MANAGING SPRINKLER IRRIGATION USING IN SITU INFILTRATION DATA

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ABSTRACT: The Lower Gunnison River Basin, located in Western Colorado, historically has had adequate water to support flood irrigation of over 135,000 acres. However, with six years of drought and water in the region declared over appropriated, farmers and ranchers are beginning to recognize the advantages of sprinkler irrigation. Over the last four years, the number of installed sprinkler irrigation systems has increased dramatically within the basin. In response, the local Natural Resource Conservation Service (NRCS) field office and Delta Conservation District began gathering soil infiltration data in March 2007 to help with sprinkler design and to support management recommendations given to producers switching to sprinkler irrigation. Soil infiltration data were gathered to correlate with soil textures, management practices and permeability data. These data are currently being used to determine design flows, sprinkler application rates and best management techniques for areas converted to sprinkler irrigation. Preliminary results show higher soil infiltration rates than previously documented by NRCS. In addition, data reveals that management practices play a larger role in increasing infiltration rates than soil textures.

INTRODUCTION

Delta Conservation District is located in west-central Colorado and includes Delta County and portions of Montrose and Gunnison counties (Figure 1). In Delta County alone, approximately 71,000 acres are irrigated and over 75,000 acres are considered prime or unique farmland (USDA 1979). Primary agricultural products include livestock, fruits, vegetables, sweet corn, and melons. Alfalfa hay, grass hay and corn for grain account for the largest acreage of harvested field crops. Surface flood irrigation has been the preferred irrigation method.

After several years of drought (2001-2006), farmers and ranchers began exploring more efficient irrigation systems. As the benefits of sprinkler irrigation systems began to emerge: increased production, reduced water use and decreased labor costs; demand also increased.

To better manage the increased use of sprinkler irrigation, NRCS and the Delta Conservation District began gathering soil infiltration data to help with sprinkler design and to support management recommendations given to producers switching to sprinkler irrigation. The program objective was to identify the expected soil infiltration rate for different soil surface textures under various management techniques. The specificity of this information will allow a better match between sprinkler design flows and soil and management conditions. In addition, irrigation professionals will be better prepared to problem solve with landowners who are experiencing irrigation difficulties.

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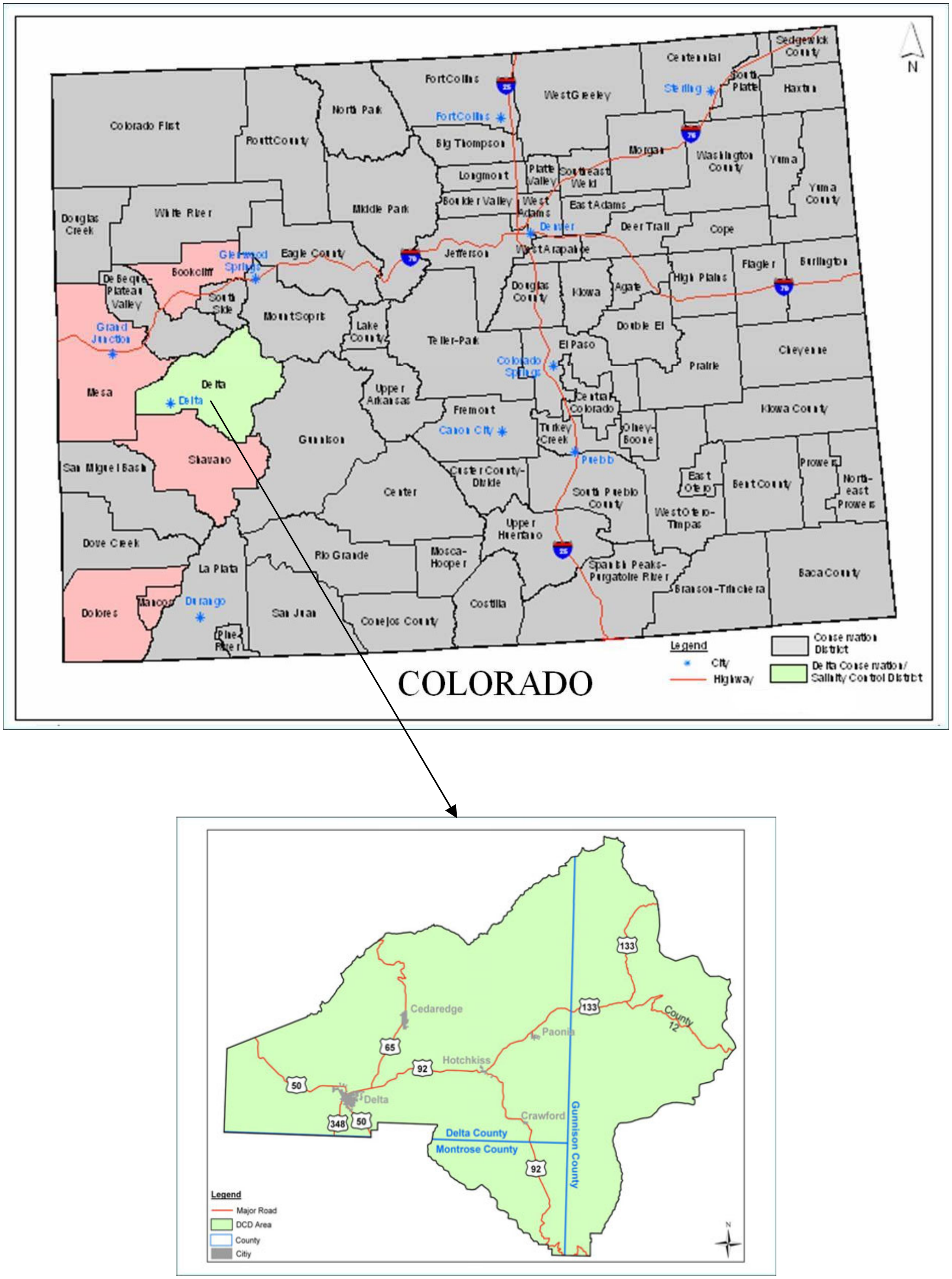

