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Grass Seed Production
in North Dakota

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GRASS SEED PRODUCTION IS A SPECIALTY ENTERPRISE. It offers an opportunity for a few dedicated producers to develop a highly profitable enterprise over time.

Producing grass seed is a long term enterprise. It requires a minimum time of two to three years before the first seed crop is harvested and dollars begin to flow back into the business. Land preparation, establishment of the seed production field and harvesting of the first seed crop usually requires a minimum of three years. If the seed production field has already been properly prepared, a minimum of two years will be required before the first seed crop is harvested. Seed conditioning, which includes seed cleaning and processing, and marketing will delay positive cash flow into years three or four, assuming a good seed production year.

Grass seed, unlike cereal crops such as wheat, barley and oats, has no dollar value until sold to a seed distributor or to the final user for hay, pasture, soil protection and/or wildlife habitat plantings. Individuals considering grass seed production as a farm enterprise must produce a grass that is in demand and have a marketing program or a production contract in place when the seed field is established.

The following seed production guidelines for selected grasses will help individuals establish a successful grass seed production enterprise. In addition, valuable information can be obtained by visiting successful grass seed producers and seed dealers. Take time to visit with several of these individuals before making your final grass seed production decision.

Seed Certification

The purpose of seed certification is to ensure that high quality seed of specified varieties is distributed to the producers. Certification ensures varietal identity and genetic purity. This is accomplished through isolation of seed production fields, field inspection, and seed testing and analysis by the state seed certification agency.

Grass seed producers should seriously consider the production of certified seed. Certified seed usually will be more readily marketable, especially if the seed producer is not well known. If the seed field is not planted with foundation or registered class seed, purchase certified seed so that uncertified seed of a known variety can be marketed.

For further information on grass seed certification, contact your local county extension agent, NDSU extension agronomist and grassland management specialist, Soil Conservation Service or the North Dakota State Seed Department, State University Station, Fargo, ND 58105. Request a copy of Bulletin 51 entitled "North Dakota Seed Certification Standards."

Species Selection

Seed producers should grow grass species and varieties that are adapted to North Dakota or to the Northern Great Plains area (North Dakota, South Dakota, Montana, Wyoming, Nebraska and the Canadian Prairie Provinces) and Minnesota. Grow varieties that are in greatest demand by producers or by the seed trade. Extension Circular R-794 entitled "Grass Varieties for North Dakota" provides a listing of commonly grown grass species and varieties.

First-time seed producers should select a grass or grasses that establish easily, possess high seed yield potential, exhibit the least difficulty in maintaining row culture (bunchgrasses) and which present the least difficulty in harvesting, conditioning and storage of the seed.

Site Selection

Seed production will be greater if plantings are made on productive soil. Select a site that will provide the required ISOLATION DISTANCE between species of the same kind for the production of certified seed. Isolation of commonly used grasses such as crested wheatgrass and smooth bromegrass may be difficult because of their widespread use on road right-of-ways and for hay and pasture.

PAST CROPPING HISTORY is also important. North Dakota field certification standards state:

1. A field, to be eligible for the production of foundation seed, must not have grown or been seeded to the same species during the previous five years.
2. A field, to be eligible for the production of registered seed, when permitted, or certified seed, must not have been in the production of the same species during the previous year unless the crop was of the same variety or strain and passed field inspection for certification.

SEED DORMANCY of the previously grown grass is a major consideration when selecting a site. For example, green needlegrass seed may lay dormant in the soil for five years or more before germinating. If the previous seed crop was green needlegrass, the land should be placed in crop production or a warm-season grass species, such as switchgrass, must be grown. Switchgrass will tolerate the use of the herbicide atrazine used for the eradication of cool-season, perennial grasses.

SOIL EROSION by water can be a serious problem when growing grass in wide row spacings on rolling land. Select a level to gently sloping site for growing grass in wide rows or plant on the contour to reduce gully erosion between the rows. Gullying between rows will make harvesting very difficult. In addition, runoff water from spring snow melt or heavy rains can carry seed of other grasses from field margins and from one seed production field to another, causing serious cross species contamination. Locate seed production fields to avoid potential contamination by runoff water.

Seedbed Preparation

Seed production fields should be free of perennial grass and broadleaf weeds. IF THE FIELD IS NOT CLEAN, DO NOT PLANT. Annual grassy weeds such as cheatgrass brome, green and yellow foxtail or pigeongrass and wild oats, and foxtail barley, a perennial, can be especially troublesome during grass establishment. Their seeds are very difficult to remove from certain grasses during the conditioning process. Field pennycress (Frenchweed), a broadleaf winter annual, and green and yellow foxtail are difficult to remove from switchgrass seed.

The ideal seedbed for grass is summerfallow. Summerfallowing permits the use of nonselective herbicides to control annual and perennial grass and broadleaf weeds, limiting the number of tillage operations. Shallow tillage is beneficial to maintain a FIRM SEEDBED. A firm seedbed holds soil moisture near the surface of the soil for seedling root growth extension during establishment and is essential to maintain a shallow planting depth. If the seedbed is not firm, use a cultipacker, harrow or run an empty press drill over the field several times before planting. The seedbed should be packed firm enough so that the tread marks of the tractor tires are only slightly visible.

How Many Acres?

The ACREAGE to be planted will depend on grower experience and whether harvesting the grass seed crop conflicts with other farming operations. Many grasses shatter or drop their

seed when physiologically mature. Therefore, the seed crop could be lost if harvest operations are not timely. Generally, commercial seed production requires an acreage of 10 acres or more. New growers should start small, increasing the size of the operation as they become more comfortable with grass seed production and marketing techniques.

Establishing the Seed Field

The DATE OF PLANTING perennial grasses will vary from year to year depending on climatic conditions. Two major considerations include soil moisture for seed germination and seedling establishment and whether a cool-season or warm-season grass is being planted.

The ideal time to plant varies by area of the state and time of seeding - spring, later summer or early fall and dormant-season seeding.

SPRING is an excellent time to plant both cool and warm-season grasses. WARM-SEASON GRASSES SHOULD ONLY BE PLANTED IN THE SPRING. Early plantings will establish better stands than late plantings, especially if broadleaf and annual grassy weeds are not a problem. Cool-season grasses begin to germinate at soil temperatures of 40 to 45°F. In comparison, warm-season grasses initiate growth at 50 to 55°F soil temperatures. The recommended spring planting dates for cool and warm-season grasses by areas of the state are as follows:

Northern North Dakota	Southern North Dakota
Cool-season grasses: Before May 20	Cool-season grasses: Before May 1
Warm-season grasses: May 20 to June 20	Warm-season grasses: May 1 to June 20

Plantings are sometimes delayed because of late season or a suspected broadleaf and grass weed problem. If weeds are a potential problem, delay planting warm-season grasses until one or two weed crops are controlled. Plantings of warm-season grasses delayed too long into the summer often are risky because of higher temperatures and reduced surface moisture for germination and seedling growth. For cool-season grasses, summerfallow to reduce the weed problem and plant in mid-summer to early fall.

Late summer or early fall is another good time to plant cool-season grasses provided surface moisture is adequate for seed germination and subsoil moisture is present for seedling root growth. Fall-seeded grasses should be established early enough to permit a minimum of two leaves, preferably three or more, to develop before growth stops. Generally, plantings made by September 1 to 10 will be well established before freeze-up. Planting of cool-season grasses on summerfallow in mid to late summer often will permit a seed harvest the following year of crested wheatgrass, intermediate wheatgrass, pubescent wheatgrass, slender wheatgrass and smooth bromegrass. Russian wildrye will not produce seedheads the following year when planted in mid-summer or fall. Green needlegrass and western wheatgrass are slow to establish and will not produce enough seedheads for a profitable harvest. Grasses planted into clean stubble in the fall generally develop weak seedlings that do not produce a harvestable seed crop the following year.

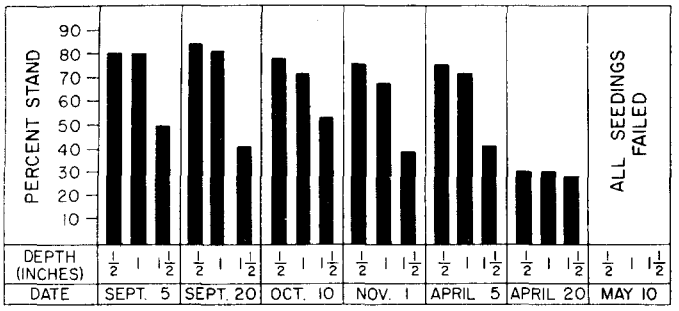
Dormant-season seedings are the most beneficial for grasses such as green needlegrass and beardless wildrye which posses a natural seed dormancy. Seed dormancy tends to break down in the soil over winter. Dormant-season seedings should be late enough in the fall so that seeds do not germinate. Although the exact date of seeding will vary, it is about October 20 in northern areas and about November 1 in southern areas. A maximum planting depth soil temperature of less than 40°F would be ideal.

DEPTH OF SEEDING: Grass seed should not be planted more than 1 inch deep into a firm seedbed. A firm seedbed and a shallow depth of seeding will provide a more uniform emergence of grass seedlings and stand establishment. In addition, a firm seedbed holds soil moisture near the surface of the soil for seedling root growth.

Depth of seeding studies conducted at the Northern Great Plains Research Center, Mandan, ND (Fig. 1 and 2) indicate that cool-season grasses such as crested wheatgrass and western wheatgrass developed better stands with a seeding depth of 1 inch or less. In contrast, warm-season grasses such as sideoats grama and switchgrass established better stands with a seeding depth of 0.5 inch or less. Depth of seeding is determined primarily by seed size and soil texture. Warm-season grasses and small-seeded, cool-season grasses such as Kentucky bluegrass do best if planted no deeper than 0.25 to 0.5 inch deep. Large-seeded cool-season grasses such as the wheatgrasses, wildryes and smooth bromegrass may be planted 0.5 to 1.0 inch deep. The deeper planting depths generally are for light textured sandy soils.

ROW SPACING: Grass species tend to react differently to wide row spacing vs solid or drilled stands. Wide row plantings generally produce higher seed yields over a longer time compared to solid plantings. In addition, row plantings require less seed per acre for establishment, weed control is considered easier, undesirable or off-type plants can be identified and rogued from the field more easily and volunteer plants from shattered seed may be controlled more effectively if a factor in certified or registered seed production.

