Seed Metering and Placement Devices for Rangeland Seeder

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ABSTRACT

VARIATION in the seeding rate when metering fluffy grass seed is a problem that was largely overcome by a semi-circular seedbox, auger agitator and pickerwheel. This device reduced the percentage change in seeding rates by 84 percentage points compared to a standard grass seeding mechanism in static seedbox tests. The experimental metering mechanism functioned well in a specially designed rangeland seeder and the flexing, runner openers operated without undue breakage from stumps and large logs. Seedbeds prepared by discing were consistantly better than other methods tested.

THE PROBLEM

Mesquite (*Prosopis glandulosa* Torr. var. *glandulosa*), an undesirable "brush" species, infests 22.7 million ha (56 million acres) of Texas rangeland and decreases rangeland productivity in addition to hampering the handling of livestock (Fisher et al., 1973a). Root plowing and reseeding depleted rangeland has been used successfully on potentially productive sites (Fisher et al., 1959 and 1973b). Presently, 15 to 25 percent of the brushland holds promise for reseeding.

Supplying a uniform amount of grass seed to the seedbed for sustained periods of time on rough, thorn-infested, log-littered, root-plowed rangeland has presented numerous problems for reseeding equipment (Fig. 1). Since most current rangeland drills require extensive land clearing procedures at costs which often may exceed the potential of the land, research was undertaken to develop a suitable seeder for rough, root-plowed rangeland.

Article was submitted for publication in October 1978; reviewed and approved for publication by the Power and Machinery Division of ASAE in January 1979. Presented as ASAE Paper No. 76-1571.

Approved as a Technical Article TA 13076 from the Texas Agricultural Experiment Station.

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Acknowledgements: The authors are appreciative for the excellent cooperation and financial support provided in part by the Brush Control and Range Improvement Association, Abilene; Pitchfork Land and Cattle Co., Guthrie; Gene Whitehead Ranch, Menard; Lorin McDowell Ranch, Big Spring; W. T. Waggoner Estate, Vernon; Clayton Williams Ranch, Alpine; George Warner Seed Co., Hereford; Post Contractors, Post; Malcom Otto, Conservation Contractor, Llano; Montey Munsell, Conservation Contractor, Mason; Guy Goen, Conservation Contractor, Spur; Clay Caldwell, E. L. Caldwell and Sons, Inc., Corpus Christi; Soil Conservation Service; Texas Agricultural Extension Service; and Darwin Paden, V. E. Jones and G. G. Schulz, Texas Agricultural Experiment Station, who assisted in the research.

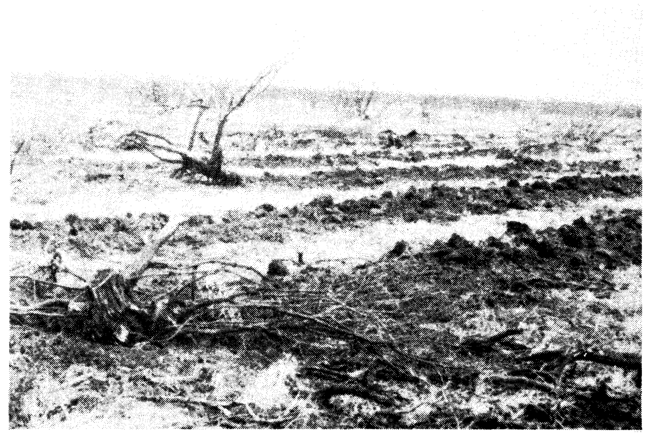

FIG. 1 Rough, thorn-infested, log-littered rangeland root plowed for control of mesquite which requires special equipment and techniques for surface seeding.

PREVIOUS WORK

Early research with root plowing for brush control and reseeding for improvement of depleted rangeland was directed toward the benefits for revegetation (Allison and Rechenthin, 1956; Carter, 1958; Fisher et al., 1959; and Jaynes et al., 1968). Their results showed that root plowing was most successful and profitable on badly depleted range sites that had deep, fertile soils which received ample rainfall to justify the cost of plowing and establishing highly productive native and introduced grasses. Seeding equipment was generally "home made", and many grass establishment failures were attributed to severe weed infestation which followed poor seed distribution, erratic seeding rates and malfunction of the seeding equipment (Fisher, 1970). The most successful seedings followed extensive land preparation including root raking twice then seeding with cropland-type drills. This technique was practical on sites suitable for crop production but not on marginal cropland or rangeland.

