Brush Eradicating, Basin Pitting, and Seeding Machine for Arid to Semiarid Rangeland

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Highlight: *A range seeding machine that increased the chances of successful seedling establishment on arid to semiarid rangeland has been designed and tested on 23 plots in southern New Mexico. Working behind a standard rootplow, the machine picks up brush, forms basin pits, firms the soil, plants seed, and replaces the brush over the planted area as a mulch. Laboratory and field research was used to demonstrate improved soil conditions for seedling emergence under such a brush mulch. Water retention by basin pits was found to be necessary to decrease runoff of the high intensity, short duration storms typical to this area. About 50% of the plots planted with this equipment were successfully seeded.*

Several million acres of once productive rangeland in arid and semiarid areas have been invaded by noxious shrubs such as creosotebush (*Larrea tridentata*) and tarbush (*Flourensia cernua*). These shrubs produce neither useful forage for livestock or wildlife nor adequate ground cover to prevent soil erosion. On many sites dominated by such shrubs, the soil is capable of useful forage production and the sustenance of sufficient ground cover to limit soil erosion if desirable species are established.

The objective of the study reported here was to modify existing equipment or to design new equipment that would accomplish the following in a single pass over the land: (1) eradicate undesirable shrubs, (2) provide a firm seedbed, (3) plant seed, and (4) windrow the dead brush over the seeded strip to shade the ground, improving conditions for seedling emergence.

Both tarbush and creosotebush can be eradicated by rootplowing. The only plants that survive this drastic treatment are those missed in a failure to overlap properly. Seedlings of these species do not appear to be a problem on large rootplowed areas having no seed source nearby. Rootplowing equipment is commercially available, and, although expensive to operate, it effectively eradicates heavy brush stands. Areas with some useful vegetation should not be rootplowed because the process often kills all vegetation.

Previous efforts to establish useful plant species by seeding after the elimination of brush stands have given erratic results, generally unsuccessful. Rootplowing leaves the soil loose and fluffy, in poor seedbed condition. The only reliable precipitation occurs in the form of summer showers in extreme west Texas, southern New Mexico, and southeastern Arizona. The small seeds of species adapted to this area dictate a planting depth of one-fourth to one-half inch. High summer temperatures and the low water holding capacity of rootplowed soil cause unfavorable conditions for seedling growth.

Microclimate Study

Some microclimatic data, collected on the Jornada Experimental Range in

Table 1. Mid-day temperatures (°F) of soil with no surface cover and under a light brush cover, Jornada Experimental Range.

	Date									
Depth and cover	7/2	7/16	7/20	7/27	8/6	8/10	8/17	8/24	8/31	9/18
1/2-inch depth										
No surface cover	120	121	120	119	126	130	125	129	130	117
Brush cover	102	105	92	97	101	103	99	101	103	97
4-inch depth										
No surface cover	97	95	101	95	101	103	99	99	101	96
Brush cover	83	82	81	82	83	91	89	88	85	84

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The research is a result of cooperative investigation of Agr. Res. Serv., U. S. Dep. Agr. and the Agr. Experiment Station, New Mexico State University, Las Cruces. (Journal Article 417, Agr. Exp. Sta., New Mexico State University, Las Cruces.)

Manuscript received June 2, 1972.

south-central New Mexico, indicated the necessity of modifying the micro-environment for seedling establishment (Table 1). On selected dates, mid-day soil temperatures at the 1/2-inch depth without surface cover ranged from 117 to 130°F. With a light brush cover, they ranged from 92 to 105°F which was 16 to 28°F lower. Even at the 4-inch depth, the soil temperatures were 10 to 20°F lower under brush cover.

A light-chamber study elucidated the effects of soil temperatures observed under field conditions on emergence and initial growth of 12 grass species and fourwing saltbush (Sosebee and Herbel, 1969). We provided two maximum daily temperatures, 103 and 128°F, at the 1/2-inch depth, and the soil moisture was maintained at field capacity by watering daily. Under the high temperature regime, survival of 11 species was reduced, and all species had stopped growing or were growing very slowly at the close of the 21-day trial. Under the lower temperatures, all species grew normally. In a similar study of 21 days with various moisture levels, it took about 2.8 inches of water for survival in the low temperature regime and 9.1 inches for survival in the high regime (Herbel and Sosebee, 1969).

