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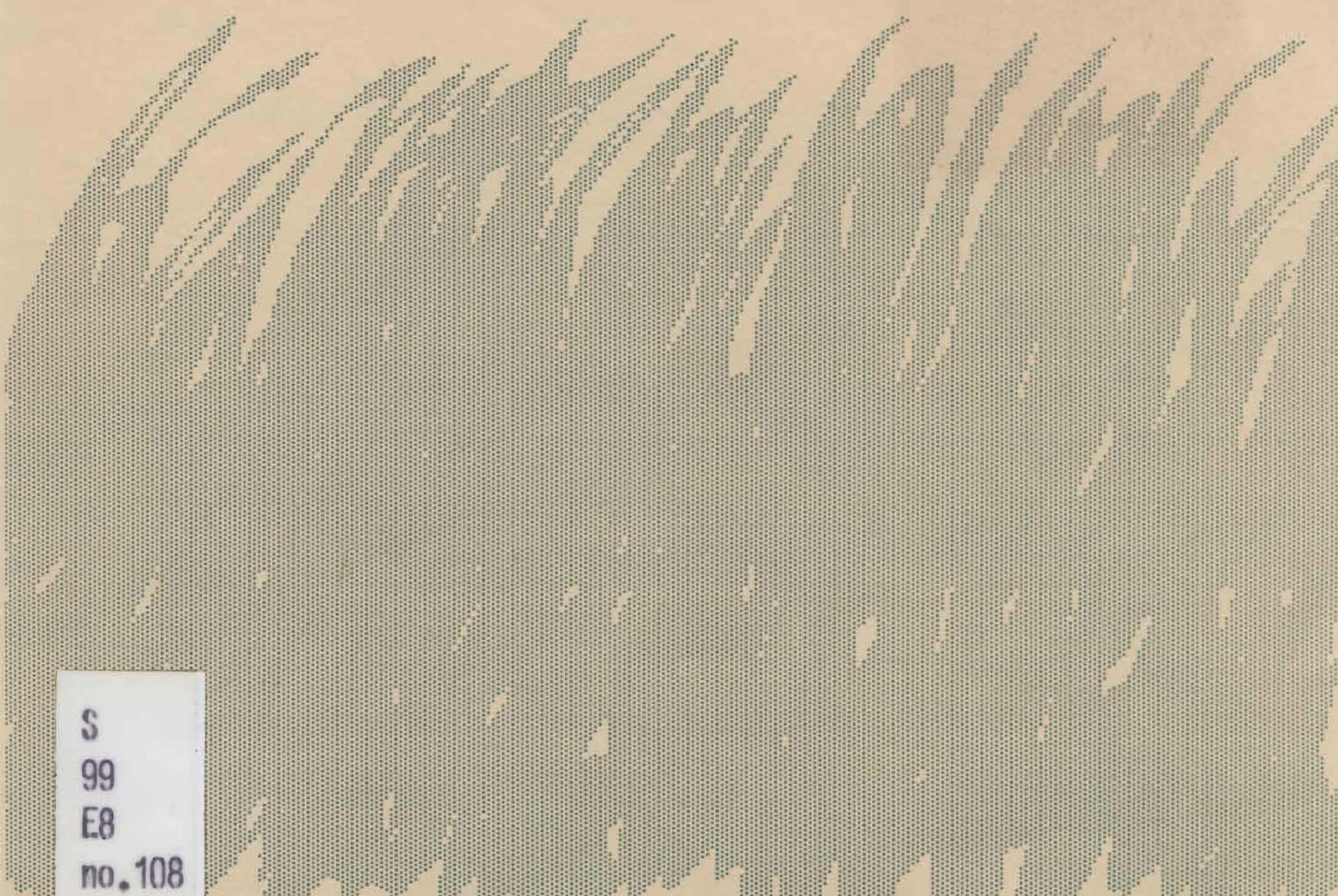
Intermediate Wheatgrass in a Perennial Cropping System for the Northern Plains



North Dakota State University
Agricultural Experiment Station

Rodale Research Center

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Intermediate Wheatgrass in a Perennial Cropping System for the Northern Plains

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This report is an introduction to a joint project of North Dakota State University and the Rodale Research Center on using intermediate wheatgrass as a perennial grain in the Northern Plains. The objectives are to explore the potential of a new cropping system that costs less, both in economic and environmental terms. Alternatives are needed, especially on marginal lands.

Research is currently underway to address many of the concerns outlined, including seed yield maintenance over time and the use of a companion legume as a substitute for nitrogen fertilizer. It is hoped that results from these and other studies will be transferable to new , higher yielding perennial species as they become available. Ultimately, we intend to quantify to what extent a perennial grass can become a grain.

