Hydrophilic polymer reduces germination of ponderosa pine in seed spots

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Ponderosa pine seedlings emerged later and in fewer numbers when a hydrophilic polymer was added to seed spots, but survival and height growth of seedlings were unaffected.

Success of direct-seeding ponderosa pine *(Pinus ponderosa* Laws.) in the Southwest is seriously reduced when moisture stress delays germination and retards initial development. Because of consistent, severe spring droughts, seeds seldom germinate until the advent of summer rains in July. When the summer rains are light or too sporadic to keep the seeds continuously moist, plant moisture stress may develop or germination may be delayed until August or early September. Plant moisture stress during germination and initial development results in high mortality and limited first-year growth of surviving seedlings (2). Moreover, seedlings germinating under high moisture stress remain retarded, even when the stress is relieved.

Because little can be done to improve the quantity and distribution of rainfall, an alternative approach is to improve the moisture-holding capacity of the soil by incorporating a soil amendment. A hydrophilic polymer called Hydrogel[1] is claimed to have 80 times the water-holding capacity, in terms of percent water by weight at field capacity, of a sandy loam soil. A mixture of Hydrogel and soil greatly enhances both the total and available water in the medium. By acting as a rechargeable reservoir, Hydrogel would hold more available water in the rooting zone and reduce fluctuations in soil and plant water potential. Jensen et al., (1) found that red kidney bean and tomato plants grown in sand amended with Hydrogel, used significantly less water, produced more fresh weight (tomato), and withstood a longer period of induced drought (kidney bean) than plants grown in pure sand.

This paper reports the results of two experiments in which Hydrogel was tested as a soil amendment in seed spots of ponderosa pine to determine its effects on time of emergence, total emergence, seedling survival, and height growth.

Methods

The experimental plots were established in 1972 and 1973 on a recent burn (May 1972) on the Coconino National Forest, Arizona. The absence of competing herbaceous vegetation and favorable soil (Soldier loam, formed from limestone and sandstone) constitute an excellent seedbed for testing direct seeding methods.

[1]Agricultural Hydrogel 50 G was supplied by Union Carbide Corporation Creative Agricultural Systems, Salinas, California.

The growing season of northern Arizona is typified by summer convective thundershowers and spring and fall droughts. Summer rains were lighter and more sporadic than normal during the 1972 and 1973 growing seasons (figure 1), providing a good test for the capacity of Hydrogel to reduce fluctuations in soil water. The experiments were begun in early July to coincide with the onset of summer rains.[2]

The 1972 experiment consisted of two treatments, Hydrogel and no Hydrogel, randomly assigned to six 1/4000-acre plots arranged in a grid. Each plot contained four seed spots with six seeds per spot, equivalent to a seeding rate of 8 pounds per acre. Ten grams of powdered Hydrogel were mixed with the soil in the bottom of designated 5-inch-diameter seed spots, seeds were added, covered with 1/2-inch of soil (even with the soil surface), and compacted. Numbers of emerging and surviving seedlings were recorded weekly during the germination period and at approximate monthly intervals thereafter. Foliage height (distance from cotyledons to shoot tip) of surviving seedlings was measured at the end of the growing season.

Because the rate of application of Hydrogel in 1972 appeared excessive, a second experiment was begun in 1973 to test several application rates: 0, 0.5, 1.0, 2.5, and 5.0 grams

[2]It is recommended that southwestern ponderosa pine be direct-seeded just prior to the onset of summer rains to minimize the period seeds are susceptible to depredation by rodents and other animals.

of powdered Hydrogel per 5-inch seed spot. Of 100 seed spots arranged in a grid with 4-foot spacing, 20 were randomly assigned to each rate of Hydrogel and the control. The seed spots were established in the same manner as in 1972, except that five seeds were sown per spot. Seedlings were counted on three occasions during the growing season: after the germination period (August 17), at the end of summer rains (September 21), and near the end of the fall drought (November 1).

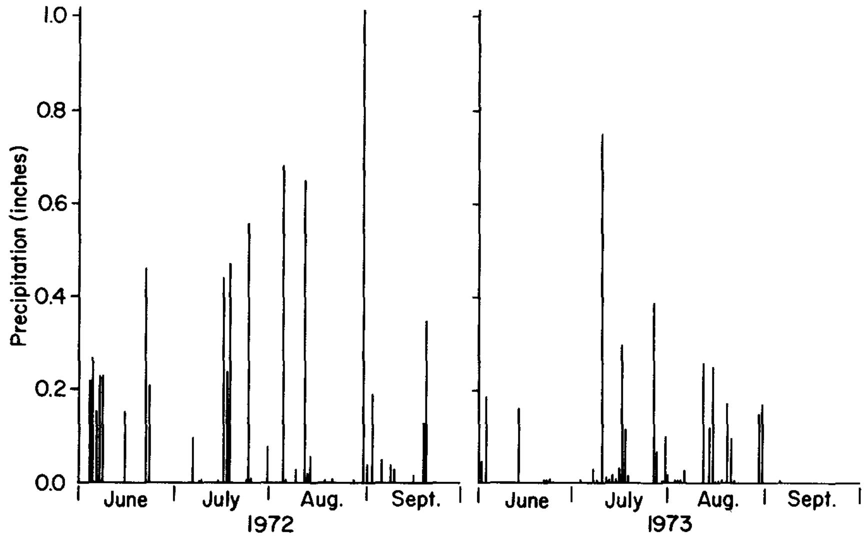

Figure 1.—Daily precipitation for the period June-September 1972 and 1973 at Flagstaff airport, 13 air miles from the study location.

