Russian Wildrye Seed Production: A Literature Review

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I. Introduction

Russian wildrye is a perennial bunchgrass native to a large area of Central Asia from the dry, saline steppes of Iran to Western Siberia and on to Outer Mongolia. The grass was introduced to the Canadian prairies from Siberia by the University of Saskatchewan in 1926 and after testing, was distributed from the Swift Current Research Station to seed growers in 1949. In Latin, the grass has two names which have been in common usage: Elymus junceus, and Psathyrostachys junceus; the latter name is gaining more prominent acceptance at the present time.

The grass has an erect naked stem rising above an abundance of basal leaves, but seed stalks seldom form when grown in solid seedings. This growth habit provides good grazing for livestock during early spring and summer as well as during late summer and early fall. The grass has rapid regrowth potential and responds quickly to summer or fall rains. The seed head is a dense spike which readily shells the seed as it matures. The size and shape of the seed is similar to the standard type of crested wheatgrass. Russian wildrye is more difficult to grow successfully than crested wheatgrass, however, because the germination and establishment of the seedling is markedly slower.

Pedigreed seed production of Russian wildrye must follow the guidelines for isolation distances and cropping history. The production field must be inspected prior to harvest. After harvest, the seed must meet standards for germination, genetic purity, freedom from disease, and absence of the seed of weeds and 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 (Bolton, 1985).

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 tags from the seed bags must be retained for the life of the stand for presentation to the crop inspector (Canadian Seed Grower's Association, 1994).

II. Varieties

Russian wildrye was grown for pedigreed seed production on less than 100 hectares in Saskatchewan in 1994. In terms of grass seed production area, Russian wildrye ranked eighth this year. Only the varieties Swift and Mayak were grown as pedigreed seed in the province. Four varieties are registered for forage production: Swift, Mayak, Cabree, and Tetracan (Tremblay, 1994).

III. Field Selection

A. Adaptation

Russian wildrye is adapted to loam and clay soils in all regions of the province. Because of the slow germination and establishment of the grass, it is very difficult to obtain adequate stands on sandy soils. The seedlings frequently do not develop adequate rooting in light textured soils before the soil dries (Lawrence and Heinrichs, 1977). The grass develops an extensive fibrous root system which confers exceptional tolerance to cold and drought. Seedling and two year old stands of Russian wildrye survived prolonged drought the best relative to intermediate wheatgrasses, Altai wildrye, western wheatgrass and green needlegrass (Currie and White, 1982). Russian wildrye also has relatively high salinity tolerance (Rauser and Crowle, 1963). In a controlled growth chamber experiment (McElgunn and Lawrence, 1973), the grass ranked fourth in seedling emergence in moderately and severely saline soil behind tall wheatgrass, Altai wildrye, and bromegrass. In very severely saline soil (E.C. > 16), Russian wildrye ranked second in emergence and third in herbage yield among the six grasses tested. At this level of salinity, all grasses had less than 50% emergence. As the stand ages, the salinity tolerance of Russian wildrye relative to other grasses increases (McKenzie and Najda, 1994). Russian wildrye will tolerate 3-5 weeks of flooding as a seed, seedling, or an established plant (McKenzie, 1951).

B. Cleanliness

The field selected for grass seed production must be free of noxious perennial grassy and broadleaf weeds. A clean weed-free field may be left unattended for several weeks with only minimal weed growth. When the field is free of quackgrass or Canada thistle, it may be left untilled for an entire season without the appearance of quackgrass or Canada thistle. Presence of noxious weed seeds in the sample disqualify the seed for market as pedigreed seed. Special weed concerns for pedigreed Russian wildrye seed production include wild oats, quackgrass, and other grasses. Because these seeds cannot be separated from the seed of Russian wildrye, it is imperative to sow this crop for seed production on land which is free of these weeds or to remove these plants from the field by application of appropriate herbicides or roguing. Presence of other weeds will also reduce the yield potential of the stand. Heavy weed pressure will weaken the new seedling, lower seed yields and may, through competition, eliminate the seedling from the stand (Dodds et. al., 1987).

Prior to seeding the grass, weed control is easily achieved with broad spectrum herbicides and cultivation. Weed control options become severely limited once the Russian wildrye is sown. The only remaining option for many weeds may be roguing by hand or with a backpack sprayer within the stand which is very time consuming and costly.

Achieving this degree of sanitation may require one to two years of planning. Eradication of quack grass is essential prior to seeding any grass. Glyphosate application at 1-2 liters per acre in the fall prior to sowing the grass will control perennial weeds such as quackgrass, Canada thistle, and sow thistle. A fallow or partially fallow field provides opportunity to control several flushes of annual broadleaf and grassy weeds prior to seeding.

C. Pedigreed Requirements

The selected field must have an adequate cropping interval between the seeded crop and any previous crop of the same kind. Russian wildrye planted with Breeder seed for Foundation status must be not be grown on land which grew a non-pedigreed crop of the Russian wildrye or a crop of a different variety of Russian wildrye for any of the preceding five crop seasons. Crops planted with Breeder seed for Foundation status must not be grown on land which grew the same variety of Russian wildrye for the previous three crop years. Crops planted with Breeder or Foundation seed for Certified status must not be grown on land which grew a crop of Russian wildrye in either of the two preceding 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 Russian wildrye seed is eligible for five years of Foundation and five years of Certified seed production. A field sown with Foundation Russian wildrye seed is eligible for ten years of Certified seed production (Canadian Seed Growers' Association, 1994).

Russian wildrye is a cross-pollinated species. To maintain genetic purity and insure that no contaminating pollen has pollinated the seed crop, adequate isolation from other sources of pollen must be observed. For fields larger than 5 acres in size, Foundation and Certified seed crops must be separated from other Russian wildrye by at least 300 m and 50 m respectively. For fields less than 5 acres, the isolation requirement increases to 400 m and 150 m respectively (Canadian Seed Growers' Association, 1994).

