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Chapter 8

Environmental Modification for Seedling Establishment

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Under rangeland conditions most grasses should not be seeded deeper than 2 cm. Harsh environmental conditions in the surface soil often prevent successful seedling establishment. Army and Hudspeth (1960) and Hudspeth and Taylor (1961) reported that under field conditions in the southern Great Plains sufficient moisture for seedling emergence of grasses planted at the customary shallow depths could not be maintained on bare surface soil except under extremely favorable weather conditions. The average annual precipitation in that area ranges from 36 to 58 cm. Environmental modification, particularly of the moisture and temperature, is imperative to insure greater success in grass establishment. Artificial and natural mulches and land-forming procedures offer increased possibilities for obtaining seedling establishment under difficult environmental conditions.

Natural Mulches

In forage establishment a covering of plant residue improves soil moisture and protects the soil surface against wind and water erosion (Duley, 1952).

Mannering and Meyer (1963) used a rainfall simulator to show that infiltration increases and runoff decreases as the amount of plant residue on the soil surface increases. Mulches reduce the impact force of raindrops on soil, so that soil is not puddled or sealed at the surface.

One of the most economical methods of obtaining mulch is to use stubble, trash, or other materials left on the soil surface during land preparation. Moldenhauer (1959) reported that emergence of grass occurred at a lower level of watering when the soil surface was covered with chopped sorghum stover at the rate of 4500 kg/ha, as compared with no cover. The mulch was much less beneficial when maximum daily temperatures were less than 21°C during the germination period than when they were about 35°C.

Stubble mulching has been used for seedling grasses in the Great Plains for several years (K. L. Anderson, 1959). The method consists of planting a residue-producing crop such as sorghum a year before the grass is to be seeded. The sorghum crop is seeded in mid to late summer to prevent seed formation before frost but yet make 15 to 20 cm of growth. Grasses are seeded the following spring with a drill designed for shallow seeding. Residue from the sorghum crop protects the grass seedlings from soil erosion around the root zone.

A mulch of over 3360 kg straw per hectare encouraged damping-off diseases to the point where mulched seedings were less satisfactory than the unmulched (Willard, 1952). However, in a dry season better initial stands were obtained under a heavy mulch than under no mulch. Increased insect populations in plant residues may also present problems in grass establishment.

In an Arizona trial emergence of grass seedlings was 4 to 20 times greater under light coverings of straw and cotton gauze than on bare ground (Glendening, 1942). Soil moisture in the surface 2.5 cm and at 15- and 30-cm depths was consistently greater under the straw and gauze than on the untreated area. Straw mulch, jute mesh, and twisted-paper mesh were effective in stabilizing the soil surface and aiding in grass establishment on earthen dams, roadsides, terrace channels, ridges, and waterways (U.S. Department of Agriculture, 1962).

In turf seedings a 3-mm cover of moist, pulverized sphagnum peat is a good mulch (Willard, 1952).

It is difficult to reduce evaporation from the soil surface. Hanks and Woodruff (1958) compared straw, black-painted gravel, aluminum-painted gravel, and plastic film mulches with bare soil. The total difference in evaporation in a year between the check and other treatments was not more than 2.5 cm of water.

Artificial Mulch

Because they are expensive, the use of artificial mulches for grass establishment is limited. However, they can be used effectively on lawns, roadsides, waterways, or other high-value areas.

Polyethylene mulches have been used to control surface evaporation in establishing turfgrasses and crops (U.S. Department of Agriculture, 1962). In dryland areas plastic mulches increased the efficiency of water use by crops. Incorporating hexadecanol into the surface soil can be used to reduce evaporation.

In Texas poor grass establishment was obtained in summer seedings under clear and black polyethylene because of the 50°C soil temperatures (Army and Hudspeth, 1959). White polyethylene has a high reflectivity index and substantially reduces maximum soil temperatures when it is used as a mulch covering. Such soil coverings as plastic, aluminum and black paint sprays, roofing paper, and aluminum foil improved moisture conditions in the seed zone (Army and Hudspeth, 1960).