Crested wheatgrass



Western wheatgrass

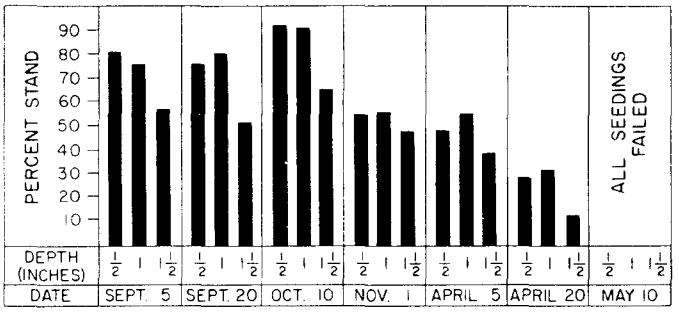
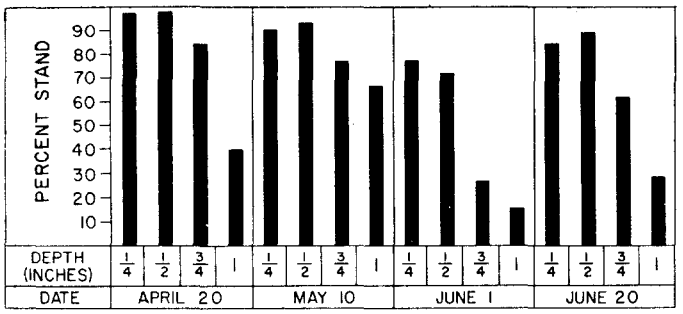


Figure 1. Influence of seeding depth and planting date on cool-season grass establishment. USDA Tech. Bul. 1097.

Sideoats grama



Switchgrass

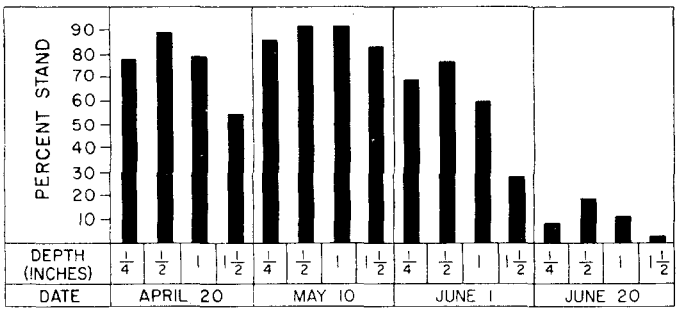


Figure 2. Influence of seeding depth and planting date on warm-season grass establishment. USDA Tech. Bul. 1097.

The desired row spacing depends primarily on moisture availability and equipment available for cultivation. Mature grass row spacings of 36 to 42 inches should be used in western North Dakota where less moisture is available for growth. In eastern North Dakota and under irrigation, a mature row spacing of about 20 to 36 inches will be more productive.

A single seeded row of grass will, within one to two years, tiller and spread out in the row. A mature row will occupy a space about 10 inches wide. Therefore, the row spacing selected will depend on the type of cultivation equipment available and width of the mature grass row. Allow approximately 5 inches on each side of the seeded row for expansion. For example, if a 20-inch rototiller is available for cultivation between rows, then an initial row spacing of 30 inches is required. Grasses grown in rows will produce more seed if new tiller shoots are given room to grow as the stands age.

Studies at the Northern Great Plains Research Station indicate that in wide row spacings, planting double rows of grass 6 to 7 inches apart produces more seed per acre than a single row. The double seeded rows of grass produced a wider row of grass sooner than the single seeded row.

Seed yields of various grass species grown under dryland and irrigated conditions in several row spacings at USDA Agricultural Research Service experiment stations and at North Dakota agricultural experiment stations are provided in the appendix.

A SEEDING RATE of 30 pure live seeds (PLS) per row foot should provide a solid, uniform row of plants. The number of grass seedlings established should be dense enough to completely fill the seeded row by the spring of the second growing season. Suggested seeding rates to provide 30 PLS per row foot for commonly grown introduced and native grasses at several row spacings are given in Table 1.

Seeding rates based on pounds of pure live seed assumes every seed is viable and capable of producing an established plant. A seed lot with 100 percent germination and 100 percent purity has a PLS index of 1.0 (100% × 100% = 1.0 PLS index). The rate of seeding or the actual pounds of bagged seed planted must be adjusted upward for seed lots with a PLS index of less than 1.0.

To determine the adjusted seeding rate for each species or seedlot of a given germination and purity percentage (percentage on seed tag), follow the steps below:

Step 1:
% germ. x % purity = PLS index
(a decimal number)

Step 2:
PLS seeding rate ÷ PLS index = lbs bagged seed/acre

Drills without grass seed attachments may have difficulty in seeding light, chaffy and/or winged seeds such as smooth bromegrass, intermediate and tall wheatgrass, creeping foxtail, blue grama, big bluestem, little bluestem and sideoats grama. Seeds of these grasses do not feed evenly through regular drills and tend to bridge in drill boxes without seed agitators, resulting in uneven seeding and skips. A CARRIER such as cracked corn is required to permit a more uniform seeding. A North Dakota seed producers uses equal parts by weight of grass seed, flax and proso millet for a solid seeding of green needlegrass. THE MILLET SEED IS HEATED IN THE OVEN TO KILL THE GERMINATION BEFORE PLANTING. A seed temperature of about 200 to 250°F is adequate to kill seed germination. Place only a small amount of the grass seed and carrier mixture in the drill box at a time to limit the amount of settling and bridging in the drill box. Stir the mixture periodically if grass seed tends to separate from the carrier. Special grass drills are available on a rental basis from a number of soil conservation districts throughout North Dakota. These drills are equipped with seedbox agitators, depth control bands and a special seedbox feed mechanism for seeding winged and/or chaffy grass seed.

COMPANION CROPS, especially normal seeding rates, are not recommended when planting grass for seed production. They tend to delay development of the stand and reduce first-year seed yields. However, if a grass drill is not

Table 1. Suggested seeding rates for grasses to provide about 30 PLS per row foot for several row spacings.

Grass species	No. seeds per lb.	Row spacing - inches				
		12 or less	24	30	36	42
		lbs PLS/acre				
Bluestem:						
Big	160,000	8.2	4.1	3.3	2.7	2.3
Little	260,000	5.0	2.5	2.0	1.7	1.5
Bromegrass:						
Meadow	80,000	16.0	8.0	6.5	5.5	4.7
Smooth	135,00	9.9	4.9	3.9	3.2	2.8
Canarygrass[1]:						
Reed	530.000	2.5	1.3	1.0	0.8	O.7
Foxtail[1]:						
Creeping	750,000	1.7	0.9	0.7	0.6	0.5
Grama:						
Sideoats	190,000	6.9	3.5	2.8	2.3	2.0
Needlegrass:						
Green	180,000	7.3	3.6	2.9	2.4	2.1
Sandreed:						
Prairie	275,000	4.8	2.4	1.9	1.5	1.4
Switchgrass	390,000	3.4	1.7	1.3	1.1	1.0
Wheatgrass:						
Crested						
Standard	175,000	7.5	3.7	3.0	2.5	2.1
Fairway	200,000	6.5	3.3	2.6	2.2	1.9
Intermediate						
Intermediate	88,000	14.8	7.4	5.9	5.0	4.3
Pubescent	90,000	14.5	7.3	5.8	4.8	4.1
Slender	160,000	8.2	4.1	3.3	2.7	2.3
Tall	79,000	16.5	8.3	6.6	5.5	4.7
Western	110,000	11.9	5.9	4.8	4.0	3.4
Wildrye:						
Altai	100,000	13.0	6.5	5.2	4.4	3.7
Beardless	160,000	8.2	4.1	3.3	2.7	2.3
Russian	175,000	7.5	3.7	3.0	2.5	2.1

[1]Grow in solid stand on good moisture sites or in rows under irrigation.

available, a carrier will be required to carry grass seed through regular grain drills. Wide row seedings should always be planted with a light companion crop seeding rate to mark the rows for cultivation. Careful, early cultivation, if weeds are a problem, will prevent serious weed problems later.

Flax and oats are widely used as companion crops. Flax is less competitive with new grass seedings than oats. Flax planted by mid summer will stand erect following freeze-up and hold a good covering of snow to protect the young grass plants. The following companion crop seeding rates are suggested.

- SOLID SEEDINGS:
  Flax - 5 to 6 lbs/acre
  Oats - 8 to 10 lbs/acre
- ROW SEEDINGS:
  Flax - 2 to 3 lbs/acre
  Oats - 4 to 5 lbs/acre

Companion crop seeding rates may need to be adjusted depending on the purity of a particular grass seedlot. When increasing companion crop seeding rates, use only as much as is needed to carry the grass seed through the drill.

If grassy weeds become a problem, cultivate between rows and/or mow as often as necessary to reduce weed competition and use labeled herbicides to control weeds (see Extension Circular W-253, "Agricultural Weed Control Guide").

CULTIVATE the grass seeding as soon as rows are visible and weeds begin to grow. Repeat cultivations as necessary. Use caution when cultivating so that the row does not become ridged. Sometimes seed producers mount a disc in place of the cultivator shovel next to the row. The discs are adjusted to pull the soil away from the grass seedlings. Cultivator shovels which follow pull the soil back next to the row. Row shields are essential to avoid covering grass seedlings. Cultivate shallow, preferably 1 to 1.5 inches deep and as close to the seeded row as possible.

FERTILIZATION generally is not needed for grass establishment. However, once the small amount of nutrients in the seed is used up, the grass seedlings depend on soil nutrients for growth and development. If soil nitrogen and phosphorus are low, an application of 10 to 15 pounds of nitrogen and 20 to 30 pounds of P_2O_5 per acre may be applied prior to planting. DO NOT APPLY MORE THAN 10 pounds per acre of nitrogen plus potassium with the seed at planting time or germination injury could occur. Fertilize for full seed production following the first full year of establishment in early fall and/or use a split application in the early fall and again in early spring on sandy soils where leaching may be a problem.

Stand Management for Seed Production

WEED CONTROL, MAINTAINING ROW CULTURE, AFTER-HARVEST RESIDUE AND FERTILIZATION are the primary concerns for management of established grass seed production fields.

CULTIVATION, USE OF HERBICIDES AND ROGUING are the primary methods for controlling weeds, maintaining row culture and eliminating off-type plants and/or invading grasses from seed production fields. Mowing of other perennial grasses around pothole areas, tree rows, drainage areas, and along roadsides bordering seed fields and maintaining a clean-tilled field border will be beneficial to prevent invasion of undesirable plants and to maintain genetic purity. Perennial grasses should be mowed before flowering.

CULTIVATE as often as necessary to maintain a weed-free stand. A minimum of three to five cultivations and/or rototillings generally will be required to control annual grass and broadleaf weeds, volunteer grass seedlings and spreading from sod-forming grasses between the rows.

Cultivate shallow, usually no deeper than 1.0 to 1.5 inches. Deep cultivation will prune the fibrous roots of the grass, reducing plant vigor and potential seed production. Begin cultivation in early spring, before growth begins, to suppress rhizomatous grass growth and early growing weeds between the rows. An additional cultivation may be required within two to three weeks. Cultivation usually will be required following seed harvest but before fall regrowth begins.

Use care when cultivating. Do not cause soil ridging in the grass seed row. Ridged rows will make it difficult to harvest windrowed grass that lays between the rows. Row shields, slow travel speed and proper adjustment of tillage equipment should keep soil ridging in the row at a minimum.

