Special Crops Conference

Proceedings

November 1, 2 & 3, 1998, Delta Edmonton South, Edmonton

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Special Crops Conference

*Opportunities and Profits II
Into the 21st Century*

*November 1, 2 & 3, 1998
Delta Edmonton South, Edmonton*

Presented by the Special Crops Product Team

Conference Partners

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Foreword

New Crops, New Opportunities

Continuing interest in the development of new crops in Alberta reflects the biological, economic and environmental factors which constrain the province's agricultural systems. We are seeing an interest in the development of new crops for food, animal feed, energy, fiber, pharmaceuticals, industrial feedstocks and ecological reclamation. This may not be surprising, because although we only have 20-30 world crops which make up over 90% of agricultural production, we still have vast natural resources which are currently unexploited. Vietmeyer (1988) reported that the global inventory for plant resources included:

- ▶ 3,000 tropical fruits
- ▶ 10,000 grasses
- ▶ 18,000 legumes
- ▶ 1,500 edible mushrooms
- ▶ 60,000 medicinal plants
- ▶ 2,000 species with pesticidal properties
- ▶ 30,000 tree species

While we know that most of these species will not flourish in Alberta, there is currently a substantial amount of research to indicate that select crops can be productive in our environment. The evaluation process for potential new species is an on-going activity in the New Crop Development Unit of Alberta Agriculture, Food and Rural Development (AAFRD). The attraction of diversification of new crops for Alberta is the reduction of both environmental and economic risk. In recent times, the pressure to find sustainable crop rotation systems has also led to the increased growing of pulse crops such as field pea.

The move away from a narrow range of large-scale agricultural crops reflects a current agricultural trend throughout the world. New crops research and production is making great strides in Europe, Australia and North America. In the United States, a group of researchers, processors and producers have brought forward the Thomas Jefferson Initiative, which "is being developed as a U.S. national research and education program which will take a comprehensive, coordinated approach to diversifying cropping systems". The Initiative "is intended to involve a variety of public and private sector partners in overcoming the barriers that exist to new crop development and commercialization". The Initiative is named for Thomas Jefferson, who wrote that "the greatest service which can be rendered any country is to add a useful plant to its [agri]culture".

The Opportunities and Profits Conference was organized by the Special Crops Product Team (AAFRD) to provide information regarding new and exciting crop diversification opportunities. I think it was a credit to the speakers that they included both the positive and negative points associated with their crop or industry. It is important that we all continue to be realistic about

what is possible when we advocate crop diversification. The danger of overstating opportunity and understating risk does not serve the agricultural industry well. Experience has shown that successful new crop development is a strong combination of production research, market knowledge and commitment to quality. However, the most important element is a strong champion. The greatest success stories have come from individuals and groups who have seized an idea and used their ingenuity and energy to make it work.

The organization of this book follows the agenda used at the conference. The first section provides an international, national and western Canadian overview of crop diversification. The second section is a comprehensive collection of presentations in the four focus areas: pulse crops, medicinal plant production and marketing, alternate field crops (using conventional equipment) and potential "next millennium" crops. The final section includes concrete information for how to develop some of the ideas that were raised at the conference. Sources of funding, technical information and support, business planning and an explanation of the potential for value-adding in Alberta were provided to provide a basic road map for those interested in diversification.

I would like to personally thank all of the registrants, speakers, organizers and sponsors who made the conference such a success. I look forward to the continued success of crop diversification in Alberta.

Stan Blade, Ph.D.
Chair, Conference Technical Agenda
Leader, New Crop Development Unit (AAFRD)

Opening Address

Doug Radke
Deputy Minister
Alberta Agriculture, Food and Rural Development
Edmonton AB

- ▶ Thank you Wayne for those remarks and good morning ladies and gentlemen.
- ▶ A warm western welcome to all our delegates, and guest speakers and especially those who traveled across the province, and country, and in some cases the U.S. to join us for the Special Crops Conference.
- ▶ We hope you will extend your stay beyond Tuesday so you can explore our magnificent province and get a good feel for the most modern and northerly metropolis of it's size in the world. You can tell, we happen to love our beautiful city of Edmonton and this vibrant, buoyant and exciting province.
- ▶ This conference is sponsored by The Special Crops Product Team, Alberta Agriculture, Food and Rural Development and a wonderful group of conference partners from both the private and public sectors. We will thank them a little later.
- ▶ These organizers have been intensely busy the past few months setting up some of the top experts in the special crops and the value-added fields to bring you a dynamite information filled two days.
- ▶ As entrepreneurs, speakers, producers and processors, you are here to obtain and share new and vital information related to field scale production, processing, value-added and marketing of special crops.
- ▶ You will learn about what buyers are looking for, why diversification is important in Canada and Alberta, what's new, and how to develop new value-added crops.
- ▶ For the next two days you will be exploring everything from *Why is Diversification Important to Canada to Medicinal Plants, Value-Added Engineering, and What's Happening in Food 'Retailing?*
- ▶ There are four information packed sessions scheduled: a *Pulse Session; Medicinal Plants Session; Alternate Field Crops and The Next Millennium Sessions*. With all this great information, concurrent sessions will be repeated this afternoon and Tuesday morning so that you don't miss out on any.

- ▶ It's no surprise the Special Crops Industry has totally taken off in Alberta. Twenty-five years ago, there was very little in the way of value-added non-food processing.
- ▶ Today in this province, the industry has about 3,700 producers, and the estimated farm gate value for special crops in 1997 exceeded \$140 million.
- ▶ It has become an increasing part of the Alberta cropping sector, with special crops planted in some 700,000 acres in 1997, and in excess of 800,000 acres this year.
- ▶ Why has this industry seen such growth? There are several key drivers. Social and health-related consumer factors are the main reason for industry growth.
- ▶ Another factor is the higher demand for organic and speciality crops. This is causing many new varieties to be grown such as Echinacea, ginseng, garlic, bird seed, pulses, peas and others.
- ▶ Seventy-five per cent of the peas which are pulse crops, flow into the feed market. It is becoming important as part of a crop rotation and a strong product force.
- ▶ Information and technology will drive new market opportunities such as Organics - a driving force for the human food market.
- ▶ Crop prices and market stability are other key factors in adoption of alternative crops and will greatly affect the annual acreages grown.
- ▶ Currently in Alberta, the leading crops are field peas, mustard, sugar beets, colored dry beans and lentils. Most special crops are, at least in part, produced under contract or for direct marketing.
- ▶ As well, crops such as mustard, sugar beets and herbs and spices are subject to considerable value-added processing, while other crops such as sunflowers, lend themselves to consumer marketing.
- ▶ The crops that need further research and technology transfer in order to develop into cropping alternatives for producers, include grain corn, safflower, caraway, essential oils, borage, canola, buckwheat, chick peas, faba beans, coriander, fenugreek, herbs and spices and speciality grains.
- ▶ New emerging special crops that you are going to hear a lot about this week include medicinal plants, fibre hemp, nutraceuticals and ginseng.
- ▶ The work required to develop these new crops includes screening and adaptation studies and technology transfer.

- ▶ The University of Alberta, with a number of government labs, other universities, the Leduc Food Processing Centre and industry partners, have a business plan in place to develop a national Centre to focus on this new and important market. Alberta Agriculture supports this endeavour and will continue to do so.
- ▶ I mentioned New Special Crop opportunities that have production potential in Alberta. The department held two symposiums on "Hemp" in early spring. Proceedings on the two symposia are available from our department.
- ▶ In the session on The Next Millennium you will hear the author Dr. Stan Blade, from the department, talk about 1998 Research Results: Is There Hope For Hemp.
- ▶ The Body Shop is one example of a retailer that believes so. They have an entire new line of hemp derived cosmetic products from cleansers to moisturizers, and you are going to see a lot more of this in the future.
- ▶ There's no doubt that this hardy fibre hemp is capable of being a crop in Alberta and that both fibre and oilseed can be sold from the same crop.
- ▶ Fibre from Alberta research plots has been used in on-going processing research for fibre board construction, and paper making. Studies have also been conducted on textile strength.
- ▶ Canadian producers have to look at the entire picture when they assess the potential for fibre hemp. The crop has had a long and useful history. The question is will it find a place on prairie fields in the 21st century. All these questions and more will be answered in the next few days.
- ▶ Just a reminder that the Special Crops Product Team produced a new Special Crops Directory with support from Alberta Agriculture, Food and Rural Development. You will find copies here (in your registration kits/at the display tables.) Be sure to get a copy.
- ▶ The Team has also produced a business plan to lead department activities in Special Crops, consistent with industry objectives, in response to diversification, and value added and market place opportunities. This Conference, is part of their ongoing goals to communicate with you.
- ▶ Just before I go, I would like to take this opportunity to ask you to join in with me to say thank you to the organizers and sponsors for all their dedication, hard work and efforts to make this conference a reality.

- ▶ Corporate partners include: the Bank of Nova Scotia; Lipha Tech Inc.; the Special Crops Business Unit at Alberta Pool; Uniroyal Chemical Ltd.; the Farm Business Management Program, and the Economic Services, Plant Industry, and Regional Advisory Services Divisions at Alberta Agriculture, Food and Rural Development.
- ▶ Much success to all of you this week.. I know you will have a stimulating and challenging time. That's what this conference is all about. Thank you.

The Potential for Crop Diversification in the New Millennium

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During the past 30 years in North America, the use of "natural" products has dramatically increased interest in medicinal and aromatic plants and other specialty crops for use as food preservatives, pharmaceutical compounds, seasonings, and flavorings. This increased interest has been driven by shifts in food preferences (supported by increased immigration from several Asian and Spanish speaking countries), a new openness about the use of alternative medicines (as efficacy is validated), and a need for new bioactive compounds (to meet medicinal and industrial needs). In addition, new roles for plants traditionally classified as medicinal and aromatic have developed in environmental protection, land reclamation and preservation, pollution control, and a host of other applications. Casual observations suggest that grocery stores, pharmacies, and convenience stores in the US are currently devoting considerable more shelf space to medicinal and aromatic plants and plant extracts than at any time in the recent past.

As the new millennium approaches, numbers of farmers in North America have been subjected to financial pressure due to low monetary return on investment in "regular" crops such as corn, wheat, soybeans, and other field crops (Table 1). Interest in "alternative" or "new" crops with relative "high" market value has been seen as a possible method to save farms, bringing increased revenues. The goal of diversification is to develop economically viable farms.

The concept of new or alternative crops in a diversification program can be defined in several ways. For example, an alternative crop could be the production of a commonly grown, regular crop having new genetic traits or the use of new production techniques. An alternative crop could be a crop frequently grown in other locations, but new to the farm. In such instances, the premise of new crops is the thought of higher gross and net return to the farm.

Table 1. Leading crops in U.S.

Crop	Production
Corn	79.2 million acres
Wheat	70.3 million acres
Soybeans	61.7 million acres
Cotton	13.7 million acres
Soybean	9.8 million acres
Sunflower	3.6 million acres
Rice	3.4 million acres

In North America, two agricultural model systems have developed: industrial and ecological. Industrial farms are relatively high technology, cultivated systems being practiced by companies or growers with relatively large farms and that utilize power tillage operations and multiple fertilizer and pest control operations. Ecological farms, generally associated with local area producers with relatively small farms, attempt to minimize expensive inputs, relying on hand-labor for crop establishment and harvest, recycled wastes for crop nutrients, and biological pest controls for insect and disease suppression. Both farming systems have the same objective, sustainability, but the approach is obviously different in inputs and expectations. Specialty crops are most frequently associated with the small acreage, low investment, minimum risk of ecological farms.

Farming specialty crops is usually referred to as niche farming. The grower locates a specialty crop market that is not being met and produces a crop to meet that need. These markets are usually quite small and may be localized within a specific area defined by the heritage and culture of the consumers or the application of the plant materials. For example, Asian vegetables will probably sell well in Asian neighborhoods. Bedding plants may sell well in areas of new housing development. The niche farmer must search for a market niche, decide on a product for the niche, produce the product, and advertise to consumers that the product is available. A fairly wide-spread niche market is organic (no synthetic pesticides) food production.

Specialty crops produced for niche markets have limited markets and thus, have limited opportunities for growers (Table 2). The relatively small quantities of farm product required and the frequently regionalized demand mean the market can become easily over supplied. To be successful, growers entering a niche market must aggressively

Table 2. Natural product markets.

- Essential oils for flavors and fragrances
- Botanicals of teas, medicines, and cosmetics
- Nutraceuticals for health and nutrition
- Green products for the environmentally conscientious

pursue and meet market demand while limiting competition. The growth in the natural product market in North America has opened opportunities for growers interested in producing crops to meet this demand.

As the natural product market increases, the demand for quality plant materials also increases (Figure 1, Table 3). Since these products are primarily used by humans, issues such as misuse, misidentification, physical and chemical contamination, and improper storage or processing of plant material that can lead to situations hazardous to human health are of primary concern. Although for some time wildcrafted plants were favored, processors now need sustainable production

Figure 1. Natural product sales in US.

of botanicals of known origin and potency. The current demand is for standardized plant materials (plant materials with a defined amount of bioactive chemicals) so that treatment recommendations can be defined which will minimize the chances of any danger to patients consuming the alternative product.

For most cultivated medicinal and aromatic plants in the U.S., the agronomic operations that will enhance productivity remain to be systematically investigated. Much of the available information on such items as recommended row widths, fertilization levels and schedules, moisture and temperature conditions, and pest control measures are based on tradition and intuition, not science. Relationships between the plant environment and bioactive constituent production are occasionally recognized, but for most species largely unquantified.

Table 3. Dietary supplement sales in US.
Supplement¹   Value   Market Share

	(million dollars)	(%)
Vitamins	5,240	44.6
Herbs/botanicals	3,650	31.1
Sport nutrition	990	8.4
Minerals	660	5.6
Meal supplements	650	5.5
Other	560	4.8

¹Data for 1996, from *New York Times*, June 10, 1998.

While medicinal and aromatic species are subject to disease and insect attack, the use of synthetic biocides with medicinal and aromatic plants is generally not allowed in the U.S. In America, federal and local regulations restrict the use of herbicides, pesticides, and fungicides to those licensed for the crop. Currently, only a few compounds are licensed for a limited number of medicinal and aromatic species. In the U.S., crop production without pesticides, along with certain other restrictions, is known as organic crop production. Organically grown crops, including medicinal and aromatic, are generally the preferred choice of most consumers, being commonly associated with safer foods. Organic production of medicinal and aromatic crops relies upon disease resistant cultures, crop rotation, diversification, and natural pest control.

The production of herbs in glass or plastic houses is substantial in the U.S. for potted plant materials to be used for resale as transplants and for fresh plants to sell in markets. Special crops, such as rosemary shaped as miniature evergreen trees, may be grown for specific holiday events.

Medicinal and aromatic plants produced in hydroponic systems in glass and plastic houses sell for premium prices in fresh markets because of the cleanliness of the plant material. Choosing the crop to produce depends upon knowing markets and growers should ensure a market before planting a crop (Table 4 and 5).

Table 4. Best selling medicinal herbs - 1997.

<u>Herb¹</u>	<u>Millions of dollars</u>
Ginkgo	90.2
St. John's Wort	47.8
Echinacea	22.2
Kava	2.9

¹ Data from *Wall Street Journal*, Feb. 26, 1998, p. B1

The cultivation of many medicinal and

aromatic currently collected in the wild is being encouraged because of the need to preserve biodiversity within these species. Over-collection, deforestation, and habitat pollution lead to loss of native stocks in the US and other countries. Current US and Canadian efforts to protect native endangered species (many of which are medicinal and aromatic plants) in North America and at other locations can be expected to continue, but active alliances among governments, consumers, collectors, and growers will be necessary to ensure production as an alternative to collection.

Table 5. Top herbal supplement brands - 1996.

<u>Brand</u>	<u>Sales</u> (millions of dollars)	<u>Market share</u> (%)
Nature's Resource	29.4	12.9
Ginsana	26.9	11.8
Nature Made Herbal	23.4	10.3
Ginkoba	18.4	8.1
Sundown Herbal	11.9	5.2
Natural Life Herbal	8.5	3.7
Your Life	7.3	3.2
Kwai Herbal	7.1	3.1
Garlique	6.9	3.0
Kyolic	4.8	2.1

¹ Data from *Supermarket Business*, June, 1997, p. 85

Continued market growth for medicinal and aromatic plants in North America can be expected as consumption and applications increase. Such increases in market growth create opportunities for growers. The successful grower will keep aware of developing trends and be prepared to meet the challenge through a viable crop diversification program.

Why is Crop Diversification Important for Canada?

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The phrase "crop diversification" refers to programs of expanding the number of crops in a region, in the hope of increasing overall productivity and marketability. Market stability may also be promoted by diversification, since producers with diversified crops are often less vulnerable to environmental and economic fluctuations that influence any given crop. Natural perils can wreak havoc on crops and financially ruin farming enterprises. Since prehistoric times, farmers have known that agricultural diversification increases security in the face of unfavourable ecological conditions. When some crops fail, there are others that can ensure survival. These days, crop insurance makes diversification of the individual farm a much less pressing issue, but nevertheless growing just one monocrop is like putting all of one's eggs in one basket. It has also been suggested that increasing the number of crops in a region improves pest control and increases soil conservation (Jolliff and Snapp 1988). For practical purposes, the phrases "alternative crops,"

"replacement crops," and "substitute crops," all refer to the search for "new crops." Most diversification crops are "minor," "specialty," "niche," "non-traditional," or "under exploited," at least initially in the region in question.

Consumers have become increasingly interested in new varieties of old favourites, as well as completely unfamiliar food plants, and this has stimulated the cultivation of new crops. Increased interest in fresh fruits and vegetables that promote health, and in organically grown crops, have contributed to this trend. Ethnic foods are increasingly popular, not just due to increased diversity of the people of Canada, but also to increased interest in trying new and unusual dishes. Modern supermarkets now offer a dazzling array of choices of fruits, nuts, vegetables, and herbs. While many of these cannot be grown in Canada, many can. The indoor growth of mushrooms and high-value crops for the winter market also has increased the variety of foods. Consumer interest in herbal remedies is experiencing an explosive growth in Canada, offering Canadian farmers new options for diversification. With increasing affluence, leisure time, and an aging population, new plants are being cultivated not just to meet the basic human needs of food, shelter, clothing, and medicine, but also for aesthetic appeal. New plants are in increasing demand as garden ornamentals, indoor potted plants, cut flowers, edible home garden plants, shade trees, hedges, and sod. This has stimulated the establishment of a growing industry, especially the greenhouse and seed supply trades. Novelty is extremely desirable when it comes to ornamental plants, and at least in this market there seems no limit on the degree of crop diversification. The following table lists additional reasons that have been advanced for increasing crop diversification

Table 1. Potential positive aspects of crop diversification

1. Increased income
2. Expanding markets, increasing exports, decreasing imports
3. Increased stability of income (less fluctuation from crop disasters and bad market years; better for planning; feast and famine fluctuations are undesirable)
4. Lower stress on farmers and associated industries, because of increased income and stability of income
5. An increased number of crops can reduce economic risk
6. Adopting higher-value crops can increase productivity per acre
7. Some crops can lower capital input
8. Reducing dependence on a small number of monocrops reduces the danger of pests
9. Crop diversification stimulates other kinds of economic diversification (e.g. development of new harvesting and processing machinery)
10. Marketers and processors can benefit when new crops are found that provide high and consistent market demand, diversify product lines, and efficiently utilize processing systems
11. Creating new industries and increasing employment opportunities (smaller crops and new specialized crops are often more labour-intensive, provide new work opportunities for research, development of harvesting and processing technology, and market development, and can stimulate improved use of family and hired labour)
12. Reversing the decline of rural economy (new crops can stimulate local rural based industries)
13. Environmental and biodiversity benefits (e.g. new turfs that need less irrigation; biomass and

- biofuel plants can replace part of petrochemical industry)
14. Marginal lands could be better utilized
  15. Finding new rotation crops (even the best rotations suffer from pest buildups, necessitating increased reliance on pesticides, and producing a detrimental impact on the environment)
  16. Health benefits for humans (from providing population with more nutritious and healthy foods; e.g. greenhouse crops can provide local fresh vegetables that haven't lost vitamins during transportation; pharmaceutical crops can prevent or cure diseases)
  17. Health benefits for livestock (new livestock feeds with increased digestibility and decreased antinutritional factors)
  18. Enhancement of intellectual industry (research and biotechnology are critical to economic success of a nation, and new crops represent a stimulus to both)
  19. Aesthetic benefits (ornamentals, plants grown as flavourants, perfumes all increase the quality of life, and producing them cheaply and abundantly makes life more appealing)
  20. A degree of freedom for the small farmer from monopolistic control of the agri-food industry (increased choice of crops increases possibility of a wider choice of processors, marketers)
  21. Tobacco replacement
  22. Security of supply in case war, crop failure, or other disasters wipe out foreign crops that are imported
  23. Finding crop substitutes for petroleum can reduce power of oil cartels and oil companies
  24. Climate change means that eventually new crops will be needed that are adapted to the new climate
  25. Governmental crop diversification programs can often be sources of financial support and advice

Fixing things that work: reasons for not diversifying crops

Farmers are generally conservative, that is, they put great faith in what experience has taught is successful. This is common sense, because changes are normally risky, and so much can go wrong in farming that taking unnecessary risks is foolish. Farmers are comfortable with crops that they have grown for years, are adapted to their soils and machinery, and for which there are established markets. For very similar reasons, processors, marketers and others in the agri-food industry don't embrace change for change's sake. For example, it is much easier to conduct business when local, national and international markets are well known. New crops or commodities made from them must penetrate the existing marketing or industrial infrastructure, and this is usually beyond the control of farmers contemplating the new crops. Seeking new crops is simply an economic decision that the risk of continuing to rely exclusively on traditional crops is probably not as wise as trying new ones. Table 2 summarizes the negative financial consequences that can result from crop diversification.

Table 2. Potential negative aspects of profit in relation to crop diversification

1. The economic gamble may be lost: new crops chosen may turn out to be less profitable than the old crops.
2. Long-term lack of profit: successful new crops often require a lengthy period of development and commercialization before any profit is realized.
3. New crops may displace old profitable crops, with no net profit.
4. Copy-cats may adapt the crop to their circumstances and out compete those who have established it, and limiting the period of profitability.

A biological reason for the failure of old and the success of new crops

Natural biological competition favours the success of new over old crops, by changing the relative survivability of crops over time. The “Red Queen Hypothesis,” proposed by the evolutionary biologist L. van Valen (1973), holds that all of the world’s species must change continually to survive. This principle is based on the observation to Alice by the Red Queen in Lewis Carroll’s *Through the Looking-Glass* that “in this place it takes all the running you can do to keep in the same place.” The basis for the theory is that all species compete, and natural selection will always favour some mutations in some species, improving them, and forcing the other species to improve or perish. While the Red Queen Theory was proposed for wild species, it applies perfectly to our domesticated plants and animals. The most important kind of competition in this regard is the “arms race” between species and their parasites, including bacterial and virus diseases. A familiar example is the regular evolution of new influenza strains that kill off human beings. It is important to note that adaptation to diseases is usually not apparent externally, and this masks the fact that all species are likely changing genetically. Because our most important crops have been enormously weakened by selection, compared to their much hardier ancestors, they are especially vulnerable to diseases, herbivores, weeds, and often inadequately tolerate soil and climatic conditions. Moreover, plant breeders regularly create new cultivars that out-compete the old ones economically. The combination of biotic and economic competition means that crops are subjected to more intense competition than wild species, and so must undergo more rapid change to survive.

A marketplace reason for the failure of old and the success of new crops

Competition in the marketplace also favours the success of new over old crops, by changing the relative profitability of crops over time. In a free market economy, the profitability of successful goods typically changes with time. Following the initial period of investment in research and development, the market expands, along with profitability. With market saturation, there may be a sustained period of profitability, but frequently copy-cat competition arises and decreases the profitability. The consequence is oversaturation of the market, the generation of surpluses, and business failures of those who remained dependent on the sale of the once-profitable item. Major crops often follow this pattern, which accordingly limits their success.

World market volatility and over dependence on a limited number of markets

Stagnant and saturated markets are the chief stimulus for new crops in Canada. No less than 70% of Canada’s agricultural production (crops and agri-food products) was exported in 1996 (the

year of the last comprehensive census). This included grains and grain products (35% of all agricultural exports), and oilseeds and oilseed products (12.8%). Our exports went chiefly to the US (51%), Japan (10.5%), the 15 countries of the European Union (7.1%), and China (5.8%). This heavy dependence on world markets suggests that new crops represent an important measure to address fluctuations in the saleability of Canada's crops. Wheat, barley and oats accounted for 65.5% of the crop acreage and 61% of the farm receipts of the Prairie Provinces in 1996, and fluctuations in the foreign cereal market have led to a particular effort to diversify crops here. Most notably, wheat, Canada's largest crop, occupied a substantially smaller proportion of total field crop area than at any time in the past 20 years, and this has been attributed primarily to farmers diversifying into other crops. The fact that more than half of Canadian agricultural exports go to one country, the US, is also a concern, as changes in political or economic conditions could drastically affect certain exports. The lumber industry, which similarly is heavily dependent on the US and Japan, is currently undergoing a large decline because of new restrictions on lumber importations in the US and a severe depression in Japan. While over dependence on wheat in Western Canada led to problems, in Eastern Canada it has been over dependence on tobacco. The reduction of tobacco production by half was a chief stimulus for diversifying crops in Ontario (Loughton et al. 1991).

Political support for subsidies

In a country such as Canada, with diverse regional and private sector interests, public policy is susceptible to change, especially when new governments are elected. This can affect the profitability, indeed the viability of given crops, making new crops more attractive when old crops lose privileges. A situation of particular concern for Canadian agriculture has been governmental support for rail transportation of grains and oilseeds, which is the primary mode of transportation of these crops to distant markets. In 1995 the nearly 100-year-old Crow's Nest Pass Agreement, along with the Feed Freight Assistance Program, were cancelled. These programs had subsidized the rail transportation of grain and grain by-products to West Coast ports and to markets in Central and Eastern Canada, and had provided for a guarantee of protection against railway non-performance. As a result, some producers experienced a doubling of freight charges. The termination of these programs reflected a general trend in Canada of reduced government program payments to the agricultural sector. So long as major countries of the world provide subsidies to given crops that compete with Canada's exports, it is necessary to equalize the playing field by subsidizing the Canadian crop. However, just how large are the subsidies depends on governmental priorities, and it is thus desirable to grow new crops that are not dependent on support policies.

Cyclical support for new crop development

The enthusiasm for crop diversification programs at both the federal and provincial levels in Canada, as well as in the agri-business community, is most directly determined by the severity of crop surpluses. That is, when there are unsold surpluses of our major crops, our governments tend to support the search for alternative or new crops. Of course, when the status quo regarding crops is unsatisfactory, it is especially sensible to search for new crops. However, as a matter of strategic policy, it is extremely important to conduct long-term research to find and develop new

crops, since major crops, indeed all crops, inevitably encounter downturns. A deliberate program of finding new crops is like a business insurance policy, providing the flexibility of surviving by introducing new products when the old ones are no longer economically viable.

Hurdles to overcome in new crop development

Many crop species that might seem worth developing as new crops are undomesticated. However, these often have a limited yield, mature irregularly, are very variable, aren't suited to current planting and harvesting machinery, or present many other problems. Plant breeding may be necessary, management techniques will have to be developed, markets will have to be located and, perhaps most importantly, the funding will have to be found to support all this. The following questions should be addressed by anyone contemplating the development of new crops (cf. Meadley 1989):

Table 3. Questions to Ask Regarding Development of a New Crop

1. Why? What demand is being met?
2. Who will grow it?
3. Who will process it?
4. Who will sell it?
5. Who will buy it?
6. Who will consume it?
7. What commodities are being replaced?
8. On whose toes will you be stepping?
9. Who should pay for the development costs?
10. Can intellectual property be protected?

Who sponsors and pays for new crop development?

This is a critical question, and probably is not applicable to just crops but indeed to all commercial innovations. Depending on how one thinks society should function, sponsorship might best be the responsibility of the individual entrepreneur, companies, collectives of business interests, academia, or governments, or combinations of these. The small or even the large farmer can rarely afford to develop new crops by himself, because new crop development often needs multidisciplinary teams of agronomists, plant breeders, entomologists, and pathologists for field aspects; chemists, engineers, and various other technical professions for industrial, processing, and storage aspects; and market specialists. Currently there are private firms that develop new crops and new crop products as capital risk ventures, from which they expect eventually to profit in one way or another. The major difficulty here is that business generally demands a short-term development period, simply to survive, and tends to concentrate on less risky ventures. A second possibility, diametrically opposed to the strictly commercial motive of reward from new crops, is to consider the problem as an intellectual one, to be pursued for what can be learned in the way of scientific principles. The benefit here are educational, since such studies are as a rule conducted in universities, but one should not discount the long-term practical values to agriculture of fundamental discoveries about how plants can be genetically improved. In any event, university professors these days are increasingly compelled to seek support for their research from the

private sector, so that long-term fundamental research is becoming more and more difficult to undertake. The remaining possibility for funding new crops is government backing. Governments support is particularly appropriate for initiatives that are particularly long-term, risky, expensive, or complicated - all circumstances that the private sector is often unwilling to undertake alone. Also, there are often policy reasons why certain technology is supported by governments. For example, supporting new crops that maintain productive capacity in the face of unreasonable international competition, that favour rural development, or benefit the environment, are all current reasons for government agricultural support.

Push vs. pull in new crop development

Should new crop development be the result of trying to meet anticipated or potential demand, or should it be pushed by enthusiastic backers? Many feel that the proper role of business is to identify and develop products that meet the needs of society (i.e. societal needs should "pull" technological innovation). On the other hand, there is no doubt that many successful entrepreneurs have created products that society initially saw no need for, may not have accepted for some time, but eventually embraced. Many new products displace old ones, and while one may with some justice often feel that the old technology or products were preferable, the marketplace very frequently rewards those who "push" new technology and products. In particular, crop scientists often become aware from their research and reading that altering an old crop or developing a quite new crop seems to have good potential.

Diversification through value-added products and on-farm activities

Primary agriculture includes growing crops and raising livestock. In Canada in 1996 (the year of the last comprehensive census) on-farm production accounted for about 24% of the \$70 billion produced by both primary agriculture and the associated agri-food sector (allied food and industrial industries, commercial sales, and the food service industry). Not only does the off-farm component of agriculture account for a much larger gross value, but (at least in many instances) it is more profitable. Because new value-added uses may have very large profitability, it is critical to consider not just new crops in the sense of new species and new cultivars, but also new value-added uses. Wherever possible, individual farmers and farmer groups ought to consider adding value to their agricultural output. Examples include: the on-farm washing, grading, and packing of vegetables and fruits; preparation of stone-ground wheat flour from organically grown cereals; processing of medicinal herbals into retail products; and the rental of wetlands on farms for gamebird hunting.

Livestock diversification as a stimulus to crop diversification

After the wheat crop (30.7 million acres), the largest area of cropland in Canada is devoted to hay and fodder (15.3 million acres in 1996). Unlike wheat, however, hay and fodder crops are increasing, to feed an expanding livestock population and even an increasing export demand. Hay and fodder crops can be grown on relatively poorer land than almost all food, oilseed and fibre plants, and so provide opportunities to use marginal lands of Canada. Indeed, there are considerable opportunities to create cultivars of both cultivated and uncultivated plants to take advantage of marginal lands not suited to conventional crops.

A stimulus to new crop research in Canada is the increasing demand for animal feedstuffs. The livestock industry is very competitive, and producing balanced rations at the lowest cost is important. In particular, increased emphasis on legume forages and fodders appears to be a promising area because these are exceptionally healthy for both livestock and the soils they grow in, and cheaper to produce than cereals, oilseeds, and other feed alternatives.

Another potentially profitable area concerns new types of livestock. Native mammals (e.g. bison, deer, elk), exotic mammals (e.g. llamas, alpacas) and exotic birds (e.g. emus, ostriches) are increasingly being raised for meat, game, and as pets. Species such as emus meet consumer demand for leaner meat, and their oils have industrial and medicinal uses. Bison offer high value export potential. Fish are also being increasingly raised in captivity, and this is bound to increase in importance as natural fish stocks are lowered by pollution and overfishing. The need for feedstuffs appropriate for the particular dietary needs of these animals is likely to create a need for special varieties of crops.

Exploiting the marginal lands of Canada

The amount of arable agricultural land in Canada upon which conventional crops can be grown is estimated to be only about 7% of the land surface of Canada. Factors of the environment, principally temperature, precipitation, soil fertility, and physical aspects of the land, limit crop growth. However, many undomesticated plants do grow in marginal, and indeed even in totally non-agricultural parts of Canada, so that in principle it should be possible to extend the amount of Canada that can be exploited for cultivated crops. It is clear, however, that this requires revolutionary new types of crops. With the advance of genetic engineering, crops with radically new properties are becoming a reality. Is it really possible that Canada's cold lands, dry lands, mountainous lands, acid-soil lands, and infertile lands, could grow productive crops? There are two possibilities for creating new crops for marginal areas. First, genetic engineering may transform our conventional crops so that they withstand environmental challenges not presently tolerated. Second, plants that currently grow in marginal lands may provide products that would justify using and improving them as crops.

The possibility of extending the range of agriculture into marginal areas is a sensitive topic. This is because the exploitation of nature by mankind has gone too far, and has produced widespread destruction of habitat and reduction of biodiversity. More than 40% of Canada is forested, and forestry practices that degrade the environment have been widely criticised in recent years. It is possible, however, to practice both forestry and agriculture in a responsible manner. The wise, sustainable management of grazing lands shows that marginal lands can be managed in ways that minimize negative effects on habitat and biodiversity.

Food-Aid

About 15% of the world's population is chronically under-nourished. While long-term solutions need to be implemented, food aid is a necessary measure from time to time to prevent starvation. The United Nations convened the World Food Conference in 1974 and set three main objectives for food aid: provide emergency relief, combat hunger and malnutrition, and promote economic

and social development. Although humanitarian motives should be the primary reason for food-aid, commercial and political motives also play determining roles. Cereal grains and flour derived from them have been most widely used in food-aid, since they are often available in surplus amounts and are easily preserved, stored, shipped and consumed. Corn is a main food staple in Africa, and is also well accepted. Pulse crops are also highly suitable. Canada was initiated into the food aid business during World War II, when, along with the US, food was supplied in support of the Allies. Since then, Canada has participated in various international agencies that contribute to the relief of inadequate food supply (Warkentine 1994). Given its position as a major world exporter of agricultural commodities, Canada has a continuing obligation to continue to provide food-aid. In as much as new crops are essential to the overall health of agriculture in Canada, and hence Canada's ability to provide food aid, new crop development is a moral imperative. An inspiring example of how Canadian breeders can breed new crops to relieve hunger is that of Clayton Campbell's work on grass pea (Henkes 1995). This creeping vine is the leading pulse crop in Bangladesh, and is also commonly grown in India, and to a lesser extent in the Middle East, southern Europe and some parts of South America. It is usually grown for grain, but can be used for fodder, and is now used as a green manure crop in Canada. This pulse is very high in protein, but a neurotoxic amino acid is present in most cultivated forms that if consumed in sufficient amounts (e.g. 30% of the diet for 3 months) can cause the irreversible crippling disease known as lathyrism. In fact, because of lack of alternatives, lathyrism from consuming grass pea is common in Asia. Campbell was responsible for the breeding of grass pea lines that can be consumed safely.

