CONSERVATION TILLAGE FACTS

Factors Affecting the Rate of Crop Residue Decomposition under Field conditions

The Fact: How fast a crop residue decomposes is influenced by climate, soil environment, crop residue type and soil-crop-residue management.

SUMMARY

The rate that crop residues decay when left standing in the field or when tilled into the soil is affected by: soil water content, soil temperature, soil nutrient status, soil microbial biomass, and soil aeration. Residue decay is influenced by the chemical and physical characteristics of the crop residue, and the chemical and physical characteristics of the soil. Crop residues decay faster when tilled into the soil than if left standing undisturbed.

SOIL TEMPERATURE AND MOISTURE EFFECTS

The major requirement for crop residue decay is an active microbial population ‘in contact with the residue. Soil microbes (bacteria, fungi, and actinomycetes) are most active and thrive under moist warm conditions. Therefore residue decomposition proceeds rapidly during wet spring, summer, rind/or fall days when it is warm and moist, Decomposition is slow during the winter when it is cold. Similarly a wet rainy summer would have greater decomposition than a cool dry summer.

Maximum decomposition occurs in soils that are wet to near field capacity (wet but not muddy wet, wet but not glistening, about 55% water filled pore space) and at soil temperatures near 90-95°F (Fig. 1). Decomposition proceeds slowly at soil temperatures below 50°F and above 95°F. Decomposition essentially stops at temperatures near freezing and at temperatures above 105°F. Decomposition is slow at soil water contents that are less than 40% water filled pore space (barely moist to the touch but not dusty dry) and stops in soils that are air dry (dusty, hard and crumbly to the touch, near a crop’s permanent wilting point). Decomposition is drastically reduced in soils that become saturated with water. The saturation of a soil with water impedes the diffusion (movement) of oxygen into a soil. Oxygen is required for maximum microbialactivity. The development of peat bogs in the upper Midwest shows how long term saturation with water slows plant residue decomposition.

CROP RESIDUE CHARACTERISTICS

The chemical and physical characteristics of a crop residue will effect how fast a residue will decompose. Residues that are low in nitrogen (N) but high in fiber are resistant to decay and decompose more slowly than crop residues that are high in N and low in fiber. Corn cobs, corn stalks, sorghum stalks, soybean stems, and sunflower stems are crop residues that are low in N, high in fiber and are slow to decompose even in warm moist soils (Fig. 2).

The leaves of corn, sorghum, soybean, and wheat are all relatively high in N and low in fiber and decompose rapidly.

The relative size of a crop residue also has an effect. Crop residues that are chopped and broken up by stalk choppers or tillage equipment have smaller particle sizes than residues that are left un-disturbed. The breaking up of a crop residue into smaller particles exposes more residue surface area to microbial attack. Broken crop residues decompose faster than residues that are left intact.

Wheat or millet stems are inherently smaller and have greater surface area per lb of residue material than corn, sorghum or sunflower stalks. A given weight of the smaller wheat and millet stem residues should decompose faster than the same weight of corn sorghum or sunflowers under the same conditions of soil temperature, water, and tillage. Crop residues that have been chopped and tilled are more intimately mixed with the soil microbial population. These residues are physically in a more favorable position for greater microbial attack and should decompose faster than residues that are left standing and undisturbed.

TILLAGE, SOIL MANAGEMENT AND SOIL EFFECTS

The primary effect of tillage is putting the residue into intimate contact with soil microbes. By burying crop

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Merle F. Vigil (Soil Scientist) USDA-ARS, Akron, CO and Dick Sparks USDA-NRCS, Alamosa, CO

residues, tillage places the residues in a better environment for microbial activity. Below the soil surface the environment is more stable with respect to temperature and soil water than at the soil surface. Microorganisms living below the soil surface are protected from those extremes in moisture and temperature. Soil at the soil air interface dries quickly during the summer months (particularly if unshaded) and can reach temperatures over 105°F.

As mentioned above tillage breaks up the residue into smaller particles, exposing greater residue surface area to microbial attack.

The physical condition of a soil effects crop residue decay. Severe soil compaction caused by improper tillage or intense wheel traffic impedes both water and air movement into a soil. If the soil is left in that condition for an extended period decomposition will be less.

The inorganic N available in a soil also determines how fast a residue decays. In general decom-position is greater in soils that have high residual inorganic N and/or high potential for mineralization of inorganic N from native soil organic matter (humus).

