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Genesis and prevention of iron-cemented layers in sand putting green soil profiles

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- A column study will be conducted in 2018. The objectives of the study are to determine how root zone chemistry and Fe rate affect formation of potential layers in the soil.
- Preliminary data show that putting greens with high pH gravel layers may be more prone to formation of Fe-enriched layers when high rates of iron are applied. Root zones with high pH sand may be less likely to form layers at the sand/gravel interface due to immobilization of Fe near the surface.
- In 2018-2019, soil samples will be collected from at least 50 golf courses to determine the distribution of Fe-cemented layers, and to create and validate a model to explain their formation.

Iron-cemented layers form in putting greens, potentially leading to decreased water infiltration and anaerobic conditions in the soil. These layers have been documented, but the factors that lead to their formation have not been studied. The objectives of this study are to determine 1) how root zone chemistry affects iron accumulation at different application rates, and 2) the distribution of these layers across the US, which will provide a dataset against which a model can be created and validated.

A column study (Fig. 1) will be established as a 2x2x3 factorial design with three replications. The root zone will be comprised of a silica sand from Florida (pH 5.5) or a calcareous sand from Wisconsin (pH 8.2); both meet USGA particle size recommendations. The gravel layer will be comprised of either limestone (pH 8.8) or granite (pH 5.4). After establishment of creeping bentgrass, columns will receive weekly applications of ferrous sulfate at a rate of 10 or 50 kg ha^{-2}, and these are being compared to untreated columns. All columns are irrigated to replace 200% of water lost through evapotranspiration to produce downward movement of water through the profile. Air permeability will be measured every 14 to 28 days to track changes in pore space resulting from potential iron accumulation.

After each iron application, x-ray fluorescence (XRF) will be used to measure the concentration of Fe inside columns in 2.5 cm depth increments. To take these measurements, we constructed an autosampler stand to position the columns for automated XRF analysis (see this video for more details: https://www.youtube.com/watch?v=iJzYzuITz44). The stand allows for scanning while columns are rotating, producing an extremely accurate way to measure average soil Fe at different depth increments inside columns (Fig. 2). This stand is the first of its kind and offers a new way to study soil formation.

Data from a preliminary trial show that after eight applications at a rate of 200 kg $FeSO_4$ ha^{-2}, a marked accumulation was observable at the interface of sand and gravel in a column with low-pH sand and high-pH gravel (Fig. 3). Iron oxidized above the gravel layer in columns with low pH sand and high pH gravel. In columns with high pH sand, the Fe became immobilized near the surface and never reached the gravel layer. These findings suggest that iron-cemented layers are more likely to form in root zones with high pH gravel. However, these layers may be less likely to form in putting greens with high pH sand, since the iron is immobilized before it reaches the gravel. Despite the accumulation of iron, there was no observable difference in air permeability, suggesting that the iron that had accumulated was not enough to reduce porosity and air infiltration rate.

Figure 1. Columns were constructed to meet the recommendations of the USGA for putting green construction.

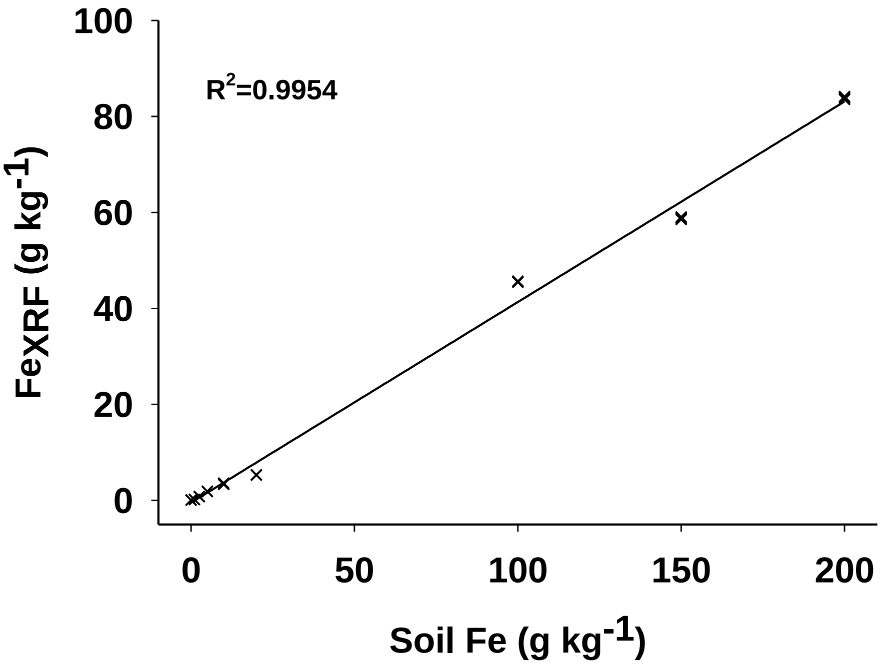

Figure 2. Calibration of an automated XRF stand with soil standards of known Fe concentration. Each sampling cluster on the graph above actually contains data points from 10 separate scans. This robust method will allow us to track Fe accumulation very accurately.

Figure 3. Iron-cemented layer at the sand/gravel interface of a root zone with a low-pH sand and a high-pH gravel. The column received eight total applications of Fe at a rate of 200 kg $FeSO_4$ ha^{-1}. Despite the visual observation of iron accumulation, there was no measured decrease in air infiltration rate after eight applications.