IMPACT OF SOIL ACIDITY ON COTTON GROWTH AN YIELD

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Abstract

Cotton production in Oklahoma has expanded significantly in recent years. A large portion of this expansion of acreage has occurred on ground that has traditionally been managed for continuous wheat systems which has led to potential problems for growers wanting to produce cotton on these acres. The objective of this research is to determine at what soil pH level we begin to see a significant reduction in lint yield or other impactful physiological characteristics. This experiment was done at 1 location during the 2019 growing season comparing 2 varieties (Deltapine 1612 & Nexgen 3930) across a soil pH gradient ranging from 4.2 to 7.4. Available results show that there is a decrease in lint yield from a point between a soil pH of 5.0 and 6.0. This observation was also true for other parameters such as plant height and NDVI, both of which also showed a critical threshold in the same range as that of lint yield. Based solely on data gathered during this project it is likely best under similar soil environments that growers should strive to keep soil pH a level between 6.0 and 7.5.

Introduction

Between 2017 and 2018 Oklahoma had an increase of just over 32% in cotton plantings at 780,000 acres. This expansion of cotton acreage continues a trend of increasing production in the state since 2015 (NASS, 2017). Much of this expansion has come from outside of the traditional cotton production area in southwest Oklahoma. With this increase in production, cotton is being planted on soils that have acidified over time under management for continuous wheat systems. Wheat can be productive down to a soil pH level of 5.5 (Zhang and Raun, 2006). The practice of banding phosphate fertilizers, a popular practice for wheat production on acidic soils in Oklahoma allows production to continue at an even lower soil pH level without being a long term solution to the problem (Lollato et al., 2013). The prevalence of acidic soils in the state poses a problem for growers looking to plant cotton on these acres traditionally managed for wheat. This study looks into the effects of soil pH on the growth of cotton across two cultivars. This work will hopefully lead to better understanding of the effects of soil acidity on cotton production and the ability to provide better recommendations for amelioration based on soil pH's impact on cotton production.

Methods

For the 2019 growing season this trial was established at the Cimarron Valley Research Station at Perkins, Oklahoma. The trial structure utilized an 8 x 2 factorial design consisting of 8 target soil pH's ranging from 4.0 to 8.0 across two cultivars (Nexgen 3930 and Deltapine 1612). Plot size was 6 m long x 3 m wide with 4.6 m alleys between replications. Soil pH was adjusted using hydrated lime (HL) and aluminum sulfate (alum). The pH gradient was first established in 2009 and has been maintained annually via application of HL and alum which are incorporated to a depth of 15 cm. This trial was planted using a 4 row vacuum planter on 05/17/2019. Soil samples were again taken post-harvest to a depth of 15 cm. Those results are used in the analyses presented. Throughout the season measurements taken included stand count, plant height, node count, NDVI and standard end of season maturity measurements. The trial was harvested using a 2 row John Deere cotton stripper.

Results

For the 2019 growing season the trial soil pH gradient ranged from 4.2 to 7.4 allowing for observation of cotton performance across a wide range of soil pH conditions. When considering available data for the 2019 growing season at the Cimarron Valley Research Station at Perkins, OK there were correlations between soil pH and most measured in-season parameters including plant height, node count and NDVI. This is reflected by the linear and linear plateau models shown below, as well as the regression examining the correlation of lint yield and soil pH.

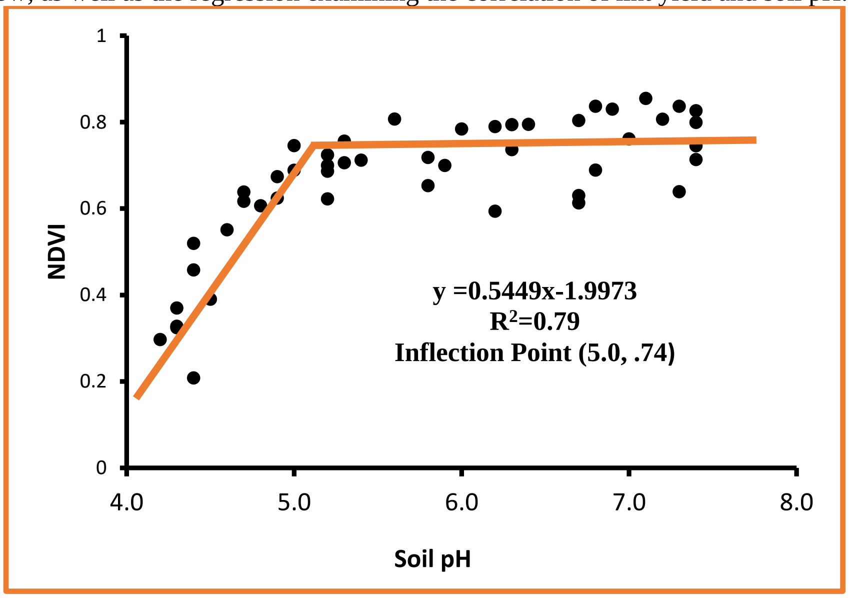

Figure 1. Linear Plateau model indicating the correlation between NDVI and soil pH (y=0.5449x-1.9973, R^2=0.79)

