

The Potential Use of Gypsum for Improved Cotton Productivity

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RESEARCH PROBLEM

Irrigation initiation, frequency and termination have a significant impact on fruit retention and final cotton lint yield and lint quality. Poor soil and irrigation management may increase surface runoff and erosion, which are responsible for extensive losses of topsoil and agricultural productivity and increase environmental liability. Surface crusting is one of the most important factors that influence such processes. Subsoil acidity and associated aluminum solubility, which is common for many Alfisols in the Mississippi delta, restricts root growth and can significantly impact water and nutrient use efficiency. A three-year study was established in 2007 with the objective of assessing the potential benefits of gypsum applications on water infiltration, and subsoil acidity.

BACKGORUND INFORMATION

Gypsum (CaSO_4) is a well known anti-crusting agent. There is evidence that applications of this material improve infiltration rates on soils prone to surface crusting. Keren et al., (1983) reported a significant reduction in seal formation when gypsum was applied to a silt loam soil. Deep lime incorporation to correct subsoil acidity is impractical and uneconomical. Methods to ameliorate subsoil acidity—by reducing the solubility of aluminum—using surface applications of gypsum have been developed (Summer, et al., 1986, Black, et al., 1984). In all these studies, increased exchangeable Ca and reduced exchangeable Al in the subsoil were reported. Gypsum can be mined or produced through the flue gas desulfurization (FGD) process at electric power plants. The FGD gypsum is normally 98% pure, with mined gypsum being of considerably less purity

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RESEARCH DESCRIPTION

An 80 acres field mapped as a Henry Silt Loam and Calloway Silt Loam was selected to assess the effect of FGD gypsum applications on aluminum solubility, cotton root growth and water infiltration. Treatments consisted of FGD gypsum at rates of 0, 1, and 2 ton/acre, with treatments replicated 3 times. Gypsum was applied with a commercial spreader, and calibrated to deliver the desired treatment rates. It was originally intended to apply the material prior to planting, but due to weather and/or land preparation, the material was applied after planting. Plot dimensions were 24, 38-in wide beds, 500 ft long. Deep soil samples (0-6 in., on 6 in. increments) were collected prior to gypsum applications during 2009. Soil pH (2:1) and extractable aluminum (2 M KCl) concentration were measured.

Soil moisture, at 7 and 15 in. deep, was monitored through the season with ECH₂O probes (Decagon devices, Pullman, Wash.). They were attached to a data logger for continued measurement, with soil moisture readings obtained hourly during the season. Two soil moisture stations (one data logger with two soil moisture probes) were installed in each treatment replicate.

Root tip length was assessed after harvest by carefully removing the soil on 1 ft radius by 3 ft deep on 3 plants per plot. Root observations were made from the 0 (control) and the 2 T/acre treatments only.

RESULTS

Soil Moisture Patterns

During the first two years of the study (2007 and 2008), no significant infiltration or soil moisture trends were observed. However, during the 2009 season some trends were obvious. Figure 1 shows average soil moisture content, 7 inches deep, for the 0 and 2 T/acre treatments during the first irrigation event. Thirty six hours after irrigation initiation the soil had reached field capacity in plots that received gypsum at 2 T/acre, while the soil moisture in the control plots had barely changed. The decreasing trend in soil moisture content was corrected in the control plots, but there was no significant increase in water storage.

Figure 2 shows average soil moisture patterns during the second irrigation event. Significant differences in water infiltration between the control and 2 T/acre treatments were observed. Soil moisture levels at 15 inches deep were considerably higher for the 2 T/acre, when compared to the other treatments. Plots that did not receive gypsum showed the least amount of stored water in the soil profile.

Aluminum Concentration

Soil samples were analyzed for soil pH, and for levels of exchangeable aluminum with 2 M KCl. The significant stratification trend is obvious and it is typical of an Alfisol with a fragipan (Figure 3). The pH levels for the top soil are within the optimum range, but that is not the case for the subsoil. Soil pH levels

below 5.0 can limit root growth significantly as the concentration of aluminum increases exponentially with increased acidity. Applications of lime are not an effective option due to reduced lime solubility and movement in the variable charged soils typical of the Mississippi delta.