Systematic searching for new crops

With a quarter million higher plant species on our planet, there certainly is no shortage of possibilities for new crops to cultivate. However, as emphasized above, very few of these can be adapted economically to the point of substituting for or displacing current crops. It has often been suggested that the search for new crops should be conducted in a logical fashion (e.g. Wallis et al. 1989), by identifying desired characteristics, and then seeking plants that meet these criteria. In practice, almost all new crops everywhere are identified in a haphazard fashion, generally by an individual who acquired insight into the promise of a given plant. A chief roadblock to conducting a systematic search for new crops is simply that there is no comprehensive registry of possibilities that one can examine. Obviously there is an urgent need for bringing together information on crop possibilities in a fashion that their potential can be ranked, so that experimentation can be conducted on a realistically small number of possibilities.

The need for a permanent advocacy body for new crop development in Canada

Regional and commodity group interests are of course desirable, but there are also advantages in having a national body that evaluates priorities for new crops and lobbies for support. Only by taking advantage of the collective knowledge of policy makers, researchers, industry representatives, and farmers throughout Canada can the breadth of vision be provided that will result in the very best potential new crops being given the attention they deserve.

The innovative, entrepreneurial spirit

Despite the recommendation, above, of collective effort to further new crop development, it must be said that crop champions are generally essential to successful new crops. It may well be that the potential of most crops is so hidden from the majority, that perceptive dedicated individuals willing to experiment and take chances are essential.

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Crop Diversification in Western Canada: A Success Story

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Crop diversification can be defined as the production of crops other than the five standard crops brought to western Canada by the early settlers in the 1800s (wheat, *Triticum* spp.; oat, *Avena sativa*; barley, *Hordeum vulgare*; rye, *Secale cereale*; and flax, *Linum usitatissimum*). Wheat is, has and will continue as the major acreage crop in western Canada. However, periodic wheat surpluses with low prices and low market quotas stimulate interest in crop diversification. Such is the case at present.

Rapeseed (canola)

The first successful new crop was rapeseed (*Brassica* spp.). It was introduced prior to WWII as a forage crop and then during WWII it developed into an oilseed crop that produced high erucic acid oil for use as a marine lubricant. In the early 1970s, low erucic acid and, subsequently, low glucosinolate oilseed types were developed to produce canola which refers to a high quality edible oil type that also produces a high quality meal used as a protein supplement in livestock rations.

Canola is now produced on 13 to 14 million acres annually in western Canada. This is an example of a relatively new crop that has successfully become a major permanent addition to our crop mix.

Pea

More recently, we have seen several other successful additions to the range of commercial crops in western Canada. The largest acreage crop is pea (*Pisum sativum*). Pea has been grown on a small area in western Canada since it was first settled by white man. The major pea acreage occurred in southern Manitoba (less than 100,000 acres) prior to 1986 when Saskatchewan became the leading pea producer. Development of the European feed pea market, starting in 1985, coincided with a period of low wheat prices, and both events combined to greatly increase the profitability of pea production relative to wheat and acreage has increased dramatically since then. In fact, pea acreage has increased every year since, except for 1989, 1990 and 1996. In 1997, pea acreage increased 50% (from 1.4 m acres to 2.0 m acres), and in 1998, pea acreage increased another 30% to 2.6 m acres. The current price scenario for wheat vs pea suggests that 1999 pea acreage will drop by 10%, perhaps 20%.

My rule of thumb is that experienced pea producers (those who understand and appreciate the N and non-N benefits of a pulse crop in their rotation) will maintain or increase their pea acreage next year whenever the farm gate price of pea is 40% greater than the farm gate price of No. 1 Canada red spring wheat. This rule holds well for central Saskatchewan and will vary a bit for other areas. Thus, \$3.00 per bushel farm gate price for Canada No. 1 red spring wheat in the 1998-99 crop year (About \$1600 per tonne final payment at Saskatoon) requires a price of \$4.20 per bushel for Canada No. 2 or better (food grade) pea to stimulate increased acreage of pea in 1999. The best pea price recently at Saskatoon has been \$3.75 per bushel for food grade pea. Thus, I am predicting a drop in pea acreage for 1999. It seems that most farmers choose their crops based on the relative returns of the various crops in the previous year. Obviously, a more current market signal is urgently needed.

Many types of pea are grown, helping to diversify crop production within the crop: yellow pea, green pea, feed pea, marrowfat pea, maple pea, and forage pea (small-seeded to keep seed costs down).

Lentil

The second most widely grown new crop is lentil (*Lens culinaris*). The first commercial planting of lentil in Canada was at Richlea SK in 1969. Lentil acreage increased to about 15,000 acres by 1973 when two years with a late spring and early fall frost nearly eliminated the crop from western Canada. The Crop Development Centre was established at the University of Saskatchewan in 1971 and we started working on lentil immediately. By 1976 we had developed a package of agronomic practices and mounted an extensive demonstration project in 1977-1979 with plots in Alberta, Saskatchewan and Manitoba. One first-time producer in the Regina area did everything that we suggested in a timely fashion and the weatherman provided some timely rains. The net result was that he averaged about 1800 lb. per acre, nearly double the long-time provincial lentil yield during the 1980s. In 1977, a major lentil exporting area, the Palouse Area of eastern

Washington and northern Idaho, experienced a severe drought and lentil yields were about 30% of normal. American lentil brokers had forward sold much of the anticipated lentil production and all of a sudden no lentil was available. They heard about the lentil crop in Canada and bid up the price to \$0.35 per lb. for the entire Canadian lentil crop. Individual lot sales have been higher than this, but this is the highest price ever paid for the entire Canadian lentil crop. Our Regina lentil producer grossed over \$630 per acre in 1977 and he had 200 acres. Word of this spread across the prairies like wildfire and lentil acreage increased in 14 of the next 17 years. Lentil acreage reached 985,000 acres in 1994, dropped a bit in 1995 and 1996 and increased in 1997 with a further increase in 1998 to a record 990,000 acres. Lentil acreage should remain above 900,000 acres in 1999.

My rule of thumb for lentils is that experienced lentil producers will maintain or increase their lentil acreage whenever the farm gate price of lentil is greater than twice the farm gate price of Canada No. 1 red spring wheat. As before, assuming \$3.00 per bushel farm gate price for Canada No. 1 red spring wheat (5 cents per lb.), the farmer needs only 10 cents per lb. farm gate price for lentil to match the returns from wheat. The lentil price has been around 15 cents per lb. for much of the year. Is it any wonder that farmers are steadily increasing their lentil acreage? The problem with this scenario is that the lentil market can absorb only so many lentils and then the price drops, resulting in reduced acreage in the following year and the cycle continues.

Mustard

The third most widely grown new crop is mustard (*Brassica juncea* and *Sinapis alba*). The three types of mustard are brown mustard, oriental mustard and white (yellow) mustard. Mustard has been grown on about 600,000 to 800,000 acres in recent years. Research is now being conducted on the development of a canola-type mustard that will have superior drought resistance and disease resistance.

Canaryseed

The fourth most widely grown new crop is canaryseed (*Phalaris canariensis*). Canaryseed has been grown on about 300,000 acres in recent years with a record production of 580,000 acres in 1996, due to the extremely high price in 1995. A recent development has been the release of a glabrous cultivar of canaryseed called Maria. Research is also being done on the possible food use of canaryseed, following the production of a mutant with a colourless seed coat.

Dry bean

The fifth most widely grown new crop is dry bean (*Phaseolus vulgaris*). Dry bean acreage has increased rather markedly in the last few years, as dry bean production has been moving up the Red River Valley from North Dakota into Manitoba. Thus, the acreage of dry bean in Manitoba now exceeds 100,000 acres. The recent development of earlier maturing, narrow profile cultivars with improved pod clearance plus the development of a modified cutter bar-pickup reel combination will greatly increase dryland production of dry bean in Saskatchewan over the next 10 years. Dry bean production in western Canada will exceed 250,000 acres by 2010.

Sunflower

The sixth most widely grown new crop is sunflower (*Helianthus annuus*). Sunflower acreage ranges between 100,000 and 150,000 acres, mostly in Manitoba. The development of sunola (early maturing, semi-dwarf types) stimulated increased production between 1990 and 1994, but this increased acreage was not maintained.

Chickpea

The newest crop for western Canada is chickpea (*Cicer arietinum*). The two types of chickpea are the desi chickpea and the kabuli chickpea. The desi chickpea has a small seed with a hard, coloured seed coat and the plant has coloured flowers. The kabuli (garbanzo) chickpea has a large seed with a delicate colourless seed coat and the plant has white flowers. The desi chickpea is dehulled and split to produce chana dhal which is freshly ground at the retail level to produce chickpea flour for use in various ethnic foods. Ascochyta blight is a very severe disease of chickpea and only ascochyta resistant cultivars can be grown successfully in western Canada. The first ascochyta resistant chickpea was grown in western Canada in 1995. By 1997 the acreage had increased to 25,000 acres and to about 100,000 acres in 1998. Predictions are that in 1999 over 300,000 acres of chickpea will be grown in western Canada. The problem then becomes how and where can we sell all these chickpeas?

Other new crops

A great variety of other crops can be grown in western Canada, but the problem then becomes one of where can I sell this crop and still make expenses? For example, small acreages of coriander, caraway, dill, anise, fenugreek, borage, triticale, faba bean, safflower, buckwheat, wild rice, quinoa, spelt, oilseed radish, ginseng, millet, corn, grain sorghum, soybean, various herbs, medicinal plants, spearmint, potatoes, seed potatoes, various vegetables, various fruits, industrial hemp, etc. are grown each year in different parts of western Canada.

The future

I think all of you will agree now that western Canada can grow a wide range of crops. The problem then becomes which ones can we grow and earn a net income per acre equal to No. 1 red spring wheat? The answer right now is many of them—due to the low price of wheat. However, the price of wheat will recover, sooner or later, and we really want to develop a sustainable production of these various crops and not one that depends on a low price for wheat.

In order for the production of these various crops to be sustained over time, we must try to develop a balance between production and sales (between supply and demand)—very difficult—or we can increase net return per acre by some form of value-added processing. However, this value-added processing must also provide an increase in net returns in order to be self-sustaining. Later in this conference, you will hear about the Alberta Value-Added Corporation and the Agricultural Value-Added Engineering Centre and their efforts to assist with value-added processing in Alberta.

Some current examples are over 300 pulse crop cleaning and bagging operations in western Canada, but this is only pre-processing, so they are only the first step. We have some 8 to 10 pea splitting plants in western Canada. We also have two plants that process pea into pea flour, pea protein concentrate, pea starch and pea hulls. One plant is dehulling and splitting lentil and another one is dehulling and splitting desi chickpea. We have several essential oil distillation plants in western Canada. The Saskatchewan Nutraceutical Network was recently established to assist in the development of the nutraceutical industry. A related aspect is the production and value-added processing of Certified Organic crops. All three prairie provinces now have food research centres, but the Saskatchewan Food Industry Development Centre is just getting started.

Conclusions

Western Canada can grow a wide range of crops, but they must consistently provide a greater net return than wheat if production is to be sustained. This requires balancing supply and demand or increasing net return by value-added processing. The secret to our past successes is the low price of land, which means that return-to-land costs are smaller than in many parts of the world. The low cost of land is directly a function of the low yield of wheat in western Canada, which means that we can produce many crops at lower cost than many other parts of the world, not that we want to. The secret to our future successes will be the ability to increase net return by value-added processing and by marketing the resulting products at a profit. We have made an excellent start, but we need to work at it harder.

Medicinal Plants: A New Diversification Opportunity?

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There have been numerous increases in the use of botanical materials and products in health care systems around the world in the last two decades. People are taking a more active role in looking after their own health by consuming healthier diets and dietary supplements such as vitamins, minerals, plant products or extracts and by seeking non-conventional or alternative medicine. Encouraged by widespread interest and greatly relaxed federal laws in the United States, sales of natural herbal remedies are growing by an estimated 15-18 percent a year, and reached 10-12 billion dollars in 1997. A conservative estimate of over 1 billion dollars for the Canadian market of herbal medicines.

This booming trade requires a huge amount of plant material and since most medicinal plants are gathered from the wild which resulted in over-harvesting. This on going trend is causing shortage of the supplies and some of the wild medicinal plants are high on the lists of threatened or endangered species. Therefore, the global clamour for more medicinal plants creates possibilities for cultivation by farmers and an opportunity for diversification from conventional crops.

Supplying medicinal plants from the wild is unpredictable. Yields are at the mercy of pests and other uncontrollable condition. Cultivation of medicinal plants would be a reasonable approach to meet the market demand and provide products with good and uniform quality.

Under cultivation, the identification, quality and yield of medicinal plants can be secured. In addition, there is the possibility of increasing the active ingredients within each crop by means of genetic and agronomic. The efficiency and success of medicinal plant cultivation will depend on proper crop management and collaboration between researchers and farmers to enhance and sustain production.

The major handicap today is that the cultivation of medicinal plants is constrained by a lack of methodologies and research funds. Intensive regional studies on selected medicinal plants are needed to determine optimum environmental requirements for sustainable production. The success of this cultivation would have a major impact on wild plant conservation, farm income, poverty alleviation, consumers' confidence and the future of the herbal industry.

When potential producers ask about alternative crops, it is relatively easy to suggest several possibilities based upon the information available regarding their horticultural environment. However, it is much more difficult to provide solid information about future market demand and economic potential of a crop presently being produced. Thus, it is unlikely that anybody will ever be in a position to suggest a few really promising alternative crops and even with a very short list, producers should be encouraged to proceed slowly until they are comfortable with the culture and management of any new crop with some real market potential.

There are a few questions to answer before any producer can proceed with the cultivation of new crops.

Which crop or crops? What variety? In what form of cultivation?

There are hundreds of crops listed in the literature which have potential medicinal value, however, in this market driven world, it is only logical to select a crop (or crops) which has a market large enough to absorb more of the product.

Consumers are more and more concerned about pesticide residues on produce. They are willing to pay higher prices for organic products. On the market, organic herbs are usually valued at twice the price of non-organic. Therefore, producers should consider seriously whether to grow organically or non-organically, before starting.

What is the cost?

Consideration and awareness of the risk factors involved in starting a new crop is important. The cost of starting a new crop varies; whatever the amount, it has to fit into the economic capability of the producer. Most important of all, the potential of net return on the investment for any new crop has to be reasonably higher than that of the existing conventional crop.

Suitability of certain crops to the region

Cultural and environmental requirements are important factors for any new crops grown in any region. In the case of British Columbia, many crops will grow well in certain regions since there are many microclimatic zones and soil types. The prairie provinces may be suitable for growing many good quality medicinal herbs, due to the natural environment. Several other considerations are control measures for diseases, insects and weeds, harvesting techniques and equipment, the effect of post-harvest conditions on therapeutic activity and potential difficulties and requirements of processing.

Where is the market and what kind of possible competition exists?

Many of the medicinal plants on the market today are supplied through the global marketplace, therefore producers are facing challenges from all over the world. Staying competitive can be done by minimizing production costs, maintaining quality (with an independent lab test), setting up a network and building up a reputation within the industry.

Is there a potential for a value-added market?

Without a doubt, the value of any product is based on the form of merchandise. The value increases from ground herbs to tinctures to extracts to standardized extracts and finally the highest value, phyto-medicines. Producers should look into niche markets for various forms of the product, a cottage industry for value-added products from their produce.

Build a cooperative effort among producers, manufactures and researchers to educate consumers

Without a doubt, the consumer is the most important factor in the success of any crop, especially medicinal plants. Public education is needed of the advantages or disadvantages of medicinal herbs. Any bad publicity will certainly damage this vulnerable industry.

In conclusion, yes, medicinal plants is a new diversification opportunity for producers and manufacturers, however, just like any other new industry, challenges are ahead for us to overcome before we can enjoy success.

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What's New in Field Pea and Bean Research?

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Field Pea

The field pea (*Pisum sativum* L.) crop is widely adapted across western Canada and is included in cereal crop rotations in most parts of the prairies. Prices rise and fall in sympathy with global grain prices but the crop continues to expand because the yield of field pea in western Canada is to the yield of hard red spring wheat. This means that western Canada is the most competitive pea production region in the world. Improvements in field pea genetics (mostly from Europe) and agronomy over the past ten years have helped the field pea crop to emerge as a major grain legume on the prairies. We will continue to improve in competitiveness as research and development efforts in agronomy, breeding, biotechnology and plant pathology become integrated into our cropping systems in the next few years.

Field pea breeding programs in western Canada are starting to catch up to the European breeding programs. Five years from now we may see as much as 20% of the production base switch to local varieties. Improved varieties with better yield, lodging, quality and disease resistance will be released from the locally based private (Agricore, Johnson Seeds) and public (AAFC Morden, Crop Development Centre at Saskatoon and the Crop Diversification Centre – North in Alberta). Collaboration among breeding programs continues to improve, both domestically and internationally. One issue facing the pea industry over the next few years will be that of the method of payment for new genetics – will it be through checkoff or through seed royalties? No matter which system is used, plant breeding must be paid for or it will not be done. At the Crop Development Centre pulse crop breeding program in Saskatoon we have entered into a 5 year agreement with the Saskatchewan Pulse Growers (SPG). In exchange for operating funds, the SPG receives variety distribution rights without royalty. Any variety that is released, of course, will only be successful if it has excellent performance. It is possible that this checkoff based system could be implemented for other breeding programs – private or public.

The field pea crop in western Canada has two major diseases. Ascochyta blight caused by *Mycosphaerella pinodes* is the main disease of concern in cool wet environments. This fungus can cause large losses in yield, especially if infection of the lower canopy starts in June and the weather remains cool and moist after the initial infection. Powdery mildew caused by *Erysiphe pisi* is more of a problem in warm dry environments, and can cause large yield reductions if the

infection becomes widespread in the first part of July. Several other field pea diseases are waiting in the wings, ready to expand if the first two diseases are controlled. In most parts of the world, various soil borne diseases increase dramatically once the pea crop becomes well established.

Controlling *Mycosphaerella* by developing better genetic resistance is a major goal of field pea breeding programs around the world. No major resistance genes to stem and foliar infection are available, so plant breeders are trying to incrementally increase tolerance to the disease through hybridization and selection using parental lines that show slight levels of improved tolerance. This is a slow process but it is the only technique readily available to field breeders at the moment. Several laboratories around the world, including the Plant Biotechnology Institute in Saskatoon, are trying to develop anti-fungal resistance genes that might eventually be introduced by transformation into the field pea crop. This is also a slow process.

Powdery mildew is a much simpler problem to deal with at the genetic level. A stable source of resistance to powdery mildew has been available for a long time. Over the next few years, all current yellow, green and maple pea varieties will be replaced by new varieties that have powdery mildew resistance. Most Canadian and European pea breeding programs are geared up for the change. In 1998, about 30% of the first year entries in the registration trials had resistance to this disease. The effect of introduction of this trait will be to reduce the need to apply late season fungicide to control powdery mildew, improve the efficacy of desiccants prior to harvest, and in general stabilize yield potential. Based on our observations in breeding trials across western Canada, average pea yield could rise as much as 10% by introducing powdery mildew resistance.

Pea breeding programs across the world now have access to transformation technology which is available from several laboratories, including the Plant Biotechnology Institute in Saskatoon. From the standpoint of introduction of foreign genes into the pea crop, we have left the age of science fiction. We are now in the age of science friction in the sense that no one really knows which genes are useful, available or marketable. In 1998 we grew the first Canadian field trials of herbicide (Liberty) tolerant pea. In 1999 we will be field testing the first herbicide tolerant pea lines that also are high yielding, semi-leafless and early maturing. Commercialization of these lines is still a few years in the future, but they will become available if market signals encourage their use.

Another technology under development at the University of Saskatchewan is development of a haploid system for field pea. This research is just beginning. The goal is to develop the capability to inexpensively produce true-breeding pea lines through microsporogenesis. If successful, the speed of the breeding cycle can be increased. For crops with large seeds, this type of improvement is especially important because it can lead to improved efficiency in plant breeding.

In the area of field pea quality, all breeding programs are attempting to improve bleaching tolerance for the whole and split green cotyledon pea market classes. At Saskatoon, we have developed a low cost system that allows us to screen for rate of green colour loss in every generation. Some of our dry green peas end up as rehydrated canned peas. We have initiated a

quality monitoring program for canning quality of newly released green pea varieties. More feedback from the marketplace is required to properly focus this effort. For feed pea quality, the old debate about protein concentration of various pea varieties continues in spite of the overwhelming evidence that most of the variation in protein concentration is due to the influence of environmental factors. Date of seeding, relative maturity, disease resistance, soil fertility, timing of crucial weather events, and foreign matter content all have a major influence on protein concentration. It is possible to boost protein concentration through genetic manipulation over a very long time, or by use of transgenes, but asking plant breeders to conventionally breed for high protein may be like asking them to predict the weather. Over the next few years, we may see some changes in the way feed peas are valued if we see implementation of feed pea quality standards with respect to acceptable levels of foreign matter. If swine nutritionists take into account both the energy and the protein concentration of feed pea, the combined level of both nutrients is relatively stable. As protein increases, starch decreases, and vice versa. One unexplored opportunity in the feed pea area is development of an efficient and effective system whereby high protein lots of feed pea could be sold at a premium to feed mills. If field pea production continues to grow at the recent historical levels, the sheer volume of production will encourage this type of separation of economic value.

Dry Bean

During the 1990s, the dry bean (*Phaseolus vulgaris* L.) crop continued to expand in western Canada for the same reasons that other pulse crops have expanded production – low cereal prices combined with high relative yield in comparison to hard red spring wheat. The geographical changes in the dry bean industry in North America over the past 8 years are stunning. The Red River valley region now produces 50% of North American production, up from less than 20% in 1990. Traditional production areas in the western USA are declining because the dry bean crop must compete with higher value crops under irrigation. In the east, the dry bean crop must compete with other crops in areas with high land values, and crops with less production risk are favoured. The dry bean crop is the world's most widely grown and widely traded pulse crop for human consumption. The same fundamental factors that have caused expansion of the lentil, field pea, and now chickpea crops will likely cause a major expansion of this crop in western Canada over the next five years.

Most current dry bean varieties, regardless of market class, originate from the USA or eastern Canada. In the early 1990s, the AAFC Lethbridge dry bean breeding program was rejuvenated and a new breeding program was initiated at the Crop Development Centre in Saskatoon. More recently, private breeding programs are represented in Manitoba. The pulse breeding program at AAFC Morden collaborates with public breeding programs in eastern and western Canada by screening potentially adapted bean breeding lines for southern Manitoba. The local breeding programs will start to make an impact on the dry bean industry over the next few years because a

new set of earlier maturing varieties will become available for commercial production. We will see improvements in all market classes.

The dry bean industry is unique in that the crop has a dual agronomic system. The major portion of production is row crop, but new areas are producing beans as a regular field crop using standard equipment. The local breeding programs have designed breeding programs specifically for direct harvest systems (either swathing or direct cut). This will have a major impact on the harvestability of the crop and the acceptance by new growers. Agronomic research is ongoing to determine how to adapt the crop to standard production systems. A complete re-evaluation of agronomy is in progress with goal of determining the most reliable practices in low cost systems. Considerable effort has gone into designing improved harvest systems specifically for the dry bean crop. A new crop lifter fitted with bristles to lift pods away from the ground was invented at the University of Saskatchewan and commercialized by Keho Alta Products of Barons, Alberta. Duncan Seeds in Manitoba and Honeybee Manufacturing of Saskatchewan are jointly developing a new lifting reel for swathing and direct harvest of bean crops. MacDon industries of Winnipeg is advertising a snub guard system to improve dry bean harvest systems. Short line implement manufacturers are aware of the opportunities that accompany the expansion of the dry bean crop.

The dry bean industry has traditionally imported much of its seed from contracted producers in the Pacific Northwest USA. In the next few years, this could change because of factors such as the improving expertise of local seed growers, the low value of Canadian currency, and use of locally bred varieties that may be more costly to grow in the USA because they are less adapted. This will create some opportunities for seed growers. This change is causing much discussion in the dry bean industry at the moment because this goes against tradition. Much of the discussion will focus on the risks and benefits of local seed production. One of the major points of discussion is the potential to increase the incidence of seed-borne bacterial diseases like common blight, halo blight and brown spot. Viruses are more of a concern in the areas where seed is now produced.

The local breeding programs collaborate with a North American genetic improvement network called the Bean Improvement Cooperative. This organization is a 30 year old collaborative research group focussed on improvement of genetics and plant pathology of the dry bean crop. The next meeting will be held in Calgary in 1999. Improvement in resistance to bacterial diseases and white mold is on stream. This research will have an impact on the dry bean crop in the next five years.

Efforts in biotechnology for the dry bean crop have focussed on the development of useful molecular markers for disease resistance and several markers are now routinely used in breeding programs. To date no protocol for transformation or development of doubled haploid systems in dry bean is readily available. The dry bean breeding program at the CDC in Saskatoon is now using molecular markers to screen for bean common mosaic virus resistance genes. In the next few months we hope to introduce a molecular screening technique for common blight resistance genes.

Research in the area of quality for dry bean focusses on the primary culinary characteristics such as seed size, seed uniformity, and retention of marketable seed colour. The ability to monitor and screen for secondary culinary characters such as canning quality (texture, hydration, colour, and appearance) is now available at both Saskatoon and Lethbridge. Selection for increased seed size is an important objective for dryland production because late season soil moisture deficit can cause dramatic reduction in seed size.

Plant breeding efforts are also integrated with improvements in agronomy. A wide variety of growth habits are available for the dry bean crop. Most breeders are trying to develop upright indeterminate plant types with early maturity. The strategy employed at the CDC is to introduce and evaluate any possible architecture that might improve harvestability without sacrificing maturity. One of the characteristics that will be evaluated at the commercial level in the next few years is a low lignin pod type that could potentially reduce shattering loss in years with hot and dry harvest conditions. This particular genetic combination also increases pod curvature at maturity and this may help improve the efficiency of some harvesting systems. Breeders and agronomists will be working intensively on joint research projects to improve agronomic systems for the dry bean crop in the next few years.

Value-Added Processing of Prairie Pulse Crops

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With a subject of "Value-Added Processing of Prairie Pulse Crops" there are trends which have emerged in our business that appear to becoming universal in the value-added processing sector that I would like to discuss. I will relate these to our business, in the hope that you can relate them to yours.

Vertical Integration and Globalization

This trend is evident in all business, however in ours we believe that vertical integration and globalization is bringing significant change to the supply chain. The boundaries between producers, suppliers, processors, exporters and endusers is becoming blurred as suppliers develop strategies for moving up the supply chain. For some suppliers this means vertical integration, diversification and value-added processing.

There are some large examples of this occurring in rural Saskatchewan. The Saskatchewan Wheat Pool initiative in hogs stands out as they have made substantial investment not only in hog production facilities through Heartland Livestock but also in feed processing through Cangrow and meat packing through Fletchers.

The benefit of the global markets is that it allows Canadian processors to deal directly with large endusers anywhere in the world. This can be seen in the special crops industry where producers work together with seed cleaning operations to prepare products such as peas and lentils for export.

Globalization has also diminished the value of brokers or middle men in transactions in mature markets. Large endusers want to deal directly with suppliers. At InfraReady Products we use brokers in our market development activities, particularly in foreign markets. Some foreign clients, dependent upon their size and expertise, view the broker as cost added to their product.

Market Efficiency

As the linkages between suppliers and endusers strengthen endusers will bypass the traditional raw material collection and distribution system in favor of identity preserving the product.

In the interests of market efficiency there is more interest in purchasing directly from producers. In our business this is evident in organic production as organic producers frequently market their crops directly to processors or endusers bypassing the more traditional grain marketing and handling system.

Market efficiency also promotes the move to more semi-finished products. We see this at the large inland terminals which can blend and clean to a flour millers specifications. We see this in our business as we produce pre-cooked cereals and legumes. At this point it might be appropriate to describe what InfraReady does.

InfraReady is a specialty processor which uses infra-red cooking technology to make products ready for the enduser. Our products offer convenience intermediate between the raw commodity and the more highly processed forms of dehydrated or freeze-dried product.

As we purchase products directly from producers and our products are semi-finished, they are "Market Efficient".

Increased Importance of Quality and Standardization

Manufacturers of value-added products, particularly food products, require consistency. Consistency in supply, quality and delivery. Companies which can provide this consistency will become the preferred supplier.

Endusers will require suppliers to have quality systems such as HACCP (Hazard Analysis Critical Control Point), GMP (Good Manufacturing Practice) and ISO (International Standards Organization). They will also require 3rd party audits for sanitation.

At InfraReady we are inspected by the Canadian Food Inspection Agency, American Institute of Baking, Organic Crop Improvement Association, and the Kasruth Council of Canada.

There will be more identity preserved production in the future and companies which can isolate, segregate, consolidate and ship consistent high quality products will be able to cash in on the Agribusiness Products of the Future.

“Customer Service” Corporate Culture

Endusers demand that suppliers be responsive. Thus speed will be of importance as end users shift the responsibility for inventory management to suppliers as they attempt to minimize their own inventories.

The customer service corporate culture for value-added processors will have a significant technical service component. In my own past experience in providing technical service to canola seed and oil customers it was essential to educate clients on the technical aspects of the product and troubleshoot problems. For me this resulted in extensive work in Mexico in the mid 1980's as the canola industry grew the market for canola from nothing to 300,000 tonnes in three years.

Constant follow-up to ensure smooth transactions will be required by those companies pursuing the customer service corporate culture. The entire process from preparing and submitting a sample to the actual receipt of an order can be incredibly long or short. Every step along the way can have a problem. For example, we were working on a pre-cooked black bean for a food service customer in the U.S. Samples were required on short notice for a trial. We sent by UPS only to have the product stopped at the border. When asked why, we were told that it didn't have the appropriate U.S. Agriculture forms for shipment. When we inquired further U.S. Customs misread the shipping documents and thought we were sending pre-cooked black bear rather than pre-cooked black beans.

At times some things work incredibly well. A Colombian customer requested samples in September. They came to Saskatoon in Mid-November to perfect the product. They ordered one metric tonne by air freight at the end of November and then in the middle of December ordered 150 metric tonnes for shipment by January 1.

Development of Alternative Forms of Capitalization

In the future there will be a significant need to raise capital for value-added processing activities. Large scale operations are capital intensive and are currently the domain of large, well financed companies. The emergence of closed cooperatives in the U.S. may be a sign of the future as producers organize the venture from concept through financing, production and marketing, leveraging their supplier position to capture higher value for their products.

Innovation

The most important trend or factor to consider in how to cash in on value-added processing is Innovation.

Innovation is a key to success. "Success through Innovation" has also become a rallying cry for the Saskatchewan Department of Economic and Cooperative Development.

For our company it is incorporated in our mission statement developed in 1994 and still relevant for us today and perhaps for the future.

"To create value in food and feed ingredients through innovation, quality and commitment"

When you give it some thought, innovation is probably the single most important way to "cash in". Considering if you are a supplier, the best way to predict the future is to create the future by playing a role in building the market for the product.

Invest in science. The agribusiness of the future will have technical expertise as a forte.

Adapt to survive. Things change, be prepared. Move quickly. Expand services and provide customers with what they want and can sell, not with what you want to produce.

I recently returned from a market development mission to Latin America. I saw a quotation inscribed at the Governors Palace in the state of Rio Grande de Sol. The quotation translated from Portuguese to English was "People without roots are people without a future". This made me think about our Saskatchewan - prairie roots. I thought about the pioneers, our history of innovative, hard working farmers, and the companies and organizations they created. This leads me to believe that to have a vision for our future doesn't necessarily mean we forget our past.

New Issues in Pulse Crop Agronomy

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Introduction

Grain legumes, or pulse crops, have become an important component of cropping systems in all parts of the Canadian prairies. While field peas and lentils are the dominant pulse species, dry beans and chickpeas are experiencing a rapid acreage expansion. The ability of pulse crops to fix most of their own N, their N benefit to subsequent crops in rotation, and the marketing opportunities they provide to producers, ensure their place in sustainable cropping systems in western Canada.

The objective of this paper is to provide a summary of the many pulse agronomy projects ongoing across the prairie provinces, and a "summary to date" on the findings of these research activities. Many of the projects that will be referred to are on-going, so conclusions may not be finalized. I wish to thank the support of my fellow agronomists in the preparation of this paper - it is truly a joint effort.

Field Pea Inoculation

Achieving proper inoculation of a pulse crop requires the application of viable *rhizobium* bacteria, their survival until root formation, and their survival under the drying soil conditions. While the amount of N fixed by a field pea crop varies with environmental conditions, a farmer should not have to provide any additional N to a well inoculated pea field. The big issue in pea inoculation in the last few years has been the release of granular formulations of inoculant. The main product has been a granule of peat based inoculant, however, clay based forms are close to being commercially available. Research trials conducted across the prairie provinces has shown that where inoculant responses were obtained, the granular product provided grain yields that were equal, or superior, to powdered peat and liquid formulations. On acid (low pH) soils in the Peace River region, and under dry soil conditions in the Brown and Dark Brown soil zones, the benefit of the granular inoculant was superior (Table 1). These results indicate that the granular product provides more viable rhizobia to the pea under stress conditions. Evaluation of nodule formation also indicates that the nodules tend to form on the lateral roots with the granular product, unlike the accumulation of nodules around the crown of the plant characteristic of peat powder and liquid formulations. These nodules on lateral roots are fixing N later in the season, resulting in higher pea grain protein.

Some advantages of the granular inoculants include the ability to meter the product into the seed row at seeding and it avoids application directly to the seed. Disadvantages are the need to invest in a third tank on the air seeder, and cost of using the recommended rates of 5 lb/ac. However, there is growing evidence to indicate that application rates can be reduced, and there is little doubt that inoculation on fields with a history of field pea production will be achieved with less than recommended rates.

Field Pea Seed Fungicides

At the seven Agri-Food Innovation Fund (AFIF) Spoke Research sites in Saskatchewan, a study was conducted in 1997 to determine interactions between seed applied fungicide and inoculant formulation in Carneval peas under zero-tillage. Fungicide treatments were a control, Apron (metalaxyl), and Apron plus Thiram. Inoculant treatments consisted of an uninoculated control, a liquid and a granular formulation. These two inoculant formulations provided a seed applied and soil applied comparison.

