Comparison of timing and volume of subsurface drainage under perennial forage and row crops in a tile-drained field in Iowa

Ryan J. Goeken, Xiaobo Zhou, and Matthew J. Helmers
Iowa State University

INTRODUCTION

To harness the productive potential of Iowa's land, subsurface drainage was installed extensively in the late 19th and early 20th centuries in order to drain somewhat poorly to poorly drained soils for agricultural production. In Iowa alone, approximately 3.6 million ha of cropland are estimated to be artificially drained, amounting to 25% of the state's agricultural land (Baker et al. 2004). At first, diverse, extended rotations were utilized, but crop rotations continue to become less diverse, consisting mostly of corn and soybeans. The widespread use of subsurface drainage coupled with a change in land use and vegetative cover may be impacting the hydrological balance of the Midwest region (Asbjornsen et al. 2007). Most of the nitrate-nitrogen (NO_3-N), a nutrient pollutant, that enters streams in Iowa enters through subsurface drainage as well (Schilling 2005). Because about 70% of NO_3-N losses through subsurface drainage in the Midwest occur before row crops are established (in the early spring) (Randall and Vetsch 2005), and a large fraction of yearly drainage occurs during this period, an analysis of drainage over this crucial but short time period is warranted. Cover crops and perennial crops are able to grow in the early spring and as such are a promising way to reduce early season loss of nitrogen because of their ability to transpire water during this time period.

In light of this, the objectives of this study were to determine the timing and volume of subsurface drainage in two different cropping systems – perennial forage (PF), which included plots planted to orchardgrass (*Dactylis glomerata*), red clover (*Trifolium pratense*), and ladino clover (*Trifolium repens*), succeeding to a monoculture of orchardgrass, and row crop (RC) (either continuous corn or a corn-soybean rotation) – and to determine whether PF establishment reduced subsurface drainage.

MATERIALS & METHODS

Research was conducted at Iowa State University's Agricultural Drainage Water Research Site, located in northwest Iowa. Six 0.05 ha plots (three control and three treatment plots), each including subsurface drainage with continuous flow monitoring, were planted to RC in 1990-2004 (the calibration period). During the treatment period (2006-2011), control plots remained in RC while treatment plots were planted to PF. To determine the difference between drainage season (March-November) subsurface drainage in the control and treatment plots, a blocked t-test ($\alpha = 0.05$) was used. For monthly data, a blocked t-test ($\alpha = 0.05$) was used to determine the difference in subsurface drainage between the control and treatment plots in the months of April, May, June, and July.