Large sheets of clear polyethylene have been used successfully in lawn establishment (Army and Hudspeth, 1960), probably because lawn grasses are seeded in the spring when high soil temperatures are not a problem. Seedings made in the cool part of the year also often benefit from the higher soil temperatures obtained under black coverings.

In an exploratory test in Colorado emergence and growth of blue grama [*Bouteloua gracilis* (H.B.K.) Lag. ex Steud.] were hastened by an asphalt mulch (Bement *et al.*, 1961). There was more soil moisture at the 2.5-cm depth under the asphalt mulch than in the check. Further a cationic emulsion of asphalt mulch held soil moisture for a longer period than an anionic emulsion of asphalt mulch.

In Israel a synthetic rubber spray formed a durable crust that temporarily stabilized sand dunes (Harpaz *et al.*, 1965). However, it had no detrimental effect on the emergence or growth rate of the seeded grasses.

Land-Forming Procedures

The primary objective of various land-forming and seeding methods is to place the seed in a favorable environment for germination and establishment of the seedling. Water conservation in site preparation is essential in dry areas. Staggered pits or interrupted contour furrows are effective in increasing soil moisture (D. L. Anderson and Swanson, 1948). They may be constructed with eccentric or cutaway disks, Pitting followed by cultipacker seeding was the most consistent method of successfully seeding ranges in Arizona (D. Anderson *et al.*, 1957). Ripping and contour furrowing were also good methods of seed-bed preparation on fine-textured bottomland soils.

In the northern Great Plains pitting accompanied by seeding has been an unsuccessful practice for seedling establishment (Barnes *et al.*, 1958). Thus additional moisture does not always insure seeding success.

An intensive study of the effects of ripping in New Mexico revealed that runoff and erosion were decreased by the treatment, but attempts to seed forage species during three years were mostly unsuccessful (Dortignac and Hickey, 1963).

Branson *et al.* (1966) evaluated the effects of the following mechanical soil treatments on water storage: interrupted furrows made with a Model B Contour Furrower, broad-base furrows made with a motor grader, trenches made with a motor grader, pits made with spike-tooth or rotary pitters, pits made with an eccentric disk pitter, ripping with an augur ripper, and ripping with an augur ripper equipped with a furrow opener. The most effective treatments were contour furrowing at intervals of 0.9 to 1.5 m and depths of 20 to 25 cm, and broad-base furrows that had low dikes 0.5 m high. The most consistent beneficial responses occurred on medium- to fine-textured soils.

In some Arizona trials Judd (1966) compared the following seedbed and planting methods: disk-broadcast seed-cultipack-mulch with native brush; disk-broadcast seed-cultipack; disk-broadcast seed-harrow; broadcast seed-disk; broadcast seed-harrow; and broadcast seed. The protective brush mulch was highly important for stand establishment and maintenance.

Deep-furrow drilling generally results in better grass stands on dry sites (Plummer *et al.*, 1955). McGinnies (1959) found that furrows only 10 cm deep significantly increased available soil moisture and improved seedling establishment over an unfurrowed check. In unstable soils the furrows were often filled by soil from local erosion in a relatively short time.

Hyder and Bement (1969) designed a microridge roller for seeding on light-textured soils. Small interrupted furrows are formed to concentrate water on the seeded rows.

Seedling Establishment Research at the Jornada Experimental Range

The climate at the Jornada Experimental Range is typical of the arid phase of the semidesert grassland. The average annual precipitation is 22.9 cm and the average during the summer growing season (July to September) is

12.7 cm. The average annual evaporation from a Weather Bureau pan is 229 cm or 10 times the precipitation. Spring is generally dry and windy. The average maximum temperature for July is 35°C and the average minimum is 18°C. Soil temperature and moisture data were collected for many of the trials.

Hay Mulch

A hay mulch was applied in a 30-cm strip over seeded rows at the rate of 2240 kg/ha and held in place with a light covering of an asphaltic emulsion. Maximum soil temperatures at the 1.3-cm depth averaged 51°C on the checks and 41°C under hay cover. Available soil moisture at the 1.3-cm depth was greater under the hay mulch.

