United States Department of Agriculture

Natural Resources Conservation Service

6200 Jefferson NE Albuquerque, NM 87109-3734

March 19, 1997

NEW MEXICO AGRONOMY TECHNICAL NOTE NO. 44

SUBJECT: ECS - *Soil Quality is Critical Factor in Management of Natural Resources - #1, Conservation Crop Rotation Effects on Soil Quality - #2, and Effects of Residue Management, No-Till on Soil Quality - #3.*

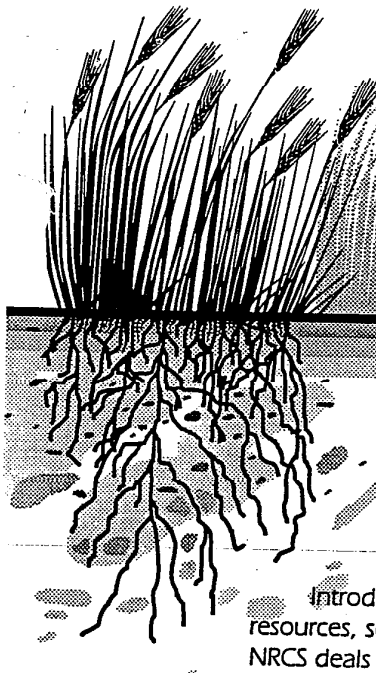
Effective Date: When received.

Filing Instruction: File in the Agronomy Technical Note binder.

Enclosed are Technical Notes 1, 2 and 3 from the Soil Quality Institute in Ames, Iowa.

KENNETH B. LEITING
State Resource Conservationist

Attachment



Soil Quality - Agronomy Technical Note No. 1

Soil Quality Is Critical Factor in Management of Natural Resources

United States Department of Agriculture

Natural Resources Conservation Service

Soil Quality Institute
Pammel Dr.
IA 50011
515-294-4592

Technical Note No. 1

April, 1996

This is the second technical note in a series of technical notes on the effects on soil quality. This technical note is general and covers broad application. For specific crop rotations consult your NRCS State Agronomist.

Introduction - Soil is one of the five resources, soil, water, air, plants, and animals that NRCS deals with in resource planning. The soil resource, and its condition is intimately related to the other four resources and its condition can either negatively or positively impact the other resources. For example, if the soil surface is functioning adequately, the soil will allow water to infiltrate, thus reducing the potential for erosion and increasing the amount of water stored for plant use. This function of soil affects water quality, plant growth, and the health of animals. In addition, protection of the surface layer resists wind erosion thus protecting the air resource. Soil Quality is a critical factor in the management of natural resources and the protection or enhancement of soil quality is the key component of all resource management assistance activities in the NRCS.

Soil Quality

Soil quality is the capacity of a specific kind of soil to function within natural or managed ecosystem boundaries to:

* sustain plant and animal productivity
* maintain or enhance water and air quality
* support human health and habitation.

As defined, the terms soil quality, soil health, and soil condition are interchangeable.

Conservation Practices Effects

One of the goals of conservation planning is to consider the effects of conservation practices and systems on soil quality. This is the first Technical note in a series on how conservation practices affect soil quality. This technical note is designed to compliment local or regional information on the specific nature of cover crops.

Cover and Green Manure Crop Benefits to Soil Quality

1. EROSION - Cover crops increase vegetative and residue cover during periods when erosion energy is high, especially when main crops do not furnish adequate cover. Innovative planting methods such as aerial seeding, interseeding with cyclone seeder, or other equipment may be needed, when main crop harvest, delays conventional planting of cover crops during recommended planting dates.

2. DEPOSITION OF SEDIMENT - Increase of cover reduces upland erosion which in turn, reduces sediment from flood waters and wind.

3. COMPACTION - Increased biomass, when decomposed, increases organic matter promoting increased microbial activity and aggregation of soil particles. This increases soil porosity and reduces bulk density. Caution: plant cover crops when soils are not wet, or use other methods such as aerial seeding.

4. SOIL AGGREGATION AT THE SURFACE - Aggregate stability will increase with the addition of and the decomposition of organic material by microorganisms.