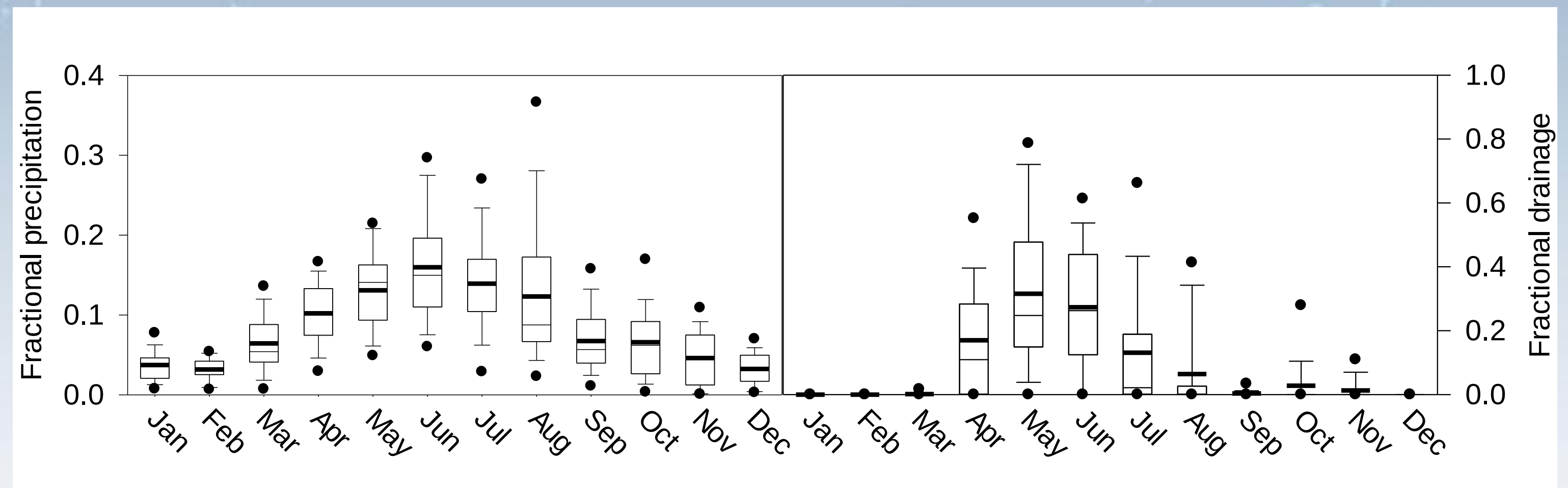

Fig. 1. Box plot diagrams of precipitation and subsurface drainage volumes. Fractional precipitation is the average from 1990-2010 based on NCDC data at Pocahontas, IA. Fractional drainage is the average from 1990-2011 in the control plots. Points on each box indicate the following: bottom point = 5th percentile, error bar below box = 10th percentile, lower boundary of box = 25th percentile, upper boundary of box = 75th percentile, error bar above box = 90th percentile, top point = 95th percentile, thin line within box = median value, thicker line within box = mean value.

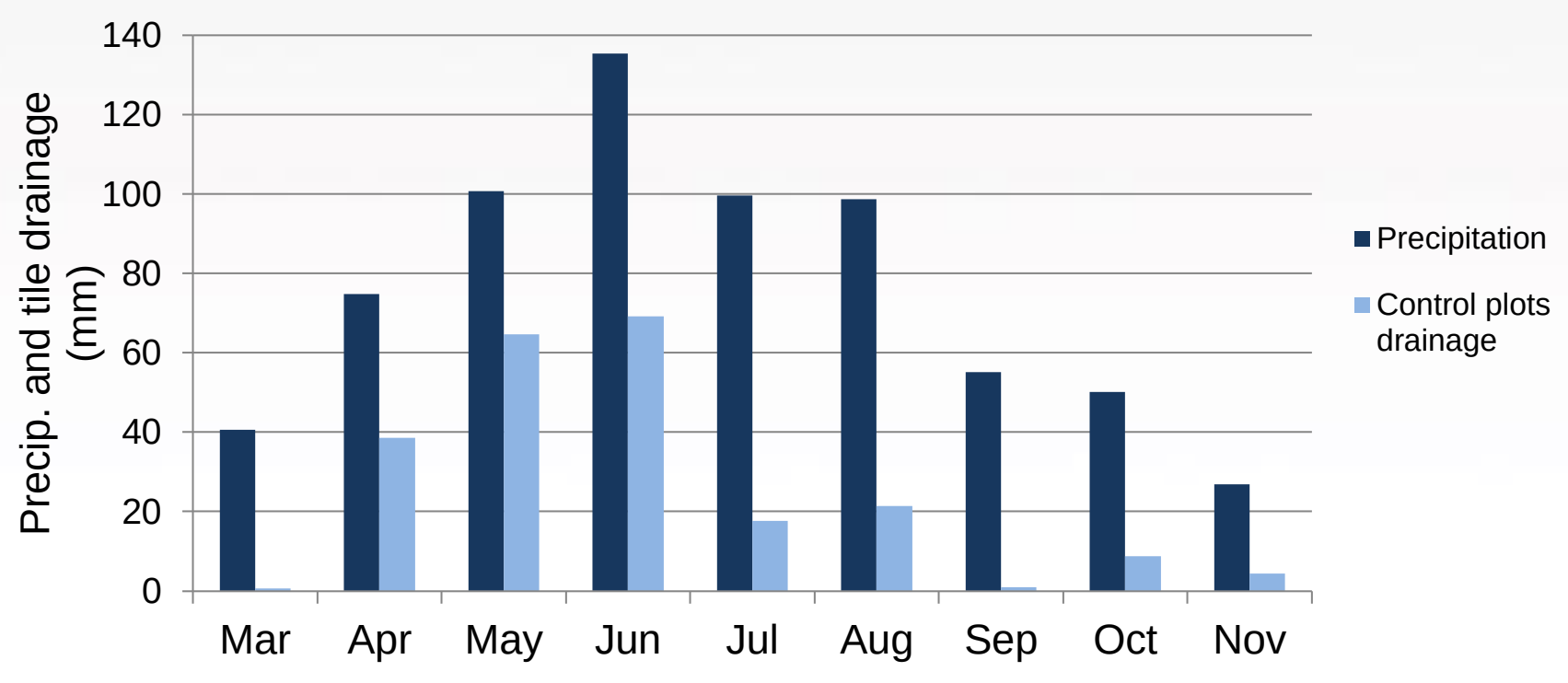

Fig. 2. Monthly precip. and tile drainage for drainage season.