Figure 4 shows average 2M KCl-extractable aluminum concentration for samples from each of the treatments. Extractable aluminum was 1 ppm in all the treatments in the first 6 inches of soil. However, average aluminum levels were 240 ppm for samples collected from the control plots, 12-18 inches deep. The effect of gypsum on aluminum concentrations is evident as the average aluminum concentration at the 6-12 inches for the 1 and 2 T/acre treatments was only 20% of that of the control plots. This effect was also evident at the 12-18 depth, where aluminum levels for the treated plots were 50-60% of the levels measured for the control plots. A standard threshold level for aluminum concentration in soil is 25 ppm (Hailing Zhan, personal communication).

Aluminum levels above 25 ppm appear to be toxic for roots. Limited root depth was evident in this field, with very little root mass observed beyond the first 10 inches of soil.

Average root tip length for samples collected from the check plots was 11 (\pm 4) inches, compared to 19 (\pm 3) inches for the 2 T/acre treatments.

PRACTICAL APPLICATIONS

Prior to the third year of the study, there was an indication that water infiltration was improved when gypsum was applied at a rate of 2 T/acre, compared to the control and 1 T/acre treatments. However, significant changes were observed prior to the third year of the study. Soil water storage appeared to be positively impacted by gypsum applications.

Soil pH showed significant stratification, with top soil samples (0-6 inches) averaging a 6.6 water pH, but samples down to 18 inches tested an average of 4.3 for water pH. This acidity level is directly correlated to excessive aluminum solubility, resulting in toxic levels for optimum root growth. Plants from the control and 2 T/acre treatments were studied for root tip length as related to treatment effect. Average root tips lengths from the control plots was 11 inches, compared to 19 inches for the 2 T/acre. Gypsum appears to be a feasible alternative to correct subsoil aluminum toxicity, as lime will not move down to such depths due to reduced CaCO_3 solubility.

The number of acres affected by acidic subsoil is not known at this time, but it is believed to be a common feature in several of the most common soil series where cotton is produced, including the Loring, Memphis, Calloway, Henry and Dubbs series.

ACKNOWLEDGMENTS

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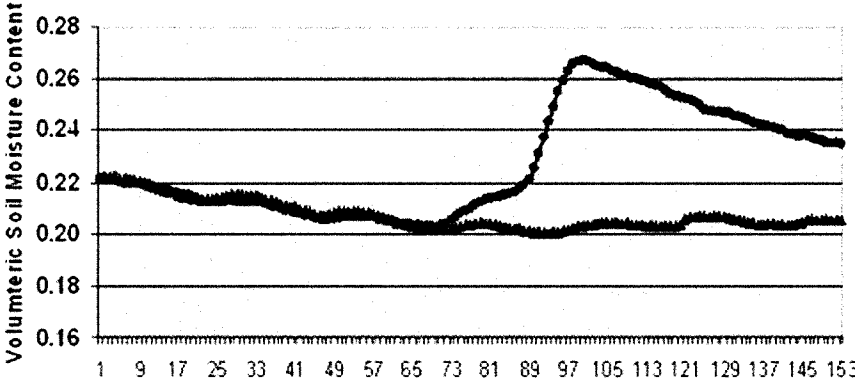


Fig. 1. Average volumetric soil moisture levels for the control and the 2 T/acre gypsum treatment after the first irrigation event at 7 inches during the 2009 season.