5. INFILTRATION - Surface cover reduces erosion and run-off. Cover crop root channels and animal activities, such as earth worms, form macropores, that increased aggregate stability and improved infiltration. Caution: Macropores can result in an increase in leaching of highly soluble pesticides if a heavy rain occurs immediately after application. However, if only sufficient rainfall occurs to move the pesticide into the surface soil after application, the risks for preferential flow are minimal. Cover crops, especially small grains, utilize excess nitrogen.

6. SOIL CRUSTING - Cover crops will provide cover prior to planting the main crop. If

conservation tillage is used, benefits will continue after planting of main crop. The increase of organic matter, improved infiltration, and increased aggregate stability will reduce soil crusting.

7. NUTRIENT LOSS OR IMBALANCE - Decomposition of increased biomass provide a slow release of nutrients to the root zone. Legume cover crops fix atmospheric nitrogen and provide nitrogen for the main crop. Legumes will also utilize a higher amount of phosphorus than grass or small grains. This is useful in animal waste utilization and management. Small grains are useful as catch crops to utilize excess nitrogen which reduces the potential for nitrogen leaching. Caution: To prevent nutrient tie ups, cover crops should be killed 2-3 weeks prior to planting main crop. Tillage tools are used to kill and bury cover crops in conventional tillage systems. However, with conservation tillage systems, cover crops are killed with chemicals and left on or partially incorporated in the soil. Caution: Research has shown that incorporation of legume cover crops results in more rapid mineralization. Due to delay in availability of nitrogen from legume cover crop residues when followed by conservation tillage of the main crop, nitrogen should be applied at planting in legume cover crop - conservation tillage systems (Reeves). "There was a study done in Minnesota (ARS Morris, MN) that reported dramatically higher Carbon loss through C02 remissions under moldboard plow plots as compared to no-till. It was reported that carbon was lost as carbon dioxide in 19 days following moldboard plowing of wheat stubble that was equal to the total amount of carbon synthesized into crop residues and roots during the growing season. Long-term studies indicate that up to 2 percent of the residual organic matter in soils is oxidized per year by moldboard plowing" (Schertz and Kemper).

8. PESTICIDE CARRYOVER - Cover crops reduce run-off which results in reduced nutrient and pesticide losses from surface runoff and erosion. Increased organic matter improves the environment for soil biological activity that will increase breakdown of pesticides.

9. ORGANIC MATTER - Decomposition of increased biomass results in more organic matter. Research shows cover crops killed 2-3 weeks prior to planting main crop, results in adequate biomass and reduces the risk of crop losses from soil moisture depletion and tie up of nutrients.

10. BIOLOGICAL ACTIVITY - Cover and green manure crops increase the available food supply for microorganisms resulting in increased biological activity.

11.WEEDS AND PATHOGENS - Increased cover will reduce weeds. Caution:Research has shown reductions in yield are possible in conservation tillage cotton systems following winter cover crops. Reductions are attributed to: interference from residue (poor seed/soil contact), cool soil temperatures at planting, increased soil borne pathogens, and increased insects and other pests. Harmful effects from the release of chemical compounds of one plant to another plant (allelopathic) are possible with crops like cotton, but losses can be reduced by killing the cover crop 2-3 weeks prior to planting main crop, and achieving good seed/soil contact with proper seed placement. Cover crops have shown some allelopathic effects on weeds, reducing weed populations in conservation tillage (Reeves).

12. EXCESSIVE WETNESS - Cover and green manure crops may remove excess moisture from wet soils, resulting in reduction of "waterlogging" in poorly drained soils. Caution: transpiration of water can be a detriment in dry climates. Planners should adjust the kill date of cover crops to manage soil water.

Summary

Cover and Green Manure Crops as a conservation practice can improve soil health. Soil quality benefits such as increased organic matter, biological activity, aggregate stability, infiltration, and nutrient cycling accrue much faster under no-till than other tillage practices that partially incorporate the residue. "One example comes from the Jim Kinsella farming operation near Lexington, Illinois. He reports that organic matter levels have increased from 1.9 percent 6.2 percent after 19 years of continuous no-till " (Schertz and Kemper). Future technical notes will deal with other conservation practice effects on soil quality. The goal of the Soil Quality Institute is to provide this information to field offices to enable them to assist landusers in making wise decisions when managing their natural resources.

