

TITLE: Impact of direct seeding on crop water use efficiency, soil physical and microbial properties and quality of soil organic matter.

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FINAL REPORT

PROJECT OBJECTIVES: 1) Determine crop water use efficiency, seed zone temperature, soil profile winter water storage, and N use efficiency under direct seed (DS) and conventional systems. 2) Evaluate the transitional soil physical and biological interactions under DS systems and the influence from different crop rotations. 3) Evaluate the quantity and quality of SOM changes under DS systems and the significance in sequestering atmospheric carbon dioxide.

KEY WORDS: direct seed, soil quality, carbon sequestration, crop rotation

STATEMENT OF PROBLEM:

Many growers are asking about costs and benefits from direct seed (DS) systems in the long term and in the transitional period. Long-term benefits are best understood, but short-term benefits are less certain given the current depressed commodity prices and the cost of getting into DS. One short-term benefit is increased soil water storage and water use efficiency under DS. Another is the change in soil pore size distribution from old root and earthworm channels under DS. In spite of greater compaction under DS systems, water infiltration seems to be increasing. Soil organic carbon (SOC) increases at the surface of DS and is the property most talked about by growers and researchers alike because it holds the key to so many vital functions in soil. Total SOC tells us little about quality of organic matter, but the particulate organic matter (POM) and light fraction (LF) of SOC accumulate quickly under DS and can be used as indicators of soil quality in the transition period. Increasing SOC under DS means C is being sequestered.

ZONE OF INTEREST: High, intermediate, and low rainfall zones.

ABSTRACT OF RESEARCH FINDINGS:

From long-term conventional and DS sites in Oregon and Washington reported previously, highest SOC was found after 70 years of grass-pasture in OR and 25 years of DS in WA in contrast to the lowest values for 68 years of conventional wheat-fallow in OR. POM C was concentrated at the soil surface under GP and DS and represented 33-35 % of total surface SOC under GP in OR and 25 years of DS in WA. The LF and POM C were the best indicators of short-term changes in soil organic matter in transition to DS. After only two years of DS in WA, the LF increased from 2.5 to 7.0 g kg C ha⁻¹ (180%) and the POM fraction increased 3.5 to 4.5 g C kg C ha⁻¹ (29%) in the surface 5 cm, suggesting that changes take place very rapidly under DS.

In studies on soil water, there was a trend for larger pore sizes at lower water tensions under natural vegetation (NP) that would allow the soil to hold more water and to provide increased soil aeration. The trend for volumetric water and water tension was similar for DS and CT soils. At higher water tensions, all soils behaved in a similar manner.

Because of the concerns for increased acidity under DS conditions, liming studies have shown to increase soil nitrate from nitrification. These results suggest that the availability of soil and fertilizer N with liming may increase plant growth. Liming also increased the microbial respiration rate, a direct indicator of microbial activity. Microbial biomass also increased with liming which is an indication of increased microbial growth that directly parallels the response in microbial respiration.

RESULTS AND INTERPRETATION:

Soil C and C sequestration

Research at Pullman compared SOC and various organic matter fractions after zero, 3 and 25 years) of DS. At Pendleton, five crop rotations with different tillage practices were compared. Most results were presented in the 2002 STEEP report. Highest SOC was found at the soil surface under DS due to the lack of tillage and redistribution of residues. With tillage, SOC was more evenly distributed with depth. The wheat-fallow rotation was the lowest in SOC because fallowing and tillage encourage residue decomposition and loss of SOC. POM C, which is organic matter of sand size and larger, was more sensitive to changes in management than SOC and it increased more rapidly under DS and grass pasture than other rotations. This POM fraction is an intermediate nutrient pool with high microbial life and activity and one that contributes positively to the soil physical condition under DS. Since the POM pool builds up slowly under DS, this may explain the transitional period noted for early DS. Once this pool of organic matter is built up, nutrient release would increase with time. Another organic matter fraction is the light fraction (LF). Using POM or the LF, substantial stratification and build up of soil C can be observed in as few as three years of DS. Therefore, changes in soil organic matter as the LF and POM C fractions do occur rapidly under DS.

