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Introduction

The agronomic performance of tillage practices is influenced by many factors, some of which the farmer cannot control. The weather, something we have little control over, dramatically affects agriculture and crop production. Our weather (climate) is also changing, which affects the agronomic performance of our cultural practices. In the Midwest, climate change has resulted in increased annual precipitation and greater frequency of intense rainfall events (EPA, 2010). Greater annual rainfall results in cold and wet soils, which reduce the number of days for field operations thus delaying important field operations like planting. Increased precipitation and rainfall intensity increases soil erosion. All of these factors along with soil characteristics (texture, internal drainage, parent material) influence our tillage system choices.

Some of the management decisions a farmer makes do influence tillage system choice and performance. Crop rotations have changed from the traditional corn-soybean rotation to more corn dominated rotations. More corn after corn results in more residues and for many that means more tillage or more aggressive tillage to bury residue. Farm size and equipment size which are related can influence tillage decisions. Large farming operations, which rely more on hired labor, generally prefer more conventional tillage systems. Ultimately farmers choose a tillage system that balances their risk: one that does not limit crop yield or profitability and conserves the soil resource. The purpose of this paper is to summarize the last 15-yrs of tillage research conducted in southern Minnesota on glacial till (clay loam) and loess (silt loam) soils.

Methods

Tillage research was conducted at two locations in Minnesota. Several tillage studies were conducted at the University of Minnesota Southern Research and Outreach Center in Waseca from 1997 through 2010. The multi-year small plot studies compared various tillage systems alone and in combination with other crop management factors including: crop rotation, hybrid selection, planting date, nitrogen application timing and phosphorus fertilizer rate and placement. Generally in these experiments tillage systems were established and evaluated on the same site for a minimum of three years. The experiments were conducted on pattern tile drained (75' spacing) Nicollet–Webster soils. Two four-year studies (1997 to 2000) were located on a well drained Port Byron silt loam soil near Rochester in southeast Minnesota. One study compared four tillage systems for corn in a corn-soybean rotation and another compared four tillage systems in continuous corn.

Results

Corn–soybean rotations

Corn yield responses to tillage are strongly influenced by soil type, climatic conditions and crop rotation. On a well drained silt loam soil, corn yields following soybean were not significantly different, when averaged across the four years of the study (Vetsch and Randall, 2002). On a poorly drained clay loam soil corn yields following soybean averaged 176, 180, 178 and 184 bu/ac with no-till (NT), strip-till (ST), spring field cultivate (SFC), and chisel plow plus spring field cultivate (CP+SFC), respectively (Vetsch and Randall, 2004). Chisel plow produced greater yields than NT and SFC, but similar to ST during the 3-year study. When several studies at Waseca with similar tillage treatments for corn following soybean were averaged (a total of 31 site-years), corn yields following soybean were 161, 170, 171 and 174 bu/ac with NT, ST, SFC, and CP+SFC, respectively (unpublished).

Tillage effects on soybean production were also compared in two studies on clay loam soils at Waseca. In a six-year trial NT soybean yields were two bu/ac less than spring disk and CP+SFC tillage systems (Randall and Vetsch, 2003). In this trial soybeans were planted in narrow rows with a drill for the spring disk and CP+SFC treatments, whereas a coulter-cart drill was used for the NT soybeans. In a three-year study, CP+SFC tillage increased soybean yields in one of three years compared with NT (Vetsch et al., 2007). When averaged across the three-year study period, the yield difference was only one bu/ac.

Corn after corn

Greater than 200 bu/ac corn yields produce vast amounts of crop residue, which can make conservation tillage for corn after corn challenging on cool Minnesota soils. Tillage effects on corn after corn were evaluated in three studies. A four-year study (1997–2000) on a silt loam soil near Rochester found tillage treatments affected corn yields in three of four years (Vetsch and Randall, 2002). Averaged across years, continuous corn yields were least with NT (155 bu/ac), intermediate with ST (162 bu/ac) and two-pass zone-till (163 bu/ac) and slightly greater with CP+SFC (166 bu/ac). The two-pass zone tillage system consisted of 15-inch deep zone tillage in the fall followed by shallow (4-inch deep) zone tillage in spring prior to planting. Two three-year studies on Nicollet-Webster clay loam soils at Waseca compared tillage systems for second-year corn in a soybean-corn-corn rotation. Five tillage systems [15-inch deep zone tillage (ZT), ST, spring disk (SD), CP+SFC and moldboard plow (MP)] for second year corn were compared from 2005 through 2007 (Vetsch and Randall, 2008). Moldboard plow produced eight bu/ac greater yields than CP+SFC and 12 bu/ac greater than ZT and ST (Table 1). In a second phase of the study (2008–2010) the ZT treatment was dropped and replaced with a two-pass disk (fall and spring) treatment (Vetsch and Randall, 2011). Results were similar as MP had nine bu/ac greater yields than CP+SFC and 11 bu/ac greater than ST (Table 2). Moreover in the cool growing season of 2009, MP had 12 bu/ac greater yields than CP+SFC and 19 bu/ac greater than ST (data not shown).

Summary

Tillage effects on crop production are influenced by crop rotation, weather and soil properties. On well drained loess soils in southeast Minnesota conservation tillage practices like strip and zone tillage produce similar yields to chisel plow (mulch tillage) systems. No tillage may result in a slight yield penalty, especially when corn follows corn. On poorly drained glacial till soils in south-central Minnesota, strip tillage, mulch tillage (SFC) and chisel plow had similar yields when corn follows soybean. While no-till yields were about 10 bu/ac less than chisel plow. When corn follows corn, moldboard plow had greater yields than chisel, strip-till and zone-till. In most years strip tillage was equal to chisel in corn after corn.

Table 1. Second-year corn yields as affected by tillage at Waseca (2005-2007 avg.).

Tillage treatment	Corn grain yield (bu/ac)
Deep zone-till	173
Strip-till	173
Spring disk	170
Chisel plow	177
Moldboard plow	185
LSD (0.10):	5

Table 2. Second-year corn yields as affected by tillage at Waseca (2008-2010 avg.).

Tillage treatment	Corn grain yield (bu/ac)
Two-pass disk	192
Strip-till	196
Spring disk	189
Chisel plow	198
Moldboard plow	207
LSD (0.10):	9

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