HERBICIDE AND OTHER ADDED CHEMICAL EFFECTS

Very little quantitative information is available concerning the effect that herbicides and fertilizer N have on decomposition of crop residues. Research at USDA-ARS, Akron indicates that these chemicals do not increase the loss of standing wheat stems under field conditions (Fig. 3). In that study all herbicides and N solutions were applied at recommended rates on August 15, 1993. Standing stem counts were made before application and monthly after application for several months (420 days).

There is a great deal of information indicating that the addition of N fertilizers to crop residues low in N increases decomposition. However, how much the rate of decomposition is increased by added N has not been very thoroughly quantified. The research at Akron indicates a trend for greater wheat stem loss with added N (applied broadcast as UAN, 32% N solution). However the increased standing stem loss was small and not statistically significant.

DEFINITIONS:

Actinomycetes: Soil microorganism important decompose of crop residues. Gives soil its characteristic good smell. Actinomycetes have been isolated from soil and are the natural producers of such common antibiotics as streptomycin, penicillin, amoxycillin etc.

Bacteria: Soil microorganism important decomposer of crop residues.

Decomposition or (decay): For the context of this fact sheet decomposition refers to the breakdown of visually recognizable crop residues (by microbial attack on the cellular structures of the residue) into unrecognizable soil organic matter. This breakdown is not unlike burning in that there is a release of energy, carbon dioxide ($C0_2$) and water. Some of the energy released and plant carbon is captured by the microorganisms in the soil and is used to carry out their daily activities and to grow. After several breakdown cycles the carbon that is left eventually forms stable soil organic matter called humus.

Fungi: Soil microorganism and/or microorganism some that are visible some are invisible to the naked eye. An important decompose of crop residues, particularly surface residues. In dryland arid soils they may be the most important decompose.

Humus: Stable (somewhat resistant to further decay) soil organic matter that is composed of unrecognizable plant and animal debris. Humus is what is left after several cycles of decay. Soil humus decomposes very slowly. Soils that contain large amounts of soil humus are dark and have good tilth. There is a direct positive relationship between a soils humus content and crop productivity.

Microorganism: Living plants and animals that are so small in size that they are invisible to the naked eye.

Mineralization: The release of nutrient elements (like nitrogen, phosphorous, sulfur) from dead plant and animal residues by microbial attack on those residues. Mineralization is the result of decomposition of plant and animal residues.

Soil organic matter: Commonly thought of as that part of the soil composed of unrecognizable dead and decayed plants and animals and their by products. After several cycles of decomposition this decayed material forms a stable matrix called humus.

Water filled pore space (WFPS): This is a measure of how wet a soil is. Specifically it is the amount of pores or open space in the soil that is filled with water. A given volume of a typical farm soil will be about 50% pore space. Immediately after an irrigation event about 75% of that pore space will be tilled with water. Typically about 2 days after irrigation most farm soils will still have about 55 percent of the pore space filled with water.

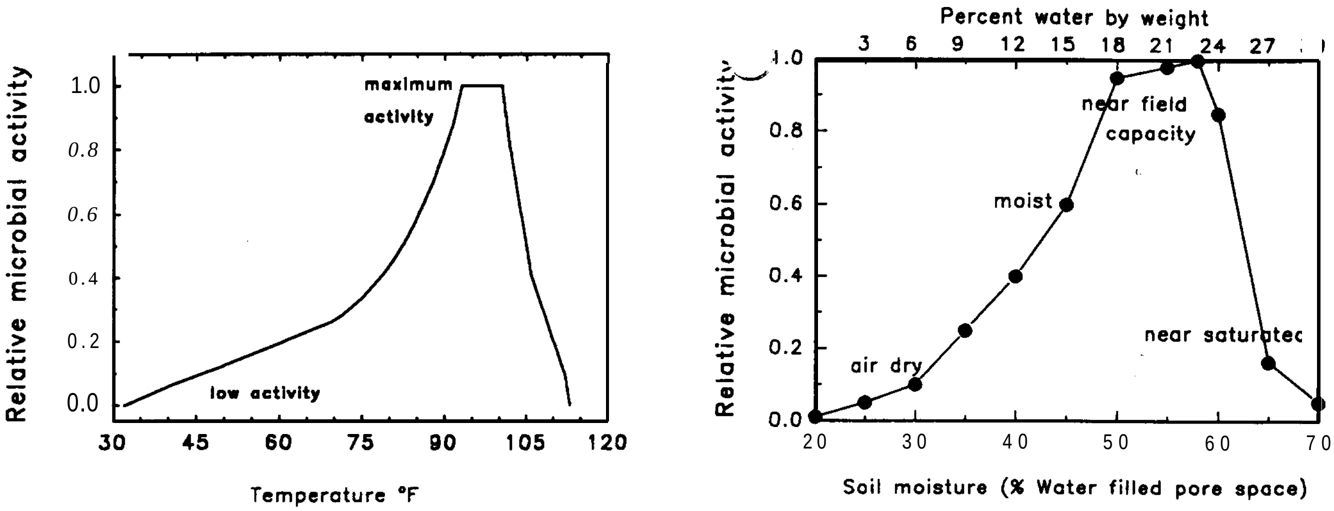

Fig. 1. Relative soil microbial activity as affected by soil temperature **and soil moisture (water filled pore space).**

