Saskatchewan Ministry of Agriculture

F A C T   S H E E T

PRODUCTION

Organic Crop Production: Soil Conservation Practices

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Soil is the production base of all agricultural systems and soil conservation is one of the pillars of sustainability. Soil quality has deteriorated due to wind and water erosion, as well as farming practices that reduce soil organic matter content. Soil conservation promotes practices that stop the decline in soil quality and, over time, improve soil quality.

Conservation practices are generally those that reduce wind speed, reduce rate and amount of water movement, and/or increase soil organic matter levels. No one conservation management system is suited to all situations due to differences in soil type, topography, type of farming operation, and climate. Furthermore, it may be necessary and desirable to employ a number of conservation practices. For example, rather than plant a large number of shelterbelts on a particular field, it may be better to plant a lesser number and reduce tillage operations or include green manure more often. The challenge to producers is to find and employ conservation practices best adapted to their farm.

The challenge is greater with organic crop production, however, because those conservation practices that use herbicides are not an option. Also, some common organic crop production practices such as post-emergent harrowing for weed control are destructive to the soil. Accordingly, the organic crop producer may need to employ additional or more aggressive conservation measures if practices such as post-emergent harrowing are used.

Crop Residues

Crop residues include roots, chaff, stems and leaves which are left after a crop is harvested. Crop residues are the prime source of organic matter replenishment. These residues improve several soil properties, such as water infiltration, water storage and particle aggregation. Crop residues also contain nutrients, including nitrogen, phosphorus, potassium, sulphur and micronutrients. Stubble left standing overwinter will trap snow and slow evaporation of soil moisture in spring, as well as prevent erosion. Moisture conservation is important to soil conservation because the additional moisture will improve crop growth, thus residue production, the following year. It may also allow extending the rotation, another conservation practice.

The amount of residue produced and the rate of decay vary among crops. The combination of these two factors determines the quality of residue in relation to its value for soil conservation. Field pea and flax generally produce about half the residue of cereals and canola. Residue from canola, field pea, lentil, and sunflower usually decays very rapidly (particularly when tilled), leaving the soil surface unprotected. Conventional tillage summerfallow after oilseed or pulse crops is not recommended, unless an extensive system of wind barriers will prevent wind erosion and water erosion is not a concern. Even where recropping is practiced, excessive tillage after oilseed and pulse crops can promote serious erosion.

Cereals usually produce an acceptable level of crop residue that decays at a moderate rate. The surface cereal residue levels required for erosion control are listed in Table 1. When designing a crop rotation, factors of this nature should be considered.

Table 1. Approximate surface cereal residue levels required for erosion control

Wind erosion control	
Soil texture	**Cereal residue required (lb./ac.)**
Medium (loam)	900
Fine (clay)	1350
Coarse (sandy)	1800
Water erosion control	
Field slope	**Cereal residue required (lb./ac.)**
Gentle (6-9%)	700-1000
Moderate (10-15%)	1000-1500
Steep (16-30%)	continuous grass
Very steep (>30%)	native vegetation

Tillage

Crop residue conservation during tillage is affected by equipment type, speed, depth and frequency of tillage, as well as soil and climatic factors. Limiting tillage depth, speed and the number of operations all conserve crop residue and soil moisture. Shallow tillage allows crop residue to accumulate near the soil surface, where it will be most effective in reducing wind and water erosion, improving infiltration and reducing evaporation. Reducing tillage speed usually lessens crop residue burial.

Tillage equipment type significantly influences residue conservation (Table 2). Tillage implements such as a wide blade cultivator or rod weeder conserve significantly more residue than a cultivator which, in turn, is better than a discer. The addition of harrows to a field or heavy duty cultivator doubles the amount of residue buried. The addition of a rodweeder to a cultivator does not significantly affect residue reduction.