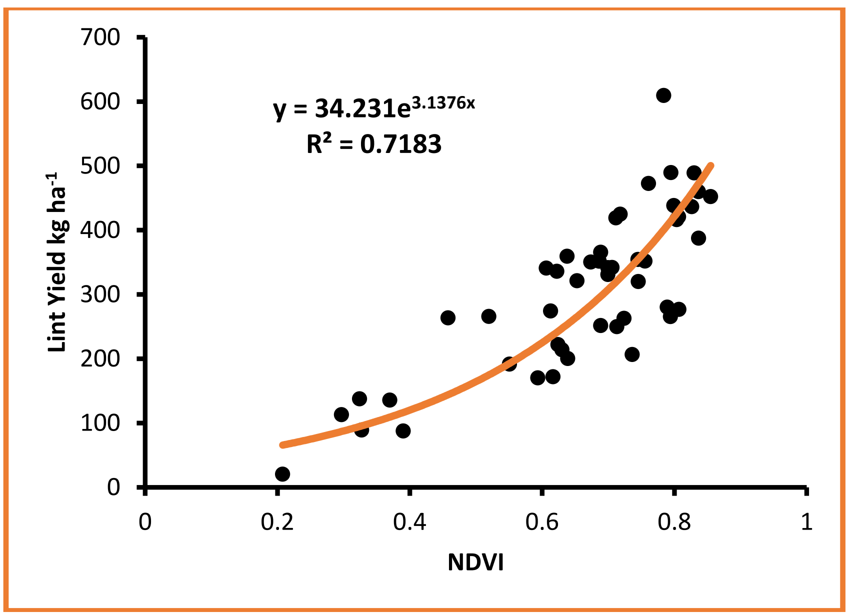

Figure 2. Correlation of lint yield and NDVI

The linear plateau regression shown in Figure 1 describing the relationship between NDVI and soil pH indicated that a critical threshold exists around a soil pH of 5.0 for this particular measurement. At a soil pH of 5.0 NDVI ranged around .74 and the regression yielded a R^2=0.79 showing a strong correlation between soil pH and NDVI. This may be applicable considering the literature citing the correlation between lint yield and NDVI as well as this trial as the non –linear regression between yield and NDVI (Figure 2) showed a strong correlation of R^2=0.72 (Arnall et al.,2016).

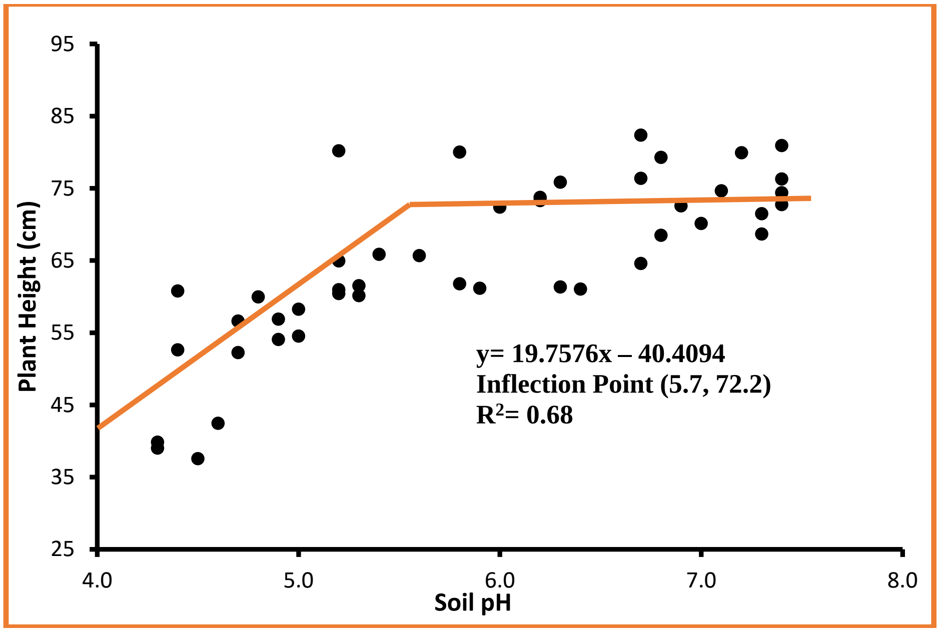

Figure 3. Correlation of plant height and soil pH

A similar pattern can be seen in the linear plateau regression showing the relationship between soil pH and plant height (Figure 3). The inflection point of the regression occurs at a soil pH of 5.7 and 72.2 cm indicating that based on plant height, soil pH is negatively affecting crop performance as we get below a soil pH of 5.7. The node count measurement also showed an interaction between total nodes and soil pH. However, this regression (Figure 4) lacked a plateau unlike the other parameters mentioned revealing that as soil pH decreases, crop performance based on this parameter also decreases at a rate of 1.42 nodes per soil pH point.