Polyethylene

White polyethylene (0.1 mm thick) was compared with checks on seeded furrows at two sites and a flat seeded area at one site. The soil was dry when the furrows were seeded. The plastic was perforated over the seeded row so that in effect the rain water was concentrated on the seeded area. After 3.8 cm of precipitation, a flat area was seeded to determine if the plastic would hold the moisture long enough for seedling establishment.

On a fine sandy loam site an excellent stand of seedlings emerged in the plastic-covered furrows whereas there was only a very sparse stand on the check furrows. Parts of the plastic were removed one week, two weeks, and six weeks after emergence. The few seedlings that emerged in the check furrows all died within two weeks. Many of the seedlings died in the plastic-covered furrows when the plastic was removed one or two weeks after emergence. This occurred even though there was adequate moisture. There were 12.9 cm of precipitation at this site during the 57 days after seeding. The soil moisture potential at the 1.3-cm depth was between 0 and 1 bar for 7 days in the furrowed check rows and 45 days in the plastic-covered furrows. By the end of the summer a fair grass stand was established where the plastic was removed one week following emergence, a good stand was established where the plastic was removed one week later, and an excellent stand was established where the plastic was left in place for six weeks following emergence.

On a loamy fine-sand site, seedlings emerged later because of less favorable moisture conditions than at the fine sandy loam site. There were 9.3 cm of rainfall at this site during the 57 days after seeding. The soil moisture potential at the 1.3-cm depth was between 0 and 1 bar for 6 days in the fur-

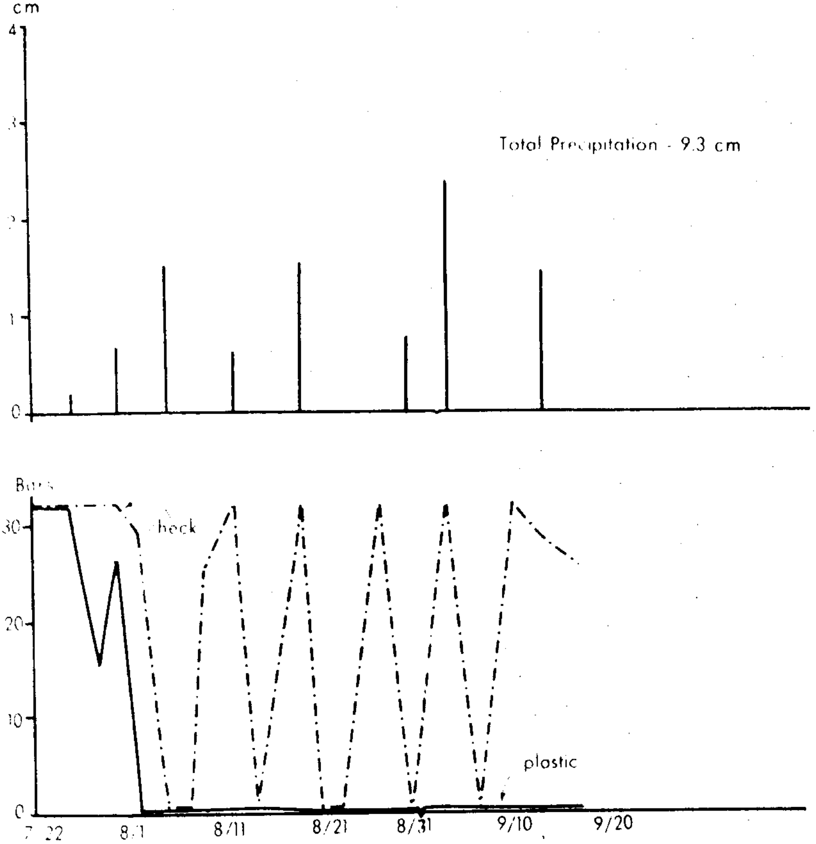

FIG. 1. Daily precipitation (cm) and soil moisture potential (bars) at the 1.3-cm depth in furrows with and without white polyethylene covering on a loamy fine sand site.

rowed check rows and 46 days in the plastic-covered furrows (Fig. 1). By the end of this period there was a fair grass stand in the plastic-covered furrows and a very poor stand in the check furrows.