United States Department of Agriculture

Natural Resources Conservation Service

Soil Quality Institute
2150 Pammel Dr.
Ames, IA 50011
515-294-4592

Technical Note No. 1

April, 1996

References:

Langdale, G.W. and Moldenhaur, W.C., (ed.) 1995: Crop Residue Management To Reduce Erosion and Improve Soil Quality.

Reeves, D.W. Cover Crops and Rotations, pages 125-158 in Hatfield, J.L. and Stewart, B.A., (1994): Crops Residue Management, Adv. Soil Science.

MacRae, R.J. and Mehuys, G.R. (1985): The effect of green manuring on the physical properties of temperate area soils. Adv. Soil Sci.3, 71-94.

Schertz, D.L. and Kemper W. D., Crop Residue Management Systems and Their Role in Achieving a Sustainable, Productive Agriculture, ISCO94 Conference in New Delhi.

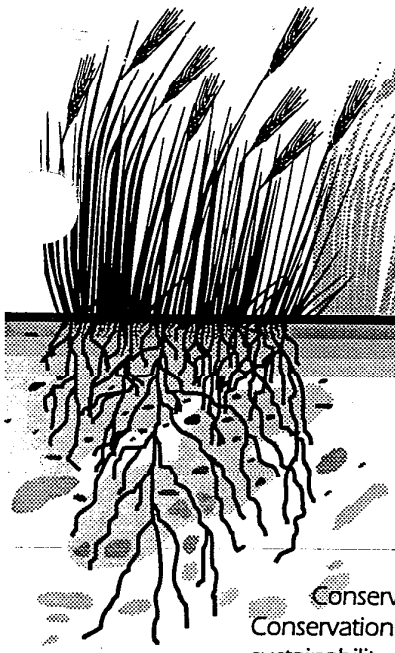
United States
Department of
Agriculture

Natural
Resources
Conservation
Service

Soil Quality Institute
2150 Pammel Dr.
Ames, IA 50011
515-294-4592

Tec
Note i

April, 1996



Soil Quality - Agronomy

Technical Note No. 2

Conservation Crop Rotation Effects on Soil Quality

United States Department of Agriculture

Natural Resources Conservation Service

Soil Quality Institute
2 mmel Dr.
Ai 50011
515-294-4592

Technical Note No. 2

August, 1996

This is the second technical note in a series of technical notes on the effects on soil quality. This technical note is general and covers broad application. For specific crop rotations contact your NRCS State Agronomist.

Conservation practices such as Conservation Crop Rotation help maintain the sustainability and the efficiency of cropland over long periods of time. Conservation Crop Rotation is a systematic sequence of crops grown in combination with other crops or with grasses and legumes. There are fewer problems with weeds, insects, parasitic nematodes, diseases caused by bacteria, fungi, and viruses when using rotations compared to monocultures. When legumes are part of the rotation, nitrogen is supplied to the succeeding crop. With forage rotations, soil organic matter will increase as a result of longer rotations. Rotations can be simple, corn followed by soybeans, or very complex, tobacco with a cover crop for two years followed by corn - double cropped wheat and soybeans using conservation tillage. Crop yields in rotation are often higher than those grown in monoculture. Practices such as conservation tillage in combination with rotations will benefit soil quality by maintaining or increasing soil organic matter. Research has shown the use of the moldboard plow reduced organic matter by an average of 256 lb/ac/yr (Reicosky, et al 1995).

Tips on Conservation Crop Rotation

- Climate and economics determine the choice of crops in rotations as well as the specific farming systems. The following principles (Magdoff, 1992) should be considered when thinking about a rotation.
- Follow a legume crop by a crop that demands high amounts of nitrogen.
- Grow less nitrogen demanding crops (small grains) the second year after a legume crop.
- Do not grow the same crop in consecutive years in order to decrease insects, weeds, diseases, and nematodes.
- Follow a crop with one that is not closely related species because of insects, diseases, weeds, and nematodes.
- Where applicable use grass or legume sod in rotations or as permanent stands on sloping highly erosive soils.
- Deeply rooted crops such as alfalfa, safflower, or sunflower penetrate to depths of 5 to 6 feet and utilize nutrients and water, and leave channels from decayed roots that improve infiltration.
- To maintain organic matter, rotate high residue crops with low residue crops or use cover crops.