Table 2. Approximate residue conservation with various tillage implements

Tillage implement	Residue reduction per operation (%)	Residue left after four operations (%)
Wide blade cultivator (35 inch sweeps)	10	50-60
Rodweeder	5-10	no data
Heavy duty cultivator (16-18 inch sweeps)	20	30-40
Heavy duty cultivator with rodweeder	20	30-40
Heavy duty cultivator with harrows	40	15-20
Field cultivator (9-12 inch sweeps)	20	30-40
Field cultivator with harrows	40	15-20
Discer	35-65	10-15
Tandem disc -- offset disc	30-70	5-15
Moldboard plow	90	no data

The need for each tillage operation should be carefully considered. For example, in the brown and dark brown soil zones fall tillage may be of little benefit unless a heavy infestation of moisture-consuming weeds is present. In many cases fall tillage reduces moisture conservation by disturbing standing stubble, which diminishes its effectiveness as a snow trap and exposes the soil to erosion. In the brown soil zone standing stubble will conserve one-half to one inch more moisture over winter than bare soil. In contrast, fall tillage may offer some advantage in the more humid black and gray soil zones where moisture is rarely limiting and where crop residues may pose a problem during preparation of the seedbed. Even in these areas, however, fall tillage may not result in increased yields.

In all situations, avoid tillage under wet soil conditions as this can degrade soil structure and significantly reduce surface residue levels.

Stubble Cutting

Moisture conservation can be enhanced by trapping more overwinter snow with “tall” or “sculptured” stubble. Tall stubble refers to stubble which is cut 12 or more inches high, usually when straight combining. Sculptured stubble refers to when a swather-mounted clipper or deflector cuts strips of taller stubble with each swath, or when alternate swaths are cut at normal height and taller.

Direct Seeding

Zero-till, direct seeding is not usually associated with organic crop production because herbicides cannot be used. Some Saskatchewan organic producers, however, do practice direct seeding. Thus, producers may wish to consider this conservation practice when fall and spring weed pressure is low, and previous crop straw and chaff have been adequately spread.

Extended Crop Rotations

Summerfallowing is destructive to the soil because no new organic matter is returned to the soil during the fallow year. Tillage also speeds the breakdown of soil organic matter and predisposes the soil to erosion. Extending crop rotations is a conservation practice because it reduces the incidence of summerfallow.

The benefits of an extended crop rotation are numerous and include improved fertility, tilth, aggregate stability, moisture storage, and resistance to soil erosion and degradation, as well as reductions in insect, weed and disease problems. All of these factors contribute to increased productivity and most have a significant positive effect on soil sustainability. Decisions regarding cropping strategies should consider not only short-term benefits, but also their long term effects on soil and environmental quality. A diverse rotation should include cereals, oilseeds, pulses, fall-seeded crops and forages. The level of crop diversity determines the significance and degree of the rotational benefits. Selection and management of legume species (pulses and forage legumes) within a rotation is a vital aspect of achieving diversity and supplying nitrogen through symbiotic nitrogen fixation.

Forage Crops

Forages contribute significant amounts of organic material to the soil. They also offer an alternative commodity in the form of hay, silage or seed. Semi-permanent forage production should be considered on soils which are inherently low in productivity and/or vulnerable to erosion. Forage production for two to four years should also be considered as part of a normal crop rotation. Selection of forage species and management practices can be tailored to specific problems such as drought, excessive soil moisture, salinity, poor soil structure, low pH and other problems. For more information on forage crops, refer to the Saskatchewan Agriculture publication, Forage Crop Production Guide.

Complementary Rotational Crops

An ideal rotation should be as diverse as possible including cereals, oilseeds, pulses, fall-seeded crops and forages. A diverse crop rotation, in addition to many other benefits, can help soil nutrient availability, because different crops have a different demand for and ability to remove particular nutrients. All crops require 16 essential nutrients, and in Saskatchewan, most soils are deficient in nitrogen and phosphorus. Some soils are also deficient in sulphur and potassium. Micronutrients are rarely deficient. For example, canola and alfalfa have a high demand for sulphur and should not be grown on deficient soils. Where copper is deficient, as in some grey soils, barley or rye will provide comparatively better yields than the other cereals.

