Altai Wildrye: A Seed Production Review

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I. Introduction

Altai wildrye is native to western Siberia and the Altai Mountain region located between Siberia and Mongolia. It was first introduced to Canada in 1934 at the Central Experimental Farm in Ottawa. Agriculture Canada at Swift Current began research with the species in 1950 and lines were distributed to Western Canadian seed growers for multiplication in 1976 (Lawrence, 1983). The grass has two Latin names in common usage; (*Elymus angustus* Trin. and *Leymus angustus* Trin. Pilger). The latter name is gaining prominence at the present time (Dewey, 1983).

There are three classes of pedigreed forage seed production in Canada: Breeder, Foundation, and Certified. Foundation seed is grown from Breeder seed and Certified seed is grown from Foundation seed. The identification tags from the seed bags must be retained for the life of the stand for presentation to the crop inspector (Canadian Seed Growers' Association, 1994).

Pedigreed seed production of Altai wildrye must follow the guidelines for isolation distances and cropping history. Two inspections are required annually for each pedigreed seed lot. The production field must be inspected prior to harvest and the seed must be inspected after harvest. The seed must meet standards for germination, genetic purity, freedom from disease, and absence of the seed of weeds and of other crops. The production of the seed must be pedigreed to be sold as a named variety. The pedigree guarantees to the purchaser the characteristics of the named variety (Canadian Seed Growers' Association, 1994).

Production of Altai wildrye has never grown beyond a small acreage. Murrell (1995) estimated total seed production of Altai wildrye in Saskatchewan at 5 tonnes for 1995. Canadian production for 1995 was estimated at approximately 12 tonne. Pedigreed production in Saskatchewan was only 12 acres in 1996 compared to 64 acres in 1995. The low acreage reflects the difficulty of producing consistent annual seed yields for this crop. There are many desirable qualities for this species, but the combination of a large seed size, difficulty in establishment, and a low seed yield limit the incentive for growers to multiply this species.

II. Description and adaptation

The grass is a long-lived perennial tolerant to cold, drought, and salinity. The plant grows erect producing coarse, erect basal leaves which vary in colour among varieties from light green through blue green to blue. The leaves and stem cure well standing and are well suited to late fall and early winter grazing. The grass is predominantly a bunch grass, but does produce short rhizomes. Seed heads of the plants are 15-20 cm in length borne on coarse, naked stems 60 to 120 cm high. The seed is three times the size of Russian wildrye. Although the seed is relatively large, growth of the seedling is slow and shallow seeding is important for successful establishment of the grass. It is well adapted to loam to clay-loam soils, but grows the best in areas receiving 350 - 450 mm precipitation (Lawrence, 1983, Smoliak et al., 1993). It has been valued for control of salinity due to saline seeps because of its ability to root to a depth of 3-4 m and use water from perched water tables (Lawrence, 1975).

III. Varieties

Several varieties of Altai wildrye are licenced for seed production. Eejay, Pearl, and Prairieland were registered in 1989 (Lawrence et al., 1991a), 1989 (Lawrence et al., 1991b), and 1976 (Lawrence, 1976; 1979), respectively, and are available for seed multiplication. Even though the seed size is large, the relative weight of seed produced per unit area is similar to Russian wildrye.

A. Adaptation

Seed production of Altai wildrye requires relatively dependable rainfall or irrigation to supply an annual precipitation of 450 mm of moisture for consistent seed yields. Without adequate moisture, seed formation may be inadequate to justify the harvest of the seed crop. Under dryland, harvest of the grass as forage or pasture will be needed in drier years to obtain revenue from a grass seed field when it has not set seed (Atkins and Smith, 1967).

Altai wildrye is renowned for its tolerance of salinity and its ability to root very deeply. McElgunn and Lawrence (1973) found that Altai wildrye is comparable to Russian wildrye in emerging from saline soils. Although tall wheatgrass produced more aboveground dry matter at soil salinities greater than 16 mmhos/cm, Altai wildrye produced more root dry matter than all the other grasses in the test.

B. Freedom from weeds

Quality standards for the grass seed market are strict. The field selected for grass seed production must be free of noxious grassy and broadleaf weeds. Presence of noxious weed seeds in the sample disqualifies the seed for market as pedigreed seed. Weeds compete with the grass seed crop, reducing the vigour of the establishing seedling and the yield potential of the stand. A clean weed-free field may be left unattended for several weeks with only minimal weed growth and no appearance of quackgrass or Canada thistle.

Weeds similar in size to Altai wildrye are extremely difficult to separate at the cleaning plant. Quackgrass, Canda thistle, wild oats, bluebur, Persian darnel, and downy brome are a challenge for seed cleaning plants and must not be present in seed production fields. Altai wildrye grown for seed production must be sown on land free of these weeds.

