Best management practices for sustaining yield and soil quality

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Management and tillage decision is one of several decisions farmers have to make every fall. However, there are many other factors that need to be considered when selecting a tillage system for any given field, or region within the state. Those factors are soil conditions, which include soil slope, soil drainage, topsoil depth or the A-horizon depth. Other equally important factors that need to be considered are hybrid selection, crop rotation, and management factors, such as residue cover, type of residue (corn or soybean), soil moisture condition at the time of making the decision, timing of tillage operation, fertilizer management in conjunction with tillage operation, type of residue management equipment, planting and harvesting equipment, compliance with conservation plans, and above all, the economic return and benefits for selecting the tillage system.

The variability in soil conditions will be a key factor in selecting a tillage system that will ultimately influence crop response and yield expectations. However, crop response to tillage systems has been demonstrated to be different for the same tillage system in different parts of the state or regions elsewhere. Different tillage systems affect soil temperature, soil moisture conditions, soil compaction, soil productivity, and nitrogen movement and N availability differently. These effects will be indicated in crop response to different tillage systems, where soil temperature plays a significant role in early seed germination, organic N mineralization, nutrient and residue incorporation, and weed and pest control.

Understanding site specific effect of tillage can significantly help in reducing input cost and also reduce the negative impact of tillage on water, air, and soil quality. Conservation tillage systems continue to be a very important component of crop production systems in terms of economic return and environmental benefits. However, the challenges in managing such systems, notably, no-tillage, are related to proper management practices that are associated with drainage in poorly drained soils, the use of residue management attachments, seeding depth, and fertilizer management. Also, the timing of field operations including N application, manure injection, etc., has to be done when the soil moisture condition is below field capacity to avoid any serious soil compaction problems.

Soil moisture and soil temperature conditions in the seedbed zone (top 2-6 inches) can promote or delay seed germination and plant emergence (Kaspar et al., 1990; Schneider and Gupta, 1985). Therefore, healthy plant growth and development require soil conditions with adequate soil moisture and minimal root penetration resistance (Phillips and Kirkham, 1962). Soil temperature can be affected by surface residue cover, which causes cooler soil surface temperatures and slower soil drying in the spring (Fortin, 1993; Kaspar et al., 1990) despite reducing soil erosion and surface runoff (Cruse et al., 2001). Removal of residue from the row can reduce in-row soil moisture content in the seedbed, while conserving interrow soil moisture. Unlike soil moisture, soil temperature has an inverse relationship with the amount of residue cover. Furthermore, tillage systems and residue management have a significant effect on N dynamics by affecting C and N pools in the soil system. Soil disturbance during the tillage process and the incorporation of surface residue increases soil aeration, which further increases the rate of residue decomposition (McCarthy et al., 1995). This process impacts soil organic C and N mineralization and the readily available N for plant use (Dinnes et al., 2002). The type of tillage system adopted can influence the amount of N losses in the soil profile, and deep accumulation of NO3-N in the soil profile represents a potential for NO3-N leaching into shallow water tables (Keeney and Follett, 1991).

Results and discussion

Tillage and crop rotation effects on yield

Corn yield response to different tillage systems in 2011 and 2012 is summarized in Fig. 1. The results show regional and year variability for corn yield in response to different tillage systems in a corn-soybean rotation system. The results show considerable corn yield decline across all tillage systems due to drought conditions for some regions in the state in 2012. Also, the data show, that corn yield response to tillage systems regardless of the seasonal moisture, is region specific. However, in the northwest region, the results demonstrated a less severe yield decline in response to drought conditions, which can be attributed to better soil water holding capacity. Generally, aggressive tillage did not mitigate the impact of drought conditions better than NT or ST. Differences in yield between tillage systems of the same year are not significant if they are less than the LSD (0.05) value of that year for each region as shown in Figure 1 below.

Residue removal effects on corn yield

Corn yield response to residue removal by N rate is summarized in Fig. 2. There was a significant effect of residue removal on corn yields as affected by different N rates and tillage practices. In the well-drained soil, corn yields were higher when 50 and 100% of the corn residue was removed across all N rates. In the poorly drained soil, corn yields were also higher when 50 and 100% of residue was removed at N rates ranging from 50 to 200 lbs N/acre. Increase in corn yield due to residue removal may be attributed to higher soil temperature, which increases potential organic mineralization resulting in greater biomass and grain production. In the continuous corn production system, residue removal in addition to exposing the soil surface to sun radiation increased soil organic matter mineralization, releasing additional mineral N, which reduced N immobilization with less corn residue on the soil surface.