In field trials, a fine sandy loam site infested with tarbush and a gravelly sandy loam site infested with creosotebush were rootplowed. During an 82-day summer period, 5.8 inches and 4.8 inches of precipitation were recorded at the respective sites. Soil moisture was recorded by the electrical resistance method with fiberglass soil moisture units. Moisture potential at the 1/2-inch depth on the sandy loam site was between 0 and −15 bars for 5 days on the area with no surface cover and 42 days on the area with brush cover. Moisture potential at the 1/2-inch depth on the gravelly site was between 0 and −15 bars for 23 days on the area without surface cover and 40 days on the area with brush cover (Herbel, 1972).

Fig. 1. *First model of overhead conveyor being pulled behind a D-7 tractor and a rootplow.*

In another trial, basin pits were constructed by lowering one end of a road grader blade about 6 inches deep, then raising it as the grader moved forward, making basins about 6 ft long. The site had a fine sandy loam soil infested with tarbush. Soil moisture was recorded at the 1/2-inch and 2-inch depths, 6 and 36 inches from the bottom of the basins and on an adjacent flat area. A light brush cover and no surface cover were compared in the pits. During a 55-day summer period, 2.5 inches of rainfall was recorded. There were more days when the moisture potential was between 0 and −15 bars in the pit than in the adjacent flat area (Table 2). Except at the 2-inch depth, 36 inches from the bottom of the pit, there were more days with available soil moisture under the brush cover than where there was no surface cover.

These data show that if uprooted vegetation can be placed over seeded rangeland, more favorable moisture and temperature conditions will be provided for germination and emergence.

Table 2. Number of days that four levels of soil moisture tension were observed at selected depths in basin pits and in an adjacent flat area during a 55-day period on fine sandy loam soil, Jornada Experimental Range.

Location, depth, and cover	Soil moisture tension			
	0-1 bars	1-15 bars	15-24 bars	> 24 bars
6-inch from bottom of basin pits				
1/2-inch depth, no cover	6	17	9	13
1/2-inch depth, brush cover	10	13	6	26
2-inch depth, no cover	7	33	15	0
2-inch depth, brush cover	13	34	8	0
36-inch from bottom of basin pits				
1/2-inch depth, no cover	6	8	7	34
1/2-inch depth, brush cover	7	13	4	31
2-inch depth, no cover	7	25	17	6
2-inch depth, brush cover	7	16	15	17
Flat area				
1/2-inch depth, no cover	1	9	3	42
2-inch depth, no cover	6	16	7	26

Machine Development

In 1965, the Agricultural Engineering Department of New Mexico State University was contracted to design equipment for rangeland seeding that would take advantage of this information. Technical assistance and financial support were provided by the Agricultural Engineering Research Division, Agricultural Research Service, U. S. Department of Agriculture.

Equipment available at the Jornada Experimental Range included a Caterpillar D-7 equipped with a bulldozer and an 8-ft rootplow. Range personnel had already designed a planter, fashioned after the Oregon Press Seeder (Hyder et al., 1961), for use on rootplowed soil. The planter consisted of separate seedboxes for chaffy and small seed and a set of four, heavy (350 pounds each) press wheels spaced 1 ft apart, with an outside band 6 inches wide. These press wheels, which were individually suspended, packed the loose soil. A 1-inch angle iron with legs down was formed around and welded to the center of the press wheel band. It made a small "V" notch in the seedbed. The seed was placed in the pressed "V" and covered by drag chains. This seeder, which was operated directly behind the rootplow, merely rolled over rocks, brush, and other plant material. The planter was used in 1966 to seed test plots.

It appeared likely that the seeding operation would be improved by picking up the brush, planting on bare soil, then replacing the brush residue on the planted strip. Having the brush out of the way during seed placement would facilitate packing the soil and covering the seed, both of which are difficult when the press wheel runs over an old plant. The brush plants also tend to retain their shape better when picked up and conveyed over the planter than when run over by the

Fig. 2. *One of two side delivery rake wheels used to windrow the brush for conveyor pickup.*

Fig. 3. *Conveyor flights in the area of brush pickup.*

heavy press wheels.