FIGURE 1: Study Area

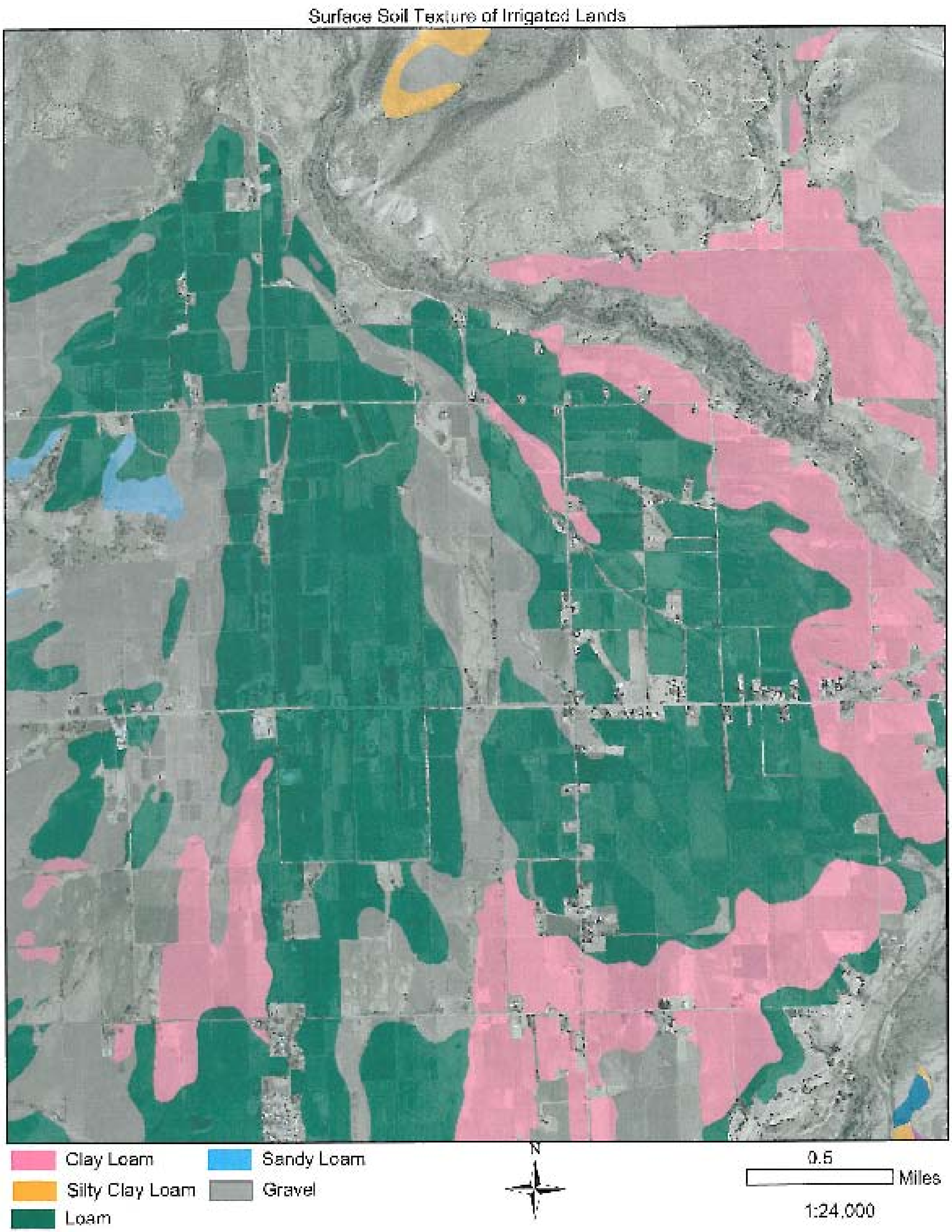

FIGURE 2: Example of Mapped Surface Soil Textures

METHODS

Surface soil textures were mapped using Geographical Information System (GIS) soil data obtained from soil surveys to identify soil infiltration testing locations (Figure 2). Initially, testing locations were selected where new sprinkler systems were planned in areas with finer textured soils. Subsequent testing was preformed on most dominant surface soil textures located in the area.

In the study area, the dominant surface soil textures on irrigated soils are clay loam, silty clay loam and loam. Prior to the collection of infiltration data, the limited available permeability data from the soil survey information showed maximum sprinkler application rates ranging from 0.2 to 1.0 in./hr. for these soils. This raised concerns about the effectiveness of sprinkler irrigation, since most sprinklers are not well adapted to soils with low infiltration rates.

Infiltration data were collected using a Cornell Infiltrometer (Figure 3; Ogden 1997). This rainfall simulator was simple to operate and convenient to use in the field. Operation required only minimal training. Rapid and replicated measurements were obtained in minimal time.

FIGURE 3: Infiltration testing with Cornell infiltrometer

For each testing site, the following information was also collected:

- Available soil data (soil mapping unit, soil description, mapped surface texture, parent material and permeability and maximum sprinkler application rate (if available);
- Soil sample data (observed soil texture, structure, moisture and root structure);
- Management practices (type of irrigation, current crop, estimated ground cover, surface residue, type of tillage, date of last tillage, and # of irrigations since last tillage).

Soil samples were also taken from each site for hydrometer and calcium carbonate laboratory tests. Hydrometer testing was conducted to determine the proportion of sand, silt and clay in the soil. This method quantitatively determines the physical proportions of three sizes of primary soil particles as determined by their settling rates in an aqueous solution. The amount of calcium carbonate in the soil was determined to better understand how its silt/clay particle size and cementation characteristics influence infiltration.