Table 1. Grain yield response of field pea to inoculant formulation at various locations in western Canada (all trials grown on fields with no history of field pea production).

Location	Control	Treatments		
		Liquid	Powdered Peat	Granular Peat
		Grain Yield (bu/ac)		
Melfort - 96	71	70	68	65
Melfort - 97	42	47	41	47
Indian Head - 96	45	50	59	60
Indian Head - 97	30	31	34	39
Swift Current - 97	33	33	-	39
Scott - 97	16	16	-	20
Peace River - 95/96	47	49	62	73

The principle benefit of seed treatment is the reduction of seedling disease, resulting in improved emergence. The results from this study indicate little effect of seed treatment on crop emergence or grain yield (Table 2). At the Canora location the Apron + Thiram treatment increased plant stand over the check and Apron alone, while at Swift Current the opposite was true. Melfort was also the only location where a fungicide response was recorded on grain yield, with the Apron alone treatment being lower yielding than the untreated check. While inoculation had no effect on plant stand, granular inoculant improved grain yield over the liquid and uninoculated check at Indian Head and Swift Current (Table 2). A similar positive grain yield response to granular inoculant was also recorded at Redvers and Scott.

Table 2. Effect of fungicide and inoculant on emergence, nodule score and grain yield of Carneval peas under zero-tillage. Means of 12 observations (4 replicates and 3 treatments).

	Melfort	Redvers	I. Head	Outlook	S. Current	Scott	Canora
<i>Fungicide</i>				<i>— plants/m² —</i>			
Control 25.6	57.3	78.1	70.1	50.0	96.0	41.2	
Apron (A)	23.9	55.7	78.9	71.9	51.3	84.0	46.3
A + Thiram	22.4	56.5	78.5	71.2	40.7	98.3	55.7
<i>Inoculant</i>							
Control 25.7	57.8	76.7	70.1	45.8	83.7	50.0	
Liquid	22.7	57.6	80.8	69.7	45.9	99.3	48.8
<u>Granules</u>	<u>23.5</u>	<u>54.1</u>	<u>77.9</u>	<u>73.4</u>	<u>50.3</u>	<u>95.3</u>	<u>44.3</u>
Lsd(0.05)	5.4	5.2	8.0	10.0	7.8	18.3	8.8
CV	27	11	12	17	20	23	22
<i>Fungicide</i>				<i>— grain yield bu/ac —</i>			
Control 63	38	29	73	37	18	39	
Apron	57	35	28	73	34	17	42
A + Thiram	61	35	27	73	35	17	41
<i>Inoculant</i>							
Control 61	29	27	73	34	16	38	
Liquid	58	38	26	72	34	16	40
<u>Granules</u>	<u>61</u>	<u>42</u>	<u>30</u>	<u>73</u>	<u>39</u>	<u>20</u>	<u>44</u>
Lsd(0.05)	4.4	2.8	2.1	1.4	2.9	1.8	7.0
CV	9	9	9	2	10	12	20

The results from the first year of this study indicate little benefit to seed treatment in crop establishment or grain yield of field pea. The benefit of using the granular inoculant at inoculant responsive test locations proved to be an economically viable option.

Fall/Dormant Seeded Pulse Crops

Work conducted with fall, or dormant, seeding of cereals, oilseeds and pulse crops at Scott Experimental Farm has shown that peas and lentils are not well suited to this practice. Ken Kirkland and Eric Johnson of Scott report that in the 3 years evaluating dormant seeded pulse crops, they had no emergence in two years, and a few plants emerge in the third year with the addition of seed applied fungicides. It would appear that dormant seeded pulse crops are a little way down the road.

Grain Legumes in Semi-Arid Regions

The adaptation of field pea to semi-arid regions has been evaluated over the past 5 years by Perry Miller and Brian McConkey at Swift Current and Stuart Brandt at Scott, Saskatchewan. Their results indicate that early seeded field pea has a high yield potential under water stress conditions, making the crop well adapted to the region. When ample water is available, pea uses less water than other crops with exception of lentil (Table 3). When water is limiting, pea grain yields are

higher than other crops, including spring wheat (Figure 1). Root measurements have confirmed the pea has less roots below 90 cm depth than spring wheat or canola.

Table 3. Yield, water use, and water-use-efficiency (WUE) by 5 crops from three soil depths when grown on fully recharged fallow at Swift Current and Stewart Valley, 1996-97.

	Yield	Soil Depth			WUE
		24-36"	36-48"	0-48"	
	lb/ac	inches of water			kg/ha/mm
CWRS wheat	2770a	1.4a	0.8a	4.9a	9.5a
Yellow pea	2350b	0.6c	0.3b	3.5b	9.2a
Desi chickpea	1710c	1.2ab	0.7a	5.1a	6.2b
Laird lentil	1300cd	0.8c	0.3b	3.9b	4.8bc
Oriental mustard	1270d	1.1b	0.8a	4.7a	4.4c

Values within a column followed by the same letter are not different (P=0.05).

As has been recorded in other areas of the prairies, spring wheat has higher yields and protein on pulse stubble than non-pulse stubbles and, among the pulse stubbles, often does best on pea stubble (Table 4).

Table 4. Yield and protein (basis 13.5% grain moisture) values for uniformly managed CWRS wheat on 7 crop stubbles from 1993 to 1997 at Swift Current and Scott, SK.

Stubble	Yield	Protein
	bu/ac	%
CWRS wheat	32b	12.1c
Dry pea	38a	13.0a
Lentil	37a	12.9ab
Desi chickpea	36a	12.9ab
Dwarf sunflower	33b	12.7ab
Mustard	32b	12.8ab
Safflower	31b	12.6b

Values within a column followed by the same letter are not different (P=0.05).

Chickpea have become a popular and profitable grain legume on many farms in the semiarid prairie. As a new crop there are several issues surrounding the future success of the crop. There are concerns that we may not be able to sell all the chickpeas, at an attractive price, that we are capable of growing. There are some problems with the establishment of kabuli chickpeas, such as the effect of seed size, seeding rate, and seed zone soil temperatures on grain yield and seed size of resulting crop. Current research at Swift Current is focused on these agronomic management

factors. There are few herbicides options for broadleaf control, none for in-crop control. Fortunately, anecdotal evidence indicates that chickpea yields are less sensitive to weed pressure than lentil. And finally, the risk of yield loss due to ascochyta is high and questions about the break down of current genetic resistance under conditions of abundant inoculum and favourable weather conditions is unknown.

Time of Weed Removal in Field Peas

One of the most popular marketing strategies for chemical companies is to advertise a wide "application window" for a particular herbicide. The wide window gives farmers the false impression that it is O.K. to wait until the end of the window to spray weeds. Chemical companies intended to promote crop safety over a wide window of application; crop yield was not in the formula. Indeed, many herbicides can be safely applied to crops at late growth stages. Late applications also kill weeds, but crop yields are not usually optimized by such treatments (Table 5). It is the weeds that emerge before or with the crop that need immediate attention. The talk about controlling late flushes is largely a marketing strategy for those that market residual herbicides; this strategy feeds on the fear farmers have that their neighbours will see weeds in their fields at the end of the growing season. The late flushes may be important for weed seed control and easier combining, but hardly figure in the yields of the current year.

Table 5. Influence of the time of weed removal in weeks after crop emergence on the grain yield of field pea at Lethbridge (1996-97) and Lacombe (1996-98) Alberta.

<u>Weeks after crop emergence</u>	<u>% Weed-Free Check</u>
1	97
2	94
3	87
4	72

(Harker and Blackshaw, Unpubl. data)

Fertilizer Management of Field Peas

The ability to achieve high field pea yields is contingent on an adequate supply of plant available nutrients. While research across the prairies has clearly shown that properly inoculated peas can fix all of the N supply required, there has been some concern about the other macro-nutrients, in particular phosphorus and sulphur. Extensive research conducted by Westco Fertilizers and Alberta Agriculture Agronomy Unit showed that peas were sensitive to high rates (>27 lb P₂O₅/ac) of seedrow applied phosphate fertilizer, however, the actual reduction in plant stand was minimal (Table 6). If the phosphate fertilizer was side banded, plant establishment was unaffected. The same study reported that sideband application provided a very minor grain yield advantage over seedrow placement of phosphate fertilizer. When N was seedrow applied, at rates up to 45 lb/ac, seedling stands were reduced as much as 55%, with subsequent grain yield reductions of 22%. At the Melfort AFIF Spoke research site a fertilizer blend

(13-20-10-10) was placed either in the seed row, side banded or spread under a sweep with the peas. The reduction in seedling stand with seed row placement was reflected in lower grain yield in 1997, however, not in 1998 (Table 7). Fertilizer placement with the seed using a 9" spread under a sweep proved to be as good as or better than side band application. However, in both studies little grain yield response was obtained from fertilizer addition, leading us to question the level of grain yield response we can expect from peas under nutrient deficient conditions.

Table 6. Plant emergence and grain yield response of field pea to fertilizer P rate and placement.

P ₂ O ₅ Rate	Fertilizer Placement	Seedling emergence Plants/m ²	Grain Yield bu/ac
0	N/A	73	64.0
13	Seedrow	72	66.0
	Side band	73	66.7
27	Seedrow	72	68.0
	Side band	73	68.7
40	Seedrow	70	68.9
	Side band	74	70.1
54	Seedrow	70	69.7
	Side band	74	70.6

Westco Unpubl. Data

Table 7. Plant emergence and grain yield of Carneval pea to fertilizer placement, Melfort 1997-98.

Fertilizer Placement	Seedling emergence Plants/m ²		Grain Yield bu/ac	
	1997	1998	1997	1998
Seedrow	39 b	51 c	48 b	41
Side banded	46 ab	64 b	54 a	39
Sweep	49 a	73 a	53 a	38

(Johnston, unpubl. Data)

Adaptation of Pulse Crops

The pulse crops currently being grown on the Canadian prairies range in their adaptation, based principally on tolerance to moisture stress. Drought tolerant species like lentil and chickpea are generally recommended for semi-arid regions, while peas, beans and faba beans are usually grown in the sub-humid Parkland or under irrigation. Recent work with peas at Swift Current indicates that they are well adapted to semi-arid regions when seeded early. To assess the production potential of a number of pulse species, a study was designed to evaluate the regional adaptation of five pulse species (faba bean, pea, lentil, dry bean and chickpea) across the agroecological zones of Saskatchewan (Swift Current, Scott, Indian Head, Redvers, Canora, Melfort and Outlook - irrigation). Each of the trial locations grew the same variety of each species, allowing a comparison across regions. The varieties included Carneval and Grande field pea, Aladin faba bean, Laird lentil, Othello dry bean, and Sanford chickpea. While chickpea was found to be well

adapted to semi-arid regions, field peas were the best adapted, and highest yielding, pulse species considered at all trial locations (Table 8). While not as high yielding, lentil was also well adapted to all regions in this drier than normal growing season (1997). Lentil was not grown under irrigation at Outlook, reflecting past experience with high yield losses due to disease of lentil under high water conditions. Dry beans were found to have little or no tolerance to moisture stress as was shown by the low yields at experienced under mid-season drought at Scott and Indian Head. It appears that dryland beans will be suited best to the wet Parkland region and under irrigation.

The early results of this five year pulse adaptation study indicate that the broad adaptation of field pea demands that it continue to receive high priority in crop management research initiatives. It is likely field pea which will be the introduction for most new pulse growers.

Table 8. Crop establishment (plants/m²) and grain yield (kg/ha) for five pulse species grown at various locations in Saskatchewan.

	Canora	I. Head	Melfort	Outlook	Redvers	Scott	S. Current
Aladin Faba Bean							
Plants/m ²	-	48.3 ab†	19.7 c	36.7 bc	41.9 b	42.7 b	62.7 a
Grain Yield	-	606 b	1333 b	3448 a	961 b	1105 b	984 b
Carneval Pea							
Plants/m ²	72.2	74.5	36.6	65.0	79.4	90.0	46.7
Grain Yield	2631 bc	1914 c	3336 b	4899 a	2378 bc	1734 c	2246 bc
Grande Pea							
Plants/m ²	151.5 a	74.5 bc	42.1 d	65.7 c	90.9 b	82.0 bc	71.5 bc
Grain Yield	3057 abc	2073 c	3034 abc	3915 a	3081 ab	3026 abc	2385 bc
Laird Lentil							
Plants/m ²	101.2	106.6	50.3	-	93.1	126.7	74.4
Grain Yield	1069 cd	1256 bc	2162 a	-	718 d	1132 bc	1495 b
Othello Bean							
Plants/m ²	45.4	23.3	31.2	33.7	46.9	29.3	41
Grain Yield	1011 bc	247 c	738 bc	2700 a	1336 b	222 c	56
Sanford Chickpea							
Plants/m ²	-	-	47	45	48	53	60
Grain Yield	-	-	1065 b	3296 a	1427 b	973 b	21

† Numbers within rows followed by the same letter are not significantly different using LSD_{0.05}.

Figure 1. Grain yield responses of field crops to variation in seasonal water use. The data is from field trials conducted at Swift Current between 1996-1998.

Root and Foliar Diseases of Peas and Their Control

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Peas (*Pisum sativum* L.) are susceptible to a number of bacterial, fungal, viral and nematode caused diseases which can drastically reduce both yield and quality. Soilborne fungal diseases discussed in this paper include seedling diseases and root rots. Foliar diseases include Ascochyta Blight, Powdery and Downy Mildew, Bacterial Blight, and Sclerotinia White Mold. Virus diseases discussed include Pea Enation Mosaic, Pea Leaf Roll, Pea Streak Virus and Pea Seedborne Mosaic Virus. Also briefly discussed is Pea Cyst Nematode as it relations to Fusarium root rot.

Seed Vigor and Seedling Diseases

Because peas are such a short season crop it is paramount that seed with good vigor be planted. With poor seed vigor (i.e. low germination, high electroconductivity readings, significant levels of hollow heart) the grower will not realize a significant profit from the resulting crop. Poor stands, slow emergence, and poor vigor results in secondary problems arising such as seed decay and severe root rot. Factors which delay emergence or result in uneven plant stands, such as cold wet soil, poor seed vigor and herbicide injury, can predispose your developing plants to seedling disease. The ability to germinate and emerge under cold, wet conditions is defined as seed vigor. One test to measure seed vigor is the electroconductivity test which measures the amount of inorganic salts released during imbibition. The higher the EC rating, the greater the risk of planting this seed into cold, wet, soil. Smooth seeded peas do not exude comparable amounts of carbohydrates and inorganic salts relative to wrinkled seeded peas and are less susceptible to seed and seedling infection.

Pythium seed and seedling disease.

An important seedling disease discussed is seed rot and root tip pruning caused by *Pythium ultimum* Trow. *P. ultimum* is a rapid grower in soil and can attack the germinating seed which exudes nutrients into soil. The poorer the germination and seed vigor the more nutrients exude and the more prone to attack by *Pythium*. Wrinkled seeded varieties are much more prone to attack by *Pythium* than smooth seeded varieties. Seed treatment fungicides such as Captan or Apron or biological agents can reduce *Pythium* attack.

Rhizoctonia seed and seedling disease.

Another seedling disease is caused by *Rhizoctonia solani* (AG-4) which can cause seed rot, hypocotyl and epicotyl rot. *R. solani* (Ag-4) is primarily located in the top 10 cm of soil and is more prevalent in reduced or no-till fields where surface litter is predominant. Clean tillage essentially eliminates the problem. In addition, pea varieties with thick stems are less susceptible to damping off by *R. solani*. Seed treatment fungicides with specific activity against *R. solani* and biological seed coatings are also effective in reducing stand and seedling loss caused by *R. solani*.

Root Rots

Root rots of peas are caused by a number of different soilborne fungal pathogens that can produce similar symptoms. This disease complex can involve the entire root system and even extend a short distance above the soil surface. Once flowering is initiated, the majority of the photosynthate produced by the plant is shunted into the developing pods and berries. The result is a cessation of root growth and a rapid decline in root vigor and health. Consequently, the more vigorous the developing root system, the better chance to resist serious root disease. In addition, early maturing varieties (i.e. bloom in the 8-10th node) have less root development and can be devastated by root disease if early season warm weather occurs. Later maturing varieties have a larger root system and have a better chance to produce an economically viable crop in spite of root disease. Root rots are also enhanced by short or close rotations between pea crops and conditions of plant stress. Conditions which limit root growth such as compaction, poor fertility, anoxia, excess or deficient moisture, herbicide injury, and suboptimal temperatures can all increase the damage due to root rot.

Fusarium root rot

One important root rot pathogen of peas is *Fusarium solani* f. sp. *pisi*. In young plants the initial center of attack by *F. solani* f. sp. *pisi* is the seed piece area and infection extends upward to the soil line and downward into the root zone. The degree of root infection and damage is directly dependent on the soil environment. A red discoloration of the vascular system may occur in the root but does not progress above the soil line. Only when the primary and secondary roots are infected by *F. solani* f. sp. *pisi* is the disease serious enough to affect plant vigor and yield. Above-ground symptoms consist primarily of stunted growth and yellowing of the basal foliage. Initial symptoms on seedling roots consist of reddish-brown to blackish streaks which coalesce.

Control of Fusarium root rot is for the grower to create conditions which allow the pea root system to grow away from the pathogen. Thus, reduction of soil compaction, good seed vigor and good soil fertility will allow the grower to manage this disease.

Aphanomyces root rot.

Common root rot is caused by the water-mold fungus *Aphanomyces euteiches*. Common root rot is the most devastating root disease of peas world-wide. *A. euteiches* can infect peas at any stage of plant development and symptoms appear approximately 1-2 weeks after infection. Symptoms include soft, watery-soaked lesions on the surface of the lower stem and root which turn tan

colored. The infection rapidly spreads through the root cortex causing an eventual discoloration of the entire root system. The infected tissue turns dark as other organisms invade. When infected plants are mechanically pulled from the soil, a strand of vascular tissue is often all that remains of the root system. Microscopic observation of infected cortical tissue reveals thickwalled sexually produced spores that can survive in soil for years. *A. euteiches* is spread by water and soil movement, infected root debris, or by farm implements. Other legumes such as alfalfa, common bean, faba bean, clover and lentils are also hosts for *A. euteiches*.

Control of common root rot is very difficult. Once a field is heavily infested, a non host (i.e. wheat, oats, barley) must be planted for at least 10 years before a profitable pea crop can be grown again. Oats have been shown to aid in reducing the inoculum potential of *A. euteiches*, perhaps due to the production of fungistatic compounds called saponins in the roots and tops. Soil can be tested for *Aphanomyces* root rot potential to avoid planting in severely or heavily infested fields. If the root rot potential is moderate to severe, the field is not recommended for peas. If the root rot potential is moderate to slight, an early maturing cultivar is recommended. Currently, there are no commercially available seed treatment chemicals or biological control agents that will consistently control this disease.

Genetic resistance to *A. euteiches* appears to be quantitatively inherited with low heritability and is associated with slower disease and pathogen multiplication in the host. Resistant/tolerant germplasm lines have been released by public breeders in the United States that are being used by commercial breeders. Resistance/tolerance, together with cultural practices, improved seed treatment chemicals and determining inoculum potential in designated fields will help reduce the economic impact of this disease.

Foliar Diseases

Powdery mildew is caused by the obligate parasite *Erysiphe pisi*. The disease is most serious when days are warm and dry and nights are sufficiently cool for dew formation. Powdery mildew can also be severe when peas are grown in late season or in low, wet areas with high soil moisture, which allows that plant to remain in the vegetative state. The disease is least serious where there is high rainfall or sprinkler irrigation. In areas where the weather becomes warm quickly, powdery mildew usually does not become severe because of early plant senescence.

Symptoms include white colored spots on the upper surface of the lowest and oldest leaves. The spots increase in size and appear as white powdery areas. On a susceptible cultivar, the disease can progress until the entire plant is covered with white, powdery mycelial growth. Tissue beneath infected areas may turn a purplish color. Severe infection results in premature crop senescence and reduced quality and yield. The pathogen over winters on infected plant debris, on alternate hosts and can be seed born.

Resistance to powdery mildew is readily available in commercial cultivars and has been stable for nearly 50 years. In areas where the disease often occurs and resistant varieties are not readily available, early maturing varieties plus chemical sprays are the most viable option. Chemical control includes spraying powdery mildew infested fields with flowable, elemental sulfur at 3-4 kg ha. Other control measures include crop rotation and immediate plowing under of the infested crop debris.

Downy Mildew is caused by *Peronospora viciae*. In contrast to powdery mildew, downy mildew most often occurs during cool moist growing conditions. The downy mildew pathogen can be either systemic or localized on leaves and/or pods. Systemically infected plants are severely stunted, usually distorted, and *P. viciae* sporulates rapidly on the plant surface. Systemically infected plants usually die before maturity. Late plant infection is usually confined to the plant top. On the upper side of the foliage, white, yellow and/or brown lesions with diffuse margins appear. Opposite the lesions, on the underside of the leaf, grey-brown patches of the fungus appear. There appears to be a positive correlation between semi-leafless foliage peas, types with reduced stipule leaves, and increased susceptibility to downy mildew.

P. viciae overwinters in the soil and on plant debris and systemic infection develops from this source. The fungus can survive for 10-15 years in soil. Pod infection can occur during periods of high humidity and can occur with foliage infection. Infected pods are deformed. The fungus can occur with the seed coats as well, however documented transmission of this disease through the seed has not been reported.

Long rotations and deep plowing of infected crop debris are recommended to control downy mildew. Acylalanine fungicides (such as metalaxyl) have been effective in reducing or eliminating early systemic infection. However, reports of fungal resistance to metalaxyl have been observed both in New Zealand and in Northwestern Washington. Several sources of resistance to downy mildew are known. However, as many as six physiologic races of downy mildew are reported to occur in Europe. No pea genotypes with complete resistance to all known races exist.

Ascochyta blight is caused by three separate fungal pathogens: *Ascochyta pisi* which causes a leaf, stem and pod spot; *Phoma medicaginis* var. *pinodella* which causes a leaf spot, stem rot and root rot; and *Mycosphaerella pinodes* which causes a leaf, stem, and pod spot and root rot. Under field conditions it is not easy to distinguish between the three and should be considered as a single disease. All three pathogens are seed transmitted and spread in pea trash. However, *Ascochyta pisi* does not produce a survival structure and will not survive in soil more than 6-12 months. In contrast, *M. pinodella* and *P. medicaginis* var. *pinodella* produce chlamydospores which can survive in soil or in pea debris for several years. Consequently, clean, non-infested seed will go far in eliminating *A. pisi* as a disease causing problem. Because both *M. pinodella* and *P. medicaginis* can overwinter by producing chlamydospores is the reason they are far more difficult to control. In addition, *M. pinodella* is by far the most aggressive and causes more severe disease losses world-wide. Only *M. pinodella* produces a perfect stage and can change

genetically to produce more virulent strains which also makes this pathogen difficult to control via disease resistant varieties.

Moist conditions are required for infection and plant-to-plant spread of all three pathogens. Plants can be attacked at any age but mature leaves are the most susceptible. The production of seed in arid growing conditions and the use of seed treatment chemicals have essentially eliminated *A. pisi* as an important pathogen of peas. Under field conditions, with and without fungicide sprays it was found in Australia that there was a 5-6% loss in yield for every 10% of stem area affected by *M. pinodes*. Also, *M. pinodes* was found to be more severe on early-maturing varieties. No commercial varieties currently exist which have a high level of resistance to this disease.

Bacterial blight, caused by *Pseudomonas syringae* pv. *pisi*, is a seed born disease found in most pea growing areas of the world. Symptoms of bacterial blight can occur at any time during the growing season, especially following a heavy rain, a hail storm or when the crop is grown under overhead sprinkler systems. Initial symptoms usually occur at the node area and on stipule leaflets. Lesions quite often develop first on the underside of leaves and appear as water-soaked lesions that appear dark green or brown on the upper surface. Older lesions tend to have light brown centers and dark borders. Pods can become infected with lesions that are circular, water-soaked and sunken. Seed become infection due to pod infection. Bacterial blight can be disseminated from one seed lot to another during threshing and milling, even when fungicides are applied. Harvesting equipment can also spread the pathogen if not disinfected between seed lots.

Planting clean seed and growing resistant cultivars are the primary means of control. Seed should be produced in arid areas and not under sprinkler irrigation. Sodium hypochlorite used in a 1% concentration is reported to reduce seed infection by 85 – 90%.

Sclerotinia white mold or vine rot is caused by *Sclerotinia sclerotiorum*. This pathogen can infect numerous dicotyledonous plants. The fungus is characterized by the production of large resistant bodies, called sclerotia, which resemble rat feces, and vary from 2.5 – 6 mm. The sclerotia germinate to form mycelia which can invade seeding roots and cause a damping-off or they can develop a perfect stage and release wind blown ascospores. Ascospores are the primary means of foliar infection and can be spread several miles by wind and still remain viable.

White mold can be serious where humidity is high and is almost always associated with the formation of a dense canopy, which restricts air movement on the soil surface. Conditions which induce excessive vine growth such as excess N, plentiful soil moisture, good soil fertility, heavy seeding rates, or plant types which produce large canopies that fill in rapidly, are conducive to white mold development.

To control white mold, sclerotia should be deep plowed after harvesting an infected crop. Following such crops as potatoes, Brassica species and beans with peas should be avoided. There are no resistant cultivars available nor has resistant germplasm been developed. Some

recommendations for fungicide applications have been made. However, it is difficult to penetrate to the soil line through the canopy with effective chemicals to stop the spread of white mold, once it is evident.

Virus diseases of peas

There are a number of viruses, which infect peas in the Pacific Northwest. All are aphid transmitted, but only one is seed transmitted. Most survive from year to year in perennial alfalfa, vetch, and/or clover. In general, the older the stand of alfalfa, the more virus infection will be present in that stand. In years where virus diseases were severe in the Pacific Northwest was when the winter was mild and adult aphids were present in early spring. The following spring was warm and the first cutting of alfalfa was early. Thus winged, viruliferous aphids migrated to the nearest pea field in pre-bloom stage.

Bean Leafroll Virus is a phloem limited virus and is not mechanically transmitted nor seed transmitted. This virus was first recorded in the United States in 1980 where it caused a serious epidemic in the Magic Valley of southern Idaho. Symptoms consist of a pronounced top yellowing and typical leaf rolling. Alfalfa and clover are considered the primary overwintering hosts.

Resistance in pea to Bean Leafroll Virus is inherited as a single recessive gene and there are several resistant, commercially available varieties.

Pea Enation Mosaic Virus has caused economically important losses in the Pacific Northwest. Symptoms caused by this virus include translucent flecks or windows, together with vein-clearing and malformation in leaves and stipules. Plants are often severely stunted and distorted. The virus can cause death of susceptible plants, especially when infected early in the growing season. This virus is not seed transmitted and is aphid transmitted, primarily by the pea aphid.

Control of Pea Enation can be aided by elimination of aphid populations and overwintering hosts. Control is often difficult when peas are grown near a clover field. Recent, published evidence states that alfalfa is not an overwintering host for Pea Enation Mosaic Virus. Resistant, commercial varieties are available.

Pea Seedborne Mosaic Virus was first described in the United States in 1968 in seed production fields in the Pacific Northwest. Since that time the virus has been found in all pea growing areas of the world. Because of the potentially high levels of seed transmission, the ease of dissemination through the international exchange of seed, and the numerous species of aphids that can transmit the virus, Pea Seedborne Mosaic continues to be an important virus disease of peas.

Symptoms vary with cultivar, temperature and environment as well as with virus strains or pathotypes. Common symptoms include downward leaf rolling, vein clearing, mosaic, pronounced pod abortion and a general stunting of the plant.

Symptoms are usually most severe on plants developing from infected seed. Plants grown in the field frequently display fewer symptoms than those which are grown in the greenhouse. Midseason cultivars typically display more severe rosetting symptoms than early maturing cultivars.

Pea Seedborn Mosaic Virus is transmitted by at least 21 different aphid species. Of special concern in the Pacific Northwest is the potato aphid wherever potatoes are grown near pea fields. Care should be taken by plant breeders and commercial growers to ensure that seed lots are relatively free of the virus. The most efficient control of Pea Seedborne Mosaic Virus is to grow resistant cultivars. Resistance to Pea Seedborne Mosaic has been described and Pea Seedborne Mosaic resistant cultivars have been released.

Pea Streak Virus is found throughout the pea growing areas of the United States. This virus can cause serious losses. Often field symptoms occur only as affected single plants in a scattered pattern. Symptoms on affected pods include brown necrotic and sunken lesions. General leaf chlorosis can also occur. Severe strains of Pea Streak Virus can kill younger plants that are infected before flower set.

Control of Pea Streak Virus consists primarily of not planting peas near established alfalfa fields and close monitoring and suppression of aphid populations with timely insecticide applications. No pea cultivars are resistant to Pea Streak Virus although several Plant Introduction accessions and several pea breeding lines have been reported to be resistant.

Conclusion

I have attempted to describe the most important diseases of peas on a national and international scale, the disease symptoms and control. The good news is that many of these diseases can be controlled economically by growing resistant varieties. Encouraging also is that resistance to such diseases as Powdery Mildew, Pea Enation Mosaic, Pea Seedborn Mosaic and Fusarium wilt (not covered in this paper) has held up for a number of years. Other diseases such as Root Rot, Ascochyta Blight, Sclerotinia White Mold, and Bacterial Blight have to be controlled via an IPM approach utilizing cultural practices, seed treatment chemicals, irrigation rates and timing, and resistant/tolerant cultivars.

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Pulse Marketing: Where are Canada's Opportunities

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Introduction

Pulse Canada is a national organization representing Canadian pea, bean, lentil and chickpea growers and the pulse trade. The Alberta Pulse Growers along with grower organizations in Saskatchewan, Manitoba and Ontario provide funding to support the Pulse Canada market development plan. Funding is also provided by members of the pulse trade through the participation of the Canadian Special Crops Association. The Government of Canada provides funding for specific projects that qualify under the AIMS initiative.

Pulse Canada is involved in projects to support the development of new markets for Canadian pulses. The organization is also involved in promotional activities in established markets. These activities focus on both human consumption and animal feed markets.

Market access is an important component of developing and expanding Canadian exports. Through work with the Canadian government and industry associations in priority markets, Pulse Canada is involved in the identification and elimination of tariff barriers, quota restrictions and phytosanitary-related restrictions that have a negative impact on the trade of Canadian pulses.

Pulse Canada also addresses trade distorting production subsidies in foreign countries that affect the pulse industry in Canada. Discussions related to market access and trade distorting subsidies have taken on a high priority as the Government of Canada prepares to table the Canadian negotiating position for the upcoming World Trade Organization's next round of discussions.

This presentation looks at market opportunities for feed peas and the activities that Pulse Canada is involved with to develop these markets. The presentation will also look at markets for edible pulses and Pulse Canada's role in ensuring that pulse buyers in these markets think of pulse crops produced in Canada.

The graphs at the end of this presentation provide statistical information about Canadian pulse production over the last ten years, global pulse trade and the value of global pulse trade as well as leading producers, exporters and importers of peas, beans, lentils and chickpeas.

The Markets for Feed Peas

Canada's primary market for peas is Western Europe. Feed peas dominate pea exports to this region.

Canadian Dry Pea Exports (metric tonnes)

Crop Year			
	'92/'93-'96/'97 (Ave)	1996-97	1997-98
Western Europe	469,477	471,627	385,130
Eastern Europe	461	127	-
Middle East	13,803	4,975	5,731
Africa	15,843	7,003	7,762
Asia	124,852	175,809	151,421
Oceania	203	22	16
South America	57,912	77,945	76,667
Central America	53,331	80,401	91,567
North America	25,766	38,214	31,420
Total Exports	761,287	856,122	749,715

(Statistics Canada)

Feed companies and hog growers in Spain, Belgium, Holland and Germany use peas from France, Canada, Ukraine as well as Scandinavian and Eastern European countries in their rations and prepared feeds. It should be noted that Canadian feed peas currently face a 1% tariff on imports to Europe whereas Ukraine and other Eastern European peas enter Europe duty-free. Some feed compounders use peas in rations at 3-4% to improve pellet quality. However, the decision to use peas in a ration is mostly a function of pea prices relative to protein and energy prices from a wide range of feed ingredients.

The European feed market is the world's leader in using a wide range of non-food ingredients to achieve the lowest possible feed ingredient costs. The list of ingredients includes tapioca, citrus pulp, beet pulp, as well as meal from oilseeds like sunflower, flax, soybeans and canola. Palm kernel meal, copra fiber, and wheat mill by-products are just some of the over fifty ingredients used in Europe. An extensive system of inland waterways, rail and road transportation combined with the wide choice of ingredient availability gives Western Europe a unique combination of influences in the world's feed-ingredient market. In this environment, peas are just one of the many ingredients that have to compete with a wide range of protein ingredients (primarily soybean meal) and a wide range on energy ingredients (like cereal grains) for a share of the feed ingredient market.

Canada's reliance on the European feed market for feed pea sales can be traced to European farm policy and price supports for cereal grains. The price for Canadian feed peas in Europe was higher than could be achieved in other markets including North America. This phenomena was due to a high intervention price for European cereals, relatively low import duties on peas and an overall protein deficit in Europe. As European intervention price support for cereal growers declined, pea prices along with other feed ingredient prices dropped to stay competitive. Peas now compete in a European market where government policy is not providing the same degree of artificial price support through high intervention prices.

Factors such as the number of hogs on feed in Europe and economic troubles on a global scale have played a role in the cyclical demand and returns from the European market.

Dutch hog numbers have declined from 16.5 to about 15.5 million hogs and will continue to fall under government mandated policies to reduce hog numbers an additional 15% in 1999. Hog cholera temporarily reduced Dutch hog numbers to 10 million hogs, which also had an impact on feed ingredient demand. France has 18.5 million hogs and, like many EU countries, has to deal with environmental concerns. Spanish hog numbers have increased in recent years although the growth has stagnated with recent negative margins in the hog industry. The European feed industry is not expected to grow significantly in the future.

The economic crisis in Russia has hurt the European hog meat industry. Prior to the Russian crisis, 30-35% of European pork exports was to Russia.

While Europe remains as Canada's most important feed pea market, efforts to diversify the market base are a priority for Pulse Canada.

Philippines

The Philippine feed market can be characterized as a progressive market with a wide range of feed companies from several countries investing in the industry. However, the industry has been shaken by the Asian economic crisis with feed production down 20-25% in 1997-98. Lower purchasing power resulting from a devalued currency has reduced demand for meat. The decline

in global pork prices combined with the currency devaluation has also lead to a decline in pork production in the Philippines.

100% of the soybean meal used in the Philippines is imported as is 10% of the feed corn. Quotas restrict corn imports. These quotas are being phased out over a ten-year period to give the Philippine corn farmer a chance to adapt to an open trade environment. High tariffs on over-quota imports keep Philippine corn prices higher than world prices. Peas can substitute for a portion of the energy supplied by corn. Therefore, the nutritional value of peas in the Philippine market is higher than the current market value of feed peas.

