UNIFYING PRINCIPLES: SIMILARITIES AMONG PRAIRIE ECOSYSTEMS

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ABSTRACT

Striking differences exist throughout the grassland and steppe areas of North America. It is a fact, however, that native vegetation patterns are similar over the entire region known collectively as the Great Plains or Prairies. Consequently, from a plant adaptability and productivity perspective significant, similarities exist. Tillage based cropping systems focus predominately on production of cool-season cereals primarily wheat. Use of fallow is common. This entire region shares a typical continental climate with a significant portion of the limited precipitation occurring in intense thunderstorms. Winds tend to be strong. These climatic factors combined with a lack of trees make soils exposed to the elements prone to both wind and water erosion. Other unifying factors include a strong livestock industry throughout the region with a predominance of cow-calf operations. The majority of feeder calves are exported for finishing in the corn belt or in irrigated areas of the prairies. Like livestock, wheat is also exported. Population is sparse, labor resources are limited, and most farming operations are large in comparison to those in more humid regions. Local economies are heavily, predominated by agriculture and consequently subject to wide swings in response to weather and market factors. Government regulations and farm programs play a large role in determining practices used, crops grown, and the profits made in most operations.

Attempts to adopt no-till and reduced tillage systems in response to economic factors and government regulations have met with mixed results. The systems have done an excellent job of conserving water and soil. They have been less consistent in translating water savings into the expected increases in yield and/or economic return. One notable reason for this lack of response has been a failure to change crop rotation practices at the same time tillage practices are changed. Rotations used in conservation systems must be more intense and diverse than those used with conventional practices. Increasing intensity and diversity, prevents weeds, diseases, and insects from becoming major limiting factors while also allowing better utilization of moisture, machinery, land, and labor resources.

The crops and rotational strategies used will vary somewhat throughout local areas of the Great Plains and Prairies just as native vegetation varies slightly. Without significant changes in rotations it is doubtful if conservation systems will ever realize their full economic and environmental potential. In fact, as ecological concerns increase, government funding declines, and economic factors change the success achieved in developing diverse rotational systems for use with conservation systems may well

determine whether the great plains and prairies are returned to a “buffalo commons” or become an important producer and processor of food, feed, fiber, biofuels, and industrial feed stock as arable land in more populous areas is removed from production.

INTRODUCTION

The desire to be unique is a basic human characteristic. We all feel that the circumstances which we face must be different than those experienced by others. Much time is spent focusing on perceived differences in races, sexes, religions, tribes, etc. while little effort goes into defining the much greater list of characteristics which they have in common. The same is true when it comes to comparing agricultural practices in differing geographical regions. Much is made of perceived differences in climate and soils while little attempt is made to look for and learn from the commonalities between the systems. No matter where agriculture is practiced or whether it is rain fed or irrigated there are some common principles that will always be present. Everyone will start with the best source of germplasm with which the producer is comfortable and the price is acceptable. Then they will attempt to provide that genetic material with conditions which are as close to optimum as is feasible with the resources available and finally will hope that mother nature will be benevolent with the crop. With this analysis all agriculture is the same. The only differences which occur are the result of how the terms “best source of germplasm”, “optimum conditions”, “feasible”, “resources available”, and “benevolent climate” are defined by the producer or by the fiscal, governmental, and physical environment in which he is growing crops.

Obviously a producer would define many of the above terms differently if he farmed in Illinois or Iowa than if the operation were in Manitoba, Montana, or Kansas. Less obvious and just as prevalent would be two growers facing identical circumstances who also would define the terms differently due to the unique nature of their personalities; ability to accept risk; past experiences; etc. The unique “system” used in each of the above cases results from assimilating all available information and personalizing it for each operation. It does not necessarily represent different approaches only variations in the same approach. For instance, if 100 random growers were given the same set of circumstances most of their decisions would be the same or so similar as to make them indistinguishable (i.e. it is unlikely that anyone would attempt to use a wheat-fallow system in Iowa or a corn-soybean rotation in Alberta).