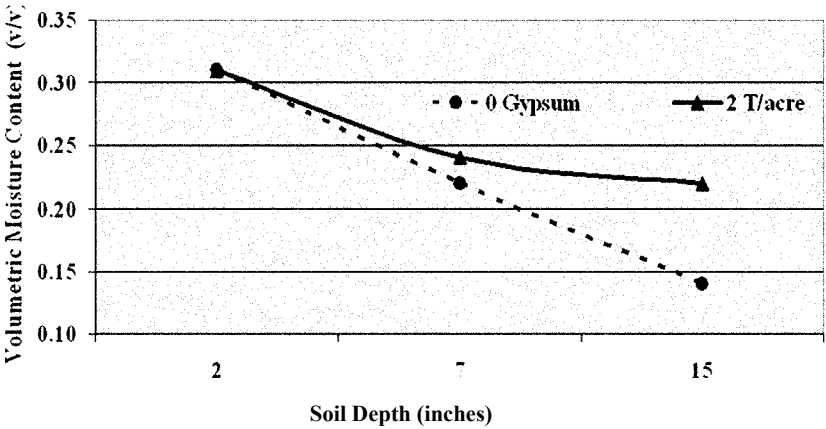


Fig. 2. Volumetric soil moisture content, for the different treatments, 4 days after a rainfall event.

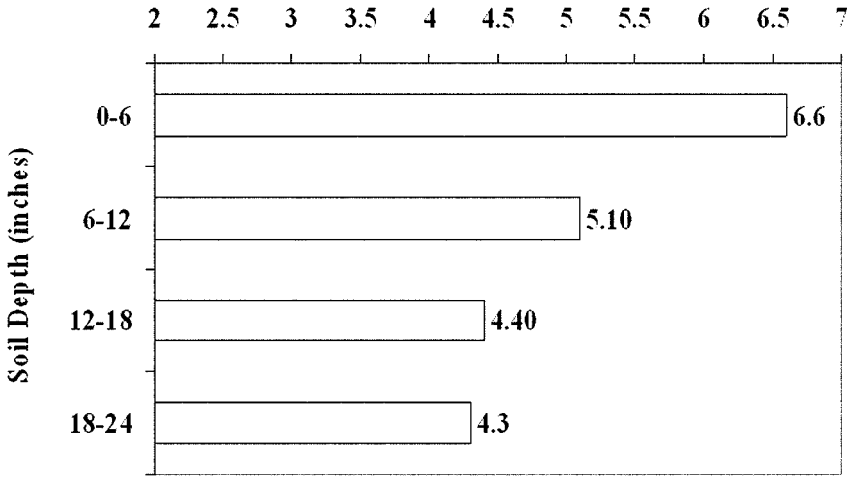


Fig. 3. Average water soil-pH for the control plots according to soil depth. Samples were collected in the spring of 2009.

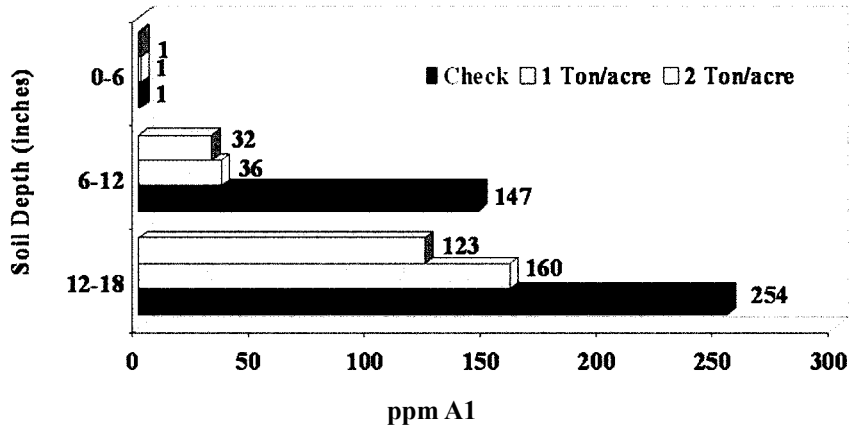


Fig. 4. Average extractable aluminum (2 M KCl), at three soil depths, according to gypsum treatment.