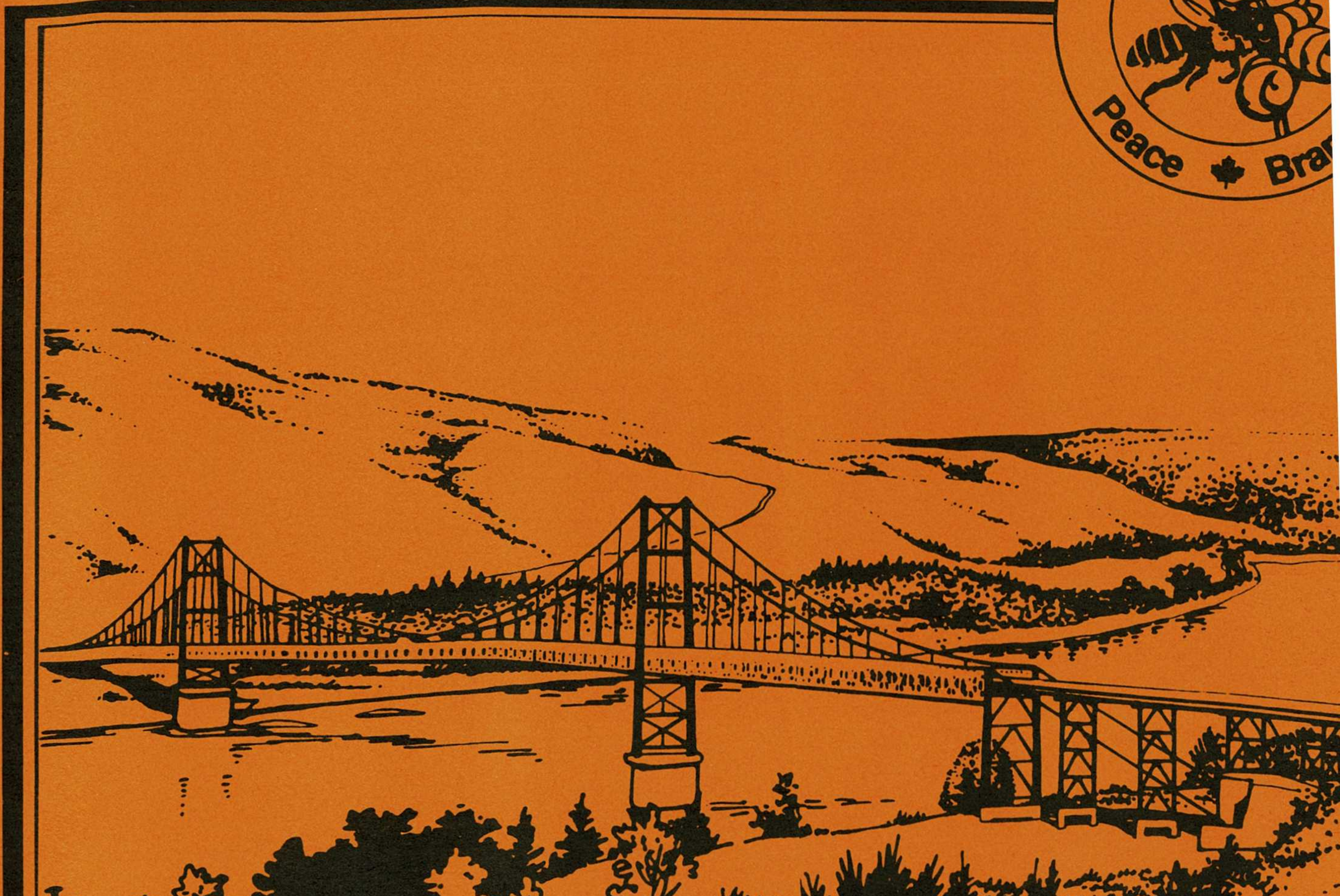
ALFALFA SEED PRODUCTION

IN THE PEACE RIVER REGION

UPDATE 1992



Twelfth Anniversary

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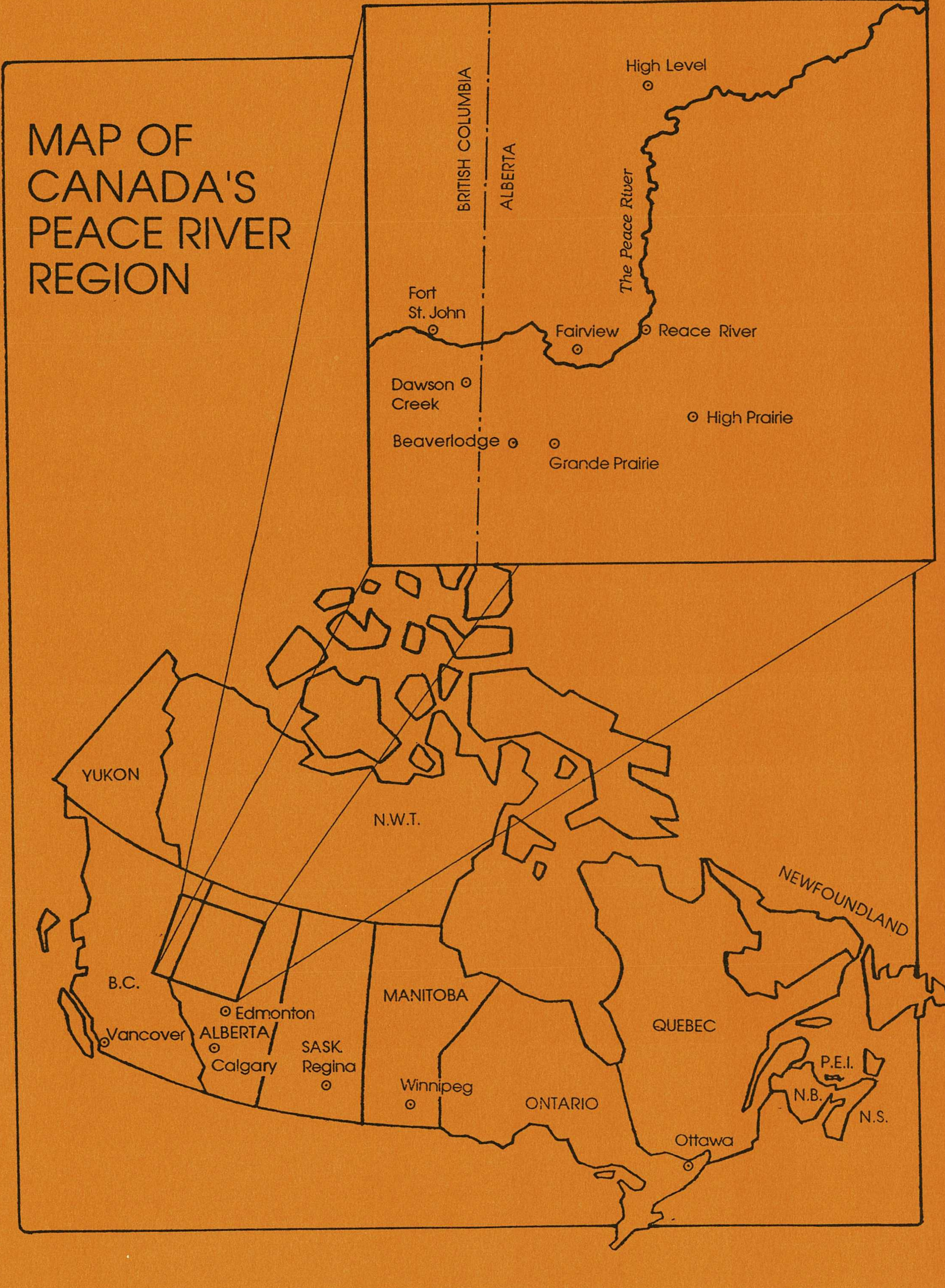

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PREFACE

The Annual Alfalfa Seed Production Seminar organized by the Peace River Branch of the Alberta Alfalfa Seed Producers' Association and Fairview College provides a unique forum for discussion among all participants of the alfalfa seed industry in the Peace River region. This publication contains some of the subjects that have been discussed at the 12th Annual Seminar on March 19 and 20, 1992. It is by no means a complete treatise on either alfalfa seed production or the proceedings of the seminar. It does however, highlight some areas of interest, and hopefully will give the reader some insight into the alfalfa seed industry in the Peace River region.

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19 March 1992

Anik Alfalfa and the Horse

by Ernest Small,
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In our present age of mechanization, it is easy to forget just how important horses were in the past. Of course, the horse is an invaluable beast of burden for haulage, but cattle have historically been even more extensively used as draught animals. However, riding horses were until recently, the most influential technology of war. Use of the horse in war was responsible for the success or failure of most nations of the world for thousands of years, and as late as the first world war, in excess of a million battle horses were sacrificed in combat. So significant has the horse been in the moulding of civilizations that there is an old Chinese saying, "nations are built on the backs of horses." It might be more accurate to say that nations have been built on fields of alfalfa, since this "king of fodders" and "queen of forages" has played a preeminent role in sustaining the horse.