Growing legumes in the rotation provides both nitrogen and non-nitrogen benefits to subsequent crops. Properly inoculated/nodulated legumes fix 50 to 90 per cent of their nitrogen requirement from the air. The remainder is obtained from the soil. However, nitrogen is also exuded from legume roots during the growing season and the legume residue decomposes and recycles the nutrients faster than non-legume residues, thus more nitrogen is usually available to the subsequent crop than if a non-legume had been grown. Furthermore, research has shown that the non-nitrogen benefits (such as disease suppression, tilth improvement, etc.) of growing legumes in the rotation may result in increased yields.

The growth patterns of various crops should also be taken into account when planning complementary rotational cropping. Broadleaf crops such as pea, lentil, flax and polish canola generally extract moisture and nutrients from shallower depths than spring-seeded cereals. Fall rye and winter wheat root deeper, earlier in the growing season than spring cereals, using early spring moisture to their advantage. Winter cereals also have an advantage over spring cereals because they usually flower earlier, when soil moisture reserves are more plentiful. Perennial forages can be very deep rooted, using moisture and nutrients from the subsoil. Shallow rooted crops appear best adapted to follow a deep-rooted crop because water recharge is likely to occur only near the soil surface and a shallow-rooted crop will not expend energy rooting deeper in search of moisture that is not there. Medium or deep-rooted crops appear better adapted to follow shallow-rooted crops as they are able to take advantage of any moisture left at depth, not used by the previous shallow-rooted crop.

For more information on legumes in the rotation and nutrients, refer to Soil Improvement with Legumes and Organic Crop Production: Fertility.

Wind Barriers

Annual Crop Barriers on Summerfallow

Annual crop barriers can be used to prevent wind erosion on summerfallow fields. Annual crop barriers are two to five rows of plants seeded every cultivator width or two in July during the summerfallow year. The greater the potential for erosion, the closer the barrier strips should be placed. Crops such as flax and oriental or yellow mustard have good “standability”, but cereals and sunflower have also been used.

A number of commercial strip seeders are available for purchase and mounting on tillage equipment. Following seeding, these barriers are left intact, to protect the soil until planting the following year. This may require adjustments of summerfallow tillage widths or removal of two or more cultivator shanks to compensate for the barriers. The following crop may look poor where the barriers were located the previous year. However, research has found yield losses amount to less than two per cent over the entire field.

Annual Crop Barriers in Crop

Barriers of “taller” annual crops have been used to a limited degree in low residue-producing crops. A divider is placed in the seedbox so that two rows of wheat or flax are seeded every seeder width or two of lentil. At harvest, the lentil is combined and the barrier strip left standing to trap snow and prevent wind erosion during the upcoming winter.

Perennial Grass Barriers

Perennial grass barriers are two rows of grass planted perpendicular to prevailing winds to reduce wind erosion, trap snow and reduce evaporative losses. Barriers should be placed 30 to 60 feet apart, depending on soil type; closest on sands, moderately spaced on clays and furthest apart on loams. Barriers may be placed further apart if other soil conservation practices are also being used. Species such as tall wheatgrass work well, as it is usually a weak competitor with most field crops and will not spread beyond the seeded rows. It also grows high enough without lodging to trap snow, helping in soil moisture recharge.

Shelterbelts

Shelterbelts can effectively reduce wind velocity for a distance approximately 20 or more times their height. This is usually sufficient to control wind erosion for a distance of approximately 10 or more times their height when planted perpendicular to prevailing winds. Their effectiveness, however, does depend upon shape, porosity and maintenance as well as height. Shelterbelts have the added benefit of increasing crop yields, particularly of less drought-tolerant crops such as canola and alfalfa. Producers are encouraged to contact the Prairie Farm Rehabilitation Administration (PFRA) Shelterbelt Centre at Indian Head for more information on shelterbelts and their design.