Erosion

Vegetative cover has a major effect on erosion. Research shows that fourth year corn, conventionally tilled at high fertility level, had erosion rates 125 times that of highly productive grass-legume sod. Cropping systems with a higher frequency of sod will reduce erosion. Growing cover crops with low residue crops and rotation of high residue crops with low residue crops are also effective erosion control practices. Some crop rotations will not reduce erosion unless other practices such as cover crops and residue management are used. Crop rotations that utilize the land more intensively such as corn, wheat and soybeans grown in two years produce larger amounts of biomass during the rotation and are more effective in reducing erosion than a continuous cropping sequence (Heath et al 1976).

Deposition of Sediment

Increase cover from grass and or legume rotations or high residue crops combined with other conservation practices such as conservation tillage will reduce upland erosion which in turn, reduces sediment from surface runoff and wind.

Compaction

Monoculture agriculture and tillage weaken soil structural characteristics increasing susceptibility to compaction (Schnitzer 1991). Sod base rotations with deep root systems can reduce compaction through the addition of organic matter and development of channels from decayed roots; thus improving water movement and aeration. Rotations that increase organic matter, microbial activity and aggregation of soil particles, will also increase porosity and lower bulk density.

Soil Aggregation at the Surface

Rotations that promote the increase of organic matter and microbial activity will increase aggregate stability. Caution: If residue is incorporated, with tillage, benefits of increased biomass is lessened.

Infiltration

Conservation crop rotation systems that promote an increase in organic matter and an increase of aggregate stability will maintain or improve the presence of pores for infiltration (Schnitzer, 1991). Decaying roots, especially those of deep rooted crops like alfalfa and safflower, will leave channels for improved infiltration. Other conservation practices may be needed in crop rotations such as crop residue management to ensure surface protection and improve infiltration. Caution: Macropores can result in an increase of leaching of highly soluble pesticides if a heavy rain occurs within a few hours after application.

Soil Crusting

If residues are left on the soil surface and sod based rotations are included with high residue crops, the increase in organic matter, improved infiltration, and increased aggregate stability will reduce soil crusting. Caution: Monoculture and low residue cropping systems with tillage will increase the decay of organic matter and reduce aggregate stability which often results in soil crusting .

Nutrient Loss or Imbalance

One of the principles of crop rotation is to precede a nitrogen demanding crop with a legume crop to provide nitrogen. Sod rotations with deeply rooted crops can penetrate to depths of 5 to 6 feet and cycle nutrients especially the more soluble nutrients such as nitrates. Crop rotations that promote increased biomass provide a slow release of nutrients to the root zone.

Pesticide Carryover

Where different crops are grown each year and crop rotations reduce the chance of pesticide buildup. The threat of pest tolerance to insecticides and herbicides are reduced with rotations (Reeves, 1994). Rotations increasing organic matter improve the environment for biological activity that will increase the breakdown of pesticides.

Soil Organic Matter

The amount and type of organic matter is indicative of soil productivity (Mitchell et al 1996). The types of crops grown, the amounts of roots, biomass yield, and efficiency of harvest, and the management of residues affect soil organic matter (Magdoff, 1993). High residue crops in rotation with cover crops and conservation tillage increase amounts of organic matter compared to conventional tillage and monoculture. It is practically impossible to increase organic matter where moldboard plowing is taking place (Reicosky et al, 1995). Vegetables and other low residue crop rotations will need other practices such as, cover crops to increase biomass yield.

Biological Activity

There is a direct relationship to the amount of residue and the population of soil microorganisms. Research in Oregon showed wheat-fallow systems had only 25% of the microorganisms found under pasture. When rotations are more complex and include sod crops soil biological diversity will increase (Magdoff, 1993). Soil organisms that are active in the soil, include bacteria, fungi, actinomycetes, protozoa, yeast, algae, earthworms and insects. Numbers of soil

United States Department of Agriculture

Natural Resources Conservation Service

Soil Quality Institute
2150 Pammel Dr.
Ames, IA 50011
515-294-4592

Technical Note No. 2

August, 1996

organisms in general are proportional to organic matter concentrations in the upper 15 inches (Schnitzer, 1991). Moldboard plow tillage systems decrease earthworms and other soil organisms.