If the above logic is extended to an examination of agriculture on the great plains and prairies it holds that there must be valid reasons things are done in a certain manner. If a large majority of the producers are using very similar systems then it is must be assumed that the reasons for the practice lie not in personalities but rather in outside factors such as economics, government policy, or climate. The tremendously similar agricultural systems employed throughout the great plains must result from an integration of these factors. What follows is an analysis of the role they have played in shaping present farming systems and what effect proposed changes will have on the way things will be done in the future.

CLIMATE AND NATIVE VEGETATION

There are only a limited number of geographic regions in the world whose climates are almost totally isolated from the direct effects of oceans or other large bodies of water. These areas have long been recognized as having characteristics quite distinct from other regions while sharing numerous climatic similarities. Most attempts to classify climatic regions have segregated “continental climates” into one or two closely related categories. The largest areas with these climates occur in the northern hemisphere specifically on the large continent of North America and in eastern Europe and Asia. Other regions with continental climates are found throughout the world but are generally limited in size. Climate in all of these areas is characterized by cool or cold winters which are not favorable for crop production and warm or hot summers with extended periods of dry weather. Precipitation can occur throughout the year but the period of greatest rainfall occurs in late spring and early summer. Much of the rainfall during this period and later in the summer occurs in intense thunderstorms. High winds are an ever present characteristic of these climates especially in late winter and early spring.

In North America the large expanse of land lying east of the continental divide and west of the influence of the Great Lakes and Gulf of Mexico is know as either the Great Plains (USA) or The Prairies (CANADA). It is true that there are striking differences which exist throughout this grassland and steppe area. More humid areas are characterized by native vegetation consisting of tall grass species interspersed with tree stands in lowland and drainage areas. Regions with a slightly drier environment contain a mixture of tall and short grass species with the former being found on soils with better water holding capacity or in small drainage ways and depressions. Large depressional areas and major drainage areas contain tress and shrubs. Even drier conditions are expressed through native vegetation consisting almost entirely of short grass and bunch grass species. Trees are rare occurring only in major drainage areas. The driest areas contain predominately bunch grasses interspersed with hardy brush species. The type of vegetation which occurs on a particular soil in a specific location is probably the best indicator of the plant adaptability and productivity potential of that site. Locations having native vegetation characteristic of all the environments listed can be found in every state and province in the great plains and prairies due to the effect soil factors, elevation, topography etc. have on determining the amount of water available to plants.

GOVERNMENT

Government programs affecting agriculture have been common since the depression. The impact these have on cropping practices can be either direct as is the case with acreage base programs in the U.S. or indirect as is the case with the Wheat Board System and Crow Rate in Canada. Government actions related to the monetary system, environmental regulations, and trade policy also have profound impact on agriculture on the prairies since a large percentage of the crops produced are eventually exported. It is extremely difficult to quantify the effects these practices have with certainty. There is however, an interesting comparison that can be made between two government systems operational on the prairies of North America. Many areas of Saskatchewan and Alberta share environments extremely similar to neighboring areas in Montana, and North Dakota. Government policies on the U.S. side of the border have tended to encourage production of program crops such as wheat and barley. Consequently, systems predominated by cereals prevail south of the border. The Canadian system in recent years has tended to place economic incentives on production of non-board crops specifically canola, peas, and lentils. In 1994 the total value of canola produced in the prairie provinces was be greater than the value of the wheat grown. This is the only time wheat has not been first since the prairies were settled. These differences in production patterns are obviously more directly related to government policies than agronomics.

No attempt will be made to evaluate the relative successes and failures of government programs. That is well beyond the discussion of this paper.

However, it is important to note that substantial changes in government policy are expected to occur in the next decade as direct subsidies are reduced, environmental and conservation requirements are strengthened, and land presently in the CRP program in the U.S. is placed back into crop production. These anticipated changes and others which we are not aware of will singly and collectively have profound impact on agriculture and most likely will lead to changes in the way things are done.