The overhead conveyor of Figure 1 was fabricated in 1967. The conveyor was towed directly behind the rootplow by a tongue hitched to the left rootplow standard. The conveyor was 4 ft wide. Two side delivery rake wheels (Fig. 2) were used to gather material from the 8-ft rootplow swath. Conveyor flights were spaced about 30 inches along the chain. The conveyor chain was No. 120 roller chain with oversized rollers. The large rollers worked very well to move the chain along guide channels, but the sprockets were less satisfactory than normal roller chain sprockets. They tended to accumulate soil between the teeth and run the chain too tight. Conveyor speed was about 250 ft/minute. At a forward speed of 1 mile/hour, the flights passed the pickup point at the front of the conveyor every 10 to 12 inches of travel. This was satisfactory for large brush plants, but more frequent pickup would be needed for small material.

The conveyor flights (Fig. 3) were constructed of 2 x 1 x 1/8 inch channel with the legs down. The legs were cut away at the ends and a slot was cut in the flat portion of the channel for bolting to chain flight attachments. No satisfactory side attachment link was found from chain manufacturers, so a set had to be fabricated in the shop. Teeth were welded to the trailing leg of the flight. The most successful teeth were hot rolled steel rod, 1/2-inch in diameter and 8 inches long. Both longer and smaller diameter teeth tended to bend too easily. Larger diameter teeth bent the flight when an obstruction was hit. The 1/2 x 8 inch teeth required some straightening, and a short piece of pipe was used for this purpose. Spring teeth would be desirable, but would add considerably to the cost of the machine.

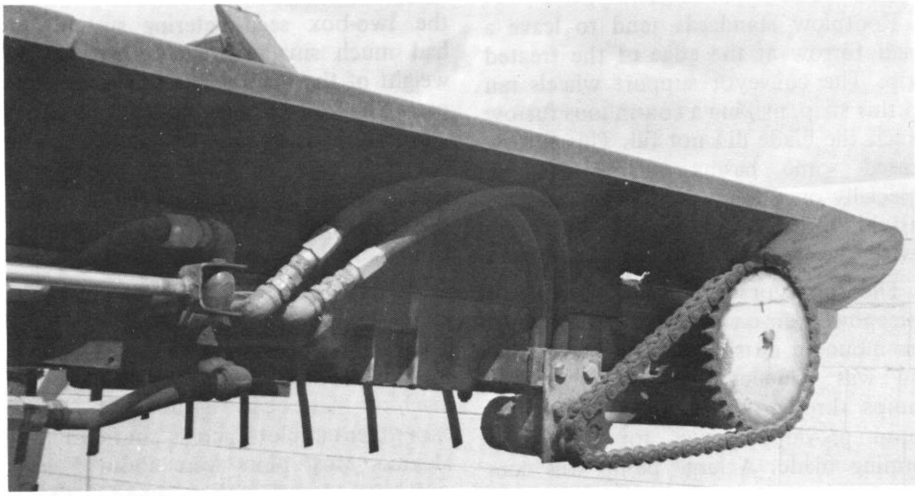

Fig. 4. *Conveyor drive showing hydraulic motor and valve.*

The conveyor was built as a semi-mounted implement. A portion of the weight was supported by the hitch on the rootplow, and the remainder was carried on four 10.00 x 15 low pressure implement tires. These carried the load well but were susceptible to puncture by mesquite thorns. Pneumatic tires are needed for good flotation, but puncture-proofing is a necessity on sites having mesquite.

Observation of the first year's plots led to the conclusion that some form of water ponding was necessary to establish grass seedlings. The best emergence and the most vigorous growth had occurred in low spots. A power-operated blade was installed underneath the conveyor and in front of the seeder to drag up basins as the machine moved forward. The blade was mounted on rigid arms that were raised by a hydraulic cylinder. The cylinder linkage was so designed that it did not pull the blade down into the soil. Blade and linkage arm weights were the only downward forces. The pivot center for the arms was rather high (18 to 24 inches), so the force of soil being pushed by the blade tended to limit the depth of blade operation. A lower pivot point and some depth-limiting wheels or slide might have made more uniform basins.

