

Agropyron cristatum (L.) Gaertn.
Agropyron desertorum (Fisch.) Schult.

CRESTED WHEATGRASS



Seed Production of
Crested Wheatgrass

Canada



Saskatchewan

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I. Introduction

Crested wheatgrass ranks second only to smooth bromegrass in acreage among cultivated grasses in Western Canada. The grass was introduced to North America from Eastern Europe at the beginning of this century, but was not widely cultivated until the revegetation programs associated with the drought of the 1930's. Production of crested wheatgrass varies widely in response to seed prices. From 1940-1955, Canadian production ranged between 200 - 500 tonnes per annum. Production rose sharply during the early 1960's, early 1970's and late 1980's to 1,000 - 1,500 tonnes per annum. In recent years, production has fallen again to 500 tonnes annually. Average seed yields of crested wheatgrass are 150 kg/ac, but yields as high as 450 kg/ac have been harvested in Saskatchewan.

Two species of crested wheatgrass are grown: *Agropyron cristatum* (L.) Gaertn. known as the Fairway type and *Agropyron desertorum* (Fisch.) Schult. called the standard type. Both types are non-creeping. The Fairway or diploid type is shorter and more leafy than the standard type and is distinguished by a short, wide seed head, a wide angle of attachment of the spikelets to the central rachis of the seed head and pubescence on the upper side of the leaf. The Fairway type also has tip awns on a slightly smaller seed. The two most common varieties of this type are Fairway released in 1932 and Parkway released in 1979.

The standard or tetraploid type grows slightly taller than the Fairway type, and has a long, narrow seed head. The spikelets are attached to the central rachis at a narrower angle and are slightly larger due to the larger number of chromosomes in the cell nucleus. The leaves of the standard type usually are not pubescent and the seeds do not usually have tip awns. The seed set of the florets of tetraploid varieties is seldom better than 50% compared to about 70% for the diploid varieties. The common registered varieties of the standard type are Summit and Nordan which were released in 1953 and 1958, respectively. Kirk and Hycrest, released in 1987 and 1984, respectively, are tetraploids showing intermediate head types between the diploid Fairway and tetraploid standard types.

Crested wheatgrass has been grown for pedigreed seed on 3000 - 3500 acres in Saskatchewan in recent years (1994-1996) accounting for 25% of the pedigreed grass seed acreage in the province. Kirk, Fairway, and Hycrest are the main varieties multiplied for seed in recent years in Saskatchewan.

II. Field selection

A. Adaptation

Crested wheatgrass is a deep-rooted bunch grass which is tolerant of the moisture stress and the low winter temperatures common in the Brown and Dark Brown soil zone. It is well suited to seed production in the Brown, Dark Brown, Black, and Gray soil zones and is adapted to most soil textures. The standard type is more tolerant of drought, but the Fairway type is better adapted to moist conditions. Crested wheatgrass is not well adapted to saline soils. Fairway, a diploid variety is more saline tolerant than the tetraploid variety, Kirk. Crested wheatgrass is not very tolerant of spring flooding. Seed yields are more consistent in regions receiving 350-500 mm of annual precipitation. Under dry conditions, seed head formation may be inadequate to justify harvest of the seed.

B. Freedom from weeds

The field selected for crested wheatgrass seed production must be free of noxious grassy and broadleaf weeds. A field may be left unattended for several weeks with only minimal weed growth and no

appearance of quackgrass or Canada thistle only to have these weeds appear later. Noxious weed seeds disqualify the seed for market as pedigreed seed.

Weeds with similar size and shape of seeds to crested wheatgrass are extremely difficult to separate at the cleaning plant. Primary noxious weeds which are inseparable are quackgrass, Canada thistle, and perennial sow thistle. Secondary noxious weeds which are difficult to remove from seed lots include wild oats, stickseed (bluebur), and Persian dandelion. Fields selected for seed production of crested wheatgrass must be sown on land free of these weeds.

Three applications of glyphosate over two to three years are required to control quackgrass. Pre-harvest glyphosate application at 1 liter per acre prior to sowing the grass greatly improves control of quackgrass, Canada thistle, and sow thistle. Quackgrass from the seed bank and dormant rhizomes in the soil will re-infest the field, so several years of control are essential to reduce the possibility of recontamination. A fallow or partial fallow period prior to seeding controls several flushes of annual broadleaf and grassy weeds.

Prior to seeding the grass, weed control is easily achieved with broad spectrum herbicides and cultivation.

C. Freedom from herbicide residues

Crested wheatgrass seedlings are sensitive to injury from soil residues of grassy herbicides. The residues of trifluralin herbicides (Advance 10G, Rival, Treflan) pose the greatest risk of herbicide injury for new seedlings of grasses. These herbicides disappear from soil by volatilization. If these products have been applied at the maximum rate for oilseed or pulse crop production, grasses should not be sown for 24 months following a spring application or 30 months following a fall application. Fortress may also have some carryover residue if the volatilization of the herbicide is restricted by dry conditions. Crested wheatgrass should not be sown in a rotation directly following a crop treated with Fortress.

Other products which have injured grass seedlings include Ally, Assert, Atrazine, Banvel, Glean, Princep/Simazine, Pursuit and Sencor. Many of the herbicides in this listing are only problems if used at high rates in the growing season prior to sowing the grass. Check the latest edition of Saskatchewan Agriculture and Food's Crop Protection Guide for current guidelines.