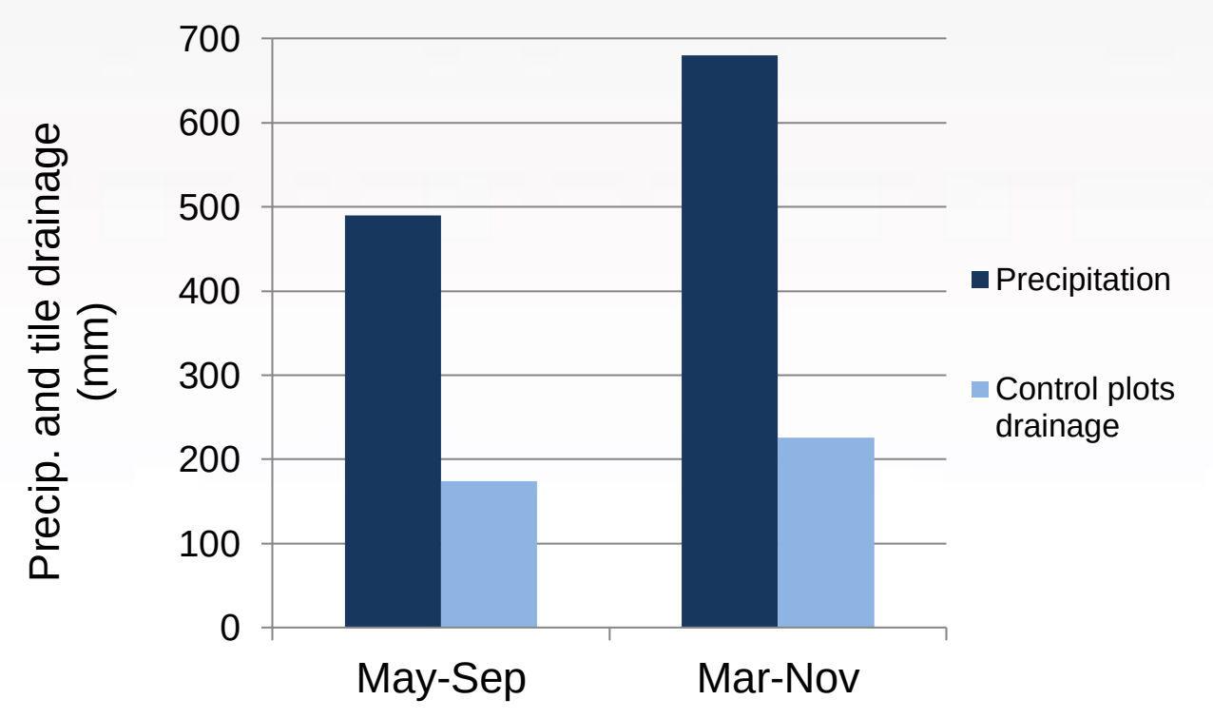

Fig. 3. Growing and drainage season precip. and tile drainage.