D. Soil fertility

The soil fertility of the grass seed field should also be evaluated when selecting the field. The easiest time to address phosphorus and potassium fertility problems is prior to sowing the Russian wildrye. Responses of Russian wildrye seed yields to applications of phosphorus and potassium are seldom economical once the stand is established. Correction of phosphorus and potassium deficiencies prior to seeding, however, will enhance the growth rate of the seedlings and improve the vigour of the young plants. The rate of fertilizer which may be placed safely in the seed row of forage grasses is minimal. Fields which are deficient in phosphorus and potassium should be fertilized at relatively high rates such as 50 kg P205/ha and 50 kg K20/ha prior to sowing the grass. Nitrogen at a rate of 20-40 kg/ha should also be applied to stubble fields prior to sowing if the field will be sown before June 1. This is required when the field is managed under zero tillage. When sowing Russian wildrye on fallow or partial fallow, soil reserves of nitrogen will most likely be adequate to carry the grass for the first seed crop. 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 Russian wildrye seed yields to application of micronutrients has not been investigated. The level of available nutrients, however, is easily checked by submitting a soil sample for analysis.

E. Moisture requirements

Seed yields of grasses vary with moisture conditions; therefore, irrigation or relatively dependable rainfall to supply 35-50 cm of moisture are essential for consistent grass seed yields. Without adequate moisture, seed head formation may be insufficient to justify the harvest of the seed crop. Under dryland, harvest of the grass as forage or pasture may be necessary in drier years to obtain revenue from a grass seed field when it has not set sufficient seed (Atkins and Smith, 1967).

IV. Crop establishment

Russian wildrye may be sown with any conventional planting equipment if shallow seeding and adequate packing are achieved. Although air seeder cultivators and hoe drills have successfully established Russian wildrye, disk drills are the most common seeding implement. Some modifications to conventional equipment will simplify the seeding operation and reduce the risk of poor establishment. The addition of depth control bands to disks and agitators in the seed box relieve many of the difficulties associated with seeding Russian wildrye. Zero tillage implements have also successfully established Russian wildrye. A good grass seed drill has the following features:

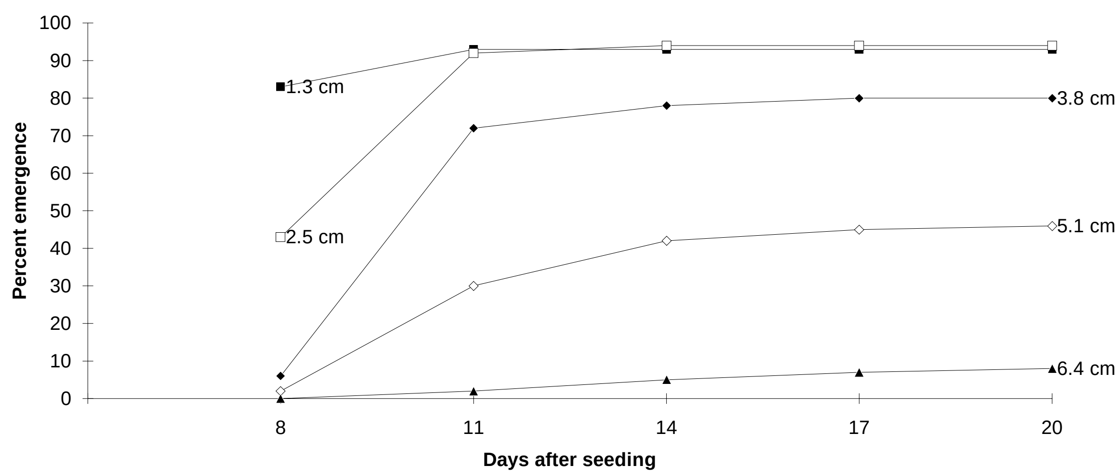
1) a packing wheel ahead of the disk opener to level and firm the soil, (for tilled soil)
2) depth control bands on the disk opener to maintain shallow penetration
3) a trailing packer wheel to ensure good seed to soil contact
4) agitation in the seed box to prevent bridging of seed.

A firm seedbed is essential for shallow placement of the seed. Packing following the last tillage operation will help to firm the soil. Some grass seed producers roll their fields before seeding to improve control of seeding depth. A rainfall following the final tillage operation will also prepare a firm and moist seedbed for placement of the grass seed.

Russian wildrye has a light chaffy seed which will readily bridge in the seed cups. This bridging causes inconsistent plant stands and missing seed rows. Agitators in the seed tank to disturb the grass seed will prevent bridging of the seed. Filling the seedbox only half full and getting extra help to mix the seed in the seedbox while planting will overcome this difficulty if agitators have not been installed in the seedbox. Using seed coated with a polymer film will improve the flow of the seed in the drill and will protect the user from any seed treatments which may be added to control disease organisms. Another helpful approach is to mix an equal volume of low nitrogen fertilizer (e.g. 12-51-0), cracked wheat, or cereal grain with the seed. 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. The increase in moisture content of the seed will decrease its viability. Senter et al. (1975) found that the germination of three grass species was reduced if the seed was in contact with a 20-20-0 blended fertilizer for more than nine days under humid conditions. The blend contained 57% ammonium nitrate (33.5-0-0), 38% super phosphate (0-46-0), and 5% ammonium phosphate (18-46-0). When the fertilizer was stored with the seeds under dry conditions, no decline in germination of any species was observed after 24 days of storage. Ahlgren et al. (1950) observed no difference in germination between bromegrass seed alone and bromegrass mixed with 18% super phosphate or fertilizer blends of 5-10-5 and 10-10-10 when the samples were stored in cloth bags at a temperature ranging between 7-13oC over a period of four months. The germination of the bromegrass seed in all treatments dropped below 80% germination after six months of storage in contact with the fertilizer. After fifteen months of storage, the bromegrass seed in contact with the blended fertilizers had little germinative seed, while the bromegrass in contact with the 18% super phosphate had germination equal to the seed stored without fertilizer. Fertilizers with low water solubility can be safely mixed with bromegrass seed for periods up to 3-4 weeks without injuring the germination of the seed if the mixture is stored under dry conditions.

Shallow placement and excellent packing of seed is important to achieve a high percentage of germination and emergence of seedlings. Control of the seeding depth is critical to successful establishment of the Russian wildrye stand. As the seeding depth increases, the time required for the seedling to emerge from the ground increases and the percentage that emerge decreases (Figure 1).

