Northwest Columbia Plateau PM$_{10}$ Project

Objective 7: Identify and Test Wind Erosion and PM$_{10}$ Emission Control Methods of Alternative Cropping Systems (tillage, crops, rotation, weed control) and Evaluate their Effectiveness through Descriptive Measurements and Portable Wind Tunnel Tests

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Objectives

Soil quality parameters were assessed at several long-term dryland cropping systems research sites in eastern Washington and northern Idaho to further define management practices that are soil building rather than degrading. The objective of this research is to characterize biological, physical and chemical soil quality parameters and monitor their changes over time in minimum tillage, no-till or direct seed seeding systems as affected by soil disturbance, crop species and management systems. This will allow the identification of soil quality parameters that can be used in the development of best management practices for conserving soil quality and enhancing crop production.

Major findings

- Soil microbiological parameters may be the earliest predictors of soil quality changes. Molecular indicators such as fatty acid methyl ester (FAME), phospholipid fatty acid (PLFA), denaturing gradient gel electrophoresis (DGGE) carbon utilization profiles and composition of ammonia oxidizing bacteria were used to analyze bacterial community structure and diversity from Washington State soils. After ten years of CRP, the microbial community was dramatically different from conventional tillage, while the microbial communities in the direct seed systems soils were most similar to CRP. The rhizosphere microbial communities from various plant species differed depending on the plant species. We also showed that microbial composition of the rhizosphere differed between field and greenhouse (Ibekwe and Kennedy, 1998; Ibekwe and Kennedy, 1999; Ibekwe et al., 2002; Weddell et al., 2001).

- The Conservation Reserve Program (CRP) has reduced erosion potential in eastern Washington; however, changes in soil quality parameters need to be followed if these lands are placed back into production. Conservation and conventional take-out practices were assessed throughout eastern Washington to determine changes in soil quality parameters. After only one year of CRP take-out in eastern Washington, we found decreases in soil quality parameters as a result of conventional tillage practices used during take-out. For dryland cropping areas of eastern Washington, direct-seed management maintained soil quality most similar to CRP grassland (Gewin et al., 1999).
• Soil disturbances associated with crop production may lead to a deterioration of soil quality and increase soil loss due to wind and water erosion. Field studies were conducted within long-term experiments with no-till and chisel till practices and addition or removal of residue. The effects of minimum tillage on microbial properties were small relative to effects of leaving a thick layer of residue on the soil surface. However, lack of severe disturbance due to tillage had a greater positive impact on soil quality than did removal of the surface residue (Petersen et al., 2002; McCool et al., 2001).

• Mycorrhizal fungi help plants explore more of the soil and increase nutrient uptake by plants. We found that addition of these fungi increased the growth of wheat when grown in soil from an eroded ridgetop. No such benefit was seen on soils from bottom or sideslope positions. Inoculation of the fungi lowered pH in the rhizosphere, decreased Mn uptake by the plant and increased phosphorus and zinc uptake. Mycorrhizal roots utilized unavailable forms of soil phosphorus. Mycorrhizal fungi can enhance plant growth, especially in low nutrient and eroded soils in dryland wheat growing areas (Mohammad et al., 1998; Arrusan et al., 2005).

• No-tillage offers potential for improved soil quality, reduced erosion, and equal or increased crop yields. To better understand microorganisms and weed seed decay in no-till systems, we evaluated the effects of tillage, soil fumigation, and fungicides on the decay of wild oat. Loss due to decay was relatively low; however, decay was occurring. Soil-borne fungi were identified that infect and decay wild oat seeds that could contribute to depletion of the weed seed bank. This research will enable scientists to create conditions necessary for weed-suppressive soils (Gallandt et al, 2004; Kennedy, 1999).

• The change with soil quality parameters in the transition period from conventional tillage to no-till appears to take longer and can be more variable in lower rainfall zones. Changes occurring with microbial communities were measured before changes in organic matter or other chemical or physical parameters. Most importantly, we found that organic matter increased with long-term direct seed. This information will provide growers and scientists with practical advice on soil quality to aid in the development of management practices (Kennedy and Schillinger, 2005).

• The biological portion of soil can be used to differentiate displaced soils. Fatty acid methyl ester analyses (FAME) of soils yield characteristic "fingerprints" that are unique to a given soil at a given time. The FAME analysis could distinguish road dust from agricultural soils. The soil of the Columbia Plateau in Washington state could be separated into six major biological groupings based on fatty acid analysis. Fatty acid methyl ester (FAME) analysis on whole soil was used to build a soil fingerprint library containing different potential sources including non-agricultural samples and agricultural operations. Samples from the San Joaquin Valley and West Texas taken from agricultural practices separated clearly from each other. Samples of dust from air around Spokane, WA were most similar to fingerprints of soil from urban areas. These data demonstrate the ability of FAME fingerprints to differentiate among soils, and therefore potential dust sources (Kennedy, 1998, Kennedy and Busacca, 1998; Kennedy, 2000; Acosta-Martinez et al., 2003).
Two analytical methods Fatty acid methyl ester (FAME) and length-heterogeneity PCR (LH-PCR) analyses were used to create unique "fingerprints" representing soils from different tillage. The methods were able to distinguish the soils and to distinguish soil samples collected between the crop rows from samples collected immediately underneath the crop. The fatty acid methyl ester analysis (FAME) was better able to distinguish soils from different origins and combining the data from both methods did not improve the resolution. This work will improve our capacity to determine the source of soils and sediments transported to surface waters (Dierksen et al., 2002).

**Ongoing Research**

Changes in the soil ecology that occur with management are dependent on many factors such as soil type, precipitation, temperature, residue cover, and soil depth. The changes that occur with the transition from one management practice to another may occur almost immediately, or may take place more gradually and require many years before changes can be detected. Effectively managing this transition period may well be one of the most important management decisions for the initial success of no-till systems, or the continued use of no-till on a long-term basis. Understanding the changing ecology of the soil during this transition period is key to effective management.

Residue management is a concern of producers adopting minimum tillage systems. In some areas, growers are faced with the management of large amounts of residue from the previous year's crop. Conversely, in the low-rainfall region of eastern Washington the must maintain enough residue to prevent erosion. We determined that cultivars of wheat and barley straw differ in their rate of decomposition in the field and this may be related to the variation in their fiber content (hemicellulose and lignin) and C:N ratio. Information on decomposition of wheat and barley cultivars will be useful to breeders and aid growers in planning rotations for reduced tillage systems.

In studies of no-till versus conventional tilled fields, we find that aggregate distribution of the soil mineral fraction changes with no-till. No-till fields have a greater proportion of soil in the larger size fraction and less soil in the smaller or more erodible fraction. Organic matter content tends to be greater in the no-till fields especially after long–term no-till.

The fatty acid methyl ester analysis for source identification shows great promise; although further development of receptor analyses is needed. We will develop receptor analyses for identifying and quantifying dust source material using the biological portion of particulates. We are developing protocols for identification of small volumes of mixed source material on receptor filters. The biological fingerprint technique will be integrated into ongoing efforts to verify the Columbia Plateau regional dust transport model.