The experience of grass seed growers indicates that three applications of glyphosate over two to three years are required to control quackgrass in a field. Preharvest glyphosate application at 1 liter per acre prior to sowing the grass will control perennial weeds such as quackgrass, Canada thistle, and sow thistle. Quackgrass seeds in the soil may still germinate and reinfest the field. A fallow or partial fallow period prior to seeding provides opportunity to control several flushes of annual broadleaf and grassy weeds.

Prior to seeding the grass, weed control is easily achieved with broad spectrum herbicides and cultivation. Weed control options become limited once the Altai wildryegrass is sown. Selective control of many broadleaf weeds is possible within the grass seed stand, but risk of reduced quality can be avoided and weed control measures simplified if these weeds are controlled before establishment. Selective weed control options for quackgrass are not available for Altai wildrye. The costly alternative is to remove them from the field after sowing by application of appropriate herbicides, spot spraying or hand roguing. The only available option for many weeds is roguing by hand or with a backpack sprayer within the stand.

The grass seed grower must be vigilant to prevent introduction of weeds to the field. Contaminating seed in irrigation water or on equipment will germinate when deposited within the field.

C. Pedigree Requirements

The selected field must have an adequate cropping interval between the seeded crop and a previous crop of the same kind. Altai wildrye planted with Breeder seed for Foundation status must be grown on land which did not grow a non-pedigreed crop of Altai wildrye for any of the preceding five crop seasons. Altai wildrye planted with Breeder seed for Foundation status must be grown on land which did not grow Altai wildrye for the previous three crop years. Altai wildrye planted with Breeder or Foundation seed for Certified status must be grown on land which did not grow Altai wildrye for the previous two years. Manure or other contaminating material should not be applied to the field prior to seeding or during the productive life of the stand (Canadian Seed Growers' Association, 1994).

The grower must notify the Canadian Seed Growers' Association in the year of seeding of the pedigree of the seed planted on the production field and the area and previous cropping history of the production field. A field inspection is required each year that a pedigreed seed crop is to be harvested. The inspection should be completed after the crop has headed, but prior to swathing or harvesting. A field sown with Breeder Altai wildrye seed is eligible for five years of Foundation plus five years of Certified seed production. A field sown with Foundation Altai wildrye seed is eligible for ten years of Certified seed production (Canadian Seed Growers' Association, 1994).

Altai wildrye is cross pollinated. Isolation distances for this species, therefore, are relatively large. Consultation with neighbours and mowing of grassed areas which may host contaminating plants are necessary precautions to safeguard the genetic integrity of the seed field. Foundation and Certified seed crops must be separated from other Altai wildrye plants by at least 300 m and 50 m respectively when the field size is greater than 5 acres. For smaller fields, the isolation distance increases to 400 m and 150 m for Foundation and Certified fields, respectively (Canadian Seed Growers' Association, 1994).

D. Soil fertility

The soil fertility of the seed field should be determined by soil analysis prior to sowing. When sowing Altai wildrye for seed production on fallow or partial fallow, soil reserves of nitrogen are likely adequate to carry the grass until the first fall after seeding. When a stubble field is sown prior to June 1, 20-40 kg N/ha should be applied to dryland fields and 50-80 kg N/ha to irrigated fields.

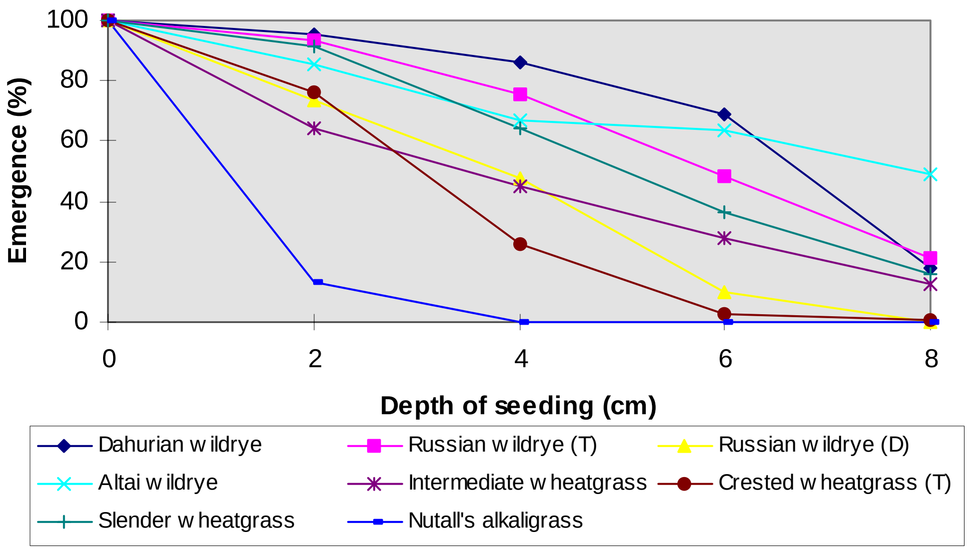
Phosphorus and potassium fertility is best corrected prior to establishment of the crop. Phosphorus enhances the growth rate and vigour of the seedlings. The rate of fertilizer which may be placed safely in the seed row of forage grasses is minimal. Yield responses of grasses to applications of phosphorus and potassium are seldom economical once the stand is established. Fields deficient in phosphorus and potassium should be fertilized at relatively high rates such as 100 kg P205/ha and 100 kg K20/ha banded prior to sowing the grass. A soil testing less than 30 lb extractable P/ac needs phosphorus fertilization. Sulphur levels will be adequate if the field has been adequately fertilized with sulphur for optimum canola production within the last two years. Response of Altai wildrye seed yields to application of sulphur as well as micronutrients has not been documented on the prairies and is highly unlikely due to its extensive rooting system.

