Background:

The Dakota Lakes Research Farm is operated by South Dakota State University but the land and other fixed facilities are owned by a nonprofit corporation established by area farmers. This group works with the manager in prioritizing research projects and planning capital improvements. The manager's salary and the base wages of the 3 full time employees is paid by the University which also contributes sufficient O and M moneys to turn on the lights and heat the building. The remaining funds to operate the program come from grants (primarily from checkoff funds) and profits on the production enterprises at the station. The goal is to make as much money as possible on the production enterprises and spend all of this money on research projects, facility improvements, and equipment purchases and upgrades. Land rent is paid to the Corporation but most of this money returns in facility improvements.

At the present time the operation consists of 3 quarters of land at the main station and about 400 acres of land at two sites located west of the Missouri River which are rented from private landowners. All of this land is farmed without tillage. We have been exclusively no-till for over 6 years and predominately no-till (tillage only used for small plots and some ridge-tillage used on gravity irrigated land) for over 10 years. The main station is about evenly split between irrigated and dryland while the off-station sites are dryland. Distance between sites exceeds 70 miles The station hosts numerous small plot studies by scientists from the main University campus but all of our work (both on and off-station) is done "production scale". This means that field size equipment is utilized with all harvest results being weighed in a 300 bu.weigh cart. Two tractors, one drill, one row crop planter, one sprayer, and one combine are used for all field work. The tractors are 85 and 105 h.p. This equipment could farm at least 2,500 acres if all of our land was in the production enterprise (no research) and we maintained our present crop mix.

We make no pretense at having all the answers for producers interested in no-till. We do hope that our experience and success at developing **no-till farming systems** will be a benefit. We are confident that many of the principles which we utilize may be adaptable for benefit in many areas.

Technology Transfer

The comprehensive nature of the systems approach to no-till requires substantial cooperation across disciplines and agencies in transferring technology to the end user. A project to address this need was initiated in May of 1997. This project is a cooperative effort between the NRCS, private industry, Ducks Unlimited, South Dakota Department of Environment and Natural Resources, South Dakota No-Till Association, and South Dakota State University Cooperative Extension Service, South Dakota Ag. Experiment Station. The scope of this project covers technology transfer approaches ranging from creating local expertise teams to developing information resources on the World Wide Web. Jason Miller from the USDA-NRCS has been stationed at the Dakota Lakes Research Farm to serve as the coordinator for the two-year trial period of this approach.

PRINCIPLES AND PRACTICES OF NO-TILL SYSTEMS

I. Different farming systems use varying levels of Tillage, Technology, and Cultural Practices.

A. Ancient systems used almost no tillage, little technology, and numerous cultural practices.

B. Systems used on the plains from the time of the pioneers until perhaps the late 1920's used moderate tillage, some technology, and many cultural practices.

C. Modern farming practices which have evolved in the last forty years rely on intensive tillage and substantial amounts of technology in order to reduce use of cultural practices.

D. High residue farming systems will require renewed utilization of cultural practices to limit excessive reliance on technology.

II. The impact of no-till on weeds, diseases, and insects.

A. Weeds

1. Some weed types are favored by tillage and inhibited by lack of disturbance. This is especially true for broad leaf weeds with large seeds and only slightly less applicable for grassy weeds with large seeds.

2. Small seeded weeds are favored by minimum tillage and high disturbance direct seeding.

3. Low disturbance seeding techniques result in less weed pressure and more uniform weed flushes.

B. Insects

1. Most insects which are harmful to crops are not affected either directly or indirectly by tillage method.

2. A few harmful insects are indirectly affected by tillage in terms of how it impacts the habitat they need for winter survival, etc.

3. Almost all insect problems blamed on use of high residue systems can be traced to failures in sanitation or rotation practices.

C. Diseases

1. Plant diseases require three factors to be present in order for plant health to be affected. Those factors are a susceptible host, a pathogenic organism, and a suitable environment for infection to occur. Tillage method is only important in how it affects these factors.

2. Some diseases are tillage neutral in that tillage plays no role in the cycle of the disease. An example would be leaf and stem rusts of wheat.

3. Some diseases are reduced due to the environment created by use of high residue techniques. Diseases caused by dry soils or by soil splash to leaves are examples.