While alfalfa is fed to many animals, its relationship to the horse is very special. The very word alfalfa is derived from old Iranian meaning "horse fodder", and man has been feeding alfalfa to horses for at least 3000 years. Except for the horse, most of man's domesticated animal grazers are ruminants (most notably cattle, sheep, and goats), and it is known that a diet of alfalfa can be of greater benefit to horses than to ruminants. Why should this be so? In the rumen of ruminant animals, microbes normally immediately ferment almost everything eaten, so that food and other chemical constituents are changed considerably before absorption into the bloodstream. By contrast, in monogastric animals like humans and horses, food is first broken down by digestive stomach enzymes, which do not alter food constituents as drastically as do the microbes in the rumen of ruminants, so that some food and chemical constituents can be absorbed into the bloodstream in a relatively unaltered form. What this means to horses in contrast to cattle and other ruminants is that some constituents of alfalfa become available in the diet in a relatively unaltered form.

What is it that makes alfalfa such good food for horses? There is no doubt that alfalfa is an exceptionally good source of protein, but so are some other forages or mixtures of forages. There must be certain ingredients in alfalfa that are responsible for its outstanding health benefits to horses, but just what these are is not at all clear. Although no components of alfalfa are known to be detrimental to either horses or ruminants, there is one constituent, that happens to be present in appreciable quantities in most Canadian-grown alfalfa, that has raised concern. However, as pointed out below, present evidence can be variously interpreted, and it is conceivable that this constituent may actually be of special benefit to horses. Before addressing this issue, some background about the history of alfalfa is useful.

There are two very different wild acestors of modern alfalfa. The first kind of domesticated alfalfa was selected thousands of years ago in western Asia from the purple-flowered wild plant that still grows there today. This was the only kind of alfalfa grown until about the 16th century, and of course the only kind available to horses. Unfortunately, this purple-flowered alfalfa was not well suited to very cold northern locations, or to acidic soils, and therefore could not be cultivated easily in some areas. About the 16th century, however, a wild Siberian alfalfa with yellow flowers was hybridized with the purple-flowered alfalfa. The resulting hybrids proved exceptionally suitable for northern Europe. In the northern parts of North America, including most of Canada, alfalfas of such mixed parentage have also proved to be superior, while on non-acidic soils in warmer climates the more ancient purple type of alfalfa is best. Anik alfalfa is derived entirely from the yellow-flowered Siberian wild plant, and is most suitable for northern locations because of its cold hardiness. Anik is the most distinctive of domesticated alfalfas, and on that account alone probably deserves more interest than it has received to date. As noted in the following, this uniqueness includes high levels of a peculiar chemical.

Saponins are a class of chemicals widely found in plants. They are rather soapy when mixed with water, and indeed some plants high in saponins were once used as a source of soap. In alfalfa there is a very unusual type of saponin, called hemolytic (literally, blood-destroying) saponin because of its ability to rupture red blood cells. This chemical is very useful in protecting the plant, since it is poisonous against many bacteria, fungi, insects, higher animals, and even some other plants. The presence of such a chemical warfare defence in a fodder plant may seem rather frightening, all the more so when one considers that extremely high levels of hemolytic saponin occur in alfalfa sprouts (up to 8%), which we commonly buy at the supermarket and put in our salads. However, research has shown that ingested alfalfa hemolytic saponins normally do not get directly into the bloodstream, and at least in humans, horses and ruminants, there is no evidence of harmful effects. On the other hand, it is well known that alfalfa saponins are very detrimental to poultry and fish, and somewhat harmful to swine and some other monogastric animals. Because of these antinutritional effects, and suspicion that there just might be undiscovered undesirable effects on humans and livestock, some varieties of alfalfa with low levels of saponins have been bred. Normally, limited saponin (usually less than 1%) occurs in the leaves of the purple-flowered type of alfalfa adapted to relatively warm, southern locations. By contrast, many purple-flowered varieties grown in colder climates such as Canada have about 1% saponin content, and the yellow-flowered alfalfa may have of the order of 2% content in the foliage.

Recall that hybridization with the Siberian yellow-flowered alfalfa improved cold-tolerance and acid-soil tolerance of northern European and Canadian varieties. Since the wild Siberian plant is very high in hemolytic saponins, this explains why northern European and Canadian forms of alfalfa are also relatively high in saponins: they inherited this characteristic from the Siberian plants. The result has been that for the last 500 years in northern Europe, and for perhaps 200 years in Canada, horses have been fed alfalfa fairly high in hemolytic saponins.

It might seem that it would be wise to avoid use of Anik alfalfa, since it has the highest level of hemolytic saponins of all alfalfas. However, this is by no means clear. It has been demonstrated that alfalfa hemolytic saponins reduce levels of blood serum cholesterol in the horse. While it is not yet obvious that this is beneficial for the horse, reducing cholesterol is certainly considered good for man, since elevated cholesterol levels clog arteries and can lead to heart attacks. Indeed, saponins are a common constituent of many herbal tonics, although the usefulness of these remains to be demonstrated. What is perhaps most interesting is that feeding alfalfa to horses has been demonstrated to dramatically improve their blood constituents (for example, the level of white blood cells, important in disease resistance). A search for a causal connection of this improvement specifically with alfalfa saponins has not yet been attempted, but given the strong ability of hemolytic saponins to affect blood chemistry, it would not be surprising.

The horse is the hardest worker of all of man's domesticated animals, and particularly hard-working are the large draught horses, such as the Clydesdale and Belgian. These are of European origin, and in northern Europe no doubt have been fed high-saponin alfalfa, upon which they have clearly thrived for hundreds of years. Almost certainly dietary benefits of alfalfa to horses are most important to animals heavily stressed by work, when protein to repair tissue damage is essential, and tonic constituents can be most effective. Modern race-horses probably represent the most stressed of all horses (at least during competition), and fortunes have been invested on their performance. It is surprising that much research remains to be carried out on the significance of alfalfa constituents, including hemolytic saponins, to improving this performance. Anik is not the only high-saponin source of alfalfa for experimentation, since, alfalfa sprouts of most Canadian cultivars may have very high concentrations. While some might consider it extravagant to feed alfalfa sprouts to a horse, some animals might merit such pampering, and the alfalfa seed industry could realize a new source of revenue.

Managing Alfalfa Seed Crops

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How many harvests should be taken from stands of winter-hardy alfalfa cultivars?

In the Peace River region of Alberta and British Columbia, where approximately 33% of Canada's forage seed is grown, the productive life of alfalfa stands is generally considered to be 4 to 6 years. Canadian Seed Growers' Association regulations for pedigreed seed production permit a maximum of eight crops to be harvested from alfalfa, provided these stands have been established with the 'foundation'-grade of seed. A study was undertaken to determine the pattern of seed production of consecutive harvests from stands of alfalfa. The winter-hardy cultivars Algonquin, Anchor, Anik, Beaver and Peace were used.

There was a significant difference in the sizes of the four successive seed crops (Table 1). The first seed crop was the largest, with a progressive decline with subsequent harvests; the final seed crop was almost one half that of the first. The stand survival in the spring following the fourth seed harvest was less than 50%.

There were also significant differences in yield among the five alfalfa cultivars used; Algonquin, Peace and Beaver yielded 391, 361 and 346 kg ha^{-1} respectively, while Anchor and Anik were appreciably lower, with 305 and 304 kg ha^{-1} respectively.

Table 1. Yield of seed crops (kg ha^{-1}).

	Seed crop	Yield
Alfalfa:		
	1	429 (23)*
	2	355 (23)
	3	326 (21)
	4	239 (13)

* approximate standard error

These results suggest that short rotations are a viable option for legume seed crops in the northerly regions of Canada. Obvious advantages of short rotations include reduced inputs of insecticides and herbicides. Short rotations can also give producers the flexibility to grow a wider selection of species and cultivars in response to varying market demands.

In the case of alfalfa, seed production in Canada has been restricted almost exclusively to winter hardy genotypes to the virtual exclusion to non-hardy types. One of the many reasons for this is the assumption that it is only worthwhile to grow cultivars that are winter hardy, that survive for at least four to five years to produce three or more seed crops. If both biologically and economically viable production technology is developed for seed production of the non-hardy alfalfa cultivars at present recommended for Eastern Canada, the amount of seed currently imported can be reduced. At the time of writing, these imports incur a negative trade balance of about Can $9 million annually.

Can the profitability of short rotations be increased with companion crops?

The use of an annual cereal or oilseed companion crops during the establishment of alfalfa seed stands is a long standing practice in the Peace River region of Alberta and British Columbia. The annual crop yields an economic return of grain during the establishment year of alfalfa, while the alfalfa will produce a seed crop the following year.

It is frequently assumed that annual companion crops reduce invasion by weeds and are generally less competitive than the weeds they displace. Nevertheless, these annual crops do compete with the alfalfa, and a number of studies have shown that competition from companion crops reduced vegetative growth and consequently, herbage yield. In contrast, the reduced vegetative growth and the thin stands that result from low seeding rates are recommended for high yielding seed stands, and it is therefore possible that the deleterious effects of companion crops may be minimal in seed stands. The likelihood of deleterious effects of establishing perennial alfalfa seed stands in alternating rows with annual crops and the accompanying changes in yield of the latter were investigated.