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Philosophy and Theory: Why The Need for Perennial Grain Crops

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Present grain crop production is based entirely upon annuals. Given the proper conditions, these crops can produce spectacular yields and provide farmers with good profits. However, annual grains are not necessarily the best crop for all situations. On hilly or otherwise marginal land, annual crop production can lead to severe soil erosion. Such erosion not only costs the farmer in terms of lost nutrients, but it also costs society in terms of siltation and degradation of water resources. In addition to being environmentally unsound, annual crop production on such land is often economically impractical. Alternative crops must be developed for use on land that can not sustain annual crop production. The development of perennial grasses as grains could provide such an alternative.

In certain situations, perennial grains could provide a number of advantages over annuals. Production inputs should be lower for a perennial grain than for an annual. For example, mechanical field operations will be greatly reduced because the soil will not be re-worked each year, thus saving on fuel and labor costs. Seed purchases and planting will be done every four to seven years instead of every year as with annual grains. Where legumes are included with plantings of perennial grains, the need for commercial fertilizers will be reduced. In addition to soil erosion control, perennial grains could actually begin to rebuild the soil structure through increased soil organic matter, water infiltration and biological activity in the soil. Because the soil will have vegetative cover during the entire year, wildlife such as game birds and mammals could benefit.

Preliminary Research

In 1983, the Rodale Research Center in eastern Pennsylvania initiated a long term research project to investigate the potential of developing a perennial grain cropping system. Close to 100 species of perennial grasses were tested at the Rodale Research Center for their potential as grains. Selection of the most promising species were based on the following criteria:

- Seeds with favorable flavor qualities
- Production of easily threshed seeds
- Manageable seed size (> 0.2g/100 seeds)
- Synchronous seed maturity
- Shatter resistance
- Strong non-lodging seed stalks
- Seedheads held above the level of the foliage
- Drydown of seed stalks at maturity
- High potential for mechanical harvest
- Vigorous perennial growth

Based on these selection criteria, the intermediate wheatgrass (*Thinopyron [Agropyron] intermedium*) complex of species, which includes intermediate and pubescent wheatgrass, appears to have good potential for development into a perennial grain crop. These wheatgrasses produce large seeds averaging 5.3g 1000^{-1} seeds (Schulz - Schaeffer and Haller, 1987) and can be mechanically harvested and threshed using commercially available equipment. Nutritional qualities of these wheatgrass seeds are being studied by the USDA Western Regional Research Center. Nutritionally, intermediate and pubescent wheatgrasses are very similar to wheat with slightly higher protein levels (Becker et al., 1986). The grain can be ground into flour for use in flavorful baked products such as muffins and breads or cooked as a whole grain, like rice. The gluten content of these perennial grains is lower than that of wheat.

A perennial grain cropping system based on these wheatgrasses has good potential for development. The ideal system would consist of a soil holding sod dominated by intermediate or pubescent wheatgrass and interplanted with a legume to provide biologically fixed N. The legume would not be harvested for seed, but would provide additional soil cover as well as a source of nitrogen in the system. This perennial grain/legume mixture could be considered somewhat analogous to a grass/legume pasture. However, instead of the primary harvest product being the hay as in a pasture, the primary harvest product will be the grain from the perennial grass. In some areas, the perennial grain/legume fields could be used for hay production or grazed as pastures after the yearly seed harvest. Thus farmers would be able to obtain two harvest products from these fields with a minimum of inputs.

Grain yields from perennial grasses will never be as high as those from annual grains since part of the perennial plant's energy goes into production of roots rather than seed. Nevertheless, a perennial grain cropping system which is well adapted to the environment in which it is growing may be economically viable. The reduced cost of inputs will make it possible to obtain a net profit at lower yield levels. Perennial grains could be grown on marginal lands that can not, and should not, support annual crops. There is already legislation which has taken erodible land out of production. This research is aimed at providing an alternative use for that type of land. Perennial grains could, in the future, provide farmers with an economic return from land that may otherwise remain idle.

Future Research Needs

The development of perennial grains will require research in a number of areas including plant breeding, agronomy, food science and marketing. To date, some research has been conducted at the Rodale Research Center in the areas of germplasm evaluation and cultural technique development (Wagoner, 1988; Wagoner and Schauer, 1988). In addition, some nutritional quality studies have been conducted by the USDA Western Regional Research Center (Becker et al., 1986). From these preliminary tests, it appears that the area of greatest concern in the development of perennial grasses which can maintain their grain yield for a period of four to seven years. This should be addressed through two major avenues of research; 1)development of higher yielding, well adapted varieties through the use of plant breeding, and 2) development of appropriate cultural techniques for the maintenance of vigorous, high seed yielding stands.

Intensive selection and breeding efforts are necessary to develop vigorous, well adapted varieties of productive, nutritious perennial grains. Currently available varieties of intermediate and pubescent wheatgrasses which have been tested for perennial grain production at the Rodale Research Center were originally developed for their forage qualities, rather than their grain producing qualities. With thorough germplasm evaluation, selection, and breeding, varieties of intermediate and pubescent wheatgrasses possessing favorable grain producing qualities could be developed (Dewey, 1978).

