Comparison of Soil Water Used by a Sagebrush-Bunchgrass and a Cheatgrass Community

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Highlight: Two contrasting plant communities occur on the Arid Lands Ecology (ALE) Reserve in south-central Washington, one dominated by a mixture of sagebrush and bluebunch wheatgrass and the other by a nearly pure stand of cheatgrass. At the beginning of the spring growing season in 1974, a year of above-average precipitation, both communities had about the same amount of soil water stored in the first 18 dm of the soil profile. During the growing season, the quantity of soil water used by the sagebrush-bunchgrass and cheatgrass communities was 15 and 8 cm, respectively. The difference in soil water used by the two communities is attributed to a deeper root system and a longer growing period by plants of the sagebrush-bunchgrass community.

Two different self-sustaining plant communities occur on the Ritzville silt-loam soil on the Arid Lands Ecology (ALE) Reserve located in south-central Washington. One is dominated by perennial species, the other by annual species. Native stands of sagebrush-bluebunch wheatgrass (*Artemisia tridentata-Agropyron spicatum*) are dominated by perennials. Agricultural fields abandoned 30 years ago are composed mostly of alien annual species, especially cheatgrass (*Bromus tectorum*).

The cheatgrass community occupies a gentle, east-facing slope located at an elevation of 305 m above mean sea level; the bluebunch wheatgrass occurs on comparable slopes at an elevation of 396 m.

This investigation describes the pattern of water depletion from soil profiles of the sagebrush-bluebunch wheatgrass and cheatgrass communities during 1974, a year of above-average precipitation.

Methods

Soil samples for gravimetric moisture content were taken routinely to 1-meter depth at 1-decimeter increments between February and October, 1974, using a sand auger (National Research Council 1962). Centimeters of water contained in each increment of soil were obtained by multiplying the percent soil moisture by its bulk density. In April and October, sampling was done to 1.8 m to account for deep soil water percolation induced by the unusually heavy precipitation during the 1974 growing season.

To determine root mass (live + dead), four soil cores were taken to 1.6-m depths as 1-dm increments on each sampling date. Roots were separated from adherent soil particles by washing over a 0.1-m screen and by floatation. Roots were ashed at 550°C for 24 hours, and the results were reported as grams ash-free weight per m^2.

Results and Discussion

The total precipitation in bluebunch-wheatgrass and cheatgrass communities during October to May of 1971, 1972, 1973, and 1974 are shown in Table 1. Average precipitation for 1971 through 1973 was 15 cm in the cheatgrass community and 17 cm in the bluebunch wheatgrass community. However, precipitation measured 31 and 36 cm between October 1973 and May 1974 at the respective sites.

Table 1. Precipitation (cm) (October–May) for 1971, 1972, 1973, and 1974.

Year	Cheatgrass	Sagebrush-bunchgrass
1970–1971	17.3	21.4
1971–1972	16.4	17.4
1972–1973	11.5	12.9
1973–1974	31.4	36.2

Soil water accumulated during the months of October, November, December, January, and February and then steadily declined the remainder of the year, even though some precipitation was recorded during the spring and summer months (Fig. 1). Total soil water in the upper 1.8 m of the profile was approximately the same in April for sagebrush-bunchgrass and cheatgrass communities, namely 29 cm and 30 cm of water, respectively.

With the onset of warming spring temperatures and accelerated plant growth, soil water losses occurred through surface evaporation and through plant transpiration processes. Water loss was especially rapid in surface soil layers and less rapid deep in the soil profile (Fig. 1). Available soil water (i.e., less than −15 bars) was depleted from the surface to a 2-dm depth by mid-May in both communities. In the cheatgrass community, available soil water persisted in the soil profile below 0.5 m after mid-July. However, soil water depletion continued in the bluebunch wheatgrass community.

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Work was performed under contract E(45-1)-1830 with the United States Energy Research and Development Administration and National Science Foundation Grant GB-31862X2 to the Grassland Biome, U.S. International Biological Program for "Analysis of structure, function, and utilization of grassland ecosystems."

The authors gratefully acknowledge Mr. Virgil D. Charles for his technical assistance.

Manuscript received August 21, 1976.

