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BURNING—Effects on Soil Quality

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BACKGROUND

Burning small grain stubble and straw as a means of managing excess residue is commonly practiced in the crop production areas of the northern Great Plains. Ranchers commonly use burning as a tool to invigorate vegetative production of pastures and rangeland. Contract holders of Conservation Reserve Program (CRP) land are utilizing burning to revitalize grass/legume stands that have become stagnant. The practice of burning is not a new idea but started many generations ago with the burning of grasslands. Burning is an inexpensive, labor efficient means of removing unwanted crop residues prior to tillage or seedbed preparation. If completed correctly, burning can be an effective management tool. With the increased use of reduced tillage equipment and tillage methods farmers and ranchers have reduced the acres they annually burn to eliminate excess residues and vegetation.

Farmers and ranchers burn stubble and excess vegetation for a variety of reasons, not just simply to remove straw and duff. Burning cereal crop residues after harvest can somewhat reduce diseases where straw serves as a host to pathogens.[1] Burning also results in changes in soil temperature, soil moisture, and nutrient availability.[2] Burning pastures and CRP grass/legume stands increases plant productivity by increasing the photosynthetic capability of plants.[2] Burning grass pastures results in short-term increases in nitrogen mineralization which results in a short burst of nutrient available for the plant.[2] Burning is also completed to control weeds and insects. For example, sagebrush can be nearly eradicated from rangelands when burned in the late fall when it is dry.[3] Burning frequently has detrimental effects. Some of these effects are: (1) removal of the extra vegetative material that would add humus and nitrogen to the soil, (2) destruction of old vegetation in the soil which functions to increase water-holding capacity, and (3) injury to living vegetation, especially short grasses and shallow-rooted grasses like bluestem and the fescues, which may be killed by a single burning .[3]

Recent research has shown that, although there are some short-term benefits to burning crop residues and grasslands, there are long-term detrimental effects to soil quality and overall cropland/grassland production. This fact sheet summarizes some research results on burning crop and grass residues in relation to effects on soil quality.

EFFECTS ON SOIL

Long and short-term studies have been completed in Canada, Australia, and the United States to determine the effects that burning has on soil quality. The results of these studies, in relation to long-term soil health, are essentially the same, with the conclusion that long-term burning of crop residues and grasslands has a negative effect on soil quality, which directly relates to reduced production. Research also strongly concluded that long-term sustainability depends on soil rather than fertilizer-derived sources of nitrogen.

Organic Matter, Carbon, Nitrogen. Gupta, Grace, and Roper (1994) completed research on arable soils in Australia (soils and climatic characteristics are very similar to Montana) associated with cereal grain production, that suffered severe declines in soil organic matter, an important source for plant essential nutrients. The objective of their study was to evaluate crop residue management systems for their ability to improve soil organic matter and Carbon and Nitrogen availability. In their study, they compared: 1) residues burned, 2) residues retained, and 3) a mixture of burned and retained residue. The findings of the study showed that different crop residue management systems had a significant impact on C and N levels which would directly affect production levels. Residue retention significantly increased the amounts of mineralizable C and N compared with when residue was burned. The study also showed that continuous retention of high C/N ratio residues (cereal grain residues) increases microbial activity in the soil but not the size of the biomass. This increased activity ensures rapid decomposition and turnover of particulate organic matter (POM) and associated labile forms of residues, which would result in greater amounts of plant available nutrients. Additionally, the study showed that the inclusion of legumes in the cropping system clearly had a beneficial role in increasing total soil C and N pools compared with cereal only sites. Legumes in the rotation increased microbial biomass but reduced its activity resulting in the accumulation of POM.

This study agrees with earlier research completed by Dormaar, Pittman, and Spratt (1979) that found that a number of soil properties were permanently affected by long -term burning of crop residues including decreases in organic matter, total nitrogen, carbon/nitrogen ratios, extractable carbon, polysaccharides, ammonium, and available phosphorus.

Biederbeck et al (1980) reported that the heat from burning residue only penetrated the soil to a depth of 1/2 inch. This means that many insects and diseases that are soil borne or overwinter in the soil are not affected by burning. While burning can eliminate up to about 3/4 of the straw from a field burning also oxidizes about 3/4 of the nitrogen that would occur from the decomposition of the straw, which reduces soil health and soil fertility. Additionally, research is also consistent in findings that burning increases the erodibility of the soil, reduces water intake of the soil, and increases soil density (reducing porosity).