Management practices were documented based on site observations and discussions with the landowner. Management practices were placed into several categories based on tillage techniques, crop residue and grazing practices. Management categories included:

1. Row crop:
    a. Minimum till to minimum till (>75% residue),
    b. Conventional till to minimum till (>75% residue),
    c. Conventional till to minimum till (<75% residue),
    d. Conventional till to conventional till (<15% residue).

2. Hay crop:
    a. No grazing
    b. Grazing at appropriate time and intensity,
    c. Grazing at appropriate time, low intensity,
    d. Grazing at appropriate time, high intensity,
    e. Grazing with poor timing, appropriate intensity,
    f. Grazing with poor timing, low intensity,
    g. Grazing with poor timing, high intensity.

Minimum till represents soil that is left undisturbed from harvest to planting except for nutrient injection and the soil surface is covered with over 75% crop residue. Conventional till leaves less than 15 percent residue cover after planting (CTIC 2006). Hay crop management categories are based on grazing practices. Grazing practices are based on an evaluation of how well forage quality matches animal units and the grazing schedule (USDA 2003).

Soil infiltration data were plotted to obtain steady-state infiltration rates. Soil infiltration rates were categorized by soil texture and management technique. Data were reviewed to determine if correlations exist between soil infiltration rates and surface soil textures for the various management practices. Graphical trends were examined to evaluate preliminary results. Statistical analysis will be performed as additional data are collected.

Future analysis will evaluate if the amount of calcium carbonate in the soil correlates with infiltration rates. In addition, infiltration rates will be compared to available soil permeability data to see if permeability can be used to accurately predict soil infiltration rates.