ECONOMICS, ECONOMICS, ECONOMICS

Just as native vegetation is the best indicator of the potential productivity of a specific location. Economic considerations are the predominate factor that will determine if a new practice is eventually accepted. Native vegetation integrates the effects of climate, soil characteristics, elevation, etc. Similarly profitability characteristics integrate the effects of agronomic and environmental factors, government policies, and the market. Bottom line economics have led Canadian farmers to grow more canola even if at times it means using rotational intervals which are not agronomically recommended. Similarly, their very close neighbors across the border grow cereals in tight rotations for the same reason. If the price of soybeans increased to $15/bushel while wheat stayed at present prices, it is almost certain that there would be substantial acreage of soybeans in areas of the prairies where they have not been grown previously.

The need to maintain profitability in the operation is the predominate unifying factor among producers on the prairies. Whether he lives in Texas. Alberta, or somewhere in between; the producer must devise a system that generates adequate profits or he will be out of business. It is also this factor that leads to the most diversity between production practices since each operator's financial situation, risk tolerance, and personality are unique. Some operations can withstand taking substantial risks in order to reap potentially high returns while others must be more conservative to guard against catastrophic losses which could wipe them out. Some producers could afford to take additional risks from a financial standpoint but choose not to do so because it conflicts with their personal philosophy or would make their spouse or farming partner uncomfortable. Some farmers must take substantial risks in the hopes that the potential high returns will allow them to put the operation on more stable financial footing.

A new practice will not be accepted by a majority of farmers until it has been locally proven to have a profit to risk ratio superior to the system they are presently using. This ratio is affected by market forces, government programs, and the availability of improved agronomic practices. One major impact of government programs in the US is to take much of the risk out of production systems (monocultures) which have high risk levels without present "safety nets".

THE FUTURE

There have been literally thousands of experiments conducted in the great plains over the last 30 years that have (without one known exception) found that no-till systems increase the amount of water infiltrating the soil and reduce the amount of water lost from soil by evaporation. In a region which has been traditionally viewed as being consistently short of moisture it was assumed that this would lead to increased yields and profitability. That unfortunately has not been the case. This is one of the primary reasons that not-till systems have not gained more widespread acceptance among producers.

In examining the reasons that the moisture savings accrued with high residue systems have not been consistently translated into improved productivity and profitability it is important to take a look at present tillage based systems. The “conventional” systems utilized by producers in a particular area did not develop at random but rather are generally the result of years of experience and local knowledge integrated with present market forces and government policies. These can be viewed to a certain extent similar to the native vegetation which would inhabit this area if farming operations cease. The rotations used have proven to be the proper ones for the tillage system employed. In the prairie system, if we could magically add two inches of moisture to this site each year we would not necessarily see dramatically increased production of the plants which are present but would expect that very quickly the species present in the prairie would make a shift to one representative of a more humid climate. The same principles apply to crop production. Adding moisture to the system by reducing tillage will not necessarily improve the productivity of rotations developed to be in “equilibrium” with the use of tillage. In fact, productivity may fall if weed, disease, and insect problems arise or excessively wet soils occur.

In order to take advantage of the increased moisture available with no-till tillage systems it will be necessary to mimic the response of the prairie in the same situation. Specifically this will entail increasing the intensity of crop rotations used. This means cropping more frequently and/or including more full season crops in the rotation. This principle applies across all climatic zones but probably will be most difficult to apply in very humid areas and in areas with short growing seasons. In traditional wheat fallow areas it is probable that utilization of reduced tillage or no-till without increasing rotational intensity will lead to growth in saline seep formation and enhanced deep leaching of nitrate nitrogen.

Increasing cropping intensity puts a producer in a better position to take advantage of the moisture saved with no-till tillage but by no means does it automatically guarantee success. Many researchers and producers recognized early on that cropping frequency could be increased. The most logical method of boosting the intensity of a crop rotation is to increase the frequency of cropping wheat in areas where fallow is utilized. When this was done, however, results were mixed since gains occurring due to increased moisture availability were often offset by problems with weeds, diseases, and insects. Depending on the individual situation it was sometimes possible to overcome these problems through use of pesticides, predictably, this often more than offset any potential increases in profitability. The most success in increasing profitability has been obtained by researchers and producers who have added diversity to the rotations at the same time that intensity was increased. One of the first successful demonstrations of this concept was the development of the ecofallow (winter wheat-sorghum-fallow) system in Nebraska. This system has proven to be quite successful and in certain geographic regions has gained widespread acceptance.