Weeds, Insects and Pathogens

Certain harmful insects and diseases over winter in the soil. Monoculture promotes increases in insects and diseases. Different crops grown in a 2 to 3 year rotation will reduce the chances for survival of insects and diseases (Agronomy Department, Virginia Polytechnic Institute, 1959). Rotations break the life cycles of specific weeds which adapted to narrow ecological niches associated with continuous cropping. Selective pressures on weeds, including crop competition, pathogens and pests, herbicide tolerance, fertility factors, and tillage are reduced when crop rotation is not practiced. (Reeves, 1994).

Soil Salinity

Conservation practices along with rotations that help control soil salinity include reducing summer fallow, increasing organic matter, use deeply rooted perennial forage crops, conservation tillage, and plant salt tolerant crops (Eilers et al 1995).

Effective crop rotations are important for sustaining productivity and conserving our natural resources. In addition to erosion protection, crop rotations increase soil organic matter and improve physical properties. They also break disease, insect and weed life cycles and improve nutrient and water usage. Conservation tillage enhances the effects of conservation rotation systems conventional tillage can often mask some of the benefits. For more information read the following references.

References:

Brady, Nyle. 1974. Glossary p. 620. The Nature and Properties of Soils 8th Edition. Macmillan Publishing Co., INC. New York, NY.

Agronomy Department, Virginia Polytechnic Institute. 1959. p. 118-126. A Handbook of Agronomy.

Eilers, R. G., W. D. Eilers, W. W. Pettapiece, and G. Lelyk. p. 77-86 in D. F. Action and L. J. Gregorich (eds.) (1995): The Health of Our Soils Toward Sustainable Agriculture in Canada.

Hatfield, J. L. and B. A. Stewart (eds.) (1994). Preface. Soil Biology: Effects on Soil Quality, Adv. Soil Science.

Heath, Maurice, Darrel Metcalfe, and Robert Barnes. 1976. p. 35. Forages The Science of Grassland Agriculture Third Edition. The Iowa State University Press. Ames, Iowa, U.S.A.

Martin, J. H., W. H. Leonard, and D. L. Stamp. 1976. Principles of field crop production. Macmillian Publishing, Co., Inc. New York, NY.

Mitchell, C. C., F. J. Arriga, J. A. Entry, W. R. Goodman, J. L. Novak, D. W. Reeves, M. W. Runge and G. L. Traxler. P. 18. The old rotation, 1896-1996 100 years of sustainable cropping research (Manuscript to be submitted as a bulletin in commemoration of the centennial of the old rotation).

Magdoff, Fred. 1992. p. 90-102. Building Soils For Better Crops. University of Nebraska Press, Lincoln and London.

Reeves, D. W. 1994. p. 125-158. In: J. L. Hatfield and B. A. Stewart (eds.) Crops residue management. Advances in soil science.

Reicosky, D. C., W. D. Kemper, G. W. Langdale, C. L. Douglas, Jr., and P. E. Rasmussen. 1995. Soil organic matter changes resulting from tillage and biomass production. J. Soil and Water Cons. 50:253-261.

Schnitzer, M. p. 33-49. Soil organic matter and soil quality, Technical-Bulletin-Agriculture-Canada-No. 1991-1E.

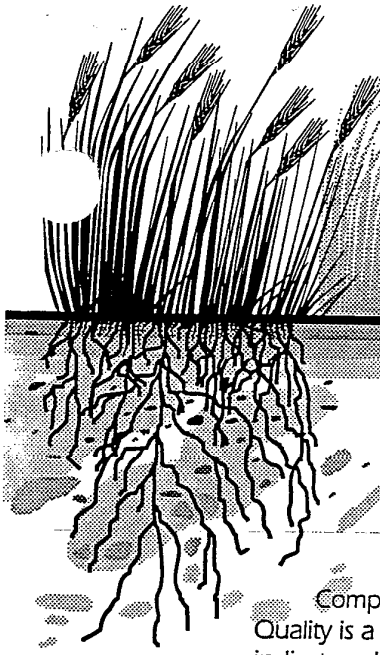
United States Department of Agriculture

Natural Resources Conservation Service

Soil Quality Institute
2150 Pammel Dr.
Ames, IA 50011
515-294-4592

T l
N .2

August, 1996



Soil Quality - Agronomy Technical Note No. 3

Effects of Residue Management, No-Till on Soil Quality

USDA

United States Department of Agriculture

Natural Resources Conservation Service

Soil Quality Institute
2150 Pammel Dr.
Ames, IA 50011
515-294-4592

Technical Note No. 3

Oct., 1996

This is the third Agronomy fact sheet in a series on on soil quality. This fact sheet is general. For specific applications, contact your NRCS State Agronomist.