Figure 1: Effect of seeding depth on rate of emergence of Russian wild ryegrass seedlings (McKenzie et al., 1946)

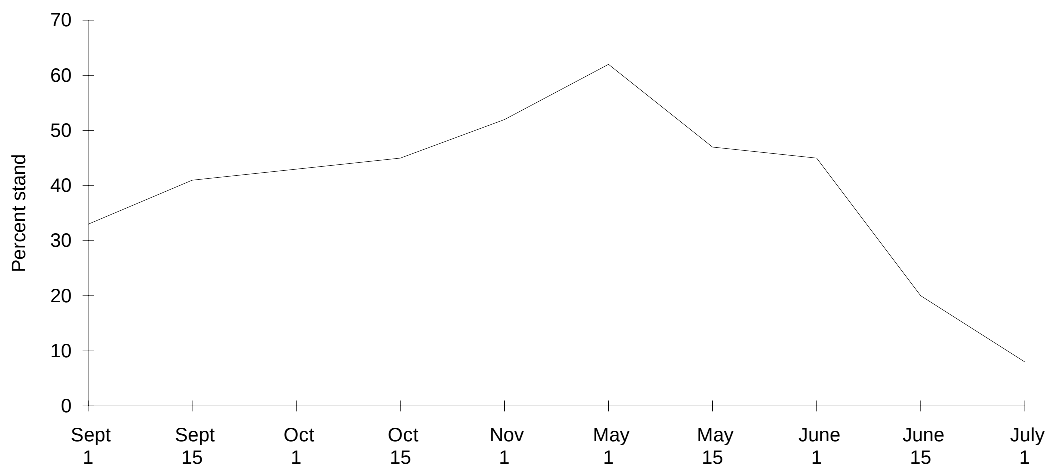


The main objective for the establishment year is to produce a vigorous stand of healthy seedlings which have profusely tillered. For sowing on well-prepared fallow or for zero tillage establishment, the best establishment is obtained with early spring seedings. McElgunn (1974) showed that Russian wildrye is sensitive, however, to planting in cold soils. For a temperature regime which alternates between 2oC and 13oC, the germination rate was only one fourth as high as for other warmer regimes. Delaying seeding until the minimum temperature has risen above 4oC will improve the germination of Russian wildrye. On the other hand, seed yields of

Russian wildrye are reduced when seeding is delayed past early spring. Research at Beaverlodge and Mandan, North Dakota indicates that Russian wildrye should be sown prior to May 23 for a satisfactory seed yield with the first crop harvest (Elliott, 1972; Schaaf, 1961). Schaaf observed poor seed yields for the first and second seed crop with late summer and fall seedings of Russian wildrye under poor moisture conditions.

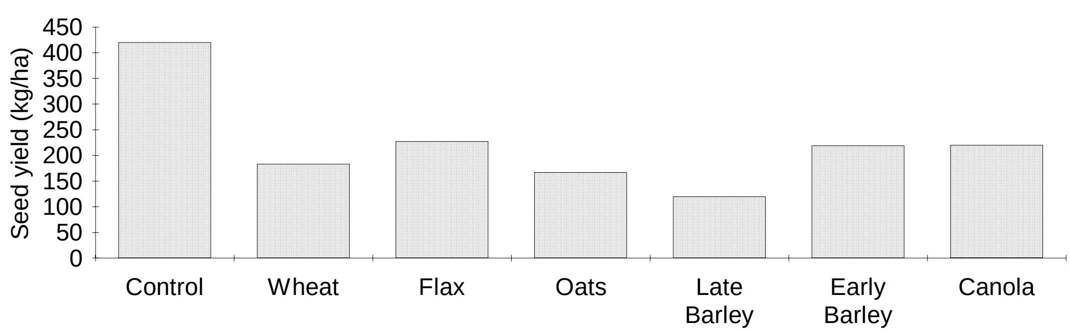
Delayed seeding increases the risk of poor emergence if weather conditions are unfavourable. Soil crusting may impede seedling emergence if a heavy rain shower is followed by intense sunshine. Desiccation of emerging seedlings readily occurs if the weather is hot and dry. Based on percent seedling stand for seedings intended for forage, Kilcher (1961) concluded that Russian wildrye could be sown anytime from September 1 until freeze-up or from first thaw until May 15. Late spring seedings produced stands with unacceptable seedling establishment (Figure 2).

Figure 2: Effect of seeding date on seedling stand of Russian wild ryegrass over five years of seeding at Swift Current (Kilcher, 1961)



Seed production of grasses is higher when no companion crop is sown with the grass seed. The seedlings grow more vigorously during the establishment year and are not stunted by the companion crop. Although the companion crop provides some revenue during the establishment year, the first seed crop of grass is sufficiently reduced to offset the benefit of the companion crop. Elliott (1973) found that seed yields of Sawki Russian wildrye averaged over six harvest years ranged between 190 and 300 kg/ha/year

Figure 3: Effect of a cover crop on seed yield of Sawki Russian wild-rye (Elliott, 1973)



higher when no companion crop was sown (Figure 3). Lawrence (1967) compared seven seed row spacings for wheat undersown with Russian wildrye. The number of established seedlings per unit length of row was not significantly different among the treatments in any of the five years of the trial. The cover crop decreased the vigour of Sawki Russian wildrye seedlings (Figure 4) as well as the seed yields (Figure 5).

Figure 4: Spring vigour score of Russian wild ryegrass seedlings when sown with spring wheat as a cover crop (Lawrence, 1967)

