North Dakota State University * Dickinson Research Extension Center
1089 State Avenue, Dickinson, ND 58601-4642 Voice: (701) 483-2348 FAX: (701) 483-2005

APPLICATIONS OF SOIL QUALITY

P. Carr , Associate Agronomist

SUMMARY

Conventional farming practices in the Great Plains have been plagued by soil erosion. Wind and water erosion generally have occurred during the black fallow period, where productive land is idled and tilled to control weeds, increase soil water content, and enhance mineralization of soil N. In response to erosion and other problems, innovative farmers began to explore no-tillage farming practices in the mid-1970s in North Dakota. Several advantages of no-tillage farming soon became evident: soil erosion was reduced or eliminated, energy costs were lessened, and labor costs were reduced. Perhaps more importantly, soil moisture content was conserved, making annual crop rotations possible (Clancy et al., 1993).

The growth and interest in no-tillage farming has dramatically increased over the last five years. Some of this interest stems from the opportunity which no-tillage farming provides for intensified crop rotations. With annual cropping comes the need to identify crops that in rotation with cereals break small grain pest cycles, enhance soil fertility levels, prevent soil erosion, generate income, and contribute to the overall health of the soil. This project would evaluate crops which may meet these criteria in several crop rotations on no-tillage farms in western North Dakota.

OBJECTIVE

Compare the effects of cereal-noncereal (legume and nonlegume) with cereal-cereal rotations on soil properties relating to soil quality at three locations near Beach, North Dakota.

INTRODUCTION

Alternating cereals with black fallow has been used extensively as a crop production strategy in western North Dakota and eastern Montana. There are several benefits that the fallow period provides: organic nitrogen can be mineralized (Haas et al., 1974), weeds can be controlled (Ford and Krall, 1979), soil water recharge can occur (Black and Power, 1965), and crop loss risk can be reduced (Smika, 1970). Along with these benefits have come costs, including uncontrolled wind and water erosion (Haas et al, 1974) and reduced soil nutrient levels over time (Haas et al., 1957). To reduce or eliminate these problems, a cereal crop-chemical fallow rotation has evolved in no-tillage systems.

The cereal crop-chemical fallow rotation is not without problems. Fallow, whether black or chemical, can lead to the formation of saline seeps (Halvorson and Black, 1974). The idling of productive land in a cereal crop-fallow rotation also raises economic efficiency questions (Ali and Johnson, 1981). Scientists in Montana (Sims, 1989) and North Dakota (Gardner et al, 1992) have questioned the practice of alternating fallow with a cereal crop in portions of the Great Plains. Farmers have similarly questioned the idling of productive land (Burmeister, 1993; Mazour, 1993), and some now grow crops annually in fields. However, most of the evolving cropping sequences only include cereal crops, thereby encouraging development of certain cereal pests and depletion of soil fertility levels.

Researchers in the northern Great Plains have promoted legumes in rotation with cereals (Gardner et al., 1992; Sims, 1989; Kandel and Schneiter, 1993). Schatz (1993) summarized the many benefits legumes offer small grain producers if incorporated into rotations, including contributing to the soil organic N pool, breaking cereal pest cycles, increasing soil biological activity, and enhancing soil quality and health. The ability of legumes to impact soil N levels may be particularly important in no-tillage systems since these environments seem particularly prone to the leaching of NO_3-N when following conventional fertilizer recommendations (Clancy et al., 1993).

The impact of pulse crops and other legumes in no-tillage systems in western North Dakota and eastern Montana is not known, even though advocates of legumes and no-tillage farming believe that both enhance soil quality. In this project the influence which legumes have on soil quality in no-tillage environments will be quantified in cereal-legume rotations and compared to cereal-nonlegume rotations. To do this a field soil quality test kit developed by J.W. Doran, a USDA-ARS soil microbiologist at Lincoln, NE, will be used. The test kit provides on-site information on soil quality and how it is affected by cropping practices, in this case cereal-noncereal [legume and nonlegume] and cereal-cereal rotations. Information provided by the test kit will be augmented with detailed laboratory analyses of soil samples to ensure accuracy of soil quality data. Results of this project will be used to quantify the influence of legumes and nonlegumes in rotation with cereals on soil quality, as well as evaluate the field kit as an accurate tool for assessing soil quality in western North Dakota. If proven reliable in this and other projects in North Dakota (J.C. Gardner, per. comm., 1994), the test kit can be made available to farmers, extension service personnel, SCS field staff, crop consultants, and others involved in assessing soil quality.

MATERIALS AND METHODS

One site will be selected in each of three fields on three farms in Golden Valley county, North Dakota, where intensive crop-crop sequences would be used. Crop rotations at the sites would be:

Site 1: (i) C-C-C-C-C, (ii) CSC-CSC-WSC-WSC-P, and (iii) C-P-C-P-C;
Site 2: (i) C-C-C-C-C, (ii) C-C-S-C-C, and (iii) C-C-B-C-C;
Site 3: (i) C-C-C-C-C, (ii) C-C-A-A-A, and (iii) C-O-P-C-O;

where C = cereal, CSC = cool season cereal, WSC = warm season cereal, P = pulse, S = safflower, B = buckwheat, A = alfalfa, and O = oilseed.

Each site would be characterized on the basis of climate, landscape, soil classification, and management. Three composite soil samples (replicates) would be evaluated at each site for microbial biomass C and N, and total organic C and N, for 0 to 3 and 3 to 6 inch depths. Soil samples from a 0 to 6 inch depth would be evaluated for particle size, cation exchange capacity, P, K, Fe, Zn, and Ca. Standard laboratory analyses would be used for determining soil chemical and physical properties. Using a field soil quality test kit, depth of the A horizon and rooting, soil pH, salinity, water content, NO_3-N, respiration rate, soil temperature, bulk density, infiltration rate, and field water-holding capacity would be assessed for the 0-3 inch depth. A hydraulic soil probe would be used to collect soil samples form 0 to 6, 6 to 12, 12 to 24, 24 to 36, and 36 to 48 inch increments within a few feet of where samples for the field kit are collected. These cores would be analyzed for water content, bulk density, pH, NO_3-N and NH_4-N, and particle size.

Site selection and characterization would occur in the spring of 1995. Soil sample collection and use of the field kit would occur in the fall following harvest (September-October). Information would be collected on production practices and chemical rates used in each field.

Data would be analyzed using paired t-tests and analysis of variance to evaluate differences between rotations. These data and analyses would be provided to farmer cooperators, other farmers of the Manitoba - North Dakota Zero Tillage Farmers Association, Dakota West RC&D personnel, and researchers at the Carrington Research Extension Center who are spearheading efforts to develop an index for soil health in North Dakota.

RESULTS

Phase 1 of this project has been completed. It was concluded that while soil chemical and physical characteristics vary widely between sites, little impact from contrasting crop sequences exist. This was expected since the crop sequences were only put into place in 1995. Soil parameters measured with equipment contained in the 'soil quality test kit' generally are reliable and generate useable data. However, some equipment (i.e., field scale) is not appropriate for collecting useable data.

Changes in soil physical and selected chemical properties are expected to result across contrasting rotations offer the next several years at each site. However, our efforts will focus on soil microbial changes and their impact on soil C and N levels resulting from contrasting rotations as the best indicator of the short-term (< 5 years) impact of changes in cropping sequences on soil quality. This will involve frequent (monthly) collection of soil samples for determining N form and quantity present at each location across differing crop sequences, as well as measuring microbial respiration and decomposition rates.

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