Compared to water or air quality, Soil Quality is a relatively new concept and relies on indicators, like organic matter, bulk density, nutrient status, and biomass for measurement. Of this, organic matter is probably the most vital in maintaining a quality soil resource. It improves aggregate stability and soil structure, reduces erosion potential, provides energy for microorganisms, is important to nutrient cycling, and improves infiltration, water holding capacity, cation exchange capacity and the breakdown of pesticides. The best ways to manage organic matter in a cropping sequence is to reduce tillage and use cover crops and crop rotations to increase organic inputs as root biomass. This technical note focuses on tillage and residue management, as the practices that most influence organic matter levels. Residue Management includes no-till that is the method of preparing a narrow slit or strip for a seedbed and leaving surrounding residue cover on the surface undisturbed. Other forms of residue management are mulch till, ridge till and seasonal residue management. Conventional tillage usually includes a moldboard, disk or chisel plowing and secondary tillage that disturbes the soil surface for seed preparation. This note focuses on the least disruptive form of conservation tillage, no-till. Local soil and climate conditions may dictate other forms of conservation tillage be used in order to maintain economic sustainability.

Factors Influencing Organic Matter Levels

The amount of organic matter in soil is the result of the combined influences of climate, inherent soil characteristics, land cover and use, and management practices. When rainfall or irrigation is sufficient, the amount of vegetation (biomass) increases with warmer temperatures, but rates of decomposition of the biomass also increase dramatically. Generally, organic matter increases with higher rainfall and cooler temperatures. Conversely, soil formed under warm, arid climates is usually low in organic matter mostly due to low amounts of biomass production. Soil texture is another influence on organic matter. Clayey soils generally have higher levels of organic matter than sandier soils. Soils with drainage limitations due to landscape position or a slowly permeable layer will generally accumulate more organic matter as a result of slower decomposition from the anaerobic conditions that limit microbial activity, than more freely drained, aerobic soils. Humans influence organic matter through the selection of management practices. Agronomic inputs like adding manure, or applying fertilizers increase vegetative growth (above and below ground), and thus increases soil organic matter. Crop diversity, cover and green manure crops, reduced tillage, and rotations with pasture or hay will promote accumulation of surface residue, and will generally increase soil organic matter in the surface layer. Conversely, management systems that require intensive tillage and low residue crops result in greater losses of soil organic matter. In the 1850s, the moldboard plow became the standard for primary tillage. The plow turned the soil over and buried most of the residue of the native vegetation or the previous crop residue. The stirring and turning of soil stimulated microbial

activity and increased the rates of residual organic matter break down. For example, the Morrow research plots in Urbana, Illinois, established in 1876, had a 23% decline in organic carbon due to tillage (Odell et al., 1982). Soil aggregates and large pores are disrupted when left unprotected from the impact of rain drops. This reduces water infiltration and increases runoff and erosion. In more arid climates, the unprotected soil surface becomes smooth, making it vulnerable to wind erosion until crusting occurs. Unfortunately, all forms of tillage decrease organic matter to some extent. Therefore, it is difficult to maintain soil organic matter levels when tillage is practiced. Adding organic materials, such as manure, may help maintain or increase the level of organic matter. However, research at Pendleton, Oregon showed that even after 40 years of adding manure at rates over 10 tons per acre per year, residual organic matter levels had not increased mainly due to tillage and summer fallow practices (Rasmussen et al., 1989). Reicosky and Lindstrom 1993, measured carbon dioxide released from soil 19 days after wheat stubble had been plowed. The moldboard plow caused as much carbon to be oxidized as had been photosynthesized in the roots and residue during the whole growing season. This rate was 5 times greater than the untilled plots. In summary, research has shown that it is practically impossible to increase organic matter when the entire land surface is tilled.