Seed yield parameters must be carefully studied in an effort to develop higher yielding varieties. Yearly reproductive tiller production and seed production per spike will be important for increasing yield potential. Synchrony of seed maturity and retention of spiklets on the rachis (reduced seed shattering) will improve yield recovery. Ease of threshing seeds from the glumes is another important characteristic to consider for obtaining clean grain.

Methods of establishing and maintaining productive stands of these grains on hillsides must be developed in order to maximize yield, maintain soil fertility and minimize weed, disease and insect problems. Information developed by the seed industry for production of perennial grass seeds can be used as a model and modified for the production of grain. Establishment techniques must be developed to minimize erosion during the first four to six months after planting perennial grains. The use of nurse crops or no-till techniques could be valuable. Fertility levels for maximizing grain production must be determined. The use of legumes as a source of biologically fixed nitrogen may be an important component for maintaining fertility in perennial grain systems. Management of thatch is another area of consideration. The timely use of techniques such as grazing, mowing or burning may be critical in the maintenance of vigorous stands of perennial grains.

Preliminary nutritional and food use evaluations of the intermediate and pubescent wheatgrass grains have been conducted at the USDA and Rodale Research Center. The seeds have been ground into flour for use in highly acceptable baked products. Initial milling and farinograph studies indicate that there may be sufficient variation among the intermediate and pubescent wheatgrass germplasm to select and develop lines for different culinary purposes such as breads, pastas, cookies, etc. More in-depth tests must be conducted to determine the best uses and markets. Perennial grains will no doubt start out in a small speciality market. The development of markets for this food ingredient will have to be timed to allow supply and demand to remain in balance.

The development of perennial grain cropping systems is a long term prospect. The participation of individuals from a broad range of disciplines is necessary to make the development of perennial grains possible. In addition to agricultural researchers, farmers will play an important role in developing appropriate cultural techniques. On-farm testing of perennial grain varieties will help determine adaptability and play a major role in the varietal selection process. The food industry must also be involved in the development of products and markets for perennial grains.

Perennial grain cropping systems could provide many environmental benefits through the reduction of soil erosion as well as the reduction of inputs necessary to produce grain crops. This process is not simply the development of a new crop, it is the development of a whole new approach to grain production on erodible land based on perennial rather than annual herbaceous plants. The development of perennial grains is an important step toward the regeneration of our soil and water resources.

References

Becker, R., G.D.Hanners, D.W.Irving and R.M. Saunders. 1986. Chemical Composition and nutritional qualities of five potential perennial grains. Food Science and Technology. 19:312-315.

Dewey, D. 1978. Intermediate wheatgrasses of Iran. Crop Science. 18:43-48.

Schulz-Schaeffer, J. and S.E. Haller. 1987. Registration of Montana - 2 perennial *Agrotricum* germplasm. Crop Science.

Wagoner, P. 1988. Perennial grain research at the Rodale Research Center - 1987 Summary, Rodale Press, Inc. Emmaus, PA.

Wagoner, P. and Schauer, A. 1988. Perennial grain production trials at the Rodale Research Center - 1987 Summary, Rodale Press, Emmaus, PA.

The Biology of Annual and Perennial Grasses in the Plains

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The Great Plains covers a large area of the central U.S. and includes two major ecological regions: the mixed (short, mid, and tallgrass) prairie and the tallgrass prairie (Fig. 1). Native plant species in these regions give us many clues as to the kind of agriculture which has developed. Early pioneers used big bluestem (*Andropogon gerardi*) as an indicator of land suitable for corn. Their western neighbors found western wheatgrass (*Agropyron smithii*) range best for wheat. Indeed, there is a link between the perennial native grasses and today's agriculture consisting of annual plants.

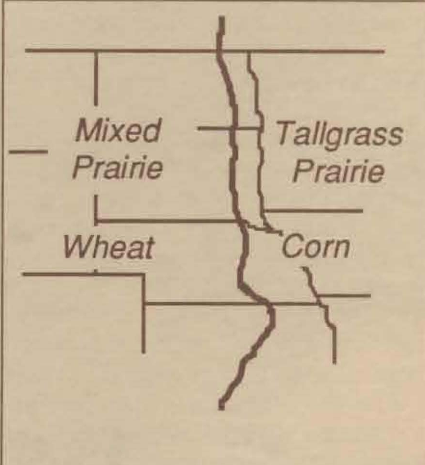

Fig 1. Perennial and annual plant regions of the Northern Plains.

If we are to be successful in developing agroecosystems with perennial grains as most recently described by Jackson (1985), we must reexamine our agricultural science of the past century, in a sense, plodding backwards. Will intermediate wheatgrass (*Thinopyrum intermedium*) be suited to areas where wheat/fallow is predominant? How do we manage wheatgrass for seed and erosion control? Can we afford the loss in grain yield from a perennial plant so that it can perpetuate itself? The remainder of this discussion will focus on the differences in physiology and ecology of annual and perennial grasses as grain crops in the Northern Plains.