CAUTION - Do not remove green vegetative growth from the margins of seed rows in early spring or after regrowth begins in the fall or potential seed production will be reduced. Most perennial grasses initiate vegetative tiller buds in the fall. These tiller buds develop into reproductive shoots in late winter or very early spring. Russian wildrye is an exception. The vegetative tillers of this grass change before freeze-up to the reproductive state. The number of reproductive shoots is determined in the fall.

Caution: Cultivation equipment may transport rhizomes of sod-forming grasses and/or tillers and live seeds between seed fields. Clean tillage equipment thoroughly before moving to another field planted to a different variety of the same grass or to a different kind of grass to avoid cross contamination of seed fields.

HERBICIDES may be required to control weeds in seed production fields. Generally, grasses can be sprayed only with herbicides such as 2,4-D, MCPA, dicamba, bromoxynil and/or combinations of these herbicides (See Extension Circular W-253, "Agricultural Weed Control Guide"). Seedling grasses should not be sprayed with 2,4-D until the three-leaf stage of growth. The herbicide bromoxynil may be applied any time after the grass seedling emerges. Apply herbicides on established grass early, preferably before jointing, but before the boot stage of growth or seed yield may be reduced. The herbicide Atrazine is labeled for use on warm-season grasses such as big bluestem and switchgrass. APPLY HERBICIDES ACCORDING TO LABEL INSTRUCTIONS.

ROGUING is essential in a grass seed production field to maintain genetic purity and for the production of high quality seed. Roguing is the handweeding or removal of inferior, non-typical or off-type grasses and/or plants from the seed field. Removal of off-type and invading grasses should be completed before the plants begin to flower. Grasses are easily identified after seedhead emergence. Rogued plants should be bagged and/or removed from the seed field.

RESIDUE should be removed following seed harvest to maintain high seed yield potential. Removal is essential because residue usually cannot be incorporated adequately into the soil by cultivation. Research indicates that residue removal, including straw and stubble, reduces plant disease potential and stimulates the production of more and larger tillers due to increased light penetration to the plant crown. Shading of plant crowns reduces regrowth potential, causing reduced food storage and seedstalk development potential.

STRAW RESIDUE OF BOTH COOL AND WARM-SEASON GRASSES HARVESTED BY THE SWATHER METHOD SHOULD BE REMOVED IMMEDIATELY FOLLOWING SEED HARVEST AND/OR BEFORE FALL REGROWTH BEGINS. The residue may be removed by raking and baling for livestock feed. Cool-season grass residues also may be removed by an early post harvest burn. (Note: Experience by a local seed producer indicates stand injury and reduced seed yield of green needlegrass following an early post harvest burn.) Warm-season grasses mature seed later than cool-season grasses and should not be burned, mowed, clipped or grazed until after freeze-up. Growth of warm-season grasses is stimulated by an early spring burn before growth begins. Late fall burning limits the amount of snow-catch for moisture conservation and exposes the grass stand to cold winter temperatures.

BURNING OF STRAW AND STUBBLE FOLLOWING HARVEST MAY BE DIFFICULT ON FIELDS WITH LIMITED STRAW RESIDUE TO CARRY THE FIRE BECAUSE THE STUBBLE REMAINS GREEN, ESPECIALLY WHEN CUT AT 6 TO 8-INCH STUBBLE HEIGHT AND SOIL MOISTURE IS AVAILABLE FOR REGROWTH.

The residue of Russian wildrye must be removed immediately following seed harvest if high seed yield potentials are to be maintained. The residue may be removed by mowing for hay, moderately close grazing or by burning. Canadian studies indicate that the sooner grazing is initiated following seed harvest the higher the seed yield the following year. Using the residue as hay or grazing provides an additional economic return to producers during years when seed production is low. Grazing has the disadvantage of possible cross contamination of seed fields from seed in animal droppings.

Generally, fall regrowth on grass seed production fields should not be utilized until after a killing frost in late fall. Maintain sufficient stubble height to catch snow for moisture conservation and to insulate the stand from cold temperatures.

FERTILIZATION of seed production fields is essential to maintain high yields of seed, especially following the first seed production year. Grass stands tend to become "sod-bound" with age. They become nitrogen deficient within one to two years following establishment. The grass stand is producing more roots than vegetative shoot growth. This condition is caused primarily by a lack of nitrogen, although phosphorus and potassium may be lacking. A soil test will determine the level of phosphorus and potassium in the soil. If soils test low in these nutrients, the response to nitrogen fertilizer application may be reduced. Suggested fertilizer application rates are listed in Table 2.

Lodging may be a problem with certain grasses during good moisture years when high nitrogen rates are applied. Research indicates that lodging is less severe when nitrogen is applied in the fall.

Table 2. Suggested application rates of nitrogen, phosphorus and potassium on established grass seed production fields.

Area of State	Nitrogen	Phosphorus Soil test level Low	Phosphorus Soil test level Medium	Potassium Soil test level Low	Potassium Soil test level Medium
Dryland:	**Lbs N/acre**	**Lbs P_2O_5**		**Lbs K_2O/acre**	
East	75-100	20	15	80	45
Central	50-76	20	15	80	45
West	40-50	20	15	80	45
Irrigation:					
Statewide	100-150	20	15	80	45

Timing of fertilizer application is very important. Tiller buds, which determine the number of grass shoots the following year, are initiated in the fall. Seed production fields of cool-season grasses should be fertilized in early fall following seed harvest and after the removal of post harvest residue. Warm-season grasses should be fertilized just prior to initiation of growth in the spring. Fertilize just before cultivation or rototilling if fertilizer is broadcast applied. Anhydrous ammonia may be knifed in between the rows. On sandy soils where leaching may be a problem, a split application of fertilizer in early fall and again the following spring is desirable. The split application, fall and early spring, stimulates fall tiller bud development and maintains vigorous growth the following spring while limiting the potential loss of nitrogen.

NOTE: If grass seed is produced with irrigation, maintain the soil water holding capacity at or above 50 percent field capacity. Adequate irrigation water should be applied before the flowering stage to maintain the grass stand until pollination is complete. Three irrigations generally will produce a seed crop during most years. Irrigate at or prior to the boot growth stage, just prior to the flowering growth stage and after flowering, but not later than the soft dough growth stage. A fourth irrigation may be required after harvest to promote active fall regrowth and food storage. DO NOT SPRINKLER IRRIGATE DURING THE FLOWERING GROWTH STAGE. Sprinkler irrigation and/or rainfall during flowering or pollination may reduce seed set, lowering the potential seed yield.

Time to Harvest

The proper time for harvesting grass seed is one of the most important decisions in grass seed production. The best time will vary depending on the grass species grown and the harvest method - direct combine vs swathing. The ideal time to harvest is at the medium to hard dough stage of seed maturity. However, seedheads of grass do not ripen uniformly.

Seedheads of grass do not emerge at the same time. Several days or more may pass before nearly all seedheads become fully visible. Therefore, flowering and seed development in a stand of grass takes place over several days to two weeks. Seed ripening will follow the same pattern. Grasses require about 30 days from the time of flowering to seed maturity. Hot, dry weather may reduce the time for ripening and cool, moist conditions may delay seed maturity. The time required for grass seed to advance in maturity from the medium dough growth stage to first seed shatter may be as short as three to four days. Timing of harvest is critical or the seed crop may be lost.

Seed producers must inspect their fields regularly during the seed development process, expecially as the crop begins to ripen. Since all grass shoots do not mature seed at the same time, a decision must be made as to when the most seedheads are ready to harvest to provide near maximum yield of seed.

The time period for harvesting grass seed is relatively short due to the potential for seed loss by shattering. Seedheads of creeping foxtail, green needlegrass, reed canarygrass and Russian wildrye will shatter readily, possibly within one to two days if too ripe. Smooth bromegrass and the wheatgrasses do not shatter as readily until mature, providing a longer period for harvest. The seed crop should be harvested when about 75

percent of potential seeds are at their optimum or proper stage of maturity. Delayed harvesting usually results in excessive loss of seed through natural seed drop as the plant matures and shattering caused by wind, rain and hail.

Guidelines for Seed Harvest

- HARVESTING A SEED CROP MAY NOT BE ECONOMICAL EVERY YEAR, ESPECIALLY ON UNFERTILIZED FIELDS. UNTIMELY RAINS, EXCESS MOISTURE DURING FLOWERING AND POLLINATION MAY LIMIT SEEDSTALK DEVELOPMENT AND/OR SEED SET. EXAMINE SEED FIELD TO DETERMINE SEED PRODUCTION POTENTIAL BEFORE HARVESTING.
- THE IDEAL TIME TO HARVEST GRASS SEED IS WHEN THE LARGEST NUMBER OF SEEDHEADS HAVE MATURED TO THE PROPER STAGE OF SEED DEVELOPMENT.
- THE BEST TIME TO HARVEST DEPENDS ON THE METHOD OF HARVEST -
  - Swathing method-Medium to hard dough stage. Do not swath unless adequate material is present to form a swath that can be picked up by the combine.
  - Direct combine method-Firm to hard dough seed stage
- GRASS SEEDHEADS USUALLY RIPEN FROM THE TOP DOWNWARD. WHEN THE TIPS OF THE SEEDHEADS BEGIN TO SHATTER THE CROP GENERALLY IS READY TO HARVEST.
- SEED SHATTER POTENTIAL
  - IF SEED SHATTERS WHEN STRIKING SEEDHEAD LIGHTLY AGAINST PALM OF HAND, SEVERE SEED SHATTER IS READY TO OCCUR AND THE CROP SHOULD BE HARVESTED IMMEDIATELY.
  - IF SEED SHATTERS WHEN STRIKING THE SEEDHEAD HARD AGAINST PALM OF HAND, THE CROP IS READY TO SWATH
- GRASSES WHICH SHATTER READILY OR ARE QUITE MATURE SHOULD BE SWATHED DURING EARLY MORNING HOURS WHEN THE HUMIDITY OF THE AIR IS GENERALLY HIGHER.

Harvesting Methods

Swathing and direct combining are the two most common methods of harvesting grass seed. The swathing method is the most common because seed losses by shattering can be minimized by earlier cutting and drying in the swath. Direct combining often is used for short-growing grasses or grasses difficult to pick up from a swath.

Stripping is a method of harvesting the seed of grasses which shatter easily. Ripe, mature seeds are stripped from the plant and unripe seed remains for later harvest. The Soil Conservation Service, Plant Materials Center, Bismarck, ND uses a grass seed stripper for harvesting the seed of certain grasses. Seed producers interested in grass seed strippers should contact the Plant Materials Center.