Tillage Effects on Organic Matter

Adoption of no-till has increased in acreage from approximately 14 million acres to nearly 41 million acres from 1989 through 1995 (Conservation Technology Information Center, 1996). Some of the benefits of no-till is erosion control, fuel, labor and time savings. Some research has shown that no-till increases soil organic matter in the surface three inches (Ishmal et al., 1994; Mahboubei et al., 1993). However, the residue cover from no-till protects the soil surface from erosion and preserves the continuity of water conducting pores. The best way to increase organic matter throughout the surface is through the use of cover crops or sod rotations in conjunction with no-till (See Technical notes No. 1 and No. 2). Reicosky et al., (1995), summarized 9 long term no-till studies, all of which showed that organic matter increased an average of 986 pounds per acre per year, or about 0.1 percent per year. Locations of these studies were in the states of Minnesota, Nebraska, Illinois, Ohio, Kentucky, Georgia, and Alabama. Research ranged from 5 to 11 years, and rates of increase ranged from 80 pounds to 2,000 pounds of average annual residual soil organic matter. These increases were the result of no-till, crop rotations with grain crops and cover crops. Increases would not be expected in low residue crops without rotations of grain crops and the addition of cover crops. Increases in organic matter such as this will affect properties such as cation exchange capacity, aggregate stability, available water holding capacity.

Impacts on Aggregate Stability/Soil Structure

Residues left on the surface help increase aggregate stability. Soil aggregates in no-till systems are more stable than in conventional tillage soils due to the added strength provided by products from the decomposition of soil organic matter and presence of bacteria and fungal hyphae. The hyphal material acts like strings that bind or tie smaller aggregates and soil particles together. A demonstration was recently conducted in the Central Valley of California compared cover crops in an orchard tilled annually, to permanent cover crops. To illustrate the benefits of a permanent cover, the researchers placed one clump of soil in a glass of water from the untilled site that had accumulated surface organic matter, and one from the tilled site that had not. The tilled sample began to disperse immediately and the water became very cloudy. The untilled sample with increased surface organic matter was stable and the water remained clear. Surface residues in no-till systems help protect aggregate stability and maintain the continuity of soil pores, resulting in increased infiltration rates and reduced soil erosion.

Impacts on Biological Activity

It is generally acknowledged that residues have several positive effects on the microbial populations in agricultural systems. Residue accumulations in the surface 3 inches provides a cooler and moister environment than conventional tillage systems. Surface residues provide more substrates or food for nitrifying and denitrifying microbes. The increased residues with high carbon to nitrogen ratio slow the rate of mineralization over a longer period of

United States Department of Agriculture

Natural Resources Conservation Service

Soil Quality Institute
2150 Pammel Dr.
Ames, IA 50011
515-294-4592

Technical Note No. 3

Oct., 1996

time (Coleman and Crossley, 1996). Soil invertebrate populations such as microarthropods and earthworms increase with less tillage as a result of increased populations of litter-decomposing fungi and help's increase nitrogen availability for plant growth. Research comparing 22 components of no-till and conventional tillage (House, et al. 1984), Shown that no-till systems had greater resilience, greater invertebrate species richness, greater soil organic matter and nitrogen turnover time. The following table highlights some of the 22 components compared between no-till and conventional tillage.

Component	No-Till vs. Conventional
Crop Yields	NT=CT (except during drought)
Weed Biomass	NT>CT
Residue Decomposition Rates	CT>NT
Surface Crop & Weed Residues	NT>CT
Surface Litter (%N)	NT>CT
Nitrification Activity	NT>CT in upper soil layer
Total Soil N	NT>CT in upper soil layer
Organic Matter	NT>CT
Soil Moisture	NT>CT
Foliage Arthropods	CT=NT
Arthropods Species Diversity	NT>CT

High residual organic matter levels increase the general fertility and productive capacity of soil (Moldenhauer et al 1995). Residual organic matter and a slow decomposition rate provide crops with a limited but continuing source of nutrients. Residual organic matter also promotes deeper rooting by improving infiltration and water holding capacity.