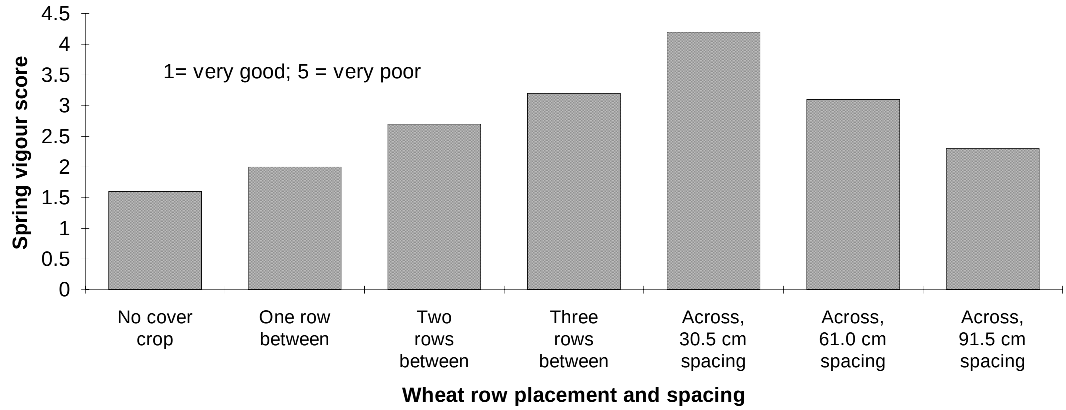
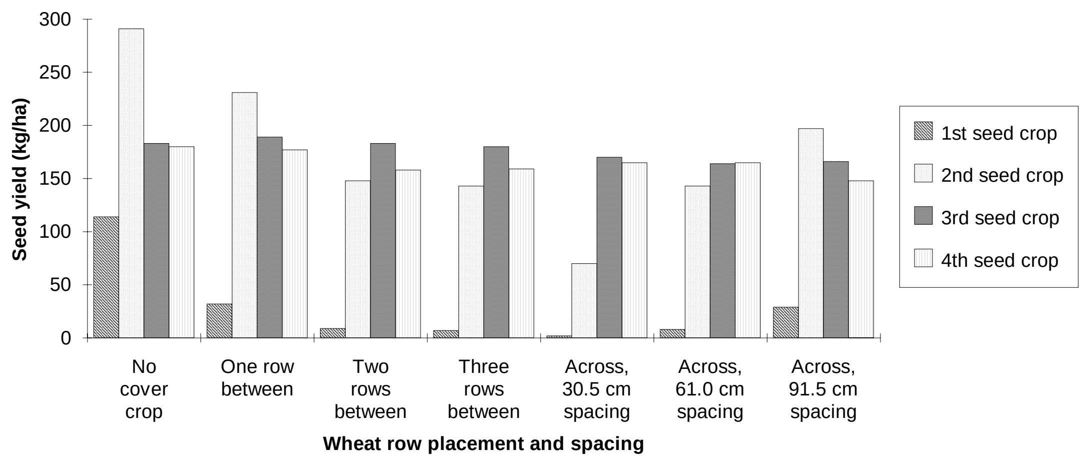
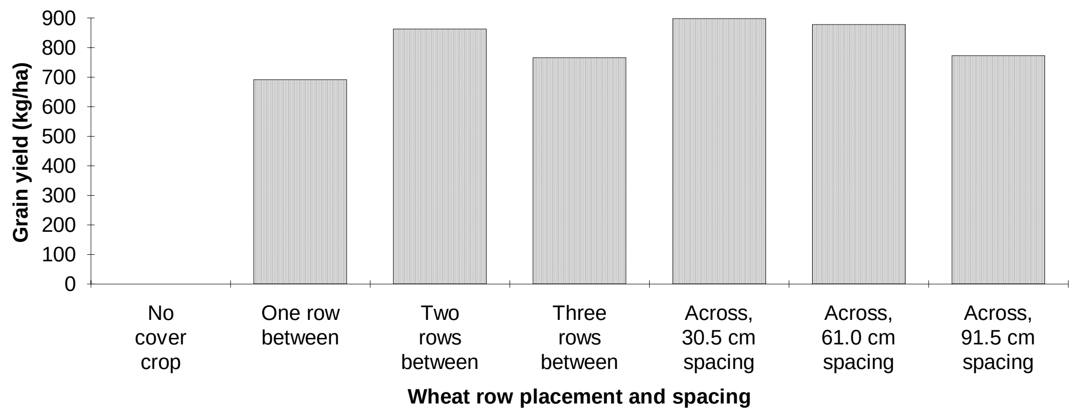


Figure 5: Effect of wheat as a cover crop on the seed yield of Russian wild ryegrass (Lawrence, 1967)



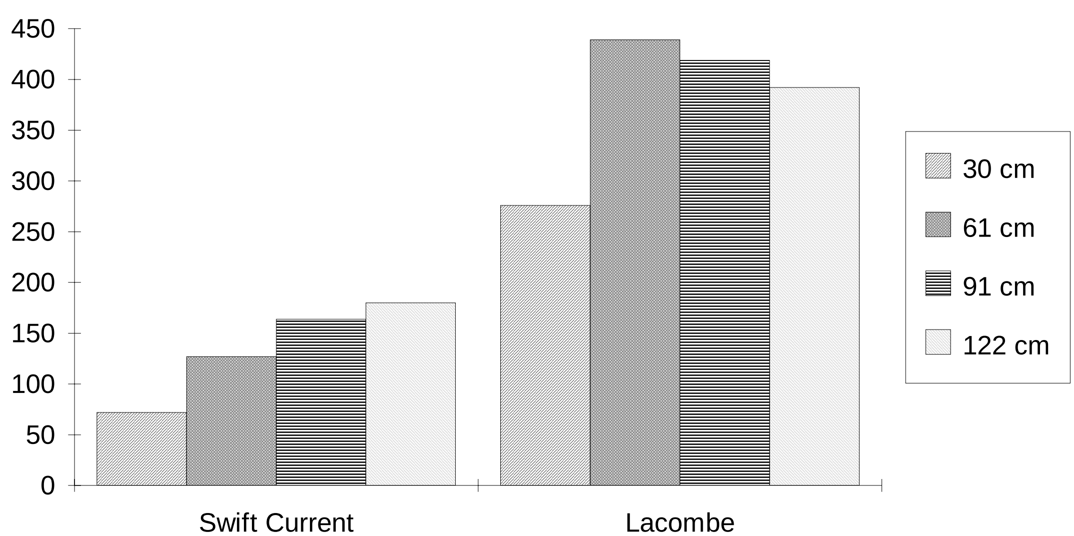
The spacing and placement of the rows relative to the Russian wildrye had no effect on the grain yield of the spring wheat cover crop (Figure 6). The use of a cover crop with Russian wildrye is not viable considering the loss in both seed and forage yield. Where a cover crop must be sown to prevent erosion, the wheat should be sown as a single row between the grass to minimize competition with the Russian wildrye (Lawrence, 1967). When harvesting the cereal, cut the grain at a height of at least 20 cm to reduce injury to the seedling grasses (Kilcher and Heinrichs, 1960).

Figure 6: Grain yield of spring wheat when undersown with Russian wild ryegrass (Lawrence, 1967)



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).

