United States Department of Agriculture
NATURAL RESOURCES CONSERVATION SERVICE
Plant Materials
Plant Materials Technical Note No. MT-58
April 2007

PLANT MATERIALS TECHNICAL NOTE

SEEDBED PREPARATION AND SEEDING TECHNICAL NOTE

BY

LARRY HOLZWORTH, PLANT MATERIALS SPECIALIST, USDA-NRCS, BOZEMAN, MONTANA

LOREN E. WIESNER (RET.), PROFESSOR OF AGRONOMY, MONTANA STATE UNIVERSITY, BOZEMAN, MONTANA

ADAPTED FROM (MONTANA INTERAGENCY PLANT MATERIALS HANDBOOK. JUNE 1990. EXTENSION BULLETIN 69. MONTANA STATE UNIVERSITY, EXTENSION SERVICE, BOZEMAN, MONTANA, NRCS MONTANA PASTURE AND HAY PLANTING (CODE 512) AND RANGE PLANTING (CODE 550) CONSERVATION PRACTICE SPECIFICATIONS. IDAHO PLANT MATERIALS TECHNICAL NOTE NUMBER 10 PASTURE AND RANGE SEEDINGS, PLANNING-INSTALLATION-EVALUATION, (REVISED) JANUARY 2006.

PRINCIPLES OF ESTABLISHMENT AND SEEDLING YEAR MANAGEMENT

SEEDBED PREPARATION

Success in establishing pasture and rangeland seedings requires careful planning and timely land preparation. Unlike cereal grains, grass, forb, legume and shrub seeds are generally small and germinate slowly. A seedbed preparation method should be selected that best suits the site, seeded species and available equipment. The selected seedbed preparation should retain the maximum amount of soil moisture.

Two methods of seedbed preparation are recommended.

Conventional or Clean Tillage – This type of seedbed can be prepared with plows, discs, chisels, tool-bars using sweeps or other types of equipment. After the tillage operation is completed, the land should be smoothed and firmed using equipment such as a roller harrow, cultipacker, spike tooth harrow or other implement to firm the final seedbed. The seed is then planted directly into the prepared seedbed using a disc or furrow-type drill. Tillage is not recommended for saline or sodic soils. It brings salt to the surface, destroys soil structure and residue for soil drainage. Plant residue, even weeds, need to be used for a no-till seeding into saline/sodic soils.

Standing Stubble – Seed can also be inter-seeded directly into most cereal grain stubble on coarse- to medium-textured soils. Stubble free from weeds and volunteer grain provides a firm seedbed and a favorable micro-climate for seedling establishment. Winter wheat stubble is not recommended for fall dormant plantings due to grassy weeds and volunteer grain that commonly germinate over winter or in early spring. Furthermore, grain straw should be removed from the field or shredded and uniformly scattered. This improves the seed-to-soil contact and reduces chaff toxicity. Harrowing and other chaff spreading operations will disturb the soil and normally cause a flush of volunteer grain. An application of a broad spectrum herbicide such as glyphosate will control this flush. Double disc or deep furrow drills with acra-plant™ openers are recommended for planting into stubble. In addition, if weeds are a problem, spraying the field with appropriate herbicides prior to seeding is recommended. If the weedy competition cannot be controlled using chemicals alone, then conventional tillage and herbicide combinations are recommended.

Some planting sites require only one or two tillage operations to prepare a seedbed. Usually tillage is for the purpose of killing all weeds to eliminate competition. Chemical weed control may be substituted for one or all of the tillage operations when preparing a seedbed. Usually a combination of treatments are best for suppressing cheatgrass infestations.

The seedbed for forage seeds should be weed free, clod-free, smooth, firm and moist. Plowing may not be necessary depending on the soil type. With minimum tillage drills and proper herbicides one may seed directly into cereal crop stubble. Seedbeds prepared by plowing and cultivation usually require packing before seeding.

When a conventional seedbed is prepared, competing vegetation will be controlled and the site will not be subject to erosion. A firm clod-free seedbed ensures seed to soil contact will be provided. A firm seedbed facilitates capillary movement of moisture to the seed and developing seedling. A good rule of thumb is a footprint will be no deeper than 1/8-inch in an ideal seedbed.

The presence of weed populations - especially noxious weeds - will impact seedbed preparations. Each field should be evaluated for weed populations. Seeding on fields with significant weed populations will be delayed until weeds are controlled mechanically or chemically with labeled herbicides. Refer to guidelines in the Field Office Technical Guide (FOTG), Section IV, Practice Standards and Specifications, Pest Management (Code 595), and *Montana, Utah, Wyoming Weed Management Handbook*. During this period a protective cover crop may need to be planted to control erosion prior to planting.

When planning a seeding, the previous several years of herbicide application must be considered. Any potential carryover problems must be addressed by delaying seeding, establishing a cover crop, and/or changing species to be planted to prevent planting failures.

If a cover crop is necessary, refer to guidelines in the FOTG, Section IV, Practice Standards and Specifications, Cover Crop (Code 340). It is often advisable to grow small grain crops for one to two years prior to the final seeding. Tillage and labeled herbicides used under small grain production economically control weeds and reduce the number of weed seeds in the soil. They also allow high levels of organic matter (root and shoot mass) time to decompose into mineral soil. High organic matter soils, such as perennial sod, make poor seedbeds because they are difficult to firm and they also tend to dry rapidly, resulting in poor seed-to-soil contact for proper seedling germination and establishment conditions. This rotation helps to break disease and insect cycles and is especially important to consider when renovating old pasture or hayland.