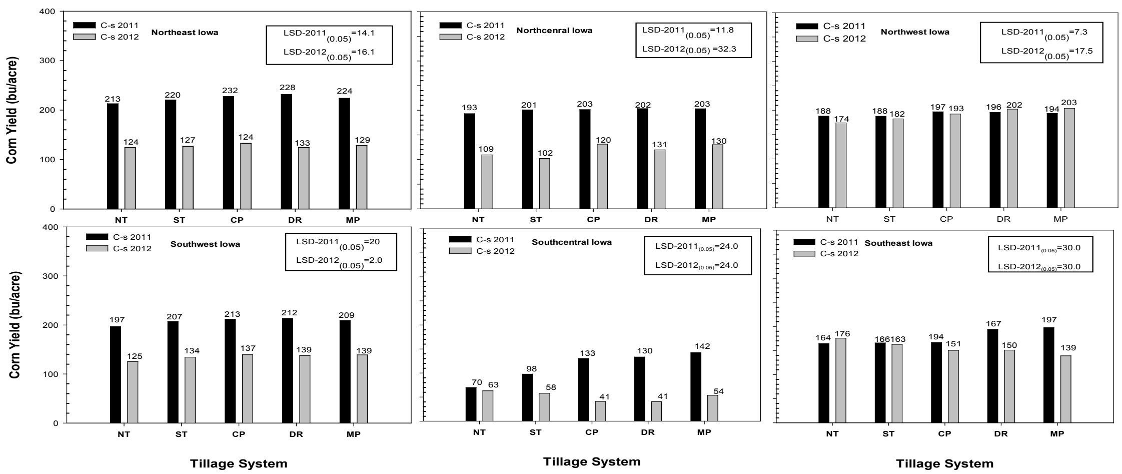

Figure 1. Tillage system effect on corn yield in different regions in Iowa. (NT=no-till, ST=strip-tillage, CP=chisel plow, DR=deep-rip, and MP=moldboard plow). Yield differences less than LSD(0.05) values are not significant.

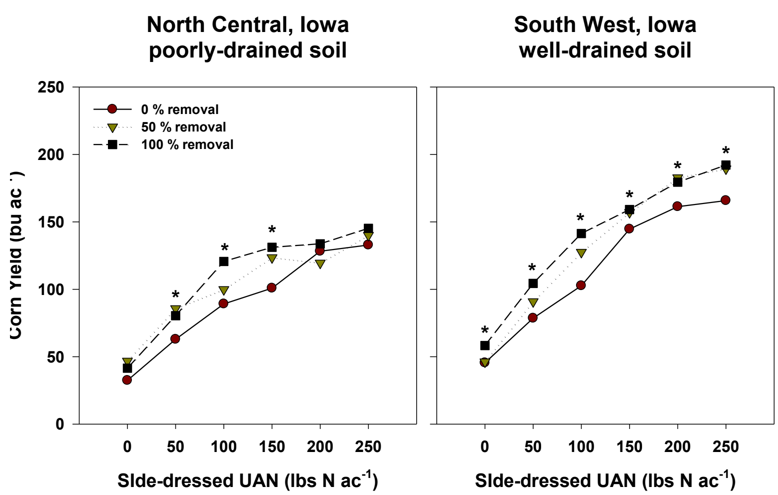

Figure 2. Residue removal effects on corn yield in north central and southwest Iowa. Asterisk indicates significant difference between residue removal treatments.

Tillage effect on soil quality

Carbon storage is affected by tillage intensity, which can have a negative effect on soil organic carbon by oxidizing organic matter. Results from tillage studies in Iowa show consistent decline in organic carbon with increased intensity in tillage operations (Fig. 3). Aerating the soil through tillage increases the rate of soil organic matter decomposition and the emission of carbon dioxide. Soil carbon is beneficial to improving soil structure as well as the nutrient and water holding capacity of the soil. The results show that crop rotation affected soil carbon, where C-S rotation caused a slight increase in soil C compared to continuous corn or C-C-S rotations. The decline in soil carbon with C-C can be attributed to two factors, 1) with C-C, there is significant amount of soil tillage and 2) even with NT, C-C rotation can have significant effect on soil microbial diversity, which is essential for carbon cycling and organic matter build up.