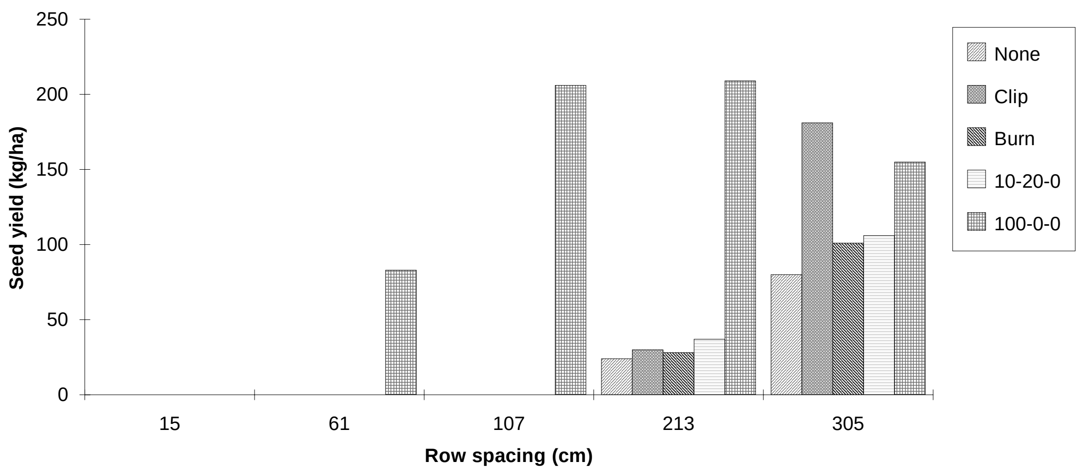
Figure 7: Effect of row spacing on seed yield of Russian wild ryegrass on dryland at Swift Current (Lawrence and Heinrichs, 1968) and Lacombe (Stelfox et al., 1954)



The best row spacing for seed production of Russian wildrye depends on average precipitation and soil fertility. Stelfox et al. (1954) determined seed yields for a row spacing of 30, 61, 91, and 122 cm for four years at Swift Current and Lacombe. Swift Current received about 10 cm less precipitation annually than Lacombe did. The best row spacing at Swift Current and Lacombe was 122 cm and 61 cm respectively (Figure 7). Lawrence and Heinrichs (1968) continued the trial at Swift Current and harvested nine seed crops over a period of nineteen years. No seed was harvested in the first year because the crop was not sufficiently developed.

Of the remaining nine years, hail destroyed the crop in three years and drought prevented seed formation in six years. Stitt (1954) found that seed yields on a dryland site in Montana were highest with row spacings of 305 cm compared to row spacings of 15, 61, 107, and 213 cm when less than 11 kg N/ha was applied. When the plots were fertilized with 110 kg N/ha annually, the highest seed yield was achieved with a 213 cm row spacing in 1952 (Figure 8). Narrower

Figure 8: Seed yield of Russian wild ryegrass as affected by row spacing and April management at Moccasin, Montana (Stitt, 1954)



row spacings such as 60 - 200 cm yield more seed than wider or narrower spacings when adequate water and nitrogen fertility are provided. At Saskatoon, seed yields were higher for a 91 cm row spacing compared to a 30 cm row spacing. Gapping of the plants in the row further increased the seed yield (Stelfox et al., 1954).

Swaths are often difficult to pick up from between widely spaced seed rows. Cutting the crop at an angle across the seed rows may alleviate this difficulty. If inter-row cultivation is practiced, however, the field becomes too rough to swath the field across the seed rows. Ridges of soil build up adjacent to the row. Picking up a swath from between the soil ridges is difficult and contributes much wear and tear to the bearings of the combine. One alternative in this situation may be to straight combine the crop. Another approach is to sow the field with a combination of three or four 30 cm row spacings adjacent to 90 cm row spacing. The narrow-spaced rows provide a level area for placing the windrow. Inter-row cultivation is still possible in the wide spacing.

The recommended sowing rate for grasses is depends on the suitability of the soil for seed germination. Because the weather is an important factor in the success of a seeding, the safe approach is to seed at a higher rate than is suitable for ideal conditions. It is wise to plan for loss of up to 80% of the seedlings. The goal is to sow enough seed to achieve a satisfactory stand without too much inter-plant competition. Seedlings which are vigourously tillering, however, will produce a higher seed yield. Sowing at a higher seeding rate increases the inter-plant competition and reduces the vigour of the seedlings. Button et al. (1993) recommend a seeding rate of 4.4 kg/ha with a 30 or 60 cm row spacing. Leyshon et al. (1981) suggest a seeding rate of 50 - 65 seeds per meter of row for the establishment of forage stands with a 90 cm row spacing. When another material is mixed with the seed to eliminate bridging of the seed, this method eliminates the uncertainty in determining the drill setting. With a 60 cm row spacing, one hectare (10,000 m2) would contain 16,667 meters of seed row. Since one kilogram of Russian wildrye contains 386,000 seeds (1 lb = 175,000 seeds), the rate ranges between 2.2 - 2.8 kg/ha (1.9 - 2.5 lb/ac). With a 30 cm row spacing, the recommended seeding rate ranges from 4.3 - 5.6 kg/ha (3.7 - 5.0 lb/ac). Using this approach, it is easy to calibrate the drill by seeding over a sheet of plywood or a pad of concrete and counting the seeds sown over a measured distance.

The injury to germinating seedlings from fertilizer occurs from two sources: the dissolved salts and the ammonium content. Fertilizers which are readily soluble in water are more hazardous than less soluble forms. Nitrogen sources which liberate ammonium are more hazardous than nitrate sources. Ammonium phosphate is relatively safe because the fertilizer dissolves more slowly when it comes in contact with moisture. The ammonium content of ammonium phosphate is only 10-12% of the weight of the fertilizer.

The quantity of fertilizer which is safely placed in the seedrow with the grass seed is dependent on a number of factors. The texture and organic matter content of the soil are the two most important factors which limit the risk of injury. The moisture content of the soil at seeding time, the proximity of precipitation to the seeding operation, the spacing between rows, and the width of the seedrow itself are the remaining considerations. Soils with a high content of organic matter and clay have a lower risk for fertilizer injury to grass seedlings. A soil with a moisture content near field capacity is less likely to have fertilizer injury. Rainfall immediately after seeding will replenish the moisture content of the soil and remove fertilizer salts from the vicinity of the grass seeds. As the spacing between the rows widen, the amount of fertilizer next to the seeds will increase if the application rate per unit area remains the same. A narrow width of the seedrow itself will place more fertilizer in close contact with the seed than a wider seedrow. The general guideline for forage seeds is for no nitrogen, potassium, or sulphur fertilizers placed in the seedrow. Application of phosphate fertilizer up to 10 kg P205/ha is safe with relatively good soil moisture.