Seeding of depleted range and/or pastureland, or cropland fields requires control of existing perennial and annual vegetation. This may be accomplished through chemical or mechanical methods. If tillage is used, a minimum of two years of cultivation and cropping is recommended to control existing vegetation and to store soil moisture. Standing cereal grain stubble provides an excellent seedbed if proper seeding equipment is used.

If chemical methods are used, multiple applications are generally required to achieve satisfactory control of perennial competition. Litter may need to be reduced to allow for proper seed placement and good seed-to-soil contact.

Many landowners want “instant” results and try to inter-seed into existing plant communities. Numerous studies have shown interseeding into existing plant communities almost always fails due to too much competition for water and nutrients from the existing vegetation. In addition, there may be allelopathic effects from living and/or dying and decaying vegetation. Therefore, interseeding is not recommended. Plantings where existing vegetation can be completely destroyed with labeled non-selective herbicides prior to seeding with interseeding-type equipment have been successful when the site is irrigated or receives 15 inches or more mean annual precipitation. Also, interseeding is more successful where the existing species is a monoculture and is vulnerable to herbicides during the same phonologic stage. However, it should be fully understood these plantings are still more risky than conventional land preparation methods.

An exception to this rule is on very wet soil locations where conventional land preparation is not possible. ‘Garrison’ creeping foxtail can be established in an existing stand of less palatable species including Baltic rush (wiregrass) and sedges. The species is very opportunistic and aggressive on wet sites. The seed can be broadcast when the site is frozen or by feeding Garrison hay and allowing livestock trampling to plant seed. With proper irrigation and fertilization, Garrison can establish and eventually crowd out less-desirable species over a 6-10 year or longer period.

EQUIPMENT FOR SEEDING

No attempt is made in this Technical Note to discuss all available equipment. For SPECIAL EQUIPMENT FOR RANGE SEEDINGS readers are referred to the Range Seeding Equipment Handbook (U.S. Government Printing Office (GPO), Washington, D.C.). Discussion in this handbook is limited to advantages and disadvantages of conventional farm machinery used for most of the forage seedings in Montana.

TILLAGE EQUIPMENT

A. PLOWS

MOLDBOARD

The moldboard plow operates best at depths of four to ten inches, which is not always desirable since it may result in a deep, loose seedbed. Other disadvantages are relatively high cost per acre; no plant residue remains on the soil surface for erosion control; high labor requirement which may severely limit the acreage prepared and seeded in a given year; additional tillage operation and/or cereal grain cropping, to work down the clods for a good seedbed on clayey soils.

Preventing plant competition is an advantage of using a moldboard plow. It is one of the most effective tools in fighting grassy weeds such as cheatgrass and foxtail (Hordeum jubatum), because it buries most seed and living plants deep enough to prevent their germination and re-establishment. On medium- and sandy-textured soils, perennial species have been successfully established when planted behind the plowing operation, plow-plant. Moldboard plowing is best accomplished when there is little or no residue on the surface, which allows complete inversion of the plow layer. It may be desirable to burn residue prior to plowing. If the plow is set about three inches deeper than any tillage carried out in recent years, the soil exposed on the surface will contain little viable weed seed.

The moldboard plow is also effective in displacing existing perennial cover in a short period of time. It is frequently best to rip or cut the sod to a shallow depth prior to plowing. Preventing the formation of large "slabs", permitting more complete inversion of the sod, and generally making it possible to prepare a good seedbed at a much earlier date following plowing.

DISK PLOW

Disks on this implement are mounted individually rather than on a central shaft as in one-ways, offsets, and disk harrows. The disk plow does not reduce weed competition as effectively as the moldboard, nor does it maintain residue on the surface for erosion control as well as subsurface tillage equipment.

Discing will work satisfactorily under drier soil conditions and handle more residue and shrubby growth than will the moldboard plow.

B. DISKS

The one-way disk is effective in reducing heavy residue and in bringing heavy weed growth under control. The chief disadvantage is that it leaves the soil loose, rather finely divided or pulverized, and more subject to blowing.

The offset disk and the disk harrow are most effective in breaking down large clods and pieces of sod, smoothing, compacting, and killing small weeds. However, neither is highly effective in maintaining residue on the surface nor in maintaining clods for resistance to blowing.

Disking leaves the soil too loose for immediate seeding.

C. HARROWS

Harrows are effective where smoothing is needed, as in hay fields. They also accomplish some compaction though not nearly as much as does special packing equipment discussed later.

Spike harrows tend to leave the surface smooth and thus more subject to blowing. More effective in preventing soil blowing are spring-tooth harrows since they leave more clods on the surface. Heavy harrows can be adjusted to operate like a spike harrow or more severe like a tandem disk.

D. SUB-SURFACE TILLAGE EQUIPMENT

The big advantage in using these implements is in controlling weeds during a fallow year while maintaining residue on the surface for erosion control.

Spikes are effective in breaking up compacted layers and working heavy residue. Blades and wide sweeps are most effective in maintaining adequate amounts of residue on the surface.

All of these implements leave the soil loose, which makes them effective for weed control, but ineffective for seedbed preparation. They should be operated at greatest depth in the first operation of the season. Each succeeding operation should be at a shallower depth, reducing the thickness of the layer of loose surface soil and tending to maintain good soil moisture closer to the surface. Ideally, seed should be placed in firm, moist soil at seeding time.