November 1998 Philippine Feed Ingredient Costs

Ingredient	Cost (Pesos/kg)
Corn	6.5
Soybean Meal	9.0
Copra meal	3.7
Wheat Shorts	3.5
Molasses	20.

(CIGI)

The opportunity price for Canadian peas in the Philippines (at the feed-mill) in November 1998 was US\$180.00/tonne. The Vancouver FOB price for peas at that time was about US\$120.00/tonne. Ocean freight, port costs and internal transportation costs have not been accounted for.

The market price of peas relative to their nutritional value in Philippine feeds should have lead to an increase in the utilization of peas in Philippine feed formulations. Export statistics, up to end of the 1997-98 crop year, show that this has not yet occurred.

Philippine Feed Pea Imports from Canada (tonnes)

	'92/'93 - '96/'97 (Ave)	1996-97	1997-98
Philippines	4,438	7,093	4,935

(Statistics Canada)

The objective of market development activities is to try and determine what additional action may be necessary to further the utilization of feed peas in the Philippines. Market development activities in this country have included feeding trials followed by seminars to discuss the trials in

1997. Pulse Canada and CIGI visited major feed companies in the Philippines in the fall of 1997 to discuss the feed pea utilization and assess the level of knowledge of feed peas at the nutritionist and buyer level. The Canadian International Grains Institute carried out a feed program for Philippine nutritionists in the summer of 1998. The objective of the program was to raise the level of familiarity among nutritionists with the practical considerations of using feed peas in hog. This program included lectures, stops at the Prairie Swine Center, commercial hog operations, and feed plants in Western Canada.

The latest market development effort in the Philippines included visits with leading Philippine nutritionists and feed companies in the fall of 1998. These visits indicated that some issues, such as the long-term availability of peas for this market, are important in the minds of some buyers. These, and other issues, will be dealt with in the upcoming second edition of a feed pea newsletter written specifically for the Philippine market. By dealing with real and perceived issues, Pulse Canada is attempting to support trade efforts to sell peas by raising the confidence level of Philippine buyers and the quantity of peas that they purchase.

China

China is another high priority market for feed pea market development. The Chinese feed industry is experiencing rapid growth and has the second largest feed industry in the world, after the United States. Total compound feed production is over 50 million tonnes per year. As incomes have risen, Chinese pork consumption has more than doubled in the past ten years to over 30 kg/person/year. The Chinese have also developed a preference for lean pork and the demand for pork is being met by increasingly sophisticated hog operations.

In November 1997 a feeding trial was set up for broilers and hogs in the province of Guangdong. The Chinese have seen this project as the first step in diversifying feed ingredients. The project was a joint effort between Pulse Canada, the Canola Council of Canada, and CIGI. Guangdong is the largest feed producing province in China accounting for 13% of China's total prepared feed production. However, the province must import all feed ingredients from other regions in China or from other countries. A growing feed industry reliant upon imported feed ingredients supporting a large hog industry makes Guangdong a high priority region within China. In fact, if the feed industry in Guangdong used feed peas at 30% in the feed formulations, this province alone would have an annual demand for two million tonnes of peas.

The results of the feeding trial demonstrated to the Guangdong feed industry that Canadian peas and canola meal can be used successfully as replacements to the traditional diets of corn and soybean meal. More importantly, peas could produce a cost saving in the ration provided that they received equal treatment regarding import duties and exemption from the value-added tax (VAT).

November 1998 Chinese Feed Ingredient Costs

Ingredient	Cost (US\$/tonne)
Corn	155.00
Soybean Meal	205.00
Wheat Bran	145.007
Fish Meal	780.00

(CIGI)

The opportunity price for Canadian peas at a Chinese feedmill in Guangdong province in November 1998 for a hog grower ration was US\$175.00/tonne. The Vancouver FOB price for peas at that time was about US\$120.00/tonne. Ocean freight costs have been quoted from US\$12-15/tonne for 50,000 tonne vessels to US\$27/tonne for a 20-25,000 tonne vessel. Port costs, duties, and inland transportation to the feedmill must also be considered.

While Canadian pea exporters may face some of the same reluctance to switch to a new feed ingredient that has been seen in the Philippines, a larger hurdle may be to achieve tariff parity for peas with other feed ingredients in the Chinese market. China currently assesses an import duty of 8% on pea imports. By comparison, soybean meal is assessed an import duty of 5%. While this puts peas at a 3% tariff disadvantage, the economics of peas is further disadvantaged by the fact that a 13-18% VAT is assessed against imported food products. Since there is no separate classification for food or feed peas, all peas are considered for human consumption and are subject to the VAT. Feed ingredients, like soybean meal, are exempt from this tax.

The Pulse Canada challenge is to identify and work with the appropriate Chinese government ministries to address the tariff inequities. At the same time, Pulse Canada will want to continue to work with the Chinese feed industry to demonstrate the value of feed peas in a ration to generate demand within the country. With encouragement from outside and within the country, it may be possible to develop enough interest in peas to achieve a policy change. This process could take months or years or it could happen quickly as China moves towards a bilateral agreement with the Government of Canada. Chinese motivation may also be to broaden the list of ingredients that can be used in animal feeds to reduce the dependence on imported soybean meal. Pulse Canada along with an official from Agriculture and Agri-Food Canada will return to China in early March 1999 to work with government officials in Beijing to have peas classified as a feed ingredient and seek tariff parity with feed corn and soybean meal. The Canadian International Grains Institute has been asked to conduct a program at CIGI on behalf of the Canadian pulse industry during the summer of 1999. This program will be used to work towards tariff elimination as well further the understanding of the use of feed peas in hog rations.

Chile

Chile is another priority market for feed pea market development in 1998-99. Chile is an importer of both corn and soybean meal.

Super Pollo, the largest integrated producer of feed, poultry and hogs, has expressed strong interest in feed pea trials to diversify their feed ingredients for a 50,000-sow operation. Expansion of their feed plant will boost capacity to 100,000 tonnes per month, as they are also the largest poultry producer in the country. Early calculations show that feed peas would be a cost effective feed ingredient for this market.

Work is currently underway with a consulting group in Chile that works with hog producers that account for 30% of the hog industry in Chile. Feeding trials will begin early in 1999. Similar to other trials, feed peas will be used to displace a portion of the traditional diet of corn and soybean meal with extensive evaluation of feed intake, feed conversion, cost of gain and other factors like impact on meat quality with a change in the ration.

While the feeding trials will not be completed by March, seminars are scheduled for Chile to discuss the use of feed peas in hog rations. A Spanish language newsletter will also be prepared in January 1999 and sent to hog growers and feed companies.

Canada currently enjoys preferential access for peas into Chile. Under the Chile-Canada Free Trade Agreement (CCFTA), Canada enjoys a 2% tariff advantage over pea imports from other countries. However, Canadian feed peas would be subject to the CCFTA 8% duty in 1999. Other feed ingredients enter the country duty-free. As part of the Agriculture and Agri-Food Minister Vancilief trade mission in September 1998, Pulse Canada was able to have this issue discussed with the Chilean Minister of Agriculture. The Chilean Department of Agriculture and Canadian Department of Agriculture are now working on a way to eliminate the tariff on feed peas completely.

Other Latin American Markets for Feed Peas

Mexico and Colombia are also priority markets for the 1998-99 year. Additional feeding trials have been proposed for the state of Jalisco or Michoacan. Seminars will also be held in Ciudad Obregon and Guadalajara, Mexico in March as well as in Medellin and Bogota, Colombia prior to the program in Santiago, Chile. The Spanish language feed pea newsletter will also be sent to these countries.

The objectives of the feeding trials, seminars and newsletters for Latin America is the same as it has been in the Philippines, and is in China. Feed users who are not familiar with feed peas as an ingredient for hog and or poultry feed must be made aware of how peas can be used. Canadians must identify their specific concerns and then carry out programs or information transfer to address these concerns.

The Canadian International Grains Institute has also been asked to conduct a feed ingredient program interpreted into Spanish during the summer of 1999. Participants from Chile, Colombia and Mexico will be invited to this program.

Edible Peas, Beans, Lentils and Chickpeas

Pulse Canada's promotion and market development activities for edible pulse markets focus on two goals. The first goal is to increase the visibility of Canadian pulses and to ensure that customers always think of Canadian product when in the market for peas, beans, lentils or chickpeas. The second goal is to keep abreast of changes that are happening in markets to determine whether additional action on issues may be needed by the Canadian industry.

Global pulse consumption is affected by four factors. These factors are dietary shifts, income level, urbanization and population growth.

Diet and income level are often closely linked. In many developing countries, a rise in income will lead to a rise in consumption of grain or grain based products like pulses, bread and rice. A higher standard of living allows these people to meet their nutritional needs. As incomes continue to rise, the types of food products that are consumed start to change. Meat and dairy product consumption often rises, while grain and grain product based consumption peaks and then declines as more 'expensive proteins' like meat and dairy replace the grain products. Developed countries are most likely to see consumption trends change as a result new food products gaining popularity. Bean consumption has increased as 'Tex-Mex' food became more popular.

However, it is important to note that global per capita pulse consumption has remained constant over the last ten years. People in developing countries consume about 7.5 kg/person/year and developed countries consume about 3.0 kg/person/year.

Global population is the single largest driver of pulse consumption. World population is increasing by about 80 million people per year. Some estimates suggest that world population could peak at 11 billion people by 2050, up from the current population of 5.9 billion. The challenge to feeding this growing population is tremendous. Even today, it is estimated that 19,000 children die each die due to malnutrition and disease.

Urbanization of the world's population also has a minor impact on pulse consumption. Urban people tend to spend less time at food preparation. This is a challenge for the pulse industry as pulses tend to take a longer time to prepare than some other products. Quick cooking pulse products will be needed to maintain and expand pulse utilization in the urban diets. Urbanization can also change the supply routes for food products. In some cases, importation of food products may be cheaper than supplies from producing regions within the country.

Pulse Canada is one of several organizations around the world that promote pulse products from their country. Pulse Australia is involved in many of the same activities that Pulse Canada is involved in with the added responsibility of providing input into research priorities. In the United

States, the National Dry Bean Council and the USA Dry Pea, Lentil and Chickpea Council coordinate promotion and development activities on behalf of state organizations. The USA Dry Pea, Lentil and Chickpea organization also has offices in overseas countries. While the budget and scope of activity of Pulse Canada can not be compared activity for activity with these other organizations, all of the organizations share their respective national interests when working in the international market.

Pulse Canada has developed brochures to promote Canadian peas, beans, lentils and chickpeas in markets around the world. These brochures have been printed in English, Spanish, Portuguese and Arabic. (Feed pea guides are available in English, Mandarin, Spanish and Korean.) These brochures are used at food shows and have been mailed to embassies and consulates around the world.

Mexico is a priority market for bean exports from Canada. Mexico's bean imports are controlled, as beans are a staple in the diet of Mexican consumers and have been an important crop for Mexican farmers. Beans can enter Mexico under a quota granted to Canada and the USA under NAFTA, under emergency import allocations or through purchases made by CONASUPO, a department of the Mexican government. Under the North American Free Trade Agreement, quotas and tariffs on imported beans will slowly be eliminated.

Under NAFTA quotas, Canada is allocated 1,739 tonnes for the 1999 calendar year. The USA will be allocated 57,964 tonnes for 1999. This allocation of quota results in Canadian beans being shipped through the United States and entering Mexico under USA quota. Pulse Canada has undertaken several initiatives to address the inequity under this quota.

Pulse Canada was also successful in having Canadian companies placed on CONASUPO's list of companies accredited to make sales to them. Prior to a Pulse Canada sponsored tour of Canada, no Canadian companies were on the list to make sales to CONASUPO. Since that August program, a sale of Canadian beans has been made to CONASUPO.

Pulse Canada accompanied federal Agriculture and Agri-Food Minister Lyle Vanclief during a visit to Latin America in September 1998. The Minister raised the issue of import access to the Brazilian market relative to the access enjoyed by Argentina under the MERCOSUR agreement. Minister Vanclief was also helpful in raising the issue of feed pea tariffs in Chile with the Chilean Minister of Agriculture. Minister Vanclief also used the opportunity of visits in Mexico to raise the issue of NAFTA bean quotas with the Mexican Secretary of Agriculture.

Pulse Canada participates in a number of food shows to help promote and increase awareness of the Canadian pulse industry. The SIAL Food Show in Paris, France is one of the largest food shows in the world and is held every second year. Over 200 visitors representing fifty countries stopped by the Pulse Canada display during this five day show in October 1998. There was strong interest in the Pulse Canada booth with many new contacts established during the show. SIAL was also an excellent opportunity to provide people with information about the Canadian

pulse industry. There was strong interest in Canadian kabuli chickpeas and in red lentils. A shortfall in Turkish production and quality was expressed through strong interest from Turkish exporters looking to Canada for supplies to meet their traditional customer base.

Pulse Canada will be attending Gulfood '99 in Dubai, United Arab Emirates. This is the region's largest food show attracting visitors from the Arab Gulf, North Africa, as well as the Indian Subcontinent. Increasing Canadian production of red lentils, chickpeas and beans will be of interest to customers in this area.

Information seminars are planned for India in March of 1999. India is one of the largest producers of pulses in the world and has experienced shortages and rising prices. In late 1998, India removed a 10% import duty on pulses and banned pulse exports to combat rising prices. Consideration is also being given to holding seminars in Sri Lanka and Pakistan at the same time. India is a market for peas, lentils and chickpeas.

Wrap-Up

The Pulse Canada business plan will continue to evolve as dictated by changes in the national industry and the global marketplace. A national approach to generic international market development activities furthers industry interests in promoting Canadian peas, beans, lentils and chickpeas. In the face of a dynamic global environment and strong competition from competing pulse exporting nations, Pulse Canada will continue to work for the interests of a growing Canadian industry.

Pulse Canada

- Purpose:
Market Development/Promotion, Market Access, National Pulse Quality Strategy
- Members Include:
  - Alberta, Saskatchewan, Manitoba and Ontario Pulse Grower organizations.
  - Canadian Special Crops Assoc
  - Support from Federal AIMS program

What are Pulse Crops?

IPeas
IBeans
ILentils
IChickpeas

Pea Acreage in Canada

Lentil Acreage in Canada

Chickpea Acreage in Canada

Dry Bean Acreage in Canada

Top Dry Bean Producing Countries (Source: FAO)

Top Dry Bean Exporting Countries (Source: FAO)

Top Dry Bean Importing Countries (Source: FAO)

Pulse Consumption Affected By:

- Dietary Shifts
- Income Level
- Urbanization
- Population Growth

Dietary Shifts & Income

- Low Income Countries:
  - ! Income = ↑ Pulse Consumption
- Developing Countries
  - ! Demand Rises, Peaks, Slightly Declines
- New Trend in Affluent Markets
  - ! Small increase in bean consumption

Trends in Pulse Consumption

Per Capita Consumption	kg/per/yr
Global	6.3
Developed	3.0
Developing	7.5

Population Growth

- Single Largest Driver In Increased Pulse Consumption!
- Areas of Rapid Population Growth Correlate with High Pulse Consumption (& low income)

Projected Global Population Growth

Urbanization

- 1986: 42% of Global Population Urban
- 1996: 46% of Global Population Urban
- Implications:
  - Urban dwellers want instant food!
  - Pulses traditionally used in raw form
  - Raw pulse is slow to cook.

Global Animal Feed Situation

- 550 MMT Commercial Feed Annually
- 150 MMT Increase Over Next 15 Years
- 30 to 50% of Increase in Hog Feeds
- Potential Shortages of Feed Ingredients
- Key Potential Growth Markets:
  - China
  - Latin America

Global Hog Population (Source: FAO)

Chinese Pork Consumption

Opportunity Price (US\$/mt) of Feed Peas (Prices as of October 9-1998)

Country	Corn	Soy Meal	Peas
Spain	\$135	\$170	\$145
Canada (Sask)	\$85	\$155	\$100
Canada (Ont)	\$75	\$150	\$85
USA (Illinois)	\$75	\$145	\$80
Mexico	\$110	\$180	\$130
Chile	\$105	\$180	\$130
Philippines	\$220	\$180	\$200
China (Guangdong)	\$160	\$230	\$180
Taiwan	\$100	\$170	\$120
Korea	\$85	\$160	\$115

Global Corn & Soybean Production (Source: FAO)

Feed Pea Opportunities

- Hog Rations in Western Canada/USA
- Mexico, Chile, Philippines and China
- Increased Use of Peas in Fish Diets

Edible Pulse Opportunities

- Consumption Will Continue to Increase in Developing Countries (69% increase in India since 1980)
- Projected Increases in Canadian Kabuli Chickpea, Red Lentil and Dry Bean Production (Western Canada)
- Increased Domestic Processing (cleaning, bagging, splitting)
- Reduced Turkish Production

Challenges to Pulse Industry

- Australia: 4x Funding Into Research
- USA: 5x Funding Into Market Development
- EU: Production Subsidies & CAP Reform
- Asian/Russian Economic Crisis
- Eastern Europe Production Potential
- Trade Barriers
- Corn and Soybean Production (Feed Peas)
- Acceptance of Biotechnology in Feed/Food

Challenges in Pulse Industry

- Domestic Transportation System
- Varietal Adaptation/Purity
- Agronomic Limitations for New Pulses
- Forward Pricing Mechanism
- Feed Pea Introduction in New Markets
- Consumer Awareness for human market
- Institutional Support

Development of the Saskatchewan Herb and Spice Crop Industry

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1997 Survey of Producers

A survey of Saskatchewan Herb and Spice Association members in 1997 asked their opinion of the current status of the herb and spice industry. The survey was developed by the Herb Research Program at the University of Saskatchewan. Fifty-eight people responded of which twenty-one producers were growing or collecting herbs and thirty-seven were producing spice crops.

Herb Production

The most common herb grown by respondents was Echinacea, followed by ginseng, basil, burdock, lemon balm, oregano, parsley, sage, and thyme. Most herb growers have been cultivating their crops for 2 to 5 years. Most herb growers reported their gross sales of herb crops was less than \$2,500 and was commonly marketed as fresh bulk, or dried unprocessed product. A small number of growers reported sales over \$5,000.

Herb crops were marketed mainly through farmers' markets, other growers, private sales and wholesalers. Of these herb crops sold, none were direct marketed outside of Canada, and very few were marketed outside Saskatchewan.

When asked if herb growers plan to expand their production in the next three years, they indicated they plan an average of a doubling of production.

When asked if they were using organic production methods, 40% of herb growers said yes, 40% of herb growers said no, and 20% said they would try organic production in the future.

When asked to rank the importance of new information in various categories, herb growers rated production information as most important, followed in descending order of importance by market intelligence, processing, seed sources, quality research, networking, suppliers and regulations. Herb growers were asked to list the greatest problems they face. Some of the responses were: propagation, weed control, marketing information, harvesting, finding information on drying and selling, deciding which herbs to grow, proposed law requiring DIN for herbs, and expensive equipment.

When asked to rate concerns in the industry, herb producers said finding new markets was of greatest concern followed in descending order of importance by processing, mechanical harvesting, propagation, pest control, irrigation, seed supply, and regulation.

Wildcrafting

Three people responded as wildcrafters. Dandelion, senega root, and yarrow were favoured plants, followed by hawthorne, colt's foot, rose hips, red clover, stinging nettle, and pigweed.

Spice Production

The most common spice crop grown in 1997 by the 37 spice growers responding to the survey was coriander, followed by caraway, fenugreek, anise, dill seed, and cumin.

Most spice crops producers reported gross sales in the range of \$10,000 to \$25,000, of which more than 50% was sold as bulk seed, 31% as dried unmilled, 18% as fresh bulk and 1% as dried milled packaged product.

Spice crops were marketed through brokers in Saskatchewan, Canadian brokers outside Saskatchewan, wholesalers in Saskatchewan, and brokers in USA. Of these spice crops reported, 11% were direct-marketed outside of Canada, and 89% were marketed within Canada, but outside Saskatchewan.

When asked if spice growers plan to expand their production in the next three years, they said they planned, on average, a 25% increase.

When asked if they were using organic production methods, no spice growers said yes, 85% of spice growers said no, and 15% said they would try organic production in the future.

When asked to rank the importance of sourcing information on various categories, spice growers rated production information as most important, followed in descending order of importance by market intelligence, processing, seed sources, and alliances.

Spice growers were asked to list the greatest problems they face. Responses included: weed control, marketing, insect control, price, seed cleaning, variety adaptability, and production requirements.

When asked to rate concerns in the industry, spice producers said finding new markets was of greatest concern followed in descending order of importance by processing, disease, propagation, pest control, seed supply and mechanical harvesting.

Research

Spice crop research programs currently underway in Saskatchewan include:

- ▶ Crop Development Centre, Saskatoon - spice breeding and agronomic research
- ▶ University of Saskatchewan, Saskatoon - spice quality analysis, processing and Minor use herbicide trials
- ▶ Agriculture and Agri-Food Canada - agronomic research and demonstration
- ▶ Agri-Food Innovation Fund - Spoke sites - agronomic research and demonstration
- ▶ Saskatchewan Agriculture and Food - demonstration sites

- ▶ Private Companies - screening potential new crops, essential oil
- ▶ Producers - on-farm testing and demonstration

Herb crop research programs currently underway in Saskatchewan include:

- ▶ Saskatchewan Irrigation Development Centre, Outlook - herb agronomy
- ▶ University of Saskatchewan, Saskatoon - herb quality, demonstration, and post-harvest processing
- ▶ Saskatchewan Agriculture and Food - demonstration sites
- ▶ Private Companies - agronomic research and demonstration
- ▶ Producers and Producer Groups - on-farm testing and demonstration

Processing

There are more than 15 companies in Saskatchewan cleaning spice crops. On-farm post-harvest processing of herbs is expanding. Essential oil processing and production of medicinal herb bulk and finished product is now being done in the province.

Exports

Most spice production in Saskatchewan is destined for the export market in bulk form. Five companies now buy and export spice crops grown in Saskatchewan. These companies offer production contracts to producers and sell inputs such as seed. Saskatchewan spice crop exports in 1997 totaled \$3.5 Million and were destined for nine countries. 80% of these spice crop exports were to USA. Essential oil exports from Saskatchewan in 1997 were valued at approximately \$350,000. (Source: Strategis, Agriculture and Agri-Food Canada)

Most herb production is not exported. A number of Saskatchewan companies now buy and export herb bulk or processed product. Reported exports of herbs from Saskatchewan in 1997 were valued at \$54,000 and were exported mostly to USA. (Source: Strategis, Agriculture and Agri-Food Canada) The value of the Saskatchewan herb industry is estimated to be approximately \$ 10 Million.

Extension

Saskatchewan Agriculture and Food and the Saskatchewan Herb and Spice Association are working together to increase the level of information available for herb and spice crops. The "Growers Guide To Herbs and Spices" is being revised through the efforts and funding of both organizations. Saskatchewan Agriculture and Food is developing additional fact sheets for producers. Internet Home Page sites of both organizations includes information on herb and spice crops. Rural Service Centres and Extension Agrologists have more information to answer questions from current and new growers.

Herb and Spice - Saskatchewan 1997

CROP	ACRES
Coriander	21,700
Caraway	12,400
Borage	6,300
Dill	200
Spearmint	950
Fenugreek	400
Anise	50
Cumin	0

Glabrous Canaryseed - Certification Program

Francois Catellier
Canadian Special Crops Association
900 360 Main Street
Winnipeg MB Canada R3C 3Z3
Phone: 204-925-3780
Fax: 204-925-3785

Glabrous or Hairless Canaryseed

- ▶ CSCA Agreement with Crop Development Center - U of S - to distribute CDC Maria
- ▶ 19 License Agreement Holders - agreed to assign all acres under contract - and to collect all progeny

CDC Maria

- ▶ Royalties to CSCA: \$3.00 per 100 lbs.
  - all pedigreed seed sold for planting
  - \$1.50 per 100 lbs. - Crop Development Center

Rationale for Certified Seed

- ▶ maintain the integrity of the hairless trait

Glabrous Canaryseed - Certification Program

- ▶ Purpose : to differentiate canaryseed that meets a certain percentage of hairless seeds
- ▶ Modeled after 'canola' trademark and logo
- ▶ Companies must sign a license agreement with Canola Council
  - to use the word 'canola' and four-petal logo on any packaging
- ▶ Establish quality standards
- ▶ 50 g lots of certified CDC Maria from 19 license agreement holders

- ▶ CDC will analyze and recommend a minimum standard
- ▶ Name-Search Contest
  - Canola is new name for rapeseed that meets quality standard
  - ??? Will be new name for canaryseed that meets quality standard
  - Contest Prize: Complimentary registration to next CSCA Annual Meeting and Convention

Glabrous Canaryseed -Trade Mark

- ▶ Registered in Canada and other market regions:
  - United States
  - European Community
  - Mexico
  - South America

Essential Oil Content in Prairie-Grown Spices

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Introduction

Little attention has been given to spice production in Saskatchewan because of their late maturity and the frost hazard. With the demise of transportation subsidies for cereals and oilseeds in Western Canada, and the fluctuating prices of grains on the world market, there have been progressive increases in the amount of land devoted to alternate crops in the region. Among the early maturing alternate crops are the spices which belong to the *Umbelliferae* family which have a more determinate growth habit. These include anise, caraway, coriander, cumin, and dill. For example, in 1995 alone, there were 5000 hectares seeded to coriander (McVicar, 1995).

Markets for *Umbelliferae* crops have increased with the growth in markets for all spices. Reasons for this include increased population growth, especially of ethnic groups, increasing domestic consumption, a trend toward utilizing spices to compensate for less salt and lower fat levels in foods, and the heightened popularity of ethnic foods (Buzzanell et al., 1995). From 1990 to 1994, the United States imported annually about 241 million kilograms of spices and spice oleoresins with a value of \$374 million, with Canada providing 15% of the supply. Over the same period, domestic consumption in the United States was 370 million kilograms of spices annually, with a per capita consumption of 1.45 kilograms.

Spice breeding and quality evaluation have been done at the Crop Development Centre for more than four years. Several tests have been conducted (yield, date of seeding, whole vs. split fruit, seeding rate/depth, nitrogen/phosphorus fertilization and weed control) on anise, caraway, coriander, cumin and dill. However, only the results of the yield tests and date of seeding tests for coriander and caraway will be presented.

Coriander

The essential oil content of coriander appears to depend on the latitude and climatic conditions. The lowest values reported in the literature were seeds grown in India with 0.18 to 0.29% (Ramachandriah et al., 1986). Intermediate values of 0.34 to 1.49% were reported in Finland (Halva et al., 1986) and 0.5 to 1.0% in Romania (Moyler, 1994). The highest reported essential oil values were for seeds grown in Russia with 2.4% (Chernodubov and Berestovaya, 1986) and 2.6% (Chislova, 1988).

Small-seeded vs. Large-seeded Varieties

The seed yields, seed weights, essential oil contents, percent linalool and essential oil yields of both the small-seeded and large-seeded varieties of coriander grown between 1994 and 1996 were averaged by variety, by year of production and by seeding date (Tables 1 and 2, respectively). The average seed yields of both the small-seeded and large-seeded varieties, each representing the highest yielding varieties in the tests, were not significantly different. The yields ranged from 1602 kg/ha for PGR-10057 to 1715 kg/ha for PGR-5741 for the small-seeded varieties and between 1915 kg/ha for Roumain to 2061 kg/ha for Richters-Long among the large-seeded varieties. The average seed yield of the six large-seeded varieties over the three years, 1999 kg/ha, was significantly ($P < 0.05$) greater than the average seed yield of the six small-seeded varieties, 1636 kg/ha. These values are double the 840 kg/ha considered to be the break-even yield to cover all costs in growing coriander (Saskatchewan Agriculture and Food, 1997).

The essential oil contents of the small-seeded varieties were not significantly ($P > 0.05$) different, ranging from 1.22 to 1.30% (Table 1). Among the large-seeded varieties (Table 2), the average essential oil contents of Chinese (0.83%), Richters-93 (0.86%) and Roumain (0.84%) were significantly less than the other three varieties (Richters-Long (0.89%), Autumn (0.90%) and ND-1 (0.93%)). The average essential oil content of the small-seeded varieties, averaged over three years, 1.27%, was significantly ($P < 0.05$) greater than the average essential oil content of the large-seeded varieties at 0.87%.

Table 1. Mean effects of varieties, year and seeding date on seed yields, seed weights, and essential oil compositions of small-seeded varieties of coriander.

Variable	Seed yield (kg/ha)	1000-seed wt., (g)	Essential Oil, % (v/w)	Linalool (% in Oil)	E.O. Yield (L/ha)
Variety¹					
PGR-5741	1715a	7.2a	1.28a	66.2a	22.1a
Saskatoon Early	1675a	7.1a	1.30a	65.6a	21.7a
PGR-10056	1610a	7.4a	1.22a	64.2a	19.8a
PGR-5742	1605a	7.3a	1.28a	63.9a	20.9a
PGR-10057	1602a	7.3a	1.22a	65.7a	21.2a
Year of Production^{1,2}					
1994	1300a	7.6a	1.23a	66.3a	17.3a
1995	1378a	8.0a	1.20a	67.0a	16.8a
1996	1809b	7.0b	1.30a	64.1b	23.5b
Seeding Date^{1,3}					
April 29-May 9	1825a	7.8a	1.31a	66.9a	24.1a
May 17-May 23	1692a	7.0b	1.28a	64.8b	21.5a
May 29-June 6	1303b	6.9b	1.17b	62.8c	15.6b

¹ Values in each column for this variable not followed by the same letter are significantly different (P<0.05).

² n=12 for 1994; n=18 for 1995 and n=40 for 1996.

³ n=26 for April 29-May 9; n=20 for May 17 to May 23 and n=18 for May 29 to June 6.

Table 2. Mean effects of varieties, year and seeding date on seed yields, seed weights, and essential oil compositions of large-seeded varieties of coriander.

Variable	Seed yield (kg/ha)	1000-seed wt., g	Essential Oil, % (v/w)	Linalool (% in Oil)	E.O.Yield (L/ha)
Varieties¹					
Richters-Long	2061a	9.6a	0.89a	62.2a	18.0a
Chinese	2052a	9.9a	0.83b	60.7a	17.0a
Richters-93	2047a	9.6a	0.86b	59.3a	17.6a
Autumn	1972a	9.3a	0.90ab	62.5a	17.8a
ND-1	1926a	9.3a	0.93a	62.0a	17.7a
Roumain	1915a	9.2a	0.84b	61.6a	16.1a
Year of Production^{1,2}					
1994	1906a	10.4a	0.87a	63.9a	16.3a
1995	1854a	10.4a	0.87a	62.7a	15.8a
1996	2082a	8.9b	0.87a	60.5b	18.2a
Seeding Date^{1,3}					
April 29-May 9	2337a	10.8a	0.87a	63.9a	20.2a
May 17-May 23	1955b	8.8b	0.91a	61.0b	17.5b
May 29-June 6	1543c	8.5b	0.85a	58.7b	13.1c

¹ Values in each column for this variable not followed by the same letter are significantly different ($P < 0.05$). ² $n=15$ for 1994; $n=18$ for 1995 and $n=48$ for 1996. ³ $n=34$ for April 29-May 9; $n=24$ for May 17-May 23; $n=23$ for May 29-June 6.

The percentages of linalool in the essential oils of both the small-seeded and large-seeded varieties were not significantly different ($P > 0.05$) although the average percentage of linalool in the small seeded varieties, 65.3%, was significantly greater than ($P < 0.05$) the average percentage of linalool in the large-seeded varieties at 61.6% (Tables 1 and 2).

Effect of Year of Production

The crop year had a variable effect on the various parameters studied (Tables 1 and 2). Among the small-seeded varieties, the average seed yield was significantly greater ($P < 0.05$) in 1996 than in the previous two years (Table 1) while the average seed yields of the large-seeded varieties were similar ($P > 0.05$) for the three crop years (Table 2).

There were significant differences among years at one location where the average seed yields for the small-seeded varieties were 986 kg/ha in 1994, 1863 kg/ha in 1995 and 2078 kg/ha in 1996. Among the large-seeded varieties at this location, the average seed yield in 1994 (1529 kg/ha) was significantly lower than the seed yield in either 1995 (2296 kg/ha) or 1996 (2526 kg/ha). At this location, the total rainfall for May, 1994 (116 mm) was much greater than the total rainfall for May, 1995 (15 mm) and May, 1996 (55 mm), respectively.

The essential oil contents for the three years were consistent ($P>0.05$) for both the small-seeded and large-seeded varieties (Tables 1 and 2), indicating that essential oil production occurs early and thereby is less affected by external circumstances such as the weather. On the other hand, the levels of linalool in the essential oils were significantly ($P<0.05$) lower in 1996 than in the previous two years for both the small-seeded and large-seeded varieties.

Effect of Seeding Date

During the course of the study, it was observed that yield differences among locations were primarily due to the date of seeding. The yield tests in the three crop years were classified by seeding date, i.e. early seeding (April 29 to May 9), normal seeding (May 17 to May 23) and late seeding (May 29 to June 6). It was found that, for both small-seeded and large-seeded varieties, the highest average seed yields were obtained for early seeding and yields declined as seeding was delayed (Tables 1 and 2).

The essential oil contents remained constant with delayed seeding for the large-seeded varieties while the essential contents among the small-seeded varieties were progressively depressed with later seeding. The linalool content of the essential oil of both small-seeded and large-seeded varieties declined with delayed seeding.

Caraway

Caraway (*Carum carvi* L.) is an important spice crop for which there is limited production in North America. The annual imports of caraway into the United States between 1990-1994 averaged 3.6 million kilograms valued at U.S.\$3.7 million (Buzzanell et al., 1995). The Netherlands supplies about 75% of the American market.

Biennial caraway cultivars yield more seed and essential oil than annual cultivars and constitute the major crop in Europe and Africa. The severe winter temperatures in Western Canada have limited the production of this biotype, but several growers have experimented with the production of annual caraway. About 2,700 hectares were seeded in 1995 (McVicar, 1995). Saskatchewan-grown caraway constituted 27.5% (364,000 kg) of total world exports of caraway to the United States in 1995 (McCumber, 1996).

The essential oil contents of annual caraway seed have been reported to vary between 1.2 to 3.0% (Bouwmeester and Kuijpers, 1993) and 2.2 to 2.3% (Putievsky et al., 1994). Essential oil quality is usually expressed as the percentage carvone in the essential oil or the ratio of carvone to limonene content (Bouwmeester et al., 1995). Besides its spice applications in foods, carvone is being used as a sprouting inhibitor for potatoes (Bouwmeester et al., 1995), a growth inhibitor of certain fungi and an insect repellent (Toxopeus and Bouwmeester, 1993). The levels of carvone reported in the literature range from a minimum of 39% in Canada (Embong et al., 1977) to as high as 80% in Israel, immediately after harvest (Fleisher and Fleisher, 1988). Other workers have reported values within the 45 to 68% range (Boshart, 1926; Fleisher and Fleisher, 1988; Hirvi et al., 1987; Puschmann et al., 1992; Putievsky et al., 1994; Toxopeus and Bouwmeester, 1993).