Temporal changes hydraulic conductivity under natural and agricultural management

We have determined seasonal changes in soil physical variables under natural and agricultural management systems. Experimental fields are located in the Palouse Region near Pullman, WA and consisted of a conventional-tillage (CT), a no-till (NT) as described in the 2002 STEEP report and a natural prairie (NP). The NP and CT fields are adjacent to each other and are located 32 Km south of Pullman. The NP field had no anthropic disturbances, thereby preserving the natural vegetation and soil that potentially preceded tillage. We specifically studied potential changes in the saturated and near saturated hydraulic conductivity, soil porosity, and bulk density during six different periods (May,

November of 2001; April, June, September, and November of 2002). For hydraulic conductivity measurements, intact soil cores of 9.2 cm in diameter and 10 cm depth were randomly taken and divided in two sections (0-5 and 5-10 cm) and saturated with a 0.005 M CaSO₄ solution until measurement. Saturated hydraulic conductivity was calculated with the constant head method. Near saturated hydraulic conductivity (1, 6, and 15 cm of water tension) was calculated in the lab under steady state conditions using tension infiltrometers. For the study of soil porosity, intact soil cores of 5.4 cm in diameter and 3 cm in length were randomly taken using a manual triple-cylinder hammer-driven core sampler. Soil water release curves were constructed by measuring the volumetric water content at water potentials varying from 0 to 100 kPa. The hanging water column and the pressure plate techniques have been used for covering the entire range of tensions applied.

Results in Figure 1 show a trend for larger pore sizes to exist at the lower water tensions under natural vegetation (NP). This would allow the soil to hold more water and to provide increased soil aeration at all depths. The trend for volumetric water and water tension was generally similar for DS and CT soils. At higher water tensions, all soils behaved in a similar manner.

Biological factors as influenced by liming soil under 27 years of no till

The purpose of this study was to characterize the effect of lime on soil respiration, soil pH, soil nitrate-N (NO₃⁻ - N), and microbial biomass of a 27 year-old NT soil. While liming is known to improve plant growth due to reduction in acidity, there are notable changes in soil nutrient status and microbial activity that may indirectly improve crop growth. Field-moist bulk soil samples were randomly taken in April 2002 from various depths in a soil under no till for 27 years as described previously. Soils were amended in the laboratory with lime at 4 rates, and monitored for soil pH, nitrification, microbial biomass, and respiration.

Results in Figure 2 show the response of liming on soil pH where a direct response was noted in the 56-day period at three soil depths. The low rate of lime (4.4 Mg ha⁻¹) corresponds to 2 US tons per acre. Response to liming soils below pH 6 is often related to an increase in microbial activity, because optimal conditions for microbial activity is somewhere between pH 6.5 and 8. The activity of nitrifying microorganisms that convert ammonium to nitrate is often increased by liming and could consequently increase the availability of N to plants. In Figure 3, the amount of nitrate-N generally increased with liming rate, suggesting that at the more optimum soil pH, the nitrification potential increased. These results suggest that the availability of soil and fertilizer N with liming may increase plant growth. Results in Figure 4 show that liming increased the microbial respiration rate, a direct indicator of microbial activity. Microbial biomass also increased with liming which is an indication of increased microbial growth that directly parallels the response in microbial respiration (Figure 5).

INTERACTION (COOPERATION) WITH OTHER SCIENTISTS CONDUCTING

RELATED ACTIVITY: We work with Dennis Roe, NRCS, Colfax on the Northwest Crop Project. David Huggins, ARS, Pullman has collaborated on the water use efficiency, seed

zone temperature, water storage, N use efficiency and crop modeling portion of this research. Stewart Wuest and Dale Wilkins, ARS, Pendleton, are involved with the earthworms and soil C modeling, respectively. Steve Albrecht, USDA-ARS, Pendleton, is cooperating with us on the carbon research.

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