V. Crop management

Herbicide registrations for the control of weeds during the seedling year provide a wide array of options for control of annual grassy and broadleaf weeds. 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 adjacent chart, Table 1, for currently registered treatments.

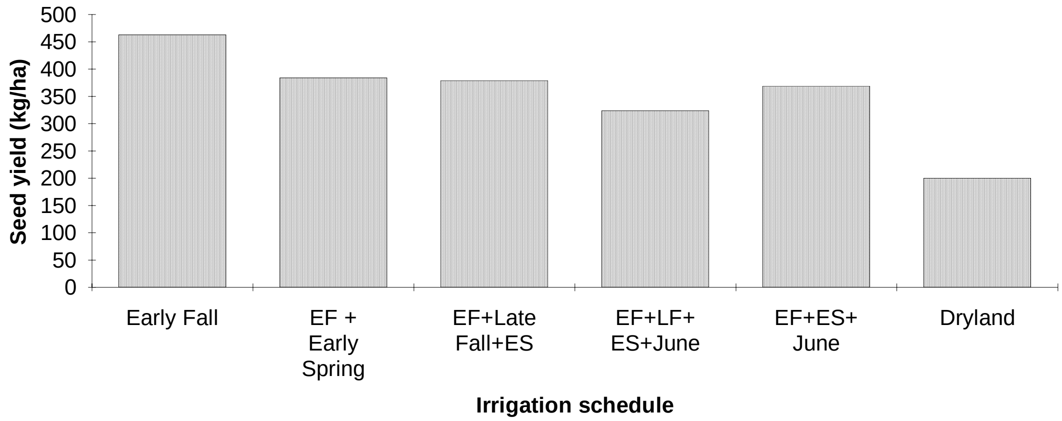
Clipping or mowing weeds is another effective strategy for control of annual weeds. The weeds should be mowed as required to prevent them from setting seed. When the soil is not disturbed, most weed seeds do not germinate. After the grass crop becomes established, fewer weeds will germinate in the seed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

Field roguing is a requirement for production of quality grass seed for the Canadian market. The chaffy grasses such as Russian wildrye have no tolerance for primary noxious weeds such as quackgrass, Canada thistle, cleavers, and wild mustard. Seeds of cleavers are extremely difficult to remove from the finer grasses such as Kentucky bluegrass. 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 1 and 2 seeds in 25 g for Canada Registered 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.

Russian wildrye has a high moisture requirement. Seed production is responsive to irrigation, but other management practices are also essential for profitable yields. Stitt (1954) irrigated his research plots at Bozeman, Montana with 15 cm of water about July 1 and August 15 each year. Lawrence (1963) applied irrigation water in May and after seed harvest each year. Each irrigation supplied 8-10 cm of water.

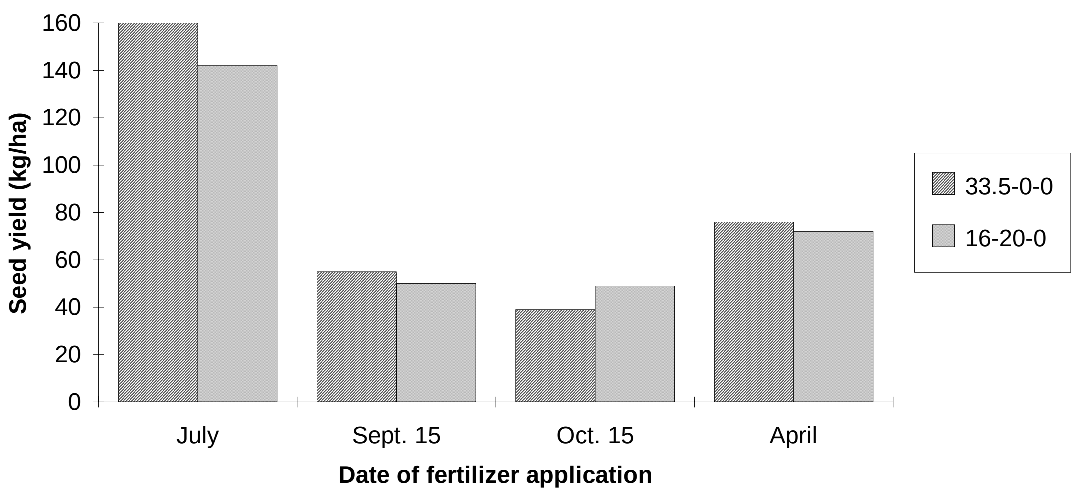
Lawrence et al. (1988) concluded that early fall irrigation in August was essential for high seed yields; late fall and early spring irrigation did not influence the seed yield of Russian wildrye when the field was irrigated in early fall. The irrigated treatments had 90% higher seed yields compared to the dryland check based on five years of production (Figure 9).

Figure 9: Effect of irrigation on seed yield of Russian wild ryegrass at Swift Current (Lawrence et al., 1988)



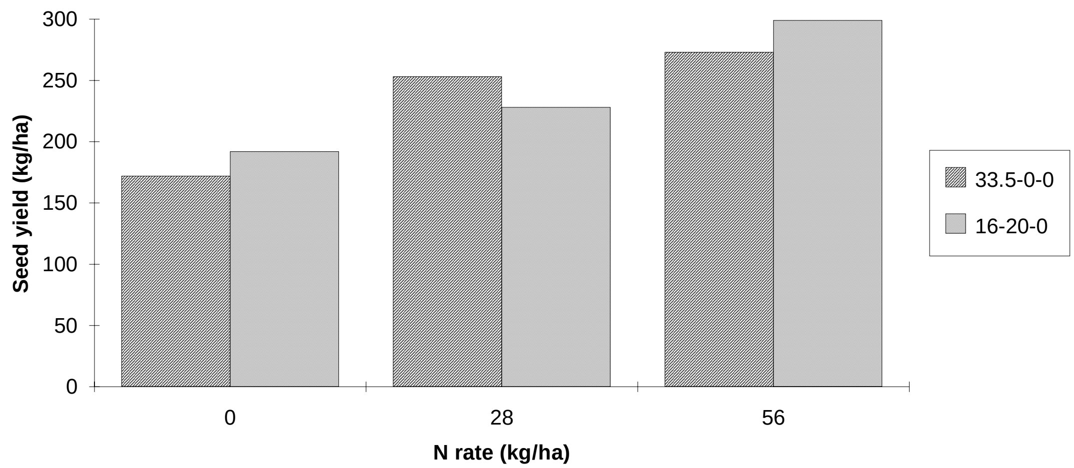
Lawrence and Kilcher (1964) applied 56 kg N/ha as 33.5-0-0 or 16-20-0 at four times during the year: immediately after seed harvest (July), September 15, October 15, and in spring (April). Figure 10 illustrates clearly that post-harvest application of