Effect of Seeding Date

The effect of seeding date on seed yield and quality is shown in Table 3. The seed yields for the first three seeding dates were similar, although the highest seed yield was obtained on third date, May 19, as well as the highest essential oil yields. The seed yield on May 29 was substantially lower than for the earlier seeding dates because plant growth and development was incomplete by the harvest date in late September.

Table 3. Effects of seeding date on seed yield, essential oil content and composition of annual caraway (var. Karzo) in 1995 (average of two locations).

Seeding Date	Yield (kg/ha)	Essential Oil (% v/w)	d-Carvone (% in Oil)	Limonene (% in Oil)	Essential Oil Yield (L/ha)
May 4	1765a	3.2b	50.1a	49.0b	56.5
May 13	1894a	3.4b	48.1ab	50.9ab	64.4
May 19	2041a	3.3b	47.4b	51.0a	67.4
May 29	1196b	4.0a	45.4c	52.5a	47.8

Values within columns followed by the same letter are not significantly different ($P>0.05$).

Previously, the common experience was that early seeding gave the highest seed yield. However, below average precipitation in May (15.0 vs. 41.7 mm) and June (32.6 vs. 63.4 mm) and below average growing degree days (165 vs 206) in May at Saskatoon were factors that delayed seed emergence and plant growth at one of the two locations.

The essential oil content at the latest seeding date was significantly greater than the essential oil contents at the three previous seeding dates (Table 3). This would suggest that the majority of essential oil formation occurs early and that extended plant growth, i.e. earlier seeding, will lead to an increase in seed weight but not necessarily to an increase in the proportion of essential oil present in the seeds.

The percentages of d-carvone in the essential oil decreased progressively with delay in seeding date while the proportion of limonene in the essential oil increased (Table 3). The data suggest that limonene was synthesized more rapidly than d-carvone as the growing season progressed but the change was small except for the low yielding final seeding date.

Biennial Caraway

The yields of Bleija, Elders-90 and Richters-Common, high yielding biennial caraway cultivars, were determined at two locations each of two growth cycles. The lack of snow cover in 1995-1996 resulted in winter killing in biennial caraway among all three cultivars, especially at Melfort. The resulting low seed yields at Melfort gave caraway samples that averaged 5.8% essential oil (Table 4), a level not previously reported in the literature. This was similar to the results with late seeding and immaturity in Table 3.

The biennial cultivar trials were grown at Saskatoon and Outlook in 1995-1996, and winter killing was not a problem in the Outlook test. Under irrigation conditions, the biennial cultivars responded exceptionally well to the full growing season in 1996 (Table 4). Seed yields at Outlook were over 50% greater than the best yields for annual caraway. With 3.8% essential oil content, the essential oil yield became 125 L/ha, nearly twice the yield obtained in the best annual caraway treatment. These results illustrate the potential for biennial caraway, provided winter hardness can be bred into this crop.

Table 4. Seed yields, essential oil content and composition of biennial caraway grown in Saskatchewan (average of three varieties Bleija, Elders-90 and Richters-Common).

Year/Location	Yield (kg/ha)	Essential Oil % (v/w)	Carvone (% in Oil)	Limonene (% in Oil)	E.O.Yield (L/ha)
1994/1995					
Saskatoon	1325b	4.1b	53.8b	45.2a	54.3
Melfort	626c	5.8a	55.1b	42.9b	36.3
1995/1996					
Outlook	3292a	3.8b	56.6a	42.5b	125.1
Saskatoon	910c	4.2b	54.6b	43.2b	38.2

Values within columns followed by the same letter are not significantly different ($P>0.05$).

Note also that the range in average carvone contents of the biennial caraway cultivars was 53.8% to 56.6% for an average of 55.0%, with the limonene average being 43.5% (Table 4). The average carvone and limonene contents of three cultivars of annual caraway were 46.4 and 51.7%, respectively. Clearly, the annual caraway cultivars and treatments gave samples that were inferior to biennial caraway in essential oil content and proportion of carvone. However, winter killing would limit the production of this biotype in Saskatchewan.

Acknowledgments

The authors acknowledge the financial support of the Agriculture Development Fund and the Canada-Saskatchewan Agri-Food Innovation Fund. The technical expertise of Ray McVicar and the Department of Crop and Horticulture Sciences and Plant Ecology Field Lab personnel (Helen Atupu, Chandra Bandera, Brent Barlow, Darrel Derksen, Scott Ife, Bonnie Li, Kiuomars Mirshahi, Leslie Papp, Joelle Paradis and Kiet Thai) is gratefully appreciated.

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New Opportunities in Buckwheat Production

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Buckwheat is a minor acreage crop that is produced mainly in Manitoba, Quebec and Ontario in Canada. Production also takes place in Saskatchewan and Alberta on a more limited scale. As the crop usually takes less inputs than most other crops and prices are high it has also attracted attention as a cash crop. Another attraction of the crop is that it is a short season crop and therefore can be seeded later than other crops to spread out labour or it can also be used as a catch crop if other crops fail.

Recent Changes in Buckwheat Varieties and Direction of Research

There has been some major changes in buckwheat varieties over the past few years. AC Manitoba was released by Agriculture and Agri-Food Canada in 1993 and is now in commercial production. Koban was released in 1996 by Agriculture and Agri-Food Canada through Kade Research Ltd. and was in commercial production in 1998. In 1998 Koto was released through Kade Research Ltd. and will be in commercial production in the year 2000.

Both AC Manisoba and Koban have increased seed size and increased seed yield over the older varieties Mancan and Manor. The variety Koto is the first large-seeded buckwheat with a black hull and increased seed density. This has resulted in increased starch content, a fact that is very desirable for the buckwheat millers. As buckwheat has no gluten, the protein that causes stickiness in wheat dough, the stickiness in buckwheat comes from the starch content. Increased starch allows for the production of better quality noodles as well as allowing the millers to blend these high starch types with low starch types obtained from China for the production of noodles.

The flowering habit of the buckwheat plant has also been modified with Koto having many long side clusters within the plant. This allows for increased yield as well as places many of the seeds within the canopy of the plant where they are protected from shattering by wind.

New Varieties

AC Manisoba

The variety AC Manisoba was released by Agriculture and Agri-Food Canada in 1993. It outyielded Mancan, the presently grown variety by 6.2%. It's seed size is large at 34.5 g/1000 seeds, however, it's seed density is slightly below that of Mancan.

Koban

The variety Koban was released in 1996 by Agriculture and Agri-Food Canada through Kade Research Ltd. It has large seed size at 32 gr/1000 seeds and increased seed density over AC Manisoba. In Cooperative Testing it yielded 6.4% higher than AC Manisoba.

Koto

The newest variety Koto is the first black seed coat buckwheat released in Canada. It has a larger seed size at 37 g/1000 seeds and increased seed density as compared to both Koban and AC Manisoba. It yielded 9.8% higher than AC Manisoba in Cooperative Testing. Its increased seed size and plumpness has resulted in increased starch content which is desirable in the Japanese market for the production of noodles. It is about 2 days earlier than AC Manisoba in maturity.

Cultural Practices for Buckwheat

Buckwheat is normally seeded the first week June to avoid the last spring frosts. This also allows cultural weed control as the first flush of weeds can be eliminated before seeding. Buckwheat is a very good competitor if it is above weed growth and a very poor competitor if weed growth gets above it. There are no broad leaf herbicides registered for buckwheat. Buckwheat can be sown as low as ½ bushel per acre to more than 1½ bushels per acre. Generally it is sown at 1 bushel per acre. Yields have been shown to be not affected by the seeding rate within this range, however, as weed control in buckwheat is mainly due to plant competition the higher seeding rates allow for faster development of the crop canopy that smothers weed growth. The increased seed cost for this in reality is for weed control.

The buckwheat plant is cross pollinating which means that pollen from one plant has to be transferred to another plant in order for fertilization to take place. In fact buckwheat has an incompatibility system and two different flower types. The pin flowers have a tall pistil or female part and short anthers or male parts while the thrum flowers have tall anthers and a short pistil. Pollen is transferred at each level. This is accomplished mainly by wind and by insects. As buckwheat pollen is heavy it usually only can pollen plants immediately adjacent to it and therefore insects play a major role in movement of the pollen.

There are few diseases that affect buckwheat. The main one is downy mildew that causes small brown lesions on the leaves that are usually surrounded by light green chlorotic areas. These leaves often dry up and fall off and therefore do not last the whole season. This disease is seed born as the spores are carried under the hull and germinate and affect the germinating seedling. It is not known if this disease affects yield as in most years it occurs at a fairly low incidence. There is no genetic resistance to this disease in common buckwheat but recently resistance to it has been found in self-pollinating buckwheat.

Seeding and harvesting of buckwheat is done with the same equipment as for cereal crops and which are readily available. Swathing should take place when approximately 80% of the seeds have turned brown or black. One of the main causes of reduced yield due to cultural practices is the premature swathing of the crop. Excessive losses during swathing can be avoided by swathing

while there is dew on the plants and by adjusting reel speed to match ground speed. Harvesting should take place when the seeds have reached 16% moisture. Cylinder speeds should be slowed to prevent dehulling of the seeds with a beginning speed of 800 rpm suggested.

Problems facing Buckwheat Production

There are three main problems areas that have historically affected buckwheat production. These are seed abortion, lack of frost tolerance which increases risk and no registered herbicides for broad leaf weed control. Although buckwheat is a crop that is fairly easy to grow these problems have contributed to yields of buckwheat varying more than desired as well as adding an increased risk factor in its production. Over the past 5 years two of these problems, seed abortion and frost tolerance, have been overcome through the production of a new self-pollinating type of buckwheat by Kade Research Ltd.. This large advance has renewed interest in the crop and bodes well for increased production.

Kade Research Ltd.

Kade Research Ltd. was established in 1995 after Agriculture and Agri-Foods decision to no longer carry the buckwheat breeding program. Kade Research has the right to use the Agriculture and Agri-Food Canada germplasm that had been developed during the course of the breeding program through a Collaborative Agreement. Thus royalties are returned to Agriculture and Agri-Food Canada and Kade has the germplasm for a basis of their program, a winning situation for both parties. Kade Research Ltd. has as it's main emphasis the development of large seeded self-pollinating buckwheat varieties for North America.

Kade Research Ltd. presently is concentrating it's efforts on the development of self-pollinating buckwheat, frost resistant buckwheat and nutraceutical products that are enhanced through crosses between different species. As increased seed density is desirable to increase the starch content of the seed the newest varieties have seeds that are larger and rounder than the older varieties.

Buckwheat Species

For many years it was thought that there were three species of buckwheat. These were *Fagopyrum esculentum* (common buckwheat), *F. tataricum* (Tartary buckwheat) and *F. cymosum* (perennial buckwheat). Beginning in the early 1990's a number of new species were found in China. At the present time 18 natural species are recognized as well as 2 man made species. The first man made species was developed in 1965 in Russia and was a cross between Tartary buckwheat and perennial buckwheat at the tetraploid level. The second was accomplished by myself in 1993 and is between common buckwheat and *Fagopyrum homotropicum* (a weedy species) at the diploid level. Kade Research Ltd. has all of the species and is engaged in making crosses between those species that have characteristics that are desirable in common buckwheat. We then move those characteristics into common buckwheat to improve it as a crop for North America. To this point we have been successful in bring in the genes(s) for self-pollination and for frost tolerance as well as for several nutraceutical compounds.

Self Pollinating Buckwheat

For many years there were efforts to overcome the seed abortion problem in buckwheat. In 1993 we were successful in crossing common buckwheat and a wild species *Fagopyrum homotropicum*. This cross not only showed us that we could cross between species at the diploid level but allowed us to develop a new self-pollinating species. This seed characteristics of this new species has been made to be the same as common buckwheat by repeatedly backcrossing to our large seeded black hulled buckwheat types. Therefore there is no longer a need for insect pollinators to move pollen between the flower types. In addition one of the main benefits of this species is that it has gotten around the problem of seed abortion.

Common buckwheat's main problem in production is that it aborts approximately 88% of its seeds before they ripen. Thus the crop that results comes from only approximately 12% of the flowers it sets. The cross with *Fagopyrum homotropicum* allowed us to get around this large problem as the self pollinating plants set 100% of the flowers into seeds. This now allows us to drastically increase yield in buckwheat. We have found, however, the plant does not have the photosynthetic capacity to fill all these seeds.

If crop yields are to double those now received we only need approximately 24% of the flowers that are now set on the plant. Indeed we need to redirect the resources that are now going into the production of 75% of the flowers into filling these additional seeds. After a quarter of a century of developing more flowers per plant we now find ourselves in the position of trying to rapidly reverse this process in order to realize the high yields that are available from this new type of buckwheat plant. With over 3600 lines undergoing field evaluation in 1998 and with lines now advancing to the Preliminary Trials it is expected that self-pollinating buckwheat could be available in two years time.

Frost Resistant Buckwheat

The development of frost resistant buckwheat has long been a dream of buckwheat breeding programs world wide. Common buckwheat has long been known to have very little frost resistance either to spring or on fall frosts. Indeed the warning that you should not walk by a buckwheat field with an ice cream cone has been passed around in years when early fall frosts have seriously damaged this crop. Having frost resistance in buckwheat would help buckwheat production in two ways. It would drastically reduce the risk of growing buckwheat and at the same time would allow for a longer growing season and therefore later maturing varieties could be produced that have higher yields.

The first crosses were attempted between Tartary buckwheat, a noxious weed in Western Canada, and common buckwheat in an effort to move the frost resistance from Tartary buckwheat into common buckwheat. Two years ago Kade Research was the first to successfully make this cross and is now moving characteristics between the two species. However, a higher degree of frost resistance has been found by Kade Research in crosses between common buckwheat and a related weedy species found in China. This has certainly been of great interest to us as it is seen as a large breakthrough for the crop and one that has been eagerly awaited. With the risk, both spring and

fall, now being virtually eliminated it is expected that production of the crop will to a much greater extent depend on the economic returns that can be expected and thus be more readily placed into longer term rotations by producers.

In the frost resistant trials the plants are frozen in a specially built growth chamber where the temperature is reduced two degrees per hour. When the temperature reaches a predetermined set point it remains at this temperature for 30 minutes and then is raised to 5°C over a 30 minute period. The plants are therefore subjected to a fairly rigorous test. Plants frozen to -6°C are actually below 0°C for 3¾ hours. We have found seedling frost resistance at the two leaf stage to temperatures below -7°C and at the flowering stage to below -6°C. This is greater than the frost resistance found in Tartary buckwheat and is therefore at a very acceptable level. We are presently also screening frost resistance in other species as well as in developed lines to determine if it is possible to increase this degree of frost resistance. In addition we have recently started crosses between a wild perennial species that survives -20°C temperatures during overwintering and common buckwheat to determine if we can further increase the frost resistance so far developed in our self-pollinating buckwheat.

In addition to finding frost resistance in self-pollinating buckwheat we have also recently found some in common buckwheat. This was not expected as all literature indicates that this species has little frost resistance either in spring or in the fall. The level of resistance found was at a lower level than for Tartary or self-pollinating buckwheat but was still substantial. Crosses are presently underway to determine if we can transfer this increased resistance into our high yielding self-pollinating lines. The first field trials of frost resistant self-pollinating buckwheat took place in 1998 and it is expected that we should have lines in advanced trials in 2-3 years.

The development of both the self-pollinating buckwheat which allows us to overcome the seed abortion problem of common buckwheat as well as the development of frost resistant buckwheat we believe will provide a boost in production of this under utilized crop. Both of these developments will allow for increased yields. This in addition to removing much of the risk factor should allow for increased production of this crop and in addition should increase returns to the grower.

Developing New Value Added Botanical-Based Pharmaceutical Industries in Alberta

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- ▶ CV Technologies is a biopharmaceutical company which develops, manufactures and markets disease targeted pharmaceutical, OTC, and health supplement products, using its strong scientific research and management expertise.
- ▶ A biopharmaceutical company which develops, manufactures and markets natural health products including health food, nutraceuticals, and natural pharmaceuticals using its strong scientific research and management expertise.
- ▶ CVT is in the unique position in the rapid growing natural health product industry due to its unique technology platform.

Natural Health Product Industry

- ▶ U.S. health food market: \$11 billion annually (Health Food Business, Apr. 1998). Herbal remedies contribute \$3 billion.
- ▶ Canadian herbal remedies market: \$300 Million annually.
- ▶ The growth rate of this industry: 25% in north America.
- ▶ 45% of Americans using natural product.

Six Reasonable Questions Are Being Asked of Health Food Preparations:

1. Is there information available in relation to the activity and the mechanism of action of the product?
  2. Is there meaningful standardization of the product?
  3. Are there quality control data available on the product?
  4. Has the product been tested for any toxic side effects?
  5. Is the product readily available for the body to use?
  6. Are any synthetic chemicals added to the product?
-
- ▶ To identify the problems existing in health food industry.
  - ▶ To provide the scientific solutions and value-added agriculture products to meet the needs of the exploding market.

Comparison of Different Preparations of a Health Food

	Preparations of Substance "X"	Immunostimulation % of Control
A	Raw Material	1,797
B	Raw Material	125*
C	Raw Material	514
D	Capsule	2,700
E	Pill	128*

*No significant effect as compared to control (100%)

Biological Effects of Different Sources of the Same Species of North American Ginseng

American Ginseng Samples	Rb 1 Content % of Raw material	Immunostimulation % of Control
A	0.4	1,623
B	1.6	5,271
C	2.6	5,679
D	1.9	10,481
E	1.1	4,936

Biological Effects of Different Cordyceps Samples with Similar Chemical Composition

Cordyceps samples	Immunostimulation % of Control
A	487
B	1,490
C	918
D	90*

*No significant effect as compared to control (100%)

Are There Quality Control Data Available On The Product?

Our quality control is carried out by an outside company so that physical and chemical analyses are determined for each batch produced.

Is There Meaningful Standardization of the Product?

Because we know how our products work on a *cellular level*, biological or pharmacological standardization ensures batch consistency.

Has The Product Been Tested For Any Toxic Side Effects?

Two toxicity tests are performed by an outside company using FDA - approved protocols and facilities.

1. 1,000 times human dose - in one feeding
2. 25 times human dose - 18 daily feedings to pregnant females and normal males

Is There Information Available in Relation To The Activity And The Mechanism of Action of the Product?

Biological Activity is studied pharmacologically.

In many cases, the mechanism of action down to the *cellular level* has been elucidated.

CVT'S Value-Adding Process

- Extraction and concentration of active components.
- Efficacy validation using bioassays indicative to certain health aspect.
- Understanding of mechanism of action of the active components using a panel of pharmacological studies.
- Application of QA, QC and SOP in manufacture process.
- Toxicity tests to ensure the safety.
- Standardization using pharmacological and chemical fingerprinting.

Ginseng

Ginseng is known to be beneficial to the aging population. One of its demonstrated effects is to improve the loss of memory or senile dementia.

Ginsenosides

Ginsenosides, a special group of compounds in ginseng, have been implicated as the active ingredients, e.g. Rb1, Rg1. However, it was not known how they work, i.e., their mechanism of action was unknown.

Pharmacological Approaches to the Treatment of Alzheimer's Dementia

- Drugs to improve the function of existing neurons
- Drugs which mimic the action of endogenous neurotransmitters
- Drugs which decrease degeneration/increase regeneration of nerves

QA, QC of CVT Products

Nutraceutical Research at the University of Alberta

Dr. Feral Temelli
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Outline

- ▶ Food for Health Initiative
  - Alberta Functional Foods Centre of Excellence
  - Plant Products Research Group
- ▶ Medicinal Crops Research
  - Rhubarb
  - Echinacea

Food for Health Initiative

- ▶ Production Efficiency/Sustainability
- ▶ Agri-Food Processing
- ▶ Nutrition and Human Health

Functional Foods and Nutraceuticals

- ▶ Functional Food
  - similar in appearance to conventional foods, is consumed as part of a usual diet, and has demonstrated physiological benefits and/or reduces the risk of chronic disease beyond basic nutrition functions.
- ▶ Nutraceutical
  - produced from foods but sold in pills, powders, (potions) and other medicinal forms not generally associated with food and demonstrated to have a physiological benefit.

Plant Products Research Group

Plant products of Alberta

cereals
oilseeds
fruits and vegetables
special crops

Limited value-added processing

Need to develop competitive and sustainable agri-food chain for plant products

Mission

to provide research leadership by applying a multi-disciplinary team approach to research and development of high-value and innovative food and non-food products/ingredients from a variety of crops grown in Alberta through economically feasible processes.

Multidisciplinary research program

Build the knowledge base

Increase research efficiency

Training of highly qualified personnel

Building partnerships

New opportunities

Development of dietary fibre and other value-added products from rhubarb

B. Ooraikul and T. Basu

Dept. Agricultural, Food and Nutritional Science

University of Alberta

Rhubarb (*Rheum rhaponticum*)

- ▶ Member of buckwheat family
- ▶ grows well in temperate or cold climates
- ▶ underutilized commodity

Rhubarb fibre

Rhubarb stalks

Cut (3 cm length)

Steam cooked (10 min)

Remove the juice with a screw press

Wash twice with water and squeeze

Dry (fluidized bed drier)

Grind into powder

Composition of rhubarb fibre

	<u>% Dry weight</u>
Protein	5.6
Ash	5.6
Oxalic acid	5.7
Malic acid	3.2
Insoluble dietary fibre	65.9
Soluble dietary fibre	8.2
Total dietary fibre	74.1

Product development using rhubarb fibre

- Vegetarian and beef burger patty
- Jerky
- Chicken surimi
- Quarg
- Sweet and sour sauce
- Toppings
- Candy

Effect of dietary rhubarb fibre on plasma cholesterol and triglyceride levels in mice

Diet	Total Chol. (mmol/L)	TG (mmol/L)	<u>HDL-Chol.</u> Total-Chol.
A	3.6 ± 0.12a	2.5 ± 0.14a	0.25 ± 0.02a
B	3.7 ± 0.12a	2.7 ± 0.13a	0.25 ± 0.01a
C	2.3 ± 0.13b	0.6 ± 0.09b	0.42 ± 0.02b

A: Control, B: cellulose+0.5% chol, C: rhubarb+0.5% chol.
(Basu et al., Nutr. Res. 13:1017, 1993)

Effect of oral administration of rhubarb fibre (27 g/day) for 4 weeks on serum lipid profiles of hypercholesterolemic men

	Pre-rhubarb	Rhubarb	Post-rhubarb
Total-chol.	6.58 ± 0.18a	6.06 ± 0.18b	6.43 ± 0.18a
LDL-chol.	4.42 ± 0.18a	4.03 ± 0.18b	4.31 ± 0.18a
HDL-chol.	1.21 ± 0.02a	1.19 ± 0.02a	1.19 ± 0.02a
Triglycerides	2.12 ± 0.12a	1.80 ± 0.12a	1.83 ± 0.12a

(Goel et al., J. Am. Coll. Nutr., 16:600, 1997)

***In vitro* binding capacities of taurocholate by various fibres**

Fibre	Taurocholate bound (mmol/200 mg)
Cholestipol	41.77 ± 0.10a
Cellulose	1.89 ± 0.87b
Corn bran	6.86 ± 0.68c
Rice bran	6.93 ± 0.65c
Wheat bran	4.52 ± 0.96c
Rhubarb fibre	12.34 ± 1.09d

(Goel et al., Nutr. Res. 18:893, 1998)

Extraction and Processing Methods for Echinacea

Principal investigator:

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Co-investigators:

F. Temelli, AFNS, UofA

B. Currie, Food Quality Branch, AAFRD

M. Fierheller, FPDC, AAFRD

Collaborations:

L. Tabil, AVEC

CV Tech.

CDC South, Brooks

Chemical constituents of Echinacea

- ▶ Caffeic acid derivatives
  - Echinacoside
- ▶ Flavonoids
- ▶ Essential oil
- ▶ Polyacetylenes and polyenes
- ▶ Alkylamides
- ▶ Alkaloids
- ▶ Polysaccharides
  - Echinacin

Pharmacological studies

- ▶ Anti-inflammatory activity
- ▶ Antiviral and antibacterial activities
- ▶ Effect on nonspecific immune system

Echinacea products

- ▶ Herb powders
- ▶ Juice
- ▶ Extracts (alcohol+water)
  - Liquid
  - Spray- or freeze-dried

Objectives

- ▶ To analyze echinacoside content of echinacea
- ▶ To study the effect of various drying and storage treatments
- ▶ To extract the active components using water, ethanol and supercritical CO₂

**Echinacoside content
(wt%, dry basis)**

	<i>E. angustifolia</i>	<i>E. pallida</i>	<i>E. purpurea</i>
Leaves/stems			
2nd year	0.049	0.065	0.022
3rd year	0.105	0.043	
Flowers			
2nd year	0.168	0.170	0.051
3rd year	0.014	0.205	
Roots			
2nd year	0.973	0.860	0.040
3rd year	1.041	1.181	

Acknowledgment

Alberta Agricultural Research Institute

Where the Herb Industry is Going: A Marketing Perspective

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The herb and spice industry is undergoing enormous change. Thousands of companies are growing or manufacturing or selling herbs and herbal products, and most are less than 10 years old. Spices are increasingly being sourced from Canadian growers.

Big players such as the pharmaceutical industry and pharmacy and food chains have jumped in, and even department stores have added herbs to their mix of products. Start up companies flush with money from the capital markets are also making big moves.

How do farmers fit in in this rapidly changing environment?

I would like to try to address this question from the point of view of marketing. In the end, your success depends on marketing. If you can't market your crops, it doesn't matter how well you grew them or how good the quality is, your crops will be failures.

In the greenhouse industry, which is my background, we have a saying, "Your plant inventory is a liability until it's sold." Why? Because, unless you can find a buyer, you have to keep watering

them, spraying for bugs, fertilizing them, and in the end you may have to dump them. For herb and spice farmers, finding buyers for your crop is a critical activity that cannot be taken lightly. There are plenty of stories of herb and spice farmers having to plow their crops under because no buyer could be found.

Herbs and spices are very different from traditional crops. Unlike soybeans, corn and wheat, there are no well established markets. There is no place where you can just show up with your crop and expect to sell it. There are no public reports of prices for herbs and spices, so you cannot watch how prices are going up or down. There are no futures markets to help you understand where the market is going. And if your crop comes in at a lower grade because it didn't rain enough, or it rained too much at harvest time, it's tough to sell. Unlike the traditional crops where it is always possible to sell at lower grades, you can't even give away herbs and spices that are substandard.

There are five themes I want to address in the context of where the industry is or is going:

1. The chicken-and-egg dilemma
2. Quality
3. Proactive marketing
4. Commodity versus niche markets
5. Collectivization of growers

Chicken or Egg

Buyers are a fickle bunch. You can't nail them down to price or quantity most of time. This is especially true for growers new to herbs and spices. Buyers want to see your product first before they will talk price or how much they want. Rarely, very rarely, will buyers ever contract to buy anything unless you have a track record of delivering on time, as promised, at the quality standard they want. Buyers will tell you that there are lots people who say they will produce something and don't deliver.

So, you have to jump in and produce a crop first. You have to have samples that you can show buyers. Typically, buyers want samples of 100 to 500 grams, enough to do tests for constituents such as essential oils and active components, or HPLC profiles. For annual crops, such as caraway, coriander, feverfew, and borage, the cash outlay is not as great compared to perennial crops such as echinacea, St. John's wort, and valerian. You are putting your cash at risk, and you have no assurance of getting a return on it.

I always recommend that new growers start slow. As a seed and plug supplier I could be very happy with the guy who wants to jump in and plant 100 acres of St. John's wort, but I am not, because I know that this guy may not be able to produce a saleable crop, and if he loses his farm, I lose a potential long term customer. I always tell my customers to start with a trial plot, one large enough to produce a decent crop but not enough to hurt badly if it doesn't sell. This trial crop will give you the samples you need to show to buyers, and it will give you a chance to learn how

to grow the crop. Typically, a quarter acre to maybe 1-2 acres is enough. I get nervous if a new herb farmer wants to do anything over 10 acres.

Fortunately, there has been a big change in attitude among Canadian herb companies, so it is easier to jump the first hoops from the starting block. In the past decade, herb companies have become much more willing to buy from Canadian farmers. It used to be Canadian companies refused to talk to Canadian growers, preferring to buy from abroad. But they are much more willing to open up lines of communication with farmers. Last year, I heard one buyer tell farmers that he wants to be invited to the farm to see the crops in the field — and that is a very big change indeed.

Quality

Quality is a big issue in the herb and spice world. Quality is assessed by laboratory analysis and by traditional organoleptic methods (smell, taste and appearance). With increasing emphasis on standardized potency herbs, buyers are demanding that herbs be analyzed for constituents levels, purity, botanical identity, cleanliness, pathogens, and other parameters. Farmers are having to become conversant on laboratory tests such as HPLC, and this will trend continue as we better understand how plant chemistry works and what components are responsible for medicinal activity or flavouring. It seems that you almost have to have a degree in chemistry now to be a successful herb grower.

Much of the driving force is from the government regulators. Governments, and industry also, like to have simple numbers such as constituents content to regulate the herbs industry by.

Botanical identity is a big issue. Buyers are starting to ask where you got your seeds or plants from. This no more true than in the case of *Echinacea angustifolia*. Our company has been accused of selling misidentified seeds in the past, but we are proud to introduce the first certified seed — seed that comes from fields that have been inspected and identified as true by independent botanists and by laboratory analysis. We will even supply a certificate signed by the botanist on request.

Proactive marketing

Farmers have to be prepared to spend a significant amount of their time marketing their crops. Although it is getting easier to sell herbs and spices, the absence of a well established marketing channel requires that growers work the phones and hit the road and schmooze with buyers. Not every farmer can do this, and herbs and spices are not for everyone.

It is important to understand that the herb industry is stratified and fragmented. By stratified I mean that there are different levels with significantly different scales of doing business. For instance, there are brokers who deal in container loads, there are regional distributors that deal in 50 to 1000 kilos, and there are retailers that deal in 1 to 10 kilos. There are manufacturers too that will buy anything from 10 kilos to container loads direct from farmers. Each one of these

levels operates at very different prices: the broker may pay only 20% of what a retailer will pay per kilo.

By fragmented, I mean that each crop is different. Ginseng is marketed to a totally different buyer than is goldenseal, yet you might want to grow both because you have invested in shade structures that both require.

You need become proactive in your marketing efforts. You need to seek out the buyers and get samples to them. After you send the samples, you need to call them up again — don't expect them to break down your door to buy — there are lots of people who are trying to sell them the same herbs and spices you are growing. You need to supply certificates of analysis, and organic certification if you are selling an organic product.

You need to understand that buyers rarely have the market strength to control prices. They have to turn around and sell too, and their customers can go to the next supplier if their selling price is too high. It's the world market — the world's buyers and sellers collectively — that determines the price. Very often prices will swing up and down unpredictably, making it difficult to know what your profit is.

The best thing you can do is to make sure you know your costs. Don't assume that by selling at the world price you will make a profit. You would be surprised how many farmers make that assumption. Always monitor costs — that knowledge will help you when you decide whether or not to plant another crop and it will help you when it comes time to negotiate a price with a buyer.

Commodity versus niche markets

There was a time when most herbs were niche markets. Usually small crops making above average profits. But herbs are becoming more and more like commodities like soybeans and corn, albeit at a much smaller market size. In commodity crops the profit levels are barely higher than what you could make by putting your money in the bank, which these days is almost nothing. Fortunately, most herbs and spices are still making more than soybeans and corn, often much more.

As more growers enter the herb and spice industry, the slide toward a commodity market behaviour will continue. Growers are now finding ways to keep their product from slipping into the commodity markets. Growers are going organic and getting, on average, the price of conventionally grown herbs. Or they are developing their own value-added products, and getting as much as 10 times as much for their crops.

Despite your best efforts it is not always possible to produce a quality product. Weather conditions have a lot to do with that. You may have produced a fabulous feverfew product at 0.6% parthenolide for two years running, but then suddenly this year, it comes in at 0.1%. That crop may not be saleable.

As world market prices go up and down, you may find that the price has dipped below your cost of production when your crop is in and you want to sell.

To spread the risk around, I always advise growers to grow at least three crops, and have a few other up-and-coming ones in the experimental plots. Be prepared to adjust your crop mix according to demand and prices. And don't plow under all of your traditional crops or give up your day job if you are just starting.

Collectivization of growers

A trend I see increasingly is the collectivization of growers into marketing units. Usually, these are regional in nature, but they are increasingly exercising strength in the market. Trout Lake Farms, though a private company, contracts with many growers, and so, in effect, acts as an agent for a collective of many farmers. Frontier Herbs is the same. There are grower groups for St John's wort in the U.S. that have over 1000 acres under cultivation. These growers have set up non-disclosure and cooperative agreements among themselves to help market their product to the largest buyers.

As growers become better organized into regional or commodity groups, they are realizing many benefits from working together. The difficulty is, however, that herb people are notorious for being independent thinkers and cooperative arrangements do not always work. However, I see collectives developing out of necessity to help balance the increasing power and size of buyers.

Final Words

There is no doubt that herbs offer good opportunities for farmers. The growth in acreage and revenue has been 10-20% per annum through the 1990s in North America. North American farmers have the skills and the resources to produce better quality product than is available from traditional sources, and buyers are showing much more interest in North American grown herbs. There is no doubt that this is a good time to get into herbs and spices, or to expand your existing acreage. But unless you can market your herbs effectively, and attend to the increasing demands of the marketplace for quality, you will not be successful in the long run.

New Crops Field Research at the Saskatchewan Irrigation Diversification Centre

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Introduction

The shrinking of budgets for mainstream health care has lead to the resurgence of alternative health care. Natural products are increasingly being used as food flavouring and cosmetics. The medicinal plant industry in north America is believed to be growing at a rate of 20% annually. The annual trade of medicinal plants is estimated to be in excess of \$3 trillion globally and greater than \$100 million in Canada. In response, the medicinal and aromatic plants production and processing are fast growing industries in western Canada, including Saskatchewan.

With directions from the Saskatchewan Herb and Spice Association and financial assistance from the Agri-Food Innovation Fund, the Saskatchewan Irrigation Diversification Centre (SIDC) has expanded its herb research program to address the needs of the of this rapidly expanding industry. The project is conducted jointly among following institutions (Table 1).

Table 1. Collaborating organizations in the AFIF Herb Development Project

Organization	Activity
Saskatchewan Irrigation Diversification Centre	Field agronomy
Department and of Agricultural Bio-Resource Engineering, University of Saskatchewan	Mechanical harvesting and post harvest handling
Department of Plant Sciences, University of Saskatchewan	Quality analysis
Saskatchewan Agriculture and Food	Extension

SIDC Research and Development Program

Crops

Agronomic studies are being conducted for several herb species that are considered to be commercially important. They include *Echinacea angustifolia*, feverfew, German chamomile, milk thistle, stinging nettle, and valerian.

