

Seed Production of Northern Wheatgrass

I. Introduction

Northern wheatgrass (*Agropyron dasystachyum* (Hook.) Scribn. or *Elymus lanceolatus* (Scribn. & Smith) Gould) is native to the Canadian prairies. Northern wheatgrass is known as thickspike wheatgrass in the United States. The grass is a close relative of western wheatgrass, but is more tolerant of drought. Native stands are often mixtures with western wheatgrass or speargrasses. Some relatively pure stands of northern wheatgrass can be found on sandy soils. Several varieties of northern wheatgrass are available for multiplication - Elbee developed at Lethbridge, and Critana developed in the United States. Another variety, Sodar streambank wheatgrass, differs only in its lack of pubescence on the heads and seeds. Sodar was also developed in United States, but is multiplied in Saskatchewan.

Production in Saskatchewan in 1995 was estimated at 5 tonnes. The average yield of clean seed is 35-50 kg/ac.

II. Field selection

A. Adaptation

This species is usually found growing on coarse to medium textured soils throughout the prairies. The grass predominates throughout the Dark Brown soil zone as well as wetter areas of the Brown soil zone and drier areas of the Black soil zone. The grass is a long-lived perennial with an extensive root system. Seedlings are small and inconspicuous, but compete well with weeds. The plants spread rapidly by sending out creeping underground rhizomes. The grass also has a dense shallow root system and a few roots that penetrate to at least 60 cm. The combination of these three systems of roots increases its resistance to invasion and its tolerance to drought. This grass is also well suited for vegetating areas prone to erosion. The grass prefers dry areas, but does respond to extra moisture and will tolerate periodic flooding. Once the stands thicken, the grass becomes unproductive and seldom sets seed. The plants are tufted with erect leaves and stems 45-75 cm tall. Leaves are light greyish green and rolled under dry conditions. Seed heads are 6-12 cm long. The seed heads are pubescent with the exception of Sodar streambank wheatgrass. 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 northern 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. The absence of quackgrass in the field is essential for growing northern wheatgrass since this weed and the crop are extremely difficult to distinguish. Noxious weed seeds disqualify the seed for market as pedigreed seed.

Weeds with similar size and shape of seeds to northern 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. Downy brome is also a serious contaminant in northern wheatgrass seed fields. Fields selected for seed production of northern 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

Northern 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. Northern 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. In other words, western wheatgrass harvested from stands of Certified western wheatgrass may not be marketed using the variety name.

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 northern 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 northern wheatgrass as required by CSGA regulations

Class of seed sown		Class of seed harvested	Contaminating crop	Number of intervening seasons
Breeder	Foundation	Non-pedigreed or different variety of northern wheatgrass		5 seasons
Breeder	Foundation	Same variety of northern wheatgrass		3 seasons
Breeder or Foundation		Certified	Northern wheatgrass	2 seasons

A field sown with Breeder northern wheatgrass seed is eligible for four years of Foundation plus two years of Certified seed production. A field sown with Foundation northern wheatgrass seed is eligible for six 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.

Northern 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

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

III. Crop establishment

Much of the seeded acreage of northern wheatgrass is sown with certified seed. Care is required to purchase stock seed which is free of downy brome contamination. 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 northern wheatgrass should be eliminated immediately. Marketability of northern wheatgrass seed free of downy brome is much greater and commands a premium in the marketplace.

The main objective for the establishment year is to produce a healthy stand of seedlings which are vigorously tillering. Northern 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. 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 northern 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.

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 northern 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 northern 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 Swift Current indicates that the greatest chance of successful establishment occurs in early spring and early fall. When the crop is not sown until fall, no seed will be produced until the second fall after seeding.

Northern wheatgrass has a light chaffy seed that readily bridges 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 P205/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 northern 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 northern wheatgrass is strongly rhizomatous, it should be sown with a row spacing of 30 - 36 inches. The wider row spacings are recommended for lighter textured soils and for seedings which will be harvested for four or more years. A minimum row spacing of 30 inches is required for inter-row cultivation. At this spacing, however, some weeds and shattered northern wheatgrass seeds will invade the stand if inter-row cultivation is not practiced. Inter-row cultivation also restricts the creeping nature of this rhizomatous grass and prolongs the life of the stand.

The wide row spacings are easily accomplished with conventional equipment by placing tape over the unwanted seed cups in the seed box. Depending of 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 20 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. Northern wheatgrass, on average, contains 155,000 seeds. For a row spacing of 2.5 feet and a seeding rate of 20 seeds/ft, one acre (43,560 ft²) contains 17,424 feet of seed row and require 348,480 seeds or 2.2 lb seed/ac. 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 northern 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 P205/ac. Likewise, for fields testing less than 200 lb K/ac, 100 lb K20/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. Northern 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 P205/ac is generally safe.

D. Companion crop

Seed production of northern wheatgrass is 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.

IV. Crop Management

A. Weed control

Weed control options are limited once the northern 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 northern 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 northern 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 northern 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.

B. Disease and insect monitoring

Serious disease and insect problems in northern wheatgrass seed fields have not been encountered to date.

C. Irrigation management

Northern 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. 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 northern wheatgrass on dryland is also feasible, but seed yields are more variable.

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. Northern 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 of 40-45%. At this stage of maturity, firm thumbnail pressure is needed to imprint the seed. The seed heads will be turning yellow, but the stems will still be somewhat 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 northern 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. Northern wheatgrass has a low 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. Initial combine settings recommended for northern wheatgrass are a cylinder speed of 800 rpm and a concave clearance of 1/8". 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 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. Maintain an even flow of material into the combine. Northern 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 elevator 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%.

Northern wheatgrass is ready for straight combining at the first hint of seed shatter. 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 reduces 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 northern 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 northern 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. An alternate approach is to spread the straw over the field and burn the field as soon as combining is completed. If this procedure is delayed, the straw will fall through the stubble and it will be difficult to remove. Burning in late fall also restricts the time available for regrowth of the tillers and injures tillers which have already started to grow.

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. Northern 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. 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. 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 this rate needs to be reduced if lodging occurs.

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.

VII. Stand removal

Northern wheatgrass is taken out of rotation 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 northern wheatgrass during the growing season.

VIII. Additional references

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