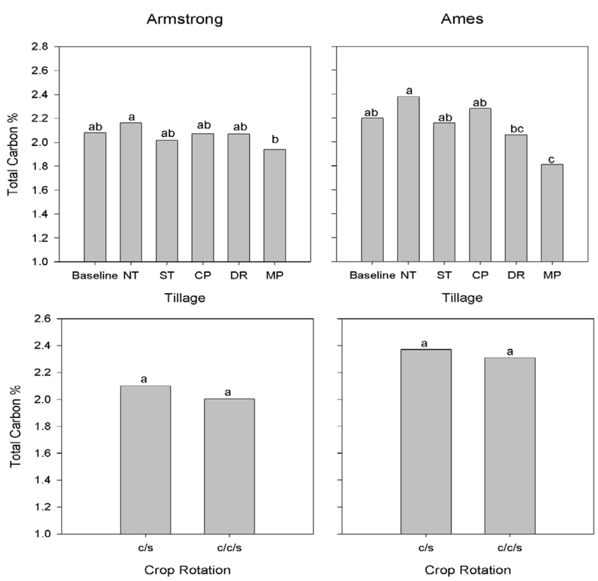

Figure 3. Soil carbon as affected by tillage and crop rotation at the top 6 inches for two sites in Iowa.

Residue removal effects on soil carbon

Effects of residue removal and tillage system on soil carbon were summarized in a three-year study near Ames and Lewis, Iowa (Fig. 4). The results show a decline in total soil carbon as residue removal rates increased, especially under conventional tillage system (CT). However, the decline occurred with both no-till (NT) and conventional tillage (CT) systems at sites with well-drained soils compared to poorly drained soils. These changes in soil carbon represent a short-term effect of residue removal under continuous corn, which can be a long-term predictor of residue removal effect on soil quality. Proper management should be considered which may include soil nutrients testing for balanced application, use of cover crop to prevent top soil loss, and appropriate crop rotation after corn harvest for the following year. A balanced approach of crop rotation, NT system, and N management is essential in managing residue removal to sustain soil productivity.

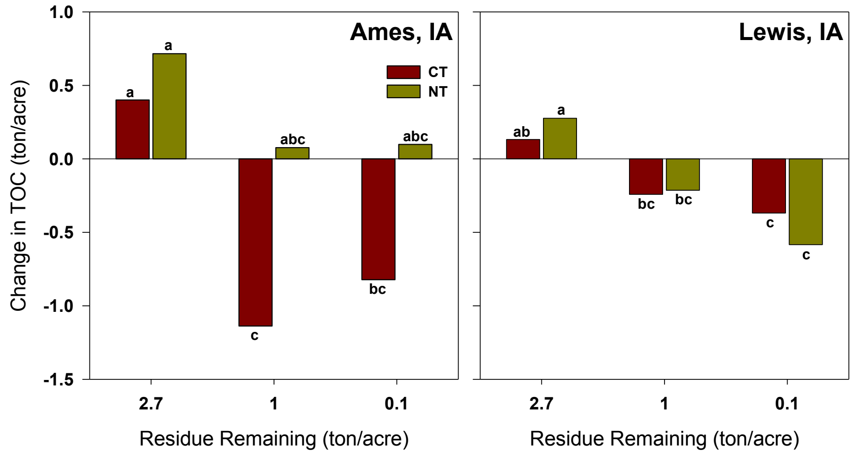

Figure 4. Tillage and residue removal effects on total soil carbon (TOC) at the top 12 inches near Ames and Lewis, Iowa. Data presented in this figure represents the average of two nitrogen rates (150 and 250 lb N/acre) and three years in continuous corn. (Treatments with the same letters are not significantly different at p=0.05).

Summary

Best management practices that protect soil quality and sustain productivity are economically and environmentally necessary. The implementation of such practices should be considered on regional and site specific basis. Site specific adoption of different tillage and conservation practices are essential to achieve intended objectives that can be easily integrated within an overall production system. These conservation plans can include, but not limited to, no-till, strip-tillage, cover crop, perennials, grass waterways, terraces, buffer strips, pasture for erosion control, manure application plan, and soil testing. Conservation planning and implementation of such practices need to be considered carefully as solutions to reduce potential row cropping system effects on soil and water quality. Consideration of site specifics and objectives of implementing conservation practices should be included in the planning process. Finally, conservation practices must be an integral and essential component of nutrient reduction, sediment and nutrient loading plans, as an effective solution to protecting soil and water quality.

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