4.3. A TEST OF STRATEGIES TO IMPROVE NEE IN CORN-SOYBEAN ECOSYSTEMS

J.M.Baker[1*] and T.J. Griffis[2]
[1]USDA-ARS, St. Paul, MN 55108, [2] Dept. of Soil, Water, & Climate, University of Minnesota

1. INTRODUCTION

A number of management options have been suggested for increasing soil organic carbon (SOC) in agricultural systems, but there is little quantitative data to properly support recommendations or policy changes. Changes are generally too spatially variable and too small relative to background levels to be detected by soil sampling and analysis within a reasonable period of time. As an alternative we have used paired, long-term micrometeorological measurements of contrasting management systems in immediately adjacent fields to examine the impact of two specific practices, reduced tillage and cover cropping, that have been proposed for increasing soil C in corn/soybean rotations, the dominant cropping practice in the Midwestern United States.

2. METHODS

2.1 Site

This research was conducted in adjacent fields at the University of Minnesota's Rosemount Research Center, approximately 20 km south of St. Paul (40°45' N, 93°05' W). The soils are highly productive silt loams that formed in glacial outwash, and have been in corn/soybean production for at least the past 50 years. Two fields were used for this project; one is 17 ha in size, and the other is 37 ha. Each has a permanent mast installed in the center of the field.

2.2 Farming Practices

Both fields were in a corn/soybean rotation. The south field was farmed conventionally, with chisel/disk tillage each fall following harvest, and a light cultivation in the spring prior to planting. In the north field alternative practices were used in an attempt to increase soil C. These include reduced tillage (strip tillage in the fall; no tillage in the spring) and a cover crop (oats) in the spring of the soybean year. The oats were planted in early April, and then the soybeans were directly seeded into them in late May, at the same time as soybean planting in the conventional field. A week after soybean planting the oats were killed with glyphosate. Chemical weed control was used in both fields, and fertilizers were added as needed on the basis of annual soil testing. Data reported in this study commenced following corn harvest in fall 2001, and continued through corn harvest in 2003.

2.3 Measurements

NEE, latent heat flux, and sensible heat flux were measured in both fields throughout the two year period by eddy covariance, using CSAT sonic anemometers and LI-7500 open-path infrared gas analyzers (Griffis et al, 2004). The instrumentation is mounted on the masts such that farming operations can be conducted without discontinuing measurements. Incoming and upwelling components of the radiation balance were measured with Eppley pyranometers and pyrgeometers, and soil temperature and water content profiles were measured with thermistors and time domain reflectometry. Susbsurface drainage was sampled with equilibrium tension lysimeters and analyzed for dissolved organic carbon. Leaf area index and above-ground biomass were measured weekly during the growing season, and crop yield was determined both by direct weighing of harvest wagons and by a GPS-equipped yield monitor on the combine. Grain sub-samples were analyzed for carbon content.

3 RESULTS

3.1 Direct Tillage Effects

For both years, NEE measurements during and immediately following fall tillage showed little difference between the two treatments. C loss was slightly higher in

* Corresponding author. USDA-ARS, Dept. of Soil, Water, & Climate, University of Minnesota, St. Paul, MN 55108 jbaker@soils.umn.edu

the conventional (chisel/disk) field than in the conservation tillage treatment, but there was no large burst of CO2 accompanying tillage, as has been reported from chamber-based measurements (Reicosky, 1997). In each year, the cumulative difference between the two fields during the post-tillage, pre-freezing period was approximately 0.1 Mg ha^{-1}. Differences in respiration between the treatments did not persist into the following spring.

3.2 Cover Crop Effects

3.3 Yields and Cumulative NEE

The soybeans in the cover-cropped field eventually recovered from their slow start to produce grain yields that were only slightly lower than the conventional field. The conventional field also produced a slightly higher yield in the corn year of the rotation, when the only difference between the two treatments was in their tillage. Overall the net removal of C in the grain during the two years was 4.67 Mg ha^{-1} in the conventionally farmed field, about 7 % greater than that which was removed in the alternative (reduced tillage and cover crop) field. Cumulative measured NEE in the conventional field was also about 7 % greater so that the ratio of NEE to grain C was about the same (0.80) in both fields. The difference between cumulative NEE and grain C was about 0.9 Mg ha for both fields; this represents either a net loss of soil C, a cumulative underestimate of NEE by eddy covariance, or some combination of the two. Energy balance closure of the eddy covariance measurements was also about 80%, suggesting that most, if not all, of the apparent soil C loss was in fact underestimation of the turbulent fluxes. In any case, the key result was that there was virtually no difference in the net C balance (NEE – grain C) for the two farming systems, indicating that the two management practices that were tested had no discernible C sequestration benefit.

3.4 Conclusions

Paired flux measurements in adjacent fields permit evaluation of the relative sequestration benefits of different farming practices. We examined two such practices that have been proposed for corn/soybean systems, reduced tillage and a spring cover crop prior to soybean. Over the span of a two-year rotation, the combined effects of these two practices were negligible.

The oats used the available spring time PAR to good effect, fixing a substantial amount of C while the conventional field, bare at the time, was losing C to respiration as the soil gradually warmed. However, this NEE advantage was rapidly lost after the soybeans were planted and the oats were killed. The oats residue slowed the initial development of the soybeans relative to those in the conventional field, and the residue itself was rapidly consumed by heterotrophic resipiration, such that there was no discernible NEE benefit from the spring cover crop.

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