A standard Nesbit grass drill (Fig. 2); a brush drill developed by the Agricultural Research Service, USDA, in New Mexico; a Nesbit drill mounted on loose-ring cultipacker; and an exhaust broadcast seeder mounted on a crawler tractor were evaluated in 1969 on seedbeds prepared by discing or roller chopping following root plowing by Brock et al. (1970). They found that the cultipacker-seeder and the roller chopper in combination with the exhaust seeder was the only seeding equipment that could be used without constant breakdown due to the presence of mesquite debris. Seeding with the exhaust seeder was unsatisfactory in most cases because of poor seed distribution. Modifications of the Nesbit drill conducted in 1970 by Wiedemann and Brock included structural improvement, removing all furrow-

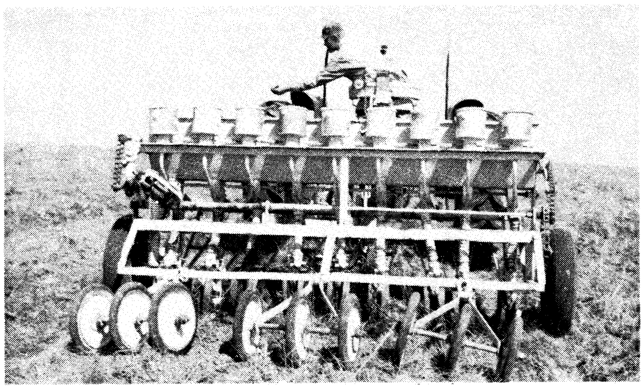

FIG. 2 Standard Nesbit grass drill for rangeland reseeding.

opening devices and use of high-ply truck tires. Mechanical operation of the modified seeder was satisfactory; however, seed metering was still erratic (Wiedemann, 1975; Wiedemann and Brock, 1975). Rate variation occurred in field studies when different amounts of seed were placed in the hopper. In addition, seed bridged around the pickerwheel causing rate variation and several species of extra fluffy grass seed stopped seeding when seedboxes were relatively full.

During the 1960's similar, erratic seeding of fluffy grass seed was experienced by Dudley (1965) with the Agricultural Research Service, USDA at Bushland, TX. To overcome this problem, he constructed a seedbox with a circular bottom in an attempt to prevent seed bridging around the pickerwheel by rotating all seed in the hopper. Field observations appeared promising.

PRELIMINARY DESIGN EXPERIMENTS

Procedure

Seeding mechanisms were designed to reduce seed bridging at the pickerwheel and reduce the effects of uneven seed fluffiness (bulk density) caused in part by the amount of seed packed into the hopper. Mechanism selections were based on the seeding rate uniformity of at least four different levels of seed in the hopper including 100, 75, 50 and 25 percent of full capacity. The percentages of full capacity were determined by the seed weight at full capacity. Seeding rate tests were terminated when seed metering failed, and then the remaining seed in the hopper were weighed. All tests were conducted with commercial El Reno sideoats grama (*Bouteloua curtipendula* (Michx.) Torr.) unless otherwise stated. Other grass used were caucasian bluestem (*Andropogon caucasicus* Trin.) and little bluestem (*Andropogon scoparius* Michx.). The standard, a commercial seeding mechanism, was evaluated under the same laboratory conditions as the experimental units.

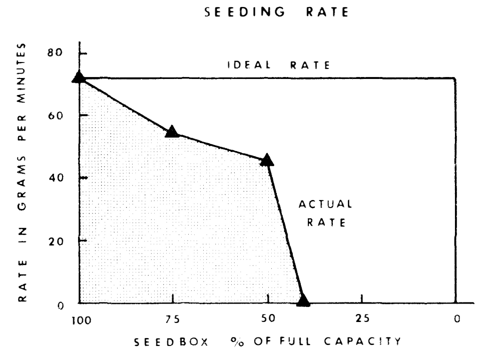

FIG. 3 Seeding rates for standard rangeland seeder at various seed levels in seedbox compared to ideal rate.