D. Pedigreed Requirements

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 seed must meet standards for germination, genetic purity, freedom from disease, and absence of the seed of weeds and other crops. The Canada Seed Act specifies that seed must be pedigreed to be sold as a named variety.

The regulations for pedigreed status of seed are outlined in the Canadian Seed Grower Association Circular 6. In the year of seeding, the grower must notify the Canadian Seed Growers' Association of the pedigree of the seed planted and the area and previous cropping history of the production field. The field should be free of volunteer crested wheatgrass prior to seeding. Manure or other potentially weed contaminating material should not be applied to the field prior to seeding or during the productive life of the stand. Table 1 summarizes the regulations on the minimum cropping interval.

Table 1: Intervening crop seasons before re-cropping with crested wheatgrass as required by CSGA regulations

<u>Class of seed sown</u>	<u>Class of seed harvested</u>	<u>Contaminating crop</u>	<u>Number of intervening crop seasons required</u>
Breeder	Foundation	Non-pedigreed or different variety of crested wheatgrass	5 seasons
Breeder	Foundation	Same variety of crested wheatgrass	3 seasons
Breeder or Foundation	Certified	Crested wheatgrass	2 seasons

A field sown with Breeder crested wheatgrass seed is eligible for four years of Foundation plus four years of Certified seed production. A field sown with Foundation crested wheatgrass seed is eligible for eight years of Certified seed production. Two inspections are required annually for each pedigreed seed lot - a field inspection and a seed analysis. The production field must be inspected after the crop has headed, but prior to swathing or harvesting for each year that pedigreed seed will be harvested. The seed lot must also be analyzed for weed and disease contamination and tested for germination. The identification tags from the seed bags must be retained for the life of the stand for presentation to the crop inspector.

Crested wheatgrass is cross-pollinated by wind and occasionally by insects. To maintain genetic purity, adequate isolation from other sources of pollen is essential. The isolation requirement depends on the class of seed produced and the size of the field as summarized in Table 2.

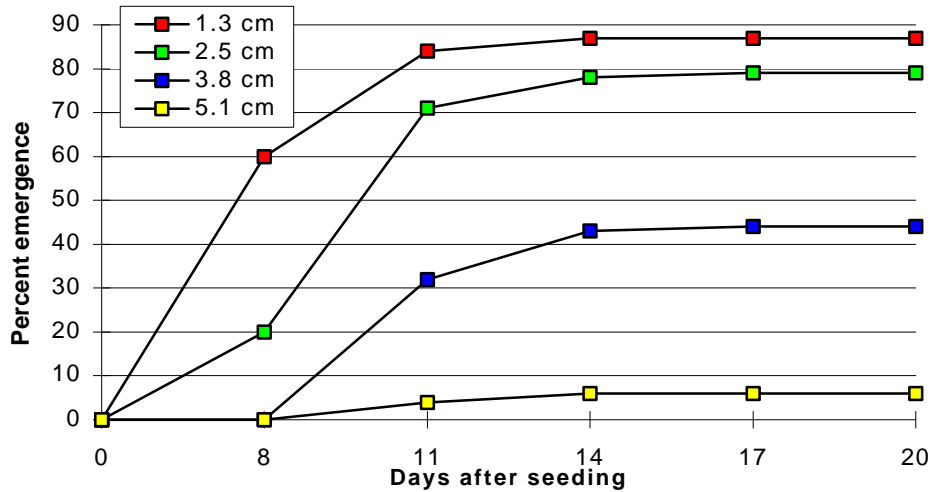
Table 2: Isolation distances required by CSGA regulations

<u>Field Size (ac)</u>	<u>Pedigree of Seed Produced</u>	
	<u>Foundation</u>	<u>Certified</u>
Less than 5 acres	400 m	150 m
More than 5 acres	300 m	50 m

III. Crop establishment

The main objective for the establishment year is to produce a healthy stand of seedlings which are vigorously tillering. Crested wheatgrass may be sown with any conventional planting equipment if shallow seeding and adequate packing are achieved. Sowing no deeper than one-half inch with firm packing helps achieve maximum germination and rapid emergence of seedlings (Figure 1). As the seeding depth increases, the time required for the seedling to emerge increases and the percentage of seedlings that emerge decreases. Although air seeder cultivators and hoe drills have successfully established crested wheatgrass, disc drills are the most common seeding implement. Zero-till seeding provides the firm moist seedbed into which the seed can be planted shallowly without difficulty. When zero-till seeding, ensure that there are options for controlling volunteer crop seedlings.

Figure 1: Effect of seeding depth on rate of emergence of crested wheatgrass seedlings (McKenzie et al., 1946)



A firm seedbed is the most important requirement for shallow even placement of grass seed. Packing after the last tillage operation helps firm the soil. Pulse crop rollers are an excellent way to level and firm the soil prior to seeding. A rainfall following the final tillage operation will also firm and moisten the seedbed.

Planting into a “stale seedbed” is an effective method for establishing crested wheatgrass. The land is tilled, packed, leveled, and left to settle for two to three weeks. Dew and one or two rains during the interim period firm the seedbed. A burn-off rate of glyphosate is applied just prior to or immediately after seeding with a disc press drill. The herbicide application effectively controls weed seedlings and minimal disturbance prevents new weed growth. The seedbed remains firm and moist to the soil surface which is an excellent environment for germination and growth of new grass seedlings.

