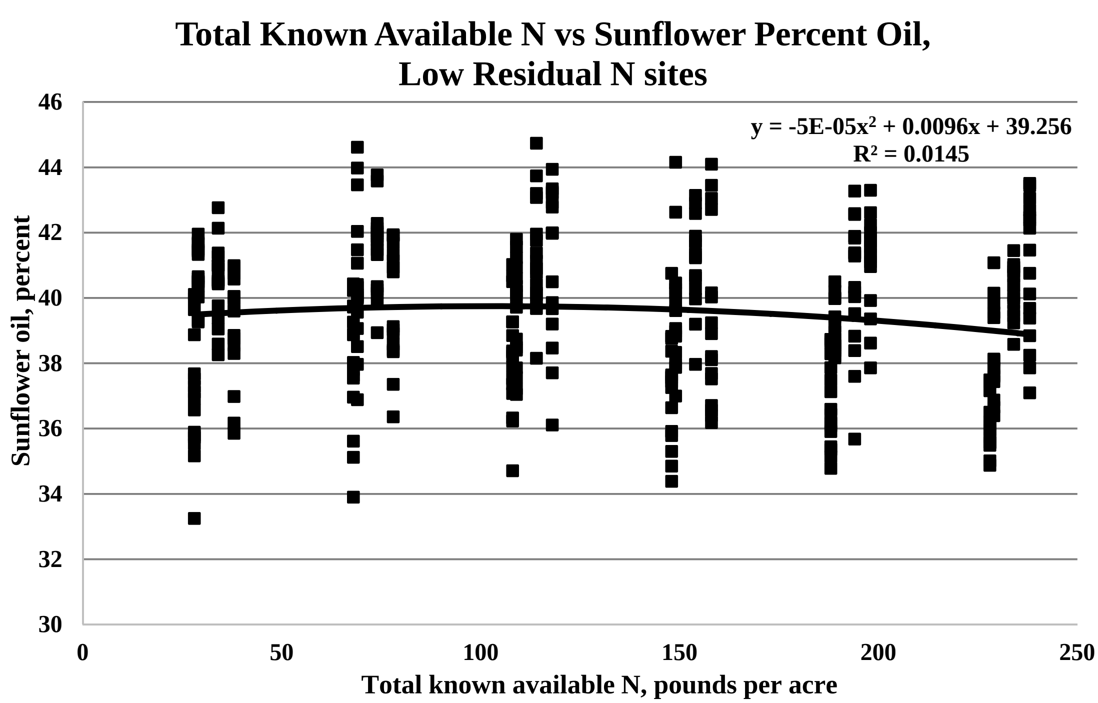

Figure 8. Relationship between total known available N and sunflower percent oil content for low residual sites (<50 lbs residual N per acre).

SUMMARY

Poor yield-N relationships for the 2014 sunflowers can be partly attributed to specific production issues. Lodging, bird damage, and downy mildew were heavy influencers on nearly half of the sites. However, high residual N impacted yield responses the greatest. This same effect was observed on oil as well. Response to P for yield or oil was minimal, and was seen on one site with very low P and the others with high P levels. This almost zero response to P suggest that P is micronutrient-like in sunflower fertility. Overall, the shape of the yield and oil response curves, particularly for the high residual N sites, suggest that deep residual N (below 2 feet) is providing substantial N for sunflower. Experiments located on sites with lower residual N indicate that modern varieties of sunflower require more N per pound of yield than formulas for the northern Great Plains currently recommend. An additional year of research will provide a more extensive dataset that is needed to adequately formulate new recommendations for sunflower growers.

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