IV. Crop establishment

The main objective for the establishment year is to produce a vigorous stand of healthy seedlings which have profusely tillered. A firm seedbed is essential for shallow even placement of the seed. On tilled soil, packing following the last tillage operation will help to firm the soil. Rolling the field with pulse crop roller smoothes lumps and ridges in the field and packs the soil one final time prior to seeding. The roller does increase the risk of soil erosion, however, because it pulverizes the soil and leaves the soil surface in a smooth fine condition. Sowing the field just after the pass with the roller minimizes the risk of soil erosion. Alternately, rainfall prior to seeding firms and moistens the seedbed. Seeding into this rain-settled soil provides a firm seedbed, and excellent seed to soil contact and moisture conditions for the germinating seedling.

Shallow placement and excellent packing of seed are important to achieve a high percentage of germination and emergence of seedlings. Altai wildrye has excellent seedling vigour and emergence from depth. Lawrence et al. (1991) found that Altai wildrye emerged from deep seedings better than Dahurian and Russian wildrye, and the wheatgrasses including slender wheatgrass. Even at a seeding depth of 8 cm, the emergence of Altai wildrye was 49% compared with only 16% for slender wheatgrass (Figure 1).

Figure 1: Emergence of grasses from various depths
(Lawrence et al., 1991)



Redmann and Qi (1991) found that Altai wildrye had the largest caryopsis weight of eight warm and cool season grasses evaluated. Altai also produced a robust root system at depths of 1.5, 3, and 6 cm, although the 3 cm depth was superior to shallower and deeper seeding depths.

Altai wildrye may be sown with any planting equipment which provides shallow seeding and adequate packing. Disk drills with depth bands and press wheels are the most common seeding implement. Some modifications, however, do simplify the seeding operation and reduce the risk of poor establishment. A good grass seed drill has the following features:

1) a packing wheel ahead of the disk opener to level and firm the soil, (for tilled soil)
2) depth control bands on the disk opener to maintain shallow penetration
3) a trailing packer wheel to ensure good seed to soil contact
4) agitation in the seed box to prevent bridging of seed.

Altai wildrye flows relatively well once cleaned to seed standards, but an agitator in the seed box disturbs the grass seed, preventing bridging. Bridging causes inconsistent plant stands and missing seed rows. Filling the seedbox only half full and getting extra help to stir the seed in the seedbox while planting improves seed flow. Some growers place a narrow cylinder over the seed run and fill the cylinder with seed as required to eliminate bridging. Mixing an equal volume of low-nitrogen phosphate fertilizer (12-51-0), cracked wheat, or other non-viable seed with the grass seed will reduce bridging. Unused seed should be separated from the fertilizer as soon as possible after seeding is completed. Fertilizer will absorb hygroscopic moisture from the air over time and increase the moisture content of the seed, reducing the longevity of the seed viability. Using seed coated with a polymer film improves the flow of the seed in the drill and protects the user from any seed treatments which have been applied to control disease organisms. Phosphate fertilizer may also be added to the seed coating to provide available phosphorus to the emerging root as soon as the seed germinates.