On the fine sandy loam site, some seedlings emerged under the plastic on the flat area by 9 days after seeding. Many of those seedlings died during a dry period in August but later seedlings survived. No emergence occurred on the flat check area. There were 9.1 cm of rainfall on this site during the 46 days following seeding. The soil moisture potential at the 1.3-cm depth was between 0 and 1 bar for 2 days on the uncovered flat area and 36 days on the plastic-covered flat area (Fig. 2).

During the summer study period, the mid-day soil temperatures at the

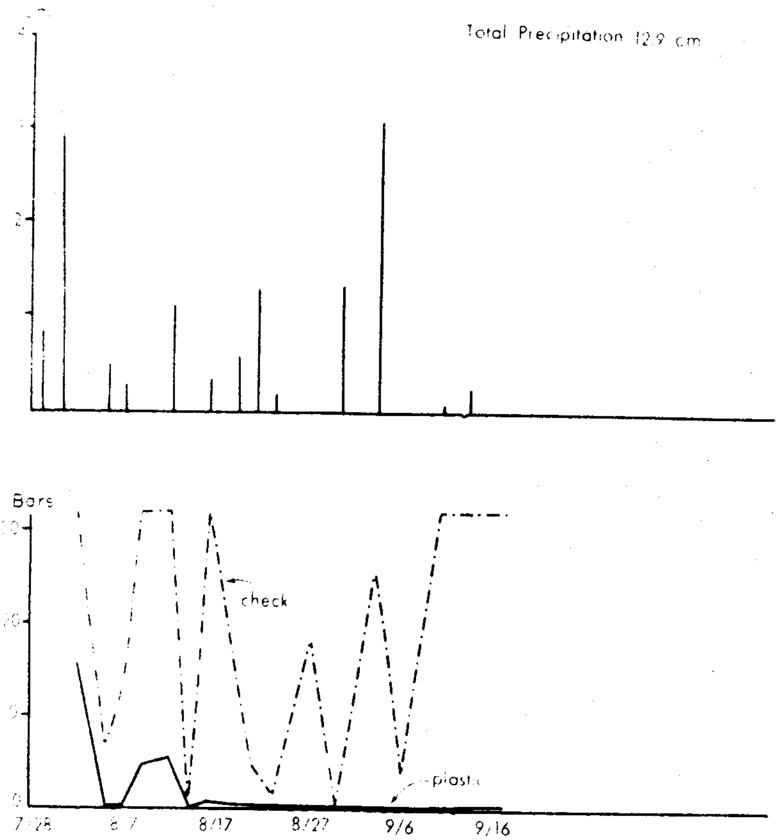

FIG. 2. Daily precipitation (cm) and soil moisture potential (bars) at the 1.3-cm depth on a flat area with and without white polyethylene covering on a fine sandy loam site.

1.3-cm depth under plastic ranged from 29 to 47°C whereas in the checks it ranged from 29 to 62°C. Soil temperatures at the 1.3-cm depth generally were 10 to 18 degrees cooler under the plastic than the checks on hot, sunny days. Only small temperature differences were observed on cool, cloudy days.

Stand establishment under white polyethylene on the sandy loam site could be attributed to more favorable soil moisture and temperature conditions. Even the two-to-three-week-old seedlings benefited from lower temperatures and possibly from protection from high solar radiation. The seedlings did not become etiolated under the plastic. Water concentration in furrows was successful when the seedlings were protected.

PITS AND FURROWS

A fine sandy loam site was treated with a pitter disk seeder. The maximum summer soil temperatures at the 1.3-cm depth were 10°C lower (41°C vs 51°C) in the pits than on adjacent flat areas. There were 10.5 cm of rainfall during the 66 days following treatment. The soil moisture potential at the 1.3-cm depth was between 0 and 15 bars for 36 days but none was recorded on the flat area (Fig. 3). A fair stand of grasses emerged on the pitted area in September.