PRELIMINARY RESULTS

Figure 4 displays the typical infiltration curve that resulted from the Cornell infiltrometer test. The infiltration rate increases as the dry soil is wetted and decreases over time until it reaches a steady-state condition. Table 1 and Figure 5 show the average infiltration rates recorded for a specific soil texture with various management techniques. Similar figures will be developed for other soil textures as additional data are collected.

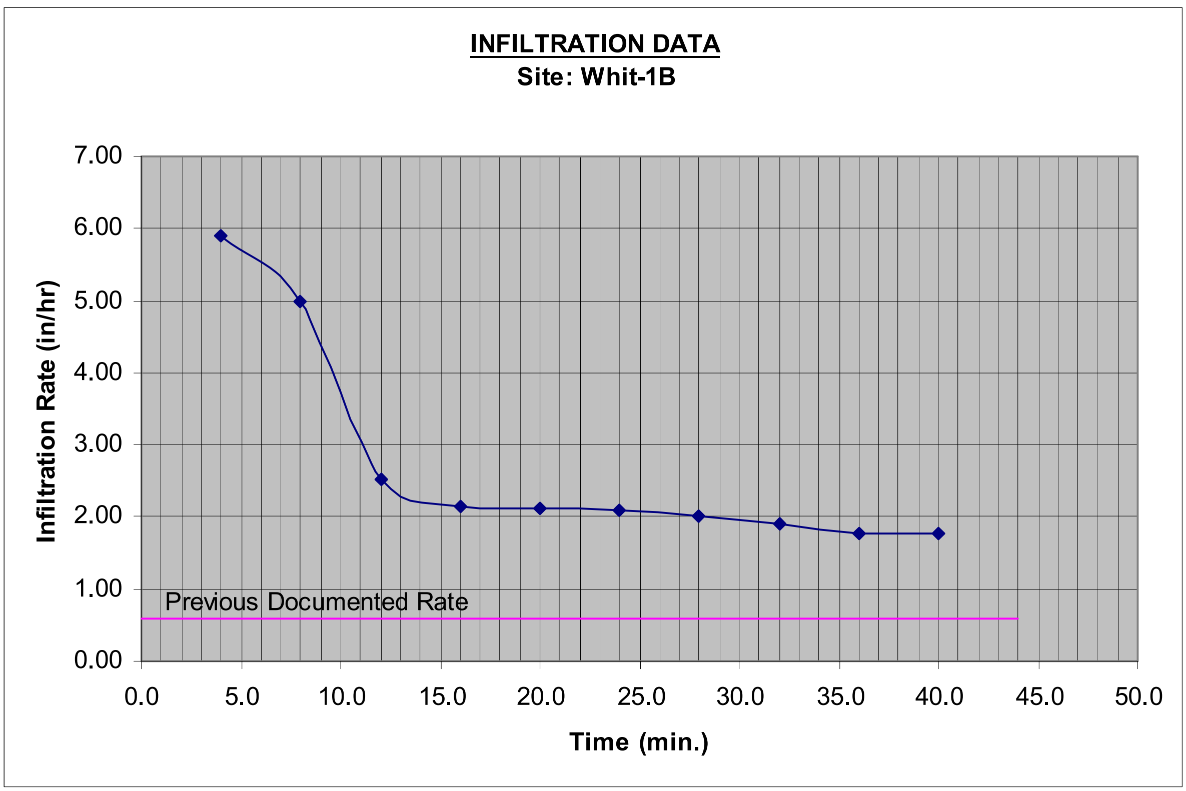

FIGURE 4: Typical Infiltration Curve

Average Infiltration Rates (in./hr.)

Management	ROW CROP		HAY CROP			# of Samples
	Surface Soil Textures					
	Silty Clay Loam	Clay Loam	Loam	Silty Clay Loam	Clay Loam	
Minimum till to minimum till (>75% residue)	7.1					4
Convention till (<15% residue) to minimum till	5.5					1
Conventional till to minimum till (<75% residue)	4.3	4.2				2, 2
Conventional till to conventional till (<15% residue)						0
No grazing			6.6		6.2	1, 2
Appropriate timing and intensity			5.0	5.0		2, 1
Appropriate timing, low intensity						0
Appropriate timing, high intensity						0
Poor timing, appropriate intensity				1.8		1
Poor timing, low intensity						0
Poor timing, high intensity					1.6	1