'Peace' alfalfa was established in alternating rows with the following companion crops: ('Bonanza') barley, ('Random') oats and ('Tobin') canola. Seed production in row-seeded pure stands of alfalfa was compared with that obtained with stands that were established with the companion crop in alternating seeding rows. One seeding rate was selected for the alfalfa, and two for each companion crop, namely, the recommended rate and half that rate.

In most instances, three to four seed crops were harvested from each alfalfa stand. Seed yield data for the second and subsequent harvests were not significantly affected by the companion crops; therefore these analyses are not reported. It should be noted that the first seed crop from an established stand produced a higher yield than that of subsequent harvests. Only the main effect of the companion crop is significant, i.e. there was no evidence of a differential effect of the seeding rate of the companion crop. The mean seed yields and standard errors with and without a companion crop are presented in Table 2. The mean yield with oats was approximately the same as in the absence of a companion, but was reduced with either barley or canola.

Table 2. Mean yield (standard errors in parentheses) and percent change due to companion averaged over years and seeding rates for the first seed crop of legumes (kg ha^{-1})

Companion Crop	Seed yield (kg ha^{-1}) of alfalfa	
	Alfalfa	%
None	448(33)	
Barley	415(21)	-7
Oats	472(24)	+5
Canola	378(19)	-16

Companion crop yields were unaffected by the rate at which each was seeded (Table 3). Differences in seed yields between all companion crops, namely, barley, oats and canola, were highly significant.

Table 3. Mean yields of companion crops (standard errors in parentheses).

(a) At recommended (1.0) and one half (0.5) recommended seeding rates.

	Seed yield (kg ha^{-1})		
Seeding rate	Barley	Oats	Canola
1.0	3252(139)	3207(137)	1278(59)
0.5	3150(134)	2804(119)	1258(59)

The results of the present study indicate that establishing alfalfa seed stands with companion crops influenced the alfalfa seed yields, but this effect was restricted only to the first seed harvest. While oats had no deleterous effect, barley reduced the yield by 7%, and canola by 16%. While any reduction is likely to have an impact on the productivity of a stand over years - in the present study up to a maximum of 4 years — the extent of this reduction was less than 17%. By contrast, a larger reduction (up to 50%) in alfalfa seed yield occurred with increasing age of stand. In view of the potential benefits of companion crops (e.g., an economic yield in the establishment year when there is no alfalfa seed yield, reduced seeding costs with a 50% lower seeding rate, control of weed ingression during legume establishment) it appears that the establishment of alfalfa seed stands with companion crops in a shorter rotation may provide greater economic advantages compared with the establishment of alfalfa monocultures. Furthermore, if a companion crop is to be used, of the three considered here, oats is clearly to be preferred.

Weed Control in Alfalfa Grown for Seed

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Weeds can be a major problem in alfalfa seed production in Alberta. For example, Canada thistle, at a density of 20 plants per square metre, has been shown to reduce the seed yield of alfalfa by 50 per cent. Decisions on how to manage weed populations in forages must take into consideration factors such as the age and the types of weeds present.

Cultural control

The key to controlling weeds in alfalfa lies in the establishment and maintenance of a vigorous, highly competitive crop stand. Some suggestions for obtaining and maintaining such a stand are as follows:

- Seed into a clean field. Heavy weed infestations should be controlled prior to the seeding of the forage crop through either cultural or chemical means. Perennial weeds, such as Canada thistle, perennial sow-thistle and quackgrass, are extremely difficult and costly to eradicate in a forage stand and should be eliminated before the stand is established. The herbicide Roundup (Laredo, Wrangler) is useful for this purpose.

- Seed into fields free of any herbicide residues. Residues of herbicides such as Glean and Tordon 202C can remain in the soil for one or more years and seriously reduce the emergence and growth of alfalfa. (See section on cropping restrictions).

- Use seed that is either weed-free or free of problem weed seeds. When purchasing certified seed check the official seed testing certificate. This certificate provides information on the type and quantity of weed seeds present. Make sure that the list does not contain too many weed seeds or seeds of weeds not present where the forage crop is to be seeded. It is particularly important to avoid seed stock containing noxious or restricted weeds such as nodding thistle, diffuse knapweed, spotted knapweed, scentless chamomile, toadflax, quackgrass, perennial sow-thistle, Canada thistle, leafy spurge and field bindweed.

- Use varieties recommended for your area and the field to be seeded.

- Seed into a firm, well prepared seedbed at the recommended rate and depth.

- Use fertilizer based on soil test results and inoculate alfalfa seed with the appropriate inoculum.

- Evaluate the option of seeding without a companion crop. Since soil type, weather, economic conditions and type of farming operation are all important factors, the choice is an individual one. In general, where soil crusting or erosion is not a problem, seeding without a companion crop is advisable. While companion crops suppress weeds and enhance herbicide efficacy, they also suppress alfalfa seedling development and yield in subsequent years. Less competitive companion crops such as flax should be considered. When a cereal companion crop is used, the application of modest amounts of nitrogen, decreased companion crop seeding rate and harvesting of the companion crop early as greenfeed or silage can aid in the establishment of the alfalfa.

- Mowing just above the alfalfa is an effective method of preventing annual weeds from smothering seedlings. Seed set of the weeds is also reduced. A flail-type mower, or one that distributes the plant material evenly over the field, is preferable to a swather.

- In well established stands of alfalfa (not less than one year old) cultivation to a depth of 2 to 4 cm with a narrow, stiff-toothed cultivator in the early spring will control some annual weeds and tufted grasses. A second cultivation at right angles to the first may be necessary.

- Pull by hand or spot spray problem weeds such as Canada thistle. Roundup (Laredo, Wrangler) will control problem perennial weeds on a spot spray basis, killing the sprayed forage crop as well. Failure to control small patches of problem weeds will lead to problems in the future.

- Remove weeds from adjoining fence-lines, roadways and rights-of-way.

- Break up old, depleted or winter-killed stands where there is no longer a vigorous forage stand to compete with weeds.

Chemical control

Herbicides should be used only when needed and to supplement, not replace, good cultural management of weeds in alfalfa. There are fewer herbicides available for use on alfalfa than cereal crops. Herbicide selection depends upon:

- The weeds present and the effectiveness of the herbicide on these weeds. The attached chart summarizes which herbicides control the main problem weeds in alfalfa. For other weeds, check with the local district agriculturist or agricultural fieldman.

- The companion crop, if used, and its tolerance.

- The stage of growth of both crop and weeds. See the herbicide label for the recommended stage of application.

- The age of the stand i.e., seedling (within approximately 3 months of the time of seeding) or established (3 months or more after seeding).

- The cost of the herbicide. Is the herbicide application economical in the short term and/or in the long term?

When a herbicide is selected for use in a forage crop, several points should be kept in mind:

- Follow label directions closely, particularly as they relate to stage of crop and weed development and water volume.

- Spray at the appropriate stage. In the year of seeding, spray post-emergent herbicides as early as label direction will permit. Young weeds, i.e. , in the 2-4 leaf stage, are easier to kill than those in the more advanced stages. Early removal of weeds will enhance alfalfa seedling vigor. Alfalfa seedlings tend to be weak and unable to effectively compete with faster growing weeds. seedlings are most resistant to herbicides for broad-leaved weed control from the first to the third trifoliate leaf stage. They should not be sprayed after reaching 10 cm in height.

- Calibrate the sprayer for uniform application of the correct amount of herbicide.

- Avoid drift onto sensitive crops growing in nearby areas.

- Spray according to environmental conditions. If conditions are very dry, consider delaying spraying until a few days after a substantial rain. The performance of most herbicides is reduced under dry conditions.

- Do not use herbicides with long lasting residues on stands that may be worked under in 1 or 2 years. Injury will occur to crops seeded in soil containing these residues.

- Consult the *Guide to Crop Protection in Alberta, Part I - chemical. Agdex 606-1* or the label on herbicide container for further information on each herbicide listed in the selector charts.

There are a number of options for dealing with weed problems in forage crops. It may pay to spray and it always pays to use good agronomic practices.

CROPPING RESTRICTIONS

Herbicide	Problem
Ally	Seedling alfalfa may be affected for 1 or more years after Ally application. On Black and Gray Wooded soils of pH 7.9 or lower, alfalfa may be planted 22 months following application of Ally. Extend the rotational interval one year if rainfall was less than 250 mm in any year following application. On Brown and dark Brown soils a test strip (field bioassay) should be seeded the year before planting forages. Yield from the test strip should be compared to yield from an adjacent untreated area.
Assert	Seedling alfalfa may be affected for one or more years after Assert application. Conduct a field bioassay (a test strip grown to maturity) the year before planting. The yield from the test strip should be compared to the yield from an adjacent untreated area.
Atrazine	Seedling alfalfa may be affected for one or more years after Atrazine application.
Banvel	Seedling alfalfa may be affected if high rates of Banvel were used for perennial weed control the year before.
Lontrel	Alfalfa may be affected for one or more years after application. For additional cropping and use information, contact Dow Elanco at 1-800-661-6436.
Princep/Simazine	Soil residues may persist for two or more year and affect seedling alfalfa.
Tordon 202C	Alfalfa should not be grown until at least the third growing season after the year of treatment. For additional cropping and use information, contact Dow Elanco at 1-800-661-6436.

Table 1. Herbicides used in alfalfa for seed.