Rod weeders are very effective when used in the last one or two fallow tillage operations. Given a reasonable amount of soil moisture, they do a good job of compacting the soil to a point close to the surface, while killing weeds and destroying a minimum amount of residue. Seed can be planted into a rod weeded surface.

E. PACKERS

The machine most universally missing in Montana for seedbed preparation is the packer. Its absence is frequently critical and many failures could have been avoided through its use. Many stands would have come into full production one to five years earlier if it had been used. A seedbed is sufficiently firm when a person walking across the field sinks no more than 1/8 of an inch.

Operators have improvised many ways to accomplish packing in some degree:

1. The tandem disk harrow compacts a deep, loose seedbed, if the soil is moist. It does not pack the top two to four inches, however, so is not satisfactory for use with a disk drill and is never as good as a standard packer.

2. A well-weighted spike harrow or other heavy drag can be used on seedbeds with little trash or residue and low erosion hazard.

3. The rod weeder is probably used more frequently in Montana than any other piece of equipment, largely because it is readily available.

4. The press drill is sometimes used twice - the first operation as a packer, the second for seeding. Evidence of the effectiveness of packing can be seen in many fields, the corners which were drilled twice, having much better stands than the remainder of the field.

5. The irrigation float, or leveler, frequently leaves the field well compacted for seeding.

FERTILIZER AND AMENDMENT APPLICATIONS

The application of nitrogen is <u>not</u> usually required for grass/legume establishment. However, if soil test results show that nitrogen levels are low or very low (below 10 ppm), light rates of available nitrogen may

be incorporated during site preparation or applied with the seed at planting - maximum of 15 pounds actual N.

Native species do not generally respond well to fertilizer applications under dryland conditions, especially nitrogen. Phosphorus, potassium, and sulfur applications will be based on soil test results and are most effective if applied during seedbed preparation. See FOTG, Section IV, Practice Standards and Specifications, Nutrient Management (Code 590), and *Fertilizer Guides for Montana, Montana State University Extension Service Publication Number EB 161, Issued January 2003*.

Legume seed should be inoculated with the proper species of viable *Rhizobia* before planting. If using coated seed, re-calibrate the planting equipment to deliver the same number of seed per area as would be applied with non-coated seed. Many species of grasses are attacked by soil-borne fungi that reduce emergence and vigor. Seed may be treated before planting with an appropriate fungicide if past experience or field history indicates a problem.

CAUTION: Select inoculants that have been stored in a cool, dry environment. Do not use inoculum after the expiration date indicated on the container.

SEEDING DEPTH AND ROW SPACING

Drill forage seeds at a uniform depth of one-half inch for small and three-quarter inch for large-seeded species. Depth bands on disks will help control seeding depth as will releasing the opener spring tension and seeding into a firm seedbed. Equip the drill with packer wheels to firm the soil over the seed after seeding.

1. Planting. Seeding will be done with a drill or air seeder that will place the seed at the proper depth, provide a uniform flow of seed at the proper rate, and have packer wheels to press the soil firmly over the seed. In lieu of packer wheels, the area will be cultipacked after seeding.

   Install plantings with equipment calibrated to the correct seeding rate and set for the correct depth of planting. Use depth bands if available. Acceptable planters include, but are not limited to, a single-disk, double-disk or furrow drill, hoe drill, or air seeder. Reference NRCS Montana Plant Materials Technical Note No. MT-30, Calibrating a Drill, dated May 1985.

2. Broadcast Rates. If planting is to be completed by broadcasting the seed–hand planted, mechanical or aerial seeded: (1) seeding rates must be doubled if no other operation will take place after seed broadcasting, or (2) recommended seeding rates may be used from Montana Plant Materials Technical Note No. MT-46, Seeding Rates and Recommended Cultivars – if the seedbed is roughened, seed broadcast, covered with a spike-tooth harrow or similar implement, and then rolled with a packer or cultipacker.

3. Seed Placement. Native grasses, forbs, and shrubs need to be seeded at a shallow depth, as light plays a key role in the germination of many species. Native grass mixtures containing varying seed sizes should be planted no deeper than one-half to three-quarter inch deep. Drills fitted with depth bands and packer wheels are strongly recommended.

   CAUTION: Many rangeland shrubs (big sagebrush, silver sagebrush, and others) require light for germination and MUST be seeded no deeper than one-quarter inch. Research has shown if these seeds are mixed with other seeds and planted deeper than one-quarter inch, the seeding will be a complete failure. Reference Montana Plant Materials Technical Note No. MT-31, Restoration of Woody Plants within Native Range Communities.

   For guidance on planting shrubs or trees using containerized stock, dormant poles, etc., refer to the FOTG, Section IV, Practices Standards and Specifications for Tree and Shrub Planting (Code 612).

   When seeding warm season grasses, native forbs with small sized seed, or rangeland shrubs, species must be drill seeded separately in alternate rows, or broadcast on the soil surface and lightly covered, for successful establishment. Another option is two seeding operations with the second operation perpendicular to the first.

4. Row Spacing. Row spacing for most range or pasture mixtures will be between six and 14 inches. The minimum row spacing for Russian wildrye is 18 inches. Where row spacing is greater than 12 inches, hazards from wind or water erosion, or weed encroachment may exist and must be managed. Consider two seeding operations, with the second operation perpendicular to the first or alternate rows with alfalfa or other legumes 18 inches wide.

5. Slope. Where slopes are greater than five percent, planting will be completed on the contour or across the general slope of the land, especially with Russian wildrye wide row spacing.

This is an alternate row of Russian wildrye with alfalfa planting.