Program Objectives:

- ▶ Evaluate the adaptability of promising medicinal and culinary herbs for Saskatchewan conditions.
- ▶ Develop management practices for mechanized commercial production.
- ▶ Develop labour saving agronomic practices.
- ▶ Compare dryland and irrigated production in relation to yield and quality.
- ▶ Assess the feasibility of direct seeding and transplanting under dryland and irrigated conditions.
- ▶ Determine stage and method of harvesting for maximum yield and optimum quality.
- ▶ Develop post-harvest handling practices (primary processing) to increase recovery and to maintain high quality.
- ▶ Develop optimal short and long term storage practices.
- ▶ Effects of production and post-harvest handling practices on quality and active ingredient profile.

Research Findings:

Preliminary results for annual species that were studied at SIDC are reported in this presentation.

Milk Thistle***Seeding Rate (1997):***

Milk thistle grew successfully in 1997 and 1998. Milk thistle has an indeterminate growth habit. A considerable proportion of mature flower heads were harvested between 95 to 125 days from seeding. A 1997 study that examined the effects of seeding rate of milk thistle grown under dryland conditions. Mature heads were harvested manually for yield estimation. Higher plant population produced twice the seed yield but did not affect seed size (Table 2). Milk thistle appears to have greater yield potential than that was observed in the 1997 study.

The indeterminate growth habit of milk thistle is a limitation for once-over mechanical harvesting. Studies are being conducted to determine the feasibility and potential for mechanical harvesting of milk thistle.

Table 2. Seed yield and average seed weight of milk thistle grown at two seeding rates: 1997

Harvest	Seed yield (kg/ha)		Average seed weight (g/1000 seed)	
	40,000 seed/ha	120,000 seed/ha	40,000 seed/ha	120,000 seed/ha
1	58	116	18.2	20.3
2	40	88	14.3	16.4
3	84	162	20.6	20.7
Total	182	366	-	-

German Chamomile

Cutting Height and Stage of Harvesting (1997):

This study was done with transplanted German chamomile grown under irrigation. The plants were spaced 60 cm between row and 30 cm within the row. The crop was harvested on August 26 and September 11. Cuttings were taken 2.5 and 10 cm from the top of the canopy.

Lower cutting height produced more than double the herbage yield at both harvests (Table 3).

Table 3. Cutting height and harvest date effects on fresh herbage yield: (1997)

Cutting height	Fresh herbage (flower + stem) yield (kg/ha)	
	August 26	September 11
Flower + 2.5 cm stem	2473	2356
Flower + 10 cm stem	4932	6328

Fertilizer Study (1998):

Yield responses to nitrogen, phosphorus, and potassium application were evaluated for transplanted German chamomile grown under irrigation.

The yield differences between fertilizer application and the zero fertilizer control were not statistically significant. However, positive yield responses were observed for phosphorus and potassium application. The response to nitrogen application was negative (Figure 1).

Nitrogen, phosphorus, and potassium effects fresh herbage yield of German chamomile

Further studies are needed to confirm the influence of fertilizer application on chamomile yield.

Feverfew

Spacing Study (1998):

Yield responses to two plant spacings, 60 cm x 30 cm (approximately 55,000 plants/ha) and 60 cm x 15 cm (approximately 111,000 plants/ha) were studied for feverfew grown under dryland and irrigated conditions. The crop was harvested at around 70% bloom.

Plant spacing effects on herbage yield for transplanted feverfew grown under dryland and irrigation.

Higher plant population produced higher herbage yields compared to the lower plant density under both growing conditions. The corresponding yield advantages were 45% under dryland and 64% under irrigation (Figure 2). Further studies are being carried out to examine the interactive effects of plant population and stage of harvest for irrigated and dryland feverfew.

Stinging Nettle

Plant Spacing and Cutting Height:

This study examined the effects of plant spacing and cutting height on herbage yield for transplanted stinging nettle grown under irrigation and dryland. The treatments included two plant spacings (60 cm x 30 cm and 60 cm x 15 cm), and three cutting heights (ground level, 10 and 15 cm from ground level).

The crop was harvested at the 100% flowering stage. The irrigated crop produced higher herbage yields than the dryland crop. Under dryland conditions, both plant populations produced similar yields, i.e. statistically not different (Table 4). However, under irrigation the higher plant population outyielded the lower plant density by 19%.

Cutting the crop at ground level produced almost double the herbage yield compared to the 15 cm cutting height (Table 4). The 10 cm cutting height produced higher yield than the 15 cm cutting height. The yield differences were 30% under dryland and 18% under irrigation. Further work is being carried out to determine the quality aspects of stinging nettle in relation to plant density and cutting heights.

Table 4. Plant spacing and cutting height effects for stinging nettle grown under irrigation and dryland

Treatment	Fresh Herbage yield (kg/ha)	
	Dryland	Irrigation
<i>Plant spacing:</i> 60 cm x 15 cm	6316	9661
60 cm x 30 cm	5961	8092
<i>Cutting height:</i> Ground level	8437	12670
10 cm above ground	5634	7540
15 cm above ground	4344	6419

Greenhouse Production of Echinacea and Other Medicinal Plants

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Echinacea

Our research team has been looking at the production of *Echinacea angustifolia* in greenhouses for the past two years and also developing a rapid method for the determination of echinacosides as an indicator of quality. This research was possible due to funding from Alberta Agriculture Research Institute, Farming for the Future Program. Due to our present research other scientists were successful in obtaining funds to look at the genetic purity of Echinacea species. During these two years of research some problems with the field production of Echinacea also became evident. Controlling weeds became a very big challenge. Hand weeding was neither economical nor practical. Winter survival of 1997 - 1998 crop was poor due to little snow cover until the end of December and then the crop faced extremely cold temperatures. Serious problems with insects and diseases also started emerging and with limited research input at this time and with a stress on organic production it will be a challenge to develop pest and disease control guidelines.

In 1998 season more than 0.5 million plugs seedlings were grown for field planting in Alberta and Saskatchewan alone. The demand for these plugs prompted and necessitated the development of simpler and faster germination methods, the use of automatic seeders and management of seedling plugs. *Echinacea* seeds are expensive and germination may be as low as 20%. Following are our research findings so far.

Seed Germination and Transplanting

These recommendations apply to *Echinacea angustifolia* and *E. pallida*. Germination can be improved by cold stratification treatment or by the use of ether¹. It was also found that seed germination and emergence is reduced by the presence of different fungi on the seed surface. Here is a method we developed to improve germination.

1. Surface sterilize seeds with 0.5% sodium hypochlorite (commercial bleach). Treat the seeds by soaking for 5 minutes with occasional shaking. Remove seed and rinse with fresh water 3 to 5 times.
2. Then soak the seed in good quality water. Very hard water (bicarbonates over 150 ppm or very soft water, sodium over 100 ppm) or chemically softened water should be avoided. Place the seed in a warm place where light can be provided for 24 hours. We have used a steady temperature of 22°C and provided light from a 40 watts light bulb for 24 hours.
3. After 24 hours the seeds have swollen and settled at the bottom of the container. Remove the water and add fresh water containing commercially available ether¹ at a rate of one ml in one

liter of water. Soak for one hour. Etherl is a plant growth regulator which produces natural growth hormone ethylene and is available from horticultural supply companies.

4. Remove the seed from the solution and spread to surface dry for a few minutes. Under Alberta conditions the seed will surface dry in about 30 minutes. This seed is suitable for hand or automatic seeding.
5. One can direct seed in a soilless growing medium in bedding plant trays or use perlite to germinate seeds for later transplanting. Transplanting of very young seedlings 2-3 days old is practical on a small scale. If you are growing several thousand then seed them directly into 128 cavities bedding plant trays or 72 cell packs. The seed should be placed on the surface so that it is exposed to light. Make sure the seed is not allowed to dry out. If the germination medium is thoroughly wetted to begin with, then an occasional light and gentle mist will be required to keep the seed moist. Place the seeded trays in the greenhouse at a temperature of 22°C with a relative humidity of 100%. Provide 24 hours light during the germination period. Forty watts, incandescent bulbs located about 6 feet above the trays and at 10 feet centers are sufficient for lighting.
6. The seeds which have been soaked in water for 24 hours and for one hour in etherl should not be directly seeded in fields. The seeds have already imbibed water and the embryo is very active. Any water stress will lead to dessication and death of seedlings.

Transplanting, although is more labor intensive, has some advantages over direct seeding. One can choose good quality seedlings and fill the cavities 100%. We have found that perlite is a very suitable germinating mix. Fill bedding plant trays with perlite and soak in water for 30 minutes. Drain out the extra water and allow only a small amount of water at the bottom. Make rows on inch apart by gently pressing the perlite. The purpose is that seed is placed in a slight depressed area and is getting enough light. Cover the tray so that 100% relative humidity is maintained. Use a temperature of 22°C and light ON for 24 hours during the germination. Seeding grown from March onward will not require additional lights for growing.

Seed cracking will start in about 36 to 48 hours although in some seed lots the cracking was seen during the soaking. A fertilizer at 50 ppm of nitrogen complete with other nutrients should be supplied when true leaves are visible. These seedlings will be ready for transplanting when true leaves are about 1-2 cm long and root is about 2.5 cm (one inch) long.

Germination is strongly dependent on seed source. If the seed is collected from the field properly and it is mature seed then germination without etherl may be over 50%. One seed lot from Southern Alberta from a three year old planting was over 80% without any treatment.

The seed should be collected ideally when the flower heads start to splitting and a black ooze start showing up on the surface which indicates seed maturity. Mechanical removal of seeds have been shown to cause damage.

Some Pointers on the Production of Good Quality Plugs

Making sure that the plugs are of the right physical age will ensure a good field establishment in the first year. Younger than 12 weeks old seedlings face the same dilemma. Seedlings grown in the third week of April and planted in late June stayed there all season long and second year survival and establishment was less than 20%. Rest of the 80% seedlings either withered or came up late in July of the following year comparable to first year plantings. It is very critical to plant the plugs at the proper physical growth stage.

1. Plugs for field planting will be ready between 12 and 14 weeks. Once the plug becomes root bound then the roots start thickening, twining and twisting in the lower portion of the cavity. If planted in field, such plugs will never develop a vertical root system. For example if seeding is done in March, the seedlings should be ready for field planting by June. A grower did not plant them by July and the seedlings were very root bound. These seedlings showed a poor establishment till October. The roots did not tend to go into the soil, instead these roots grew and spread laterally into the upper portion of soil.
2. Plugs need to be fertilized with a complete nutrient solution. Maintain a nitrogen level between 75 to 100 ppm of nitrogen as a constant feed.
3. Plugs tend to dry out quickly because of smaller growing media volume. Lower leaves will turn yellow if plugs are exposed to severe water stress at any stage of growth. This may result in leaf drop and pre-mature plug dormancy.
4. The plugs should be grown on a moist to dry regime. We have not seen any serious root rot problems under normal cultural practices. Over crowding of seedlings in open flat tray may cause grey mold to develop and destroy the seedlings. Use of field soil for plug production is not desirable.

Commercial Production In Greenhouses

Production in Styroblocks

Styroblocks are containers made with expanded polystyrene normally used for tree seedling production. They are available in different cavity sizes and depths. In 1997 we compared Styroblocks ranging in cavity volume from 105 ml. to 700 ml. The plant density ranged from 56 plants/ft² to 10/ft². The crop was seeded in May, planted in Styroblocks in a soilless growing medium in June and harvested in December. The dry weights of roots ranged from 24.5 grams/ft² to 71.25 grams/ft².

In 1998 the different seeding dates were studied in Styroblocks 112. These blocks have 105 ml of growing medium in a cavity. There were 112 plants in 2 ft² area. We also compared nitrate nitrogen and ammonium nitrogen as to their effect on root weight. Here is a summary of results from this trial.

Seeding Date	Harvest Date	Treatment	Avg. Fresh Wt. per plant (per sq ²) grams	Avg. Dry weight per plant (per ft ²) grams
16.01.98	15.09.98	Nitrate-N	10.04 (562.04)	3.22 (180.25)
16.01.98	16.09.98	Ammonium-N	9.13 (511.21)	3.00 (167.96)
16.01.98	24.09.98	Nitrate-N	9.57 (535.81)	3.08 (172.55)
16.01.98	25.09.98	Ammonium-N	9.32 (522.22)	2.96 (165.79)
11.03.98	30.09.98	Nitrate-N	7.52 (421.24)	2.29 (128.11)
11.03.98	01.10.98	Ammonium-N	6.61 (370.27)	2.07 (116.18)
11.03.98	08.10.98	Nitrate-N	7.98 (447.00)	2.35 (131.75)
11.03.98	08.10.98	Ammonium-N	7.47 (418.25)	2.28 (127.26)
16.04.98	15.10.98	Nitrate-N	4.83 (270.60)	1.38 (77.49)
16.04.98	19.10.98	Ammonium-N	4.12 (230.98)	1.32 (73.75)

This data indicates that 180 grams of dried roots of *E. angustifolia* can be produced from January to September in 112 Styroblocks. It would require 2.5 ft² of area to produce 450 grams (one pound) of dried roots. If a price of \$30 is obtained per pound of dried roots then the gross revenue potential is approximately \$12/ft².

We are also studying the production in an aeroponic system. This is a type of hydroponic system where seeds of *Echinacea* are germinated in rockwool cubes and are placed in a grow channel which is approximately 1 foot wide and 1 foot deep and the top portion is removable. Holes are made in the top portion and rockwool cubes containing the young seedling are inserted in the top panel. A water sprinkling system is set up at the bottom of the grow channel. Sprinklers are set up at one foot intervals and are connected to a submersible pump in a nutrient holding tank. The pump is connected to an automatic timer. A crop of *Echinacea* was seeded in the first week of January, planted in the grow channels in the middle of February and harvested towards the third week of September. There were 35 plants/m². Average root dry weight was 16.37 grams/plant. This means 572.95 grams/m². Compared to Styroblocks this root biomass is lower. Aeroponic system offers many advantages like clean roots, no labor involved in extracting the plugs and no washing of roots. It is planned to study higher plant densities/ spacing in an aeroponic system.

Quality of greenhouse grown *Echinacea*

Quality is determined by the following parameters.

The buyers look for:

- Clean, dry material.
- Mature roots that are darker in color.
- Echinacoside contents are important.
- The material must have normal taste and have its classic numbing effect.

At present estimation of echinacosides in *Echinacea* roots is very expensive. Air dried *Echinacea* roots are grounded up into fine powder and extracted over night with methanol on a Soxhlet apparatus. This extract is evaporated almost to dryness on a rotary evaporator, re-dissolved in a small amount of methanol-water and separated into a number of fractions on a Sephadex column. Thin layer chromatography and reverse-phase high pressure liquid chromatography (HPLC) is used for the isolation and purification of the Echinacosides and estimated against the standards.

In 1997- 19988 following *E.angustifolia* root samples were analyzed. The purpose was to compare field grown roots with the greenhouse grown material.

Field Grower # 1, Two years old roots:

Sample # 1, west of the field.....	Echinacosides 1.36%
Sample # 2, east of the field.....	Echinacosides 1.18%

Field Grower # 2, Two years old roots:

Sample # 1.....	Echinacosides 0.83%

Greenhouse Grown , 9 months old roots, aeroponic system:

Sample # 1.....	Echinacosides 0.72%
Sample # 2.....	Echinacosides 0.94%

Greenhouse Grown, 9 months old roots in peat medium:

Sample # 1.....	Echinacosides 1.81%
Sample # 2.....	Echinacosides 1.64%
Sample # 3.....	Echinacosides 1.18%
Sample # 4.....	Echinacosides 1.26%

These preliminary results suggest that the quality of *E. angustifolia* roots grown in greenhouses is comparable to field grown root material. Further research is in progress on enhancing the biomass of roots and increasing the Echinacoside contents.

Feverfew (*Tanacetum parthenium*)

This is one of the easiest plant to grow. A crop can be harvested in 10 to 12 weeks time after seeding. The selection of a cultivar which has good parthenolide contents is a priority. You cannot take a chance on growing a cultivar which has poor parthenolides and you learn about it after you have grown it. We compared two plants from two sources. One source was from Canada and one from the U.S. We also compared parthenolide contents at different stages of plant development. Parthenolide contents in plants obtained from U.S sources were 0.18% in one week old seedlings, 0.13% in four weeks old seedlings and 0.23% when flower buds were not visible.

Parthenolide contents dropped to 0.19% when the sample got wet due to rain and then dried for analysis. The highest parthenolide content was 0.24% in plants which were flowering and entire plant was analysed.

The plants from Canadian sources showed a parthenolide content of 0.58% in one week old seedlings and 0.56 in four weeks old seedlings. The highest contents of parthenolides was 0.74% in samples which included both flowers and leaves when plants were about nine weeks old.

This study showed that choose a seed source which guarantees a certain parthenolide contents. Flowers accumulate the highest amount of parthenolide.

Feverfew in greenhouses can be harvested up to four times. In our experiments the first crop was harvested in 10 weeks and second harvest was completed in 27 days. Feverfew can be grown in a standard commercial soilless growing medium. A complete nutrient feeding is required at 200 ppm of nitrogen. The plants are susceptible of magnesium deficiency which appears as interveinal chlorosis in lower leaves. Research is required on precise nutritional requirements and its role in parthenolide contents.

In our experiments we obtained a per plant fresh weight of 83 grams at 8 x 8 inch spacing and a dry weight of 10.1 grams. The second harvest yielded 62.7 grams of fresh material and 7.1 grams of dry weight. The plant is easy to air dry and store.

Thrips and aphids can be two potential problems in greenhouse production. Because of fast growing nature of this crop the management of these insects should not present a major problem.

Calendula officinalis

This is another plant which is easy to grow. It is commonly grown as a bedding plant and its flowers are used to make lotions and skin creams. A crop of *Calendula officinalis* was seeded on 12.04.96 in bedding plant trays using a standard soilless growing medium. The seedlings were transplanted on 24.04.96 in four inches pots containing a soilless medium. Flower harvest started on 23.05.96 and last harvest took place on 01.07.96. The number of flowers harvested per plant were 20.63 which translates to about 40 flowers/ft². The plants were drastically cut back on 02.07.96 which regenerated nicely and flowers were harvested on 07.08.96 and last flowers were

removed on 15.08.96 (38 days). A total of 9.86 flowers were harvested per plant from this second crop. A crop was grown in six inches pots and 22.35 flowers were obtained from each plant.

Calendula requires a constant application of 200 ppm of nitrogen from a complete nutrient source. The plant can tolerate severe water stress and that promotes flower bud development.

Insect problems included aphids and thrips and the use of mineral oil appeared to be doing a satisfactory job. Furthermore, because flowers are used for medicinal purposes, so biological program can be successfully used.

Other Herbs of Interest

We are studying Gotukola (*Hydrocotyle*), St. John's Wort (*Hypericum*) and Calamus (*Acorus calamus*) as possible crops for greenhouse production. A preliminary study with purslane (*portulaca*) was conducted to determine its yield and fatty acid contents.

Acknowledgments

Financial assistance from the Alberta Agricultural Research Institute under grant # 970750 is acknowledged. Technical assistance of Wanyu Chen, Martin Blank and Jackie Tievlie is greatly appreciated.

What are Medicinal Plant Buyers Looking For?

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The commercial medicinal herb market is booming internationally. Here in Canada we have a unique opportunity to capture a large portion of the international market. This can only be achieved through cooperation and understanding between growers, manufacturers and distributors. By understanding each other's needs we will be able to harmonize our efforts and reduce costs while increasing our quality and international reputation. This paper examines the issues from a primary Canadian manufacturer of medicinal herbal products viewpoint.

Canadian herbs, production facilities, and consumer products are legendary worldwide. Unfortunately almost all "Canadian" herbal products require the use of imported raw materials. All of the Canadian manufacturers I have spoken to have expressed their desire to purchase herbs from Canadian farmers. The same manufacturers have also expressed their frustration in their attempts to source products from Canadian farmers.

Speaking as a proud Canadian manufacturer, Health 4 All/ Global Botanical sees its best interests served by encouraging Canadian farmers to grow medicinal herb crops. Despite this, we are

forced or the most part to source our raw materials outside Canada. This even applies to crops that are widely grown here.

The advantages to sourcing from Canadian farms are significant and calculable. More often than not Canadian crops are equal or better in quality to crops from Europe or the United States. This quality gap is narrowing, but it still exists today.

The most obvious advantage to sourcing in Canada is cost savings. The savings come from several areas. There are savings realized in the area of transportation. It is generally cheaper to ship within Canada because there are no customs charges, broker charges, or duties. There are savings from not having to worry about currency fluctuations, increased transit times, or hassles and delays due to Canada Customs. In our firm we have calculated that these savings could equate to 1 - 35% of total product value.

The question then is why with these advantages do we source most of our crops outside Canada, when they are available in Canada? The answer is that for the most part Canadian medicinal herb farmers must learn from their American and Western European counterparts how to conduct business with manufacturers.

In order to understand the differences I will go through the purchasing process at our company. Once contact with any grower has been established, we normally request a sample of the herb(s) and any accompanying documentation. These are sent to our quality control department (Q.C.) for approval. Foreign growers will usually have a generous amount of supporting documentation. These include proof of organic certification, lab analysis documents, proof of identification, bacteriological analysis, and active constituent analysis. Rarely will a Canadian farmer provide more than a sample. This supporting documentation makes it easier to market finished product both inside and outside Canada. Governments look increasingly to this documentation before allowing products to be sold. These documents add value to the products because if they are not provided the manufacturer must go through the expense of running the tests. It is less expensive for a grower to do this for their entire crop once, as opposed to each company they supply running these tests themselves.

Once a product is approved by Q.C. We begin to discuss price, quantity, and delivery dates. Many farmers set their price intuitively. They make a trip to their local retailer, look at the price of a finished good, and then work backwards. This method once resulted in a grower from Ontario asking a price for Stinging Nettle that was over four times our selling price at the time. Clearly this method is flawed.

To understand why this does not work we have to examine the steps a product goes through before arriving in a consumer's home. For illustration purposes I shall use a common product, Echinacea Purpurea Tincture. Assuming we buy the root from a Canadian farmer the costs incurred are:

Transportation from farm	Product testing
Warehousing	Manufacturing the tincture
Other ingredients (alcohol, water)	Labor to fill the package
The Packaging (bottle, label, dropper, cap)	Government fees (DIN, paperwork)
Government site licensing fees	Sales/Marketing
Overhead	

The bottle will then be sold to either a broker or distributor. They incur many of the same costs (excluding the raw ingredients, package, and manufacturing). The product is then sold to a retailer who incurs transportation, warehousing, marketing, overhead, theft, and government regulation. The bottle is then sold to the consumer. The bottle selling for \$8.95 may seem exorbitant until you examine the steps and costs associated directly to that package.

One way for growers and manufacturers to work together is to enter into a contract growing agreement. These are legal agreements between the parties that allots an entire crop, or portion of it, to a manufacturer at a prearranged price and delivery schedule. The normal rule of thumb is to negotiate the contract before planting, but can be done prior to harvesting. In this scenario everyone wins. The grower is certain of the sale of his crop at a guaranteed price, while the manufacturer is guaranteed of obtaining supply at an acceptable price.

In order for the system to work, Q.C. must approve a previous year's crop and state that the future crop will be acceptable if it varies "minimally" from the sample. The farmer then estimates his yield, and closely approximates his harvest and delivery schedule. Consideration must be given to the manufacturer by communicating any anticipated shortfalls, delays, etc. since production schedules are planned according to expected availability.

All the products our company deals in are dried at a low heat and out of the sun. Most of our products are purchased in a cut or powdered form (specs for which can be given once interest is determined). Pricing is dependant upon the market value of that specific botanical, the form it is being purchased in (whole, cut, or powdered), as well as the volume.

Many farmers ask about the viability, prices, and demand for organic crops. Demand for organic crops varies from product to product. It generally depends on the proliferation of organic product within that specific crop, the certifying agency, and the overall quality of the product.

Proliferation of organic product in that specific crop is an important factor. For certain products (Echinacea) it is almost expected to be organic and the premium organic material will command is approximately 3 - 5%. For products such as Feverfew that have a moderate organic presence, the

premium can be 6 - 15%. Some products, such as Chamomile, have negligible organic presence and the premium they command is a maximum of 3%.

Unfortunately many people feel that "Organic" is the pinnacle of our industry. They forget that the certificate is only as good as the agency issuing it. If the agency has no reputation, then the product has none either. In cases where we do not trust the certifying agency, we are unwilling to pay the premium because we will be forced to sell the product as commercially grown.

The other factor is overall quality, a condition our company emphasizes. Quality Control has rejected "Organic" product in favor of commercial product because the commercially grown product was of better quality.

It is to be hoped that this paper has achieved its objective by explaining our process for purchasing, as well as the steps needed in preparing a product for market. Only by harmonizing our efforts can we make Canada an Industry leader in the production and marketing of Quality Medicinal Herbal Products.

Following is a current listing of our approximated annual botanical usage. Please determine what products are specific to your region. Suggested contacts for more information on growing and native species are:

- Agriculture Canada
- Your Provincial Ministry of Agriculture
- Any regional Universities or Colleges

Once the products you may be interested in growing is determined, I will be happy to speak with you regarding an approximate value for these products to help in your final planning.

Good luck growing.

Buyers Wish List

One of the requirements being placed upon the wholesaler is a stringent and detailed paper trail. In addition to lot specific Certificates of Analysis, this paper trail must document the crop from its conceptual stages to its final delivery to us, the Purchaser.

WE WILL BE REQUIRED TO KEEP THE FOLLOWING INFORMATION FOR EACH PRODUCT LOT PURCHASED:

What crops were grown on the land prior to the lot being offered for sale.

If the land is Certified Organic, or in the process of becoming so. (If Certified , a copy of the Certificate will be required with the other documentation.)

What sprays (insecticides, fertilizers, etc.) were used on this land prior to and during the production of the lot being offered for sale.

Where the seed for the lot being offered for sale was purchased.

What type of machinery was used to plant the product, and how and when it was planted.

How the product was grown, and what it was grown beside.

Any machinery used in the weeding, and harvesting of the product.

What geographical location the product was grown in .

How the product was dried.(Specific procedures including times and temperature, as well as machinery used).

If the product was cut, what machinery was used, and the procedure used to process it.

A sample of the product being offered is appreciated prior to the purchase of the product.

What the product is packed in. (Specific packaging materials)

If any other agencies assisted in the production of this product, and if so who.
(Example: Agriculture Canada or Agriculture Ontario).

A detailed Certificate of Analysis which includes microbiological and chemical analysis that is lot specific to the crop.

As the Purchaser, we would also like to keep in contact with you the Farmer during the growing process. In this way both of us may have our questions and/or concerns addressed.

To aid in production scheduling , we would like to be informed as soon as possible of any anticipated delays in availability dates, or adjustments in the anticipated harvested yield.

By keeping detailed records of your crops and supplying complete Certificates which are lot specific helps to aid in the marketability of your product. If we can easily obtain the information requested, it saves us time and money and makes your crop that much more attractive.

Happy Growing!

Wildcrafting in the Parklands of the Prairies

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I have worked with wildcrafters in Northern Saskatchewan for over ten years. During this time I have seen the interest in wildcrafting increase significantly as people realize the opportunity to earn some supplemental income from harvesting products from the wild. The generation of some income may get some people started in the industry but the opportunity to get out and enjoy nature is what sustains their continued participation. A knowledge of the outdoors, a means of transportation and hard work are the most important factors for success.

Wildcrafting is the gathering of plant material in their natural habitat. Products harvested may range from bark, twigs, moss, and lichen which are used in the floral and craft industries, to wild berries and mushrooms and medicinal plants which are used as food and health products. The interest in wildcrafting has grown dramatically over the last few years as companies seek natural ingredients in their products. Wildcrafting has also become very popular in areas with depressed economies because people can earn some supplemental income by harvesting various plant products. The ease of access into an industry where participants do not have to spend a lot of money to get into is the major attraction.

A common myth about wildcrafting is that there is lots of money to be made harvesting products from the wild. It has often been referred to as a goldrush mentality. Occasionally when prices are good and there is an abundant crop, good profits can be made. Stories about someone making hundreds of dollars a day spread like wildfire. However, the norm is that long hours and strenuous work are often required to make any returns. A lot of time is also spent just scouting out sources of product. People who are trying to make a living in this industry have to concentrate on products which will bring the highest return. There must also be an abundant supply of the product to make it feasible. Therefore, harvesters will switch between several different products depending on the markets, availability of product and demand.

In Northern Saskatchewan, wildcrafters have concentrated on wild mushrooms because they bring the highest return, are plentiful in good years, and have well-established markets. Buyers will often establish buying stations in good mushroom picking areas so that they have first access to the product. This model could also be used for the purchase of other forest products including medicinal plants.

I would now like to discuss some of the issues surrounding wildcrafting.

Plant Identification

Before anyone goes out to harvest plant materials, you must be able to positively identify the product. There are many poisonous plants and mushrooms which can make the final consumer very sick or even cause death. There are some very good plant field guides which can be used to aid identification. A good guide for the parkland/forest region is *Plants of the Western Boreal Forest and Aspen Parkland* by Johnson/Kershaw/MacKinnon/Pojar. A good book on wild mushrooms is *Mushrooms of the Boreal Forest* by Eugene F. Bossenmaier. For prairie plants, *Wildflowers Across the Prairies* by Vance/Jowsey/McLean is very useful. In addition to using a good field guide, going out with someone who is knowledgeable about plants will assist wildcrafters in identifying plants and learning about the habitat where they can be found.

Sustainable Harvests

The increased demand for natural products has heightened concern about the environmental effects of harvesting wild plants. Many people are concerned that wildcrafting will destroy plant ecosystems. A far greater concern should be the destruction of ecosystems by other activities not related to wildcrafting. However, it is important that wildcrafters harvest plant material in a responsible manner so they do not destroy plant populations. It is in the best interest of wildcrafters to do this so that there will be something to harvest in the future. This is often referred to as ethical harvesting.

There are many different suggestions as to how much plant material can be safely harvested without causing irreparable damage to a plant population. This will vary greatly depending upon the species, site and various conditions. A general recommendation is that less than one-third of the plants should be harvested. If you are harvesting the roots of plants, the oldest and largest plants should be dug up. These plants are usually found in the centre of a patch. Various practices can also be carried out to help the spread of the plants. Leaving the crown of some rootstocks, spreading the seed or harvesting only a portion of the rhizomes will assist the plant in regeneration or in establishing increased populations.

Many buyers will only purchase product that has been ethically wildcrafted. Companies selling ethically wildcrafted products have an advantage in the marketplace.

Many companies also obtain organic certification for product harvested from the wild. In order to obtain organic certification, certifying bodies must inspect areas to determine that sites are being harvested in a sustainable manner. The products must also be free from pesticides and pollution. Plant material harvested for food or medicine should not be harvested near busy highways due to heavy metal pollution from automobile exhaust. Power-line right-of-ways, road and railway ditches should often be avoided because they may have been sprayed with herbicides.

Time of Harvest

The time of harvest is dependent on the plant part required and the needs of the buyer. Root crops such as dandelion, seneca, wild licorice, wild sarsaparilla and calamus root are harvested when the plant is dormant. This can be in the spring before new growth begins or in the fall when

the plant is going into dormancy. The highest concentration of phytochemicals is usually found in the root at this time.

Herbaceous plants such as stinging nettle and fireweed are best cut just prior to flowering or in early bloom. Flower blossoms of such plants as red clover should be harvested in mid-morning after the dew has dried.

The bark of trees and shrubs such as birch, willow, and aspen are best harvested in the spring when the sap is running. The bark can be easily stripped off at that time.

The seeds of wild plants should be collected when they are mature but before they drop off. The time period that you have varies with the plant species.

Regulations and Training

If harvest is done on provincial forest lands, licensing may be required authorizing individuals or companies to harvest or process forest products. In Alberta, you should check with your local Environmental Protection Branch to find out what the regulations are regarding commercial harvesting of plant material.

The industry is seeing an increasing demand for some sort of harvester/wildcrafter certification program to prevent over harvesting and illegal harvesting. Certification programs which train harvesters about plant growth and reproduction, proper harvesting techniques, quality control, and other factors would improve their skills producing qualified professionals. However, the industry must increase in size before such a program would be feasible.

Wildcrafters must have access to the resource. Close co-ordination with other forest/land users can facilitate access. A lot of plant material can be obtained from areas designated for timber harvesting. This practice helps to promote the more efficient use of our limited resources. Much of the plant population that is harvested from these areas will not regenerate in these areas until there is sufficient forest canopy.

Wildcrafting on private lands is not as restrictive. However, landowners or lessees should be consulted to obtain their approval.

Processing Requirements

The proper handling, drying and storage of plant material is critical to the success of any wildcrafting operation. Facilities must be adequate to handle the volumes that are harvested. Premium prices will be paid for a quality product which has been picked at the proper time, cleaned and dried if required, and stored properly.

Conclusions

The interest in wildcrafting continues to increase as markets for natural products improve and new uses of plant products are discovered. Before wildcrafters harvest any plant material, they

should ensure that they have a market for the product they plan to harvest. They should also be aware of the requirements of the buyer to avoid any disputes at the time of sale.

Concern for the environment must remain a priority of wildcrafters to ensure that they have product to harvest. Products which may be harvested in a sustainable manner will help to justify the protection of plant ecosystems by demonstrating that higher returns may be obtained through non-destructive harvesting.

Research must be carried out on plants which have often not received much attention because it was felt that they did not have much economic importance. Wildcrafting is helping to change this attitude as new uses for many plant products are found.

What's Cooking in the Alberta Potato Industry?

Patricia Duplessis¹ and Clive Schaupmeyer²

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Alberta's potato industry is made up of three main sectors: processing, seed and table. The province's total potato acreage is approximately 30,000 acres with processing accounting for about 16,000 acres, seed for 8,000 acres and table the remaining 6,000 acres. Over 70 percent of the potato acreage is irrigated with 100 percent of the potatoes grown for processing under irrigation.

The processing sector is located in southern Alberta. There are three existing processing plants with one under construction and one more announced. These two new plants will add approximately 20,000 acres to the province's commercial acreage by 2000. By 2001 the total potato acreage in Alberta will be in excess of 50,000 acres.

The farm gate value of Alberta's potato crop is approximately \$50 million annually with a processed value of \$150 million. By 2002 the processed value of the potatoes in Alberta may be as high as \$400 million.