Seedling stands	Established stands
Assure	Assure
Avadex BW[1]	Fusilade II
Avenge[1]	Kerb
Basagran	Poast
Edge	Princep/Simazine[3]
Embutox/Butyric/Cobutox	Sencor[4]
Eptam	Velpar
Fusilade II[2]	
Hoe-Grass 284	
Mataven	
Poast	
Treflan	

[1] Use only if forage crop is underseeded with a companion crop for which herbicide is registered.

[2] Do not harvest for feed or graze livestock in year of treatment.

[3] Established at least one year. Apply in the late fall before freeze-up.

[4] Irrigated alfalfa only, established at least 18 months. Apply in fall to dormant stands.

Marketing Alfalfa Seed in 1992

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Many growers are reacting with alarm to the present drop in alfalfa seed prices. When prices go from $0.85/lb to $0.40/lb on common alfalfa, they have just cause for alarm. But let's step back and have a look at the past in relation to where we are now and where we may be able to go in the future.

The last boom and bust cycle in Canada occurred from 1968 to 1972. At that time, U.S. production went from 115.8 million to 140.4 million pounds and Canadian production was very small. This basically occurred in the Bow River area of Alberta. One must remember that the leafcutting bee industry was in its infancy ten to twelve years ago. The 11th Annual Canadian Alfalfa Conference is being held on January 9, 1992 in Winnipeg. This tells us how new this industry is in Canada. Let's look at some production figures.

Table 1. Canadian alfalfa acreage inspected.

	1984	1985	1986	1987	1988	1989	1990	% Change 1984-1990
Ontario	69	61	20	14	40	60	87	+ 26.1
Manitoba	8139	11703	13322	15462	18555	20841	20325	+149.7
Sask.	12489	14863	17439	19193	23736	25153	23566	+ 88.7
Alberta	14071	13525	11888	13024	13389	13369	12649	+ 10.1
B.C.	-	30	50	230	428	566	546	N/A
	34768	40182	42728	47924	56148	59989	57173	

Table 2. Canadian production of alfalfa seed by provinces[1].

Province	5 year average 1985-89	1989	1990
	---------- Thousand lbs ----------		
Ontario	8.8	8.8	6.6
Manitoba	5148	5500	9900
Sask.	5812	10371	9986
Alberta	4268	4840	6600
B.C.	8.8	242	-
Canada	15246	20962	26492

[1] Statistics from Agriculture Canada

As we can see, in the last ten years there has been a tremendous increase in seed production, with 1990 setting a production record in Canada of 26.5 million lbs. Let us see how Canada fits into this picture of alfalfa seed production and why we in Canada should realize how small a player we are by looking at some American production figures.

Table 3. U.S. data: alfalfa seed production in the northwest States.

Alfalfa Seed Production[1]

1989	1990	1991
----------millionof lbs----------		
45.5	62.4	69.5

[1] Includes Idaho, Washington, Oregon, Nevada and Montana. Data from various industry sources; figures represent rough estimates.

1991 Alfalfa Seed Production Estimates[2]

	Acres	Average Yield	Million Lbs.
Idaho	39,500	725	28.64
Washington	28,800	550	15.84
Nevada	19,000	684	13.0
Oregon	11,000	682	7.50
Montana	26,000	170	4.55

[2] Data from various industry sources. These are rough estimates only.

The U.S. production is comprised of two major areas - the Pacific northwest and California, with some wild card production in the midwest states.

The Pacific northwest triangle is comprised of five major states. These are Washington, Idaho, Oregon, Nevada and Montana. The majority of this production is under irrigation and from Table 3, we can see that average yields are between 600 and 700 lb/ac^{-1}. This also includes the dry land production, individual farmers have grown up to 2000 lb/ac^{-1} under irrigation. This area produced a total of 69.5 million pounds.

Table 4 gives us the California production which has been the major producing area in North America. Due to the drought, which has been continuing in California, their production has been dropping off recently.

Table 4. Alfalfa seed production in California.

Year	Acreage Harvested (thousands)	Yield Per Acre (pounds)	Production (1000 Lbs.) (cleaned seed)
1981	94	580	54520
1982	a/	a/	a/
1983	62	630	39060
1984	81	685	55495
1985	82	585	47970
1986	93	500	46500
1987	67	605	40541
1988	67	529	35466
1989	67	489	32766
1990	71	493	35065
1991	69	633	43675

Table 5. Midwest catch crop.

	1989	1990	1991
	----------	millions lbs. -	----------
Kansas	0.75 - 1.0	1.0 - 2.0	2.0 - 4.0
Nebraska	0.5 - 1.0	0.5 - 0.75	1.0 - 1.5
South Dakota	1.5 - 2.5	1.0 - 2.0	7.5 - 10.0
North Dakota	0.2 - 0.3	0.2 - 0.5	1.0 - 1.5

In Table 5, we have what I call the "wild card" production in the mid-western states. I call this "wild card" production because it can vary so much. These producers can go either way by producing hay or seed, depending upon the price and supply of hay. This year, due to cheap hay prices, they left it for seed. Traditionally, they will sell their seed for whatever price they can get. This is a cash crop to them and they want to move it in the fall. From this you can see why we in Canada are such small players. The state of South Dakota can produce anywhere from one million pounds to half of Canada's total seed production. Right now it is estimated that there is 160 million pounds of alfalfa seed in north America with an estimated consumption of 75 million pounds. We have the equivalent of one year's production as carryover with another crop coming this fall.

Some of the factors that have lead to this large carryover are:

1. A depressed dairy industry was caused when milk went from 15.00 cwt to below 10.00 cwt. Midwest dairymen are still under tremendous pressure to keep costs down. Alfalfa seed purchases and new stand establishment are considered major costs factors.
2. There have been two consecutive and very big seed crops from the northwest states. Producers have had excellent weather for seed production. They have also become much better bee managers and have been buying extra bees from Canada. Growers have put bees out at the rate of up to 40,000 bees per acre. The registration of the new insecticide "Capture" has dramatically reduced pests and mortality levels in the bee populations.
3. American farm programs such as the Conservation Reserve Program are weakening and the amount of land being set aside for forages is way down, thus affecting seed consumption.
4. Canadian production has doubled in the last two years. Canada has gone from a net importer of seed to a net exporter of seed.
5. Finally, companies involved in the production of alfalfa seed were very aggressive in trying to increase their market share. As a result, they have been promoting extra production when it should have been cut back.

In the European alfalfa seed market, some of the major off-shore players are Italy, France and Spain. The east block countries seem to have some production, but no one seems to know how much they produce or need. The Italians, acting as agents, are noted for dealing with other countries. A couple of years ago, they sold lots of seed to Iraq and Iran, but since the war occurred, this has ended. There also appears to be a limited opportunity for off shore sales because there is surplus production at the present time in France, Spain and Australia.

What options do Canadians have with regards to producing alfalfa seed and forages? From looking at the previous production figures, even if we quit producing seed, it would have a limited impact on seed carryover. There will be a large plow out of seed as new contract prices are half of what they were a year ago. The other advantage Canadians have is production cost. Americans have high production costs with irrigation, and they also have many alternate crops like onion seeds, sugar beets, peas, and vegetable seed crops they can grow. We in Canada have fewer crop options, and our land and production costs are much less. Right now, any alternate crop does not look any better than forages. I think we have to try to decrease our acreage somewhat and try to produce as efficiently as possible. We must make a commitment to effective bee management and proper use of herbicides and insecticides to maximize our seed production. The challenge will be to see if we can produce seed more economically than the Americans can.

Once the price of alfalfa drops below $1.00/lb, Americans may start switching to more of their alternate crops. If Canadians can produce alfalfa seed for $0.70 to $0.80/lb, it may give us an opportunity to maintain a fairly active seed industry in Canada. Companies will try to bring their production and inventories in line. We will probably see a lot more fixed price contracting of alfalfa in the future. What's happening in our industry is all relevant to what's happening around us. The recession has hurt everyone from manufacturers, to small business, to agriculture. It is a matter of "toughing it out" and being there for the better times ahead. As producers, I think that we should not make any dramatic changes in our operation. Diversification and optimization of our crops and management skills should be our guiding goals.

Alfalfa Seed Production Under Irrigation in Central Saskatchewan

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A team of forage scientists has studied alfalfa seed production problems in the Lake Diefenbaker irrigation district near Outlook, Saskatchewan since 1986. This work is relevant to alfalfa seed growers in the Peace River region because of the production problems common to both areas.

Over the last few years, Saskatchewan has surpassed Alberta to become the largest producer of alfalfa seed in Canada. However, when this project was initiated in 1986, there was no alfalfa seed being produced under irrigation in central Saskatchewan. Irrigated seed production was attempted in the early 1970s, but yields were very low and the initial attempts were abandoned. A research team consisting of a plant breeder, an entomologist, a plant pathologist and a soil fertility specialist was formed to determine if alfalfa seed production was possible in the Outlook district, and to identify the main production constraints. Studies on forage production and agronomy under irrigation were also initiated.