DATE OF SEEDING

Most forage legumes and grasses are seeded in the spring to allow the seedling to become well established before being subjected to freezing temperatures. Make spring plantings as early in the spring as possible to provide for optimum germination temperatures and to allow forage seedling to get a jump on the weeds. There are a few species such as cicer milkvetch and some of the cool season grasses which require warmer soil temperature and should not be planted until later in the spring. Some of the grasses which contain dormant seed may be planted in the fall. However, it is best to plant these species in late August to allow seedlings to become established or to plant late in the fall ("dormant seeding") so seed germination does not occur until spring. If winter annual weeds, such as cheatgrass are not a problem, a dormant planting is an excellent time to plant due to allocation of labor and soil moisture/seed imbibition. In a farm or ranch operation, there is more time available to plant in the fall and the seed is in position within the soil to allow incipient germination during favorable temperature and moisture conditions for quicker establishment the following spring. On wet saline soils, dormant plantings may be the only option available in order to transverse the field.

Planting shall be scheduled during periods when soil moisture is adequate for germination and establishment. *Spring seedings* will be completed by May 15. Seedings are allowed after May 15 *only* when there is a minimum of two feet of moist soil. The soil must also be moist to within two inches of the surface. As a good rule of thumb, if the soil is wet enough to stick to the coulters, it is too wet to plant. These seedings must be completed by August 15. Warm-season species prefer summer planting as they require 55º F. soil temperatures for germination.

Dormant fall seedings can be made after October 15 or when soil temperatures two inches below the soil surface remains at 40° F. or less for ten or more days. Cool-season plants can initiate germination around 40° F. As a general rule, legumes should be planted in the spring except where winter moisture is low or the soils are well drained.

Species with a high percentage of dormant seed such as green needlegrass and Indian ricegrass must be planted as a dormant fall seeding unless germination by standard seed test is greater than 50 percent. If dormant species are a minor component of a mixture; spring seeding is acceptable. *When irrigation is provided*, planting may be completed at any time during the growing season that allows adequate root system development prior to a killing frost (45 days).

For chaffy grass seed, especially native species, planting should be done at three to five miles per hour. The fluffier the seed, the slower the drill speed. Rice hulls or other carriers may be required for adequate flow through the drill box. Recommended amounts for rice hull or other carriers can be found in the Montana Plant Materials Technical Note No. 52, Mixing Seed with Rice Hulls.

Very light grass seed such as Garrison creeping foxtail may require the use of a carrier in the drill box to assure uniform flow through the planter.

Avoid backing up the drill when it is in the down position to eliminate plugging of the drop tube. Minimize making turns so sharp as to cause one end of the drill to back up.

When planting around a field rather than back and forth, drill with the drill drive wheel to the inside of the field. Avoid figure-eight turns.

Alternate row plantings may be used to improve establishment where inter-species competition is a problem and more than one species is planted. Planting two or three rows of one species with one row of another may also be used to reduce competition.

RECOMMENDED SEEDING RATES (PLS) AND SPECIES SELECTION

1. Seeding rates will be calculated based on a Pure Live Seed (PLS) basis. Use tables in the Montana Plant Materials Technical Note No. 46, Seeding Rates and Recommended Cultivars to determine pounds of PLS required for a pure stand or full seeding.

2. Seeding rates of plus or minus ten percent of the recommended rate (on a PLS basis) will be considered as meeting this standard.

3. Use Forage Suitability Group Descriptions and Ecological Site Descriptions located in the Field Office Technical Guide (FOTG), Section IIE, to assist in species selection and potential production estimates. Also reference Montana State University, Extension Service, Extension Bulletin 19, “Dryland Pastures in Montana and Wyoming” revised 2003, and Extension Bulletin 99 ”Irrigated Pastures in Montana and Wyoming” reprinted 1994.

4. Native grass mixtures generally consist of a variety of seed sizes, shapes, and textures that will result in a uniform flow through the seed box. Rice hulls or other carriers are usually only required for adequate flow through the drill box when small or light seed dictates carriers are needed. Fungicide recommendations must adhere to all manufacturer's label directions and precautions for treatment.

5. An agitator is very useful to assist in seed flow when seeding native grasses. In seed drills that do not have an agitator, watch for settling of the smaller and heavier species, or bridging of fluffy, or winged seeds (blue grama, big bluestem, sideoats grama) planted alone, or in high percentages (greater than 50 percent).

COMPANION OR NURSE CROPS

In general, seeding companion crops with perennial grasses or forbs is not recommended as they provide too much competition for seedlings and will typically reduce the subsequent seedling and stand establishment and forage yield, particularly when moisture is limited. However, under eroding conditions, in heavy clay soils prone to crusting, or in higher precipitation areas, they can be successfully used.

Decrease the companion crop seeding rate to a maximum of 15 PLS pounds per acre and seed the crops at right angles or in alternate rows to reduce competition.

Irrigated companion crops may be used at full or reduced rates and harvested for forage or grain. Irrigation will be applied to meet the needs of the seeding.

Under dryland conditions companion crops are not recommended for establishing pasture or hayland where annual precipitation is less than 16 inches. In areas where annual precipitation is 16 inches or greater, or where erosion is a concern, a spring grain companion crop may be seeded at the following rates:

Spring wheat	10 lbs./acre (3.0 seeds/ft.)
Barley	10 lbs./acre (2.75 seeds/ft.)
Oats	10 lbs./acre (2.5 seeds/ft.).

