PASTURE PITTING MACHINES

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Pasture Pitting Machines

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Forage production in arid and semi-arid regions is low due to lack of moisture and part of the forage produced is of inferior quality and low palatability. It is not practical in most cases to completely renovate the areas and replace existing vegetation with improved plant species because of the soil types, terrain and the uncertain quantity and intensity of rainfall. Two alternatives to complete renovation are improving the existing environmental conditions for plant growth, and introducing improved species.

It is possible through pasture pitting to improve plant environment and provide suitable situations for seed germination. The more favorable environmental conditions in the pits encourages the return of vegetation to the pits by natural means or through reseeding.

Pitting simply means the forming of small depressions or pits in the soil which catch and hold rain and runoff. Moisture retained by the pits becomes available to existing vegetation around the pits. This publication reports results of research made to evaluate several pitting machines, including a pitter-seeder for seedling establishment.

Previous Work

The concept of mechanically modifying the surface of pastures and ranges for water conservation is not new. Contour furrowing (1,2) * received considerable attention in the thirties as a means of conserving surface water. Knudson and Zoerb (3) reported in 1960 that this practice was growing in popularity in South Dakota. Basin tillage using a lister with damming attachment has also been used to a limited extent in the plains (4,5).

Pitting studies were conducted in Wyoming (6) using a harrow plow with eccentric mounted disk blades for forming pits. This system was effective to varying degrees in catching and holding water, in producing desirable changes in vegetative composition and in increasing the

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*Numbers in parenthesis refer to the appended references.

Research reported herein was conducted under Oklahoma Station project No. 678 and 973.

total forage production. Broadcast seeding in the pits was not generally successful. Range pitting and reseeding trials with a modified harrow plow were conducted in Texas (7) during a period of below average rainfall. In all tests, pitting increased moisture penetration and in turn stimulated plant growth. Pitting and reseeding was most effective on upland areas. Broadcast seeding following pitting was more effective than broadcasting seed prior to pitting. Reseeding trials on prepared seedbeds during this period were unsuccessful.

Field trials were conducted with a heavy punch type pitting machine in Colorado (8). This machine featured spikes on the periphery of a heavy drum which formed relatively narrow holes or pits approximately 14 inches deep. The functions of this machine were to break up subsoil hard pan and increase water penetration and retention. Test results showed an increase in grass production and water penetration in treated areas. On many soil types, however, the pit life was relatively short. Pitting and listing on native short grass rangeland in Texas (9) proved relatively unsuccessful in that the additional moisture stored by the pits was used by weeds. A seeding of Caucasian bluestem was not successful; however, within two years native grasses had re-established in the pits.

Frost and Hamilton (10) reported from Arizona that sloping fan-shaped basins 5-6 feet long and 6-10 inches deep in suitable soils are practical for collecting rainfall. A study of moisture penetration showed that for four or five storms of high intensity, with amounts of less than ½ inch, moisture penetrated to a depth of 30 inches below the pits. Placement of seed in grooves across the pits and using presswheels to pack soil over the seed resulted in good stands. Jordan (11) found that pitted seedbeds in Arizona were effective in reducing runoff from rains of intensity as high as four inches per hour. However, seedbeds prepared by a pitter were generally not as effective as those prepared by a rootplow for establishing range seedlings.

Taylor and Houlton (12) found that pitting did not constitute a suitable seedbed for stand establishment in Northern Montana. Herbel (12), New Mexico, has investigated various methods of reseeding and improving the micro-environment for seedlings on rangeland. His conclusions were that (A) it is necessary to remove weed competition, (B) there is some advantage to plowing the soil before planting, (C) soil temperatures should be reduced and soil moisture increased in the seed zone, (D) rodent control is sometimes necessary, (E) broadcasting is a poor method of seeding, (F) crusting may be a problem in some soils, and (G) no one method will be the most successful for all sites.

Pitting Machines

Equipment was developed to form pits which had stable characteristics, maximum water storage capacity, and a micro climate which favored seed germination and survival. The following machines were evaluated:

Rotary Sub-Soiler

A commercial rotary sub-soiler was used to form pits. (Figure 1) It consisted of two spike wheels mounted on a horizontal shaft with sufficient weight attached to force the spikes into the soil. The unit could be placed in operating position by inverting the frame. Pits formed by this machine measured four by eight inches at the soil surface and decreased in cross-sectional area with depth. Maximum depth was approximately 17 inches. (Figure 2) Pits were spaced two feet along the row with a row spacing of 36 inches.