The Physiology of Annual and Perennial Grasses

The family of plants known as the grasses (*Gramineae*) are among the most widely adapted species known. Their unique shape and structure, with long, narrow, and erect leaves, as well the location of the meristems, being located at the base of the leaf, allows grass species to be easily illuminated, burned, grazed, and mown with little lasting damage. Both annual and perennial grasses have similar methods of obtaining resources such as nutrients and water and producing photosynthate. Where they differ is in the allocation of energy needed for reproduction.

Growth curves and dry matter partitioning of wheat in the Great Plains are well documented (Waldren and Flowerday, 1979; Bauer et al., 1987). The seed germinates and root and leaf growth are begun. Root growth continues until near anthesis. At this point, the reproductive strategy of wheat's annual habit takes over. The production of seed is of primary importance. Thus, leaves, stalk, and roots now serve the developing seeds, exporting stored metabolites and water. Ultimately, seeds are produced which typically consist of at least half of the total dry matter produced during the entire season.

A perennial grass behaves much differently. Once established, a seasonal cycle of dry matter allocation is begun. Reserve carbohydrates stored in the crown and lower internodes of the plant are used in early spring to initiate new leaf growth. As new leaves develop, they first supply the needs of additional leaf area. Once a sufficient canopy is produced, excess photosynthate is then allocated to storage carbohydrates until just before flowering. Though reserve carbohydrates are usually found to be depleted for a short time during flowering and seed-set (Fig. 2), many studies (Sampson and McCarty, 1930; Weinmann, 1948; McKendrick, 1971) have shown the decline due to rebuilding of the root system and not as a result of seed formation. Unlike annuals, established perennials seem most likely to renew their investment in roots during a time of little vegetative development, which occurs during and after flowering. At least one fourth of the total root biomass is renewed each year. After the root system is rejuvenated, reserve carbohydrates, not the developing seeds, are the principal destination for photosynthate.

Recent studies of perennial grass physiology suggest the dynamics of resource allocation (carbohydrate, nitrogen, water, etc.) contribute far more to the competitive ability and longevity of perennial grass stands than do total amounts of carbohydrate stored (Caldwell et al., 1981; Richards and Caldwell, 1985).

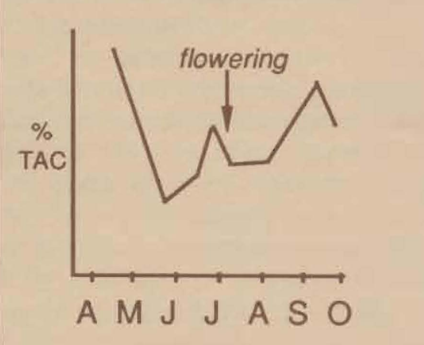

Fig 2. Percent Total Available Carbohydrates in storage organ of cool season grass by month.

Two distinctly different internal plant economies are evident (Fig. 3). The annual lives for the seed and the perennial lives in spite of it. The perennial has three needs not found in annuals, all of which add up to a significant physiological cost. They are: 1) maintenance of the carbohydrate storage organ itself, living tissue which is largely non-photosynthetic 2) storage carbohydrate to

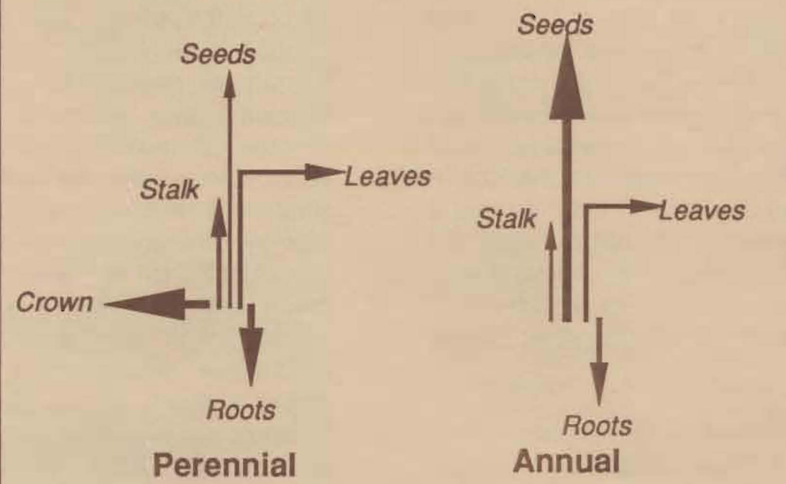

Fig 3. Relative allocation of resources among plant tissues between perennial and annual grasses.

fill the storage organ and permit perenniality, and 3) the energy required for remobilization of nutrients and carbohydrates to thestorage organ. Physiologically, the ability to both produce high seed yields and store enough carbohydrate to insure winter survival and vigor seems a major consideration in the successful development of a perennial grain. A better understanding of the dynamics of growth is needed for both the development of promising perennial species and the strategies that will be required to manage them as grains.