Direct Combining Method

Advantages:
- Seed more mature when harvested
- Less time and labor required

Disadvantages:
- Seed high in moisture, drying necessary
- Crop more vulnerable to weather, stands in field longer
- Slower harvest, green, leafy foliage present

Swathing Method

Advantages:
- Faster harvest of field-cured foliage
- Earlier harvesting possible
- Less seed loss by shattering
- Harvested seed usually dry, safe to store

Disadvantages:
- Light swaths difficult to pick up
- Light rains may delay harvest
- More weed seeds in grass seed
- Wind damage possible with fluffy swaths

Stripping Method

Advantages:

- Higher yields and improved seed quality
- Less chaff
- Mature seed removed leaving immature seed for later harvest

Disadvantages:

- Increased harvest cost
- Soil compaction
- High moisture content seed, drying necessary

Preferred harvest methods, growth stage for harvest, lodging and seed shatter potential, and an estimated grower demand for commonly grown grasses are provided in Table 3. Grasses with a high seed shatter potential generally are swathed at an earlier growth stage than those with a low shatter potential. Swathing requires sufficient seedstalk production to permit combine pick-up. Grasses such as Altai wildrye, an inherent low seed producer, and Russian wildrye, which may produce a limited number of leafless seedstalks, often are direct combined. Direct combined seed generally will require drying before storage, especially if early harvest is required due to the potential loss of seed by shattering. The best harvest method may differ from that indicated depending on growing conditions from year to year and should be determined on an individual field basis.

Combine Preparation

The common grain combine is used to harvest the seed of forage grasses. The combine should be thoroughly cleaned, especially if more than one variety or a different species of grass will be harvested. A few simple adjustments will be required for threshing all commonly grown grasses. Consult the combine owner's manual for detailed instructions. The following adjustments usually are essential:

Table 3. Suggested harvest method, growth stage for harvesting, potential for lodging and seed shatter and estimated demand for seed of commonly grown grasses.

Grass species	Preferred harvest method	Harvest stage	Lodging	Shatter potential	Seed demand
Bluestem:					
Big	direct or swath	med-hard dough	no	low[1]	medium
Little	direct	hard dough	no	low[1]	medium
Bromegrass:					
Meadow	swath	hard dough	no	low	medium
Smooth	swath	hard dough	yes	low	high
Canarygrass:					
Reed	swath	medium dough	no	high	low
Foxtail:					
Creeping	swath	medium dough	no	high	low
Grama:					
Sideoats	direct or swath	hard dough	no	low	medium
Needlegrass:					
Green	swath	light seed shatter	no	high	medium
Sandreed:					
Prairie	direct or swath	hard dough	no	low[1]	low
Switchgrass	direct or swath	hard dough	no	low	medium
Wheatgrass:					
Crested	direct or swath	med-hard dough	no	low[1]	high
Intermediate	swath	med-hard dough	no	low[1]	high
Pubescent	swath	med-hard dough	no	low[1]	high
Slender	swath	med-hard dough	no	low[1]	medium
Tall	direct or swath	medium dough	no	low	low
Western	swath	hard dough	yes	low	high
Wildrye:					
Altai	direct	hard dough	no	low	low
Beardless	swath	hard dough	yes	low	low
Russian	swath	medium dough	no	high	low

[1]high at maturity

- ADJUST AIR INTAKE: Light, chaffy seed, such as creeping foxtail seed, requires that all air be shut off. Sometimes the fan housing must be sealed or the fan deactivated. Grasses with heavier seed, such as the bluestems, smooth bromegrass, switchgrass and the wheatgrasses, require a small amount of air.
- SIEVES AND CHAFFER: Remove all sieves and chaffers from the cleaning shoe except the upper chaffer. Open the chaffer wide enough for seed to drop through while most straw rides out of the combine.
- CYLINDER SPEED AND CONCAVE SPACING: Chaffy grass seed requires a wider cylinder concave spacing than heavier seed. The cylinder should be run only as fast as required to dislodge all ripe seed. Generally, a concave spacing of about one-fourth inch and a cylinder speed of 900 to 1,000 RPM will be satisfactory.
- CLEANING SHOE: If the cleaning shoe has a tailings rake or adjustable tailer, cover or close completely to prevent material from returning to the cylinder.
- SICKLE POSITION: Position the sickle when direct combining to cut 90 percent or more of the seedheads and as little green foliage as possible.
- TRAVEL SPEED: Maintain a combine travel speed that moves an even flow of material to the cylinder and over the chaffer.

Care of Seed

Grass seed is considered safe to store in bulk at 10 to 12 percent moisture. If stored in bags, 12 to 15 percent moisture is usually safe. Storage conditions that are cool and dry are best to maintain good seed germination.

STORAGE "RULES OF THUMB"

- SEED LIFE IS DOUBLED FOR EVERY DROP IN AIR TEMPERATURE OF 10°F.
- THE NUMERICAL SUM OF AIR TEMPERATURE (0°F) and THE RELATIVE HUMIDITY (%) SHOULD NOT EXCEED 100. Example: relative humidity (15%) + temperature (85°) = 100.

Seed Conditioning and Marketing

Marketing high quality seed depends on many factors. However, seed conditioning which includes seed cleaning and/or processing is a major consideration if seed of high germination and purity is to be marketed. Grass seed, to be properly cleaned and processed, requires special equipment. Most seed conditioning plants are not equipped to condition all types of grass seed. Anyone planning to include grass seed production as a farm enterprise should locate a seed conditioning plant during the initial planning stages that can properly condition grass seed.

Major marketing decisions should be made before establishing the seed production field. For many seed producers, a seed conditioning and marketing agreement with an established commercial grass seed distributor would be highly desirable.

Acknowledgement is given to Dr. Kenneth Larson, former agronomist with North Dakota Agricultural Experiment Station, North Dakota branch experiment stations and USDA Agricultural Research Service for research data used in the preparation of this circular. A special thanks is extended to Fred Schumacher, Kindred, ND for consultation, review and comment on circular content.

APPENDIX
GRASS SEED PRODUCTION YIELD DATA

Location	Grass species	Table No's.
	DRYLAND YIELDS	
Dickinson, ND	Bromegrass, smooth	3,4
	Needlegrass, green	8
	Wheatgrass, crested	1,5
	intermediate	6
	slender	2
	Wildrye, Russian	7
Edgeley, ND	Bromegrass, smooth	9
	Needlegrass, green	9
	Wheatgrass, crested	9
	intermediate	9
	slender	9
	Wildrye, Russian	9
Fargo, ND	Bromegrass, smooth	10,11,14,15,17,25,29,30
	Fescue, creeping red	21,28,30
	Needlegrass, green	13,18,24,30
	Switchgrass	13
	Timothy	26,29,30
	Wheatgrass, crested	12,16,22,30
	intermediate	12,20,23,30
	slender	12
	Wildrye, altai	29
	basin	29
	Mandan	13
	Russian	13,19,27,29,30
Langdon, ND	Bromegrass, smooth	31
	Needlegrass, green	31
	Wheatgrass, crested	31
	intermediate	31
	slender	31
	Wildrye, Russian	31
Mandan, ND	Bromegrass, smooth	33
	Needlegrass, green	34
	Switchgrass	35
	Wheatgrass, crested	32,36,37
	Wildrye, Russian	38,39,40,41
Sidney, MT	Needlegrass, green	43
	Wheatgrass, intermediate	44
	Wildrye, Russian	42
	IRRIGATION YIELDS	
Carrington, ND	Bromegrass, smooth	45
	Wheatgrass, crested	45
	slender	45
Mandan, ND	Bromegrass, smooth	47
	Needlegrass, green	47
	Wheatgrass, crested	47
	intermediate	47
	pubescent	47
	tall	47
	Wildrye, Russian	46,47
Bismarck, ND	Bluestem, big	48
	Creeping foxtail	48
	Grama, sideoats	48
	Indiangrass	48
	Needlegrass, green	48
	Sandreed, prairie	48
	Switchgrass	48
	Wheatgrass, pubescent	48
	western	48
	Wildrye, Russian	48

DRYLAND GRASS SEED PRODUCTION STUDIES

DICKINSON EXPERIMENT STATION
Dickinson, ND

Table 1. Dryland seed yield of crested wheatgrass grown in solid stands and 42-inch row spacings.

Year[1]	Solid		Rows	
	Trial 1	Trial 2	Trial 1	Trial 2
	lbs/acre		lbs/acre	
1921	233		151	
1922	459		348	
1923	217		252	
1924	433		590	
1926	100		100	
1927	123	235	121	198
1928		135		182
1929		238		254
1930		69		256
Ave	263	169	275	223

[1]No harvest in 1925

Table 2. Dryland seed production of slender wheatgrass grown in solid stands and 42-inch row spacings.

Year[1]	Solid		Rows	
	Trial 1	Trial 2	Trial 1	Trial 2
	lbs/acre		lbs/acre	
1921	160		125	
1922	661		308	
1923	173		49	
1924	590		240	
1926	0		0	
1927	0	683	0	323
1928		414		249
1929		126		211
1930		0		0
Ave	264	306	120	196

[1]No harvest in 1925

Table 3. Dryland seed production of smooth bromegrass grown in solid stands and 42-inch row spacings.

Year[1]	Solid		Rows	
	Trial 1	Trial 2	Trial 1	Trial 2
	lbs/acre		lbs/acre	
1921	180		143	
1922	265		314	
1923	174		163	
1924	408		440	
1926	0		0	
1927	125	173	171	126
1928		87		182
1929		148		218
1930		0		142
Ave	192	102	205	167

[1]No harvest in 1925

Table 4. Dryland seed yield of smooth bromegrass grown in solid stands and 42-inch row spacings and fertilized with various rates of nitrogen.

Lbs 'N' per acre	Solid			Rows		
	1956	1957	Ave.	1956	1957	Ave.
	lbs/acre			lbs/acre		
0	39	52	45	90	236	163
33	31	56	43	112	212	162
50	26	71	48	75	176	126
100	22	64	43	120	189	154
Ave.	29	61	45	99	203	151

Table 5. Dryland seed yield of crested wheatgrass grown in solid stands and 42-inch row spacings when fertilized with various rates of nitrogen.

Lbs 'N' per acre	Solid			Rows		
	1956	1957	Ave.	1956	1957	Ave.
	lbs/acre			lbs/acre		
0	24	60	42	163	404	283
33	43	65	54	172	405	289
50	31	86	58	170	404	287
100	30	134	82	200	395	297
Ave.	32	86	59	176	402	289

Table 6. Dryland seed yield of intermediate wheatgrass grown in solid stands and 42-inch row spacings when fertilized with various rates of nitrogen.

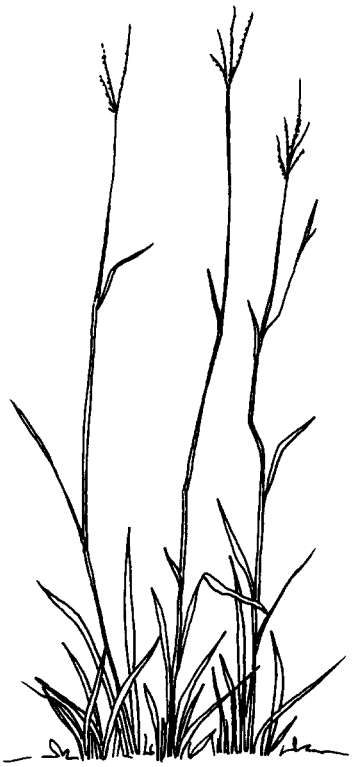
Lbs 'N' per acre	Solid			Rows		
	1956	1957	Ave.	1956	1957	Ave.
	lbs/acre			lbs/acre		
0	5	52	28	31	250	140
33	9	65	32	23	264	144
50	9	86	48	22	255	139
100	9	102	55	21	247	134
Ave.	8	76	41	24	254	139

Table 7. Dryland seed yields of Russian wildrye grown in solid stands and 42-inch row spacings when fertilized with various rates of nitrogen.

