Interrelations of the Physical Properties of Coppice Dune and Vesicular Dune Interspace Soils with Grass Seedling Emergence


Highlight: Vesicular soil surface horizons are found throughout the arid and semiarid areas of the world associated with sparse vegetation. In the Great Basin this horizon occurs in the surface 5 or 8 cm of dune interspace soil. Vesicular horizons are characterized by a high silt content, low organic matter, poor aggregation, and low infiltration rates. Our intent was to study the influence of organic matter removal on vesicular development and to determine the effect of a vesicular horizon on seedling emergence. Removal of organic matter from coppice dune soil resulted in a poorly aggregated vesicular soil with properties similar to those of the untreated interspace soil. Crested wheatgrass and squirreltail seedling emergence was poor and seedling stress was high in vesicular dune interspace soil.

Coppice dunes are aeolian deposits under and around shrubs and perennial bunch grasses (Fig. 1). These dunes are formed by deposition of silt and very fine sands from river flood plains and from the recently dried Pleistocene lakes or playas throughout the Great Basin. Dune interspace is defined as the area between coppice dunes (Melton 1940; Stuart et al. 1971; and Blackburn 1975). Surficial vesicular horizons occur in arid and semiarid parts of the world with sparse vegetation. Volk and Geyger (1970) stated that in warm, arid regions of southern Spain, Morocco, and southwest Africa, barren areas free of vegetation occurred in a mosaic-like pattern, although lack of vegetation could not be attributed to low precipitation, soil salinity, or overgrazing. The soil surface had a vesicular horizon that apparently prevented penetration of precipitation. In the Great Basin, this horizon is typically associated with a northern desert shrub, salt desert or southern desert shrub overstory, and sparse understory vegetation. Vesicular horizon occurs in the surface 5 or 8 cm of dune interspace soil (Fig. 2), and seldom occurs in well-aggregated coppice dunes. Vesicular development is generally strongest in the middle of the dune interspace and becomes weaker nearer to the coppice dune areas of regular organic matter addition.

Springer (1958) reproduced vesicular pores similar to those occurring naturally by wetting and drying sieved soil samples from a vesicular horizon. As water infiltrated into the sieved soil materials, the particles became rearranged, closely packed, and air collected into larger pores. Soil particles and voids were continually rearranged by repeated wetting and drying, while air bubbles moved toward the top of the soil sample and escaped. He concluded that vesicular porosity was unstable, transitory, and quickly reformed in certain soils.

Miller (1971) studied vesicular pore formation under furrow irrigation in Washington and speculated that a platy structure developed first. He found that under saturated, unstable conditions, the pressure of air entrapped in pores was sufficient to form the cavities between platelets into spheres. Additional air would be trapped in the soil with each wetting and drying cycle.

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Under wet, fluid conditions, the small vesicles should merge into larger ones since the surface area per unit volume decreased as the vesicles enlarged. These theories may be substantiated by measuring any decrease in bulk density with vesicular formation and enlargement during repeated wetting and drying. Miller's study also indicated that vesicular horizons were commonly high in silt (40 to 70%). Application of heat to the soil surface during drying periods also had no effect on vesicle formation.

Blackburn (1975) found that vesicular dune interspace soil had an exceedingly low infiltration rate, sometimes 3 to 4 times lower than coppice dune areas. Likewise, greater sediment loss came from these interspace areas. He also observed dune interspace soil to have a shallower surface horizon, a lower organic matter content, a higher bulk density, and a higher percent silt than the coppice dune soil. Dune interspaces have massively crusted, over structured platy A horizons as compared to the granular structure of the coppice dunes. Vesicular horizons are the major factor contributing to low infiltration rates and sediment production from large areas of arid and semiarid rangelands.

Several questions arise as a result of these studies. Will the removal of organic matter from coppice dune soil produce a vesicular soil similar to the interspace soil? What is the influence of vesicular interspace soil on seedling emergence? The objectives of this study were to characterize some of the physical attributes of coppice dune and vesicular dune interspace soils and to determine the effect of a vesicular horizon on seedling emergence.