Alberta produces top-quality seed for domestic and export markets. Canada has a national seed potato inspection program that is regulated by the Canadian Food Inspection Agency (CFIA). There are eight classes of seed potatoes beginning with the nuclear generation. Tissue culture facilities produce disease-free plants that are planted in greenhouses to produce the nuclear tubers which are then grown in the field to produce the Pre-Elite class. Each year the seed drops a class and in the case of high disease incidence the seed can drop more than one class in a single year. All seed potatoes must meet minimum standards or they can not be sold as seed.

The earlier the generation of seed the higher the costs and the revenue. The generation of commerce in Alberta is Elite 3 or Elite 4 (fourth or fifth field generation) compared to eastern Canada where the generation of commerce is the sixth or seventh field generation. A producer of nuclear tubers must therefore read the market well in advance as they will be producing tubers for commercial sale 5 or 6 years later. Seed potato production can be more profitable then commercial potato production but there is also more risk involved.

Alberta is Canada's largest seed potato exporter to the United States with the majority of that seed shipped into Washington, Oregon and Idaho. Alberta also produces a large portion of Canadian seed potato exports into Mexico. Our national inspection program ensures that all Canadian seed potatoes of a given class meet the same standards. In the United States each state has its own inspection agency and therefore it is more difficult for them to participate in international trade.

With significant increases in Alberta's processing acreage expected over the next 3 years there is also room for increased seed acreage. Alberta's domestic market will almost double and the export market remains strong. Growers interested in considering seed potatoes as an alternative crop should do their homework first by talking to existing growers and learning as much about the industry as possible. Deciding what varieties to grow is key to a successful operation.

Alberta's table potato industry is the smallest sector and has been losing acres to seed and processing production over the last several years. Alberta producer's have difficulty producing the 'perfect' potato that the consumers have been trained to expect so the majority of the table potatoes sold in Alberta are imported. Many small niche markets are being developed for specialty varieties by individual grower's to ensure a premium price for their product. Gourmet, organic and 'heritage' are three such markets.

The greatest obstacle for growers interested in growing potatoes as an alternative crop is the large capital investment required. To produce a quarter section of potatoes under irrigation (one pivot $\approx$ 130 acres), the capital costs for used equipment and storage can be in excess of \$600,000. The largest portion of this cost is for new storage that would be required to store the product. This capital does not include costs of land or irrigation.

The potato industry in Alberta is growing and with the announcement of two new state-of-the-art processing facilities it is obvious that the world is aware of the quality product produced here. There is room for expansion in all sectors of the industry and the next 10 years will see growth in Alberta's potato industry.

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The Alberta Dry Bean Industry: Production and Processing

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I am here today to talk to you about dry edible bean production and processing in Alberta. What are the keys to success and what might it take to make them profitable on your farm? Let's start by defining what we are talking about when we say dry beans. Beans are a pulse crop, not unlike peas and lentils in some ways. They use Rhizobia to fix N from the air, and they fit very well in rotation with many of the crops currently grown in Alberta. As many of you might know, pulses are a major source of dietary protein for people who can't afford to eat as much meat as we decadent North Americans.

Dry edible beans are the single largest produced pulse crop in the world. The 20 million MT or so that are produced each year represent about 1/3 of the pulses produced. It is interesting to note that while they are the largest produced pulse, very little of that production is commercially traded, most years less than 15%. Another rule of thumb is that the closer to the equator you live, the more likely that beans are a major part of your diet. Half the beans in the world are produced in three countries - India, Brazil, and China. Canada fits into the "Others" category. Let's take that world production, and drill down a bit. Around 20 million MT are produced in the world annually. India grows about 4.5 million MT of that. The USA produces about 1.3 MMT. Canada's production is a paltry 160,000 MT (about .6% of the world) and in a fantastic year Alberta can produce 40,000 MT of that!

Dry Bean Production

World production is about **20,000,000 MT** per year

India's production is about **4,500,000 MT** per year

USA production is about **1,300,000 MT** per year

Canada's production is about **160,000 MT** per year

Alberta's production is a maximum of **40,000 MT** per year

As I said though, much of the world's production is not traded. The big exporters don't totally equate with the big producers. Although they bounce back and forth for first place, Myanmar (Burma), who produce only 4% of the beans is as large an exporter as China who produces 14%!

As you can see on this graph, we are no where near the biggest exporter of beans, but we are significant. We don't totally determine prices with our production, but we do impact them.

There are many types of beans, the biggest difference between the various types is what they look like. The difference in appearance differentiates the various types of beans into different marketplaces, different uses and different prices. Much of that differentiation is driven by ethnic history – your ancestors ate white beans, and so to you beans are not supposed to be black. In Alberta, we presently grow five types which are sold into 27 different countries. Pinto beans are often found in fast foods, refried beans, soups, stews and canned. Pink beans are strongly desired by some US consumers, but they also end up in the more generic refried market. Small red mexican beans are dry packaged for grocery stores, but are also canned or used as an ingredient in a number of Mexican dishes. Great Northern Beans are white in color, sold in dry form and used in soups and baked beans. The most recent addition to the Alberta roster is black beans. They are the most nutritious of the various types, often showing up in soups, chili and rice dishes.

The production of these various types in Alberta currently generally follows much the same pattern. Almost all Alberta bean growers plant them as a row crop. This means that very specialized equipment is needed. The beans are planted on well drained, flat, non-saline, rock free fields. They are planted using a precision seeder that precisely places them in rows on 22 or 30 inch spacings. Seeding is done at the end of May, after the chance of frost has basically past and soil temperatures at seeding depth have reached at least 16 C. Special care must be taken in handling the seed, as it is very susceptible to cracking, and once it's cracked it won't grow. Beans are Very Susceptible to frost damage at all stages of growth.

Weed control is critical because beans are lousy competitors especially in wide rows. Most Alberta growers will use herbicides, however they also usually cultivate the crop in between the rows, a minimum of 2 times during the growing season. A number of applications of fungicides and foliar feeds are very common. Beans are very susceptible to sclerotinia. Harvest is handled differently too. The bean rows are undercut and then the plants are windrowed together before being picked up by a combine. Adverse weather at harvest time has ruined more than one crop! From the field the beans are normally delivered directly to the bean processing plant. They are scalped while you wait, and then graded and put into storage. Quality, as Mr. Ford said, is job #1. Earhtag and/or discoloration quickly downgrade a product judged solely on how it looks. The beans are very fragile, and splits and cracked seed are downgrading factors. From storage, the beans are cleaned over an air/screen machine, a gravity table, a destoner table, and sometimes color sorted, depending on the end use customer's specs. Almost all the beans are shipped to the customer in 100 pound poly bags. In Alberta, we have started to do some value added processing too. Sometimes they are washed, sometimes they are polished, and more and more are being processed into a dehydrated, instant, refried bean.

Why do Bean growers grow beans?

- ▶ Reasonable returns
  - Long term average yield is 2000 lbs/acre, LTA price is 25 ¢/lb
  - = \$500/acre, inputs \$300/acre net \$200/acre
- ▶ Rotations
  - Sugar beets, Soft Wheat, Barley
- ▶ Equipment utilization Sugar beet growers

Why don't more farmers grow beans?

- ▶ Heat units
  - Need minimum 2100 (about 1700 G.D.D.)
- ▶ Timely moisture
  - Not too much, at the right times
- ▶ Beans perform much better grown as a row crop
  - Disease, aerated soils

So what prevents the Alberta acreage from expanding beyond the 40,000 acres we currently see as the maximum grown? A number of things. Beans mature according to the amount of heat they have accumulated. . The unit of measurement is degree days, or corn heat units. Corn heat units are the number of daylight hours above 10 C, and night hours above 4 C. Beans require an absolute minimum of 2100 CHU, and are more comfortable around 2250 – 2300. They usually need at least 110 frost free days to accumulate that much heat. Beans are not a major water user, in fact they drown if left standing in water for 24 hours, but they must have it at certain times, especially at flowering. This is one of the reasons they tend to be grown under irrigation, most people find it hard to time rain showers! It also requires a major investment in equipment or a significantly increased risk if you try to do it with conventional equipment. The management skills required to grow them successfully can be demanding.

The heat requirements of beans are the major limitation to expanding the production areas in Alberta. A great deal of work has gone into developing earlier maturing, upright, bush type bean varieties. The benefit, when these finally arrive, is that bean production will no longer require a specialized line of row crop equipment for seeding and harvest.

Low-THC Hemp (*Cannabis sativa* L.) Research in the Black and Brown Soil Zones of Alberta Canada

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Introduction

In the past three years, there has been a renewed interest in the production of fibre hemp (*Cannabis sativa* L., Cannabinaceae) in Alberta. This effort has sparked a great deal of interest and speculation regarding the crop's potential. Since 1995 fibre hemp research plots have been grown in various parts of Alberta to evaluate the potential of this crop for both seed and fibre

production. Research licenses were granted by the Health Protection Branch of Health Canada, the branch of the federal government charged with enforcing legislation concerning this species. In March, 1998, Health Canada announced that commercial production of low-THC hemp would be allowed through a licensing process.

Hemp is an annual herbaceous plant which flourishes in temperate regions. All cultivars tested in Alberta have been low-THC (delta-9-tetrahydrocannabinol) genotypes. Canada has adopted the 0.3% THC standard established by the European Union and the OECD as the concentration which separates non-psychoactive strains suitable for legal fibre production from those which are illegally grown for their properties of intoxication. The 0.3% THC designation is very conservative. Most narcotic strains range from 8-10% THC, with cleaned, high potency material reaching as high as 30% THC. It is postulated that THC was useful to the plant by providing protection from UV-B exposure. The cannabinoid complex (which includes THC) of compounds is secreted by epidermal resin glands which are most numerous on and around the reproductive structures. This makes sense, since the reproductive structures require the highest level of protection. Low-THC varieties secrete resin, but it is composed of non-intoxicating substances.

Plant growth is very vigorous. Fibre hemp can reach heights of up to nine meters, but the usual average under commercial production is 2-4 meters. The crop has been subject to intensive breeding programs in Poland, Rumania, Hungary, France, the Ukraine and several other European countries. Breeders have attempted to increase bast fiber yield and quality. One method has been to select monoecious strains (male and female reproductive organs located on the same plant) which eliminates the problem of different maturities between male and female plants. Due to the fact that flowering is dictated by day length, most land races have been selected to mature in early autumn, to take full advantage of the temperate growing season. Breeders also prefer to select for long internodes and a hollow stem, which increase the quality of the fiber.

The plant consists of a single main stalk, with an external sheath of bast fibre and an interior core of white, fibrous hurd. The plant has been used for a wide variety of purposes including rope-making, textiles, paper production and construction materials; the seed has been used as a source of high quality oil (both for industrial and edible uses) and protein (22%).

History

It is believed that hemp originated somewhere in Central Asia. There is evidence of hemp use as a food grain as well as for fish nets, clothing and rope 6500 years ago in China. The crop gradually moved into Europe, and the first reports of hemp growing in the New World began in Chile in 1545. Hemp was so important to the navies of England and the American colonies that farmers were legislated to dedicate a portion of their land to the production of the crop. George Washington and Thomas Jefferson were hemp growers; shortly after independence, U.S. taxes could be paid with hemp if farmers chose to do so. Acreage of hemp in the former Soviet Union peaked at almost a million hectares in the early part of this century, but has declined to approximately 60,000 ha in the Ukraine and western parts of Russia. In 1992, the world's largest producers of hemp fibre were India (45,000 t) and China (24,000 t).

Hemp was a popular crop in Eastern and Central Canada throughout the 18th and 19th centuries. During the period 1923-1942 there was an extensive research effort by the Canada Department of Agriculture to test agronomic management, processing and some crop improvement at approximately 30 locations across Canada. A concise report on the trials including: seeding methods, date of planting, plant breeding efforts, harvesting methods and processing procedures is available. The hemp acreage in Canada decreased during this time period due to the high cost of production and because of strong competition by other fiber crops produced in the tropics.

In 1938 the Canadian government made the cultivation of *Cannabis sativa* illegal (through the Opium and Narcotics Act), although a small amount of production was allowed during the war years. In 1994, the first license in decades was granted for a low-THC hemp research plot in southern Ontario. This prompted the current research effort taking place in Alberta since 1995.

Materials and Methods

Varietal screening tests were done (1996-97) in Brooks (dryland and irrigated) and Gwynne (dryland). Precipitation at Brooks was 207 mm during the growing season; at Gwynne during the same period the rainfall was 658 mm. The trials were seeded as soon as the required research licenses were received from the Health Protection Branch of Health Canada. The Brooks trials were planted on June 12 and the Gwynne trials were seeded on May 16. Varieties tested included (by country of origin): Poland (Beniko, Bialobrezski), Ukraine (Zolotonosha lines, USO lines), Hungary (Kompolti, Unico), Romania (Irene, Lovrin 110, Secuieni) and France (Fedora 19, Felina 34, Futura 77).

Brooks. Plots were seeded into summerfallow which had received an application of 250 kg ha⁻¹ of 27-27-0 (broadcast and disced prior to seeding). Seeding rate was 75 kg ha⁻¹, except for certain low-rate (LR) treatments of 20 kg ha⁻¹. The plots were laid out in a RCBD design, testing eight cultivars obtained from various European countries. Plots consisted of 6 rows (18 cm interrow spacing) which were 6 m long. THC testing was done on all varieties by Meatherall Consulting (Winnipeg, Canada), using the protocol established by Health Canada.

Gwynne. Plots were seeded on cereal stubble which had been fertilized for an optimum canola crop. The seeding rate was applied at 20 and 40 kg ha⁻¹. The plots were laid out in a factorial RCBD which included two seeding rates and ten varieties. Plots consisted of 6 rows (23 cm interrow spacing) which were 6 m in length.

Harvesting at each location was done by hand using sharp knives at physiological maturity. Weights were taken and samples of stalk were dried in a forced air drier for moisture determination. Seed was hand-threshed, or run through a stationary small-plot combine. Selected small seed samples were selected for oil extraction and analysis. Analysis of variance was done using SAS, and LSD at the 95% probability level was used for mean separation.

The evaluation of the textile properties were done by determining the linear density of fibres. Common units of linear density are tex (weight in grams of 1,000 m of fiber) or denier (weight in

grams of 9,000 m of fiber). The tensile strength of single fibres 70 mm long is measured with an Instron Universal tester using a gauge length of 40 mm and test speed of 200 mm min⁻¹. The force (Newtons) needed to break each fiber is determined, as will as the extension (%) at break. The average tenacity (N tex⁻¹) of 25 fibers from each hemp sample was determined.

Results and Discussion

THC levels

The Health Canada regulations require that all hemp have a THC level of less than 0.3%. In 1996 THC levels were <0.05-0.30. In 1997, THC levels were <0.01-0.65%. The only variety above the required minimum was re-evaluated in 1998, since there were concerns about seed quality and purity of the cultivar in question.

Varietal evaluation-Gwynne

The Gwynne site (Table 1) had much higher productivity than Brooks. This was due to higher levels of precipitation and an extended period of warm weather. The total biomass ranged between 8.92-17.32 tonnes ha⁻¹. The low yield of Zolotonosha 24 was caused by poor germination which resulted in a reduced plant stand. Following 72 hours of drying at 100° C the moisture content was calculated to be approximately 57%. The significant difference in biomass yield between cultivars indicated that further screening may identify specific cultivars which are well-suited to Alberta conditions.

The seed yields at Gwynne ranged between 563-1341 kg ha⁻¹. This result was very interesting, because one goal of the trial was to investigate whether seed production was possible in Alberta. The results indicated that seed production was possible. The seed was harvested from only the upper portion of the stem (80 cm) to make harvesting and threshing easier. It is estimated that, averaged across all cultivars, the sampling method collected approximately 95% of total seed production.

Varietal evaluation-Brooks

The variety Kompolti produced the highest total above ground biomass yield both under irrigated and dryland conditions (Table 2). Plants seeded at higher rates and under irrigation, produced higher biomass yield than those plants seeded at the low seeding rate and under dryland, respectively. The total biomass yields ranged from 7-14 t ha⁻¹ of dry matter. The stalk yields from this total biomass ranged from 3400-7600 kg ha⁻¹. These yields are somewhat less than the higher biomass and stalk yields reported from Europe. This is, however, quite comparable to some European yields in spite of the hail damage suffered by the plants in mid-July. The difference between irrigated and dryland biomass yields were less than expected, possibly due to residual water available in the summerfallow for the dryland crop.

Most of the varieties matured early enough to produce viable seeds. The seed yield of these varieties are shown in Table 8. The irrigated plants yielded better than their dryland counterparts. Potential seed yields ranged from 216-1322 kg ha⁻¹ with Fedora 19, Zolotonosha 11 and

Zolotonosha 13 giving the highest yields. Kompolti which gave the highest biomass and stalk yield was the lowest seed yielder. Plants seeded at the lower rates appeared to yield better than those seeded at the higher seeding rates. Plants in the outside 'guard' rows yielded much higher than those plants in the inside rows indicating that the plants potential can be increased given more favourable growing conditions.

Oil Analysis

The hemp seed contains approximately 25-35% oil. Analysis of seed oil from the different varieties together with a typical canola oil is shown in Table 4. The predominant fatty acid was linoleic 54.6 - 56.1%, followed by linolenic 17.8 - 19.2 and oleic 11.8 - 12.8%. It is interesting to note that the oil also contains 1.5-2.2% of gamma linolenic acid. Only slight differences in oil composition was noted among the varieties. The high percentage (73.7 - 74.6%) of the polyunsaturated fatty acids (linoleic + linolenic) indicates a good, nutritious but unstable oil. This compares with canola oil that has high (55.6%) monounsaturated fatty acid in the oil. The presence of the gamma linolenic acid makes hemp oil even more nutritionally desirable. This fatty acid is the important component found in evening primrose and borage seed oils. The analysis also indicated high levels of various anti-oxidants, including tocopherols and sterols.

Fibre analysis

The hemp samples tested from Alberta grown hemp (Table 5) were evaluated for some of the primary characteristics associated with fibre quality. The tensile strength was measured to be 1.6 g d-tex⁻¹ at 33 days after planting, and reached an optimum (3.0 g d-tex⁻¹) at the August 7 measurement. This coincided with the time of flowering. As described in the literature, the tensile strength of the Alberta-grown fibre decreased following flowering. The parameters for hemp fibre were well within the range generally observed for hemp. The results indicated similar characteristics to flax fibre. The extension at break was lower than reported figures for cotton.

Can hemp compete with flax or cotton for fine textiles? There are many factors to consider, not the least of which is the cost and difficulty of processing the fibre into fine yarns. Considering only fiber properties, hemp is remarkably similar to flax, a fiber that is prized for many of its characteristics-its beautiful luster, light resistance, absorbency and dyeability.

Summary

The preliminary research reported here indicated that low-THC hemp can be produced in Alberta. Current European varieties are available that have acceptable levels of THC which are low enough to be acceptable for industrial purposes. Several varieties were identified as excellent seed or fibre lines. Lower seeding densities resulted in higher seed yields; higher planting rates resulted in greater fibre yields. The composition of the seed oil indicated a high level of polyunsaturated fatty acids, as well as high levels of anti-oxidants. Fibre testing indicated that the time of harvest will determine the quality of the fibre, and that hemp grown in Alberta has interesting fibre characteristics.

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Table 1. Total biomass, seed weight, individual plant weight and height of ten low-THC hemp cultivars grown at Gwynne, AB in 1997.

	Total biomass	Seed Weight	Plant weight	Height
Cultivar	(t ha ⁻¹)	(kg ha ⁻¹)	(g plant ⁻¹)	(cm)
Beniko	13.74	1016	70.6	22988
Irene	16.17	1169	50.1	22088
Lovrin 110	11.82	563	52.2	227
Secuieni	17.33	1341	72.1	233
USO 31	11.8	1024	59.7	203
USO 14	11.91	925	50.1	189
Zolotonosha15	15.97	1094	90.6	228
Zolotonosha 24	8.92	685	109.4	202
Zolotonosha 13	15.53	1070	60.2	201
Bialobrezeski	11.33	973	42.5	196
LSD (0.05)	3.62	511	26.9	32

Table 2. Total biomass and stalk yield of hemp varieties grown at Brooks in 1996.

Variety	Total biomass (t ha ⁻¹ dry matter)				Stalk yield	
	September 12		October 28		(Sept. 12, Irrig.)	
	Irrigated	Dryland	Irrigated	Dryland	% of total biomass	Dry matter (kg/ha)
Zolotonosha 11 (LR)*	7.3	7.4	9.0	8.4	46.9	3450
Zolotonosha 11	8.6	7.5	9.1	7.8	51.8	4469
Zolotonosha 13 (LR)	7.2	6.8	7.3	6.8	46.9	3368
Zolotonosha 13	8.4	7.9	10.4	7.7	50.9	4271
Kompolti (LR)	11.5	8.8	11.9	10.8	66.7	7648
Kompolti	11.2	9.3	14.1	12.1	68.3	7616
Beniko	9.4	8.4	7.1	8.4	51.1	4787
Fedora 19	9.0	8.7	8.8	9.2	53.1	4767
Felina 34	9.8	8.4	7.8	8.0	51.9	5077
Futura 77	10.1	8.9	10.5	9.4	60.6	6145
Unico	10.2	-	7.8		63.4	6448
Mean	9.3	8.2	9.4	8.8	55.6	
LSD .05	2.2	1.5	4.2	2.6	3.7	
C.V. (%)	13.9	10.4	26.5	17.0	3.9	

* LR means Low Rate of seeding

Table 3. Seed yield (kg ha⁻¹) of different hemp varieties grown at Brooks in 1996.

Variety	Samples harvested from inside rows with borders		Samples harvested from outside guard rows	
	Irrigated	Dryland	Irrigated	Dryland
Zolotonosha 11 (LR)*	1326	750	1339	1417
Zolotonosha 11	1186	694	1470	1301
Zolotonosha 13 (LR)	1322	801	1593	1741
Zolotonosha 13	988	834	1591	1556
Kompolti (LR)	216	377	475	441
Kompolti	347	329	647	750
Beniko	787	685	2170	1670
Fedora 19	1491	1145	2900	2676
Felina 34	890	1066	2123	2762
Futura 77	863	848	2235	2155
Unico	596	-	1130	-
Mean	910	753	1607	1647
LSD .05	467	369	634	1030
C.V. (%)	30.1	28.6	23.1	36.5

*LR means Low Rate of seeding

Table 4. Fatty acid composition of the seed oil of different hemp varieties grown at Brooks in 1996.

Fatty Acid	Variety						Typical canola*
	Felina 34	Beniko	Fedora 19	Futura 77	Zolotonosh a 11(LR)	Zolotonosh a 13(LR)	
	- Percent -						
Palmitic (16:0)	5.4	5.5	5.5	5.6	5.4	5.6	3.2
Palmitoleic (16:1)	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Stearic (18:0)	2.8	2.8	2.8	3.1	2.9	2.9	1.2
Oleic (18:1)	11.8	12.2	12.0	12.8	12.1	12.2	55.6
Linoleic (18:2)	56.1	56.4	56.1	54.6	55.6	55.6	21.7
Gamma Linolenic (γ 18:3)	2.1	2.1	2.0	1.5	2.2	2.2	-
Linolenic (α18:3)	18.5	17.8	18.1	19.2	18.4	18.1	12.9
Arachidic (20:0)	0.8	0.8	0.8	0.8	0.4	0.8	0.6
Eicosenic (20:1)	0.4	0.4	0.4	0.4	0.4	0.4	2.2
Behenic (22:0)	0.3	0.3	0.3	0.6	0.3	0.3	0.3
Lignoceric (24:0)	0.2	0.2	0.2	0.2	0.2	0.2	0.4
Others	1.4	1.3	1.6	1.3	1.5	1.5	-
Erucic	-	-	-	-	-	-	1.5

* Data obtained from Dr. Terry Rachuk, Canadian Agra Foods Inc., Nisku, Alberta.

Table 5. Fibre yield, tex, tenacity and breaking extension of Kompolti hemp.

Retting time (d)	Fibre yield (%)	Tex (g/km)	Tenacity (cN tx-1)	Extension at break (%)
4	30	4	31 +/- 5	2.7
4	31	4	41 +/- 9	2.4
5	27	3	40 +/- 9	0.8
5	17	3	40 +/- 6	2.2

Fenugreek: New Fodder Crop for the Prairies?

Surya N. Acharya
Forage Breeder
Agriculture and Agri-Food Canada
P.O. Box 3000
Lethbridge AB Canada T1J 4B1

Why Fenugreek?

- ▶ An Annual legume - for short rotations
- ▶ Adapted to dryland conditions of western Canada
- ▶ Known for medicinal qualities
- ▶ Produces high quality forage independent of maturity

Nutrient composition, diosgenin (dios) and IVDMD of fenugreek and alfalfa (% of DM)

	<u>Age of plants (wk)</u>			<u>Alfalfa</u>
	9	15	19	(early bloom)
CP	25	20	16	18
NDF	29	37	39	44
ADF	25	31	34	36
Lignin	5	6	6	8
Ash	13	10	9	9
Dios	.15	.06	.06	ND
IVDMD	64	67	66	59

The presence of steroidal compounds such as diosgenin in addition to high quality at late stages of maturity makes it interesting for the cattle industry.

Problems with Fenugreek?

- ▶ New crop
  - Unknown cultural practices
  - No forage cultivars
  - Unknown effect on animal productivity

Fenugreek Research Objectives:

Develop an agronomic package for optimum forage production in western Canada

Compare forage production and quality with other legumes

Forage Yield: Lethbridge Irrigation

	2 Year Mean (t DM ha ⁻¹)	
	80 seeds/m ²	40 seeds/m ²
Fenugreek	6.6	5.4
Field Pea	5.5	4.0

Forage Yield: Lethbridge Dryland

	2 Year Mean (t DM ha ⁻¹)	
	80 seeds/m ²	40 seeds/m ²
Fenugreek	3.3	3.3
Field Pea	3.3	3.0

Forage Yield: 3 Alberta dryland locations

	Lethbridge	Claresholm	Vegreville
t DM ha ⁻¹	4.4	3.5	3.4

Forage yield @ seeding date & rate (Leth. Irrigation 97 & 98)

Herbicide action

Herbicide	Rate (ai/ha)	Tolerance	Control
Edge	0.85 - 1.0 kg	excellent	grasses, some broadleaf
Treflan	0.85 - 1.0 kg	excellent	poor volunteer cereal
Pursuit + surfactant	50 g	initial injury	broadleaf
Odyssey + surfactant	20 - 30 g	initial injury	grasses, broadleaf

Forage yield potential

Introductions	kg DM/ha
PI577713	13,911
L3058	13,463
L3002	12,056
PI174393	11,379
L3111	11,254
PI1203474	109
*one year progeny row data	

Forage quality: Fenugreek and Field Peas

Effect of feeding alfalfa & fenugreek silage on growth weight of backgrounding steers

What do we know about Fenugreek?

- ▶ Has potential for high forage yield
- ▶ Responds well to irrigation
- ▶ Seed early for higher yields
- ▶ Use at least 80 seeds m⁻²
- ▶ High quality forage all summer
- ▶ Does not cause bloat

Although we started with a ?

Fenugreek: New fodder crop for the prairies?

We have seen enough evidence to say

Fenugreek: A new fodder crop for the prairies.

Medicinal Plants of the Prairies

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There are ten crops with potential for the future on the prairies. These include:

Black Cohosh (*Cimifuga racemosa*) may be one of the most important herbs for menstrual and female hormone issues. With growing concern over the safety and ecological considerations regarding synthetic hormones; and with an aging baby boomer generation, this herb could well be one of the most sought after in the next millennium.

The dried root does not compare to the fresh in terms of potency. It also is extremely important for a variety of "whiplash", fibro-myalgia and other nerve muscle oriented conditions. The plant is perennial.

Sea Buckthorn (*Hippophae rhamnoides*) has been spoken of before; but again, this is a plant of the future. The berries are one of the richest natural sources of Vitamins A, C and E, as well as glutathione. What this means is that the fruit is a powerful anti-oxidant, and free radical quencher. Glutathione possesses the ability to make fat soluble toxins, water soluble, so they can be excreted via the kidney system. The plant is both salt and drought resistant, and new spineless varieties developed in Saskatchewan make this a good future investment. Remember this shrub/tree can be

used as part of shelter belts, fence lines and perimeters of other herbal plants as a windbreak, and attractant of birds that eat insects.

Lomatium (*L. dissectum*) is a familiar perennial to the coulees and valley of the southern prairies. It is one of the most valuable anti-viral medicines we have. In studies it has shown varying degrees of inhibition of 62 species of bacteria and fungi, including shigilla, staph, strep, and candida albicans. It has been shown highly effective against both DNA and RNA viruses. Chronic viral infections such as HIV, chronic fatigue syndrome, Herpes simplex 1 and 11; as well as a host of other immune compromising infections will all require more and more attention in the next millennium. Lomatium is presently wildcrafted, but has been successfully propagated by warm, cold and then warm seed stratification. Plant one foot apart. Fresh, mature roots are preferred.

Milk Thistle seed (*Silybum marianum*) is one of the top five herbal products in Germany; and making rapid gains on the market in North America. This is because the seeds not only are a powerful detoxifier of the liver, but they actually help to increase the growth of healthy new liver cells. It is used in conditions of hepatitis, and cirrhosis; as well as health concerns regarding heavy metals, mushroom poisoning, industrial solvent work environments. Many district agriculturist would appreciate a honest, well proposed discussion with regards to deliberate thistle planting and management. However, it is one of the most important herbs of the next decade, and will only increase in demand. It is an overwintering annual.

Purslane (*Portulaca oleracea*) is a hardy, self sowing annual. that is extremely high in vitamin and mineral content. It is also one of the only plant rich in Omega 3 fatty acids. All together, this plant is an extremely good choice for spray drying for the next generation of green drinks. Will survive on dry soil, but absolutely thrives on twice weekly deep watering. This is a plant that you would want to contract out, or have ready market; detailing final product. It also juices and freezes well.

Astragalus (*A. membranaceus*) root is a perennial vetch, but a valuable medicinal one. The roots contain valuable polysaccharides that enhance the immune system. It is particularly useful in protecting the body from the deleterious effects of chemotherapy and radiation; without interfering in the anti-cancer regime. The seeds germinate in 3-10 days in full sun; and the plant is incredibly drought and poor soil tolerant. Like native vetches, it is aggressive, growing up to four feet, planted one foot apart. Its future value comes from fresh, organic roots that have not been fungicided, nor fumigated like the present inexpensive Chinese product.

Puncture Vine (*Tribulus terrestris*) is a vining annual with extremely dangerous seed pods. They will puncture bicycle tires, and hence the common name. However, if the valuable pods are harvested before dropping off, it can be a valuable plant. It is used mainly today for its testosteronic influence. In many human studies out of Bulgaria, it has been shown to increase body levels of testosterone by 30% in as little as a week. More exciting, it will not cause the side effects common to anabolic steroid use. Organic puncture vine seed and pods are virtually unavailable in North America- first one out of the chute will have a ready market.

And finally, more for information, **Canaryseed (*Phalaris canariensis*)**. The present haired seed contains almost 100% pure silica. With some cooperation and research at the University, it may well be that a market could be created for this left over plant material. It certainly would be a boon to those who have piles of canaryseed husks now going to waste. The reason is simple. Organic silica is a huge health market product. All at present is water extracted from Horsetail. While this is a very valuable product, the Canadian government has trouble with any horsetail product containing thiaminase; which canary hull does not. And as it is virtually a waste product at present, why not investigate?

Organic silica plays a major role in cardiovascular and connective tissue health, keeping us flexible and increasing elasticity. It plays a major role in osteoporosis and osteoarthritic health, as well as skin, hair and nails.

Robert Dale Rogers is a well known herbalist with thirty years experience in medicinal plants of the prairies. His two volume book Sundew Moonwort, Medicinal Plants of the Prairies is a valuable resource to those seeking good, reliable information about the plants- both introduced and native- at live around us.

Agriculture and Food Council, Growing Alberta

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History

1992/93	“Creating Tomorrow” industry consultations and workshops
1994	Agriculture and Food Council incorporated - Societies Act
1995	Value-added leadership Conference “Growing Alberta” awareness program launched
1997	Leaders Challenge Conference; Vision and Goals refined Canada appoints Council to manage \$9.5 MM CARD Fund Alberta appoints Council to manage “Growing Alberta” Office established in Leduc Strategic directions refined

Vision

Growing Alberta

- Accelerating global competitiveness in Food, Agriculture and Agri-business

Goals

- ▶ To increase Alberta's share of world food, agriculture and agri-business markets
- ▶ To improve sustainable resource and environmental management
- ▶ To expand the vision , competency and quality of life of people in industry

Industry Driven

- ▶ 25 elected Council members, 3-year term
- ▶ 6-7 new members to be elected annually
- ▶ Representation;
producers, processors, marketers, academia

Key Council Roles

- ▶ Strategic Leader of Agri-industry
- ▶ Conveners of Common Interests
facilitate creation of stakeholders alliances
- ▶ Catalysts for Action
identify opportunities and accelerate implementation
- ▶ Advocates for Agri-industry
influence policy direction of government
- ▶ Fiscal Agent
non-government organization program delivery

Strategic Initiatives

- ▶ Seven Action Teams
Council chairs and industry representatives
  - CARDF Review Team
  - Growing Alberta
  - Value Chains
  - Attract Capital
  - Leader's Challenge
  - Think Tank
  - Communications
- ▶ Post 1999 Government Programs
Facilitating industry consultations in Alberta

Canadian Adaptation and Rural Development Fund (CARDF)

Management

- ▶ Agriculture Canada elects Council as Alberta CARDF manager January 18, 1997

Investment

- ▶ \$9.55 million fund
- ▶ \$5.7 million committed to date leveraging \$12.6 million other investments

Deadlines

- ▶ March 31, 1999
deadline for assistance offered to applicants
- ▶ March 31, 2000
deadline for all funds to be spent by applicants

Benefits

- ▶ Initiatives supported are to provide broad industry benefits vs. benefits to single applicants

Eligibility

- ▶ Private sector companies conducting commercial profit activities are not eligible
- ▶ Individuals, corporations, associations, communities and governments are eligible to apply

Program Priorities

- ▶ Environmental Sustainability
- ▶ Technical and Marketing Skills
- ▶ Capital Availability
- ▶ Innovation and Technological Advancement
- ▶ Value Chains
- ▶ Rural Economic Development
- ▶ Safe, Healthy Food and Fibre Products
- ▶ Develop Vision and Competency of People in the Industry

Approved Initiatives

Recipient	Purpose	Funding
Alberta Conservation Tillage Society	▶ "Reduced Tillage Initiative" ▶ "Sustainable Cropping Research Foundation"	\$1,000,000
Olds College	Center of Excellence development and delivery of specialty farming training seminars	\$250,000
Alberta Sheep Wool Commission	▶ Study to establish sheep flock health program	\$40,000
Alberta Ostrich Products Ltd.	▶ New product development and market feasibility study	\$15,000
Alberta Pulse Growers Association	▶ Extension and communication materials	\$39,000
University of Alberta Faculty of Agriculture	▶ Manure management research	\$23,000
Alberta Agriculture Research Institute	▶ Value-Added Technology Transfer Program	\$450,000
Agricultural Value-Added Engineering Centre	▶ Engineering support for the value-added processing industry	\$951,000
Alberta Foundation for Animal Care	▶ 2-year public communication program "Farmers Care"	\$68,000

Council Led Initiatives

- ▶ Capital availability and access study
Inventory of financing sources and government programs for Agri-industry (resource guide)
- ▶ Human resource strategy and action plan for Agri-industry to year 2005
Phase 1 (underway) involves issue clarification, knowledge gathering and presentation to stakeholders
- ▶ Value Chain development
"Co-operating to Compete"; a Phase 1 project: to collect a body of knowledge, identify processes and develop a strategy to accelerate value chain development

AVAC Corporation - Stimulating the Growth of Alberta Agri-business

Bruce W. Healy
AVAC Ltd
Calgary AB Canada

AVAC's Mandate - to be a catalyst in growing Alberta's agri-value-added sector to \$20 Billion

What AVAC is

Provider of:

- ▶ Off balance sheet financing for specific pre-commercialization agri-value-added projects; contingent royalty return calculated as a percentage of future revenues.
- ▶ Mentoring, networking and other collaborative services designed to enhance the potential success of a project.