Figure 10: Effect of time of fertilizer application on seed yield of Russian wild ryegrass (Lawrence and Kilcher, 1964)



nitrogen increased seed yields by 90-120 kg/ha compared to September or October applications. Spring applications increased seed yields more than fall applications. Nitrogen in the form of ammonium nitrate was more efficiently converted to seed yield

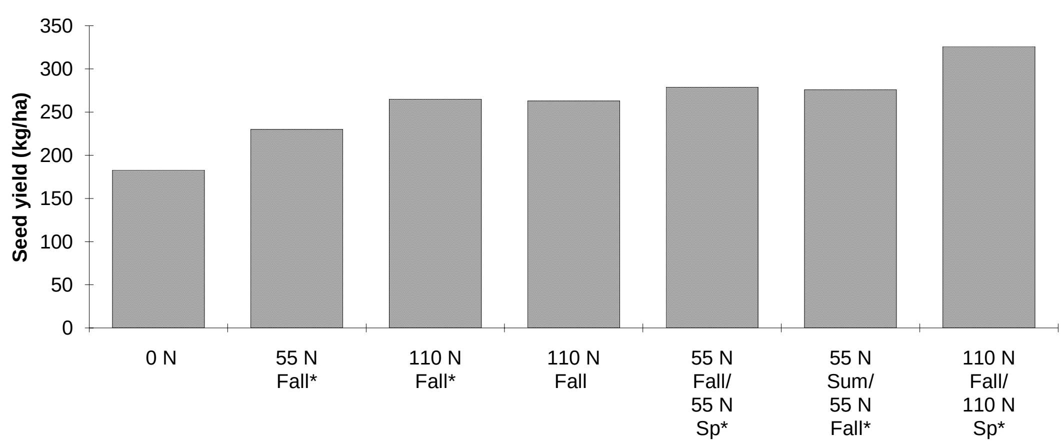
Figure 11: Seed yield response of Russian wild ryegrass to application of fertilizer (Lawrence, 1963)



than ammonium phosphate. A subsequent trial found 16-20-0 equal to 33.5-0-0 for fertilization of Russian wildrye at rates up to 56 kg N/ha (Figure 11).

Rogler and Lorenz (1964) applied higher rates of nitrogen to their irrigated Russian wildrye seed trials. They found that seed yields from single applications of 110 kg N/ha in the fall were equivalent to split applications in the spring and fall. Higher rates of N application sustained seed yields over the seven year period that seed was harvested from the trial (Figure 12).

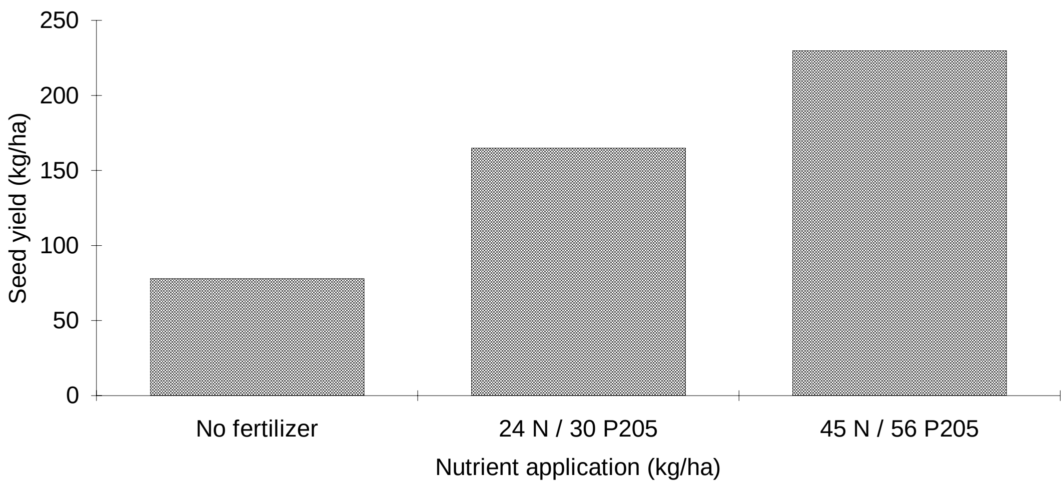
Figure 12: Effect of N rate (kg/ha) and time of application on seed yield of irrigated RWR at Mandan, ND (Rogler and Lorenz, 1964)



* 49 kg/ha P205 at seeding

Lawrence and Heinrichs (1968) found that seed production of Russian wildrye on dryland is also feasible, but more variability in seed yield should be expected (Figure 13). Seed was harvested in nine of nineteen crop years. Hail destroyed the seed crop in three years while drought prevented seed production in six years. Seed yields of Russian wildrye returned to economic levels following a prolonged drought. Strong correlations were found between August and September precipitation and seed yields in the following year. Nitrogen fertilization was essential to obtain this seed yield response.

Figure 13: Seed yield response of Russian wild ryegrass to fertilizer on dryland (Lawrence and Heinrichs, 1968)



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 Russian wildrye. Swathing and picking up the windrow is the least-risk method of harvesting. The crop is ready to swath in mid to late July when the moisture content of the head drops to 40-45% (Najda et al., 1994; Elliott, 1972). This corresponds to the medium dough stage, which occurs when no liquid is left in the seed and some pressure is required to imprint the seed. The straw will be just turning golden yellow at this time. Swath the crop just above the leafy basal growth and thresh after several days. 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 5-7 days. Initial combine settings recommended for Russian wildrye are a cylinder speed of 850 rpm and a concave clearance of 1/16". The fan speed is generally set between 400-500 rpm with the sliding covers over the exterior fan housing fully open (Tober, 1988). Because of the potential for contamination and the value of grass seed, thoroughly clean the combine before harvesting grass seed. 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).