Grass species on both ends of the spectrum are most common today. Intermediate wheatgrass is one of the better compromisers presently available, striking somewhat of a balance between longevity and seed yield. Even with this species, however, seed yields will have to be increased to provide an economically viable alternative to annuals on marginal lands. Perhaps some of the more promising perennial species will be the result of work such as Schaeffer and Haller's (1986) who have made crosses of wheat and wheatgrass. A successful perennial grain will have to be capable of a relatively high productivity level to satisfy producer needs and proper management will play a large role in maintaining that productivity.

Ecology of Annuals and Perennials in the Northern Plains

Grasses native to the Northern Plains are a product and indicator of the physical environment. The combination of low but highly variable rainfall and high evaporation make the Plains a hostile environment for seedlings. It is no coincidence that perennial grasses are native, most of which reproduce not by seeds but by rhizomes in the eastern Plains and by tillering in the western Plains. Over time, these methods are far more successful than seeds in this environment. Even the few seeds that are produced by the native grasses possess a wide variety of dormancy and longevity mechanisms which spread germination over many years.

Annual grasses served as the opportunists before agricultural annuals were introduced. An opportunist establishes itself quickly in areas where soil is disturbed. Opportunists are often called weeds. They are fiercely competitive for a short period of time while gathering their resources to make seed, but after this period they die. Perennials are dominant in the Plains after an initial colonizing period of annuals because they don't require large flushes of nutrients or water. Perennials develop a deeper root system then annuals and build up a reserve of carbohydrates for energy. Perennials do require the same inputs as annuals, such as nitrogen and water, but spread the acquisition of these needs over a long period of time. There is a compounding effect of this timing of resource needs and perennial grass growth. This results in nutrients and other resources largely available in cycles and thus only cyclically usable by plants. The slow release of these bound resources thus satisfies the perennial but not the annual.

Thus, both the physiology and the ecology of perennials and annuals differ. Perennials need to spend energy on reserve carbohydrates and rebuilding root systems. Annuals spend as much as possible on the seed. Over time, annuals will gradually exhaust the resources which are required for growth, and if these resources are not replenished, will eventually decrease in abundance. Perennials, in both the individual plant growth or physiological sense, and in their abundance or ecological sense, start slowly. The strategy is not to capitalize on every opportunity to acquire nutrients or water, but instead to simply survive and slowly multiply.

The Development of a Perennial Grain

The impact of a significant acreage of the Northern Plains planted to a perennial grass for grain production would be obvious. Planting would only occur every five to ten years. The undisturbed soil surface and the sustained growth of the fibrous root system would increase organic matter, improve soil structure, and reduce erosion. Nutrients would be largely bound in microbial pools and slowly released. The agroecosystem of the perennial, if managed properly, would perpetuate, instead of exhaust, itself.

Development of such a system, however, has significant obstacles. New species must be bred to improve the balance between seed production and over-wintering ability. Management techniques will also have to be discovered which will encourage seed production and maintain the longevity of high seed yields. Though difficult problems, they seem ideally suited for application of our new knowledge in genetic engineering and the biological sciences.

References

Bauer, A., A.B. Frank, and A.L. Black. 1987. Aerial parts of hard red spring wheat. I. Dry matter distribution by plant developmental stage. Agron. J. 79:845-852.

Caldwell, M.M., J.H. Richards, D.A. Johnson, R.S. Nowak, and R.S. Dzurec. 1981. Coping with herbivory: Photosynthetic capacity and resource allocation in two semiarid *Agropyron* bunchgrasses. Oecologia 50:14-24.

Jackson, W. 1985. New roots for agriculture. University of Nebraska Press, Lincoln, NE.

McKendrick, J.D. 1971. Big bluestem and indiangrass vegetative reproduction and critical levels of reserve carbohydrates and nitrogen. PhD Dissertation. Kansas State University, Manhattan, KS.

Richards, J.H. and M.M. Caldwell. 1985. Soluble carbohydrates, concurrent photosynthesis and efficiency in regrowth following defoliation: A field study with *Agropyron* species. J. Applied Ecol. 22:907-920.

Sampson, A.W. and E.C. McCarty. 1930. The carbohydrate metabolism of *Stipa pulchra*. Hilgardia 5:60-100.

Schaeffer, J.S. and S.E. Haller. 1986. Registration of Montana-2 perennial X *Agrotriticum intermediodurum* Khizhnyak. Crop Sci. 27:822-823.

Waldren, R.P. and A.D. Flowerday. 1979. Growth stages and distribution of dry matter, N, P, and K in winter wheat. Agron J. 71:391-397.

Weinmann, H. 1948. Underground development and reserves of grasses. J. Brit. Grassland Soc. 3:115-140.

Contrasting Production Practices of Annuals versus Perennials

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The initial perception of a perennial farming system is that of few equipment needs, greatly reduced direct inputs such as fuel and pesticides, and a surplus of labor. This concept stems from our initial reaction of visualizing the whole system being dedicated exclusively to either annual or perennial crops. This is to be expected since the only perennial crop systems common in the Northern Plains are alfalfa or native range. The image of the equipment and cash flow necessary on a ranch in the western Dakotas versus a Red River Valley farming operation might be brought to mind. It is questionable however, if we will ever have individual farms that deal exclusively with perennials. What is possible is a farming system where the highly productive land is dedicated to an annual crop rotation, while the highly erodible, lower producing acreage will be planted to perennials. Costs of production of the whole farm can thus be reduced to the extent of the proportion of acreage within the perennial system. This system, that of producing both annual and perennial grain crops on the same farm, will require high levels of management and expertise.