Numerous research projects focusing on the interactions of tillage and rotations or on determining proper rotations for specific conservation systems such as no-till have been or are presently being conducted throughout the great plains and prairies. Much of this work is included elsewhere in the proceedings. On examining these results it is clear that reductions in tillage have to be accompanied by commensurate increases in diversity and intensity in rotations. In fact, one of the main advantages associated with the use of conservation techniques especially no-till may be that it allows production of crops in areas where they could not be grown consistently using tillage based systems. Since land costs are less in these areas than where the crop is traditionally produced using tillage, a substantial economic advantage exists. Increased diversity also allows more efficient utilization of labor and machinery resources if crops are chosen so that seeding, spraying, and harvesting periods do not conflict. These two factors combine to provide substantial economic advantages to diverse and intense systems with no use of tillage. These types of systems are finding widespread acceptance with fairly large geographical areas having the majority of acres involved in systems of this sort. One striking example involves Brown and Spink counties in South Dakota. This area is where no-till rotation research in the mid-80's established that potentially large increases in profitability could be obtained by replacing conventionally tilled continuous cereal rotations and minimum tillage systems with at least 2/3 small grains with intense no-till rotations containing 50% to 75% full season crops (specifically corn and soybeans). In response to this increased profit potential soybean acreage in these two counties grew from 1,900 acres (mostly irrigated) in 1983 to over 250,000 acres in 1993 with almost all of these acres being no-tilled. No-till is the predominate farming system in this area at the present time.

Including soybeans and corn along with wheat was the correct answer for proper no-till rotations in Brown and Spink counties. Other areas will need to find solutions which fit local climatic, soil, and market factors. The exact systems will vary among producers with similar situations due to the uniqueness of their personalities as discussed before, but changes in rotations must occur along with tillage shifts if profitability and acceptability are to be obtained. It doesn't work to try to change tillage first and switch rotations later.

The future of no-till on the great plains and prairies will probably depend on how quickly proper rotations are identified and suitable genetic material and management practices developed. In fact, the success achieved in this task may well determine the economic viability of local economies in the future. There has always been a strong livestock component in the agriculture of the great plains. However, this has focused almost exclusively on cow-calf operations with the calves being exported to the corn belt or irrigated areas of the prairies for finishing. This was necessary since feed grains and high protein crops were not part of the rotation. The ability to grow these crops and feed them to locally produced livestock could bring tremendous economic growth to the region as urban and industrial needs begin competing for land and water resources in traditional feeding areas. As fossil fuel supplies dwindle and biotechnological abilities increase it is possible that large areas of the prairies could someday be involved in the production and processing of biologically derived fuels and industrial feed stock. The local oil industry which already exists in some regions has much of the needed infrastructure in place for that to happen. Conversely, if active efforts are not made to develop environmentally sound, no-till systems that are profitable and widely accepted it is possible that environmental regulations and changes in economic conditions such as fuel, machinery, labor, and transportation costs will make crop production practices on the prairies unprofitable. If that occurs we may be faced with the "buffalo commons" alternative which has created so much discussion in the past few years.

POST SCRIPT

It is not the intent of this paper to be a comprehensive guide to rotational planning. There are a couple of tools that have been helpful in our work that make the process of evaluating rotations more straightforward in the initial phases. The first is an intensity rating. Rotational Intensity can be evaluated by assigning a value of 1 to cool-season and short-season crops and to crops used for green fallow. Examples would be all small grains, canola, pulses, millet, etc. A value of 2 is assigned to full-season crops grown during the warm part of the summer. Examples would be corn, forage sorghum, safflower, sunflower, edible beans, etc. Fallow receives a value of 0.