Establishment - Alfalfa production manuals always emphasize the importance of knowing the field, planning the rotation well in advance and seeding the alfalfa crop early to take advantage of cooler, moist conditions in the spring. We were forcibly reminded of these points in our first year of studies at the Saskatchewan Irrigation Development Centre (SIDC) site at Outlook. Various constraints caused seeding to be delayed until the middle of July in 1986, on land one third of which turned out to be contaminated with residue of a persistent but unknown herbicide. Seedlings that were not killed by the herbicide were subject to extreme heat and drying, to sandblasting caused by wind erosion of the sandy soil, and finally to attacks by grasshoppers. Only 3 of 9 trials established well enough in 1986 to be used for research purposes.

In subsequent years, stand establishment was generally excellent. Weed control and crop rotation were planned in advance, and timely seeding and good seed-bed preparation promoted rapid germination and establishment. Depth control was critical for seed placement in the very light sandy-loam soil at this site, and our only establishment problems occurred when seed was planted too deep.

Irrigation management - After the establishment year, the trials were irrigated heavily in late May to late June each year. Irrigation was stopped before leafcutting bees were set out in late June or early July. Alfalfa requires abundant soil moisture for maximum vegetative growth, but switches to flower production only when under some drought stress. Nectar production is also stimulated by drought stress. Irrigation during seed development and into the fall was applied only under conditions of extreme drought stress.

Seeding rates and stand thinning - In general, stands were seeded at a rate of 2 kg/ha in rows one meter apart. In most instances, this resulted in a stand that was too thick for optimum seed production. Stand density was reduced in the fall of the establishment year by cultivating at right angles to the rows with a cultivator which had every second shovel removed.

Two experiments were conducted to determine the effect of stand density on seed production. The first trial, seeded in 1986, compared broadcast seeding (solid stand) vs. row seeding, and plots of both seeding methods were either thinned (cross-cultivated) or left as control treatments. In the summer of 1987, conditions for pollination of alfalfa flowers were less than optimal, being predominantly cool and cloudy. Seed yields were low, averaging only 280 kg/ha, and highly variable within the test. Differences among treatments were not significant (Table 1).

The summer of 1988 was hot and dry, resulting in excellent pollination by the leafcutting bees. Alfalfa seed yields averaged 583 kg/ha. The treatment with the thinnest stands produced the lowest yields (Table 1), the opposite results of of the previous year. In 1989, favourable weather conditions and good bee activity resulted in seed yields averaging 474 kg/ha. However, establishment of volunteer plants had occurred within the plots, so that the treatments were virtually indistinguishable. As a result, there were no consistent differences in yield among treatments and the trial was plowed down.

A second trial was established in a grower's field in the spring of 1989. The stand was seeded at 2 kg/ha, with 1 m between rows. Cross-cultivation treatments (once, twice or three times) were applied that fall. In May of 1990 the cultivated treatments had thinner stands and shorter plants with fewer leaves than the non-cultivated control (Table 2). Conditions during June and early July were wet and cool, resulting in vigorous vegetative growth, little flowering and low seed yields. Under these conditions, the densest stand produced the lowest yields (Table 2).

In the spring of 1991, the cultivation treatments were applied again because the abundant vegetative growth the previous summer had reduced the differences among treatments. Unfortunately, an early snowfall occurred before the plots (and the grower's field) could be harvested.

The results of these two trials are not conclusive, but we have noted that when conditions for flowering and pollination are not optimum, yields are higher in thinner irrigated stands. When conditions for flowering and pollination are good, a dense stand produces more seed than a thin one. Previous studies on dryland alfalfa production in central Saskatchewan have shown that thin stands (approximately 10 plants per m^2) produce the highest seed yields.

Climatic effects - Leafcutting bee activity was positively correlated with temperature and hours of sunshine. This was reflected in the amount of bee cell increase from 1987-89 (Table 3). The incidence of parasitism of bee larvae was relatively high in both 1988 and 1989 (Table 4), which indicates that conditions that were good for leafcutting bees were also good for other injurious insects like parasitic wasps. Special efforts were made to decrease the number of parasitized cells set out in the field, and by 1991 the rate of parasitism had decreased to below 0.3%, as compared to the provincial average of 1.2%.

Winter conditions can also have an important impact on seed production through effects on stand survival. Differential survival from low-temperature injury among alfalfa lines was observed in a forage production trials. However, there was little injury noted in tender lines in adjacent seed production trials. This indicates that plants grown for seed are less susceptible to low-temperature injury than plants harvested for forage. In our seed production trials, we did not desiccate the plots until after the first killing frost, which normally occurs after the soil temperatures have fallen substantially. Desiccant application made earlier in the fall could force elongation of crown buds and leave plants more susceptible to low-temperature injury.

Cultivars - We are conducting a trial to examine the seed production potential of relatively tender cultivars adapted to the eastern Canadian market. These lines have survived over two winters, but their yields in 1990, the first production year, were low (mean 181 kg/ha). Also, these cultivars tend to flower later than better-adapted cultivars, and harvest is delayed. This makes them a bigger gamble for producers, especially in northern areas.

Insect pests and diseases - Insect pests were sampled at the SIDC site at weekly intervals throughout each summer. In each year (1987-91), the numbers of lygus and alfalfa plant bugs were over the economic threshold of 5 bugs per sweep (data from 1987-89 illustrated in Figure 1). The number of alfalfa plant bugs increased over the years relative to the number of lygus bugs. Insecticide applications to control these pests, using either dimethoate or deltamethrin, were made several days before the leafcutting bees were placed in the field. Pea aphid numbers were high in late July and August in most years, but this did not appear to affect seed yield. The insect fauna in seed fields was found to be similar to that in neighboring forage fields.

Parasites of the plant bugs, especially parasitic wasps, were also examined as part of this study. The incidence of parasitism of the plant bugs examined in the study was generally around 5% and rarely over 10%. Identification of these parasites is continuing.

In the early years of the study, conditions were too hot and dry for epidemic development of foliar diseases. However, cool, wet spring conditions in the last two years have resulted in substantial epidemics of spring black stem, downy mildew, common leaf spot and yellow leaf blotch. Although these diseases reduce seed yields, their impact on forage production is generally small. As a result, breeding for resistance has not occurred in material which is adapted to northern regions, and differences in resistance among existing cultivars are of minor importance.

Verticillium wilt of alfalfa, which is a major problem in southern Alberta and British Columbia, has not been reported from northern regions of Saskatchewan or Alberta, and no incidence of its occurrence was found in our plots. It appears that this pathogen cannot survive under dryland conditions in northern regions.

Fertilization - The impact of fertility on alfalfa seed production is being examined in trials at three sites. The major elements (N, P and K) are being examined, together with sulphur, boron and molybdenum. We have not yet observed any differences in seed yield among treatments at any site.

Problems - Weed control was a problem in our trials. Wide row spacings and low seeding rates, which maximize seed production when conditions are less than ideal, produce a thin plant cover. In several plot areas, broad-leaved weeds became a significant problem despite repeated herbicide applications. The diversity of weed species encountered under irrigation exacerbated this problem. Weed invasion represents an important problem for producers, resulting not only in direct yield loss, but dockage and loss of grade. Some producers have suggested that solid seeding at a very low plant density provides better weed competition than wide-row seedings, but this has not been examined experimentally.

The recent slump in alfalfa seed prices has made growers of irrigated crops reluctant to enter this market. However, they may reassess their options when prices recover.

Conclusion - We demonstrated that the potential for alfalfa seed production under irrigation in central Saskatchewan is good. Irrigation management, especially timing of water applications during the season, was the most important factor for achieving good yields. A pesticide application for control of plant bug populations was required each year to ensure adequate seed production at the study site. Biological control does not represent a viable control option at this time. Weed control continues to be a major problem under irrigation.

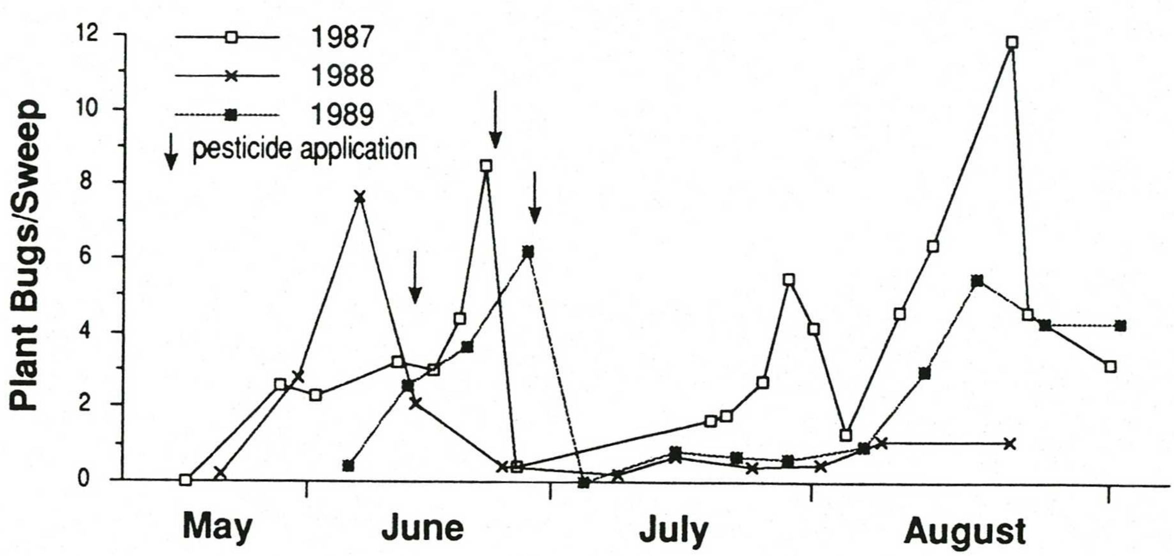

Fig. 1 Lygus and alfalfa plant bug populations in an alfalfa seed field, Outlook, 1987 to 1989.

