Integrated crop-livestock system: effect on soil compaction, microbial biomass, and grain yield.

Matt W. Maughan, Germán A. Bollero, Dept. of Crop Sciences, University of Illinois.
Benjamin F. Tracy, Dept. of Crop, Soil & Environmental Sciences, Virginia Tech
Photo of beef cattle grazing on a cool season perennial pasture at the DSF June 2007.
Introduction

- Integrated crop-livestock systems are a method of diversifying a farm for improved long term sustainability. Recent research has shown these systems to be beneficial in affecting soil parameters that improve soil quality (Katsvairo, 2006; Acosta-Martinez, 2004). On the contrary, cropland grazing of crop residues and cover crops associated with integrated systems have been reported to compact the soil (Clark, 2004; Franzluebbers, 2005).

- In Illinois, a traditional corn-soybean farm was converted into an integrated crop-livestock research farm. Various agronomic, ecological and economic effects of this system are being researched (Sulc, 2007). Included in this in this study is an assessment of soil compaction (SC), and soil microbial biomass carbon (SMBC).
Objective

• Determine if cattle have introduced SC to the integrated farm while grazing. Our study quantifies the SC among treatments, with particular emphasis on grazed cropland, and its effect on subsequent corn yields.

• Analyze SMBC for a comparison among treatments
Materials and Methods

In 2002, a 90 ha corn-soybean (Zea mays L.)/[Glycine max (L.) Merr.] farm was converted into an integrated crop-livestock farm known as the Dudley Smith farm (DSF). This University of Illinois farm is located near Pana, Illinois on Virden series soil consisting of silty clay loams. The experimental design is a RCBD consisting of 3 replicates. Each replicate consists of 4 treatments (figure 1):

i) cropland pasture planted to corn in spring and harvested for grain in fall,
ii) cropland pasture planted to oats in the spring, harvested for grain in July and then planted to a winter cover crop consisting of oat (Avena sativa L.), cereal rye (Secale cereale L.), and turnips (Brassica spp.),
iii) continuous corn
iv) perennial pastures.
Individual replicate of the Dudley Smith Farm (DSF) system consisting of 4 grazing treatments: (1) corn residues (CR), (2) winter cover crops (WCC), (3) perennial pastures (PP), and (4) continuous corn (CC). PP are rotationally grazed spring-fall, while CR and WCC are strip grazed during the winter months. CC receives no grazing.
Materials and Methods

- Perennial pastures (PP) are rotationally grazed spring-fall at a stocking density of 2.5 beef cows ha⁻¹ while adjacent cropland pasture cash crops are growing.
- In late fall cattle are moved to cropland pasture where they are given equal access to the winter cover crops (WCC), and the corn residues (CR) left over from previous corn harvest.
- A method of strip grazing is implemented and beef cows graze the WCC and CR throughout the winter months, until forage is depleted.
- Each spring, Cropland pasture treatments are rotated so that corn yield can be assessed following grazing of WCC.
- Continuous corn (CC) plots remain ungrazed.
- Conventional tillage is used prior to planting of each crop.
Sampling & Analysis

- Samples were taken in late winter/early spring following winter grazing of cropland pasture and prior to planting of corn and oats for SC and in fall 2006 for SMBC.
- 2 years of data were collected for SC and 1 year for SMBC. 20 soil profile samples were collected per plot each year using a soil penetrometer for penetration resistance (PR) measured in psi and the converted to kPa.
- Soil samples were collected using core samplers to a depth of 30 cm. Soil was then cut to obtain soil depths of 0-5, 5-15, and 15-30cm. These samples were then used to determine SMBC utilizing a chloroform fumigation-incubation method. Actual Microbial Biomass C was calculated using the method from (Voroney and Paul, 1984).
- Results were analyzed using SAS.
Collecting soil samples to be used for soil microbial biomass and soil moisture, fall 2006
Results

• Soil Penetration Resistance (PR) profiles were influenced by grazing and previous crop treatment.

• Significant overall differences existed between grazing treatments (WCC, CR, PP) and non grazing treatments (CC).

• In 2004 (a), PR was significantly higher (p=0.05) for WCC and CR compared to CC.

• In 2007, significant differences (p=0.05) existed between grazed treatments and CC.
Results

• Soil PR differed among depths of grazed treatments (WCC, CR, PP), when specific depths were compared to the correlating depths of CC.

• Asterisks * represent significant differences (p=0.05) between specific grazing treatments and the control (CC) at the same depth.

• In 2004 (a), PR resistance was increased by both cropland grazing treatments (WCC, CR) at all depths.

• In 2007 (b), WCC showed increased PR at the 0-5 and 5-15 cm depths.
SMBC was increased in the 0-5 cm layer for WCC compared to CC.
average SMBC was influenced by crop treatment. Significant difference (p=0.2) between WCC and CC is represented by the asterisk *.
Corn yield following grazing of WCC influenced subsequent corn yield. In 2006 corn yield following WCC was significantly higher ($p=0.05$) than the CC control yield. Different letter represent significant differences within years.
View of pasture, and growing corn, summer 2007
Summary

• SC as measured by PR is increased by grazing. Significant increases were very evident in 2004 among both grazed cropland treatments (WCC, CR). Grazing cropland compacts the soil, however it appears that conventional tillage operations following grazing and prior to planting of the following crop alleviates most if not all of the significant SC.

• SMBC is increasing under WCC and pasture treatments. WCC contribute a large amount of plant residue to the soil, acting as the primary reason for this increase under the WCC treatment. PP also contribute large amounts of plant litter including plant roots to the soil, which most likely contributes to its increase in SMBC. Over time, soil organic matter may increase as well as soil quality due to the use of PP and WCC. The effect of grazing on increased SMBC is not determined.
Summary

• Crop yields are not negatively affected by the increased PR, indicating again that conventional tillage may alleviate most if not all of the soil compaction in the grazed cropland treatments. Corn yield may be enhanced by the diversity of the crop rotation and the increase in plant residue input. Increased SMBC as an indicator of soil quality may be contributing to the trend of increasing corn yield.

• Known effects of CC on non-increasing crop yield may be a factor in CC not performing as well as the grazed cropland. Further research including other cropping sequences such as the corn-soybean rotating may better indicate the advantages of the integrated crop-livestock system.

• Overall, the benefits and advantages of integrated crop-livestock systems seem promising when compared to continuous cropping systems.
References