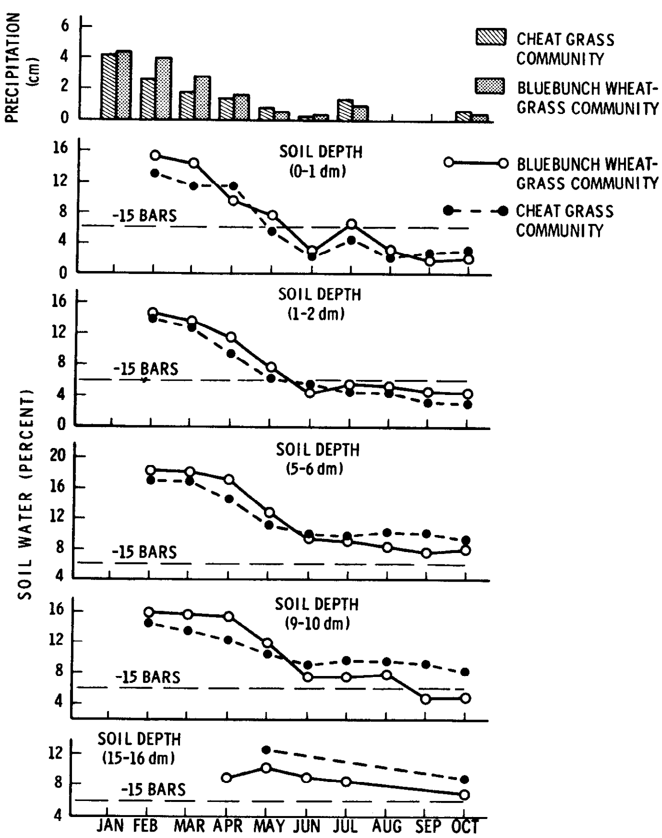

Fig. 1. *Comparison of precipitation (cm) and soil water content (% dry weight) in cheatgrass and bluebunch wheatgrass communities, 1974.*

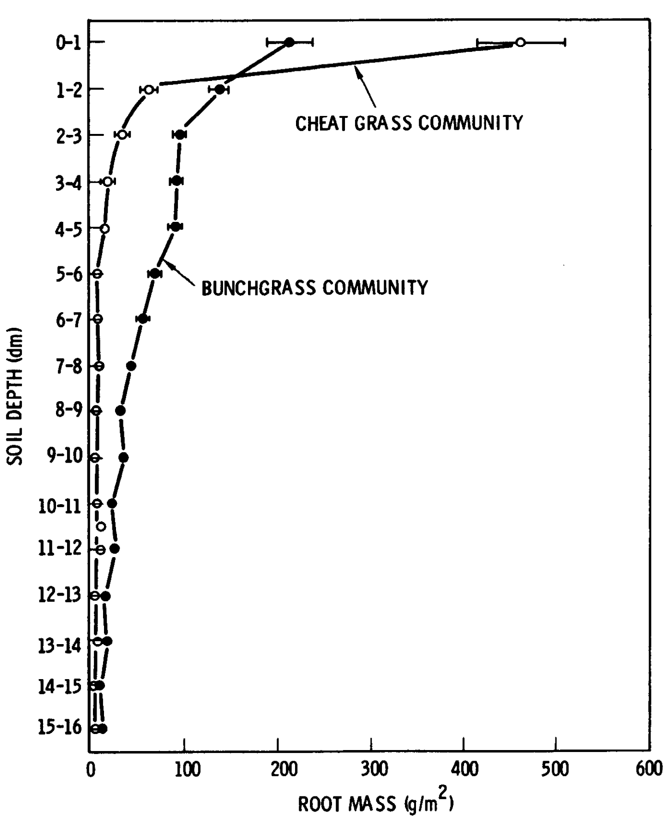

Fig. 2. *Comparison of root mass (ash-free) expressed as g/m² in the upper 14 dm of the soil profile at the end of the 1974 growing season in cheatgrass and bluebunch wheatgrass communities.*

Through the summer, transpiration continued in the bluebunch wheatgrass community by the perennial evergreen species such as big sagebrush, erigeron (*Erigeron filifolius*), and phlox (*Phlox longifolia*). Transpiration losses were not a factor in the soil water loss from the cheatgrass community because the plants die by mid-May. The cheatgrass community has most of its roots in the surface decimeter of soil and relatively few roots deeper in the profile as compared to the bluebunch wheatgrass community (Fig. 2). Two phenomena might explain the differences in water usage between perennial and annual plant communities other than total root biomass; they are: (1) longer active growth periods by the perennial plants, and (2) deeper penetration of functional roots.

A different view of soil water distribution and precipitation in the two communities is shown in Figure 3. These data reveal that the bluebunch wheatgrass community was efficient at removing soil water from soil depths below 0.5 m, but the cheatgrass community was not. These data show that during years of above-average precipitation (i.e., 1973–1974) soil water at lower depths is not exploited by the annual plants of the cheatgrass community, but instead accumulates deeper in the soil profile. Conversely, during the drier years, soil moisture is depleted by annual plants in the upper 0.5 m and little soil moisture is available from the lower part of the profile, thus giving the competitive advantage to the cheatgrass community.