The blade-lifting cylinder was actuated by a solenoid-operated valve. The solenoid was controlled by two roller cam switches operating by a shaft connected to one of the support wheels with a roller chain. Different shaft sprockets could be installed to adjust basin length. The solenoid valve was excellent for blade control, but the switches gave considerable trouble until two fully enclosed, high quality, cam-operated switches were installed. The hydraulic cylinder was double-acting. Speed of raising and lowering was controlled by cylinder size and pump speed. A small vane-type pump running at about 1000 rpm drove the 1½-inch diameter cylinder at a reasonable speed. Cam lengths were adjusted so that the cylinder reached the end of its stroke in both directions. This resulted in the pumping of some oil through the pressure relief valve each time the cylinder reached the end of its stroke. The excess time was kept to a minimum to avoid heating the oil. Basins formed in this research were about 12 ft long, with 3 to 4 ft required to raise and lower the blade.

Fig. 5. *Final version of conveyor having pickup height adjustment (A), basin-forming blade (B), and low profile planter (C).*

Rootplow standards tend to leave a small furrow at the edge of the treated strip. The conveyor support wheels ran on this strip, making a continuous furrow which the blade did not fill. This furrow caused some basins to be drained, especially on sloping sites. Future designs should include some soil-smoothing device ahead of the basin-forming blade.

The conveyor was powered by an 18 horsepower, air-cooled gasoline engine. It was mounted outside the conveyor frame and was connected to two hydraulic pumps through a chain drive. A small pump provided power for the basin-forming blade. A large pump was connected through a flow divider to a hydraulic motor to drive the conveyor and a hydraulic cylinder that controlled the height of brush pickup. Hydraulic drive for the conveyor proved to be highly desirable. Torque was limited by the oil pressure control system, and the valve handle could be operated to reverse the chain quickly and clear obstructions. A wide range of speeds could be obtained by (1) changing engine speed, (2) changing drive ratios between engine and pump, or (3) changing ratios between the hydraulic motor and the conveyor drive shaft. Use of an hydraulic drive also made it possible to power the conveyor through the rear shaft as shown in Figure 4, so the conveying portion of the chain was also the tight side of the drive.

The planter originally used in the experiment had large press wheels. In 1969, the lower profile version shown in Figure 5 was constructed. It also utilized the two-box seed-metering system but had much smaller wheels. Part of the weight of the planter chassis was used to press the soil through a rod and spring assembly. Future planters should be of the unit type, so that spacing can be readily changed. If part of the weight of the conveyor can be carried by the planter, large, heavy press wheels will not be necessary.

Experimental Plantings and Conclusions

The combination rootplow-seeding machine has been used to plant 23 experimental plots across southern New Mexico. Most plots were about 5 acres and were seeded with a mix of desirable species adapted to the site. Plots were planted yearly from 1966 through 1970, so a variety of machine configurations were used. The conveyor was first used in 1967, and the basin-forming blade was added in 1968. Mechanical improvements were made in 1969 and 1970, but these had no significant effect on plot work.

The last complete evaluation was made in the fall of 1970. About 50% of the seedings were considered successful. Of the eight plots which had poor stands, seven were on the Jornada Experimental Range, where drought prevailed during the experiment. Further, the soil on one of the sites may be too fragile for this treatment. The most successful sites were near Carlsbad, Alamogordo, and Deming. A reasonable amount of rainfall occurred at all of these locations in 1968 and 1969. The Deming site was particularly droughty in 1970, and the stand rating decreased from excellent to good. A detailed discussion of results, including species response, will be available in a companion article by Herbel et al., 1973.

This research has demonstrated that much of the depleted rangeland in southern New Mexico can be restored. On sites completely dominated by creosotebush and tarbush, rootplowing followed by seeding with the proper equipment can be successful. Site requirements include: fine-textured soil to resist wind erosion, a slope percent low enough to resist water erosion, and reasonable rainfall. The planting equipment should remove the brush to allow planting on bare soil and provide for seed covering to a very shallow depth. Small water-holding basins must be formed, and the brush residue should be placed over the planted area.

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