Table 1. Mean seed yield of alfalfa grown under different plant densities in at Outlook, 1987-89.

Treatment	Shoots (per m^2) in 1988	Yield (kg/ha) 1987	1988	1989	Mean
Solid Seeded	325	233	708	489	477
Solid Seeded, Cultivated	235	197	607	473	426
Row Seeded	310	306	621	477	468
Row Seeded, Cultivated	171	382	395	457	411
Mean	260	280	583	474	446

Table 2. Stand characteristics (assessed on 2 m row samples) and seed yield of cultivated or uncultivated Beaver alfalfa, 1990.

No. of Cultivations	No. of Crowns	No. of Shoots	Height (cm.)	No. of Leaves	Weight (kg/ha)
None	13.9a*	261a	13a	7.0a	134.a
One	9.8b	171b	11b	5.9b	186.b
Two	9.1b	163b	10b	5.6b	208.b
Three	7.9b	100c	9b	5.7b	178.b

* Means followed by the same letter in the same column are not significantly different at P=0.05 based on Duncan's Multiple Range Test.

Table 3. Number of sunshine hours in July and leafcutting bee cell production, Outlook, 1987 - 89.

	1987	1988	1989
Sunshine (hours)	230.8	351.7	309.4
Bee cells harvested (kg)	8.1	30.2	23.4
Bee cell increase	1.4X	5.0X	3.9X

Table 4. Quality factors of leafcutting bees (% of total sample) from Outlook, and mean values from across Saskatchewan.

	1987		1988		1989	
Category	SIDC	Sask.	SIDC	Sask.	SIDC	Sask.
Healthy prepupae	69.6	76.2	69.4	79.6	70.5	78.3
Dead larvae/prepupae	2.8	4.8	8.6	4.1	8.4	4.4
Moldy cocoons	6.6	6.4	0.7	2.8	1.3	3.7
Parasitized larvae	0.1	0.5	3.6	2.1	4.4	1.4
Second generation larvae	0.1	1.4	0	0.6	0.6	1.0
Pollen balls	19.7	9.6	16.3	9.3	14.3	9.5
Crushed cocoons	1.0	0.7	1.3	1.3	0.4	1.2
Other	0	0.4	0	0.2	0.1	0.3
Live count/kg	8368	8752	7785	8922	8052	8852
No. of locations	1	59	1	71	1	40

COCOON TESTING CENTRE SUMMARY

The Cocoon Testing Centre is the accredited establishment in Canada for leafcutting bee cell quality. The Centre is operated under the auspices of the Canadian Alfalfa Seed Council and appointies fo the Council serve as a Technical Advisory Committee that serves as a consulting body for the operation of the Centre.

Angela Spencer and Jan Neufeld are the technicians at the Centre who perform quality tests on all leafcutting bee cell samples. The following is a summary of the results on all the samples that have been analyzed as of February 26, 1992.

QUALITY OF LEAFCUTTING BEE CELLS PRODUCED IN CANADA: 1991 PRODUCTION
(From Canadian Cocoon Testing Centre, Brooks, Alberta, Nov. 1, 1991 - Feb. 26, 1992)

Prov./ Canada	Live Prepupae per kg.	Percent									
		Prepupae		Larvae		Pollen	Second			Machine	
		Live	Dead	Immature	Dead	Balls	Generation	Parasites	Predators	Damage	Chalkbrood
AB	8855	74.7	1.6	1.2	1.8	12.2	0.5	1.5	0.1	3.8	2.29
(156)[1]	5416-11737[2]	49-96	0-13	0-4	0-7	2-32	0-9	0-15	0-2	0-14	0-26
BC	9652	81.3	1.7	1.1	2.6	8.9	0.8	0.1	0	3.1	0
(3)	8479-10758	68-89	0-3	0-2	1-5	5-15	0-2	0-1		1-5	
SK	9707	80.8	1.0	0.9	1.4	10.8	0.5	1.8	0	2.8	0
(121)	6338-11839	52-97	0-8	0-4	0-7	0-37	0-3	0-21		0-17	0-0.3
MB	8605	76.0	1.2	1.4	2.4	14.4	0.3	1.3	0	2.7	0
(126)	5099-10798	51-95	0-6	0-4	0-9	3-34	0-2	0-14		0-14	0-0.5
ON & QB	8170	70.3	2.3	2.0	3.7	11.4	5.8	0.8	0	3.4	0
(7)	5020-9478	43-83	1-9	1-3	1-9	7-14	6-33	0-2		0-6	
CANADA	9021	76.8	1.3	1.2	1.8	12.4	0.5	1.4	0	3.2	0.9
(415)	5020-11839	43-97	0-13	0-4	0-9	0-37	0-33	0-21	0-2	0-17	0-26

1 Number of samples
2 Minimum and maximum, respectively

questionnaires every year. We need updates and we need input from producers within and outside of areas with chalkbrood.

The Questions

Here are the reasons for each question.

1. ***Sample number*** cross references to X-ray results. The *location* is needed to identify the area where bees were produced. This information is very important as the address of the producer on the x-ray results is not always the same as the location where the bees were produced.

2. Information on *tumbling* bees and use of a *cell breaker* helps to determine if these practices have any detrimental effects. For instance, tumbling bees with a high incidence of chalkbrood may spread the disease by breaking open cadavers and releasing spores.

3. Information on *nesting material* helps to determine if some kinds of material are better for bee production in some areas. For instance, wood material may favor chalkbrood in certain areas.

4. Information on *equipment disinfection* helps to determine if present recommended practices are adequate to stop the spread of chalkbrood. It will also help to determine whether new practices such as fumigation are better than present practices such as bleach dipping.

5. Information on *treatment of bee cells* helps identify any problems associated with these practices: Are parasites becoming resistant to Vapona? Do we really need to treat bee cells to adequately control chalkbrood?

6. Information on *disinfection of cells* sent for x-ray analysis helps identify if the methods used are affecting bee parameters such as viability and sex ratio.

7. Information on *placement of shelters* helps determine if using the same field location year after year results in a build up of chalkbrood spores in the vicinity and therefore increases chalkbrood potential.

8. Laboratory studies suggest that some *fungicides and insecticides* increase susceptibility of leafcutting bee larvae to chalkbrood. This means chalkbrood susceptibility may be linked to chemical "stressors." I need information on herbicide and insecticide use to test this theory.

Results Summary Analysis for 1990/91

Table 1 summarizes the results from questionnaires submitted with bee samples to the Cocoon Testing Centre in 1990/91. According to the summary, most samples from all areas were tumbled. Fewer samples were passed through a cell breaker, especially in Saskatchewan. Most producers disinfect nesting materials, although fewer disinfect other equipment and shelters.

Table 1. Questionnaire Response Summary 1990/91

	Percent of answers with positive response				
	Man	Sask	sAlb[1]	cAlb+PR[2]	Canada[2]
Cell treatment:					
Bees Tumbled	85	97	92	58	85
Cell Breaker	35	7	60	29	35
Equipment disinfection:					
Incubator	21	53	35	4	29
Incubation Trays	48	38	48	20	43
Nesting Materials	61	75	78	54	67
Shelters	26	13	43	0	25
Stripper	37	20	24	4	28
Tumbler	28	17	14	0	21
Other equipment	0	0	2	0	4
Bee treatment:					
Treated for Parasites	72	83	71	64	73
Treated for Chalkbrood	2	4	30	0	10
Bees Disinfected	0	5	2	7	5
Shelters Same Location	40	75	59	36	50
Herbicides & Insecticides	90	91	96	57	89

[1] Southern Alberta

[2] Central Alberta and Peace River region

Most producers treat cells for parasites. In southern Alberta, 30% of producers treat their bees for chalkbrood. Very few of the cells were treated before being shipped to the Cocoon Testing Centre.

Shelters are mostly placed in the same locations every year. Most producers who reported shelters were not in the same location said it was because they were placed in a new field. Most producers use a chemical pesticide; the Peace River area had the lowest proportion of producers using pesticides.

We cannot make firm conclusions or give any recommendations based on such a preliminary analysis of one year's results. We need several years' data and we need to analyse the information in detail before we can reach any firm conclusions. We also need to tie the answers from the questionnaires to the x-ray analyses.

Questionnaire response rates

Table 2 shows the questionnaire response rate for 1989/90 and 1990/91. Your cooperation has been excellent with an overall increase of 23% from last year. Questionnaires were returned with 55% of the samples.

Central Alberta/Peace River and Manitoba had the highest rates of return (71 -63%) followed by Saskatchewan (52%). Unfortunately, southern Alberta, the region with the most needed information as far as evaluation of chalkbrood control practices is concerned, had the lowest rate of return (38%). This is unfortunate but it is over twice the response of last year, which is encouraging. As of mid-January, 1992, the overall response rate for this year has been about 61%. If this trend continues for the rest of the year, we will have another year's information to add to our data bank.