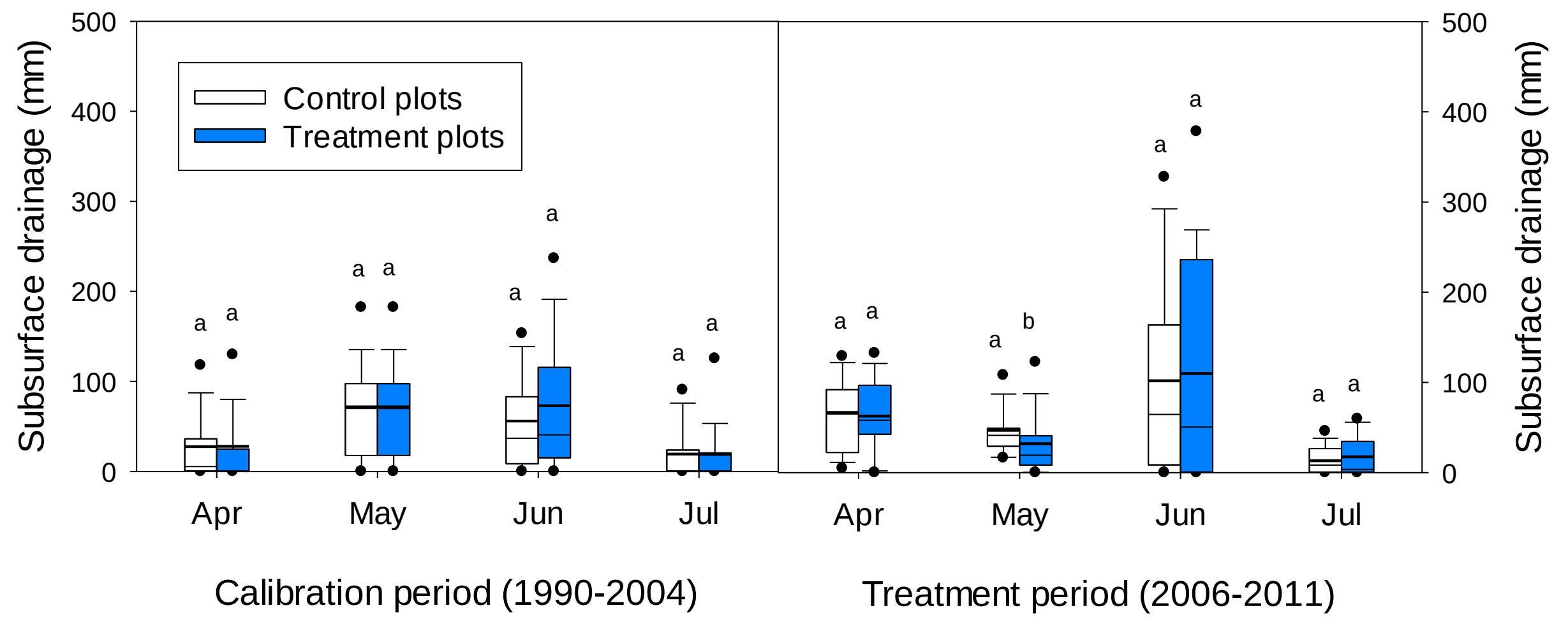

Fig. 4. Difference in monthly subsurface drainage between control (row crops during both periods) and treatment plots (row crops during calibration period and perennial forage during treatment period) during calibration and treatment periods for months of April-July. Within periods and months, bars labeled with different letters denote a significant change in subsurface drainage ($p<0.05$). Percentile placements for boxes are identical to Fig. 1.

RESULTS & DISCUSSION

The drainage season (March-November in this study) is a period in which the ground is usually not frozen and is able to discharge soil water as drainage. During the 22 years of the study, the average drainage season precipitation was 680 mm, or 3% below the long-term normal of 704 mm for the area (Figure 3). Drainage season precipitation ranged from 458 mm in 1997, or 35% below normal, to 908 mm in 2010, or 29% above normal. The average drainage season subsurface drainage for the control plots over the research period was 226 mm. Drainage ranged from 5 mm in 2000 to 437 mm in 2007. Even in years with nearly identical precipitation, drainage can vary widely. There was 684 mm of precipitation in 2000, while in 2001 there was 686 mm, but there was only 5 mm of drainage during 2000 as compared to 189 mm in 2001. During April and May, 2001 had nearly 2X the precipitation of 2000. Lawlor et al. (2008) found similar results, as drainage volumes are directly tied to soil moisture, rainstorm timing and intensity, and the crop water demand during a given part of the growing season.

In general, only a small amount of drainage occurred in March, followed by a sharp increase in April, with the most monthly fractional drainage occurring in May and June, decreasing to small amounts in September-November, whereas precipitation increased more gradually throughout the year, peaking in June (Figures 1 and 2). On average, 71% and 75% of drainage season drainage occurred during the months of April-June for control and treatment plots, respectively.

Subsurface drainage comparison between PF and RC

- For the complete drainage season, the calibration and treatment periods showed no significant difference in drainage between treatments in any individual year or on average.
- In the months of April-July, during the calibration period there was no significant difference on average, although there was a significant difference in monthly drainage between the control and treatment plots in June of 1991.
- Over the treatment period, during the month of May, the treatment plots showed a significant decrease (32%) in monthly subsurface drainage as compared to the control plots. Both May 2007 and May 2010 showed a significant reduction in drainage due to PF within the year.

CONCLUSIONS

Although forage plots planted to perennial orchardgrass did not significantly reduce subsurface drainage over the entire drainage season, this treatment did reduce subsurface drainage during the month of May as compared to row crops. The early spring, especially May, is a critical time for subsurface drainage in row crop fields in Iowa, as this is the period when the most drainage occurs and when significant amounts of NO_3-N are lost due to leaching; therefore, the results presented in this study suggest that perennial cropping systems could reduce deleterious effects of subsurface drainage in Iowa. More research is needed, however, as different types of perennial cover will cause varying responses in subsurface drainage, and these responses will vary in different geographic regions due to contrasting weather patterns.

ACKNOWLEDGEMENTS

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