Standard Rangeland Drill Seeding Rates

A standard Nesbit rangeland drill was selected for seeding rate investigations at various depths of seed in the seedbox (Fig. 2). This drill used a 12-tooth, 6.35-mm (1/4-in.) thick, 12.7-cm (5-in.) diameter pickerwheel to dispense large fluffy seed such as sideoats grama. A pickerwheel speed of 30 rpm was selected as an average of numerous field settings. Seedbox depths of 100, 75, 50 and 25 percent of full capacity were based on a full hopper of seed weighing 2000 g.

Under static conditions, a 99 percent seeding rate reduction was experienced before 75 percent of the seed was dispensed. Fig. 3 shows the actual rates as related to the ideal rate.

Experimental Seed Metering Device

Semi-circular Seedbox: A semi-circular seedbox with a 30.5-cm (12-in.) diameter was constructed with a horizontal agitator which rotated all seed within the hopper to eliminate grass seed bridging effects (Fig. 4). A 12.7-cm (5-in.) diameter seed pickerwheel was installed through the bottom of the hopper to meter seed. Initial observation of seed metering action appeared highly promising and investigations are explained by components. The seedbox held 4000 g sideoats, 5000 g caucasian bluestem, and 1800 g little bluestem.

Pickerwheel Design: Pickerwheels patterned after the Nesbit 12-tooth picker were constructed in widths of 6.4, 12.7, 25.4, 50.8 and 101.6 mm (1/4, 1/2, 1, 2, and 4 in.), and tested at speeds of 25 to 200 rpm (Fig. 5). Exceptionally high seeding rates were obtainable with the wide pickerwheels in the semi-circular seedbox. It was noted, however, that the 12.7-mm (1/2-in.) pickerwheel developed similar seeding rates to the 6.4-mm (1/4-in.) pickerwheel at approximately one-half the speed. The 12.7-mm (1/2-in.) pickerwheel was selected for further evaluation since it was felt that the slower

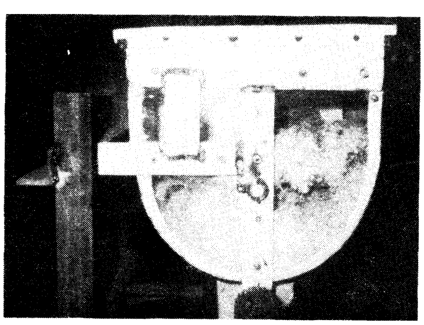

FIG. 4 Semi-circular seedbox with agitator to rotate seed in hopper; thereby, preventing the bridging of grass seed at pickerwheel.

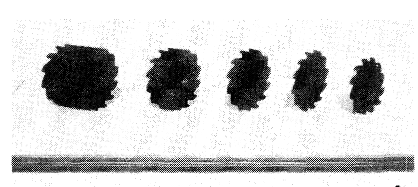

FIG. 5 Pickerwheels 6.4, 12.7, 25.4, 50.8 and 101.6 mm (1/4, 1/2, 1, 2, and 4 in.) in width evaluated in semi-circular seedbox.

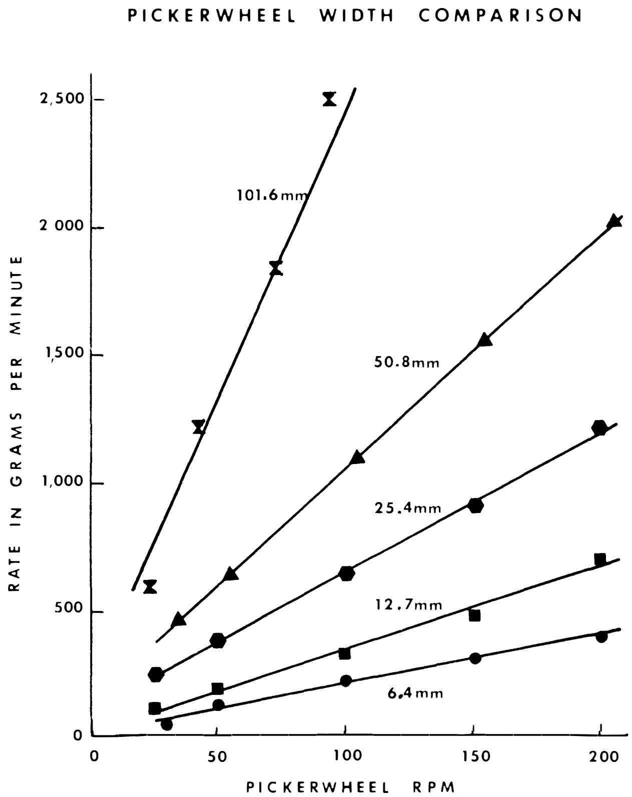

FIG. 6 Seeding rates for five different width pickerwheels evaluated in semi-circular seedbox. Regression equations are:

6.4 mm	$\hat{y} = 11.61 + 1.93X$	$r = 0.99$
12.7 mm	$\hat{y} = 15.79 + 3.23X$	$r = 0.99$
25.4 mm	$\hat{y} = 97.12 + 5.47X$	$r = 0.99$
50.8 mm	$\hat{y} = 134.68 + 9.12X$	$r = 0.99$
101.6 mm	$\hat{y} = 201.67 + 22.16X$	$r = 0.98$

speed would reduce chances of seed bridging around the pickerwheel. Data are shown in Fig. 6.

A 12.7-mm (1/2-in.) wide pickerwheel with eight teeth and similar design was compared to the aforementioned 12.7-mm (12.7-in.) wide pickerwheel at

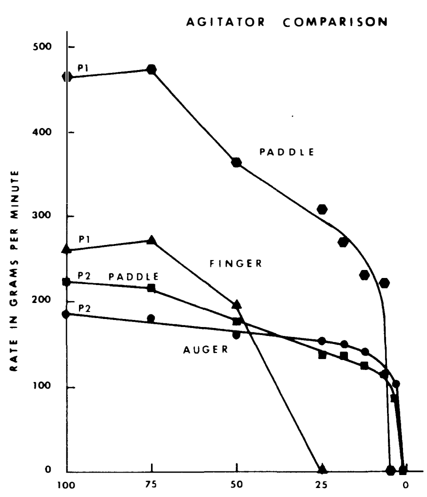

FIG. 8 Seeding rates for finger, paddle and auger agitators with the auger unit developing the most uniform seeding rate in the semi-circular seedbox. Test conducted with 25.4-mm (1-in.) and 12.7-mm (1/2-in.) pickerwheels labeled P1 and P2, respectively, operating at 30 rpm and each agitator operating at 15 rpm.

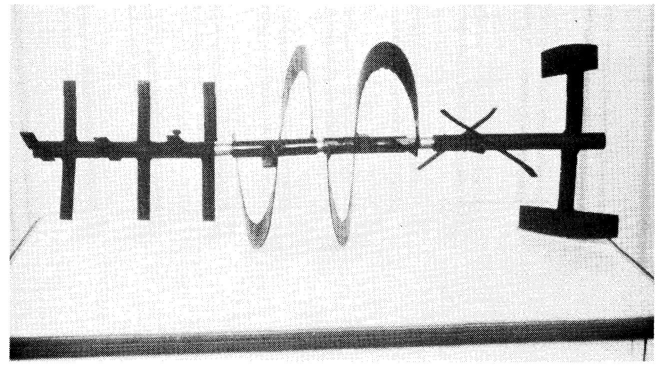

FIG. 7 Agitators evaluated in semi-circular seedbox from left to right, finger, auger and paddle styles.

speeds of 10 and 30 rpm and 100, 75, 50 and 25 percent of full seedbox capacity. The 12-tooth pickerwheel, with 50 percent more teeth than the 8-tooth picker, increased the seeding rate by an average of only 30 percent. The 8-tooth pickerwheel was selected for the seeder.

Agitator Design: Agitators in the standard Nesbit drill were mounted on a horizontal shaft above the pickerwheel and consisted on a set of two fingers rotating on either side of the pickerwheel. Fingers were constructed from 2.3 x 12.7-mm (1/8 x 1/2-in.) steel strap and were approximately 10 cm (4 in.) long. They rotated at one-half the speed of the pickerwheel.

Three agitators were constructed for the semi-circular seedbox consisting of finger, paddle and auger styles (Fig. 7). The auger agitator resulted in a more uniform seeding rate at the various depths of seed in the seedbox (Fig. 8).