Lbs 'N' per acre	Solid 1957	Rows 1957
	lbs/acre	
0	65	186
33	93	211
50	117	178
100	118	279
Ave.	98	213

Table 8. Dryland seed yield of green needlegrass grown in solid stands and 42-inch row spacings when fertilized with various rates of nitrogen.

Lbs 'N' per acre	Solid 1957	Rows 1957
	lbs/acre	
0	58	118
33	73	130
50	74	129
100	97	113
Ave.	75	122



EDGELEY EXPERIMENT STATION
Edgeley, ND

Table 9. Dryland seed yield of various grasses established in 1962 in solid stands vs 36-inch row spacings and fertilized with various rates of nitrogen and phosphorus.[1]

Lbs fertilizer per acre		Solid			Rows			Solid			Rows			Solid			Rows		
N	P_2O_5	63	64	Ave	63	64	Ave	63	64	Ave	63	64	Ave	63	64	Ave	63	64	Ave
		lbs/acre						lbs/acre						lbs/acre					
		Nordan Crested wheatgrass						Lincoln smooth bromegrass						Intermediate wheatgrass (Nebr. 50)					
0	0	958	279	618	719	280	499	461	263	362	440	416	428	142	325	233	109	286	197
50	0	791	127	459	866	312	589	534	150	342	569	536	552	163	458	310	116	—[2]	—
100	0	643	171	407	528	226	377	352	135	243	486	579	532	185	458	321	123	239	181
50	92	828	157	492	721	343	532	272	140	206	533	525	529	207	538	372	167	263	215
100	92	1056	122	589	632	328	480	526	88	307	608	445	526	185	311	248	145	235	190
Ave.		855	171	513	693	298	495	429	155	292	527	500	513	176	418	296	132	256	196
		Primar slender wheatgrass						Lodorm green needlegrass[3]						Vinall Russian wildrye[3]					
0	0	962	738	850	990	976	983	No harvest	359	—	No harvest	177	—	No harvest	116	—	No harvest	234	—
50	0	1114	1032	1073	1067	1210	1138		272	—		354	—		96	—		260	—
100	0	778	903	840	878	1129	1003		227	—		419	—		123	—		175	—
50	92	886	832	859	1379	943	1161		150	—		326	—		85	—		236	—
100	92	918	891	904	1101	1029	1065		169	—		286	—		111	—		301	—
Ave.		932	879	905	1083	1057	1070	xx	235	xx	xx	312	xx	xx	106	xx	xx	241	xx

[1]Fertilized 9/5/62, 9/3/63, 9/14/64
[2]Seed sample lost
[3]No harvest in 1963 due to poor stands

Table 10. Dryland seed yield of an old smooth bromegrass stand established prior to 1925 when fertilized in late fall with six rates of nitrogen.

lbs 'N' per acre	Years																			
	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	19 yr. ave.
	lbs/acre																			
0	12	40	3	32	10	12	77	54	5	96	43	30	27	39	28	9	42	22	22	32
33	49	162	3	93	5	54	112	64	6	57	92	8	58	132	48	14	93	29	40	59
66	79	232	36	128	26	124	89	40	16	162	132	17	37	114	100	30	183	29	99	88
133	53	257	66	135	35	232	99	41	77	136	100	61	49	110	64[1]	20	183	25[2]	69	95
200	43	257	65	140	26	291	156	68	91	160	84	73	129	152	76[1]	39[1]	244	23[2]	126	118
266	18	201	101	201	29	400	168	82	127	307	71	126	219	138	80[1]	57[1]	176	17[2]	218	144
Lsd .05[3]	40	78	40	NS	NS	100	NS	NS	NS	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

[1]rodent damage
[2]severe lodging in high fertility treatments
[3]Within a year fertilizer treatments must differ by the amount shown to be significantly different in seed yield. NS = not significant, NA = Lsd not available.

Note: Bromegrass stands become severely sod-bound with age. High rates of nitrogen increase forage yields substantially, but flowering stems are not sufficiently abundant to produce high yields of seed.

Table 11. Dryland seed yield of smooth bromegrass varieties established in 1952 in 42-inch row spacings and fertilized in late fall with nitrogen annually.

Variety or strain	0-N						100-N[1]					
	Years						Years					
	53	54	55	56	57	Ave	53	54	55	56	57	Ave
	lbs/acre						lbs/acre					
Canadian	482	290	157	235	90	251	515	381	173	563	300	386
Homesteader	410	250	140	301	104	241	591	215	201	421	171	320
Lincoln	485	228	174	266	57	242	552	193	176	535	196	330
Lyon	486	225	224	312	86	267	475	188	111	579	186	308
Manchar	344	494	101	287	172	280	474	468	107	599	310	392
Mandan 404	404	386	169	258	101	264	519	382	232	576	256	393
Southland	503	269	172	312	65	264	621	229	284	565	221	384
Lsd .05[2]	110	72	99	173	159	xxx	110	72	99	173	159	xxx
Year ave.	445	306	162	282	96	258	535	294	183	548	234	359

[1]Fertilized with 100-N fall 1952, 53, 54 and 133-N fall 1955, 56.
[2]Within a year varieties must differ by the amount shown to be significantly different in seed yield.

Table 12. Dryland seed yield of wheatgrass varieties established in 1952 in 42-inch row spacings and fertilized in late fall with nitrogen annually.

Variety or strain	0-N Years						100-N[1] Years					
	53	54	55	56	57	Ave	53	54	55	56	57	Ave
	lbs/acre						lbs/acre					
Crested wheatgrass												
Common, Std.	268	392	178	311	309	291	174	407	222	421	385	322
Fairway	591	424	235	268	208	345	480	352	256	536	322	389
Nordan	276	403	209	290	319	299	232	415	182	403	319	310
Year ave.	378	406	207	290	279	312	295	391	220	453	342	340
Intermediate wheatgrass												
Common	412	205	149	65	160	198	371	152	121	99	194	187
Nebraska 50	408	187	149	75	99	184	370	192	162	98	215	207
Ree	359	167	90	53	95	153	361	140	115	115	212	189
Year ave.	393	186	129	64	118	178	367	161	133	104	207	194
Slender wheatgrass												
Primar	546[2]	352	69	78	157	240	480	395	33	241	204	271
Lsd .05[3]	110	72	99	173	159	xxx	110	72	99	173	159	xxx

[1]Fertilized with 100-N fall 1952, 53, 54 and 133-N fall 1955, 56
[2]30% seed shatter loss
[3]During any one year varieties within a species and between species must differ by the amount shown to be signficantly different in seed yield.

Table 13. Dryland seed yield of several perennial grasses established in 1952 in 42-inch row spacings and fertilized in late fall with nitrogen annually.

Variety or strain	0-N Years						100-N[1] Years					
	53	54	55	56	57	Ave	53	54	55	56	57	Ave
	lbs/acre						lbs/acre					
Green stipagrass	83[3]	344	133	46	[4]	—	55[3]	341	199	154	[4]	—
Switchgrass	216	116	209	[4]	[4]	—	275	88	203	[4]	[4]	—
Wildrye:												
Mandan	1202	658	209	[4]	[4]	—	1124	806	152	[4]	[4]	—
Russian[2]	29	308	23	315	189	173	26	339	40	541	549	299
Lsd .05[5]	110	72	99	173	159	xxx	110	72	99	173	159	xxx

[1]Fertilized with 100-N fall 1952, 53, 54 and 133-N fall 1955, 56
[2]Average of four varieties and/or strains
[3]85% seed shatter loss
[4]Poor stands, no seed harvest
[5]During any one year varieties within a species and between species must differ by the amount shown to be signficantly different in seed yield.

Table 14. Dryland seed yield of Lincoln smooth bromegrass established in 1952 in three row spacings and fertilized with four rates of nitrogen in spring and fall annually.

Years	Solid Stand				24-inch rows				36-inch rows			
	0	33	66	133	0	33	66	133	0	33	66	133
	lbs/acre											
Spring Fertilized												
1953	310	262	237	264	852	586	541	613	456	538	473	495
1954	121	76	124	127	311	288	287	299	208	269	253	223
1955	204	228	221	114	210	430	428	355	127	255	324	297
1956	167	329	288	480	303	321	583	606	246	368	383	480
1957	47	115	158	222	267	355	403	404	154	255	324	328
1958	19	54	59	178	79	124	268	220	57	91	68	167
1959	2	13	31	131	25	38	133	166	16	25	69	143
Ave.	124	154	160	217	293	306	378	380	181	253	260	305
Fall Fertilized												
1953	315	323	293	312	600	628	566	649	458	438	399	417
1954	120	155	172	180	306	272	347	320	228	239	208	313
1955	179	261	178	195	501	482	563	550	154	225	190	131
1956	183	448	430	435	362	490	587	652	410	359	480	557
1957	47	91	171	257	283	308	421	439	182	194	298	305
1958	35	65	84	238	104	120	218	455	38	73	135	253
1959	4	27	59	184	59	121	80	195	20	45	40	133
Ave.	126	196	198	257	316	346	397	466	213	225	250	301
Spring-fall ave. over all years	125	175	179	237	305	326	387	423	197	239	255	303

Comments:

- Spring fertilization vs fall fertilization was not significantly different during any year.
- Based on an average of all years and fertility treatments 2-foot row spacing produced significantly more seed per acre (Solid stands - 179 lbs/acre, 2-foot rows 360 lbs/acre and 3-foot rows 248 lbs/acre).
- Fertilizer rates were significantly different in all years except 1953 and 1954. Higher rates are best. Based on average of all years 0-N yielded 209 lbs seed/acre, 33-N - 247 lbs, 66-N - 274 lbs and 133-N - 321 lbs/acre.

Table 15. Dryland seed yield of smooth bromegrass varieties established in 1953 in solid vs 36-inch row spacing and fertilized with 100-N in the fall annually.

Variety	solid stand						36-inch rows					
	Years						Years					
	54	55	56	57	58	Ave	54	55	56	57	58	Ave
	lbs/acre						lbs/acre					
Lyon	675	520	698	261	180	469	490	534	585	339	209	431
Lancaster	747	620	517	368	216	494	547	577	590	359	277	470
Mandan 404	941	273	467	219	71	394	640	461	524	406	130	432
Homesteader	932	548	568	275	175	500	573	526	624	374	197	459
Southland	779	495	750	350	146	504	599	476	674	379	326	491
Achenbach	891	498	498	173	126	439	480	397	460	290	150	355
Martin	858	359	543	286	158	441	476	499	529	327	164	399
Fischer	849	455	551	301	152	462	590	452	644	367	229	456
Elsberry	390	578	671	303	125	413	519	434	560	321	244	416
Lincoln	687	458	622	291	198	451	480	458	654	338	238	434
Manchar	934	360	567	240	102	441	686	360	555	492	136	446
Canadian	825	444	580	340	122	462	645	579	600	410	229	493
B. in 12	816	499	664	328	170	495	518	464	615	390	251	448
Kuhl	761	506	696	306	176	489	433	480	616	418	166	423
Lsd .01[2]	99	127[1]	102	48	61	xxx	99	127[1]	102	48	61	xxx
Year ave.	792	472	600	288	152	461	548	479	588	372	211	440

[1]Lsd .05
[2]Within a year varieties must differ by amounts shown to be signficantly different in seed yield.