What this all means for production of crops is reduced yields over the long-term. Most research has shown that short-term burning (somewhere between seven to fifteen years of burning) has little measurable effect on overall soil health and crop production. Where burning is prolonged over periods in excess of 15 years, soil quality is measurable with a final result of reduced yields.

Active Pools of Carbon and Nitrogen in the Soil. It is important to understand how plants utilize nutrients from the soil and how burning affects available soil nutrients. Long-term annual burning results in lower levels of soil organic matter and net N mineralization rates, but higher levels of plant productivity compared with no burning (Ojima 1987). This indicates a change in N cycling and use. Microbial biomass is important to crop, pasture, and grass production in that a constant "pool" of microbes are needed to break down straw, stubble, and duff into nutrients that are useable by plants. When there are very few microbes (a small pool), there is less total activity to break down straw and stubble and, thus, less nutrients available for the plant. This in turn relates to reduced production. Fertilizer can be added to somewhat help increase the amount of available nutrients in these cases. However, research has shown that with the reduction of microbial biomass, more and more fertilizer is required to maintain production levels. Hence, the size and ratios of biologically active pools of C and N are important indicators of soil health and sustainable production.

Ojima (1987) found that microbial biomass C and N were reduced by long-term annual burning, but were affected very little by short-term burning (1-2 years).[2] The study also showed that short-term burning created increased active N and N mineralization rates (increase in available N for the plant). However, long-term burning resulted in a decrease of soil organic matter and N mineralization rates.

Doran and Smith (1987) suggest that changes in nutrient cycling, and thus greater nutrient availability, are associated with changes in the size and activity of labile and stable organic matter "pools" in the soil. In CRP or reduced-till agricultural systems, a greater amount of N is conserved by immobilization into less "active pools" (pools that release large amounts of N). CRP and reduced -till systems receive inputs of straw, stubble, and duff from primary production, and the soil organic matter interacts with the primary production by providing nutrients. This relationship is regulated by factors such as moisture and temperature, and disturbances such as fire, tillage, or mowing, or grazing.[2] Reduced tillage management systems such as no-till and minimum-till, that maintain large amounts of residues, increase the relative size of active pools of carbon and nitrogen which relates to greater production and better soil quality and overall soil health.

Burning CRP and Grasslands. Since the introduction of CRP in 1985, CRP contracts have maintenance requirements associated with the grass stands that are designed to improve wildlife habitat, air quality, water quality, control erosion and reduce sedimentation of riparian areas. Burning is one of the options available to contract holders to control weeds and invigorate vegetative growth to accomplish these goals. Periodic burning, if completed properly, can benefit most grass stands.

Burning should be carried out in early spring after hard freezing weather is over, but before grasses start growth, and only in occasional years when an excess amount of dry material is in the CRP stand or on the pasture from the previous year(s). Burning too late in the spring will also be detrimental to nesting birds so should be scheduled appropriately. It should be noted that burning has very little effect on control of weeds unless completed in the spring. Spring burning warms the soil which accelerates competitive grasses to grow and out-compete weeds.[3]

On CRP acres, steps should be taken to address wildlife habitat when developing a burn plan. Instead of burning all acres at one time, which could eliminate nesting habitat for a season, consider burning portions of the acreage in any one-year. For example, burning 1/3 of the total acreage for three years retains adequate wildlife habitat while meeting the objectives of the CRP contract.

Burning pastures periodically may benefit livestock weight gains. Anderson (Anderson et al., 1970; McGinty et al., 1983) reported increased gains following spring burning and attributed this to increased protein content and digestibility in the herbage.[4] The study also showed that fertilization with nitrogen increased crude protein concentration by 18% and forage dry matter by 111%.

SUMMARY

Research has shown that occasional burning of straw, stubble, and grass may provide the producer with an economical and effective management tool, and in some cases increase small grain and grass production in the short-term. However, the same research has shown that repeated, long-term burning of straw or grass (pastures) can have a more permanent negative effect on soil quality and overall soil health. Repeated burning can cause long term reduction in yields. These long-term losses in yield cannot be offset by the addition of fertilizer. Additionally, soils that are high in fertility may take several years to show the detrimental effects of burning. However, research has furnished concrete evidence of the slow but sure consequences of repeated burning of grass or stubble to soil health. Furthermore, what may look like a savings in fertilizer, pesticides for weed control, or insecticides for insect control, will eventually turn into increased long-term costs to maintain productivity due to continual loss of organic matter, organic nitrogen, organic carbon, and the size and quantity of microbial pools.

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