Kilcher and Lawence (1970) observed superior emergence of Altai wildrye from depths of 9 cm in the greenhouse at 25$_o$C. Smooth bromegrass, tall wheatgrass, and Russian wildrye did not score as highly as Altai wildrye based on four criteria: days to first emergence, rate of emergence, final emergence, and height after six weeks of growth. Lawrence and Kilcher (1972) found, however, that Altai wildrye emerged at a slower rate at cooler temperatures than tall wheatgrass, smooth bromegrass, intemediate wheatgrass, and Russian wildrye seedlings even though the final emergence was not significantly different. In this experiment, air temperature was maintained at 20oC while soil temperature was held constant at 10oC, 15oC, and 20oC by temperature controlled water baths. Altai wildrye seedlings increased their rate of growth at a slower rate compared to other seedlings as the soil temperature increased. The rate of tillering in Altai wildrye actually decreased as soil temperature increased. The authors concluded that delaying seeding until the soil is warmer is advantageous for Altai wildrye. Soil fertility had no impact on seedling emergence for all of the tested species. The total dry matter yield of Altai wildrye grown at a soil temperature of 10oC, however, was reduced by the application of nitrogen fertilizer. The same rate of nitrogen increased dry matter yields by 92% over the control when a high rate of phosphate was also applied. McElgunn (1974) observed a sharply reduced germination rate for Altai wildrye when germinating under a temperature regime with alternating 12 hour periods of 2oC and 13oC compared to the other temperature patterns tested. Increasing the daily minimum and maximum temperatures by only 2oC improved seed germinaton from 5% to 88%. Romo (1990) tested the effect of a number of environmental scenarios on the germination and establishment of Altai wildrye. He found that subjecting moistened seeds to freezing temperatures for a short period sharply decreased the seed's capacity to resist external water stress. Subjecting the moistened seeds to drying for short period, however, improved the germination of the seeds. Romo (1990) agreed with Kilcher and Lawrence (1970) and McElgunn (1974) that delaying seeding until the soil warms enhances the rate of germination, emergence, and seedling growth of Altai wildrye. This strategy also circumvents the risk of reduced germination from freezing temperatures. The desirable seedbed for Altai wildrye would minimize temperature fluctuations which damage seed vigour. Suitable conditions include relatively rough seedbeds and direct seeding into cereal stubble because soil temperature would fluctuate less compared to smooth or black soil surfaces. Sowing stands during early or warmer springs may overcome establishment difficulties.

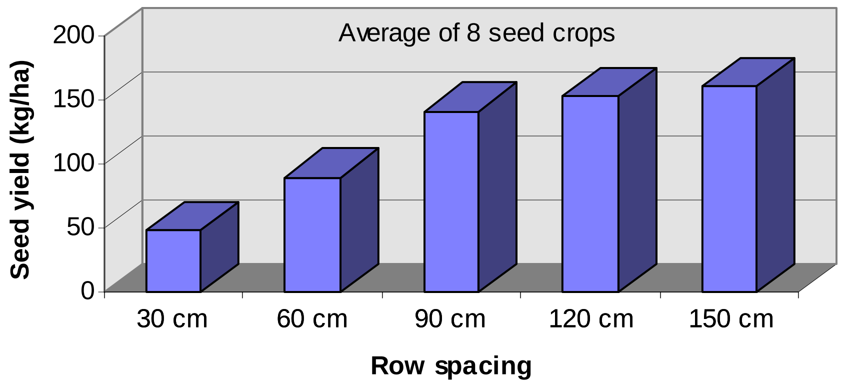
The effect of extracts from roots of various plants on the germination of grasses was studied by Lawrence and Kilcher (1962). Altai wildrye had a relatively high germination (46%) when soaked in alfalfa root extract compared to other grasses (1-16%). Dandelion root extracts, however, had a large inhibitory effect on the germination of Altai wildrye.

No experiments have been conducted evaluating the effect of companion cropping on seed yields of Altai wildrye. The mediocre seedling vigour of Altai wildrye suggests that it is a poor candidate for companion establishment.

Row planting of grass seed fields provides a number of benefits. Planting in wider-spaced rows reduces the seed requirements which reduces input costs. The stands can be tilled with a row crop cultivator or gang rototiller to control weeds. Seed yields will be higher, especially as the stand ages. Roguing of the field is more thorough and easier (Patterson et al., 1956). Row production of grass seed under dryland conditions reduces the risk of lower seed yields due to drought (Knowles et al., 1969).

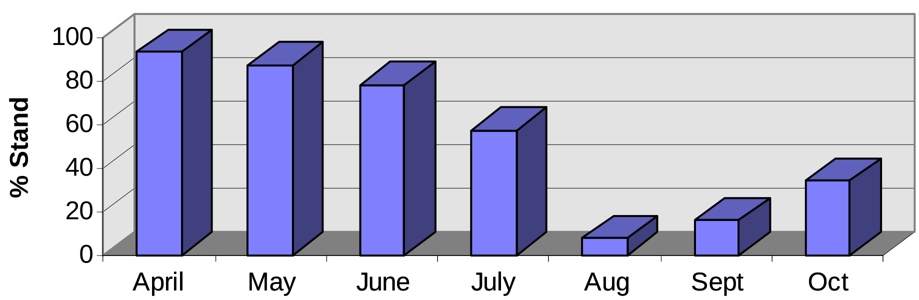
Lawrence (1980) found that seed yields of Altai wildrye under dryland are higher when sown in wider spaced rows. Minimum row spacing for seed production was 90 cm. Seed yields began to level off with a 120 cm row spacing. Over an eight year period, the relative seed yield for the 120 cm row spacing ranged from 200 to 800% compared to the 30 cm row spacing. The advantage for the wider row spacing increased with the age of the stand.