Table 16. Dryland seed yield of Nordan Crested wheatgrass established in 1958 in solid vs 24-inch row spacing and fertilized early and late with various rates of nitrogen.

Lbs 'N' per acre	Solid stand					24-inch rows				
	Years					Years				
	60	61	62[3]	63	Ave	60	61	62[3]	63	Ave
	lbs/acre									
	FERTILIZED EARLY[1]									
0	549	472	213	366	400	484	1017	666	616	696
33	601	632	284	297	453	531	1031	583	582	682
66	546	672	344	432	498	555	1075	634	698	740
100	617	843	498	590	637	641	1237	642	859	845
133	664	660	347	629	575	612	1135	578	976	825
66 early, 66 late	592	712	436	812	638	627	1167	476	919	797
Average	595	665	354	521	533	575	1110	596	775	764
	FERTILIZED LATE[2]									
0	549	472	213	366	400	484	1017	666	616	696
33	548	616	470	458	523	520	1149	480	859	752
66	627	596	455	561	560	709	1163	677	761	827
100	694	770	441	588	623	620	1096	678	760	788
133	574	701	344	702	580	600	1111	420	917	762
66 early, 66 late	592	712	436	812	638	627	1167	476	919	797
Average	597	644	393	581	554	593	1117	566	805	770

[1]Early - 10/29/59, 8/30/60, 8/11/61, 8/7/62
[2]Late - Spring 1960, 10/7/60, 10/5/61, 10/26/62.
[3]Excessive rainfall during pollination and lodging.

Table 17. Dryland seed yield of Southland smooth bromegrass established in 1958 in solid vs 24-inch row spacings and fertilized early and late with various rates of nitrogen.

Lbs. 'N' Per Acre	Solid stand Years 60	61	62[3]	Ave	24-inch rows Years 60	61	62[3]	Ave
	lbs/acre							
	FERTILIZED EARLY[1]							
0	576	336	51	321	491	516	261	423
33	569	459	153	394	503	521	379	468
66	558	636	226	473	407	884	386	559
100	545	810	163	506	531	1167	404	701
133	568	825	125	506	460	1241	344	682
66 Early, 66 Late	648	919	153	573	499	1276	428	734
Average	577	664	145	462	482	934	367	594
	FERTILIZED LATE[2]							
0	576	336	51	321	491	516	261	423
33	651	608	187	482	648	820	409	626
66	552	697	389	546	580	1064	521	722
100	629	836	152	539	610	1076	355	680
133	518	807	119	481	477	1111	319	636
66 Early, 66 Late	648	919	153	573	499	1276	428	734
Average	596	700	175	490	551	977	382	637

[1]Early - 10/29/59, 8/30/61, 8/7/62.
[2]Late - Spring 1960, 10/7/60, 10/5/61, 10/26/62.
[3]Excessive rainfall during pollination and lodging.

Table 18. Dryland seed yield of Lodorm green needlegrass established in early fall of 1958 in solid vs 24-inch row spacings and fertilized with five rates of nitrogen in late fall.[1]

Lbs 'N' per acre	Solid stand Years 60	61	62	Ave.	24-inch rows Years 60	61	62	Ave.
	lbs/acre							
0	300	651	580	510	402	907	699	699
33	214	745	540	500	308	1135	694	712
66	150	724	472	449	360	826	798	661
100	195	692	419	435	423	1019	772	738
133	240	658	481	460	356	901	719	659
Ave.	220	694	498	471	370	958	736	688

[1]30% seed shatter from high winds in 1961.
Only scattered seedheads produced in 1959.

Table 19. Dryland seed yield of Vinall Russian wildrye established in early fall of 1958 in solid vs 24-inch row spacings and fertilized with five rates of nitrogen in late fall annually.[1]

Lbs 'N' per acre	Solid stand Years 60	61	62	Ave.	24-inch rows Years 60	61	62	Ave.
	lbs/acre							
0	369	423	131	308	728	532	312	524
33	276	525	238	346	870	579	339	596
66	358	680	345	461	829	663	461	651
100	342	742	322	469	1096	833	423	784
133	363	184	214	254	666	783	509	653
Ave.	342	511	250	368	838	678	409	642

[1]No seed produced in 1959.

Table 20. Dryland seed yield of intermediate wheatgrass established in early fall of 1958 in solid vs 24-inch row spacings and fertilized with five rates of nitrogen in late fall annually.[1]

Lbs 'N' per acre	Solid stand Years 60	61	62	Ave.	24-inch rows Years 60	61	62	Ave.
	lbs/acre							
0	137	28	6	57	396	240	221	286
33	199	64	28	97	435	274	98	269
66	122	57	21	67	469	367	137	324
100	169	80	45	98	515	406	158	360
133	256	89	41	129	534	461	175	390
Ave.	177	64	28	90	470	350	158	326

[1]Produced an average of 239 and 266 pounds of seed/acre in 1959 from rows and solid stands, respectively.

Table 21. Dryland seed yield of creeping red fescue established in early fall 1958 in solid vs 24-inch row spacings and fertilized with five rates of nitrogen in late fall annually.[1]

Lbs 'N' per acre	Solid stand Years 60	61	62	Ave.	24-inch rows Years 60	61	62	Ave.
	lbs/acre							
0	203	145	81	143	301	274	170	248
33	150	285	105	180	212	219	146	192
66	136	329	81	182	212	253	77	181
100	140	227	63	143	274	274	79	209
133	179	155	73	136	308	336	151	265
Ave.	162	228	81	157	261	271	125	219

[1]No seed produced in 1959.

Table 22. Dryland seed yield of crested wheatgrass established in 1963 in solid vs 24-inch row spacings and fertilized with five rates of nitrogen annually.

lbs 'N' per acre	Solid stand Years						24-inch rows Years					
	64	65	66	67	68	Ave.	64	65	66	67	68	Ave.
	lbs/acre						lbs/acre					
0	46	35	19	24	58	36	241	280	151	162	214	210
33	437	298	76	144	340	259	498	564	307	397	576	468
66	536	400	127	254	422	348	538	499	288	540	589	491
100	603	361	167	293	387	362	530	622	327	582	558	524
133	622	425	234	517	586	478	626	549	413	733	649	594
Ave.	449	304	125	246	359	297	487	503	297	483	517	457

Table 23. Dryland seed yield of intermediate wheatgrass established in 1963 in solid vs 24-inch row spacings and fertilized with five rates of nitrogen annually.

lbs 'N' per acre	Solid stand Years						24-inch rows Years					
	64	65	66	67	68	Ave.	64	65	66	67	68	Ave.
	lbs/acre						lbs/acre					
0	238	86	9	6	4	69	419	254	69	15	52	162
33	530	169	12	21	36	152	550	284	63	102	257	251
66	602	186	26	24	62	180	573	340	120	126	344	301
100	755	270	6	32	134	239	688	402	89	140	369	338
133	652	240	12	31	142	215	733	450	144	200	376	381
Ave.	555	190	13	23	76	171	593	346	97	117	280	287

Table 24. Dryland seed yield of Lodorm green needlegrass established in 1963 in solid vs 24-inch row spacings and fertilized with five rates of nitrogen annually.[1]

Lbs 'N' per acre	Solid stand Years					24-inch rows Years				
	65	66	67	68	Ave.	65	66	67	68	Ave.
	lbs/acre					lbs/acre				
0	134	86	76	96	98	173	122	86	57	109
33	530	249	227	291	324	420	172	354	138	271
66	486	295	462	406	412	324	230	382	242	294
100	704	270	421	479	468	539	356	306	461	415
133	747	319	357	522	486	432	397	217	398	361
Ave.	520	244	311	359	358	378	255	269	259	290

[1]No harvest in 1964

Table 25. Dryland seed yield of smooth bromegrass established in 1963 in solid vs 24-inch row spacings and fertilized with five rates of nitrogen annually.[1]

lbs 'N' per acre	Solid stand Years					24-inch rows Years				
	65	66	67	68	Ave.	65	66	67	68	Ave.
	lbs/acre					lbs/acre				
0	26	37	14	36	28	133	59	34	84	77
33	85	123	226	376	202	252	124	273	190	210
66	108	273	270	588	310	252	300	334	512	349
100	109	447	316	580	363	373	402	269	317	340
133	224	410	378	905	479	418	482	304	678	470
Average	110	258	241	497	276	286	273	243	356	289

[1]No harvest in 1964

Table 26. Dryland seed yield of timothy established in 1963 in solid vs 24-inch row spacings and fertilized with five rates of nitrogen annually.

lbs 'N' per acre	Solid stand						24-inch rows					
	Years						Years					
	64	65	66	67	68	Ave.	64	65	66	67	68	Ave.
	lbs/acre						lbs/acre					
0	192	118	117	72	44	109	289	395	268	112	126	238
33	460	273	197	202	102	247	543	608	402	191	266	402
66	479	378	262	317	290	345	528	580	370	208	282	393
100	438	336	291	374	223	332	570	579	486	279	312	445
133	438	359	367	362	260	357	589	594	480	258	328	450
Average	401	293	247	265	184	278	504	551	401	210	263	386

Table 27. Dryland seed yield of Vinall Russian wildrye established in 1963 in solid vs 24-inch row spacings and fertilized with five rates of nitrogen annually.[1]

lbs 'N' per acre	Solid stand					24-inch rows				
	Years					Years				
	65	66	67	68	Ave	65	66	67	68	Ave
	lbs/acre					lbs/acre				
0	92	4	7	6	27	337	24	31	25	104
33	310	26	46	50	108	539	138	142	121	235
66	368	62	46	101	144	584	242	217	192	309
100	736	50	52	88	231	942	91	179	185	349
133	875	73	64	177	297	1080	118	356	210	441
Average	476	43	43	84	161	696	123	185	147	288

[1]No harvest in 1964

Table 28. Dryland seed yield of creeping red fescue established in 1963 in solid vs 24-inch row spacings and fertilized with five rates of nitrogen annually.

lbs 'N' per acre	Solid stand					24-inch rows				
	Years					Years				
	64	65	66	67	Ave	64	65	66	67	Ave
	lbs seed/acre									
0	39	185	32	6	65	96	362	186	52	174
33	208	236	71	46	140	108	509	269	148	258
66	225	380	154	90	212	109	419	234	136	224
100	143	392	190	82	177	137	363	136	134	192
133	236	168	126	132	165	139	208	147	196	172
Average	170	252	115	71	152	118	372	194	133	204

Table 29. Dryland seed yield of several grasses established in 1972 in 24-inch row spacings and fertilized with 133-N annually.