The Inputs of Time and Skill

Annual crop production systems can be typified as an intense series of management decisions. Each decision is normally associated with a particular phase of crop growth and is repeated every year. Most decisions also have the potential to determine the success of the crop. This is based on observing varied outcomes from many different individual production practices given similar environments.

Experienced producers can easily recall circumstances from recent growing seasons where a single management decision or combination of decisions resulted in poor results and a loss of income. Many cultural decisions must be made during the season based on ever changing environmental conditions. The final yield and net income per acre are determined by the level of accuracy by which each individual management decision is made. Success among farmers is determined by the level of overall skill they possess in both the business and the biology of agriculture.

Lack of time to thoroughly assess a given situation is often the reason improper management decisions are made. This is particularly true with the production of annual crops in the short growing season of the Northern Plains. Here, individual farms will produce four to six different crops, each with its own set of optimum production techniques. The combination of crops and associated intertwining of production practices creates an intense atmosphere for decision making. The intensity may strain the producer's management skills and heighten the opportunity for inaccurate or improper decisions.

Management decisions can be classified as either design or control decisions (Hart, 1984). Design decisions are those made in the off-season that determine the plan of an individual's farming system. Crop rotation, cultivar, yield goals, etc. are examples of design decisions. Control decisions are the skills of management that are required during the growing season. Rainfall, temperature, pest prevalence, and markets are some of the unknown factors which constantly influence and require control decisions. With perennial cropping systems one design decision will be carried out over several years. Control decisions will also be required less frequently.

Differences In Management Requirements Between Perennial and Annual Cropping Systems

	Perennial Crops		***Annual Crops***
Year 1	Design of Cropping System	*Yearly*	Design of Cropping System
	Control of Cropping System		Control of Cropping System
	seedbed preperation		soil fertility mgmt
	fall planting		seedbed preperation
Year 2	weed mgmt		spring planting
	seed harvest		weed mgmt
Year 3 - ?	residue harvest		insect / disease mgmt
	soil fertility mgmt		harvest
			residue mgmt

Grain production with perennial crops offers a stark contrast to annual cropping practices. As the crop is established initial management decisions will be similar, both in number and importance. Field operations and management may be greatly reduced in subsequent years, however, limited to maintenance and grain harvest. In fact, we may discover very few field operations will be necessary on an annual basis within a perennial system. It is foreseeable that the only operation in certain years may be that of grain harvest.

The amount of management associated with perennial crop acres will also be influenced by whether the producer is strictly involved with crops or is diversified with livestock. A diversified producer will have at least one additional field operation per year, residue or straw collection. This added dimension may be well worth-while, however, increasing net profits and expanding the biological diversity within the crop production system.

A whole farm system consisting of both annual and perennial crop production will have a shift in the distribution of the workload. An annual system demands intensive management of each acre. The farm with both annuals and perennials should provide additional management time made available from the reduced requirements of the perennials. This additional time could be targeted toward the annual crops and theoretically reduce the number of inaccurate decisions. Resultant profits from annual crops should increase. A production system with both annuals and perennials may be complementary, but will require a change of emphasis with new skills to be mastered.

Cultural Practices: The Annuals

Most individuals involved with Northern Plains agriculture are familiar with the production practices associated with annual crops. Though the types of operations are similar among crops, implementation of the practices varies. Proper planting date and rate, herbicide, fertility and other factors are different with each crop. Planning annual crop production begins with placing each crop in the best sequence possible. Benefits of proper crop rotations are well accepted. Selection of crop cultivars is an important procedure requiring time spent in the winter months interpreting the latest performance trial results. Proper cultivar selection will buffer many potentially damaging environmental influences such as outbreaks of plant disease, insects and harvest difficulties. Differences among varieties can also affect the market price and strategy.

The weeks preceding planting can be characterized as very intense, especially when the planting of two to three crops coincide. During this short period of time, the seedbeds are prepared, fertility levels are established, herbicides may be applied, plant densities are determined and finally the seed is planted at a time and depth thought best for the current season. Actual distribution of the workload will vary with each producer's level of expertise, availability of labor, equipment and location. Production techniques practiced early in the season will have a profound effect on the annual crop's establishment, health, and initial yield potential.

Once the crop has emerged, the final yield will then depend on the season's environment and how skillfully the producer can manage pests and recognize nutritional imbalances. Management of weeds, diseases, and insects is the predominant farming activity between planting and harvest. Mid-season maintenance may include practices such as split applications of fertilizer.

The final production phase is the grain harvest. The effort put forth depends upon the crop, but may include windrowing, threshing and drying. Actual procedures vary and rely on the producer's skill at matching equipment and labor with crop and weather conditions.