Companion crops are best removed early as hay or silage leaving a tall stubble (6-8 inches) for snow trapping. However, they may be harvested for grain. When grass and/or legumes are seeded with the companion, crop seeding depth will not exceed one inch.

COMPARING SEED LOTS AND COST, CALCULATING PLS AND SEEDS PER ROW FOOT BASED ON PLS POUNDS/ACRE

Most of the cereal crops a farmer plants are consistent in percent pure seed and germination. Based on these consistencies the industry has adopted a set of Seed Standards for these crops when sold on the market. Consequently, the producer may plant the seed at a regular rate of pounds of material per acre and expect to obtain the stand they desire, providing proper seedbed and planting procedures were used, and the weather conditions are favorable. However, many of the grasses and legumes are so variable in both purity and germination it is impractical to set a commercial seed standard. For this reason a different means is necessary to determine the value of the planting material and to determine the amount of material to plant for a desired stand. The Pure Live Seed method provides a reliable means of determining these factors.

Pure Live Seed (PLS), expressed in percent, is the term used to designate the calculated quantity of viable seed to plant. The percent PLS of a seed lot is obtained by multiplying the percent purity times the percent germination and dividing the product by 100. In the case of legumes, where "hard" seed are counted, the percent of "hard" seed is added to the percent germination before multiplying it times the purity.

The PLS is important in determining the amount of material needed for planting and in determining the quality of the seed to be purchased. It is the best way to determine the actual cost of the seed. As an example, examine the following lots of seed:

Lot #1	Lot #2
Purity: 90%	Purity: 80%
Germination: 92%	Germination: 70%
Cost/lb. Material: $2.35	Cost/lb. Material: $2.15
$\%PLS = \frac{90 \times 92}{100} = 83\%$	$\%PLS = \frac{80 \times 70}{100} = 56\%$

The cost of one pound of PLS = $\frac{\text{Cost per pound of Material} \times 100}{\%PLS}$

Lot #1

Cost per pound PLS = $\frac{\$2.35 \times 100}{83}$ = $2.84 per pound PLS

Lot #2

Cost per pound PLS = $\frac{\$2.15 \times 100}{56}$ = $3.84 per pound PLS

At first glance Lot #2 might appear to be the best buy, but it actually costs $1.00 (35%) more per pound of PLS. Differences in some situations are often greater.

Following are several examples of the use of PLS in determining costs and planting rates (all examples are based on the following hypothetical lot of seed):

- Purity: 90%
- Germination: 80%
- Planting rate: 6 lbs. PLS per acre
- Seed units: 150,000 seeds per pound of pure seed
- Cost of seed: $2.40 per pound.

Pure Live Seed:

% PLS = $\frac{\%\text{Purity} \times \%\text{Germination}}{100} = \frac{90 \times 80}{100}$ = 72% PLS

Amount of Planting Material Needed Per Acre:

Pounds of Material per acre = $\frac{\text{Planting Rate in lbs./acre PLS} \times 100}{\%\text{PLS}}$

Pounds of Materials per acre = $\frac{6 \times 100}{72} = \frac{600}{72}$ = 8.33 lbs. material per acre

Cost of seed per acre: = lbs. of material x cost/lb. = 8.33 x $2.40 = $20 per acre.

Cost per pound of PLS:

Cost/lb. PLS = $\frac{\text{Cost/lb. Material} \times 100}{\%\text{ PLS}} = \frac{\$2.40 \times 100}{72}$ = $3.33/lb. PLS

Pounds of Material to Yield 1 lb. of PLS:

Pounds of material to yield 1 lb. PLS = $\frac{100}{\%\text{PLS}} = \frac{100}{72}$ = 1.39

Planting Rates:

Viable seed (PLS)/sq. ft. = $\frac{\text{Seed units/lb. pure seed} \times \text{lbs. PLS/acre planted}}{\text{sq. ft./acre}}$

Viable seed (PLS)/sq. ft. = $\frac{150{,}000 \times 6}{43{,}560} = \frac{900{,}000}{43{,}560}$ = 20.6 viable seed/sq. ft.

Viable seed (PLS) per row foot = $\frac{\text{Seeds/lb. pure seed} \times \text{Planting rate lbs. PLS}}{\text{row ft. in acre at width to be planted}}$

Example in 36-inch rows there are 14,520 row feet per acre. (43,560 ft²/acre ÷ 3 ft. = 14,520)
Viable seeds per row ft. = $\frac{150{,}000 \times 6}{14{,}520}$ = 62 viable seed/row ft.

Example - You plan to seed production planting with above lot of seed and want to seed approximately 35 viable seed per row foot in 36-inch rows. It would be computed as follows:

Planting rate lbs PLS = $\frac{\text{Viable seeds/row ft. x row ft./acre}}{\text{Seed units in pound of pure seed}}$

Planting rate lbs PLS = $\frac{35 \times 14{,}520}{150{,}000}$ (row feet in 36" rows) = 3.39 lbs. of PLS per acre

You would then need to buy:

$\frac{3.39 \times 100}{72}$ = 4.7 pounds of material for each acre you were going to plant.

Seeding rates of PLS for various row spacings are contained in Montana Plant Materials Technical Note No. 46, Seeding Rates and Recommended Cultivars.

When comparing two lots of seed usually the one with the higher purity and germination will give the highest quality seed and will be cheaper per unit of viable seed. High purity assures the buyer of freedom from contamination with troublesome or noxious weeds. High germination assures vigorous seedlings that will establish good stands in a minimum period of time.