North-south and east-west furrows, 30-cm deep, were established on a loamy fine-sand site in early summer. Grasses were seeded on the middle of each slope and in the bottom of each furrow. Excellent emergence was obtained on all the slopes within a few days after seeding. However, as seedlings emerged in the bottoms they were covered by drifting sand. The average maximum air temperature 10.2 cm above ground surface during the summer was 34°C. The average maximum temperatures at the 1.3-cm depth

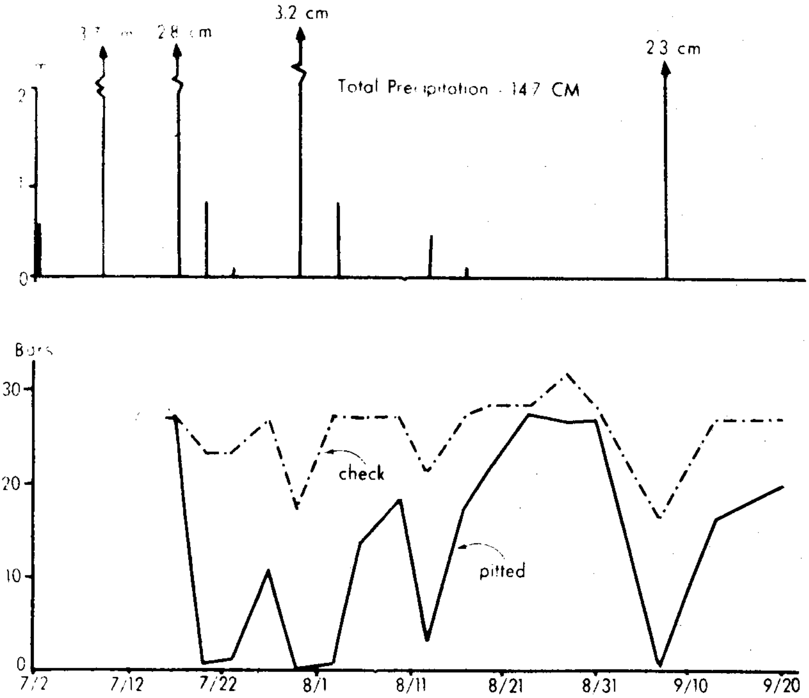

FIG. 3. Daily precipitation (cm) and soil moisture potential (bars) at the 1.3-cm depth in the bottom of pits and a flat area.

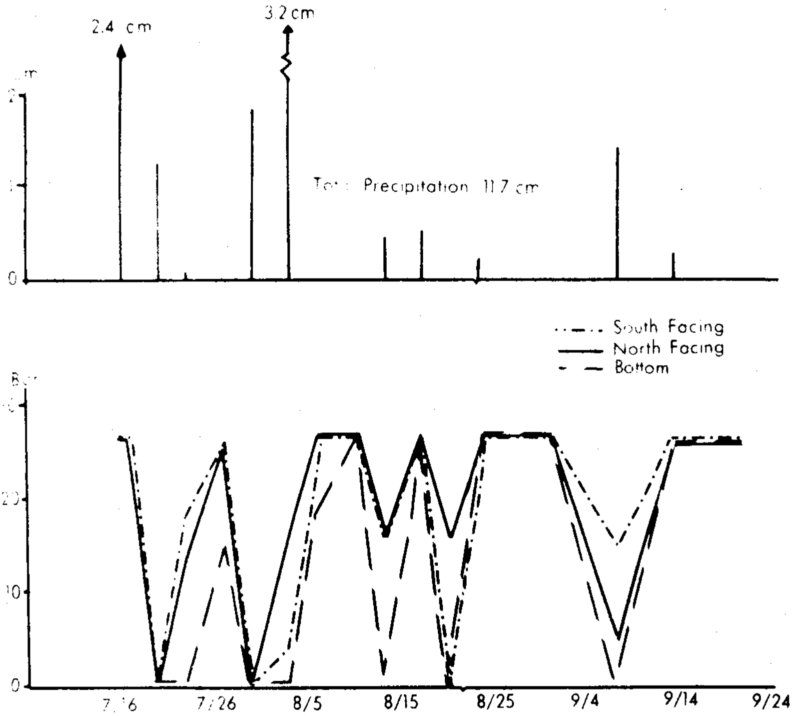

FIG. 4. Daily precipitation (cm) and soil moisture potential (bars) at the 1.3-cm depth in the bottom of a furrow and the middle of the north- and south-facing slopes of a furrow.