Soil tillage associated with an annual crop system will depend upon which crops are included in the rotation, the level of dependence on herbicides, equipment, and choice of residue management options. Most tillage systems in the Northern Plains include at least one fall tillage after harvest, often two in years of an extended fall. The following spring up to three tillage operations are used before the next crop is planted. In the case of row crops, one or two cultivations are also usually implemented for weed control.

Cultural Practices: The Perennials

Field operations required in the year of perennial establishment will be very similar to production of annual crops. The process of seedbed preparation, seeding rate, fertility and weed control will all need consideration. Pest control and maintenance will be important decisions since it is believed that these operations will determine both the useful life of the stand and annual production levels. The traditional techniques of grass seed production, such as wide rows and ample fertility, may not be suited to growing grasses as grains on erodible land. The best techniques will be determined over time through field experience and research.

Pest control in perennial crops may not be a significant problem. Herbicide use may be similar to annual crops the first year, however, a competitive crop stand should prevent weed problems thereafter. Potential disease and insect problems will depend upon the grass being grown. The most promising perennial grasses do not have significant susceptibility to many of the common diseases of annuals.

Maintenance operations will include soil fertility and residue, or thatch, removal. Fertility can be maintained with a large quantity of phosphorus and potassium applied prior to establishment. Nitrogen requirements could be met through annual applications of manure or fertilizer. Research is currently underway to determine if a legume, growing in companion with the perennial grain, can provide the nitrogen needed to sustain grain yields.

Residue maintenance must be conducted after grain harvest. Residue removal or reduction may be necessary in the eastern portion of the Northern Plains to prevent thatch accumulation and to promote fall growth. This may include mowing, burning, grazing or haying. Grain harvest itself will involve operations similar to those in an annual system.

The most significant management decisions made within a perennial cropping system are going to be those which influence the productive life of the grass. Much data have been collected which indicate that grass seed yields are reduced substantially after two to four years. New production techniques or grass species must be discovered to increase the life of the perennial grass. As is clearly evident in the economic analysis, the longer acceptable yields can be obtained from a perennial grass the more economically competitive with annual cropping systems it becomes. This is a major objective of current research.

In summary, the inputs required initially are similar between perennial and annual systems of crop production. Thereafter, the perennial system will require far less labor and cash inputs. In addition, the perennial system may prove to be much less sensitive to the annual level of management devoted to it as compared to annual crops. This may benefit the entire farming operation by stabilizing yields and providing time necessary for optimum management of annual cropping systems.

References

Hart, R.D. 1984. Agroecosystem determinants. in Agricultural Ecosystems, R. Lowrance, B.R. Stinner, and G.J. House, eds. John Wiley & Sons, NY

Economic Feasibility of A Perennial Grain: Intermediate Wheatgrass

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Environmental, biological, and farm-level sociological comparisons have been made between a perennial and annual cropping system on the Northern Plains. Possibly of greatest concern, at least in the short term, are the economic comparisons between the two systems. The following is an analysis of the key factors that would influence the needed market price to sustain the culture of intermediate wheatgrass as a perennial grain.

Budget Details

To be economically viable, the cost of establishment must be recovered during the life of the stand. There is much discussion of the best way to establish a good stand with respect to nurse crops, costs and revenues. In this study, no nurse crop is included. As research continues, the calculations can be performed with greater accuracy as appropriate. Table 1 shows the cost of establishing a perennial grain. Table 2 details the annual cost of the grain crop by crediting the operation with the return from hay harvested.

It is expected that higher seeding rates and higher forage yields are probable the farther east in the Northern Plains the crop is raised. Depending upon dry climate performance, intermediate wheatgrass may be most competitive in the western region, on lands traditionally fallowed in alternating years. Thus, the budgets presented here are hypothesized for the western end of North Dakota. Adjustments to the cost calculations can be made using this paper as a guide.

Costs calculated in this analysis follow the work of Johnson et al. (1986). In the following discussion it is assumed that an existing farmer would plant only part of the farm to perennial grain. Total costs are calculated because it is also assumed that this enterprise will become a standard part of the farm's crop rotation. With only part of the total farmland in perennial grain there should be only a slight adjustment in the needed machinery complement. This reduction in machinery needs is ignored in the analysis. The establishment of intermediate wheatgrass requires a firm seedbed, common to that of many other crops in North Dakota. The costs of establishment are thus generated from that experience.

Two computer budget generators (Kletke, 1979; Edwardson, 1987) were used to generate these budgets. Variable costs are calculated for the month incurred. Interest on operating capital is calculated using a rate of 13.5 percent multiplied by the time the capital is needed. For the establishment budget, interest is calculated to the end of the calendar year. The capitalized cost is the annual payment required to pay off the total establishment cost at the ownership interest rate for payments lasting over the lifetime of the stand established.

Machinery variable costs are repairs and fuel. They are a per hour cost times the number of hours required to produce the crop. Labor time is calculated as 1.1 times tractor hours plus 1.2 times self-propelled machines.