Applying this technique for planting into standing cereal stubble is an equally effective variation. The standing stubble provides protection from the wind, an ideal microclimate for establishment of the grass seedling. The anchored stubble also reduces the risk of erosion from heavy summer rains. Effective spreading of chaff and straw prior to seeding are essential for successful use of this technique.

Simple equipment modifications relieve many potential difficulties and minimize the risk of poor establishment. A packing wheel ahead of the disc opener levels the seeding surface and packs the soil. Depth control bands on discs maintain a shallow sowing depth and prevent overdeep seed placement. Packer wheels following directly behind the seeding disc provide good seed to soil contact.

The crested wheatgrass seed crop may be sown any time between early May and mid June with little difference in seed yield for the first seed harvest. With a longer delay in seeding, the first crop seed yield may be reduced, but subsequent crops often compensate for the smaller initial seed crop. Research at Beaverlodge, a northern station, indicates that crested wheatgrass should be sown prior to June 13 to obtain a satisfactory seed yield in the following year. Late fall and dormant seedings also work well for establishment of crested wheatgrass, but no seed will be produced until the second fall after seeding.

Crested wheatgrass has a fairly light seed that may bridge in seed cups. Bridging causes inconsistent plant stands and missing seed rows. Agitators in the seed box prevent bridging and improve flow of the light chaffy seed to the seed cups. If agitators are not available for your seed tank to disturb the grass seed, filling the seedbox only half full and getting extra help to mix the seed in the seedbox while planting will work. Polymer

seed coatings improve the seed flow in the drill and protect the user from exposure to any seed treatments which may be added to control disease organisms. Carriers such as phosphate fertilizer (11-52-0) up to 15 lb P_2O_5 /ac, non-viable grain, or horticultural vermiculite clay may be mixed with the grass seed to help prevent bridging. Seed may also be mixed with phosphate fertilizer and "drilled" through the fertilizer attachment. 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. Seed mixed with fertilizer can be stored up to 3-4 weeks without injuring the seed germination as long as the mixture is stored under dry conditions.

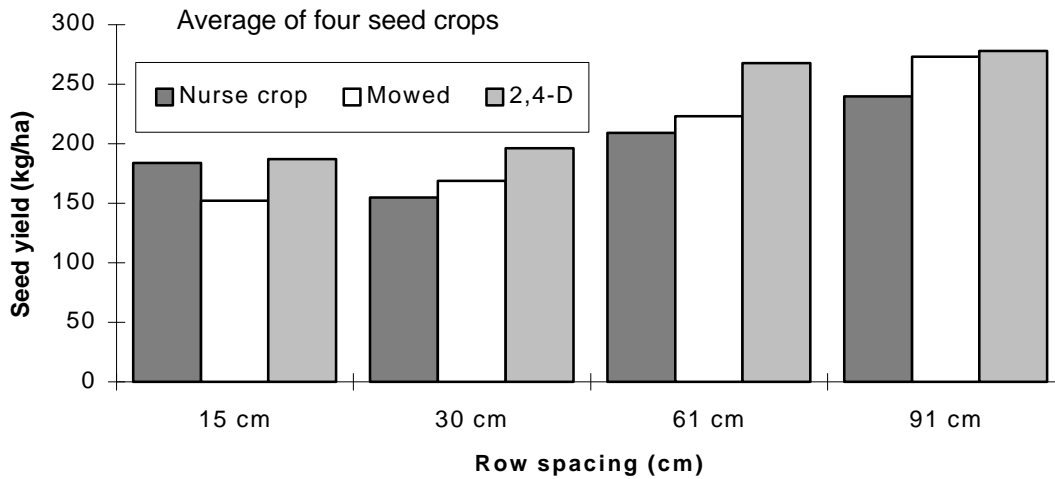
B. Row spacing

Wide row planting of crested wheatgrass has several advantages. Planting in wider-spaced rows reduces the seed requirements, lowering input costs. As the stand ages, the plants can expand into the vacant area between the rows and maintain a higher seed yield potential. Although inter-row cultivation may stimulate new weed growth, tillage is easily performed with a row crop cultivator or gang rototiller. Weeds for roguing are easier to spot when the grass is sown in rows. Row production without irrigation also reduces the risk of seed yields reduced by drought. Because crested wheatgrass is a bunch grass, it should be sown with a row spacing of 12 to 24 inches (Figure 2). The wider row spacings are recommended for lighter textured soils and for seedings which will be harvested for four or more years. If inter-row tillage is practiced, the row spacing should be increased to 30-36 inches. At this spacing, however, some weeds and shattered crested wheatgrass seed will invade the stand if inter-row cultivation is not practiced.

The wide row spacings are easily accomplished with conventional equipment by placing tape over the unwanted seed cups in the seed box. Depending on the equipment, raising unwanted discs or seed boots may also be possible. Some growers release the spring pressure on hoe drills so that the shoe just rides along the surface of the soil. With airseeders, blocking of outlets in discharge heads needs to be symmetrical to maintain uniform airflow. A wide range of modifications are easily accomplished depending on the type of equipment owned.