Agitator speeds were compared at agitator to pickerwheel speed ratios of 1:2, 1:3, 1:4 and 1:5. At pickerwheel speeds of 10, 25, and 50 rpm the 1:2 resulted in the highest seeding rate while 1:5 gave the lowest rate. The 60 percent reduction in auger agitator speed (1:2 versus 1:5 ratios) reduced the seeding rate an average of only 10.2 and 12.4 percent for pickerwheel speeds of 30 and 10 rpm, respectively, at 100, 75, 50 and 25 percent of full seedbox capacities. The 1:2 ratio was utilized in all other experiments unless otherwise stated to maintain the highest seeding rate.

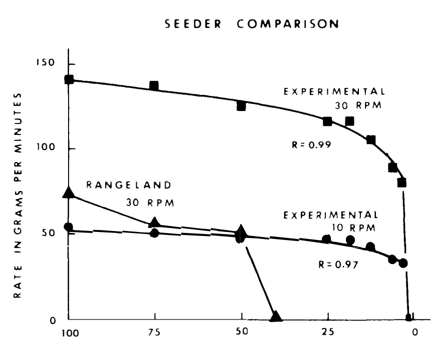

FIG. 9 Comparison of uniform seeding rates of the semi-circular seedbox, auger agitator and 12.7-mm (1/2-in.) wide, 8-tooth pickerwheel (experimental metering device) to the non-uniform rates of the standard rangeland seed metering device. Experimental unit prediction equations are:

10 rpm $\hat{y} = 26.39 + 12.82 \log X$

30 rpm $\hat{y} = 59.44 + 40.57 \log X$

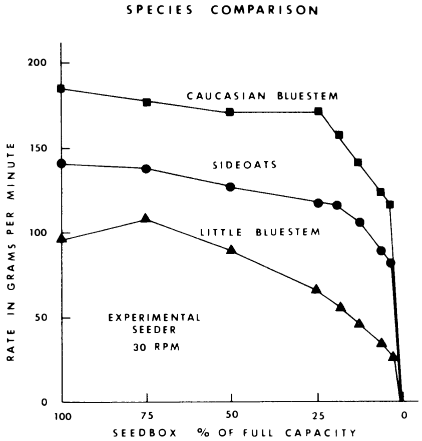

FIG. 10 Comparison of seeding rates for caucasian bluestem and little bluestem to sideoats grama (the standard grass seed for experiments) dispensed by the experimental metering device.

FIG. 11 Experimental rangeland seeder with semi-circular seedbox and auger agitator system plus flexing, runner openers for seed placement on log-littered surfaces. Unit operated without undue mechanical breakage on seedbed prepared by anchor chaining following root plowing of mesquite infested rangeland near Guthrie, Texas.

Combinations

Operation of the semi-circular seedbox using the auger agitator and the 12.7-mm (1/2-in.) wide, 8-tooth pickerwheel at speeds of 10 and 30 rpm resulted in very uniform seeding rates (Fig. 9). The experimental metering device gave a seeding rate decrease of only 15 percent while dispensing 75 percent of the seed from the hopper at 10 rpm (a comparable seeding rate to the standard drill 30 rpm test) and easily metered 97 percent of seed from hopper.

Vertical extension of the semi-circular seedbox to accommodate 200 percent of capacity (8000 g) did not change the uniformity of the seeding rates shown in Fig. 9. The increase in weight from 100 to 200 percent of full capacity increased the seeding rate by only 7.3 and 8.7 percent for 10 and 30 rpm pickerwheel speeds, respectively, based on the regression equations. The uniform agitation of the seed by the auger near the pickerwheel appears to be the reason for the uniform seeding rate even when additional seed weight was placed above the auger.

The exponential curve developed by regression analysis from actual data points for $3 \leqslant X \leqslant 200$ when X equal the amount of seed as a percentage of a full seedbox, was selected to describe the change in seeding rates. The correlation coefficient for this curve was higher than the curve developed for $3 \leqslant X \leqslant 100$. The regression coefficients for both $3 \leqslant X \leqslant 100$ and $3 \leqslant X \leqslant 200$ equations were not significantly different at the 0.1 percent level for both pickerwheel speeds.