When the germination of a given seed lot is a great deal below the usual germination for seed of the same variety or species of comparable age it should be suspected at any price. Many of the factors which contribute to unusually low germination also damage the seeds which are viable. Seedlings from this seed may be so defective or low in vigor they will fail to produce good stands under the best field conditions.

Formula for calculating seeding rates for row spacing greater than 12 inches:

First Step:

$\frac{\text{Row Spacing desired (inches)}}{\text{12 inches}}$ = adjustment factor

Second Step:

$\frac{\text{Pounds/A at 12-inch row spacing}}{\text{adjustment factor}}$ = actual seeding rate (lbs./A)

Example for using footnote in Table 3-Ia for calculating pound per acre and seed per foot of row

Assumption: Seeding alfalfa in 30-inch rows on irrigated land.

Find: Seeds per foot of row and pounds per acre.

Seed per foot of row = 28 or the same as the 12-inch row spacing.

$\frac{6 \text{ (pounds/A at 12-inch row spacing)}}{\text{Adjustment factor = 2.5 (from footnote chart for 30-inch row spacing)}}$

Pounds per acre for 30-inch row spacing = 2.4

DRILLS AND SEEDERS

Selection of equipment for the seeding operation should be based upon three main objectives: (1) preparation of the best possible seedbed (2) weed control and (3) seed:soil contact. No single piece of equipment is best for all seeding situations. The type of grass seeding equipment available will strongly influence the options for seedbed preparation. If seeding into standing stubble or crop residue a double disk, furrow drill, or no-till drill with coulters will be required to achieve proper seed placement.

The technician and operator must consider all the factors for each individual situation, and then pick the best machine available. Frequently, there is no satisfactory machine available. In this case, the operator should be told frankly the chances of success are poor and they should either wait until conditions prevail that are favorable to success with the machinery available, or until they can obtain adapted equipment.

A. DISK DRILLS

SINGLE-DISK

Single-disk drills are particularly adapted for seeding hard and brushy seedbeds. They can be obtained in standard, semi-deep, and deep-furrow models.

DOUBLE-DISK

Double-disk drills are useful for seeding in stubble and on well-prepared seedbeds. They work best when equipped with depth bands; spring pressure can then be applied to assure uniform penetration in soft and hard ground. Depth bands can be made locally from scrap iron, or commercial types can be purchased. For best results, the disks should be kept sharp.

This is a good grass drill showing double-disk openers with depth bands and packer wheels.

B. DEEP-FURROW

The deep-furrow drill puts seed in the moist soil in the bottom of a deep furrow, yet the seed are only covered the normal depth in the bottom of the broad furrow. Deep-furrow planting may be done with either a lister (also called shovel) or a disk-type drill. Deep furrows are particularly useful where surface soil drying is a problem and for seeding through trash or stubble cover and into deep, loose seedbeds.

Snow and rainfall tend to concentrate in the furrows and drilling should be on the contour on sloping land. In stubble seedings the furrow drill parts the stubble, allowing more sunshine to reach the ground which may speed up germination.

Deep-furrow planting is not without its dangers and should be confined to relatively stable soils. In loose or erodible soil, the soil may slough in, covering the seed too deeply. High intensity summer storms or high winds can fill the furrows with eroded material and bury seed or seedlings.

C. SEMI-DEEP FURROW (HOE DRILL)

The semi-deep furrow disk drill forms a smaller furrow and has many advantages of the deep-furrow disk drill. The disks have less concavity and the planting shoe is smaller. To benefit from this type of drill, the furrow should be at least two inches deep.

D. OTHER DRILLS

Air seeders are excellent planters for cereal grains, but seeding depth must be monitored for perennial grasses and forbs. Also, fluffy seeds tend to plug drop tubes. A carrier is recommended to facilitate an even flow.

Numerous other interseeding or special drills for seeding grass are also available. No-till drills can be used to plant into heavy cereal stubble. Other drills have cotton seed boxes with special force-feeding devices for seeding chaffy seeds. They also have fine-seed hoppers.

Grass and legume seed boxes are available for most grain drills and are very useful for seeding fine seeds. Most grass seeds are best distributed through the standard grain box, however, agitation is required. When legumes are seeded with grasses, it is generally best to use both boxes, so that separation of small and large seeds in the drill box can be avoided. Also, the percent of legume in the established stand can be better controlled by seeding the legume only in every second or third row.

Alternate row seeding is easily accomplished when grass is seeded through the grain box and legumes through the fine-seed hopper by blocking alternate rows in each box with duct tape or small bags of sand (about one pound).

E. BROADCAST AND OTHER SEEDERS

Broadcasting is generally not a good method of seeding large-seeded species. Specialized seeders such as the Brillion is an excellent seeder for small-seeded turf species such as Kentucky bluegrass. Broadcasting onto a roughened surface combined with excellent packing and immediate precipitation has also been successful. In most cases, the recommended seeding rate should be **doubled** to compensate for seed buried too deep or that dry out on the surface. Broadcasting is most successful when used as a dormant fall or winter seeding on deep, loose seedbeds or on fresh burn areas where wetting/drying or freeze/thaw will cover the seed and increase the chance of germination.

Fertilizer spreaders are commonly used for grass/legume seedings. The Valmar™ is an orifice gravity flow with a paddle spinning wheel. An air-flow propels seed at a high velocity down vertical tubes onto the soil surface. The force can impregnate the seed into previously packed and then re-roughened soil surface. Both mechanical broadcast seeders require packing after seed application.

This is a packer following a broadcast seeder.