The seeding objective 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. Because the weather is an important factor in the establishment of a seeding, the safe approach is to seed at a higher rate than is suitable for ideal conditions. It is wise for inexperienced growers to plan for loss of up to 80% of the seedlings. The seeder should be calibrated to sow at least 25 seeds per foot of seed row. When another material is mixed with the seed to eliminate bridging, the seeds per foot method of drill calibration eliminates guesswork. The seed size of crested wheatgrass also varies between varieties. Tetraploid seeds such as Kirk and Summit are larger than diploid seeds such as Fairway and require a slightly higher seeding rate on a

Figure 2: Effect of row spacing and method of establishment on seed yields of Fairway crested wheatgrass at Saskatoon (Knowles, 1961)



weight basis. Using the seeds per foot method, the same rate of 25 seeds per foot of seed row is appropriate. Diploid crested wheatgrass, on average, contains 218,000 seeds per pound compared to 163,000 seeds with tetraploid crested wheatgrass. For a row spacing of 2 feet and a seeding rate of 25 seeds/ft, one acre (43,560 ft²) contains 21,780 feet of seed row and require 544,500 seeds or 3.3 lb seed/ac for a tetraploid variety. The drill is easily calibrated by seeding over a sheet of plywood or a pad of concrete and counting the seeds sown over a measured distance.

C. Fertility

The soil fertility of the seed field should be determined by soil analysis prior to sowing. When sowing crested wheatgrass for seed production on fallow or partial fallow, nitrogen is likely adequate to carry the grass until the first fall after seeding. When stubble fields are sown prior to June 1, 20-40 lb N/ac should be applied to dryland fields and 40-60 lb N/ac to irrigated fields. A fall application of 30 lb N/ac to establishing seedling fields will promote maximum seed production in the first seed crop.

Phosphorus and potassium deficiency are best corrected prior to establishment of the crop. Phosphorus enhances the growth rate and vigour of the seedlings. Yield responses of grasses to applications of phosphorus and potassium are marginal once the stand is established. For fields testing less than 15 lb P/ac, phosphate fertilizer should be applied at 50-75 lb P₂O₅/ac. Likewise, for fields testing less than 200 lb K/ac, 100 lb K₂O/ac. should be applied prior to sowing the grass. Sulphur levels will be adequate if the field has been fertilized with enough sulphur for optimum canola production within the last two years. Crested wheatgrass responses to micronutrients have not been documented on the prairies, but the extensive root system of perennial grasses is likely able to absorb all required micronutrients.

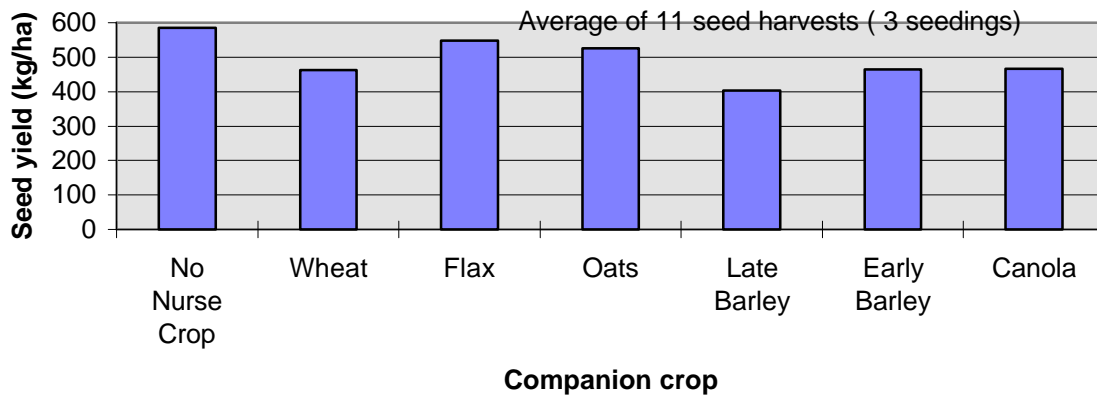
The quantity of fertilizer which is safely placed in the seedrow with the grass seed is dependent on a number of factors. The organic matter and clay content of the soil, the moisture content of the soil at seeding, the time interval between seeding and the first precipitation after seeding, the row spacing, and the seedrow width affect the risk of seedling injury. As the content of organic matter and clay increase, risk of fertilizer injury to grass seedlings decrease. A soil moisture content near field capacity reduces "fertilizer burn" of seedlings. Rainfall immediately after seeding replenishes soil moisture and removes fertilizer salts from the vicinity of the

seed. For a constant rate of fertilization, as the spacing between the rows widens, the amount of fertilizer next to the seeds increases. A narrow width of the seedrow itself will also place more fertilizer in close contact to the seed. The general guideline for forage seeds is for no nitrogen, potassium, or sulphur fertilizers placed in the seedrow. Application of phosphate fertilizer up to 15 lb P₂O₅/ac is generally safe.

D. Companion crop

Seed production of crested wheatgrass is slightly higher when sown without a companion crop. The seedlings grow larger, tiller more, and compete more effectively with weeds during establishment and first seed year when sown without a companion crop. The seed yield of crested wheatgrass with a companion crop, however, is often similar to the seed production without one. Crested wheatgrass seedlings are able to recover from the reduced vigour associated with establishment under wheat as a

Figure 3: Seed yield of Fairway crested wheatgrass seeded with various companion crops at Beaverlodge, AB (Elliott and Howe, 1977)



companion crop better than many other grass seed crops. By sowing the companion crop on a wider row spacing at a reduced rate, competition of the companion crop with the establishing grass seedlings is minimized. A trial conducted at Beaverlodge found seed yields of crested wheatgrass averaged over eleven harvest years were only 30 lb/ac/yr. higher without a companion crop (Figure 3). The least competitive companion crops were flax and oats.