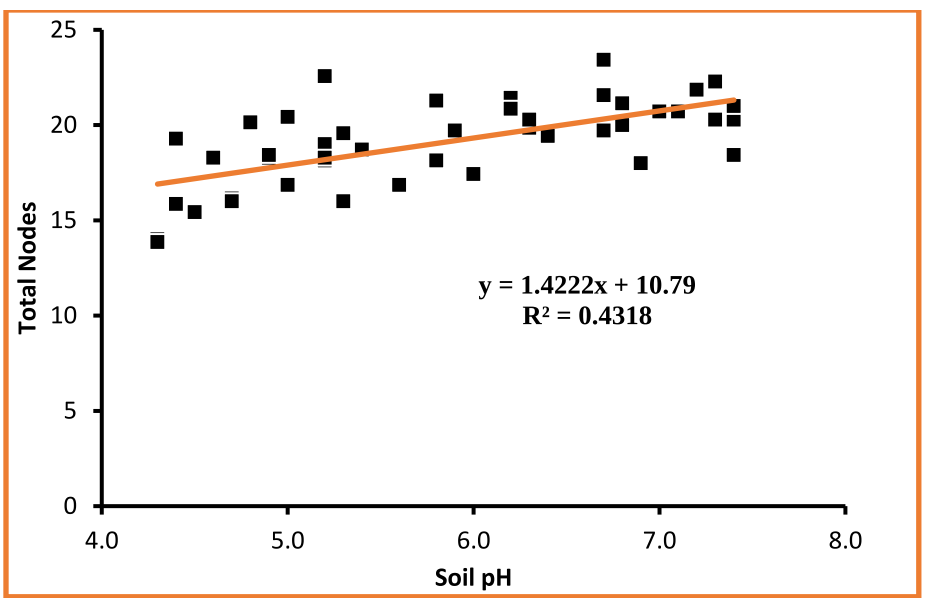

Figure 4. Correlation of plant height and soil pH

Between the three previous measurements there did not appear to be any difference between cultivar based on looking at the charts. However, when looking at lint yield by soil pH (Figure 5) it appears that there is a difference in critical threshold between the two cultivars (DP 1612 & NG 3930). This can be observed in Figure 3 below where the linear plateau regression for the Deltapine variety showed a critical threshold at a soil pH of 6.0 and lint yield at around 432 kg/ha^{-1}. Meanwhile, the Nexgen variety appeared to have a lower critical threshold at a soil pH of 5.1. However, these regressions only yielded r-squared values of .59 and .50 respectively.

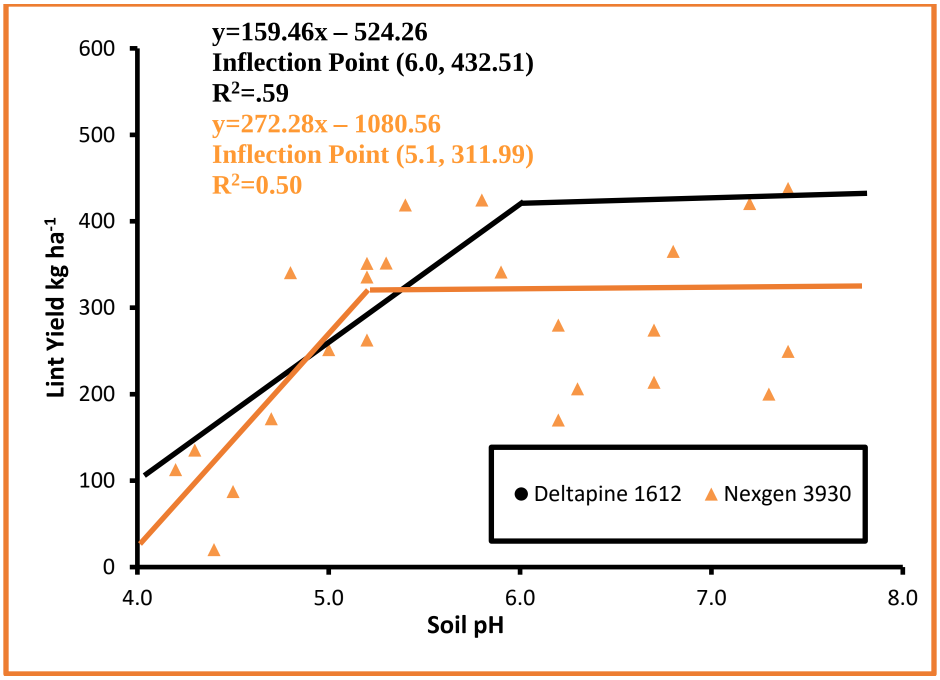

Figure 5. Correlation of soil pH and lint yield by cultivar

Summary

The correlation between cotton performance and pH is expressed by the measurements described above. Even while less than 60% of the variance in lint yield is explained by soil pH for both varieties, the impact on crop performance whether it's a measure of reflectance, node count or plant height all of these measurements pointed to stressors on the crop throughout the growing season, one of them being soil pH. These early results concur with other studies such as Butchee et al. (2012) and Lofton et al. (2010) observing a similar response to acidic conditions by other crops (Grain sorghum and canola in particular). In the future this research will allow for development of extension materials educating producers on the potential impact of soil acidity to their cotton crop.

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