Disk Plow

This pitting device consisted of a two bottom, 26-inch disk plow with a 20-inch diameter eccentric furrow wheel. (Figure 3) The rear

Figure 1. Rotary Sub-Soiler in Transport Position

Figure 2. Pit Made by Rotary Sub-Soiler

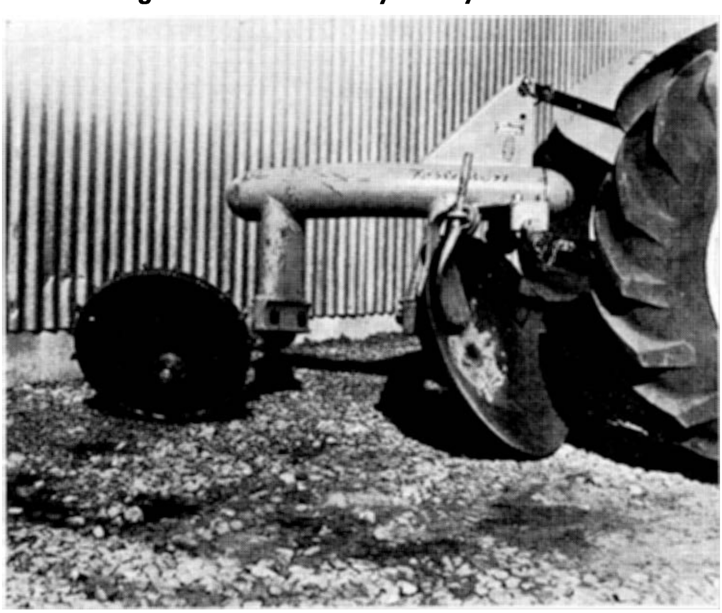

Figure 3. Disk Plow

plow bottom was removed to avoid throwing soil into the pits made by the front bottom. The furrow wheel was mounted three inches off center which provided a vertical movement of six inches. A 36-inch row spacing was the closest that could be used without throwing soil into the previous row of pits. The pits produced by this machine were oval-shaped depressions having smooth and relatively flat side slopes. (Figure 4) Practically no loose soil remained in the pits. The average dimensions of the pits formed by this machine were 60 inches long, 12 inches wide at the center, and a depth of 4 inches. Twelve to 18 inches of non-disturbed soil remained between successive pits.

Bush and Bog Harrow

A tractor mounted, single action bush and bog harrow equipped with eight 24-inch notched disk blades was modified to produce pits. (Figure 5) Alternate blades on each gang were removed, resulting in a pit row spacing of 18 inches. Portions of the remaining blades were cut away to effect an intermittent cutting action. These blades were mounted symmetrically on the arbors with the gangs timed to minimize side draft on the tractor. The pits were approximately 48 inches long, 11 inches wide, and 3 to 4 inches deep. (Figure 6) The pits were quite

Figure 4. Pits Made by Disk Plow

Figure 5. Bush and Bog Harrow

Figure 6. Pits Formed by Brush and Bog Harrow

free of loose soil; however, much of the displaced soil was deposited near the pits which permitted much of the soil to be carried back into the pit during the weathering process.

Lister

A 12-inch lister bottom was used to form pits using an arrangement that would alternately raise and lower the bottom. (Figure 7) Raising and lowering was accomplished by taking power from the tractor drive-wheel through a connecting link. Pits made by the lister bottom had a roughened surface with considerable loose soil in and around the pit. (Figure 8) Forty-eight inches of non-disturbed soil separated the pits. The pits averaged 88 inches long, 12 inches wide, and 7½ inches deep.

Disk Pitter-Seeder

A four-row pitting machine* was used for pitting and seeding tests on native range. (Figure 9) Pits were formed by disks with approximately half of each disk blade removed. The disks were positioned on

*An experimental machine furnished by E. L. Caldwell and Sons, Inc., Corpus Christi, Texas.