IV. Crop Management

A. Weed control

Weed control options are limited once the crested wheatgrass 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 the crop is sown. Weeds also compete with the young crested wheatgrass seedling, reducing its vigour and the yield potential of the stand.

Herbicide applications play an important role in the production of quality grass seed. Typical herbicide requirements during the seedling year for crops sown in the spring include late spring application of wild oat and broadleaf herbicide followed by a second broadleaf herbicide in fall. The spring application in the seedling year is often replaced by mowing to prevent seed set of weeds, especially if weed populations are thin. A broadleaf herbicide (and a wild oat herbicide if required) is sprayed in early spring of the first seed crop. Check

the latest edition of the Crop Protection Guide published by Saskatchewan Agriculture and Food for new registrations of herbicides for grass seed crops.

Clipping or mowing is another effective strategy for controlling annual weeds. The weeds should be mowed as required to prevent them from setting seed. After the grass crop becomes established, fewer weeds will germinate during seed production years.

Field roguing is a requirement for production of quality grass seed for the Canadian market. Primary noxious weeds such as quackgrass, Canada thistle, cleavers, and wild mustard must be removed from the stand. Selective herbicide control of quackgrass in crested wheatgrass is not available. Quackgrass can only be removed from the field after sowing by spot spraying glyphosate with a backpack sprayer or hand roguing. Unthreshed wild mustard seeds lodge in the beak of the seed pod and this broken remnant of the pod cannot be removed because of its similar size to crested wheatgrass seed. Secondary noxious weeds such as wild oats, Persian darnel, scentless chamomile, shepherd's purse, stickseed (bluebur), and stinkweed are tolerated in small numbers, i.e. 4-10 in 25 g.; however, some market standards are more stringent than Canada Seed Act standards. Certain seeds are very difficult to separate and these weeds must be eradicated in the field.

The seed grower must be vigilant to prevent re-introduction of weeds to the field. Crowns and rhizomes from previous perennial grass crops in the rotation will re-establish in seedling stands. Weed or crop seed in irrigation water or on equipment are one source of contamination when deposited within the field.

Downy brome is a potentially serious weed which occasionally appears in seed from American sources. Downy brome has a reddish head colour and if nested in new stands of crested wheatgrass should be eliminated immediately.

B. Disease and insect monitoring

Disease and insect problems in crested wheatgrass seed fields are usually minor, but, on occasion, can lead to significant seed yield losses. The more common problems are silvertop, stem smut, and ergot. Silvertop reduces seed yield by prematurely halting development of the seed head. The head emerges from the stem, but turns white when the supply of water and nutrients is cut off. This is caused by puncturing of the stem by one of several insect species. The seed head turns white above the last node, and the seed head develops no viable seed. Sweeping with insect nets and looking for insect activity other than flies in early spring provides an early warning for some causes of silvertop. The incidence of silvertop usually increases as the stand ages. If silvertop affected more than 10% of the seed heads in the previous year, spraying with dimethoate prior to early boot stage of the grass is strongly recommended.

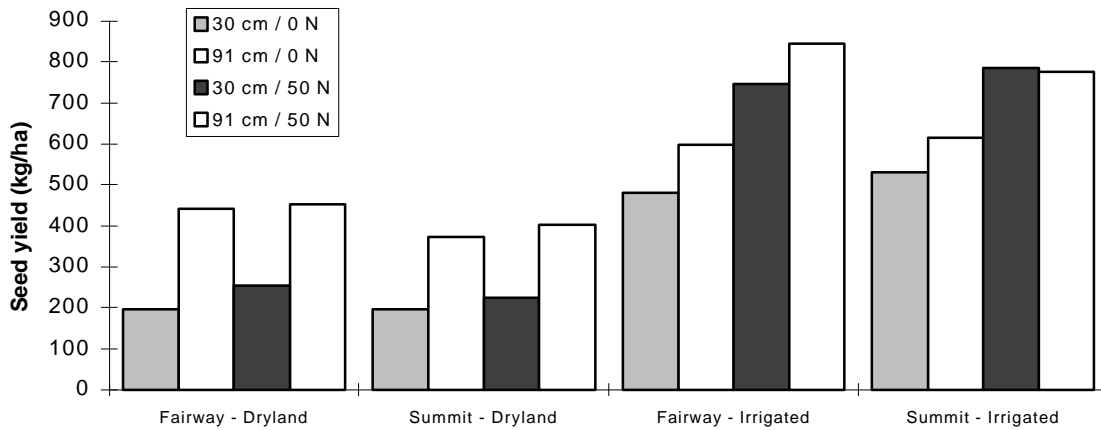
Stem smut and ergot are usually minor diseases in crested wheatgrass seed crops. Both are seed borne diseases. Ergot, a seed borne disease, is usually minor in crested wheatgrass seed crops. Ergot is indicated by collection of a sticky honeydew on the surface of infected florets during flowering or the presence of large black fungal structures that replace individual seeds in the mature seed head. Ergot is controlled by sanitation and by use of ergot-free seed. Seed cleaning is able to remove most of the ergot bodies from the seed lot. Storing the seed for a full year prior to using it reduces the viability of the ergot bodies. Field burning will reduce the survival of ergot bodies and provides some control of leaf spot diseases. Mowing of field edges will reduce infection from adjacent areas. Stem smut cannot be controlled by seed treatment because the underground buds and soil can also harbour the pathogen.