were 43°C, 44°C, 48°C, and 43°C for the north-, east-, south-, and west-facing slopes, respectively. During a 66-day summer period, 11.7 cm of rainfall was recorded. Moisture potential at the 1.3-cm depth was between 0 and 1 bar for 4 days on the slopes of the furrows and 13 days in the bottoms of the furrows (Fig. 4).

Concentrating moisture by employing various land-forming procedures does not always insure seedling establishment. The surface soil still dries rapidly and, particularly on medium to heavy textured soils, forms a heavy crust. If the surface could be further protected to reduce evaporation and hence delay crusting, seedling emergence would be greatly enhanced.

ROOTPLOWING AND SEEDING

Fine sandy loam and gravelly sandy loam sites infested with brush were rootplowed. This was followed by a till-and-pack seeder which pressed most of the brush into the soil. Some grasses emerged in September, primarily in the tractor tracks, on the fine sandy loam site. On the gravelly sandy loam site, a large number of seedlings emerged in July but died during August; other seedlings emerged in September. The maximum air temperature 10 cm above the surface of the ground ranged from 29°C to 34°C during the latter half of July and the early part of September. During August it ranged from 38°C to 40°C. The minimum relative humidity ranged from 27% to 57% during July and September and 16% to 17% during August. Maximum soil temperatures at the 1.3-cm depth averaged 51°C with no ground cover and 38°C under sparse brush cover. A high temperature of 59°C was recorded at the 1.3-cm depth with no surface cover and 41°C under brush cover.

During an 82-day period, 12 cm of rainfall was recorded from July 2 to

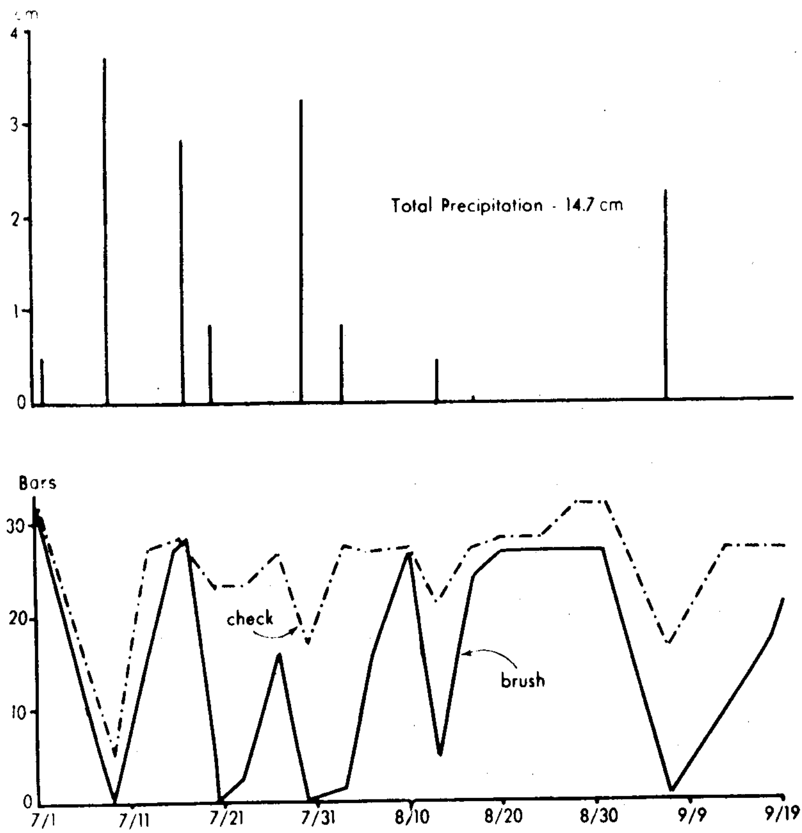

FIG. 5. Daily precipitation (cm) and soil moisture potential (bars) at the 1.3-cm depth without surface cover and under brush cover.