Figure 7. Lister

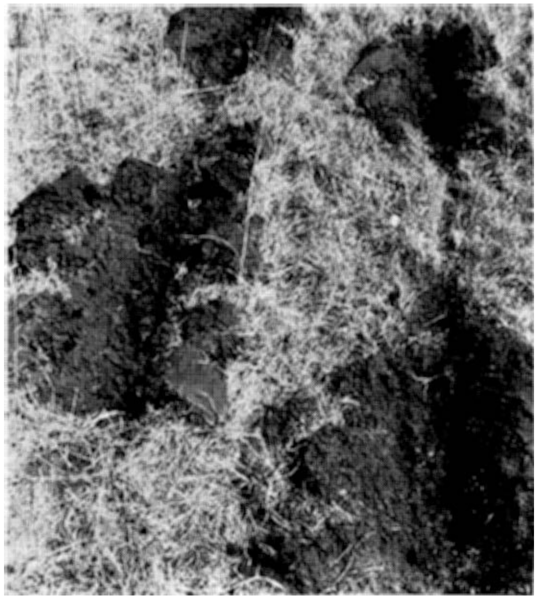

Figure 8. Pits Formed by Lister

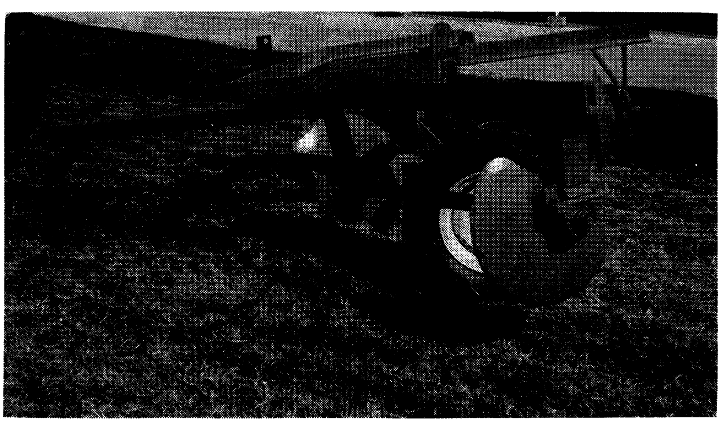

Figure 9. Disk Pitter Before Modification

the arbors so that alternate pitting would occur. The pits were approximately 12 inches wide, 48 inches long, and of variable depth depending upon the setting of the hydraulic cylinder. (Figure 10) Depth could be varied from 2 to 7 inches. Fertilizer distributors, seed boxes, and seedbed preparatory equipment were added to permit testing of various methods of seed placement and seedbed preparation.

Figure 10. Field Pitted with the Disk Pitter

Pit Stability and Storage Capacity

Plots were treated with all machines, except the disk pitter-seeder, for the purpose of evaluating pit stability and water storage capacity. Vegetation on the area selected consisted largely of native grass species, particularly big and little bluestem. The slope of the area ranged from one to four percent. Rows of pits were formed both on the contour and parallel to the slope to evaluate effects due to slope. Water holding capacity was determined by placing a sheet of plastic material in the pit and measuring the amount of water the pit would hold. Pit stability was judged by the reduction of water holding capacity.

Rainfall data near the test site are presented in Table I. The frequency, intensity, and amount of rainfall is believed to have some bearing on pit stability. No attempt was made to correlate these rainfall attributes with pit degradation.

Discussion of Results

Pits formed by the rotary sub-soiler held between one and two gallons. Pit stability was found to be very poor as many pits had become completely filled within a one-year period. No evidence of forage response due to pitting was observed in the test area. The rotary subsoiler pits did not appear to have qualities which would be conducive to seed introduction in or near the pits. For this reason and because of

Table I. Annual Rainfall and Days Receiving Stated Amounts of Rainfall

Inches Per 24-Hour Period	1959*	1960 (Days)	1961
0-1	18	56	36
1-2	6	7	9
2-3	3	2	2
3-4	2	0	0
4-5	1	0	1
5-6	0	0	1
6-7	1	0	0
Annual Inches Per Year	50.16	29.07	39.47

*Rainfall records were started in July, 1959, when the plots were established. Annual total represents rainfall for the total year.

poor stability and a potential hazard for livestock grazing in a freshly pitted area, work with this machine was discontinued.