What AVAC is not

- ▶ Government granting agency; AVAC is a private corporation with private sector based Board of Directors.
- ▶ Venture Capital firm - we do not make equity investments.
- ▶ Lending institution
- ▶ PURPOSE IS TO FILL FINANCING GAP BETWEEN BASIC RESEARCH AND ESTABLISHED COMMERCIAL OPERATIONS

What is agri-value-added?

Any activity that increases the value of a primary agricultural commodity to downstream customers

Opportunities for value-added application of Special Crops

- ▶ New and enhanced food products - ie: legumes, oilseeds
- ▶ Fibre products - ie: hemp, flax
- ▶ Industrial Products - ie: essential oils, cosmetics
- ▶ Medicinal products - ie: ginseng, echinacea

What specific special crop activities will AVAC support?

- ▶ Pure Primary Production activities - NO
- ▶ Generic development of new seed varieties - NO
- ▶ Either of above where activity is precipitated by a specific need of a downstream customer - YES
- ▶ New innovative secondary processing - YES

Eligible uses of proceeds

- ▶ R & D for new or enhanced products
- ▶ Market feasibility studies, business plans
- ▶ Prototype development, beta testing
- ▶ Regulatory approvals

Eligible costs include labour, materials and pre-production equipment

Special Crops - a unique opportunity for new value-added applications

- ▶ Further along the value chain than traditional commodity crops

The Challenge

- ▶ Let's work together to identify and address these opportunities

Agricultural Value-Added Engineering Centre - A New Resource

John Chang

Program Manager

Rm. 201 7000 - 113 Street

Edmonton AB Canada T6H 5T6

Phone: 780-427-8764

Fax: 780-422-7755

e-mail: bonnie.weber@agric.gov.ab.ca

[Http://www.agric.gov.ab.ca/navigation/engineering/processing/index.html](http://www.agric.gov.ab.ca/navigation/engineering/processing/index.html)

Goal

- ▶ Promote the competitiveness and growth of Alberta's agricultural value-added processing industry (food and non-food sectors) by providing engineering support
- ▶ Funded by the Canadian Adaptation and Rural Development Fund (CARDf)
- ▶ Complements other programs & services

AVEC Research Centre

- ▶ located at the Ellerslie Research Station of the University of Alberta, Edmonton

AVEC Resource Centre

- ▶ located in the J.G. O'Donoghue Building, Edmonton

Financial Assistance for co-funding eligible projects, up to \$20,000 per project

AVEC Research Centre

- conducts in-house projects
- collaborative projects and activities
- contract research projects
- Resident Engineers: Dr. Lope Tabil, Hong Qi
- Technical support: Victor Dyck, Ryan White

Co-ordinated by: Kris Chawla

AVEC'S Resource Centre can provide information and assistance on

- processing technologies and systems
- processing machinery and equipment
- standards and regulations on processing
- planning a processing operation or plant
- consultants & other service providers

Co-ordinated by: John Kienholz

Financial Assistance Program

- provides engineering support for the development and adoption of innovative technologies, systems and facilities
- support available to companies, organizations or individuals on a cost-shared basis, up to \$20,000 per project

Co-ordinated by: Marshall Eliason

Engineering Staff: John Chang, Marshall Eliason, Kris Chawla, John Kienholz, Lope Tabil, Hong Qi

Administration: Bonnie Weber, Brenda Gregor

Contract Staff: Ike Edeogu

Research Tech. Support: Victor Dyck, Ryan White

Technical Support: Joanna Fyck, Dave Scott

Summer Staff, 1998: K. Berg, R. Govindasamy, J. Gallinger

- Projects: over 30 at various stages
- Clients counseled: over 105 from June 1997 to August 1998
- Membership: 8 professional associations, technical committees & boards
- Staff participates in professional & technical programs and activities

Research Projects

- Determining properties of special crops
- Reducing sugar loss during storage of sugar beets
- Drying and storage characteristics of *Echinacea* roots
- Utilization of hemp for building panels
- Distillation unit for essential oils

Sugar Beets

- Investigate beet storage conditions to maximize the benefits of ventilation, and reduce capital and operating costs
- Determine the physical properties of sugar beets for improving handling and storage
- Measure changes in beets under controlled temperature storage conditions
- Study the ventilation of sugar beets - air flow rates, pressure drops, effect of soil on the beets
- In co-operation with: Rogers Sugar Ltd, CDC-South

Echinacea

- Determine the drying characteristics and the effect of drying temperature on the echinacosides content of echinacea roots
- Determine safe storage conditions for dried echinacea roots (3 R.H. levels)
- Microbial assessment of dried roots
- In co-operation with: AAFRD - CDC North & CDC South, and Food Quality Lab; AFNS- University of Alberta

Acknowledgments

Thanks to the Agriculture & Food Council for their tremendous support of the AVEC program. Our gratitude to the University of Alberta for their assistance

Please contact us if we can be of assistance

Assessing the Feasibility of Your New Venture

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There are many so different special crops to consider (i.e. field scale crops, essential oils, culinary herb market, medicinal herbs, wildcraft herbs). How can you tell which option is the best one for you?

I challenge you to think of the special crop ideas you have and to do a feasibility assessment and analysis on each one *before* you spend a large amount of time, energy and money on your new venture.

Before Writing Your Business Plan

A business plan is the road map that helps you decide where you want to go with your business over the next few years. The parts of the business plan are : executive summary, business description, industry analysis, market analysis, marketing plan, management/operations, and financials. Putting your goals and thoughts down in writing helps you clearly focus and shape the future of your venture. It's also necessary to have a clear and concise business plan if you are looking for any kind of financing.

Before you even begin to write a business plan, you need to make a realistic assessment of the different venture options you are considering. A feasibility assessment helps you answer the question, "Is this business likely to succeed?" There are no right or wrong answers. Most of the information you collect will be used in your business plan later. Consider keeping a file for each section of the business plan so you can keep the information you collect along the way organized and easy to access. This will make it easier to fit the pieces together later when you prepare your business plan.

Good Feasibility Planning will help:

1. Identify enterprise alternatives
2. Accurately predict the physical/financial outcomes
3. Allow a thorough examination of the option without unnecessary risk
4. Answer the question: "Will the returns for the change justify the investment needed?"

Feasibility Assessment Steps

1. Define the opportunity or challenge. For example, ask yourself: "Is the problem that I need more production on my land or is it that I need more income during certain times of the year?"
2. Develop a list of options to address the problem.
  - a. *Consider personal and family goals.* These are the non-monetary needs. Are you looking for employment for your children or for some additional income. Are you willing to make sacrifices in family time and income during the start-up phase? Your personal preferences and needs could reflect your tolerance to risk, the type of work you prefer to do or if you like managing employees.
  - b. *What resources do you already have?* Consider the physical resources you already own, such as machinery, equipment, buildings, availability of water or good access to the highway. Under-utilized facilities in the area to lease and/or purchase may become important to you if you are considering processing.

Think about the management and labor resources you already have access to. You and your family may be interested in or good at the technical aspects of the business, the financials or management. Be aware that we can't be experts at everything. It will become clear what parts of the business you may need to hire the skills for.

Also consider financial resources you already have including savings, asset equity, credit risk, government loans/funding available, and potential equity partners.

3. After assessing your current resources, see if there are any combinations of skills, markets and under-utilized resources that could create a new business opportunity? These kinds of opportunities should be considered first because you already own them and there should be no increase in fixed costs.

Consider making an evaluation chart to rate each of your ideas in the following categories on a scale of one to ten:

- ▶ can the family financial resources cover the start-up costs?
- ▶ is the commodity preferred by the family?
- ▶ does the venture make use of underutilized resources?
- ▶ does the venture have market potential?
- ▶ does the venture use under-utilized management and labor?

Once you have prioritized the alternatives/options, you are ready to select the one or two ideas that warrant further study through a feasibility analysis.

Feasibility Analysis Steps

1. Market analysis (Will it Sell?)
2. Technical Analysis (Can it be Done?)
3. Profitability/Sensitivity analysis (What If Questions)
4. Financial Considerations (Can you Afford it?)

1. Market Analysis

Non-traditional crops usually have no established markets or have an invisible marketing infrastructure. They require more up-front planning, research and personal commitment. Usually there are no real established markets for special crops, therefore it is very important to do the market research before you start production of your crop.

Having a *market focus* vs. a *production focus* to your market analysis questions lets you see the production cycle in terms of what the end user/final buyer wants. This also helps you to make long and short term production decisions based on analysis of the marketplace. Asking market focused questions concentrates on the needs and desires of the end user. These kind of questions helps you to select varieties for a specific market, research new markets and avoid fads but recognize trends. It also helps you to add value to your products so they fit the customer's requests.

Examples of production focused questions:

- ▶ Is it a perennial or annual plant?
- ▶ Susceptible to insect/diseases?
- ▶ What kind of soil does it grow best in?
- ▶ What is the expected yield?

Examples of market focused questions to ask the end-user:

- ▶ How large is the market?
- ▶ What price will the end-user pay?
- ▶ What is the end-user's preferred variety?
- ▶ When does the customer want the product?
- ▶ Who are the competitors?
- ▶ What are the costs of marketing/distribution (hidden costs, customs, brokerage fees, duties, tariffs, freight, storage)

Start to do your homework with market research. Doing this legwork will help you find the niche that best suits your operation.

Think of the 5 Ws: Who , What , When, Where and Why.

Who will buy how much of your product?

Where is the market located? Consider what type of fresh products local restaurants, hotels, institutions want.

What is the market size? The medicinal market may be high management, small acreage or plot crops that fit into narrow niche-markets.

When and where do they buy? Are brokers, agents or processors looking for specific products to sell into a wider marketplace?

What are the product specifications of the buyer? Get a clear idea of what the buyers want. I.e. for the medicinal market, what is currently selling in health food stores? Specifications of the buyer may include quality, cleanliness, color, aroma and flavor of the product.

What will it cost to produce the crop?

What is the retail/wholesale price?

How much do prices fluctuate?

Is the market mature? Growing? Room for more production?

What regulations must I comply with if the product is exported?

Are there any value-added opportunities?

Types of Markets

1. Filling a market need (demand pull). This is the most accessible way to market a new crop, but caution is needed. What if the traditional production gets back to full production? Can you maintain a market share when the traditional suppliers can't meet demand? Can you still be competitive in a lower priced market?
2. Established market. Having superior quality can also mean service to market is faster, you have a better distribution system and exceptional quality control.
3. Creating a "new" market. (Technology push) This is a long and difficult process to gain buyer acceptance. There is a high failure rate, BUT has the greatest return if the product is successful.

Marketing Errors

- ▶ If the end-user doesn't want it, it won't sell. Consumers are usually reluctant to switch, unless there is a clear benefit for them to do so.
- ▶ Bad timing or having a "me-too" product. If you are late in the market and do not have a substantially superior or differentiated product, you will be at a major competitive disadvantage!
- ▶ Inadequate market research. Does your product fill a market need? Has there been a realistic assessment of how much time, management expertise or financial resources are required in production and marketing of the crop?
- ▶ Lack of commitment. Consider following the 4 Ps of business success:
  - presence,
  - patience,
  - persistence,
  - and performance.
- ▶ Lack of clear benefit to the end user. Ask yourself: "What is in it for the end-user?" It is important to know the difference between a benefit and a feature. For example, in a vehicle, the airbag is the feature and the benefit to the end-user is a safer car.
- ▶ Poor positioning. Do you have a "cocktail party line" where you can describe your product or business succinctly in 30 seconds or less? What is unique about your product? Why would the competition buy from you rather than the competition?

2. Technical (production) analysis

Ask yourself if the production and marketing of the new crop takes time and resources away from other profitable crops you currently produce? Adopt a crawl-walk-run approach. Start small with a test plot to learn the tricks of the trade along the way and to maintain high quality.

3. Profitability Analysis

Consider all the costs involved. (Raw materials, capital expenditures, delivery, administration). Can you prepare projected statements for at least 3 years? When doing a sensitivity analysis, ask yourself the “what if” questions. What if you had to pay \$1.00 more on labor per hour? How would that affect your bottom line? Also do a break-even analysis. This shows the point there is no profit or loss.

4. Financial Analysis

The financial analysis includes the income statement (relates revenue to expenses), the balance sheet (the equity in the business) and cashflow (the cash inflow and outflow). The outcome of your financial analysis will be the acid test to determining the feasibility of your new venture. Speak to a Farm Management Specialist or a Rural Development Specialist-Business if you need more assistance with the financial analysis.

Working through these 4 types of analysis will help you realistically determine the feasibility of your new venture.

In summary

- ▶ Be prepared to spend one year on intensive market research before producing the product or growing the crop.
- ▶ Ask market-focused questions.
- ▶ Start small...maintain quality control
- ▶ Have a clearly defined market.
- ▶ Network. Establish personal contact with buyers and processors. Attend more conferences and meetings like this. Find the niche market that best suits your operation.
- ▶ Expect to spend more time marketing the crop than producing it.
- ▶ Expect higher labor costs than traditional cereal crops.
- ▶ Understand the level of value-added processing the market requires
- ▶ Objectively and thoroughly assess the marketing, production, management and economic “fit” the enterprise has with your personal situation.
- ▶ Consider the 4 P’s of success: presence, patience, persistence and performance

For More Information...

Contact your local Alberta Agriculture, Food and Rural Development District Office by dialing 310-0000 and ask to be connected to the Extension Specialists closet to you:

- ▶ Special Crops
- ▶ Farm Management
- ▶ Rural Development - Business (see the attached brochure)
- ▶ Market
- ▶ Agri-Food Development

Other good contacts with AAFRD: Crop Development Centre North/South, the Food Processing Development Centre, Processing Industry Division or the Agri-Food Development

Branch. A good federal government contact is the Agri-Food Trade Service (Agriculture and Agri-food Canada) at (780) 495-2119. Other contacts to consider are researchers, associations, processors and buyers.

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Closing Remarks

Don Macyk
Director, Plant Industry Division
Alberta Agriculture, Food and Rural Development
Edmonton AB

After listening to some of our opening presentations yesterday, I thought the conference should have been titled 'from buckwheat to viagra'.

This has been a truly special conference - special in many ways:

- ▶ This conference reflects the emerging diversity in our agriculture and food industry.
- ▶ It has been about 10 years since the first special crops conference in Lethbridge where we talked about special crops ranging from mustard to peas and beans to forage seeds to corn.

- ▶ Our conference 3 years ago broadened that base as essential oils and the rapid emergence of the pea industry were added to the agenda
- ▶ Today's conference reflects the truly diverse nature of this area of endeavor in our Agri-food industry - and includes plant extracts for food and medicinal purposes, amenity and non-food crop kinds and uses, vegetable crops, and species not yet explored fully for their value.
- ▶ This conference reflects the special and diverse business and working relationships among farm, agricultural supply, processing and marketing distribution businesses.
- ▶ And this conference shows what it takes by way of research, extension, trial and error, testing and evaluation and networking to make it happen.

There are always a few things you take home from a conference that won't be recorded in the proceedings but are nonetheless valuable, useful and memorable.

- ▶ Like Ernest Small's depiction of the evolution of an idea or new crop - how imagination blended with foresight and commitment results in a successful new idea quickly copied and sometimes soon unprofitable. That we can become so successful that we can come to dominate a market in a decade, in areas such as lentils or peas in Western Canada.
- ▶ That it takes champions, leadership, often single minded determination, grit and talent to get a new crop going.
- ▶ That we must look beyond the rich diversity which we have even today to new areas some where the market signals are still weak, some where they are stronger - whether grass peas, new species to sustain water fowl and habitat, new amenity grasses, and nursery products, small fruit, organic and identity preserved protocols, new vegetable crops, nontraditional uses of basic crop kinds and the growth of crops for specific plant based active ingredients from canola producing hirudin to plant based estrogens and yes now even plant based testosterone.
- ▶ We heard that we are often one year late in responding to market signals - that this years high prices give way to next years low prices or market crisis - I'm sure it's not quite that simple but that high prices cure high prices and low prices cure low prices is a pretty sure old market proverb that any market analysts is sure to share .....they just won't tell you when it will happen.
- ▶ That in this business - we are almost always on the steep part of the learning curve - we must want to be life-long learners to succeed.
- ▶ That research has its success stories and it's failures - and that we can often learn as much or more from the failures - and that accidental success - can be very outstanding .....
- ▶ That many of our diversification efforts require a solid value chain from research bench to marketplace to succeed.

The goal of the conference has been to offer a practical base of information and knowledge to farmers, Agri-business, processors, marketers looking for ideas, innovations, business opportunities - in casual, social and workshop environment - my impression is that your participation, enthusiasm and contact with others has also been a valuable outcome - and that in all senses the conference has been very successful.

While recognition and thanks have been offered, I would like to recognize again all those who made a valuable contribution.

- ▶ Thank you Special Crops Product Team - for superb conference organization and delivery
- ▶ Thank you to those who made the Special Crops Product Team look good by contributing their time and talents to take care of all of the details that make all of the difference - these folks and a few more I'm sure are listed on page 6 of your program.
- ▶ Thank you to all of our sponsors, to those who set-up displays and posters - you have added a significant dimension to this conference.
- ▶ Thank you to all speakers and workshop presenters - without exception, interesting vital presentations, well delivered.
- ▶ And thank you to our chairpersons for quality sessions well introduced and thanked.

This past two days has brought together people with ideas, knowledge, experience and a common sense of what it takes to build a business, to make a contribution to something new, exciting and of lasting value.

This whole area of special crops and diversification represents a positive valuable part of our agriculture and food industry - and it represents opportunity but I think it's even more that... as I travel this province regularly from Ft. Vermilion to Milk River I see the research trials of new and old crop kinds in every corner of the province.

I see new business ventures such as processors and greenhouses, and new crops beside our traditional grains and oilseeds - a couple of years ago, I raised a few eyebrows by using a favorable set of statistics to point out that our efforts at diversification on the crop side resulted in a larger industry than either hogs or dairy - and that the potential was just as great for the future - the major difference is that this area is attracting more new businesses and farmers, and is spread throughout the province - it is an opportunity area to use management skills, knowledge, and a bit of sweat equity - not just capital and economics of scale - to build new businesses - there are new farm enterprises who are a successful business by doing commercially what was until recently a lab procedure - tissue culture/micropropagation. The greenhouse industry has doubled in the past several years and is producing new vegetable and flower crop kinds and is testing medicinal plants types and agro-forestry. Sugar-beets and potatoes are doubling; pulse crops growth continues, spices, essential oils continue to forge their place, sunflowers, safflower, herbs, hemp, trees for fibre and amenity and forage seeds for turf and forage, hullless oats and barley, triticale, field horticulture crops, small fruit, new vegetable kinds, field grown flowers and dry flowers - many of these are successful enterprises on their own, some are sideline enterprises for current farm businesses and some are the first step for someone new entering the agriculture and food industry.

This success is born of enterprise, entrepreneurial skills, commitment, vision, tenacity, trial and error, management skills, curiosity, willingness to take a risk and the ability, to develop partnerships and alliances to create the necessary resources and knowledge..... you have seen ample evidence of the many players who are prepared to help realize the commercial

opportunities, the Agriculture and Food Council , AVAC, AVEC, Research Organizations and Agri-business.

On behalf of Alberta Agriculture, Food and Rural Development, I want to assure you that our commitment from all staff in all areas is to work with you in both traditional time honored ways and in Not so traditional ways - employing whatever resources, energies knowledge and skills we may offer as an organization to help you realize the opportunities you see, the visions we may share together.

Abstracts

Approaches to Genetic Improvement of Perennial Cereal Rye - A New Forage Crop

Perennial cereal rye (PC rye) is a high yielding cereal forage crop with considerable potential for both silage and pasture. However, the interspecific origin of PC rye (*Secale cereale* x *S. montanum*, backcrossed to *S. cereale*) contributes to irregular chromosome pairing at meiosis and reduced seed head fertility.

To improve fertility and agronomic traits in this crop, approximately 300 plants with a normal tetraploid chromosome number ($2n=4x=28$) were selected. These plants displayed winter habit and a vernalization procedure was developed to induce flowering. Another culture is now being used to produce PC rye haploids ($2x$). Doubling the chromosome number of these haploids may result in improved chromosome pairing and fertility.

In addition, although PC rye is largely open pollinated, a few plants with above average self fertility have been identified. These plants may be useful in developing self-pollinated lines of PC rye.

For more information contact: S.N. Acharya (B.R. Orshinsky)
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Where Have All The Peas Gone? Updating The Risk Management Toolbox

Field pea production is a complicated process that can be derailed at numerous points of the decision making process.

Direct seeding, inoculants, row spacing, seeding rate and time of weed removal are factors that have been studied alone and in combinations at Lacombe, Beaverlodge and Fort Vermilion. Some of these factors can have a major impact on field pea production.

Yield increases of 0 - 140 per cent or 20 - 40 bushels per acre have been documented for some combinations of these factors. The art and science of combining these factors for consistent yields and reducing the risk of growing field peas will be discussed in the poster.

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Special Crops For The Peace

A special crops trial was established on Alberta Agriculture's Research farm near Fairview AB to evaluate their potential as a crop for the Peace River Region of Alberta.

Forty-five different annual & perennial special crops were established from transplants or seed on May 26, 1998 on a clay-loam soil. Crops in the trial include skullcap, tansy, valerian, english, french and basil, thyme, greek oregano, rosemary, lemon grass, sweet fennel, feverfew, burdock, blessed thistle, borage, buckwheat, coriander, caraway, canaryseed, lupines, lathyrus, sunola, sunwheat, french marigold, common marjoram, curled mallow, calendula, St. John's wort, summer savory, lovage, lime, sweet, anise and Thai basil, lemon bergamot, curled dock, elecampane, evening primrose, lemon balm, dill, fenugreek, soapwort, pennyroyal, lemon catnip, common comfrey and clary sage. Detailed records were kept on flowering, height and growth habit for each of the crops. One half of each perennial crop were mulched and half left uncovered this fall and will be evaluated next spring for overwintering hardiness.

Ginseng and garlic were seeded in the fall of 1998 and a number of other crops are to be added the following spring. The trial will be run over the next five years to determine which crops can be grown in this region and how they will produce.

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Crop Management Effects on Biological Soil Health in North-Western Alberta

The effects of tillage and crop rotation on soil microbial biomass, diversity and activity (CO₂ evolution) were investigated under a wheat crop in north-western Alberta.

Tillage reduced both microbial biomass and diversity, but increased CO₂ evolution. The wheat following summer fallow in rotation had the lowest microbial biomass and diversity, and the wheat following legume crops (red clover green manure and field peas) tended to have high microbial diversity and low CO₂ evolution.

High microbial biomass is indicative of potential for high soil organic matter content and high microbial diversity implies more diverse (and sustainable) contributions of soil microbes to crop growth. Less CO₂ evolution means less organic matter is lost from the soil, and it also means less contribution of this greenhouse gas to the atmosphere. Therefore, these results show that zero tillage and legume-based crop rotations are a good combination for sustainable agriculture.

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Management of Lentil Anthracnose

Lentil anthracnose is wide spread in Manitoba and Saskatchewan, and severe attacks occur in areas of intensive production. A premature leaf drop at early flowering indicates that fungicide application may be necessary. Application of Bravo 500 at early flowering and 10-14 days later controls anthracnose and ascochyta blight. Field trials in Manitoba have shown that fungicide sprays increased yield by 930 kg/ha under high disease pressure. Under less disease pressure, the increase ranged between 590 and 650 kg/ha. A split application each of 0.8 l/ac was always better than a single application of 1.6 l/ac. The pathogen forms microsclerotia on infested plants. These structures survive for up to three years on debris in the soil, but viability declines within one year if the stubble remains on the soil surface. Zero-tillage can contribute to reduction of anthracnose inoculum, and should be combined with a 3-4 year crop rotation. Inoculum travel long distances by wind, and anthracnose could be introduced into Alberta in this way. The pathogen is present in wind-borne dust clouds generated during combining of infested crops, and large amounts of microsclerotia are present on lentil debris spread by high winds in the fall. New lentil crops should therefore be planted at a distance from anthracnose infested fields. We are

presently evaluating the relative importance of early disease symptoms, rainfall, 5-day weather forecast, and plant density for predicting disease development and the need for fungicide control. This research is funded by the Agri-Food Innovation Fund.

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Value-Added Processing of Crops

The Crop Utilization research group at Saskatoon Research Centre of Agriculture and Agri-Food Canada has collective expertise in investigating the products and processes needed for the commercial development of special crops.

The research group has scientists trained in the chemistry of plant products. Their interests span the major plant components such as oils, proteins, and starches to the minor plant components like terpenes, sterols, flavonoids, phenolics, and alkaloids. Other group members have interest in crop fractionation and process development. Crop Utilization has the necessary expertise, equipment and facilities in-house or has access to them to assist value-added development of special crops.

Through the Matching Investment Initiative of Agriculture and Agri-Food Canada, Crop Utilization is available to work with special crop growers to co-discover new products and develop innovative processing methods. Examples of process optimization, structural identification, determination of functionality, crop fractionation and technology transfer will be presented.

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Granular Field Pea Inoculant Trial - Peace Region

Field pea production is an important crop rotation for producers in the Peace Region. One advantage of field peas is that ability to fix nitrogen through N fixing bacteria. This regional trial is set up to test the new NITRAGIN *Soil Implant*® + granular inoculant against the commonly used products and an uninoculated check.

The objective of this trial is to determine the effect inoculant formulation has on nodulation characteristics and yield of field pea across the Peace Region plus evaluate the rate of granular products that will deliver the best net returns and to observe the granular product during the seeding operation for compaction and flow through the delivery system.

There were some significant differences between the type of inoculants (granular versus normal). The granular (both rates) scored significantly higher than the peat/liquid treatment. Also, significant differences were observed between the two rates of granular while no significant differences were found between the check and the normal (peat or liquid). The producers that used the product were satisfied with the flow of the granular inoculant. No problems with compaction were observed.

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Attention to Pea Seed Quality Could Boost Seedling Establishment

Field pea seed is often damaged by contact with augers and rough handling during harvest and cleaning, which can exacerbate its vulnerability to attack by soil-borne fungi after seeding.

In years where cool, wet conditions prevail after planting, seed rot and seedling damping-off due to *Pythium spp.* can become major limiting factors to stand establishment and yield in peas. Field plots were established to study the effect of *Pythium* damping-off on seed yield of field peas, to evaluate the effectiveness of fungicidal seed treatments to prevent seed decay and seedling blight by *Pythium*, and to assess the impact of seed damage on seedling establishment and fungicide efficacy.

Seedling establishment and yield were enhanced by seed treatment with Apron fungicide, reduced by inoculation with *Pythium*, and diminished by mechanical damage to the seed. Fungicide seed treatment ameliorated the effect of seed damage, but did not elevate establishment and yield to the same levels as non-damaged seed that had undergone the same treatment. This study showed that

planting fungicide-treated, high quality pea seed was the most effective means of maximizing emergence and stand in the field.

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Weed Management in Caraway, Coriander and Dill

In western Canada, caraway, coriander and dill are grown on approximately 18,250, 9300 and 1800 acres, respectively. Weed management practices for these crops are required for economic production since these crops are weak competitors in the seedling stage.

Field experiments were conducted in Brooks, Alberta to evaluate various herbicides for the control of redroot pigweed, mustard and several other weeds in these spice crops. Tolerance of caraway and coriander to linuron (Linuron, Afolan, Lorox) at 0.4 to 0.8 kg/ha was excellent however, dill was injured at the latter rate. Caraway and coriander were not tolerant to metribuzin (Sencor/Lexone), clopyralid (Lontrel), oxyfluorfen (Goal), and rimsulfuron (Prism). Growing biennial caraway involves the selection of an appropriate companion crop. Lentil and coriander grown with seedling caraway have not affected subsequent seed yields, however only the latter crop is compatible with the use of linuron.

All four spice crops had excellent tolerance to ethalfluralin (edge) and sethoxydim (Poast). Seed yields of caraway and coriander were unaffected by linuron, similarly, oil yields and carvone (an important flavour constituent) content were in most instances unaffected by a combination of ethalfluralin PPI followed by linuron postemergence. At this time, Edge, Afolan F and Poast are registered for use in caraway, coriander and dill.

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Molecular Genetic Diversity Between Two Echinacea Species

Echinacea is now being commercially grown in Alberta. In 1996, one Echinacea field (*E. Angustifolia*) in Clive, Alberta was examined. The mature plants showed *E. Pallida* morphology although the seeds were obtained from and *E. Angustifolia* supplier. The contents of isobutylamides (echinacosides) were lower than those present in *E. Angustifolia*. This has raised a concern as to the true genetic nature of Echinacea species grown in Alberta and other parts of Canada.

The genetic diversity between *E. Angustifolia* and *E. Pallida* was studied by generating molecular markers. Genomic DNA samples of these two Echinacea species were subjected to DNA fingerprinting using a RAPD assay. Two molecular markers were developed after screening 20 single primers of an arbitrary nucleotide sequence. The preliminary results showed that *E. Angustifolia* individual plants were more genetically homogeneous than *E. Pallida* plants. These findings also indicated that there was a clear DNA polymorphism in the amplification fragment patterns between these two Echinacea species.

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Fertilizer Requirement of Irrigated Alfalfa

An experiment to evaluate the response of irrigated alfalfa to fertilizers and to measure the usefulness of soil and tissue tests was conducted from 1994 to 1996. Rates of phosphorus (P) were banded and P and N treatments were broadcast at nine sites and potassium (K) were applied at six sites. Methods to determine soil P were evaluated. Yields did not differ appreciably between high and low rates of P or broadcast and shallow banded treatments.

Kelowna analysis methods gave a better prediction of available P than the Miller & Axley method on a soil with a large amount of absorbed P. Potassium deficiencies are frequently incorrectly indicated by tissue tests which use sufficiency standards developed in the USA. Soil tests were more reliable than tissue tests. Nitrogen gave small increases in yield of alfalfa. Plant tissue levels

of copper (Cu) and Zinc (Zn) on treatments which received P were lower than the control treatments. Tissue levels of calcium (Ca) and N were higher and K were lower than USA standards.

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Native Plants as an Alternative Crop

The objective of this program is to develop commercial sources of native plant material by testing, developing, and releasing native plant selections suitable for use in reclamation, revegetation, and ecosystem restoration in western Canada.

For the past 10 years, the Native Plant Development team has been working to test, develop, and release reclamation varieties and ecovars of native plant species. The selection criteria has focused on improving agronomic characteristics to facilitate commercial seed production while maintaining ecotypic adaptation. In addition, research is conducted on basic cultural requirements of these species to facilitate commercial production and reclamation end-use.

To date, the reclamation varieties developed at ARC have received wide-spread interest including interest from the United States and Europe. Despite the growing interest in this research area, ARC is one of the few Canadian organizations that are developing suitable sources of native plant material to mitigate the impacts of industrial and large-scale disturbances. The outcome of this research will benefit a fledgling reclamation and native seed industry. In addition, these varieties are potential new crops and will provide an added opportunity for crop diversification to Alberta's agricultural industry. The development and promotion of these and other varieties of native plants will increase the availability of native seed on the commercial market, and thereby facilitate both changes in reclamation and revegetation practices and the sustainable-use of Alberta's natural resources.

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Does the Method of Inoculation of Field Pea Affect Rhizobia Survival?

In the Peace River region, soil inoculation with rhizobia increases field pea (*Pisum sativum* L.) yield by 37% as compared to seed inoculation.

Field studies were conducted in 1996 and 1997 to determine survival of *R. leguminosarum* bv *viciae* 128C56Gstr^R (spontaneous streptomycin resistant mutant) on the seed and in the rhizosphere with soil (granular) or seed (liquid or peat) inoculation. With seed inoculation, rhizobia numbers on the seed were reduced by 1 - 2 log units between inoculation and seeding (<1h). Between 8 and 28 days after planting, soil inoculation resulted in rhizobia counts in the rhizosphere equal to or greater than seed inoculation with peat, while seed inoculation with liquid resulted in rhizobia population levels less than with peat and granular inoculation. Nodule numbers and nodule occupancy by 128C56Gstr^R were greater with soil than with seed inoculation. Soil inoculation appears to be important for effective nodulation of field pea grown in the Peace River region.

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Physical Properties of Special Crops Grown in Alberta

Proper design of machines and processes to harvest, handle and store agricultural materials and to convert them into food, feed and fibre requires an understanding of their physical properties. Information on physical properties of special crops are almost non-existent. AVEC is establishing a database of physical properties of agricultural and food materials with emphasis on Alberta-grown crops as well as specialty and new crops. The data is important in streamlining processing plant operations, energy conservation and taking the guess work out of processing and handling mechanisms to be employed for specific agricultural material.

The physical properties we are working include: a) physical attributes such as dimensions and densities; b) hygroscopic properties like drying characteristics and equilibrium moisture contents; c) viscoelastic and mechanical properties including strength in compression and tension and viscosity and fluid flow properties; d) aerodynamic properties such as terminal velocity and drag coefficient; e) solid flow properties like angles of repose and internal friction; f) thermal properties which includes specific heat and thermal conductivity; and, g) electromagnetic properties such as color, electrical conductivity, etc.

There are several applications of the use of physical properties data. Physical attributes and aerodynamic properties are required in the design of combines and cleaning of harvested crops. Solid flow properties information are needed for design of handling equipment. Information on

hygroscopic properties is needed to dry and store crops safely. Physical properties data are needed for the development of sensors to control machines and processes, as well as detect quality. Physical properties of crops are requisite for better design of storage and ventilation system.

We are presently procuring samples of crops for physical properties measurement. Experimental setup to measure the physical properties of a wide range of agricultural materials are being built.

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