Management Concerns

Soil compaction may become a problem with no-till. Limited deep tillage and strip tillage may be useful in breaking up compacted areas without disrupting the entire surface area. Also, no-till crop production in the beginning, may require more chemical weed control, but over time the residue cover increases to the point weed seeds cannot germinate because they are not brought to the surface by tillage. Vines and other perennial weeds can become more prevalent in no-till monoculture systems, because certain weeds may not be controlled by the herbicides nor is there tillage for weed control. Crop rotations along with no-till systems may alleviate some pest and compaction problems. In agricultural soils that have been degraded, it may take 3 to 5 years to see benefits from no-till. However, no-till used in combination with crop rotations and cover crops can be a valuable tool for improving the soil resource.

Summary

Organic matter is one of the most important indicators of soil quality. Some of the beneficial effects of soil organic matter includes better aggregation and aggregate stability, longer cycling of nutrients, higher microbial activity, more water holding capacity, greater cation exchange capacity, and lower bulk density. Tillage operations have a significant effect on soil organic matter. Even high inputs of manures have limited success in maintaining levels of soil organic matter if the soil is continually tilled. Following are some beneficial practices for protecting soil organic matter.

1. No-till and other reduced tillage practices leave residues on the surface and protect the soil from wind and water erosion. Along with crop residue the no-till system increases aggregate stability, organic matter, microbial activity and invertebrates, infiltration, and available water holding capacity.
2. Crop rotations provide biodiversity to reduce insects, weeds, and disease in no-till systems.
3. Cover crops provide protection of the soil surface and add residue and organic matter to the soil.
4. Rotations that include grass and legumes are good for erosion control and increase organic matter.

References:

Conservation Technology Information Center, personal communication. 1996.

Glenn, S. and J. S. Angle. 1987. Atrazine and simazine in runoff from conventional and no-till corn watersheds. Agric. Ecosystems and Environ. 18: 273-280.

House, G. J., B. R. Stinner, and D. A. Crossley Jr. (Chapter 5 and pages 109 -139) In D. C. Coleman and D. A. Crossley, Jr. 1996., (eds.). Fundamentals of soil ecology.

United States Department of Agriculture

Natural Resources Conservation Service

Soil Quality Institute
2150 Pammel Dr.
Ames, IA 50011
515-294-4592

Ter
No

Oct., 1996

Ismail I, Blevins RL, Frye WW. 1994; Long-term no-tillage effects on soil properties and continuous corn yields. Soil Sci Soc Am J 58:193-8.

Mahboubi AA, Lal R, Faussey NR. 1993; Twenty-eight years of tillage effect on two soils in Ohio. Soil Sci Soc Am J 57:506-12.

Moldenhauer, W. C. , W. D. Kemper, and R. L. Blevins. 1995. Long term effects of tillage and residue management. p. 88-95. In: R. L. Blevins and W. C. Moldenhauer, (eds.). Crop residue management to reduce erosion and improve soil quality.

Natural Resources Conservation Service, Soil Quality Institute Staff. 1996. Soil quality is critical factor in management of natural resources. Soil quality - agronomy technical note no. 1.

Natural Resources Conservation Service, Soil Quality Institute Staff. 1996. Conservation crop rotation effects on soil quality. Soil quality - agronomy technical note no. 2.

Odell Russell T., S. W. Melsted, and William A. Walker. 1984. Changes in organic carbon and nitrogen of morrow plot soils under different treatments, 1904-1973. p. 160-171. Soil Science Vol. 137, No. 3.

Rasmussen, P. E., P. Collins, and R. W. Smiley. 1989. Long term management effects on soil productivity and crop yield in semi-arid regions of eastern Oregon. Oregon State University Bulletin No. 675.

Reicosky, D. C., W. D. Kemper, G. W. Langdale, C. L. Douglas, Jr., and P. E. Rasmussen. 1995. Soil organic matter changes resulting from tillage and biomass production. J. Soil and Water Cons. 50:253-261.

Reicosky, D. C., and M. J. Lindstrom. 1993. Fall tillage method: Effect on short-term carbon dioxide flux from soil. Agronomy Journal 85: 1237-1243.

United States Department of Agriculture

Natural Resources Conservation Service

Soil Quality Institute
2150 Pammel Dr.
Ames, IA 50011
515-294-4592

Technical Note No. 3

Oct., 1996