Figure 2: Effect of row spacing on seed yield of Altai wildrye (Lawrence, 1980)



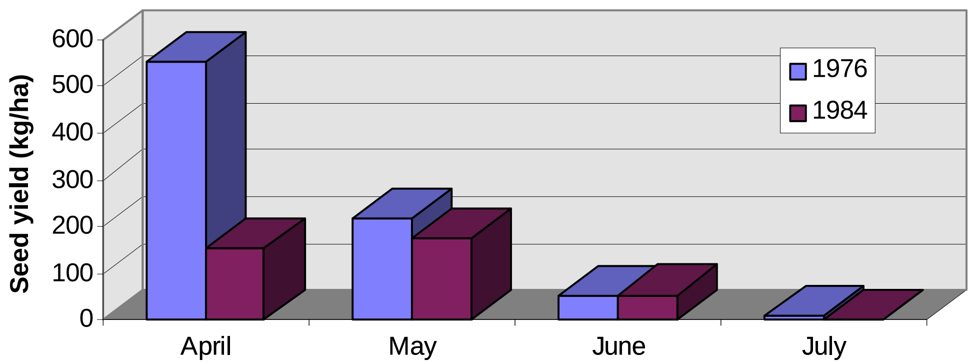
Seeding date has a major impact on the first seed year yields. Altai wildrye is similar to Russian wildrye with regard to the juvenile period required for seed production. Lawrence et al. (1990) oberved a thermal requirement of 1500oC for the juvenile period based on a 4oC base temperature. First year seed yields drop sharply for seedings later than early May. In one irrigated experiment, late fall or early spring (prior to May 1) seedings produced the highest seed yields after a full year of establishment. A second irrigated experiment conducted in 1984 achieved satisfactory stand establishment only for April to June seedings. Stand establishment dropped sharply during the month of June to less than 60% in July. The best seed yields in this trial were obtained with early spring seedings.

Figure 3: Effect of seeding date on stand establishment with irrigation at Swift Current (Lawrence et al., 1990)



The goal for the seeding rate is to sow enough seed to achieve a satisfactory stand without too much inter-plant competition. Seedlings which are vigorously tillering will produce a higher seed yield. Seeding during opportune conditions is better than seeding at a higher rate to compensate for a higher rate of seedling mortality due to sowing too deeply.

Figure 4: Effect of seeding date on yield of first seed crop of Altai wildrye (Lawrence et al., 1990)



The simplest means of calibration of the seeding implement is to count the number of seeds per unit distance sown by the drill when driven over a plywood sheet or concrete pad. Holzworth and Wiesner (1993) recommend a rate of 22 seeds/foot (72 seeds/m) for a 90 cm row spacing. The average kilogram of Altai wildrye seed contains 121,000 seeds (Lawrence, 1983). On a 90 cm row spacing, one hectare contains 11,111 meters of seed row. At 72 seeds/m, this seeding rate approximates 6.6 kg/ha (5.8 lb/ac).

V. Crop Management

Clipping or mowing weeds is an effective strategy for control of annual weeds. The weeds should be mowed as required to prevent them from setting seed. When the soil is not disturbed, most weed seeds do not germinate. After the grass crop becomes established, fewer weeds will germinate in the seed production years.

Herbicide registrations for the control of weeds during the seedling year provide only a few control options for annual grassy and broadleaf weeds. Several herbicide treatments hold promise for the control of weeds in the Altai wildrye seed field during the establishment year (Malik, 1991). The most difficult weeds to control include quackgrass, downy brome, green foxtail, and Persian darnel. Control measures for annual grasses during a seed production year would reduce the requirement for roguing. Refer to Table 1 for currently registered treatments.

Table 1: Herbicides registered for use on Altai wildrye

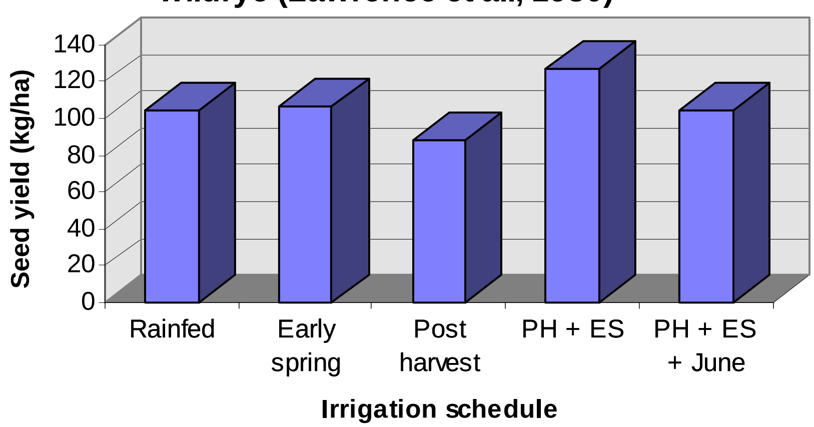
Altai wildrye	Lontrel	2,4-D Amine		MCPA Amine	
Ball mustard		X	X		
Burdock		Seedling		Seedling	
Canada thistle	X				
Cocklebur		X	X		
Comon ragweed			X	X	
False ragweed		X	X		
Flixweed		X	X		
Goat's beard		Seedling		Seedling	
Great ragweed		X	X		
Hare's ear mustard			X	X	
Indian mustard		X	X		
Kochia	X	X			
Lamb's-quarters			X	X	
Narrow leaved hawk's beard				X	X
Perennial sow-thistle		Topgrowth			
Plaintain		X	X		
Prickly lettuce		X	X		
Russian pigweed			X	X	
Scentless chamomile		X			