Further investigations were conducted utilizing caucasian bluestem and little bluestem both of which are noted for poor seed metering because of which are noted for poor seed metering because of their extra fluffy characteristics. Seeding rates were not as uniform as sideoats grama (Fig. 10), but seed was easily metered and 97 percent of the seed was dispensed in each case. Rates for the fluffier seed metered from the experimental unit were more desirable than sideoats grama metered from the standard drill.

EXPERIMENTAL RANGELAND SEEDER

Seed Metering Devices

A semi-circular seedbox was constructed from 30.6-cm I.D. (12-in.) steel pipe utilizing the fluffy grass seed metering system outlined under the experimental seed metering device. The 1.83-m (6-ft) long seedbox with six pickerwheels on 30 cm (12 in.) centers was mounted on a heavy-duty, 76 x 6.4-mm (3 x 1/4-in.) square steel tubing, frame with 41 cm (16 in.) of ground clearance and 8-ply truck tires (Fig. 11). Based on the minimal effect from changes in agitator speed, the auger agitator was driven directly from the drive wheel rather than the pickerwheel shaft. This reduced the strain on the seed metering power train. Small slick grass seed were metered from six Planet Junior seeding devices mounted on the rear of the semi-circular seedbox. The Planet Junior mechanism was standard on the Nesbit Drill and has been used for many years on rangeland seeders.

Seed Placement Device

A flexing, runner opener was designed to place the seed in the seedbed without undue breakage from stumps and logs up to 30-cm (12-in.) diameters (Fig. 11). The runner opener, 5.1 x 7.6-cm (2 x 3-in.) rectangular steel tubing mounted at a 45-deg angle, also served as the seed tube. A V-shape wedge welded to the opener at the seed discharge point formed the desired furrow to trap the seed (Wiedemann, 1971). Weight attached to the opener determined operating depth. Lifting of the six, independently-mounted, flexing openers and termination of seed dispensing was controlled with a single hydraulic cylinder. Openers were attached with bolts for easy removal to compare broadcast and drill seeding.

Safety Considerations

A platform was constructed on the front portion of the seeder frame to provide a safe boarding of the seeder for seedbox inspection and loading. The seeder was designed with the center-of-gravity ahead of the wheels to prevent an accidental overturn when not attached to tractor because of a full seedbox and personnel working on the seedbox.

FIELD TESTING

Reseeding following root plowing of mesquite infested rangeland at eight ranch locations in the Rolling Plains of Texas over a 5-yr period under a broad range of rainfall, soil type, seedbeds, grass species and seeding rates was conducted. The number of surviving seedlings for all seeded species after the first growing season were compared. Additional information concerning these experiments is covered by Wiedemann and Brock (1975) and Wiedemann et al. (1978).

The experimental rangeland seeder metered fluffy grass seed and withstood the rigors of rough, log-littered, root-plowed rangeland exceptionally well in repeated tests over the entire period. Early seedings with slick seed metered from the Planet Junior device resulted in uneven rates caused in part by plugging of the small metering hole. Grass seed, by its nature, is often trashy, non-uniform in size and uneven in shape which aggravates seed metering through an orifice. Six John Deere double-run, internal cupfeed seeding mechanisms (part number AN 161321) were installed on the seeder for slick grass seed metering. This modification has worked very well on all later seeding. Mixtures of slick and fluffy seed do not meter uniformly and plantings were totally unsatisfactory. Consequently, separate metering mechanisms are necessary for both seed types.

Planting with the experimental seeder increased seed densities 107 percent compared to aerial seding in nine tests over a 5 yr period (6.35 versus 13.13 plants/m^2, significant at 1 percent level of probability, Table 1). Use of the flexing runner openers on the experimental seeder increased seedling density by 17 percent compared to the use of no openers (11.73 versus 13.67 plants/m^2, significant at 10 percent level of probability) in five tests over a 3 yr period.