4. Several diseases can be favored by systems which leave residues on the soil surface.

a. Many of these diseases can be dealt with by using adequate rotational intervals and proper sanitation techniques.

b. In some cases it may be cost effective to use fungicides if effective, labeled, products are available to obtain shorter rotation intervals.

III. Sanitation

A. Preventing weeds from going to seed.
1. Mowing field borders.
2. Spot spraying patches.

B. Avoid introducing weeds or diseases.
1. Cleaning equipment.
2. Using clean seed.
3. Remove and feed chaff.
4. Compost manure.
5. Limit Disturbance
6. Exercise great care if grazing is to be used.
7. Treat borders and field margins.

C. Break insect and disease cycles through proper inter-crop and in crop management.

1. Control weeds and volunteer plants prior to periods when flights of cutworm and armyworm moth are expected.

2. Maintain a "no green" period especially before seeding winter wheat to break insect cycles associated with wheat streak and barley yellow dwarf mosaics and to minimize vulnerability to certain root diseases.

3. Volunteer crop and other weeds serve as hosts to carry disease and insect problems through rotational years.

D. Probiotic Vs Antibiotic or Antiseptic; Utilize biological methods rather than physical methods to lower population of harmful organisms.

1. Present systems sanitize with tillage, burning, etc. designed to kill all organisms. Hope only good ones return. Physical methods.

2. Biological methods focus on creating an environment which lowers populations through competition, predation, and planned impotence.

a. Similar to use of probiotics in livestock where introduction of beneficial or non harmful organisms lowers populations of harmful ones.

b. Establishment of crop canopy conditions which cause resting phases to become active while a non susceptible crop is being grown. (impotence)

1. green fallow Vs chem. fallow
2. continuous cropping with good rotations.
3. less inter-crop period but longer interval between the same crop type.

c. Earthworms and other soil fauna are predators.

d. Biological activity is much more rapid under full canopy conditions

IV. Competition.

A. Encourage fast uniform canopy formation.

1. Accurate seeding depth.
2. Starter fertilizers.
3. Good seed quality and seedling vigor.
4. Narrow rows.
5. Spread straw and chaff completely.
6. Move residue from the row area in some conditions.
7. Wheat with Black straw (allows faster warm-up)

B. Provide less than optimum conditions for weeds.
   1. Limit disturbance.
   2. Place fertilizer.
   3. Spread straw or chaff.

V. Rotations (Diversity, Intensity, and Profitability)

A. Diversity

1. In crop type, seeding, and harvesting date.

   a. Cool-season grasses
      1. Winter wheat
      2. Spring small grains

   b. Cool-season broadleaf crops.
      1. Flax
      2. Canola
      3. Lentils
      4. Field peas
      5. Lupine

   c. Warm-season grasses.
      1. Corn
      2. Sorghum
      3. Millet
      4. Rice
      5. Forage sorghum

   d. Warm-season broadleaf crops.
      1. Soybean
      2. Sunflower
      3. Safflower
      4. Cow peas
      5. Chick peas
      6. Cotton
      7. Edible Beans

   e. Perennial and biennial crops
      1. Alfalfa
      2. Clovers
      3. Vetch
      4. Perennial and biennial grasses.

f. Fallow

2. Diversity in herbicide program used.

    a. Know herbicide families

    b. Rotate herbicides to prevent resistance.

3. Diversity to spread risk and work load.

    a. Bad weather at the wrong time for one crop can be good weather for another crop type

    b. Handle more acres with the same fixed costs.

4. Diversity to create proper conditions for the subsequent crop.

    a. Seedbed conditions.

        1. Dark colored residue produces warmer seedbed in spring.

        2. Heavy residue with light color provides more surface moisture.

    b. Soil moisture

        1. Most moisture with light-colored, upright, heavy, residue in areas where it snows.

        2. Areas without snow save more moisture with flattened residue.

        3. Interval between harvest and peak water use determines potential water storage.

5. Diversity to aid in weed control.

    a. Variations in seeding dates.
    b. Differing spectrum of herbicides available.
    c. Each crop type favors and discourages a different spectrum of weeds.
    d. Variation in harvesting dates.
    e. Perennial and forage crops can be excellent tools to control certain weeds.
    f. Winter wheat or rye compete very well with summer weeds.

6. Diversity to aid in disease control.

a. Not all diseases are residue (rotation) related.
b. At least three crop types preferred in a rotation. Two grasses; one broadleaf.