For small areas, hand broadcasting is the most practical method. The small hand (knapsack) broadcasters will give a more uniform seeding than scattering by hand. For large areas some type of power broadcaster is desirable. Power broadcasters are normally run by gasoline engines, electric motors, or the power take-off on the tractor. The hopper must be equipped with a good agitator or seed will not flow through it smoothly.

Two-wheel fertilizer spreaders can be used for very fluffy seeds that will not pass through conventional drills. Seed should then be covered with a packer.

Drills and broadcasters should be operated at rather low speeds (under two mph) for the best performance and uniform seed delivery. When operated at higher speeds, there will likely be many "skips", disk penetration will be much more erratic, and furrow openers will throw soil into adjoining furrows.

The airplane and helicopter are excellent for broadcasting large areas. The Venturi type of seed distributor is advised for use on airplanes. Field flagging will be necessary to prevent overlap and skips. Where landing fields are distant and elevations not too high, the helicopter may be better than the airplane. It can land in any small clearing, and requires less ground control. It should be equipped with standard dusting hoppers.

This is an aerial broadcast seeding following a fire.

Machinery alone cannot guarantee success in getting good stands of grasses and legumes. But it is one of the factors we can control, to increase our chances of seeding success.

DRILL OR SEEDER ATTACHMENTS

A. PACKER WHEELS

Packer wheels are necessary on any drill or seeder to plant grass or legumes. It is crucial to have the soil firmed around the seed to keep it in contact with moisture during germination and emergence. After broadcast seeding, the last planting operation should be packing with a roller packer. Packing following seeding restores capillary pores to facilitate capillary soil moisture movement to the seed for germination and seedling establishment.

B. FERTILIZER ATTACHMENTS

Fertilizer attachments on drills enable placement of fertilizer near the seed where it will do the most good. When fertilizer is broadcast, a high percent of it is used by weeds which become more competitive with the developing grass or legume seedlings. Some drills are equipped to deliver a deep band of fertilizer ahead of the seed placement, and in this case complete fertilization can be made during the seeding operation.

The seed box should be of the force-feed type. In grain drills, the fluted feed has generally proved the best force-feed type. A simple agitator prevents bridging of the seeds being planted in Montana. Very few Montana drills are equipped with an agitator. Stands would be much more uniform if they were so equipped. Bridging can also be reduced by never filling the drill box more than one-third to one-half full or someone may ride the drill and stir the seed frequently with a stick.

For seeding steep slopes install baffles in the drill box every two feet to prevent the seed from running to one end of the box when seeding on the contour.

MANAGEMENT OF DRYLAND SEEDED PASTURES

All range plantings will be protected from domestic grazing from the date of seeding for at least two consecutive growing seasons (April 15 to October 1), or longer if the seeding is not well established at the end of two years. If shrubs are included in the planting, their successful establishment should be used as the criteria for grazing deferment.

A planned grazing system that follows FOTG, Section IV, Practice Standards and Specifications, Prescribed Grazing (Code 528) will be applied immediately to the planted areas after the establishment deferment period is over.

During the two-year establishment period, excessive amounts of competitive weeds will be controlled by applying labeled herbicides or by clipping. Control weeds that compete with seedlings for sunlight and/or moisture during the growing season of the species planted and initiate clipping when weeds reach a height of six to eight inches. Clipping will be done before weed seed development, or prior to significant soil moisture competition. Heavy weed infestations should be clipped and removed from the site, while lighter stands can be spread uniformly across the planting site.

Herbicides must be applied very carefully to avoid injuring new seedlings. Apply herbicides according to label instructions. See FOTG, Section IV, Practice Standards and Specifications, Pest Management (Code 595), and *Montana, Utah, Wyoming Weed Management Handbook* for herbicide recommendations.

Practically all dryland pastures in Montana are seeded to cool-season species, and most management problems are related to the growth patterns of these species. In general, cool-season grasses make their initial growth in early spring and reach maturity in July, depending upon species and climate. To gain maximum forage use of these grasses it is desirable to pasture them during this period. Exceptions to this would be later-maturing warm-season grasses or those which remain palatable through midsummer or fall.

A. MANAGEMENT OF THE SINGLE SPECIES PASTURES

The best time for utilization of single species pastures is during the period when palatability and growth are at their maximum. To maintain production, pasturing should begin in the spring when new foliage is four to six inches tall. Animal numbers should be adjusted so the grass will be allowed to grow and not be over-grazed. Some grasses such as crested wheatgrass and Russian wildrye can be more closely grazed than other species without loss of the stand, but too early and too severe use will decrease the vigor of any grass.

Introduced grasses usually reach their peak of production in about four to six years while natives will maintain vigor and productivity over a longer period. Therefore, introduced species should be grazed closer the first few years for maximum livestock production. Careful management based on an understanding of the growth habits of introduced grasses can extend the productive period of a stand. Proper grazing levels and occasional rest periods to allow recovery of vigor are required to sustain productive stands.

Single species stands are easier to manage than mixtures, especially in rotational grazing systems. Each species can be grazed during its period of maximum productivity and palatability.

B. MANAGEMENT OF MIXTURES

Mixtures of grasses and legumes usually yield more than a mixture of grasses or a single species grass planting. The nutritional values of grasses and legumes are higher than those of a single grass or mixture of grasses. A mixture of grasses having different growth habits gives more varied forage throughout the season. Differences in livestock preferences for the species in a mixture may cause uneven grazing. Species composition in a mixture may change because the preferred species become weak from overgrazing and are replaced by less palatable species. The management of mixed grasses should be keyed to the use made of the preferred species.