Shepherd's purse		X	X
Stinkweed	X	X	
Sunflower	X	X	
Sweet clover	X	X	
Tumble mustard		X	X
Wild buckwheat	X		
Wild mustard	X	X	
Wild radish	X	X	
Wormseed mustard		X	X

Field roguing is a requirement for production of quality grass seed for the Canadian market. The chaffy grasses such as Altai wildrye have no tolerance for primary noxious weeds such as quackgrass, Canada thistle, cleavers, and wild mustard. Unthreshed wild mustard seeds are often retained in the beak which are difficult to clean out of a chaffy grass sample. Wild oats, Persian darnel, scentless chamomile, shepherd's purse, stickseed, and stinkweed are secondary noxious weeds which are limited to 4 and 10 seeds in 25 g for Canada Certified No. 1 and No. 2 grades respectively. Any of these weeds which appear in the stand must be eradicated before the field is inspected. Although downy brome is not listed as a noxious weed, some customers will not purchase seed containing this weed. The weedy plants may be uprooted manually by hoe or hand-pulling. Roundup is an effective herbicide for controlling perennial weeds in grass seed stands, but it must be applied by spot treatment directly on the target weeds to prevent injury to the grass seed crop.

Altai wildrye has a high moisture requirement (Morrow and Power, 1979), but seed production was not responsive to irrigation. Lawrence et al. (1980) applied five irrigation regimes to an Altai seed stand: 1) rainfed, 2) early spring, 3) after seed harvest, 4) after seed harvest and early spring, and 5) after seed harvest, early spring, and mid June. Each irrigation applied 10 cm of water by sprinkler irrigation. Although the seed yields averaged over five seed harvests were highly variable and not significantly different among these treatments, the highest seed yield among the treatments was observed for the after harvest and early spring irrigation regime. The single irrigation after harvest treatment produced the lowest seed yield.

Figure 5: Effect of irrigation schedule on seed yield of Altai wildrye (Lawrence et al., 1980)



VI. Harvest

Grasses need about 30 days after flowering for the seeds to develop. Hot, dry weather shortens the ripening period while cool, moist conditions will delay seed maturity (Tober, 1988). Grasses grown under irrigation or moister conditions have a higher ash content which increases the likelihood of shattering (Najda et al., 1994). The ripening process begins at the top of the seed head and proceeds down the stem. Seeds at the top of the head may begin to shatter while those at the bottom are only starting to fill seed. Frequent inspection of the seed field is necessary to determine when the maximum yield of seed will be harvested.

The appropriate harvesting approach depends on the seed size, plant height, maturity, shattering traits, seed head abundance, seed fill, and moisture content (Tober, 1988). Conventional harvest equipment is suitable for harvest of Altai wildrye. Although Altai wildrye shatters less readily than Russian wildrye, swathing just above the leafy basal growth and threshing with a combine several days later is recommended by Lawrence (1983). Tober (1988), on the other hand, recommends direct combining as the preferred harvest method. Windrowing of Altai wildrye introduces two difficulties. First, the seed shatters readily once the crop has matured to the firm dough stage even while lying in the swath. Second, recovery of the swath from fields sown with a wide row spacing is difficult to impossible (Lawrence, 1960). The crop is ready to swath in mid to late July when the seed is in the firm dough stage (Lawrence, 1977), and the moisture content of the head drops to 40-45% (Najda et al., 1994). No liquid is left in the seed at this stage of development and some pressure is required to imprint the seed. The straw will be just turning golden yellow at this time. Swathing early in the morning or in the evening when the air humidity is higher reduces shattering losses. If the heads are laid in the center of the swath instead of to the side, some of the shattered seeds will be retained on the top of the swath (Najda et al., 1994).