Species variety	Years 1973	1974	1975	Ave
	lbs/acre			
Bromegrass				
Baylor	449	410	222	360
Magna	584	341	355	427
Timothy				
Climax	301	108	139[1]	183
Wildrye				
Altai[2]	83[3]	249	—[4]	—
Basin	73	185	128	129
Russian				
Mayak	357[5]	503	151	337

[1]32% seed shatter loss
[2]Poor initial stand
[3]7% seed shatter loss
[4]Poor seed set
[5]25% seed shatter loss

Table 30. Summary of average seed yields for grass species by selected experiments. Fargo, ND (1953-68)

Grass species and Experiment	Solid stand lbs N/acre 0	33	66	100	133	24-inch rows lbs N/acre 0	33	66	100	133
	lbs/acre									
SMOOTH BROMEGRASS										
1953-59	125	175	179	—	237	304	326	387	—	423
1960-62	321	438	509	522	533	423	547	640	690	696
1965-68	28	202	310	363	479	77	210	349	340	470
Ave.	158	272	333	442	416	268	361	459	515	530
CRESTED WHEATGRASS										
1960-63	400	488	529	630	608	696	717	783	816	795
1964-68	36	259	348	362	478	210	468	491	524	594
Ave.	218	373	435	496	543	453	592	637	670	694
INTERMEDIATE WHEATGRASS										
1960-62	57	97	67	98	129	286	269	324	360	390
1964-68	69	152	180	239	215	162	251	301	338	381
Ave.	63	124	123	168	172	224	260	312	349	385
GREEN NEEDLEGRASS										
1960-62	510	500	449	435	460	669	712	661	738	659
1965-68	98	324	412	468	486	109	271	294	415	361
Ave.	304	412	430	451	473	389	491	477	576	510
RUSSIAN WILDRYE										
1960-62	308	346	461	469	254	524	596	651	784	653
1965-68	27	108	144	231	297	104	235	309	349	441
Ave.	167	227	302	350	275	314	415	480	566	547
TIMOTHY										
1964-68	109	247	345	332	357	238	402	393	445	450
CREEPING RED FESCUE										
1960-62	143	189	182	143	136	248	192	181	209	265
1964-67	65	140	212	177	165	174	258	224	192	172
Ave.	104	164	197	160	150	211	225	202	200	218

LANGDON EXPERIMENT STATION
Langdon, ND

Table 31. Dryland seed yield of various grasses established in 1962 in solid stands vs 36-inch row spacings and fertilized with various rates of nitrogen and phosphorus.[1]

Lbs fertilizer per acre		Solid			Rows			Solid			Rows		
N	P_2O_5	1963	1964	Ave.	1963	1964	Ave.	1963	1964	Ave.	1963	1964	Ave.
		lbs/acre						lbs/acre					
		Nordan crested wheatgrass						Lincoln smooth bromegrass					
0	0	85	41	63	293	228	261	69	31	50	168	34	101
50	0	206	114	160	359	299	329	175	68	122	199	86	143
100	0	332	201	267	436	353	395	139	93	116	222	173	198
50	92	178	134	156	498	318	408	157	70	114	197	103	150
100	92	332	222	277	464	364	414	193	101	147	242	147	195
Ave.		227	142	185	410	312	361	147	73	110	206	109	157
		Primar slender wheatgrass						Lodorm green needlegrass					
0	0	308	11	160	279	61	170	307	70	188	222	144	184
50	0	470	31	251	325	63	194	102	161	131	85	153	119
100	0	478	53	266	397	41	219	154	209	181	120	180	150
50	92	504	65	285	401	85	243	128	110	119	162	117	139
100	92	547	100	324	242	106	174	77	184	130	102	203	152
Ave.		461	52	257	329	71	200	154	147	150	138	159	149
		Vinall Russian wildrye[2]						Nebraska 50 intermediate wheatgrass[3]					
0	0	89	—	—	57	142	99	154	No harvest	—	51	No harvest	—
50	0	214	53	133	60	256	158	282		—	34		—
100	0	145	35	90	105	369	237	512		—	120		—
50	92	119	—	—	82	275	178	333		—	94		—
100	92	94	93	93	46	388	217	282		—	77		—
Ave.		132	—	—	70	286	178	313	—	—	75	—	—

[1]Fertilized 9/14/62, 8/8/63
[2]Stands highly variable
[3]No harvest in 1964 due to poor stands

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Table 32. Dryland seed yield of crested wheatgrass grown in solid stands and in 42-inch row spacings planted as single and close spaced double rows.

	Solid	Rows - single		Rows - double		
Year	Trial 1[1]	Trial 1[1]	Trial 2	Trial 1	Trial 2	Trial 3
	lbs/acre					
1923		116				
1924		392		360	796	
1925	342	67	123	110	420	[2]
1926	90	104	134	141	302	432
1927	210	170	314	172	475	376
1928	0	14	59	31	54	31
1929	31	95	300	78	163	175
1930	33	95	209	47	124	128
Ave.	118	132	190	134	333	228

[1]Unfavorable sites for seed production
[2]Good seed harvest, identity lost
Source: USDA Technical Bulletin No. 307.

Table 33. Dryland seed yield of smooth bromegrass established in 1943 in 18, 30 and 42-inch row spacings.

Row spacing	Years				
	1944	1945	1946	1947	Ave.
(inches)	lbs/acre				
18	233	117	20	72	111
30	294	218	75	129	179
42	194	306	73	145	180

Source: USDA Technical Bulletin No. 1097.

Table 34. Dryland seed yield of green needlegrass established in 1942 in 18, 30 and 42-inch row spacings.

Row spacing	Years			
	1945	1946	1947	Ave.
(inches)	lbs/acre			
18	233	111	147	164
30	350	217	252	273
42	272	267	300	280

Source: USDA Technical Bulletin No. 1097.

Table 35. Dryland seed yield of switchgrass established in 1943 in 18, 30 and 42-inch row spacings.

Row spacing	Years					
	1944	1945	1946	1947	1948	Ave.
(inches)	lbs/acre					
18	171	311	90	66	4	128
30	101	333	170	123	61	158
42	86	341	176	149	137	178

Source: USDA Technical Bulletin No. 1097.

Table 36. Dryland seed yield of crested wheatgrass established in 1943 in 18, 30 and 42-inch row spacings.

Row spacing	Years					
	1944	1945	1946	1947	1948	Ave.
(inches)	lbs/acre					
18	75	420	125	108	30	152
30	73	470	216	179	56	199
42	33	387	375	173	59	205

Source: USDA Technical Bulletin No. 1097.

Table 37. Dryland seed yield of Nordan and Fairway crested wheatgrass grown in solid stands.

Year established	Nordan				Fairway			
	1951	1952	1953	Ave.	1951	1952	1953	Ave.
	lbs/acre							
1950	748	432	534	571	786	382	282	483
1951	—	304	699	502	—	—	—	—
1952	—		791	—	—	—	902	—

Source: ND Agric. Exp. Stn. Bimonthly Bulletin 16(4):150-52.

Table 38. Dryland seed yield of Vinall Russian wildrye grown in wide row spacings.

Year planted	Harvest year			
	1	2	3	Ave.
	lbs/acre			
1951	156	462	111	243
1954	439	583	231	418
1956	586	236	116	313
1957	256	126	—	—
1958	58	—		—
Harvest year average	299	351	153	xxx

Source: ND Agric. Exp. Stn. Farm Research 21(4):4-6.

Table 39. Dryland seed yield of Russian wildrye established in 1943 at various row spacings.

Year	Row spacings - inches						
	6	12	18	24	30	36	42
	lbs/acre						
1945	11	41	81	215	143	280	231
1946	6	10	12	23	31	67	114
1947	37	25	58	63	102	141	131
Ave.	18	25	50	100	92	163	159

Source: USDA Technical Bulletin No. 1097.

Table 40. Dryland seed yield of Russian wildrye established in 1947 at four row spacings.

Year	Row spacing - inches			
	42	48	60	72
1949	167	171	207	138
1950	213	210	244	226
Ave.	190	190	225	182

Source: USDA Technical Bulletin No. 1097.

Table 41. Influence of planting date on subsequent seed yields of Russian wildrye established in 1957.

Date planted	Years		
	1958	1959	1960
	lbs/acre		
May 23	140	108	371
June 6	83	102	385
19	49	134	435
July 3	9	108	336
23	T[1]	147	444
Aug. 2	0	106	479
16	0	105	381
Sept. 3	0	55	462
13	0	52	436
26	0	52	449

[1]T = trace
Source: Agronomy Journal 53:353-354.

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Table 42. Dryland seed yield of Russian wildrye when grown in 30, 42 and 60-inch row spacing on the contour and fertilized with various rates of nitrogen and phosphorus (1964-69).

Year and row spacing	Lbs/acre[1]					
	Check	20-N	40-N	40-N 50-P_2O_5	60-N	60-N 50-P_2O_5
	Lbs/acre					
30-inch						
1964	311	325	316	338	325	414
1965	388	473	506	526	547	602
1966	183	190	185	154	151	214
1967	203	393	399	428	442	485
1968	89	135	203	203	170	219
1969	87	150	188	216	259	205
Ave.	210	278	300	311	316	357
42-inch						
1964	290	404	374	370	390	494
1965	403	427	449	519	528	528
1966	122	155	231	182	171	210
1967	335	362	532	488	526	539
1968	170	203	229	250	242	285
1969	56	112	225	261	251	270
Ave.	229	277	340	345	351	388
60-inch						
1964	254	250	296	311	335	394
1965	348	386	489	434	440	513
1966	90	80	190	216	174	236
1967	276	389	509	500	478	522
1968	120	130	142	170	141	174
1969	171	220	232	300	267	279
Ave.	210	242	310	322	306	353

[1]Nitrogen applied in early spring annually.
P_2O_5 applied in 1963 and again in 1967.
Growing season precipitation was 7.8, 11.3, 3.9, 6.3, 6.2 and 7.7 inches during 1964 through 1969, respectively.
Source: Agronomy Journal 61:801-805. Personal Communication, A.L. Black, Director, Northern Great Plains Research Laboratory, Mandan, ND.

Table 43. Dryland seed yield of green needlegrass when grown in 30, 42 and 60-inch row spacing on the contour and fertilized with various rates of nitrogen and phosphorus (1964-69).

Year and row spacing	Lbs/acre[1]					
	Check	20-N	40-N	40-N 50-P_2O_5	60-N	60-N 50-P_2O_5
	Lbs/acre					
30-inch						
1964	374	426	550	525	539	560
1965	427	633	614	629	698	717
1966	151	198	239	292	304	296
1967	111	189	259	286	240	273
1968	82	92	125	137	123	113
1969	No harvest - invaded by other grass species					
Ave.	229	308	357	374	381	392
42-inch						
1964	312	331	327	348	318	347
1965	288	317	410	437	400	564
1966	103	132	202	212	165	238
1967	130	160	243	242	233	262
1968	80	87	134	134	111	123
1969	No harvest - invaded by other grass species					
Ave.	183	205	263	275	245	307
60-inch						
1964	185	245	219	221	230	209
1965	163	201	278	293	293	314
1966	125	162	167	158	163	176
1967	175	176	228	204	195	232
1968	42	62	69	62	62	67
1969	No harvest - invaded by other grass species					
Ave.	138	169	192	188	187	200

[1]Nitrogen applied in early spring annually.
P_2O_5 applied in 1963 and again in 1967.
Growing season precipitation was 7.8, 11.3, 3.9, 6.3, 6.2 and 7.7 inches during 1964 through 1969, respectively.
Source: Agronomy Journal 61:801-805. Personal Communication, A.L. Black, Director, Northern Great Plains Research Laboratory, Mandan, ND.