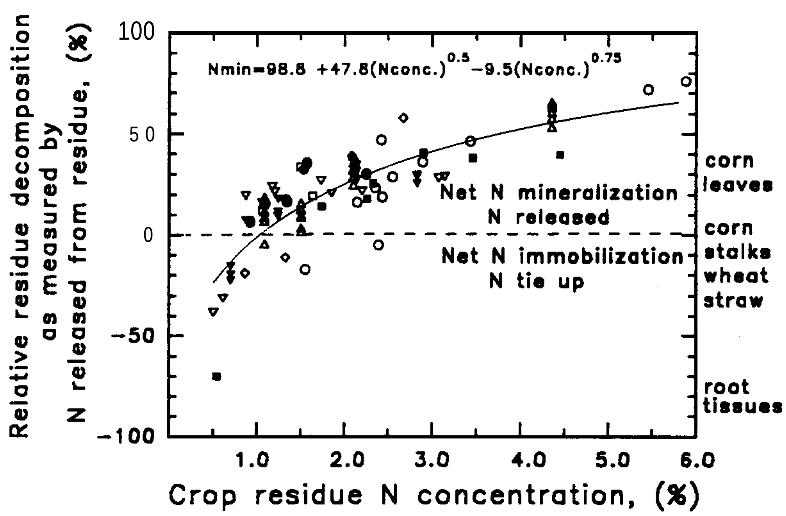

Fig. 2. Relative microbial decomposition of crop residues as affected by crop residue N concentration **in** the **residue tissue as assayed by crop residue N release or tie up.**

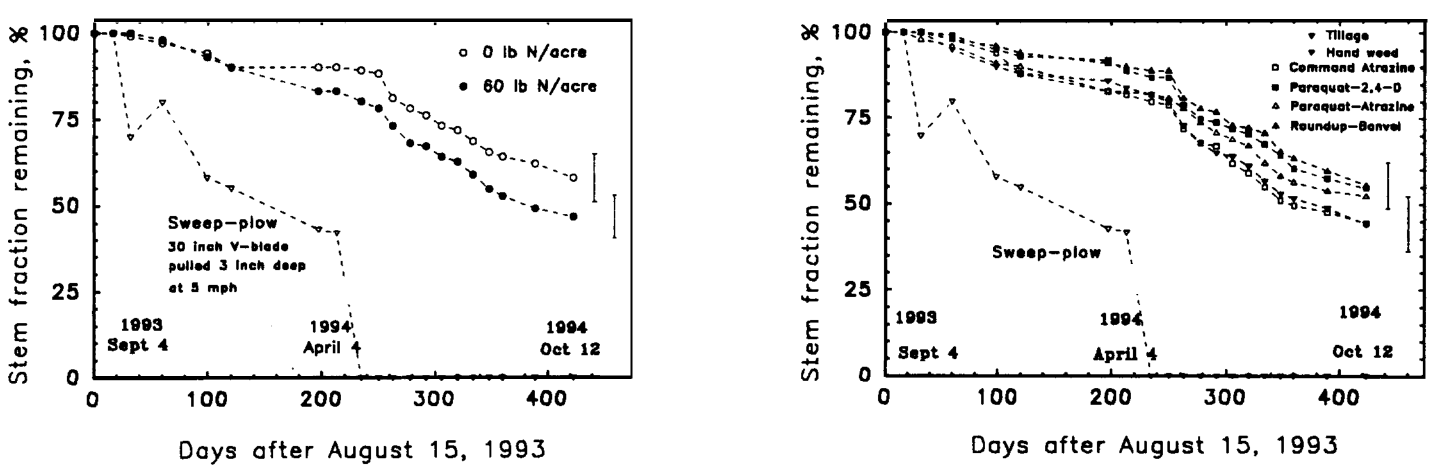

Fig 3. The percent of standing stems remaing in the field as affected by nitrogen and herbicide treatments over a 420 day period. Nitrogen applied broadcast as UAN (32 % N solution).