Under good drying conditions, the crop will be ready to combine in 4-7 days. Initial combine settings recommended for Altai wildrye are a cylinder speed of 750 rpm with a concave clearance of 3/8". The fan speed is generally set between 400-500 rpm with the sliding covers over the exterior fan housing open approximately 5 cm (Tober, 1988). Lawrence (1983) prefers rub-bar cylinders over tooth types because they do not break up the straw as much. The sieves should be set at 1/3 to 1/2 open. Direct the air toward the front of the sieves. Reduce the speed of the pickup to reduce shattering losses. Because of the potential for contamination and the value of grass seed, thoroughly clean the combine prior to harvesting. Maintain an even flow of material into the combine. Grass seed crops often require a slower forward speed than conventional crops. Slower combining speeds improve the seed separation from the chaff and straw and greatly reduce losses over the straw walkers and sieves (Najda et al., 1994). The seed can be stored safely in open storage up to one year when the moisture content is 10-12%. Mold growth and insect damage may still occur at this moisture content. The safe moisture content for open storage of grasses for longer periods is 8-10% (Harrington, 1960).

Seed that is direct combined will need immediate aeration and drying to maintain the quality of the seed. Many of the short stems that remain in the sample have a high moisture content which promote heating of the seed. Some grass seed growers install an aeration tube directly into their grain truck so that the seed can be easily aerated without dumping into a storage bin. Running the seed over a sieve to remove much of the chaff and straw will reduce the risk of heating in direct combined seed. If the seed is left in a small pile for only a few hours, significant heating may still occur which reduces the viability of the seed. The heating is dependent on the moisture content of the seed, the air temperature, and the position of the seed in the pile. Air temperature is less important as the moisture content of the seed increases, but is significant at lower moisture contents (DeWitt et al., 1962).

The drying of grass seeds must be conducted with care to maintain the viability of the seed. Most direct combined grass seed will range between 20 -40% moisture. The bulk density of grass seeds is often 1/3 to 1/5 that of cereals. When the seed has a high moisture content, the temperature of the air flow must be maintained low enough to prevent injury to the germination of the seed. The resistance of the seed to germination injury from high temperatures increases as the moisture content of the seed decreases (Grabe, 1957).

VII. Post harvest management

1. Residue management

The removal of straw and stubble from Altai wildrye seed fields is an important step in maintaining the seed productivity of the stand. Lawrence and Lodge (1975) grazed the aftermath stubble of Altai wildrye seed stands with cattle. Seed yields averaged over 5 production years were increased from 70 to 109 kg/ha by fall grazing. Lawrence (1973b) found that clipping the aftermath stubble with a rotary mower soon after seed harvest each fall increased the average seed yield of Altai wildrye over a 6 year period from 34 kg/ha to 62 kg/ha. Close examination of the plots showed absence of any aboveground mesocotyl formation in clipped plots while unclipped plots showed elevation of the growing points above ground level. The development of long mesocotyls above the soil surface predisposes the primordial seed heads to winter injury. Lawrence (1973a) found that stands cut in mid-September for hay could be cut or grazed until early May without jeprodizing that year's seed production. Seed yields were higher for the early spring cutting treatment as compared to the control where no spring cutting was permitted.

2. Fertilization

Lawrence et al. (1980) fertilized an irrigated trial at Swift Current for five years with up to 400 kg N/ha applied post-harvest as 34-0-0. Seed yields were not responsive to different rates or times of nitrogen application.

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VIII. References

Atkins, M.D. and Smith, J.E. Jr. 1967. Grass seed production and harvest in the Great Plains. U.S.D.A. Farmer's Bull. 2226. USGPO, Washington, DC.

Canadian Seed Grower's Association. 1994. Regulations and procedures for pedigreed seed crop production. Circular 6-94. Ottawa, Ont.

DeWitt, J.L., Canode, C.L., and Patterson, J.K. 1962. Effects of heating and storage on the viability of grass seed harvested with high moisture content. Agron. J. 54:126-129.

Dewey, D.R. 1983. Historical and current taxonomic perspectives of {uAgropyron}, {uElymus} and related genera. Crop Science 23:637-642.

Harrington, J.F. 1960. Thumb rules of drying seed. Crops and Soils 13(Oct.):16-17

Grabe, D.F. 1957. Artificial drying and storage of smooth bromegrass seed. Agron. J. 49:161-165.

Holzworth, L.K. and Wiesner, L.E. 1990. Principles of establishment and seedling year management, pp. 170-228. In Baldridge, D.E. and Lohmiller, Montana interagency plant materials handbook. Mont. State Ext. Bull.#EB69.

Kilcher, M.R. and Lawrence, T. 1970. Emergence of Altai wild ryegrass and other grasses as influenced by depth of seeding and soil type. Can. J. Plant Sci. 50:475-479.

Knowles, R.P., Cooke, D.A. and Elliott, C.R. 1969. Producing certified seed of bromegrass in Western Canada. Can. Dept. of Agr. Publication #866, The Queen's Printer, Ottawa, Ontario.

Lawrence, T. 1960. Quality of Russian wild ryegrass seed as influenced by time and method of harvesting. Can. J. Plant Sci. 40:474-481.

