

# TECHNICAL NOTES

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U S Department of Agriculture

Natural Resources Conservation Service

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TN - AGRONOMY - CA-54

September 1997

## SOIL QUALITY TECHNICAL NOTES - AGRONOMY NO. 1 AND AGRONOMY NO. 2

Enclosed are copies of the first two Agronomy series Soil Quality Technical Notes produced by the NRCS Soil Quality Institute titled:

Agronomy No. 1: Soil Quality is Critical Factor in Management of Natural Resources

Agronomy No. 2: Conservation Crop Rotation Effects on Soil Quality

Soil Quality Institute Agronomist Michael D. Hubbs in Auburn, Alabama is the principal author for these technical notes. It is the goal of the Soil Quality Institute to provide useful information that will assist field offices in assisting clients/decision makers to consider the whole resource (soil quality) in conservation planning. These technical notes are meant to be used with the practice standards to assist planners when considering alternatives with the client/decision maker.

These technical notes provide useful information supporting sustainable agriculture. Technical Note No. 1 discusses the benefits of Cover and Green Manure Crops to soil quality. Technical Note No. 2 covers the effects of crop rotations on soil quality.

Field offices are encouraged to provide copies of these technical notes (as well as any other technical notes) to clients/decision makers, as needed, to accelerate progressive conservation planning.

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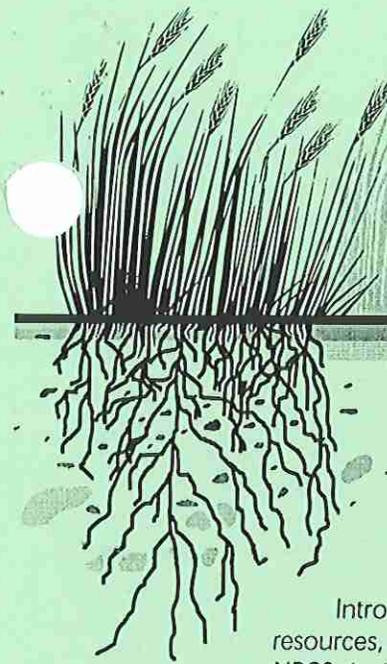
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# Soil Quality - Agronomy

Technical Note

No. 1



## Soil Quality Is Critical Factor in Management of Natural Resources

**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

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*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 cropping rotations contact your NRCS Agronomist.*

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 CO<sub>2</sub> reemissions 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.

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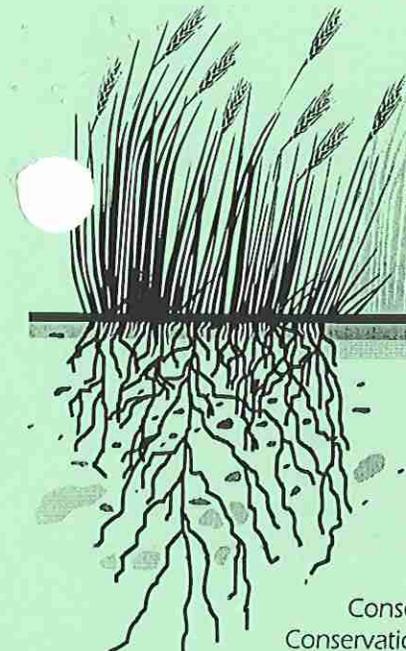
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# Soil Quality - Agronomy

Technical Note

No. 2

## Conservation Crop Rotation Effects on Soil Quality

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*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 cropping rotations contact your NRCS Soil Conservation 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).

- 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.

### 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.

### 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

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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.

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