Pits formed with the disk plow left 75 percent of the surface area undisturbed. Except in heavy sods, the soil removed by the disk was crumbled and scattered in the area between pit rows. Following weathering and consolidation of this soil, much of the vegetation originally covered had survived. The storage capacity of pits on the contour averaged 4.75 gallons when first constructed. Based on a 36-inch row spacing, these pits could provide a water storage capacity of 0.4 acre-inch. After 54 inches of rainfall, the storage capacity had been reduced 25 percent. Further capacity reduction has been slow because of a lack of loose soil to wash into the pits and because of the soil stabilizing effect of the increased vegetation in and around the pits. Pits formed parallel to the slope had an average storage capacity of 2.75 gallons when established. After 54 inches of rainfall, much of the undisturbed soil between the pits had eroded resulting in a 45 percent decrease in storage capacity. During the fall of 1960, apparent increases in seed set were observed on pitted plots as compared to non-pitted areas nearby.

Average storage for pits formed on the contour by the bush and bog harrow was 3.4 gallons. These pits would provide 0.6 acre-inch of surface storage. After 54 inches of rainfall, the storage capacity had been reduced by about 40 percent. Pits formed parallel to the slope had an average initial capacity of 2.30 gallons. After 54 inches of rainfall, the capacity was reduced 20 percent and some erosion at the lower end of the pits was observed.

The lister formed pits had a capacity of 7 gallons. Assuming a 36-inch pit row spacing, these pits would have an initial storage capacity of 0.3 acre-inch. Quantitative assessment of pit stability was not made; however, the pits were surrounded by loose soil which soon washed into the pits.

Seedling Establishment with Disk Pitter-Seeder

The disk pitter-seeder was used to investigate seedling establishment in pits. Three single row planting units were mounted on the disk pitter-seeder. The fourth row served as a check with no seeding or fertilizing in the pits. Planting unit one is shown in Figure 11. The surface of the pit was prepared by the opener blades which made slits one-fourth inch wide and three-fourths inch deep to receive the seed. A presswheel followed to close each slit and to pack soil over the seed. Plates welded to the front of each opener aided in sliding the opener up and over the end of each pit. The horizontal attitude of the opener was maintained by parallel links. Figure 12 shows a pit treated by this unit.

Planting unit two dropped seed at random into depressions made by rake teeth welded to the periphery of the disk. (Figure 13) The teeth were spaced approximately five inches apart and extended one