**Methods and Materials**

Soils from Coils Creek Watershed (Table 1) were used to study vesicular horizon properties and their influence on seedling emergence. The soils are fine, montmorillonitic, mesic, Xerolic Natuarargids. Soil samples were sieved through a 2-mm screen. Greenhouse experiments were conducted with pots 10 cm in diameter and 8 cm high, unless otherwise stated. Soils were watered to saturation.

**Seedling Stress during Emergence**

Seedling stress during emergence was determined in untreated coppice and interspace soils. Twenty-four pots were filled with 6 cm of coppice soil and another 24 with 6 cm of interspace soil. Within each soil type, 12 pots were watered every 3 days, and 12 pots were watered every 6 days. Within each watering cycle, six pots were planted with 10 crested wheatgrass (Agropyron desertorum (Fisch.) Schult) seeds, 2.5 cm deep, and six pots with 10 squirreltail (Sitanion hystrix (Nutt.) J. G. Sm.) seeds.

Total emergence was determined after 3 weeks and each seed or seedling was examined and given a stress rating as follows:

1. No stress—Coleoptiles were longer than 2.5 cm, straight, and well developed.
2. Slight stress—Coleoptile length was > 2.5 cm but the coleoptile was slightly curved or wavy.
3. Moderate stress—Coleoptile length was < 2.5 but greater than 1 mm. Coleoptile had prominent wavyness.
4. Heavy stress—Coleoptile length was < 2.5 cm but greater than 1 mm. Coleoptile growth was retarded.
5. Extreme stress—Germination was initiated, but coleoptile grew < 1 mm.
6. Failure—Seed did not germinate or coleoptile did not break the seed coat.

**Organic Matter Removal**

Two liters each of coppice dune and dune interspace soil were boiled in hydrogen peroxide (H₂O₂) to oxidize organic matter. Untreated soil and soil boiled in water were used as controls. Percent organic matter content was determined by the Walkley Black method (Black 1965). Soil from each treatment was also evaluated for bulk density and crust strength by the modulus of rupture technique (Black 1965) after four saturation-drying cycles. These measurements are extremely useful for characterizing specific physical properties and as manifestations of soil structure (Taylor and Ashcroft 1972). Soil from each treatment was placed in 4-cm dia by 4-cm pots and planted with five crested wheatgrass seeds. A set of pots from each treatment was watered every day and another set was watered every 2 days. Seedling emergence was determined after 3 weeks.

Statistical inferences were based on a one-way analysis of variance and mean separation by Duncan's multiple range test (Steel and Torrie 1960).

**Results and Discussion**

**Seedling Stress during Emergence**

Significantly more seedlings emerged in the coppice dune than in the dune interspace soil (Table 2). Differences in emergence were not significant between watering treatments, although a trend toward lower emergence percentages was observed with less frequent watering. Crested wheatgrass seedling emergence was 88% in untreated coppice dune soil and 15% in untreated dune interspace soil watered every 3 days. When watered every 6 days, 80% emerged in coppice soil and 3% emerged in interspace soil. Similar trends were observed for squirreltail, although emergence percentages were lower than for crested wheatgrass.

Crested wheatgrass and squirreltail exhibited the least seedling stress in coppice dune soil watered every 3 days (Table 2).
squirreltail seedlings in dune interspace soil exhibited symptoms of moderate to extreme stress. When watered every 6 days, crested wheatgrass and squirreltail in coppice dune soil were not stressed or were moderately stressed. However, a large percentage of seedlings of both species planted in dune interspace soil exhibited symptoms of extreme stress, and some seeds did not germinate.

**Organic Matter Removal**

When dune interspace soil was watered daily, there was no significant difference between treatments on emergence (80 to 95%) of both species, and percentage emergence (80 to 96%) was similar to coppice dune soil treatments. However, crested wheatgrass emergence (44%) was significantly reduced in untreated dune interspace soil watered every 2 days as compared to treated soil. No seedlings emerged in hydrogen peroxide-treated soils subjected to the 2-day watering cycle. Vesicular soil kept moist exerted little resistance to seedling emergence; however, once dried, these soils crusted and retarded seedling emergence. Emergence of seedlings in coppice dune soil with the organic matter removed to the level of that in interspace soil (Table 4) was retarded to the same extent as emergence in interspace soil.

