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Managing Water for Tomorrow's Agriculture

NDSU NORTH DAKOTA STATE UNIVERSITY

MN-CLAY1, MN-CLAY2, MN-CLAY3

Conventional Drainage, Drainage Water Recycling, Non-Drained

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SITE SUMMARY

The research is conducted on three privately-owned fields located in Clay County, Minnesota (Figure 1). The soil series in all fields is Bearden silt loam, a somewhat poorly drained soil.

The northwest field is non-drained (UD) and the northeast field is conventionally drained (FD). The south field was divided into three zones varying in size from 41 to 51 acres . The drainage mains are located on the west side of the field and the irrigation mains are on the east side of the field. There are no physical barriers between zones to control lateral water movement.

Subsurface drainage lines were installed at a depth of 3 to 4 feet with lateral spacing of 40 feet. A subirrigation system in the south field is fed by water pumped from the ditch to a storage tank located at the northeast corner of the field. The tank is used to create elevation difference for delivering water through gravity and to allow for the deposition of sediment prior to delivering water to the tile drains for subirrigation.

From 2012 to 2014 the southern zone of the south field was used as controlled drainage, while the middle zone was used as controlled drainage with subirrigation (CD/SI). Since 2015, both the middle and the south zones are CD/SI. The north zone of the south field was excluded from research because it is adjacent to the drainage ditch.

- Controlled drainage, subirrigation
- Controlled drainage (2012-2014)
- Conventional drainage
- Non-drained
- Drain tile
- Irrigation line
- Irrigation tank and pump
- Control structure
- Monitoring weir
- Weather station
- Observation well
- Soil moisture sensor

Figure 1. Map of the Clay County, MN controlled drainage and subirrigation site.

Box 1. Site info

CHARACTERISTICS

- Soil: Bearden silt loam
- Rotation: Corn-Soybean, occasionally Sugar Beet

WATER MANAGEMENT PRACTICES

- Non-drained
- Conventional Drainage (depth 3-4 feet, spacing 40 feet)
- Controlled drainage (depth 3-4 feet, spacing 40 feet)
- Controlled Drainage with Subirrigation (depth 3-4 feet, spacing 40 feet)

MEASUREMENTS IN DATABASE

DRAINAGE SYSTEM

- Tile Flow (2013-2018)
- Tile Water Quality: Nitrate-N, pH, Electrical Conductivity (2012-2018), Reactive P (2016-2018)
- Water Table Depth (2012-2018)
- Irrigation Flow (2014-2018)

WEATHER

- Precipitation (2013-2018)
- Air Temperature, Relative Humidity, Solar Radiation, Wind Speed and Direction (2010-2016)

SOIL

- Soil Texture (2011)
- Soil Water Retention (2011)
- Soil Moisture and Temperature (2012-2018)
- Soil pH (2017)
- Soil Electrical Conductivity (2012-2018)
- Soil Fertility: Sodium Adsorption Ratio, Salinity (2011, 2017)
- Soil Nitrate (2016-2018)

CROP

- Crop Yield: Corn (2012-2018), Soybean (2013-2016, 2018), Sugarbeet (2015)

USDA United States Department of Agriculture National Institute of Food and Agriculture

This material is based upon work that is supported by the National Institute of Food and Agriculture , U.S. Department of Agriculture , under award number 2015-68007-23193 , "Managing Water for Increased Resiliency of Drained Agricultural Landscapes", http://transformingdrainage.org. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the view of the U.S. Department of Agriculture.

SUMMARY OF RESULTS

WATER QUALITY

The average concentrations from the water samples are shown in Figure 2. The highest chemical concentration in the CD/SI field, however, did not yield the highest chemical load, due to the controlled drainage practice. With the same amount of rainfall on the two adjacent fields, the average annual drainage flow from the CD/SI field (0.72 in) was 50% lower than that from the FD field (1.08 in). With the reduced drainage flow, the total NO3-N load from the CD/SI field (9.66 lb/ac) was about the same from the FD field (10.02 lb/ac). However, the soluble reactive phosphorus (SRP) load from the CD/SI field (0.16 lb/ac) was much less than that from the FD field (0.55 lb/ac). Since very few water samples were collected from the surface runoff water from the UD field, a direct comparison on June 24, 2015 showed that the highest NO3-N concentration (16.5 mg/L) was found in the CD/SI structure. Again, due to controlled drainage practice and no drainage flow, the NO3-N was not leaving the field and caused any water quality problems in the surface. However, the NO3-N from the FD outlet (11.9 mg/L) entered the surface drainage ditch and might potentially increase the NO3-N at the downstream ditch. The SRP concentration (1.39 mg/L) was the highest from the UD surface runoff, comparing to all other samples. The downstream ditch water also had a higher SRP concentration due to the UD surface runoff contribution. The SRP concentrations in the CD/SI, FD and upstream ditch were relatively low.