Windrowing of Russian wildrye introduces two difficulties for the harvest of the crop. First, the seed shatters very 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). An alternative is threshing the crop before shattering occurs and immediately drying the seed artificially. This practice, however, sometimes reduced the germination rate of the seed. Conard (1936) found that many Russian wildrye seeds were still soft just prior to seed shattering. The germination of the seed was significantly reduced when the cylinder speed was higher than 1100 rpm because of mechanical injury. Although lower cylinder speeds left some immature heads unthreshed, this loss was estimated at only about 5% of the total seed yield. Lawrence (1960) found that the germination of Russian wildrye increased as the seed maturity progressed toward seed shattering. The germination of straight combined seed was 15 to 37% lower than seed which cured while attached to the culm. In one year, seed which was straight combined qualified for the grade Common No. 1 in only the last two days prior to seed shatter while all the samples which were swathed qualified for this grade. The percentage of emerging seedlings from straight-combined seed correlated well with seed germination. The 100-kernel weights of the seed increased for each day that harvest was delayed up to the time when seed shattering became common.

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).

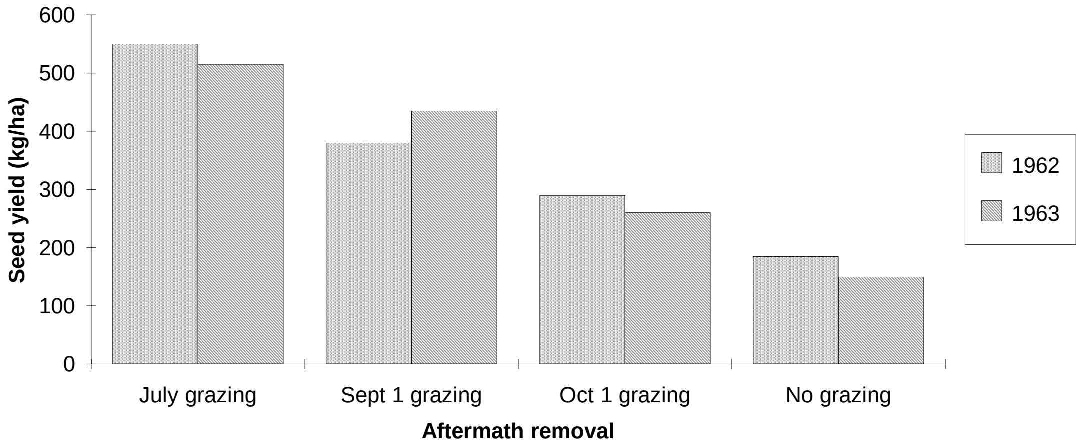
The drying of grass seeds must be conducted with care to maintain the viability of the seed. Lawrence (1960) found that straight combined seed which was dried at 32C had the same germination as seed dried at the ambient air temperature.

The longevity of germination in Russian wildrye seed is influenced by the harvest method. Seed which was harvested by swathing at the firm-dough stage, allowed to dry while attached to the culm, and threshed still maintained germination near 75% after five years of storage at 20-26 C and 15-30% relative humidity. Seed which was harvested by straight combining at the same stage of development maintained germination of only 50% after five years of storage under the same conditions. The straight combined seed had limited commercial value after five years, but the swathed seed cut three to four days prior to seed shattering still was marketable as commercial seed (Lawrence, 1967).

VII. Post harvest management

Removal of straw from the Russian wildrye seed production field is essential to maintaining viable seed yields. Lawrence and Ashford (1964) found that grazing was an effective means of removing the aftermath from seed production fields. Figure 14 indicates the dramatic response in seed yield to grazing of Russian wildrye by sheep immediately after harvest. A subsequent study on the same plot area

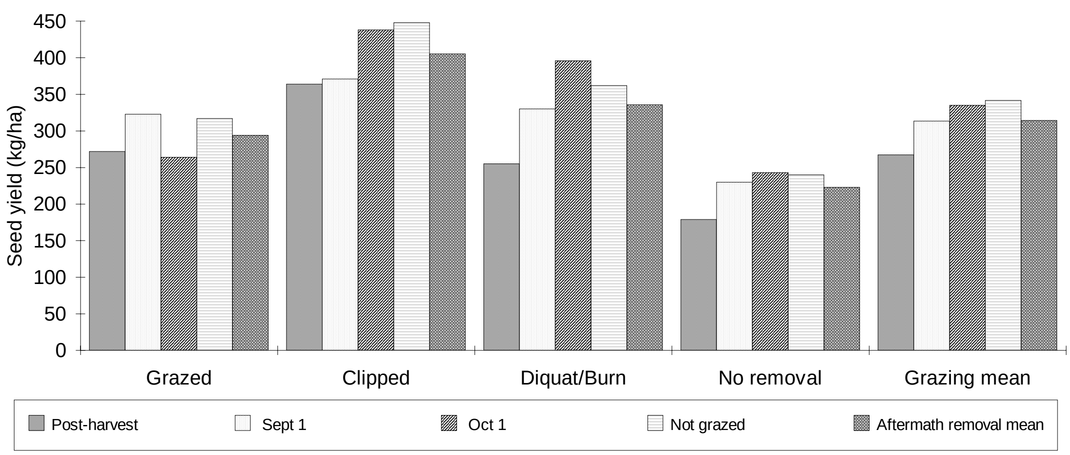
Figure 14: Effect of grazing by sheep on seed yield of Russian wild ryegrass (Lawrence and Ashford, 1964)



indicated that annual grazing following the seed harvest reduced seed yields relative to close clipping with a rotary mower (Lawrence, 1970). The highest seed yields were observed for close clipping with a rotary mower (Figure 15). Delaying grazing until late September or October is suggested as a means to sustain maximum seed yields from Russian wildrye fields. An alternate strategy could graze the seed fields every two to three years with close clipping of the stubble in the intervening years. Grazing with cattle may also achieve the benefits of higher seed yield without injury to the vigour of the stand. Lawrence and Lodge (1975) reported an increase in seed yield of Russian wildrye from 149 to 213 kg/ha by grazing after the seed harvest until the cattle no longer gaining weight.

Nitrogen application to the Russian wildrye seed field following harvest of the seed is critical for sustained profitable seed yields. The principles of efficient fertilization of seed production fields have been discussed under the crop management section of this review.

Figure 15: The effect of method of aftermath removal on seed yield of Russian wild ryegrass (Lawrence, 1970)



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