Strip Cropping

Strip cropping consists of alternating strips of crop and summerfallow at an angle perpendicular to the prevailing winds. The strip width varies depending on soil texture. Sandy soils are the most prone to wind erosion, followed by clays, then loams. Strip cropping works well for loams to clays where eight to 10 strips per quarter section will significantly reduce the potential for wind erosion. With sandy textured soils, however, too many strips are required to be manageable. Keep field equipment sizes in mind when establishing strip widths.

Strip cropping is a more common practice in the drier areas of the prairies where often too little crop residue is present to prevent wind erosion. It can be used in wetter areas, however, provided the strips also run perpendicular to the slope, so that water erosion does not become a problem.

Cover Crops

Rotations should also include the use of cover crops to protect the soil from wind and water erosion during vulnerable periods such as summerfallow or partial fallow where normal standing stubble is not available. Cereal crops should be seeded at a rate of one-third to one-half bushels per acre between August 15 and September 1. This plant material will be killed by fall frosts and remain on the soil surface until spring planting, providing valuable soil protection. Fall seeded cereals such as winter wheat or fall rye may be used in a similar fashion. In the following spring these crops may be removed by tillage or used for short term livestock grazing or grown to maturity in the case of winter wheat or fall rye.

Green Manure

Green manuring involves the incorporation of any green, fresh vegetative material into the soil. Green manure crops add organic matter to the soil, improve soil tilth, and if a legume, contribute nitrogen fixed from the atmosphere. Even weeds can be regarded as green manure. The extent of soil improvement depends on the type and quantity of plant material returned to the soil. The greatest benefits usually occur by using biennial (sweetclover) or perennial legumes (alfalfa or true clovers) as green manure on poor structured soils with low organic matter levels. If sweetclover is used as a green manure crop, it should be incorporated into the soil by mid-June (approximately 10 per cent bloom) to allow soil moisture recharge for the following year's crop. Crop quantity and quality are good by this time and little is gained by delaying incorporation.

Grain legumes (pulses) can be used effectively as green manure. Due to their annual growth habit these crops will not contribute nitrogen or crop residue to the same degree as a biennial or perennial legumes. They may, however, be more adaptable to an existing crop rotation. Pulses such as Indianhead lentil have been specially developed for this use.

Non-legume crops such as buckwheat have also been used as a green manure crop.

To protect against soil erosion, do not over-incorporate green manure crops.

For more information on green manure and nitrogen fixation by legumes, refer to Soil Improvement with Legumes.

Animal Manure

The spreading of livestock and poultry manure provides not only nutrients required for plant growth but has a major beneficial effect on soil tilth and particle aggregation. The organic materials contained in manure act as binding agents in stabilizing soil structure. This positive change in soil structure caused by the addition of manure is equally, if not more important, than the nutrient contribution provided. Changes in structure of this nature positively affect water infiltration, water holding capacity and aeration, as well as resistance to wind and water erosion.

The nutrient value of manure is highly variable depending on numerous factors such as animal type and age, type of feed, amount of straw, and method and time of storage. Typically, barnyard cow manure contains approximately three to five lbs. of crop available nitrogen, four to 11 lbs. of phosphate, nine to 16 lbs. of potassium and about three lbs. of sulphur, per ton of manure. Manure usually has sufficient micronutrients present to prevent plant deficiency symptoms from occurring. Soil testing laboratories test animal manure for nutrient content and make recommendations on manure application rates.

Application rates of manure will vary depending on availability, soil type, location, slope, crop rotation and production practices. To prevent leaching losses and potential environmental contamination, rates of manure application should not exceed what a crop can use in one growing season. Following the application of manure, it should be incorporated as quickly as possible into the soil to prevent nitrogen loss. In addition, changes in soil nutrient levels resulting from manure should be monitored by soil testing on a regular basis.

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