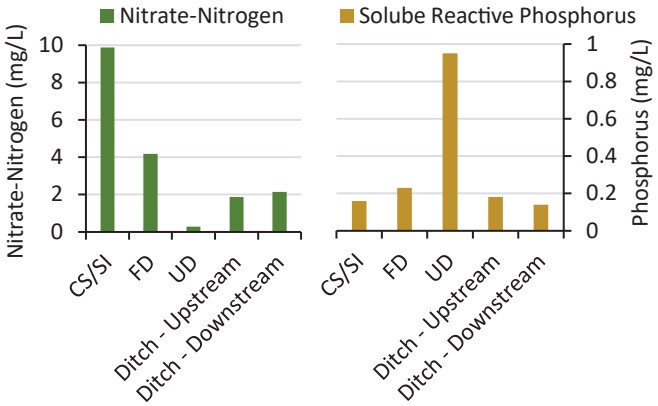

Figure 2. Average nitrate-nitrogen and soluble reactive phosphorus concentrations (2013-2019) in CD/SI, FD, and UD treatments.

CROP YIELD

The crop yields in the UD, FD, and CD/SI fields were compared with the county average for corn and soybean in Figure 3. For corn, the highest yield difference was 28% between the CD/SI field and the county average in 2013, while the lowest yield difference was -9% between the UD field and the county average in 2014. For soybean, the highest yield difference was 65% between the FD and the county average in 2014, and the lowest yield difference was 13% between the UD and the county average in 2018. When corn was grown in all three fields in 2017, the corn yield in the FD field (196.8 bu/ac) was the highest, possibly due to different rotations, with soybean in the previous year in the FD and UD fields and corn on corn in the CD/SI field. A higher off-season precipitation could also result in an optimal soil moisture condition for spring planting in the FD and CD/SI fields, and led to relatively high yields comparing to the UD and the county average yields as evidenced in 2013, which demonstrated the benefits of drainage in wetter years.

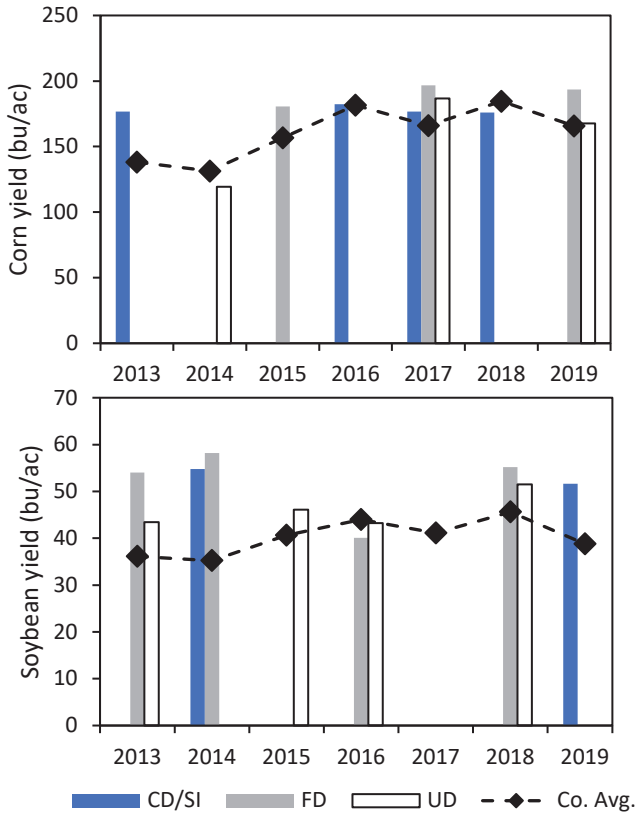

Figure 3. Comparison of corn and soybean yields in the CD/SI, FD, and UD fields vs. the county average yield in Clay County, MN.

PUBLISHED WORKS FROM THE SITE

Jia, X., T. F. Scherer, D. D. Steele, and T. M. DeSutter. 2017. Subirrigation system performance and evaluation in the Red River Valley of the North. *Applied Engineering in Agriculture* 33(6): 811-818.

Kolars, K., X. Jia, D.D. Steele, and T.F. Scherer. 2019. A soil water balance model for subsurface water management. *Applied Engineering in Agriculture* 35(4): 633-646.

Niaghi, A. R., and X. Jia. 2019. New approach to improve the soil water balance method for evapotranspiration estimation. Water 11: 2478; doi:10.3390/w11122478. https://www.mdpi.com/2073-4441/11/12/2478/pdf

Niaghi, A. R., X. Jia, D. D. Steele, and T. F. Scherer. 2019. Drainage water management effects on energy flux partitioning, evapotranspiration, and crop coefficients for corn. Agricultural Water Management 225 (2019) 105760. https://doi.org/10.1016/j.agwat.2019.105760

Data Access

Data from this site are available through the USDA National Ag Library Ag Data Commons repository (https://doi.org/10.15482/USDA.ADC/1521092) or the interactive website at Iowa State University with visualization and querying capabilities (https://drainagedata.org).

ACKNOWLEDGEMENTS

TRANSFORMING DRAINAGE PROJECT

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