Anchor chaining, roller chopping and discing are commercial, lost-cost techniques for seedbed preparation and land smoothing on log-littered root-plowed rangeland (Fisher et al., 1973b). Soil disturbance and cost is minimum for chaining, $7.41 to $14.83/ha ($3 to $6/acre); moderate for chopping, $24.71 to $37.01/ha ($10 to $15/acre), and maximum for discing $37.01 to $49.42/ha ($15 to $20/acre). Whenever brush raking is required to remove excessive amounts of timber, cost is increased by $61.75/ha ($25/acre). Due to vast differences in the amount of brush debris present between locations, the ability of equipment to operate over logs and availability of equipment, equal numbers of comparisons between seedbed types using aerial and/or drill seeding methods were not feasible.

The maximum number of comparable seedbeds was used with aerial seeding. Average plant/m^2 densities from four sites during 2 yr were 4.74 for anchor chaining, 5.17 for roller chopping, and 6.78 for discing. Discing was significantly better than chopping or chaining and there was no statistical difference in the latter two at the 5 percent level of probability. Although the drill seedings were not as complete in numbers of seedbed comparisons, the average plant/m^2 densities of 10.01 for chaining (2 tests), 10.23 for chopping (2 tests) and 14.10 for discing (5 tests), we feel, support the hypothesis that discing is significantly better than chopping or chaining. Packing of disced seedbeds before seeding with a roller weighing 967 kg/m (650 lb/ft) increased the plant/m^2 densities by 5 percent which was not significantly different.

The experimental seeder tends to overcome many of the inadequacies of seedbeds compared to aerial seeding as noted by seeding into a freshly disced seedbed near Menard, 9.67 compared to 20.66 plant/m^2 for aerial versus drill, as opposed to disced seedbed near Vernon which had received heavy rainfall prior to seeding, 1.51 compared to 17.33 plants/m^2 for aerial versus drill. The special furrow openers tend to overcome seedbed deficiencies also; however, successful seedings near Guthrie with the drill pulled directly behind the disc (18.95 versus 18.62 plant/m^2 for no openers and openers, respectively) indicates that it would be feasible to attach the seeder on the disc for an integral discing-seeding operation.

TABLE 1. RESULTS OF RANGELAND SEEDING ON LOG-LITTERED SURFACES

Treatment	No. of tests	Grass plants per* m^2	(ft.^{2})	Statistical difference
Seeding method				
aerial	9	6.35	(0.59)	—
experiment seeder	9	13.13	(1.22)	yes @ 1%
Seed furrow openers				
no openers	5	11.73	(1.09)	—
flexing openers	5	13.67	(1.27)	yes @ 10%
Seedbed preparation-aerial seeding				
chaining	4	4.74	(0.44)	none
roller chopping	4	5.17	(0.48)	none
discing	4	6.78	(0.63)	yes @ 5%
Seeding preparation-drill seeding				
chaining	2	10.01	(0.91)	not tested
roller chopping	2	10.23	(0.93)	
discing	5	14.10	(1.31)	
Packing disced seedbed				
no packing	4	12.49	(1.16)	—
packing	4	13.13	(1.22)	none

*Surviving grass seedlings following first growing season.

Experience gained over the 5 yr period suggests that the experimental seeder can operate on chained, roller chopped or disced seedbeds but the determining factor is the amount and size of brush debris littering the area following seedbed preparation. Operation for sustained periods was possible over sparse amounts of logs and stumps up to 30-cm (12-in.) diameters or sparse to moderate amounts of much smaller brush debris. Greater amounts of brush debris would require brush raking before surface seeding could be conducted. Commercial drills would have been incapable of successful operation on these log-littered sites.

CONCLUSIONS

The semi-circular seedbox with an auger agitator provided the most uniform seeding rates—a 15 percent rate decrease while dispensing 75 percent of the seed from the hopper as compared to a 99 percent rate decrease while attempting to dispense an equal seedbox capacity from the standard rangeland drill. Flexing, runner openers provided a method of preparing and placing seed in a seed furrow without undue mechanical breakage from traveling over logs or stumps up to 30-cm (12-in.) diameters. Seedling densities were 107 percent greater for plantings with the experimental seeder compared to aerial seeding, and discing was consistently better than chaining or roller chopping for seedbed preparation.

The experimental rangeland seeder offers a method of seeding rangeland where sparse to moderate brush debris is present following root plowing and low-cost smoothing for seedbed preparation has been conducted.

Moreover, the minimal land clearing required by this seeder increases the potential for improving brush infested rangeland by root plowing and reseeding with improved grasses.

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