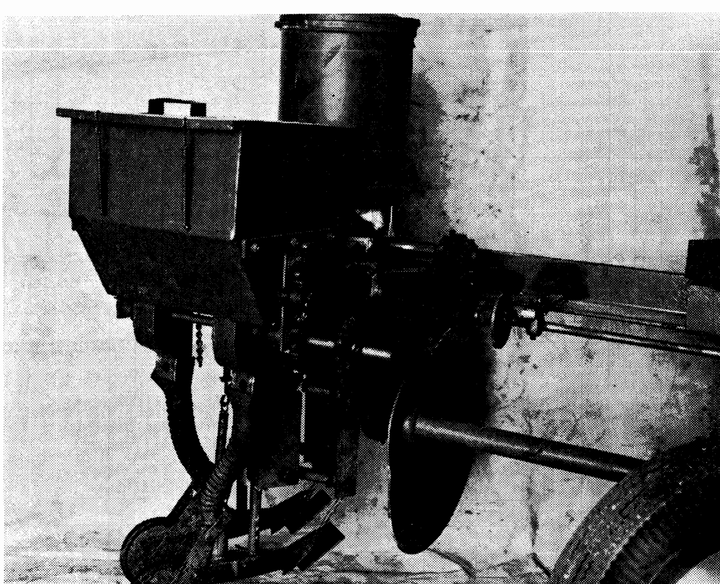

Figure 11. Planting Unit One

Figure 12. Pit Treated by Planting Unit One

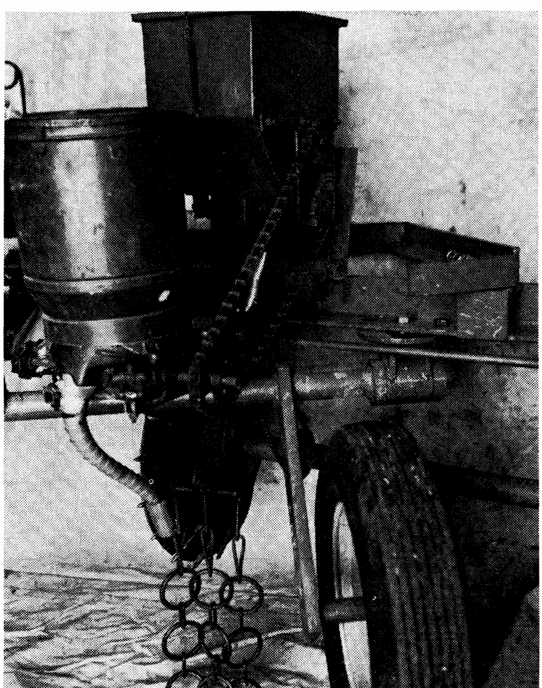

Figure 13. Planting Unit Two

inch beyond the edge of the disk. Drag chains covered the seed. Figure 14 shows a pit treated by planting unit two. The teeth marks are visible at the side of the pit.

Planting unit three is shown in Figure 15. A four-inch wide, spring loaded, zero pressure presswheel was rolled through the pit after the seed was dropped. A treated pit is shown in Figure 16.

A clutching mechanism was used to start and stop the planting and fertilizing units to permit seeding and broadcasting the fertilizer only in the pits.

Two series of plots were laid out in bluestem sod at Stillwater, Oklahoma. One series of plots was fertilized and seeded, the other was seeded only. Little bluestem was seeded in the pits at approximately 0.0011 pounds per pit and fertilizer (20-20-20) was applied at the rate of 0.071 pounds per pit. The plots were treated April, 1963.

In May, 1963, the plots were sampled for pit measurements. The maximum width, length, and depth of the sample pits were measured and analyzed for differences. No significant difference among planting unit means was found for width, length, or depth in either the fertilized or non-fertilized plots which averaged 11.82, 47.50 and 4.62 inches, respectively.

Figure 14. Pit Treated by Planting Unit Two

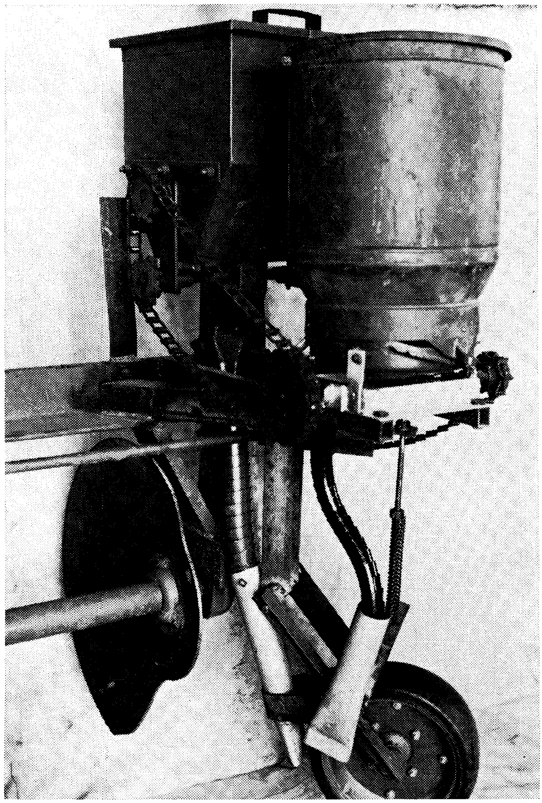

Figure 15. Planting Unit Three

A total plant population count was made during May, 1963. The results of the analysis of this data are presented in Table II. No significant difference was found among planting unit means for either the fertilized or non-fertilized plots. Substantially larger numbers of plants, including weeds, were found in the fertilized plots; however, the experiment design did not provide for comparisons between fertilized and non-fertilized plots.

During January, 1964, a sampling was made to compare the effects produced by the seeding units. Two pits were selected at random for each planting unit in each replication. The bluestem grass seedlings in these pits were counted. These data were analyzed and the results are presented in Table III. In both fertilized and non-fertilized plots, the seedling count for planting unit one was significantly greater than check and planting unit three. Planting units two and three were not significantly different in either plot.

