ENERGY BALANCE COMPARISON AMONG TILLAGE PRACTICES IN CORN AND CORN-SOYBEAN SYSTEMS

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INTRODUCTION

There is little information available on the effect of common management practices on the energy balance of corn and soybean cropping systems. This type of information is needed to assess the sustainability of these systems. Such information will also be useful for designing improved cropping systems. The objective of this study was to compare the energy balance among continuous and rotated corn and soybean under six tillage systems using data from a long-term study conducted in eastern Nebraska.

METHODS

The tillage study was initiated in 1986 at the Rogers Memorial Research Farm near Lincoln, NE under natural rainfall conditions. Soil at the site is a Sharpsburg silty clay loam. The experimental design was a completely randomized block with a split-plot arrangement of treatments and six replications. Tillage system (tandom disk, chisel plow, moldboard plow, subsoil tillage, ridge tillage, and no-tillage) was applied to the whole plots and cropping treatment (continuous corn, corn in a corn-soybean rotation, soybean in a corn-soybean rotation, and continuous soybean) to the sub-plots. Cultural practices were similar to those used by local producers. Seeding rates varied from 40,000 to 58,000 seeds ha^{-1} for corn and from 250,000 to 375,000 seeds ha^{-1} for soybean. Varieties/hybrids were changed approximately every four years to take advantage of genetic improvements. Pesticides were used at recommended rates as needed each season. Corn was fertilized with 113 kg ha^{-1} as NH_4NO_3 and no fertilizer was applied to soybean.

Energy inputs included diesel consumption during field operations and energy equivalents for seed, fertilizer, and pesticides. Energy associated with labor was not included as it accounts for <0.2% of total energy in most modern cropping systems. In addition, solar energy was not included as its magnitude would mask variation in other energy inputs (Hülsbergen et al., 2001). Energy inputs for drying, storage, and transportation from the farm to consumers was not included. Fuel use efficiency by machinery and for production of N fertilizer has improved over time and energy consumption was determined for three periods (1986 to 1990, 1991 to 1995, and 1996 to 2001). Fuel use for equipment from these three time periods was obtained from the Nebraska Tractor Test Laboratory. Energy equivalents for N fertilizer were 49.4 MJ kg^{-1} for 1986 to 1990, 35.3 MJ kg^{-1} for 1991 to 1995, and 32.2 MJ kg^{-1} for 1996 to 2001. Calculations were made using a 50 ha field located 5 km away from the farm. Energy output was calculated by converting yields to energy equivalents assuming 15.6 MJ kg^{-1} for corn and 23.8 MJ kg^{-1} for soybean.

RESULTS

During the study period annual precipitation averaged 708 mm and mean annual temperature was 19.9^{o} C. Mean annual grain yield ranged from 2.4 to 10.6 Mg ha^{-1} and averaged 5.8 Mg ha^{-1} for continuous corn. Yields for corn rotated with soybean ranged from 3.1 to 11.0 Mg ha^{-1} and averaged 7.1 Mg ha^{-1}. Averaged over years, corn yields were greatest with plow tillage and least with no-tillage. Yields for soybean ranged from 1.3 to 3.5 Mg ha^{-1} and averaged 2.4 Mg ha^{-1} for continuous soybean. Yields for soybean rotated with corn ranged from 1.6 to 4.0 Mg ha^{-1} and averaged 2.6 Mg ha^{-1}. Averaged across years, soybean yields were similar among the tillage treatments. Seasonal temperature and rainfall patterns influenced corn and soybean yields and the effect of tillage on yields (Wilhelm and Wortmann, 2004.).

There was variation among years in the energy balance due to weather effects on crop yield and therefore on energy output and efficiency. In spite of year-to-year variation there were tillage effects and crop effects on the energy budget. Energy input was similar among tillage practices when averaged across years (7.9 MJ ha^{-1}). Energy output was greatest with plow tillage (96.1 MJ ha^{-1}) and least with no-tillage (90.4 MJ ha$^{-1)}$. Similarly, energy gain was greatest with plow tillage (87.4 MJ ha^{-1}) and least with no-tillage (83.0 MJ ha^{-1}) while the output:input ratio was greatest for no-tillage (12.8) and least for plow tillage (11.2).

Energy input was greatest for continuous corn (9.7 MJ ha^{-1}) and least for continuous soybean (5.9 MJ ha^{-1}). Differences in energy input are due to differences in fertilizer N inputs between the two crops. Energy output was greater for corn (107.5 MJ ha^{-1}) than for soybean (63.8 MJ ha^{-1}). Energy gain was greater for corn (97.8 MJ ha^{-1}) than for soybean (57.8 MJ ha^{-1}), the result of yield differences between the crops. The output:input ratio was greater in corn-soybean rotation (13.1) than in continuous corn (11.4) or soybean (11.4).

CONCLUSIONS

Weather effects on yield influences annual energy budgets.

Averaged across years, crop (differences in applied fertilizer N, yield, and energy content of the grain) influences energy balances more strongly than does tillage in rainfed systems of the western Corn Belt.

While there were significant tillage by crop interactions their effects were small compared to those discussed above.

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