Ownership costs are those costs that do not change with annual machine usage. They are costs that result from ownership of a specified machinery complement for the farming operation. Ownership costs include machinery replacement cost, interest, and insurance. Interest is calculated by multiplying the average capital invested by 9 percent.

Land charge is calculated as a cash cost for the region. Although land is often rented on a share basis, the cash equivalent is calculated and charged as if it were a cash charge. No cost was imputed for management in these budgets.

The Results

The yield potential of intermediate wheatgrass as a perennial grain on marginal lands is speculative at this time. It is reasonable to expect yield to decrease for older stands, reaching some point where it will be economic to re-establish or rotate to other crops. Average yield and longevity of the crop greatly affect the breakeven price (Table 3). A breakeven price over 20 cents per pound would need a dedicated specialty crop market. A price below 6 cents per pound could penetrate existing markets. This analysis illustrates the importance of current research aimed at increasing the productive life

The combination of hay and grain as a dual product is an added incentive for mixed crop-livestock operations. The hay/grain characteristics of wheatgrass also provide flexibility in varietal development and selection. Hay and grain prices do not always move together and thus aid marketing as weather and prices vary. And, as already mentioned, utilization of the leftover forage may be required to insure stand longevity.

It is feasible that conservation interests will subsidize or legislate perennial grains on marginal lands because of the conservation benefits. A subsidy could make perennial grains immediately competitive with existing food grains.

Table 1. Intermediate wheatgrass establishment costs for western counties of North Dakota.

	Units	Price per Unit	Quantity	Cost Per Acre	Annual Cost
Variable costs:					
Seed	Pounds	$2.00	7.00	$14.00	
Nitrogen	Pounds	0.14	0.00	0.00	
Phosphate	Pounds	0.18	0.00	0.00	
Herbicide & insecticide	Acre	1.00	2.00	2.00	
Repairs	Acre			7.01	
Fuel-gasoline	Gallons	.90	1.63	1.47	
Diesel	Gallons	.96	4.85	4.66	
Lube (15% of gasoline and diesel)				.92	
Labor	Hours	5.00	1.85	7.90	
Interest on operating capital	Dollars	0.135	12.52	1.69	
Total variable costs				$39.64	
Ownership Costs:					
Capital replacement				10.00	
Insurance				0.89	
Interest	Dollars	0.09	68.44	6.16	
Total ownership costs				$17.05	
Other costs:					
Land charge				$15.00	
General farm overhead				4.18	
Total other costs				$19.18	
Total establishment cost				$75.87	
Capitalized Cost over lifetime of 8 years					$13.71

Table 2. Intermediate wheatgrass costs and returns for western counties of North Dakota.

	Units	Price Per Unit	Quantity	Cost Per Acre	Cost Per Pound of Production
Variable Costs:					
Nitrogen	Pounds	0.14	30	4.20	
Custom combining	Acre	15.00	1	15.00	
Baling	Acre	8.90	1	8.90	
Hauling	Acre	7.00	1	7.00	
Labor	Hours	5.00	0.45	2.25	
Interest on Var. Cost		0.135	1.39	0.19	
Total Variable Cost				$37.54	
Other Costs:					
Land charge				$15.00	
General farm overhead				4.18	
Total other costs				$19.18	
Annual Production Cost				$56.72	
Credit for hay harvested	Tons	$40.00	1.0	40.00	
Total of above costs				$16.72	
Yield per acre	Pounds	100			
Break even price for established crop					**$0.17**
Cost per pound including establishment costs					**$0.30**

Table 3. Break-even price in cents per harvested pound of intermediate wheatgrass grain.

Years Harvested	Annual average pounds per acre yield: 100	200	300	400	500	600
4	40.1	20.1	13.4	10.0	8.0	**6.7**
6	33.6	16.8	11.2	8.4	6.7	**5.6**
8	30.4	15.2	10.1	7.6	**6.1***	**5.1**
10	28.5	14.3	9.5	7.1	**5.7**	**4.8**

** numbers in bold represent break-even prices which are competitive with spring wheat.*

References

Asay, K. H. and R. P. Knowles. 1985. The Wheat grasses. Forages:The Science of Grassland Agriculture. Heath, Maurice El, Robert F. Barnes and Darrel S. Metcalfe, eds. Iowa State University Press.

Edwardson, S. E. and H. G. Hughes. 1988. COMPBUD - A Computerized Crop Budget Generator for North Dakota Agriculture. Software Users Guide #5, NDSU Extension Service, Fargo, ND.

Johnson, Roger G., Mir B. Ali, David M. Saxowsky, Randall D. Little, Cost of Producing Farm Commodities in North Dakota. Agricultural Economics Misc. Report No. 90, Department of Agriculture Economics, NDSU, Fargo, ND, January 1986.

Kletke, Darrel D. 1979. Operation of the Enterprise Budget Generator. Research Report P-790. Oklahoma State University, Agricultural Experiment Station, Stillwater, OK.