TABLE 1: Preliminary Results

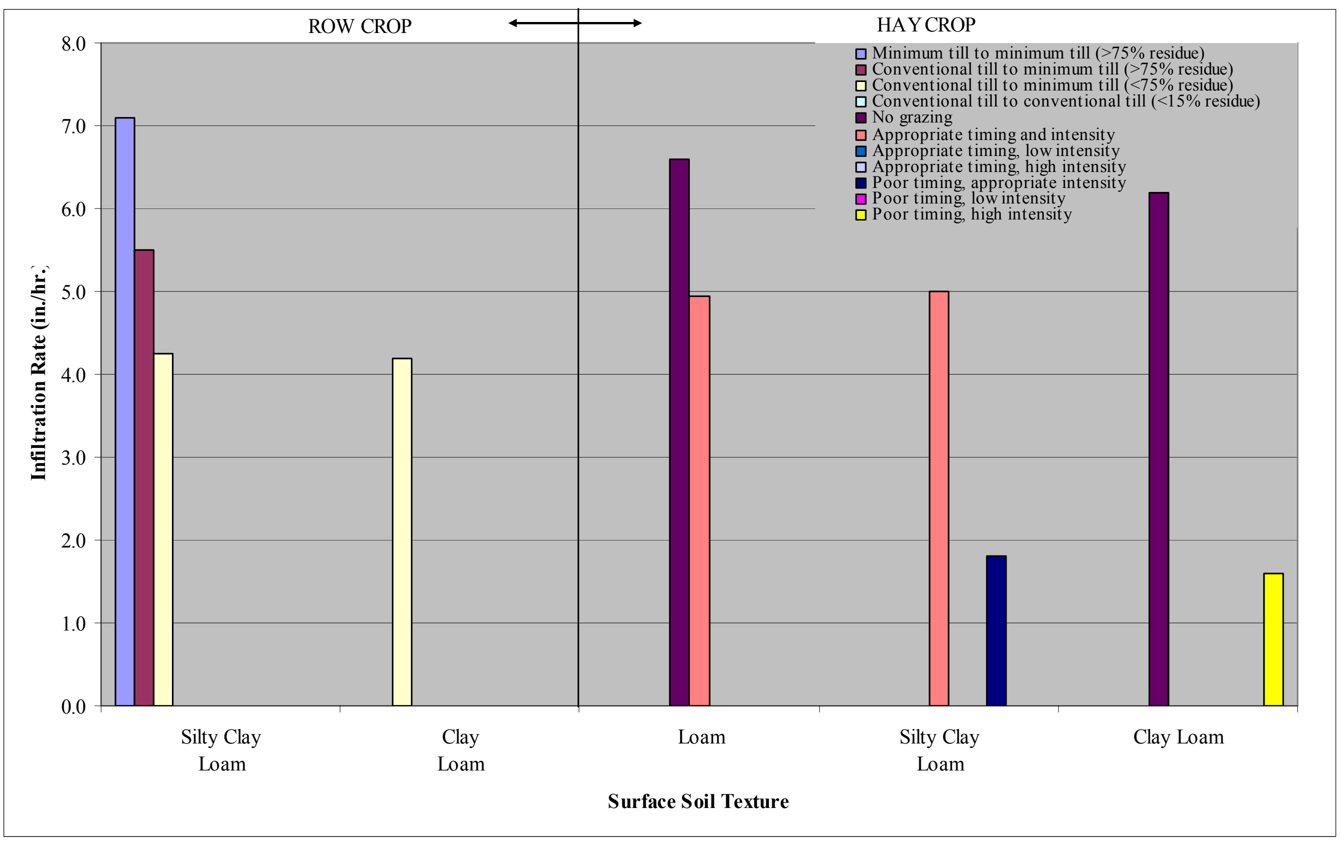

FIGURE 5: Preliminary Results

CONCLUSIONS

Preliminary results suggest that management techniques play a larger role in increasing/decreasing infiltration rates than soil textures. Management techniques greatly impact factors that influence infiltration, such as surface soil structure, soil pore space, compaction and amount of organic matter present in the soil. Soils that maintain blocky structure, high organic content, continuous pore spaces and limited compaction result in higher infiltration rates and more effective sprinkler irrigation.

Infiltration rate were also higher than previous documented by NRCS. This is a result of how previous data were collected. The previous data were based on constant-head permeability tests performed in the laboratory without consideration of existing management conditions.

Additional data are required for statistical analysis. Additional data will better define confidence intervals for mean infiltration rates for various soil textures. In addition, infiltration rates should be tested to see if they are statistically different for various management techniques.

These data are currently being used to select design flows and application rates for sprinklers being installed, to support management recommendations and trouble shoot previously installed sprinkler irrigation systems that may not be working effectively. As additional data are collected and correlations are statistically tested, sprinkler designs will continue to improve across the wide variety of soil conditions in our region.

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