**Soil Physical Properties**

**Bulk Density**

Boiling coppice dune and dune interspace soils in water did not significantly change the bulk density; likewise, boiling dune interspace soil in hydrogen peroxide did not alter the bulk density. After the organic matter content was reduced by boiling in hydrogen peroxide, the bulk density of coppice soil (1.20 g/cc) was similar to that of dune interspace soil (1.23 g/cc).

**Modulus of Rupture**

After four saturation-drying cycles, the hardness or modulus of rupture of untreated coppice dune soil with 5.1% organic matter was 0 millibars, and untreated dune interspace soil with 1.31% organic matter was 45 millibars. After four saturation-drying cycles, the hardness of coppice dune soil boiled in hydrogen peroxide with 1.14% organic matter was 110 millibars, and interspace soil boiled in hydrogen peroxide with 1.09% organic matter was 210 millibars.

**Organic Matter Removal**

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destroyed in the interspaces between shrubs. The organic matter in the interspace soil is reduced by rapid oxidation, and with no addition of organic matter, vesicular horizon development expands and strengthens. This tends to lower the potential of the site by reducing the infiltration rate and increasing the stress placed on seedlings. This type of retrogression results in a mosaic type vegetation, consisting of rather unpalatable shrubs associated with the coppice dune surface soil and relatively vegetation-free spaces associated with vesicular dune interspace areas. Millions of hectares of our arid and semiarid rangelands are in this poor condition mainly because of past livestock abuse. Since it will be difficult, if not impossible, to revegetate the vesicular dune interspace areas naturally or through grazing management, use of some mechanical treatment will probably be necessary to rehabilitate these areas.

Literature Cited


Spring Forage Selection by Tame Mule Deer on Big Sagebrush Range, British Columbia

W. WILLMS AND A. McLEAN

Highlight: A study was made on a spring range to determine forage selection by deer (Odocoileus hemionus hemionus) during a critical period in their nutritive status. The period from mid-February to the end of May was characterized by a diet changing from shrub to grass to shrub and forb. Generally, selection favoured the most recently produced grass and forb species. Of the grass species, Sandberg bluegrass (Poa sandbergii) constituted the most bites in the diet but bluebunch wheatgrass (Agropyron spicatum) was preferred. Considerable variation occurred in the diets among the deer. One deer preferred shrubs while the other two preferred grass.

Seasonal diets of both mule deer and cattle have been studied in southern British Columbia in order to evaluate potential competition for forages (Willms et al. 1976; McLean and Willms 1977). The studies were based on rumen samples. The samples for deer were obtained from dead animals, thus the diet represented individual preferences of many animals. This resulted in considerable variation in the estimate of each plant group or "type" among samples. Despite the variation, the deer showed marked selection for non grasslike plants during most of the study period from fall to early spring. Considerable deviation occurred in early spring from mid-March to mid-April when consumption of grass was high. Cattle, on the other hand, preferred grass throughout the year.

Grass provides the first new-growth forage for deer following a winter diet of shrubs and forbs, which was high in fiber and low in crude protein (unpublished data). Grass is very palatable in spring being high in crude protein and low in crude fiber and only big sagebrush (Artemisia tridentata) has digestibility near that of bluebunch wheatgrass (Hickman 1975). However, microbial activity and consequently digestion may be inhibited by the essential oils present in big sagebrush (Nagy and Tengerdy 1968; Oh et al. 1967).

In earlier studies by Willms et al. (1976) and McLean and Willms (1977), grass became available to deer in mid-March, or earlier when fall regrowth was present. The time of availability corresponded approximately to the 130th day of gestation for deer. This is prior to rapid fetal development and may be instrumental in conditioning the doe for that phase and the later period of lactation.