August 3 on the fine sandy loam site, followed by 2.3 cm on September 7. Moisture potential at the 1.3-cm depth was between 0 and 15 bars for 5 days on the area with no cover and 42 days on the area with brush cover (Fig. 5). On the gravelly sandy loam site there were 8.6 cm of rainfall from July 2 to August 3 and 2.8 cm on September 7. Moisture potential at the 1.3-cm depth was between 0 and 15 bars for 23 days on the area without cover and 40 days on the area with brush cover (Fig. 6).

The effects of dead shrubs on soil temperatures were studied on a fine sandy loam site. A single shrub plant was used for the light plant cover and a layer of three shrub plants for the heavy cover. The average maximum air temperature 10 cm above the ground surface for a summer period was 33°C. The average daily maximum soil temperature at the 1.3-cm depth was

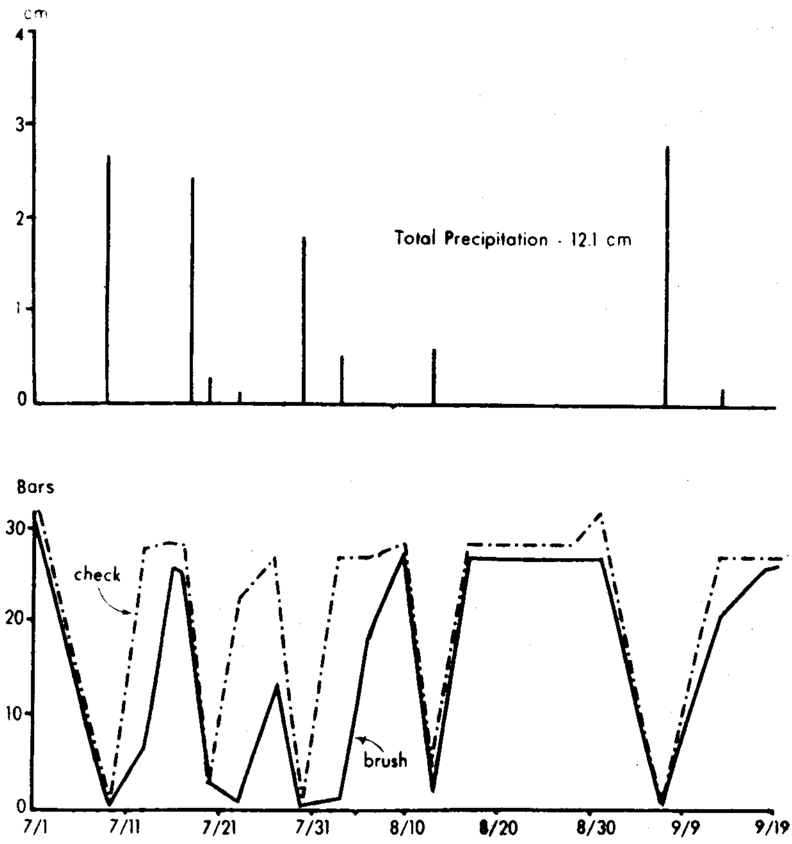

FIG. 6. Daily precipitation (cm) and soil moisture potential (bars) at the 1.3-cm depth without surface cover and under brush cover.

57°C under no cover, 49°C under light cover, and 36°C under heavy brush cover (Fig. 7).