Table 2. Percent of Bee Samples accompanied by Questionnaire.

	Man	Sask	sAlb[1]	cAlb+PR[2]	Canada
1989/90	45	34	15	44	32
1990/91	63	52	38	71	55

[1] Southern Alberta

[2] Central Alberta and Peace River region

HELP ME HELP YOU! FILL OUT AND SUBMIT QUESTIONNAIRES WITH YOUR SAMPLES THIS YEAR!

It's still not too late to fill in your questionnaire and mail it to the Cocoon Testing Centre. The greater the response rate, the more meaningful is the data base. After 1 April, please send your questionnaires directly to me. Don't forget to include the sample number from the CCTC x-ray results on your questionnaire. Also, if you have any suggestions or questions, please feel free to contact me.

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Paraformaldehyde For Fumigation of Leafcutting Bee Nest Material and Research on Parasite Control Methods and Leafcutting Bee Cell Viability

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Annual surveys undertaken in Saskatchewan over the past six years have indicated a trend to increased parasitism in 1988-1990 surveys, with parasitized bee cells averaging 1.64% in samples analysed. Parasitized bee cells comprised only 0.84% of cells evaluated during 1985-1987 surveys. Over the same period, parasite-free bee populations dropped from 51.2% (1985-1987) to 19.8% (1988-1990) of bee cells in populations analysed. This increase in parasitism has caused many producers to use dichlorvos for spring parasite control at rates which exceed the recommended rate of 0.75 resin strip per 1000 ft^3 (28.3 m^3). Some producers are also using dichlorvos treatment for an extended period in the incubation cycle rather than restricting its use to the 7-14 day period as generally recommended.

To examine the effect of increased dichlorvos rates over various time periods on bee development and emergence during incubation, preliminary tests were undertaken during spring, 1991. These tests involved treatment of a replicated number of bee cells (n=100) with various rates of dichlorvos (recommended rate, 0.5x, 2x, 4x, and 8x recommended rate, and untreated control) at several time regimes (day 1-7, 7-14, 14-21, and 0-21). Bee cells were incubated in a system of 0.75 ft^3 mini-incubators within a large incubator (30°C/50% R.H.). Bee cells containing healthy prepupae, as determined by x-ray analysis, were held under various treatments and incubated to determine percent adult emergence.

Emergence of adults from control treatments was uniformly high (98.9-100.0%), while emergence in all dichlorvos treatments was very low, even at 0.5x (54.0%) and 1x (28.0%); bee mortality increased with increasing dichlorvos rates. The surprisingly low emergence at 0.5x and 1x rates was determined to be due to the relatively small number of bee cells used per treatment, resulting in an exaggerated dose effect per unit of organic material (i.e. bee cell). A series of interesting observations made during dissection of unemerged bee cells indicated that a teratogenic effect (i.e. one causing abnormal pupal development) had occurred. The characteristic teratogenic phenotype was a late-stage pupae or pre-emergent adult with poorly differentiated head, thorax, and abdomen, little or no apparent development of appendages, and retarded wing development. This phenotype was observed in all dichlorvos treatments but was more apparent with increasing dichlorvos rate and in time regimes which included the 0-7 day period.

Further research on the effect of dichlorvos on bee development was undertaken in late summer of 1991. The object of this series of tests was to investigate bee mortality in relation to dichlorvos rate, treatment time, and number of bee cells treated. Dichlorvos rates of 1x and 4x the recommended rate were utilized, along with controls; all treatments were replicated with

300 and 3,000 bee cells containing healthy bee prepupae. Treated cells were incubated to determine percent adult emergence (Table I).

Table I. Effect of dichlorvos rate, treatment time, and number of bee cells on percent adult emergence (1991b).

Treatment		Percent Emergence	
Dose	Time	300 Bee Rep.	3000 Bee Rep.
Control	-	94.8	93.7
1 X	Day 0-14	3.1	55.2
1 X	Day 7-14	4.2	70.8
4 X	Day 0-14	0.0	24.0
4 X	Day 7-14	0.0	24.0

Emergence was significantly higher in 3,000 bee cell replications than in 300 bee cell replications at both dichlorvos rates, indicating the importance of a minimum critical amount of organic material to normal bee development. As well, percent emergence at the 1x (recommended) rate, was higher in the 7-14 day group than in the 0-14 day group, supporting previous data on the deleterious effect associated with day 0-7 dichlorvos treatment. Evaluation of the contents of unemerged cells indicated that cadavers of pupae and pre-emergent adults exhibited the dichlorvos-related teratogenic phenotype described previously.

Further evidence of this dichlorvos-related effect was found in samples of bee cells submitted by a producer who was concerned about bee development during incubation. Mortality of the type described here was found at levels exceeding 10.0%, and was apparently related to dichlorvos use early in the incubation period and to use of dichlorvos at a level that was too high for the number of bee cells in the incubator.

Work was also done to determine the effect of various dichlorvos treatments in relation to cell position in incubation trays. A comparison of percent adult emergence from cells on the surface of trays and cells from random samples taken from throughout the trays indicated that emergence from cells in the top layer was substantially lower than emergence from cells in random samples, (Table II), presumably due to increased dichlorvos exposure.

Table II. Effect of dichlorvos rate, treatment time, and cell position on percent adult emergence (1991b).

Treatment		Percent Emergence	
Dose	Time	Top Layer	Random Sample
Control	-	96.0	93.7
1 X	Day O-14	28.0	55.2
2 X	Day 7-14	32.0	70.8
3 X	Day 0-14	4.0	24.0
4 X	Day 7-14	12.0	24.0

Research to elucidate the mechanism at work in the area of dichlorvos and its effects on leafcutting bee development is continuing. Alfalfa seed producers are cautioned in use of dichlorvos during leafcutting bee incubation and advised to not exceed the recommended rate and treatment period. Data presented here suggest that even when used at the recommended rate, dichlorvos may cause some degree of leafcutting bee mortality.

The safety to alfalfa leafcutting bee prepupae of fall dichlorvos use for parasite control has also been investigated. Fall dichlorvos use may be necessary either when adult parasites are brought in from the field with filled leafcutting bee nests, or when large numbers of larval parasites pupate and emerge as adults once the nests are in the storage facility. The effect of fall dichlorvos treatment on bee prepupae within cells was examined in 1989/90 and 1990/91.

In the fall of 1989, polystyrene laminate nests consisting of 300 tunnels, were treated at a rate of 0.75 dichlorvos resin strip per 1000 ft^3 (28.3 m^3). Nests were treated for 1, 4, and 7 days; they were then removed and the cells were harvested from the nest laminates. Cocoons from the apex, middle, and base of each tunnel were kept separate for each treatment, stored at 5°C from fall, 1989 through March, 1990, and incubated (100 cocoons from each position within each treatment) to determine percent emergence and mean time to emergence. In 1990, this work was repeated using treatment periods of 1, 4, 7, 14, and 21 days.

Data collected in 1989/90 and 1990/91 experiments on the safety of fall dichlorvos treatment to alfalfa leafcutting bee prepupae indicated no differences in percent emergence or in mean time to adult emergence related to treatment time or tunnel position (Table III) except for a slight increase in time to emergence related to the greater proportion of females in base cells.

Table III. Percent adult emergence and mean time to emergence (days) in various time treatments and at three cell positions in 1989 and 1990 fall dichlorvos tests.

Treatment	Percent Emergence		Days to Emergence	
	1989	1990	1989	1990
Control	94.3	94.0	28.2	23.9
1 Day	97.2	95.4	27.5	24.0
4 Day	100.0	96.4	27.1	23.7
7 Day	98.3	94.6	26.7	24.4
14 Day	-	97.5	-	24.4
21 Day	-	96.3	-	24.3
Apex	95.2	97.1	27.7	23.4
Middle	99.0	98.6	26.7	23.9
Base	98.1	91.4	27.8	25.1

Use of dichlorvos in the fall at a rate of 0.75 dichlorvos resin strip per 1000 ft^3 (28.3 m^3) prior to harvesting of cells appears to be a relatively safe procedure for periods of up to 7 days, and possibly for periods of 14 or 21 days. Caution is advised in the use of dichlorvos resin strips during the fall period; it should be noted that in this study, female longevity and fecundity was not evaluated subsequent to adult bee emergence.

In research to identify possible alternatives to the use of dichlorvos for control of alfalfa leafcutting bee parasites, three compounds were tested for efficacy in control of chalcid parasites and prevention of re-parasitism. These compounds were designated TRO (fatty acids + pyrethrins), INS (fatty acids), and PBO (pyrethrins + piperonyl butoxide); they are formulated to break down rapidly after application. In tests on parasite control, groups of 10 parasitized cells and 100 cells containing viable bee prepupae were mixed, replicated twice, and treated with TRO, INS, or PBO spray daily from day 8-14 during a 21 day incubation period. Untreated and water spray-treated control cells were also included in tests. A parallel experiment to test the effect of each of the compounds on bee development was undertaken with viable bee cells only (n=100). All material was incubated at 30°C/ 40%R.H. Data from combined tests is presented in Table IV.

Table IV. Rate of re-parasitism and adult emergence profile associated with treatment of leafcutting bee cells using experimental spray compounds (1991a).