B. Intensity: Dryland rotations must be more intense.

1. Put water saved by no-till to work.

a. If water saved by no-till is not put to good use it will cause problems. (Saline seeps)
b. Full benefit of no-till will not be evident unless intensity is increased.
c. Growing crops provide competition for weeds and can help break certain disease cycles.

2. Less fallow and more high water-use crops.

a. Minimizes loss of nitrogen and water below the root zone.
b. Lower land costs provide competitive advantage in producing crops normally grown in higher rainfall areas.
c. No-till fallow is expensive.

3. Proper intensity reduces risk.

a. Rotations with insufficient intensity will be too wet.
1. Poor plant growth in normal to wet years.
2. Loss of nutrients.
3. Trafficability problems.
4. Potential for more disease.

b. Rotations with excessive intensity will be too dry.

1. Poor plant growth in normal to dry years.
2. Difficulty in establishing adequate stands.

4. Proper intensity will depend on:

    a. Weather.

        1. Use two or more rotations with varying intensity if weather tends to be variable.
        2. Use rotations which allow adjusting intensity based on weather conditions. (i.e. forage-grain flex crops)

    b. Soils: Some soils hold more water than others.
        1. Soils with high water holding capacity.
            a. more intensity.
            b. more high water use crops.
            c. longer "fallow" periods.
        2. Shallow soils or coarse soils.
            a. Slightly less intensity.
            b. More short season crops.
            c. Shorter inter-crop periods.

    c. Location: Precipitation and heat interact.
        1. Warm environments require more water per unit of production.

    d. Irrigation: Similar intensity as when tillage is used. (lower water costs.)
        1. Irrigated systems normally have intensity limited by the heat available rather than moisture unless water supply or cost are constraints.
        2. Savings occur in amount of irrigation water used.
            a. runoff reduction.
            b. less evaporation loss.
        3. Opportunity to utilize more efficient sprinklers with lower operating pressure.

5. Native vegetation is best indicator of proper intensity.

    a. Integrates precipitation, temperature, and soil factors.

        1. Environments with trees will support the most intensity.
            a. more water than heat.
            b. easily become too wet.
            c. 100 percent high water use crops and/or over crops and multiple cropping.

        2. Tall grass prairie mixed with trees.

a. typical of the corn belt and black soil zones in Canada.
b. supports substantial intensity.
c. Nearly 100 percent high water-use crops and/or cover crops and multiple cropping.

3. Tall grass prairie with few trees.
   a. Too dry some years with very intense rotations (all high water use crops)
   b. 75 to 100 percent high water use crops with limited use of cover crops and multiple cropping.
   c. Dark brown soil zone in Canada.

4. Mixed grass prairie.
   a. Too dry most years for very intense rotations.
   b. 50 to 75 percent high-water use crops. No multiple cropping and few cover crops.
   c. brown soil zone in Canada.

5. Short grass prairie.
   a. Almost always too dry for very intense rotations.
   b. 50% or less high water-use crops.
   c. Longer inter crop periods required.
   d. Some producers may use a small amount of fallow.
   e. Rotations which allow varying intensity fit for some producers.
   f. brown soil zone in Canada.

6. Short grass prairie mixed with more drought tolerant plants.
   a. Almost always too dry for a high water-use crop.
   b. Few if any high water-use crops in the rotation.
   c.. Rotations with fallow and/or flexible intensity.

6. Getting started and varying intensity.

   a. Look at conventional tillage rotations in areas with similar temperatures but 2 to 4 more inches (50 to 100 mm) of rain.

      1. Should be about right in terms of intensity but may not have other desirable characteristics.

b. Start with rotations more intense than those used with tillage.

1. Wheat-Fallow may become Wheat-Corn-Fallow or Wheat-Sorghum-Fallow

c. Experiment with increasing intensity even more by changing one component of this new base rotation.

1. Substitute a green manure crop, forage crop, or flex crop on part of the fallow acres.
   a. Wheat-corn-black lentil
   b. Wheat-corn-oat/pea (for forage)
   c. Wheat-corn-pea (flex)
      1. Forage if dry year.
      2. Grain if wet year.