We found that a shrub cover could be utilized to substantially reduce soil temperatures and increase the period of available soil moisture. Therefore, in cooperation with the Agricultural Engineering Department at New Mexico State University, we designed and built equipment for seeding brush-covered rangelands (Fig. 8). The basic part of the equipment was a rootplow with a 2.4-m wide blade. Properly used, the rootplow is very effective in killing the brush and, generally, other competing vegetation. However, the rootplowed seedbed is very loose and fluffy, so we designed a seeder, patterned after the Oregon Press Seeder (Hyder *et al.*, 1961), which firms the surface soil. A brush conveyor was added which picks up the brush behind the rootplow and deposits it behind the seeder. The seeder is only 1-m wide so the brush from a 2.4-m area is concentrated on a strip 1-m wide. In addition there is a hydraulically operated bulldozer blade in front of the seeder which forms basin pits. Thus we were able to concentrate water and provide shade for part of the seeded area. This method was used to seed 12 plots across southern New Mexico in 1967–68. Excellent grass establishment was obtained on nine of these plots. Even on the other three plots with droughty conditions, good grass stands were obtained under some of the brush-covered areas which coincided with slight depressions where water was concentrated.

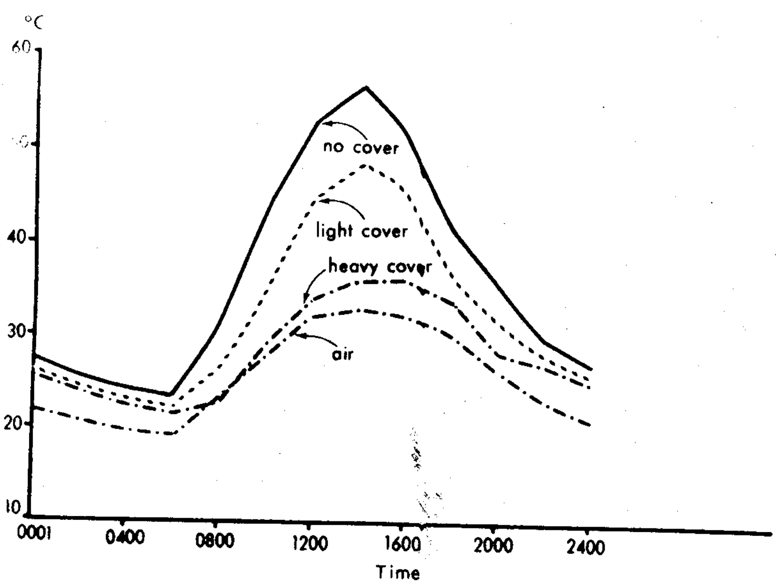

FIG. 7. Average daily soil temperatures at the 1.3-cm depth with light and heavy brush cover and without cover, and air temperatues 10 cm above the soil surface.

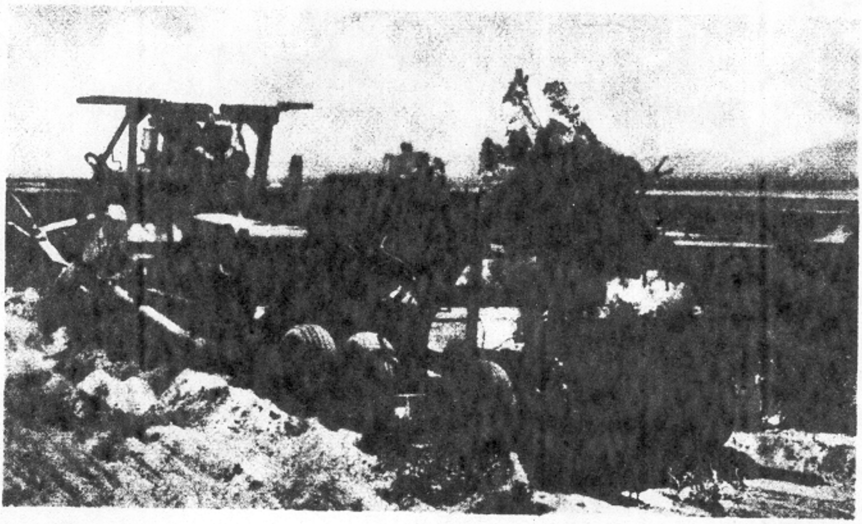

FIG. 8. Rootplow, brush conveyor, pitter, and seeder for treating areas infested with brush.

For seeding success on areas with high temperatures and where the surface dries rapidly, some covering for the soil surface is essential. Seeding success on areas where cool temperatures are a problem may be enhanced by the use of black or clear coverings to increase soil temperatures while conserving moisture.

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