Treatment	Re-parasitism		Adult Bee Emergence
	Level (%)	Percent Emergence	Days to Emergence
Control	22.0	98.0	23.97
H_2O Spray	64.0	99.0	23.82
TRO Spray	10.0	97.0	24.42
INS Spray	31.0	98.0	24.09
PBO Spray	1.0	96.0	24.73

All three compounds provided control of parasites under laboratory conditions, but residual toxicity to parasites emerging between spray treatments and subsequent re-parasitism was variable; rep-parasitism of bee cells was highest in control groups, but INS also failed to prevent a high level of parasite activity. PBO and TRO both provided excellent control of parasite activity, though control with TRO was more variable.

Data also indicate that spray treatment with TRO, INS, and PBO had no significant effect on pupal development and adult emergence. However, post-emergence monitoring indicated that adults emerging from PBO-treated cells lacked the longevity of adults in other treatments. TRO was therefore chosen for small-scale field tests in June, 1991. Cooperating producers at each of two locations treated approximately 200,000 incubating bee cells with TRO spray once per day beginning on day 7 of incubation. By day 10 of incubation, three spray treatments per day were carried out, but producers found that the residual effect of TRO was not adequate to control parasites emerging throughout the day. Experiments at both locations were terminated and dichlorvos was then used at each site for parasite control.

Two new compounds identified and currently being tested for parasite control and leafcutting bee safety are designated SM-DS (pyrethrins + piperonyl butoxide + N-octyl bicycloheptene dicarboximide) and SM-PY9 (pyrethrins + piperonyl butoxide). These compounds are unique in that they are formulated as pressurized aerosols for use in an automated aerosol dispenser system. The dispenser is calibrated to release a metered dose of formulated compound at regular intervals. A continuous release system may faci parasite control with pyrethrin compounds having a relatively short residual pe residual effect rendered TRO spray non-efficacious in field-scale parasite control previously.

Testing of SM-DS and SM-PY9 compounds has involved spray treatme viable bee cells (n=200) and treatments of mixed groups of 100 viable b parasitized cells. To date, the effect of these two compounds on pupal develo emergence, and their efficacy for control of parasites, has been determined (T experimenation currently underway with these compounds will provide necess on treatment periods and rates prior to field testing in 1992.

Table V. Rate of re-parasitism and adult emergence profile associat treatment of leafcutting bee cells using experimental spray compounds (1991b).

Treatment	Re-parasitism		Adult Bee
	Level (%)	Percent Emergence	Da Eme
Control	28.0	90.6	[illegible]
SM-DS Spray	0.0	92.7	
SM-PY9 Spray	0.0	86.5	

A summary of data from paraformaldehyde research conducted control of microflora in three types of nest material and on bee cell surf VI. These data indicate that paraformaldehyde fumigation at a rate of 20.(control of microflora in all nest materials tested, with overall control leve to 99.0%.

Mould species commonly occurring in leafcutting bee nest mater *alternata*, *Aspergillus niger*, *Eurotium chevalieri*, *Mucor* sp., *Penicilliu* and *Trichoderma citrinoviride*, were virtually eliminated from polystyre by paraformaldehyde fumigation. In polystyrene block and wood lamir mould control was very good except in the case of the *Eurotium/Pen* all nest material with the exception of wood laminates the mould *Rhiz* persistent contaminant, was totally controlled by paraformaldehyde

The most common yeast species associated with leafcutting bee populations, *Trichosporonoides* and *Saccharomyces* spp., were well controlled in all types of nest material. Control of bacterial contaminants (predominantly *Bacillus*, *Corynebacterium*, *Enterobacter*, and *Pseudomonas* spp.) was most efficient in polystyrene nest material.

Table VI. Efficacy of paraformaldehyde fumigation (20.0 g/m³) for control of microflora (combined data from 1988-1990 tests) in leafcutting bee nest material and on leafcutting bee cell surfaces.

Material Treated		N	Mean CFU	Range Min.	Range Max.	(SE)	% CFU Reduction
Poly. Lamin.	Control	40	525.5	4	3501	128.6	-
	Treated	40	5.1	0	44	1.4	99.0**
Poly. Block	Control	8	410.8	43	666	83.8	-
	Treated	8	13.8	1	71	8.3	96.7*
Wood Lamin.	Control	28	410.7	2	3022	128.3	-
	Treated	28	43.8	0	174	9.6	89.3*
Bee Cells	Control	24	888.8	175	2155	133.0	-
	Treated	24	12.8	0	232	9.6	98.6 **

** Reduction significant at $p < 0.001$ level.

* Reduction significant at $p < 0.01$ level.

Observations made in the field in typical tests on bee activity in paraformaldehyde-treated and untreated control nest material indicated that fumigated nest material was clearly acceptable to leafcutting bees. Initial rate of tunnel filling was often higher in paraformaldehyde-treated material. Observations indicated that the proportion of tunnels filled in fumigated material was not significantly different than that filled in control material.

There was no indication of prepupal mortality related to paraformaldehyde treatment of nest material. In fact, percent healthy prepupae was significantly higher in paraformaldehyde-treated nest material than in untreated control nest material (Table VII). Results of incubation tests carried out on healthy prepupae harvested from fumigated and control nest material are also given in the table. Percent adult emergence data was similar between groups of incubated prepupae from fumigated and control nest material at all sites. It was also found that mean adult emergence time profiles for combined males and females were uniform between fumigated and control nest material groups.

It is noteworthy that the paraformaldehyde fumigation technique described here has also been investigated to determine its efficacy for control of chalkbrood (*Ascosphaera aggregata* Skou). This economically damaging fungal disease causes high mortalities in alfalfa leafcutting bee populations in the northwestern United States and in southern Alberta. Collaborative research based on paraformaldehyde fumigation methods developed in Saskatchewan as part of this project was undertaken in 1989 and 1990 with colleagues in Washington and Alberta; this work demonstrated that paraformaldehyde fumigation provides significant control of chalkbrood spores in field and laboratory tests.

Table VII. Mean percent healthy prepupae, mouldy cells, and adult emergence, and time to emergence in leafcutting bee cells harvested from paraformaldehyde-treated and untreated control leafcutting bee nest material.

Nest Material Tested	Healthy Prepupae (%)	Adult Emergence (%)	Mean Time to Emergence (days)
Poly. Laminate			
Control	72.5	87.0	41.6
Treated	82.1 *	89.0	41.0
Wood Laminate			
Control	86.4	99.0	40.0
Treated	90.3 *	98.0	39.7

* Percent healthy prepupae significantly higher ($p < 0.05$ level).

Pheromones: Promising Tools for Pollination Management

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Many crops require bee pollination to set a commercially viable crop but also may be unattractive to bees, suffer competition from other plants attracting pollinators or have poor weather coinciding with the pollination period. A lack of pollinating insects can cause insufficient pollen transfer, resulting in reduced fruit and seed quality or yield.

The use of pheromone sprays shows great promise as a management tool for improving the efficiency and consistency of pollination in many crops that routinely experience pollination problems. To date, the only pheromones with potential for improving crop pollination have been identified from honey bees. Honey bee queens produce a five-component pheromone blend from the queen's mandibular glands that is highly attractive to worker bees at extremely low concentrations. The application of a dilute spray of this pheromone blend can significantly increase the number of honey bees foraging on many crops and can increase crop quality and/or yield, particularly when the number of pollinators foraging on the crop is low. Although application of pheromone attracts more honey bee foragers to many crops, this increased foraging activity results in increased yield in crops or seasons where pollinator activity falls below the threshold required for adequate crop pollination, and pollination enhancement techniques are economically viable when pollinator activity falls below the economic threshold.

Further research into economic pollination thresholds for individual crops is continuing in order to maximize the long term benefits of attractant pheromones to seed yield and quality.

Dr. Currie, who recently joined the staff at the University of Manitoba, will be working on pheromones.

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MEMBERSHIP INFORMATION
YOUR INVITATION TO JOIN THE ALBERTA ALFALFA SEED PRODUCERS' ASSOCIATION
PEACE BRANCH

OBJECTIVES: The Peace Branch exists to enhance cooperation and coordination among all participants in the alfalfa seed industry in the Peace River region of Alberta and British Columbia; and to provide the opportunity to report, exchange and evaluate information pertinent to the production and marketing of alfalfa seed and leafcutting bees.

MEETINGS: The annual general meeting of the branch is held in conjunction with an alfalfa seed production seminar organized by Fairview College. The 12th annual meeting is scheduled for March 19 & 20, 1992. Also, a summer meeting/picnic will be held for all members and their families.

PROJECTS: The Branch conducts an annual chalkbrood survey on leafcutting bee populations in the region and participates in research and technology transfer activities with Agriculture Canada and Alberta Agriculture.

PUBLICATIONS: The Branch publishes two newsletters - in the spring and fall of each year. In addition, an update publication on alfalfa seed production and the results of the chalkbrood survey and quality of cells in the region are published in conjunction with the annual seminar.

MEMBERSHIP: Regular memberships are available to all residents of Alberta and British Columbia. Associate and patron memberships are available to all interested persons.

Detach and Mail
AASPA, PEACE BRANCH MEMBERSHIP APPLICATION 1992
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Name: ______________________________
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Please enrol me as follows:

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