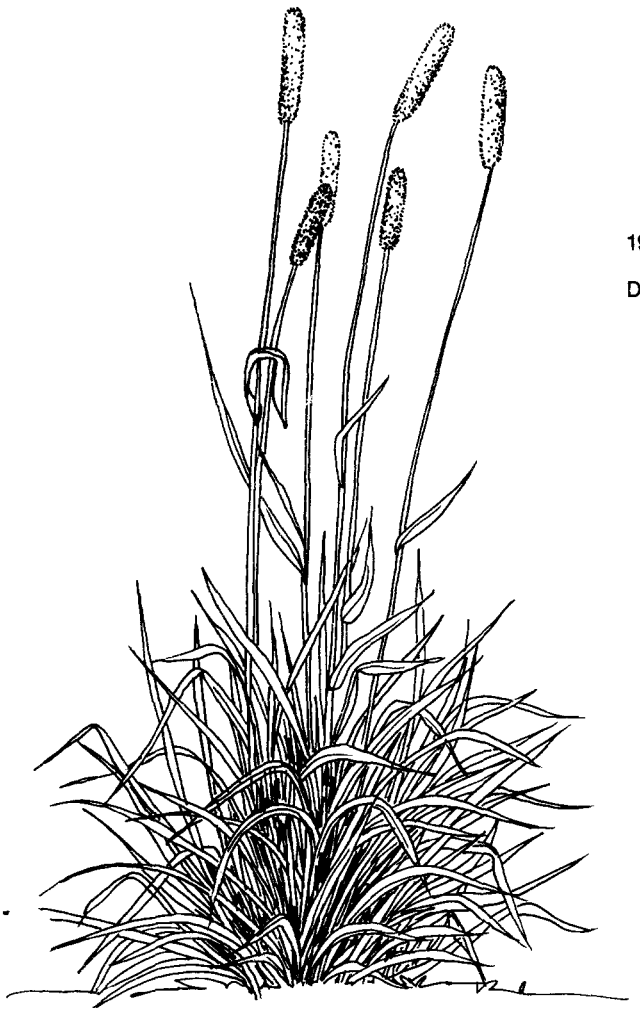
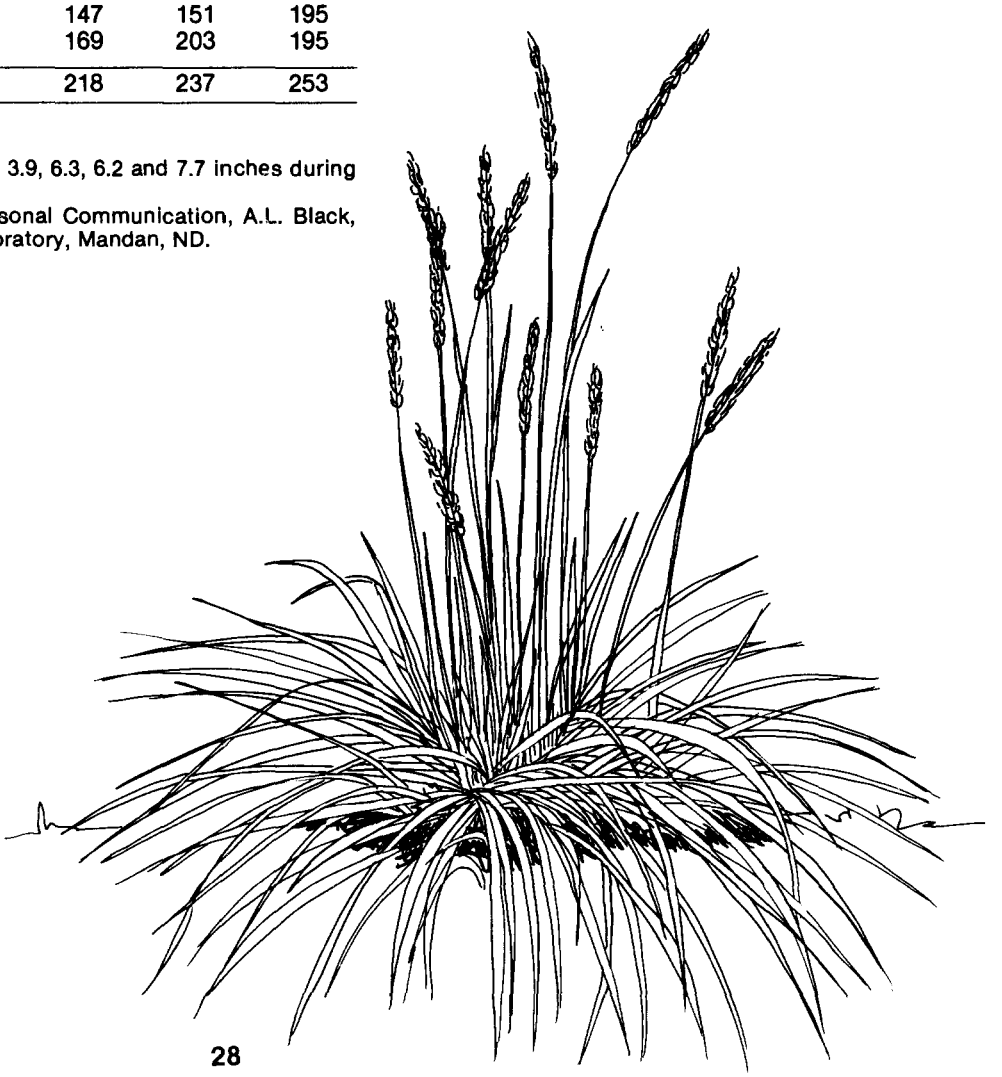


Table 44. Dryland seed yield of intermediate wheatgrass when grown in 30, 42 and 60-inch row spacing on the contour and fertilized with various rates of nitrogen and phosphorus (1964-69).

Year and row spacing	Lbs/acre[1]					
	Check	20-N	40-N	40-N 50-P_2O_5	60-N	60-N 50-P_2O_5
	Lbs/acre					
30-inch						
1964	312	311	385	339	362	346
1965	259	350	463	564	645	619
1966	45	49	93	121	102	124
1967	133	169	256	327	338	311
1968	53	96	178	178	182	179
1969	27	73	121	127	136	183
Ave.	138	175	249	276	294	294
42-inch						
1964	320	336	393	380	366	388
1965	260	398	471	487	472	535
1966	74	88	125	141	137	177
1967	135	235	273	261	285	267
1968	85	92	139	165	202	189
1969	27	86	119	154	148	169
Ave.	150	206	253	265	268	288
60-inch						
1964	215	217	265	287	268	326
1965	249	320	349	396	444	444
1966	77	93	92	95	116	96
1967	162	202	203	213	237	259
1968	102	129	132	147	151	195
1969	49	116	137	169	203	195
Ave.	142	180	196	218	237	253

[1]Nitrogen applied in early spring each year.
P_2O_5 applied in 1963 and again in 1967.
Growing season precipitation was 7.8, 11.3, 3.9, 6.3, 6.2 and 7.7 inches during 1964 through 1969, respectively.
Source: Agronomy Journal 61:801-805. Personal Communication, A.L. Black, Director, Northern Great Plains Research Laboratory, Mandan, ND.



CARRINGTON EXPERIMENT STATION
Carrington, ND

Table 45. Irrigated seed yields of several grasses grown in solid stands and 36-inch row spacings and fertilized with various rates of nitrogen (1963).

Lbs nitrogen per acre	Solid	Rows
	lbs/acre	
Nordan crested wheatgrass		
0	115	673
50	479	598
100	541	765
Primar slender wheatgrass		
0	353	496
50	316	542
100	423	385
Lincoln smooth bromegrass		
0	33	266
50	98	304
100	107	368

USDA, ARS, NORTHERN GREAT PLAINS RESEARCH CENTER
Mandan, ND

Table 46. Irrigated seed yields of Vinall Russian wildrye grown in 36-inch row spacings and fertilized with various rates of nitrogen and phosphorus.

Treatment		Harvest year							
N	Time[2]	1	2	3	4	5	6	7	Ave.
lbs/acre		lbs/acre							
0	—	288	227	157	204	72	130	66	163
50[1]	fall	231	182	132	335	234	192	129	205
100[1]	fall	226	183	142	351	336	241	179	237
100	fall	241	174	158	391	365	185	133	235
100[1]	fall-sp	244	156	154	366	383	281	157	249
100[1]	sum-fall	250	179	153	321	381	230	209	246
200	fall-sp	202	164	144	322	465	462	276	291

[1]44 lbs P_2O_5 applied along row at planting time.
[2]Fall, spring, summer applications made in late October, late May and late August.
Source: Agronomy Journal 56:501-503.

Table 47. Irrigated seed yields of various grasses grown in 36-inch row spacings.

Grass species or variety	Years[1] 1952	1953	1954
	----------lbs/acre----------		
Lincoln brome	559	87	118
Nordan crested	689	450	[3]
Green needlegrass	[2]	711	454
Pubescent wheatgrass	728	220	[3]
Intermediate wheatgrass	657	128	[3]
Tall wheatgrass	777	761	[3]
Russian wildrye	[2]	233	217

[1]Ave. of 0, 50, 100-N treatments as yields were not significantly different.
[2]Stand failure, reseeded in fall of 1951.
[3]Destroyed by hail.
Source: ND Agric. Exp. Stn. Bulletin No. 437.

USDA, SCS, PLANT MATERIALS CENTER
Bismarck, ND

Table 48. Irrigated seed yields of several introduced and native grasses grown in 42-inch rows from various age stands.

Grass species or variety	Years 78	79	80	81	82	Ave.
	----------lbs/acre----------					
Bluestem, big						
NDG-4	92	192	32	124	123	113
Creeping foxtail						
Garrison	184	24	66	57	151	96
Grama, sideoats						
Killdeer	115	330	236	217	235	227
Pierre	10	375	125	346	344	240
Indiangrass						
ND-444	128	50	177	167	255	155
Needlegrass, green						
SD-93	447	123	157	280	221	246
Sandreed, prairie						
ND-95	75	71	95	93	47	76
Switchgrass						
NDG-965-98	377	170	130	63	111	170
Wheatgrass						
Pubescent						
Mandan 759	320	207	203	271	210	242
Western						
Rodan	273	85	120	33	23	107
Wildrye, altai						
ND-1713	123	68	133	153	128	121

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