Alfalfa, sweet clover, or other legumes planted in mixtures with grasses provide nitrogen to sustain and increase yield and nutritive values of the entire mixture. However, it sometimes is difficult to keep legumes in the mixture because of their high palatability. Also, legumes may be removed by drought, winterkill, diseases, parasites, or inappropriate or over use of herbicide applications.

To reduce the hazard of bloat, alfalfa should be maintained at not more than one-third of the total composition. Any mixture containing a bloating legume should be pastured early, before the legume becomes a major part of the forage. Bloat usually is most likely during the first two or three years of a stand except in higher rainfall areas, where the danger period may be extended. As stands mature, the legume becomes less abundant in the composition and thus, less likely to produce bloat.

C. PASTURE RENOVATION AND MANAGEMENT OF OLD STANDS

Pastures of introduced grasses without legumes generally show marked reductions in yield the third or fourth year after establishment. The reduction frequently is caused by a lack of available nitrogen. Yields often can be increased somewhat by tearing up the pasture sod, but the beneficial effects of this practice usually are short-lived. Seeding alfalfa into old stands of crested wheatgrass that are fairly open sometimes has been helpful. Applications of commercial fertilizers often boost yields sharply (except in dry years, where no yield advantages may be expected). To maintain any yield increased through fertilization applications will have to be made every year or two. Soil test results are recommended to base fertilizer application rates. Nitrogen fertilizer tends to favor grasses while phosphorus favors the legumes. A balanced fertility program will maintain a grass-legume composition.

One of the best ways to maintain continuous high production of improved pastures is through a crop-rotational system. When pasture production begins to fall off the pasture is broken and cropped for several years, then re-seeded to grass. Old, low-producing stands can be broken and fallowed for a year and then re-seeded. This method may not be practical on marginal lands or areas subject to accelerated erosion.

D. GENERAL MANAGEMENT OF SEEDED PASTURES

The most efficient and economical method of utilizing seeded and native pastures is to manage them in combination. This will provide an extended grazing season and give maximum production on both areas. The use of seeded pastures in early spring allows the native range to develop to grazing readiness without the stress of grazing. Further benefits of this kind of management and a discussion of techniques and systems are found in the FOTG Section IV, Forage Integration.

RANGE SEEDINGS

Proper management of range seedings depends first upon deferment of grazing until the stand is fully established and then stocking it at proper levels during the season of use best adapted to the seeded species. Native species often exhibit delayed germination and seed dormancy, and when this is coupled with fluctuating weather conditions during the establishment period deferred grazing for two or three complete growing seasons is usually necessary. On National Forest ranges there usually is a required three years deferment for protection of any areas plowed and seeded. Exceptions are made if the project is included in a management system providing later rest and/or deferment. Range interseeding or other practices, which do not completely destroy the pre-existing cover, may be ready for grazing at the end of the second growing season. Deferment or light use during this critical period is essential to stand establishment since it allows seedlings to become vigorous mature plants. Grazing may be controlled by fencing; when fencing is impossible management of seedings becomes considerably more difficult.

In planning grazing management for re-seeded ranges we must recognize these lands have, in most cases, been re-planted because the original native vegetation was destroyed through improper grazing practices. It is important suitable management practices be developed that prevent depletion of the re-seeded forage stand.

The management of re-seeded ranges differs in one respect from other range lands. The objective is to maintain the seeded species and discourage natural plant succession that would bring an increase of less desirable native species. On native ranges the objective of management is to encourage increase of the

more desirable native species through natural succession. In other respects, the basic principles of good grazing management are equally applicable. Conservative stocking use promotes sustained high yield of forage stands as well as high animal productivity, lower maintenance costs and animal death losses, and usually higher net income.

Grazing must be controlled to obtain proper use of the established stand. Also, many seeded areas may support remnants of native vegetation on non-seeded areas of rough topography. The native range areas or invader species in the stand may be only lightly used when the seeded species are fully grazed. In such case management must be based on the seeded species alone. In some situations the seeded species becomes less palatable as the season progresses and the use shifts to the native vegetation. It is extremely difficult to balance and manage rangeland for dual use.

The optimum season of use for seeded stands depends on the species planted. Introduced species are usually planted in pure stands and fenced for controlled use during a specific season which best fits their growth and development, nutritional value, and palatability. On the other hand, seedings of native species often are tolerant of season-long grazing if not stocked too heavily. However, native seedings have also been deferred for use at specific seasons with considerable success.

REFERENCES

Holzworth, L.K., Wiesner, L.E., and Bowman, H.F. Grass and Legume Seed Production in Montana and Wyoming. Special Report No. 12. Revised 1990. 31 Pgs.

Montana State University, Extension Service. Montana Interagency Plant Materials Handbook for Forage Production, Conservation, Reclamation, and Wildlife. EB 69. June 1990. Pgs. 175-185.

USDA, Natural Resources Conservation Service. Idaho Plant Materials Center. Pasture and Range Seedings, Planning-Installation-Evaluation Technical Note 10 (Rev.) Jan. 2006.

USDA, Natural Resources Conservation Service. Montana Field Office Technical Guide (FOTG), Montana Conservation Practice Specifications, Pasture and Hay Planting (Code 512) and Range Planting (Code 550).

Weed Control Handbook 2006-2007 Montana, Utah and Wyoming. Cooperative Extension Service Publications, Bozeman, Montana 59717. 265 Pgs.