Lawrence, T. 1973a. Control of seed culm formation in Altai wild ryegrass by spring cutting. Can. J. Plant Sci. 53:549-550.

Lawrence, T. 1973b. Seed yield of Altai wild ryegrass as influenced by aftermath removal. Can. J. Plant Sci. 53:545-546.

Lawrence, T. 1975. Comparison of root penetration of Altai wild ryegrass and Russian wild ryegrass. Can. J. Plant Sci. 55:851-852.

Lawrence, T. 1976. Prairieland, Altai wild ryegrass. Can. J. Plant Sci. 56:991-992.

Lawrence, T. 1977. Altai wild ryegrass. Agr. Can. Publ.#1602/E

Lawrence, T. 1979. Registration of Prairieland Altai wild ryegrass. Crop Sci. 19:296.

Lawrence, T. 1980. Seed yield of Altai wild ryegrass as influenced by row spacing and fertilizer. Can. J. Plant Sci. 60:249-253.

Lawrence, T. 1983. Altai wild ryegrass. Agr. Can. Publ.#1983-3E

Lawrence, T., Jefferson, P.G. and Ratzlaff, C.D. 1991a. Eejay, Altai wild ryegrass. Can. J. Plant Sci. 71:551-553.

Lawrence, T., Jefferson, P.G. and Ratzlaff, C.D. 1991b. Pearl, Altai wild ryegrass. Can. J. Plant Sci. 71:547-549.

Lawrence, T. and Kilcher, M.R. 1962. The effect of fourteen root extracts upon germination and seedling length of fifteen plant species. Can. J. Plant Sci. 42:308-313.

Lawrence, T. and Kilcher, M.R. 1972. Emergence, seedling growth, and yield of Altai wild ryegrass and other grasses as influenced by soil temperature and fertility. Can. J. Plant Sci. 52:795-800.

Lawrence, T., Korven, H.C., Winkleman, G.E., and Warder, F.G. 1980. The productivity and chemical composition of Altai wild ryegrass as influenced by time of irrigation and time and rate of N fertilization. Can. J. Plant Sci. 60:1179-1189.

Lawrence, T. and Lodge, R.W. 1975. Grazing seed field aftermath of Russian wild ryegrass, Altai wild ryegrass and green needlegrass. Can. J. Plant Sci. 55:397-406.

Lawrence, T., Ratzlaff, C.D. and Jefferson, P.G. 1990. Effect of seeding date on stand establishment, seed and forage yield of Altai wild ryegrass. Can. J. Plant Sci. 70:727-730.

Lawrence, T., Ratzlaff, C.D. and Jefferson, P.G. 1991. Emergence of several Triticeae range grasses influenced by depth of seed placement. J. Range Mgt. 44:186-187.

Malik, N. 1991. Altai wild ryegrass yield response to herbicides applied during establishment. Can. J. Plant Sci. 71:115-125.

McElgunn, J.D. 1974. Germination response of forage grasses to constant and alternating temperatures. Can. J. Plant Sci. 54:265-270.

McElgunn, J.D. and Lawrence, T. 1973. Salinity tolerance of Altai wild ryegrass and other forage grasses. Can. J. Plant Sci. 53:303-307.

Morrow, L.A. and Power, J.F. 1979. Effect of soil temperature on development of perennial forage grasses. Agron. J. 71:7-10.

Murrell, D. 1995. Grass seed production statistics. Sask. Ag. and Food, Prince Albert, SK.

Najda, H., Lopetinsky, K., Bjorge, M., and Witbeck, B. 1994. Harvesting grass seed. Agri-fax: Field crops. Agdex 127/50-1. Alta. Ag., Food and Rural Dev., Edmonton, AB.

Patterson, J.K., Schwendiman, J.L., Law, A.G., and Wolfe, H.H. 1956. Producing grass seed in Washington. Wash. State Univ. Coop. Ext. Serv. Publ # 41, Pullman, WA

Redmann, R.E. and Qi, M.Q. 1991. Impacts of seeding depth on emergence and seedling structure in eight perennial grasses. Can. J. Bot. 70:133-139.

Romo, J.T. 1990. Stratification, freezing, and drying effects on germination and seedling growth of Altai wildrye. J. Range Mgt. 43:167-171.

Smoliak, S., Ditterline, R.L., Scheetz, J.C., Holzworth, L.K., Sims, J.R., Wiesner, L..E., Baldridge, D.E., and Tibke, G.L. 1990. Plant species, pp. 9-169. In Baldridge, D.E. and Lohmiller, Montana interagency plant materials handbook. Mont. State Ext. Bull.#EB69.

Tober, D.A. 1988. Methods and timing of grass seed harvest, pp. 4:1-9. In Johnson, J.R. and Beutler, M.K., Proceedings of Northern Plains Grass Seed Symposium, South Dakota State University Research and Extension Center, Rapid City, SD.