Average the intensity value for each crop in the rotation. For instance a wheat-fallow rotation produces a value of 1 plus 0 divided by 2 equals 0.5. Continuous wheat, wheat-canola, etc. give values of 1.0. Wheat-Corn-Pea produces intensity of 1.33. Intensity values of no-till systems should be 0.5 to 1.5 points higher than those used with tillage depending on the tillage used and soil parameters.

The other tool being developed to aid rotational planning is a Diversity Index. This index attempts to quantify diversity in rotations in as simple manner as possible. It like the intensity rating is designed to be used in preliminary planning only. More careful scrutiny of promising rotations is suggested. There are two steps used in determining the Diversity Index. The first involves determining the average interval between crop types in the rotation. Crops used in the rotation are classified into one of four types (cool-season grass, cool-season broadleaf, warm-season grass, and warm-season broadleaf). Determine the number of years between each cool-season grass and the one that preceded it in the rotation. If it was the same crop (i.e. wheat both times) use the number of years as its interval. If the preceding crop was of a different crop (i.e. oats or barley) add 0.5 to the number of years. Do the same thing for the warm-season grass crops (corn, millet, forage sorghum, sorghum, etc). Perform the same operation for the broadleaf crops disregarding the difference between warm and cool-season types. In other words use the interval between the crop of interest and the last broadleaf crop of either type. This is done since many of the broadleaf crops share diseases in common. Just as with the grass crops, remember to add the 0.5 is the preceding broadleaf was not the same crop. Average these numbers across the rotation. Fallow is treated as another crop type. Some examples are: Wheat-Fallow (1 + 1 = 2 divided by 2 years in the rotation produces and interval average of 1.0); Wheat-Corn-Pea (2+2+2=6 divided by 3 equals 2); Wheat-Barley-Canola (1.5 + 0.5 + 2 = 4 divided by 3 equals 1.33); Wheat-Wheat-Canola (1+0+2=3 divided by 3 equals 1.0); Wheat-Canola-Millet (2+2+2=6 divided by 3 equals 2.0). The Diversity Index is obtained by adjusting the interval average to account for some work-load spreading, weed, and disease concerns. If both a grass and a broadleaf crop are used in the rotation add 0.5. If both a fall and spring seeded crop are used in the rotation add 0.5. If the shortest broadleaf to broadleaf interval is 2 years make no adjustment. Add 0.5 is the shortest broadleaf-broadleaf interval is 3 years or more. Deduct 0.5 for each year this interval is less than two years. Deduct 0.5 if the ideal seeding time for one crop coincides with the ideal seeding time of another segment. Examples of this interference would be deducting 0.5 if both spring wheat and barley are used. Spring wheat-Barley-Canola rotations have the same ideal seeding time for all three crops in some environments leading to two 0.5 deductions for a total discount of 1.0. Deduct 0.75 if two seeding time conflicts occur on two separate occasions. For instance, in a corn-soybeans-corn-soybeans-wheat rotation interference occurs between the two corn segments and the two soybean segments to give a deduction of 0.75. Use of deductions for seeding time conflicts need to be made based on local knowledge of the impacts of delayed seeding. Conflicts which arise due to harvesting of one crop at the same time another needs to be seeded (millet harvest and winter wheat seeding for instance) have not been included since different equipment is used and the operations can be done at different times of the day. This factor should be considered when doing a final analysis of a rotation.

Rotations with high Diversity Index Values (greater than 2.5) will provide the most workload spreading and present the least disease and weed risk. They will produce the most return only if they also have proper intensity. In some environments it may be difficult to obtain ideal levels of both diversity and intensity. In the early stages of no-till producers often have success with rotations which have proper intensity but lack diversity. Part of this is due to the fact that the land being used has not had a history of many of the crops being used (especially the broadleaf crops) so disease and weed problems have not yet developed. Another factor is that the producer's machinery is sized for a tilled system so he does not realize the potential value in adding diversity (smaller machinery or more acres). Use of both grass types and a broadleaf provides the most diversity possible especially if winter cereal is incorporated into the system.