C. Irrigation management

Crested wheatgrass responds to good moisture conditions. Irrigation will increase seed yields if moisture stress occurs during the rapid spring growth, pollination or seed development stages (Figure 4).

Frequent light sprinkler irrigation after seeding provide adequate moisture for germination and establishment. Flood irrigation is difficult in newly seeded fields because of the risk of erosion and crusting. Once the crop is established, irrigation during periods of high evapotranspiration promote vigorous growth. Soil moisture should be maintained above 50% of field capacity. Adequate soil moisture during the period of rapid growth in spring and during the boot stage are the most critical periods for high seed yields. Water penetration to a depth of 60 - 120 cm indicates adequate soil moisture. The soil profile should be at field capacity just prior to pollination. Irrigation during flowering may reduce seed set, but a final irrigation just after pollination may be required to fill the developing seeds. Seed production of crested wheatgrass on dryland is also feasible, but seed yields are more variable.

Figure 4: Effect of row spacing, nitrogen fertility and irrigation on seed yield of crested wheatgrass at Scott, SK (Crowle, 1966)



V. Harvest

Grasses need about 30 days after flowering for the seeds to develop. Hot, dry weather shortens the ripening period while cool, moist conditions delay seed maturity. Grasses grown under irrigation or moister conditions have a higher ash content which increases the likelihood of shattering. Ripening 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 important to determine the best time to harvest. Crested wheatgrass is usually ready to swath in late July to early August. The crop is ready to swath at the hard dough stage which corresponds to a seed head moisture content between 35-40%. At this stage of maturity, firm thumbnail pressure is needed to imprint the seed. The seed heads will be brown, but the stems will still be green. Some seed will shatter when the seed head is firmly struck against the palm of the hand.

The moisture content of the seed head is unreliable when determined with conventional grain moisture testers. The seed head should be clipped off just below the lowest seed. Sample enough seed heads to weigh about 100 g. After determining the wet weight, dry the sample in a conventional oven set at 82°C until the sample reaches a constant weight. The sample may also be dried in a microwave oven using relatively short heating intervals of about 1 minute. Place a cup of water in the microwave with the sample to prevent it from catching fire at lower moisture contents. Record the dry weight of the sample. The moisture

content of the sample is calculated using the following formula: % moisture = ((wet weight - dry weight) / wet weight) * 100.

Conventional equipment is suitable for harvest of crested wheatgrass. Some combines may separate more seed if equipped with a modification kit to slow the fan speed. Swathing and picking up the windrow is usually the least risky harvest method, but in years of low seed yield, early maturity or reduced foliage, straight combining may be more appropriate. Crested wheatgrass has a moderate shatter risk relative to other grasses and seldom lodges unless very heavy rates of nitrogen have been applied. Swathing early in the morning or in the evening or at night when the air humidity is higher will reduce 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 within the swath.

Windrows are difficult to pick up from between widely spaced seed rows. Cutting the crop at an angle across the seed rows minimizes this difficulty. If inter-row cultivation is practiced, however, the field becomes too rough to swath the field across the seed rows. One alternative is to direct combine the crop with a straight-cut header. Another alternative is to sow the crop with groups of three or four closely spaced seed rows (12" spacing) at intervals where the swath can be laid.

Under good drying conditions, the crop will be ready to combine in 4-7 days after swathing. Because of the potential for contamination and the value of grass seed, thoroughly clean the combine before threshing grass seed. Some growers install one to three filler blanks in the concave to increase the aggressiveness of the cylinder. Initial combine settings recommended for crested wheatgrass 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 closed. The combine should be set so that the lemma and palea are retained on the seed. Seeds which retain these seed parts have longer viability in conventional storage. The concave setting should be adjusted to minimize straw breakage so the sieves do not become clogged. A properly adjusted concave just breaks up the head into separate seeds. The spikelets must also be broken up to permit separation of the seeds. Maintain an even flow of material into the combine. Crested wheatgrass often requires a slower forward speed than wheat to improve separation of the seed from the chaff and straw. The air flow needs to be high enough to lift the chaff about 10 cm at the front of the sieve so that the seed can be separated from the chaff on the sieve. A very clean sample, however, usually indicates that too much seed is being lost. Use a shovel to check seed loss at the back of the combine. Watch for plugging of the return when the sample is quite chaffy. The seed can be stored safely in storage bins 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 storage of grasses for longer periods is 8-10%.

Crested wheatgrass is ready for straight combining at the first hint of seed shatter. Tetraploid varieties are less prone to shatter than diploid varieties, and therefore, are less risky to straight combine. When the seed shatters as the seed head is lightly struck against the palm of the hand, seed shatter is imminent and the field should be straight combined immediately. This is usually about 3-5 days after the crop was ready for swathing. The risk of losing the crop from brisk winds is high. Seed that is direct combined needs immediate aeration and drying to maintain seed quality. Some grass seed growers install an aeration tube directly into their grain truck so that the seed can be aerated without dumping into a storage bin. Running the seed over a sieve to remove much of the green leaves, insects, chaff and short-stemmed straw will reduce the risk of heating in the direct combined seed. Significant heating which reduces the viability of the seed may occur within only a few hours.