Figure 16. Pit Treated by Planting Unit Three

Table II. Total Plant Population, May 2, 1963

	Fertilized Plot		
Planting Unit	#1	#2	#3
Mean Pop./Pit	7.65	9.70	6.75
Check 6.55			
No significant difference among means at .05 level.			
	Non-Fertilized Plot		
Planting Unit	#1	#2	#3
Mean Pop./Pit	1.50	2.70	2.15
Check 1.85			
No significant difference among means at .05 level.			

Table III. Seedling Count Within Pits

	Fertilized Plot		
Planting Unit	#1	#2	#3
Average Number Per Pit	16.00	9.25	7.13
Check 3.75			
	Non-Fertilized Plot		
Planting Unit	#1	#2	#3
Average Number Per Pit	14.63	9.75	8.25
Check 2.63			

An area of approximately one acre was pitted and seeded in April, 1965, near Buffalo, Oklahoma.* Two plots of deep pits (5 inches), one fertilized and seeded the other seeded only; and two plots of shallow pits (3 inches), one fertilized and seeded, the other seeded only, were laid out. Tucson side oats grama was seeded at the rate of 0.002 pounds per pit and fertilizer (12-12-12) was applied at a rate of 0.024 pounds per pit. There were approximately 1,870 pits per acre with the average width and length of the pits being 12 inches and 48 inches, respectively.

The plots at Buffalo were evaluated in May, 1967. Pit stability was excellent in that both shallow and deep pits were still intact with much of the displaced soil remaining where it had fallen during the pitting operation. Rainfall in the plot area was below average for 1965 and 1966 (Table IV) which retarded pit deterioration. Very little vegetation was found in the pits. Approximately 70 percent of the pits had no grass cover and the remainder had no more than 20 percent cover. Within the plots where buffalo grass was prevalent, some buffalo grass was found in the pits but very few bluestem and hairy grama seedlings were found. No Tucson side oats grama grass was observed in the pits. Weeds (mostly sage) were found in about 60 percent of the pits; however, weeds could not yet be considered a problem in the plot area. Wherever increased vegetation was present, it was found around the pit edges. Statistical evaluation of the planting units was impossible due to the failure to establish Tucson side oats grama seedlings.

*Appreciation is expressed to Mr. Bob Gates on whose farm the plots were established and to Mr. E. H. McIlvain, Superintendent, U.S. Southern Great Plains Field Station and Darwin Hedges, Soil Conservation Service for their cooperation and assistance.

Table IV. Rainfall Data for the Plot Area near Buffalo, Oklahoma (Monthly Totals in Inches)

Year	April	May	June	July	August	September	Annual Total (Inches)
1965	0.92	3.51	2.60	2.15	1.99	1.98	19.28
1966	0.68	0.79	1.04	1.06	3.84	2.09	11.96
					81 Year Average		16.19

Summary and Conclusions

Several machines for forming pits in range and pasture land were designed, constructed, and evaluated. The physical dimensions of pits formed by these machines were measured and pit stability was determined. Three planting units were combined with a disk pitter to investigate combined pitting and seeding operations.

Pits made by a rotary sub-soiler do not provide a suitable place for introducing seeds and lack sufficient pit stability for long range benefits.

On the contour, disk plow pits experienced a 25 percent reduction in water storage capacity and the pits formed by the modified bush and bog harrow had a 40 percent reduction in water storage capacity after 54 inches of rainfall. Since the loose soil has disappeared and vegetation has increased around the pits, further storage reductions of such magnitude are not expected. Seeding at pitting time should help to rapidly stabilize the pits and minimize reduction in storage capacity.

Generally, pits formed with the major axis parallel to the slope would be unsatisfactory because of erosion and consequent reduction in storage capacity. The pits formed by the disk plow are apparently more subject to erosion and loss in capacity than are pits formed by the bush and bog harrow.

The pits formed by the disk plow and the lister would appear to provide better conditions for introducing the seed than those formed using the modified bush and bog harrow. Relatively little soil preparation would be necessary for seeding in the lister formed pits. More seedbed preparation would be required in the disk plow pits to provide a satisfactory place to deposit seed. Any seedbed preparation in or near the pits formed by the bush and bog harrow would tend to destroy the pits.

Based on results obtained with the disk pitter-seeder, precision drilling of grass seeds across the length of the pits was as good or better than was broadcasting seed into grooves followed by drag chains or broadcasting followed by a press-wheel packer.

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