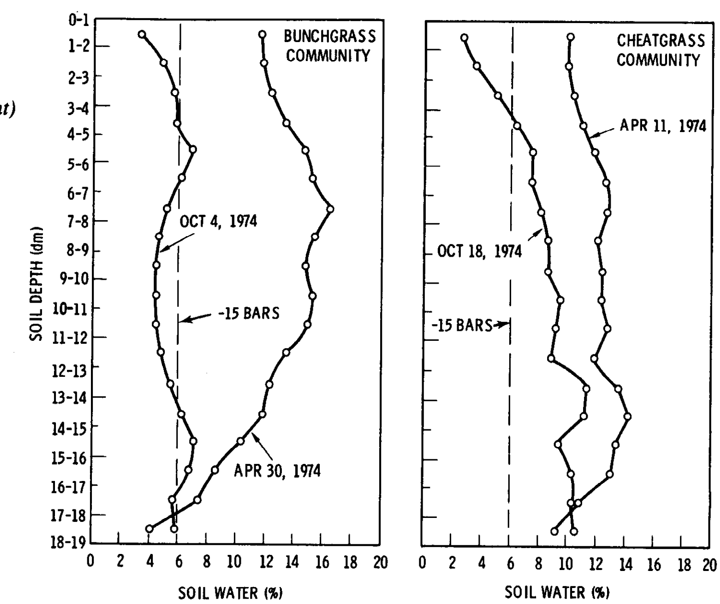

Fig. 3. *Percent water in the soil profile within the bunchgrass and cheatgrass communities during the beginning and end of the 1974 growing season.*

The amount of soil water extracted by evapotranspiration during the growing season is presented in Figure 4. These data show that soil water use was similar in both communities in the upper 0.5 m of profile, but moisture exploitation between 0.5 and 1.4 m depth was greatly pronounced in the bluebunch wheatgrass community. Approximately 15 cm of soil water was exploited by bluebunch wheatgrass as compared to only 8 cm by the cheatgrass. Most observers report that cheatgrass does not readily invade native perennial vegetation unless given an opportunity by some prior disturbance (Daubenmire 1970; Tisdale 1947; Stoddart 1946). However, once cheatgrass has become established, opinions differ as to how fast perennials regain dominance, Stewart and Hull (1949) reported that perennials have a good chance of regaining dominance in a

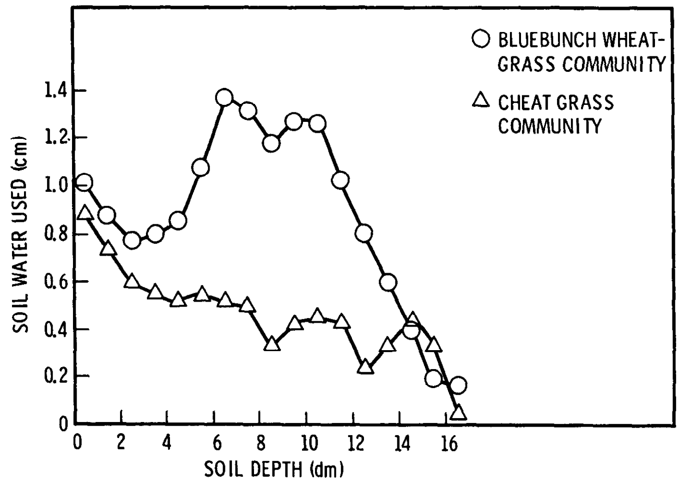

Fig. 4. *Amount of soil water extracted (cm) by evapotranspiration from the two communities during the growing season of 1974.*

cheatgrass community in areas where the annual precipitation exceeds 22.9 cm. Rummel (1946) found that cheatgrass seedlings are a superior competitor of seedlings of perennial plants; therefore, the seedlings of perennial plants must have a definite competitive advantage to survive. Stark et al. (1946) and Hull and Stewart (1948) showed that failure generally resulted when perennial grasses were seeded into cheatgrass stands without seedbed preparation.

The amount of time necessary for perennials to become established in a cheatgrass community varies. In Montana, Warg (1938) found that Sandberg bluegrass began to appear in fields abandoned 7 years, and after 10 years scattered individuals of bluebunch wheatgrass and Idaho fescue (*Festuca idahoensis*) became evident near the edges of fields. Hafenrichter (1942) in Idaho noted perennials were not able to invade cheatgrass swards on abandoned cropland even after 25 to 30 years. Daubenmire (1975) observed abandoned fields in extreme southeastern Washington and found that cheatgrass resisted reinvasion by perennials despite an abundance of seeds of perennials. In other eastern Washington studies, Harris (1967) showed that after July, soil moisture was available to plants at the lower soil depths, but not at the upper levels. Deep soil moisture conditions favored the growth of established perennial plants; however, young plants were unable to invade an established cheatgrass sward.

Conclusions

Soil water use by a 30-year-old cheatgrass sward was compared with that of a native bluebunch wheatgrass community during the spring and summer of 1974. Total precipitation and soil-water storage was nearly identical in both communities at the beginning of the spring growing season. Plant growth was arrested in the cheatgrass community with the onset of summer and soil water stored below 0.5 m was not fully exploited. However, the plants of the bluebunch wheatgrass community exploited deep soil water throughout the summer months, and by October very little soil water remained in the soil profile. It was concluded that cheatgrass communities are efficient users of soil water at shallow depths but are inefficient at exploiting deeper soil water. This study illustrates through soil water utilization patterns that the invasion of deep-rooted perennial plants into a cheatgrass sward may be enhanced by years of above-average precipitation by fostering the storage of soil water below the effective rooting zones of cheatgrass. Once a deep-rooted perennial plant has successfully penetrated below 0.5 m, it would be relatively free from root competition by cheatgrass and have a large supply of available soil water to exploit.

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