Handling of crested wheatgrass seed can be challenging. Because of its light chaffy nature, the seed flows more like silage than like grain, especially if the sample is not dry. Belt conveyors and front-end loaders

handle chaffy grasses gently and efficiently. Large diameter augers can effectively transfer the seed if the intake opening is large enough to avoid bridging. In the grain bin, the seed is sometimes more easily handled with a pitchfork than with a shovel.

Drying of grass seeds must be conducted with care to maintain the viability of the seed. When the seed has a high moisture content, the temperature of the air flow must be lower 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.

VI. Post-harvest management

Two fall management practices of crested wheatgrass which are critical to sustaining seed yield potential are stubble management and nitrogen fertilization.

A. Stubble management

The first step is to windrow the straw behind the combine and bale and remove the straw as soon as possible after threshing. If the stubble was cut quite long and moisture conditions are good, the stubble should also be windrowed, baled, and removed as soon as possible to stimulate high future seed yields. When the fall is very dry, this stubble could be left until spring to trap moisture. Once spring arrives, the long stubble should be burned or clipped and removed before regrowth begins in spring. The weather will not cooperate in some years to allow burning in spring before regrowth occurs.

B. Nitrogen management

Nitrogen increases the seed yield of grasses primarily by promoting growth of tillers and by stimulating the growth of larger seed heads in those tillers which will form seed heads. Tillers must have grown enough to be induced to form seed heads by the correct daylength and temperature for each species. The period of the year when this physiological change occurs differs among grass species. The period when tillers are induced to form seed heads and when the new seed head starts to grow may occur very close together or may be separated by several months. Crested wheatgrass can develop new tillers during the fall if moisture is available. An early September nitrogen application of 20-25 lb N/ac under these conditions will promote greater tillering and increase the number of seed-forming tillers. The new seed head starts to grow in April and early May. In early October, the application of an additional 50-55 lb N/ac will stimulate the growth of the young developing seed heads in early spring. If conditions are dry, all 70-80 lb N/ac can be applied in mid-September or early October. If the weather turns very cold and the nitrogen cannot be applied until spring, all 70 lb N/ac should be applied as soon as spring breaks, preferably prior to the greening of the grass (Figure 5). If spring arrives late or the fertilizer cannot be applied until May, the rate should be decreased to 30-40 lb N/ac. Established irrigated fields require a total application of 100-125 lb N/ac per year, but the rate needs to be reduced if lodging occurs. The seed yield response to nitrogen is dependent on precipitation levels (Figure 6 and 7). Responses to fall applied phosphorus are marginal (Figure 8).

Figure 5: Effect of time of N application on seed yield of crested wheatgrass at Indian Head, SK (Buglass, 1964)

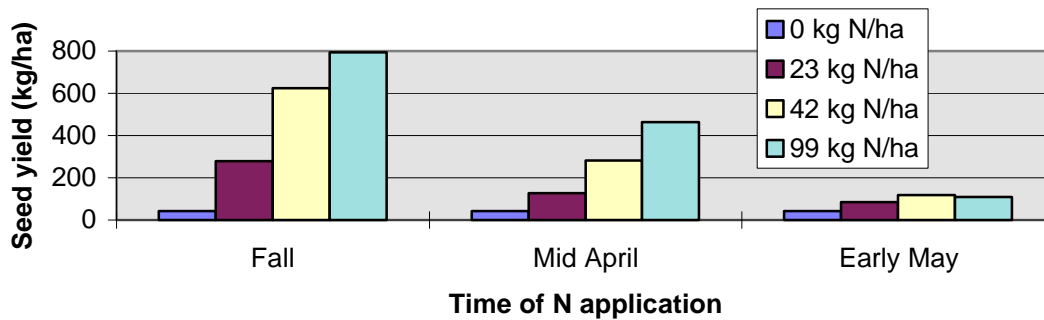
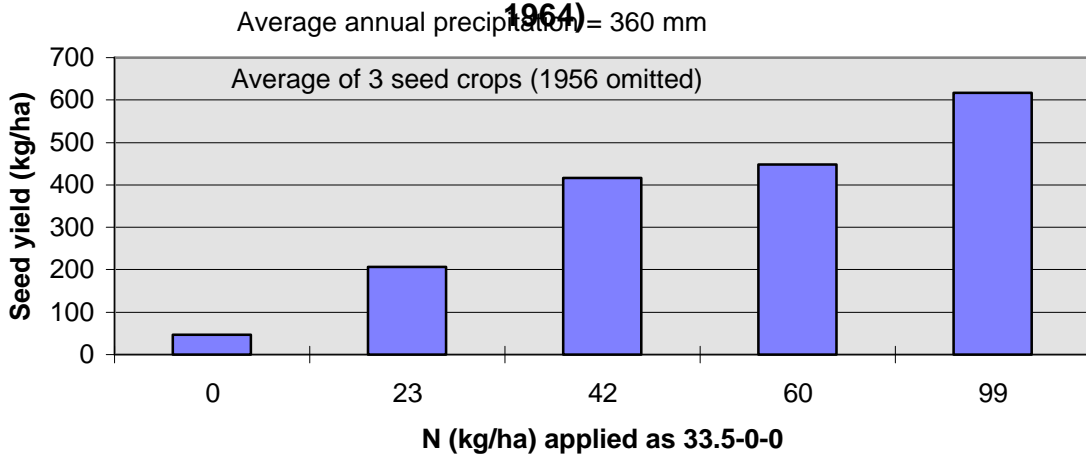