2. Substitute a cool-season broadleaf crop for fallow on part of acreage.
   a. Wheat-corn-peas
   b. Wheat-corn-lentils
   c. Wheat-corn-flax
   d. Wheat-corn-canola

3. If even more intensity appears possible, try some more intense rotations.
   a. Wheat-corn-soybean
   b. Wheat-corn-sunflower
   c. Wheat-corn-safflower
   d. Wheat-w. wheat-corn-soybean
   e. Wheat-w. wheat-corn-edible bean
   f. W. wheat-sunflower-corn-canola
   g. many more variations depending on climate and grower preference.

C. Profitability: Risk versus Return

1. Each situation requires balancing diversity and intensity to achieve the desired risk and return characteristics.

a. High intensity with high diversity is difficult to obtain in many environments due to lack of adapted crops or length of growing season.

b. High intensity with low diversity can offer high risk but also potentially high return per acre until major problems develop.

1. Low diversity limits acreage or requires more fixed cost/crop acre.
2. Continuous corn and corn-soybean rotations would be examples in the US wheat-canola or wheat-edible beans would be examples in Canada.

c. Moderate intensity with high diversity (at least 3 crop types and 40% to 80% high water-use crops). Less risk, less gross return/acre but can increase total net profit.

1. Spreads workload and fixed costs.
2. Reduces price and weather risks.
3. Reduces potential for weed, disease, or insect problems.
4. Examples
    a. S. wheat-corn-soybean
    b. S. wheat-corn-canola-w.wheat-soybean
    c. S. wheat-corn-soybean-corn-soybean
    d. S. wheat-w.wheat-corn-soybean
5. Seems to fit in areas between the corn-soybean and wheat-fallow belts in US

d. Low intensity with high diversity (less than 40% high water-use crops at least 3 crop types) used on soils with lower water-holding capacity and in short grass prairie areas.

1. Similar characteristics as previous type.
2. Trades reduced risk in dry conditions for less gross return in good years.
3. Examples
    a. W. wheat-corn-cool season broadleaf
    b. W. wheat-corn-forage or flex crop
    c. W. wheat-corn-broadleaf-fallow
    d. W. wheat-millet-broadleaf

e. Low intensity with low diversity (only one or two crop types with few if any high water use crops) Combines high fixed costs/acre, higher risk, and lower gross return.

1. Little or no potential for these rotations in most no-till situations.
2. Some have worked well with tillage.
    a. tillage adds intensity (uses water)

        b. tillage partially replaces diversity by burying residue.
    3. Examples:
        a. Wheat-fallow
        b. Continuous small grains.
        c. Wheat-canola
    4. Look good only in very dry years.

VI. Each producer must determine system which works best for him.

A. Ability to accept risk/need or desire to maximize return.

1. Personality
2. Landlord, banker, partner, or spouses personality.
3. Debt
    a. Low debt load allows the producer to accept more risk if he desires.
    b. Moderate debt load may preclude taking large risks until debt is reduced.
    c. High debt load may require taking more risk in order to increase returns.

B. Other enterprises in the operation.

1. Cattle and Sheep
    a. Makes forage/grain flex cropping more feasible.
    b. Can utilize crops which do not initially have established local markets.
        1. feed peas, corn, sorghum, forages, millet, etc.
    c. Can use chaff and other aftermath to add value to the crop.
    d. Planned grazing or forage sequences add diversity with little risk.
        1. Grazing no-till can increase weed pressure because of disturbance.
    e. May limit acreage of some crops because peak times overlap.

2. Swine and poultry
    a. Can utilize grains such as peas, corn, sorghum.

C. Off-farm interests.

1. Job
2. Spouse's job.
3. Hobby and leisure activities
4. Children's activities
5. Travel
    a. Leisure
    b. Farm or professional activities.

D. Resources
   1. Labor
   2. Land
   3. Machinery

VI. Mistakes will occur

A. Tilled systems sometimes failed
B. Problem not that no-till does not work rather some component in the system was wrong.
C. Look to Rotation, Sanitation, and Competition for solutions.

CONCLUSIONS

Crops other than small grains can be successfully and profitably produced all areas of the Great Plains. Adding diversity to present rotations by growing alternative crops can have positive ecological benefit while at the same time improving the potential profitability of most operations. High residue systems benefit most from inclusion of alternative crops and in many cases use of these systems is necessary to assure adequate moisture is available to grow them. Combining high residue systems with alternative crops increases management requirements but also provides the greatest potential for increasing returns by spreading workload, optimizing efficient utilization of water; and reducing weed, disease, and insect concerns