Figure 6: Response of seed yield of crested wheatgrass to N fertilizer at Indian Head, SK for 1954-1957 (Buglass, 1964)



The form of nitrogen applied to grass seed fields has a major impact on the seed yield response when applied with a broadcast spreader. The best nitrogen source for broadcast application is 34-0-0 (ammonium nitrate). This form is highly soluble in water and readily moves with soil moisture to plant roots for rapid uptake into the plant. Ammonium nitrate is not vulnerable to volatilization and is less prone to adsorption by stubble residues in the field. Liquid nitrogen is another excellent N source especially if dribbled under cloudy cool conditions or applied by spoke wheel injection. Because grasses efficiently absorb water from the soil, risk of leaching or denitrification is minimal. The ammonium nitrogen in urea (46-0-0) or even ammonium sulphate (20-0-0-24) is not only less accessible to the plant but also more vulnerable to loss by volatilization. If the application can be timed just prior to a significant precipitation event, any N form will be equally effective.

Figure 7: Response of seed yield of crested wheatgrass to N at Indian Head, SK from 1959-62 (Buglass, 1964)

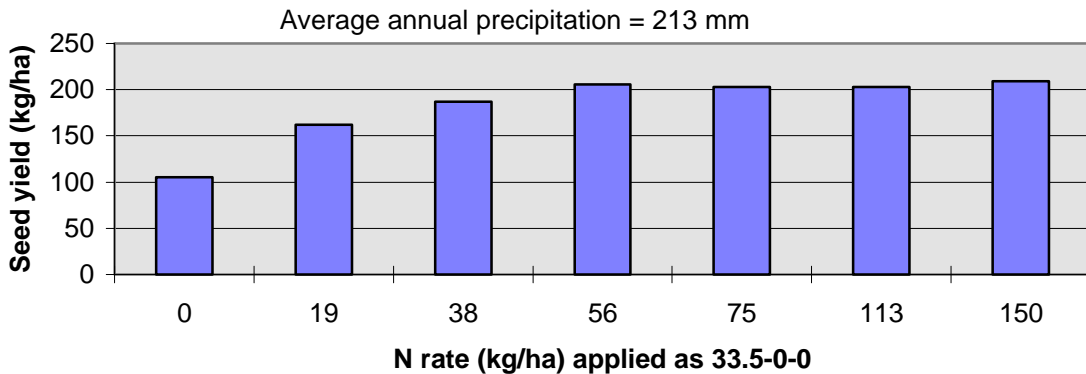
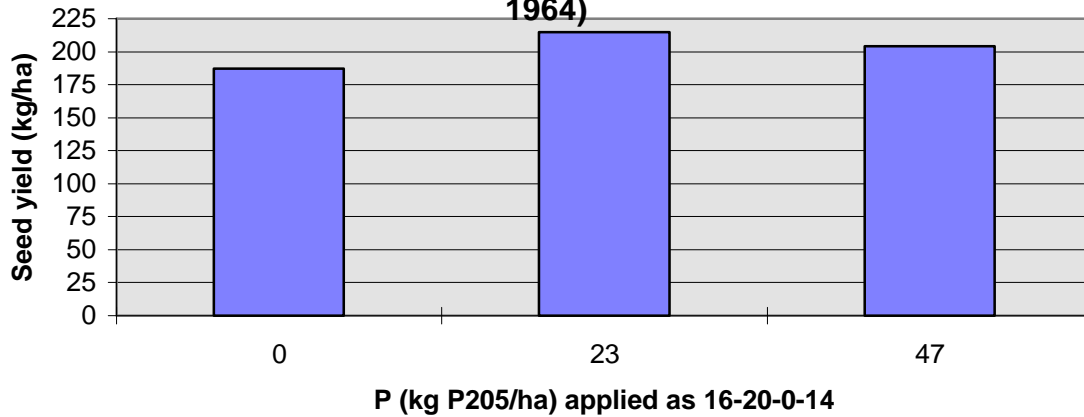


Figure 8: Response of seed yield of crested wheatgrass to P fertilizer at Indian Head, SK from 1959-62 (Buglass, 1964)



VII. Stand removal

Crested wheatgrass is taken out of rotation relatively effectively by glyphosate application. The crop should be cut as high as possible during the last harvest season to leave as many green leaves as possible for absorption of glyphosate. Following harvest, glyphosate should be applied at 1-2 liter/ac on the green growth. The stand can then be broken with tillage with a lower fuel requirement. Some regrowth of the grass is likely during the subsequent growing season. If a broadleaf crop is sown the following spring, several graminicides are available to control regrowth of volunteer crested wheatgrass during the growing season.

VIII. Additional references

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

Smith, S.R. 1996. Pedigreed forage seed production. Can. Seed Growers' Association, Ottawa, Ont.