Results

Germination was delayed and reduced in seed spots amended with Hydrogel in 1972 (figure 2). Initial seedling emergence was delayed by approximately 1 week. To quantify the effect on time of emergence, a calculated parameter called speed of emergence (SE) was adapted from Maguire's (3) "speed of germination", which takes both the rate and completeness of germination into account. The calculated mean SE for plots receiving Hydrogel was 0.225, compared to 0.604 for plots not receiving Hydrogel (significantly different at the 0.01 probability level). Germination culminated in spots amended with Hydrogel approximately 3 weeks earlier than the controls. Total emergence on November 6 in seed spots amended with Hydrogel was 29.1 percent less than in seed spots without Hydrogel (also significant at the 0.01 probability level).

The 8.1 percent difference in survival of emerging seedlings on November 6 (figure 2) was not significant, and diminished to 3.7 percent by June 1, 1973. Mean foliage height of surviving seedlings, measured on October 10, 1973, was similar for the two treatments: 3.5 cm for seedlings in spots containing Hydrogel and 3.3 cm for spots without Hydrogel.

The results of the 1973 experiment (figure 3) , expressed in number of live seedlings per 100 seeds, tend to support the outcome of the 1972 experiment. The presence of Hydrogel in seed spots, even small amounts, reduced the number of emerging seedlings and thus the population of surviving seedlings at the end of the growing season.

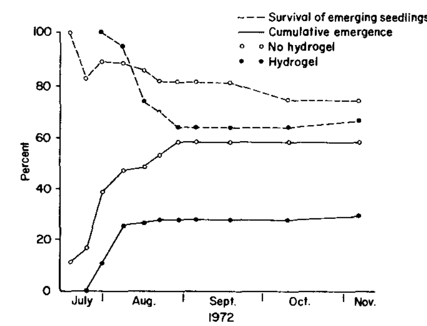

Figure 2.—Cumulative percentage emergence and percentage survival of emerging ponderosa pine seedlings in seed spots with and without the hydrophilic polymer soil amendment.

Discussion

Overall, the addition of Hydrogel to seed spots delayed and reduced seedling emergence, but did not affect survival and height growth following emergence. A likely explanation for the negative results in 1972 is excessive application rate. Excess Hydrogel could have retained too much water during moist periods, creating a poorly aerated environment for seed germination and initial seedling development. Some of the seed spots were dome-shaped during moist periods due to expansion of the Hydrogel. In the laboratory, germination of ponderosa pine seeds is retarded by excess moisture (4). Larson and Schubert (2) reported that soaking in water without aeration for 24 hours re-

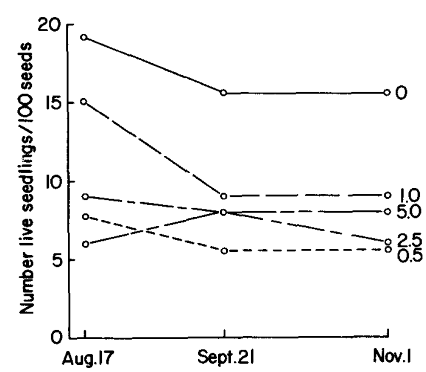

Figure 3.—Number of live seedlings per 100 seeds sown resulting from application rates of 0.0, 0.5, 1.0, 2.5, and 5.0 grams of Hydrogel per seed spot.

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duced germination of ponderosa pine seeds. Germination was better at -3 bars of osmotic potential than at either 0 or -7 bars, further illustrating the preference of ponderosa pine for an unsaturated, well-aerated germination environment.

The negative effect of low application rates and the tendency of the data for all application rates to be clustered together suggest that Hydrogel may inhibit ponderosa pine seed germination. In a separate test, however, germination of ponderosa pine seeds was found to be unaffected by 25:1 and 30:1 (water:Hydrogel, w/w) extractions of Hydrogel.

Further research is needed to identify the cause of the detrimental effect of Hydrogel on seed germination. It is apparent from these experiments, however, that any benefits from additional water retention in the soil due to the presence of Hydrogel are outweighed by the detrimental effects on ponderosa pine seed germination. Thus we must conclude that Hydrogel is not a suitable soil amendment for seeding ponderosa pine. The approach of using a hydrophilic soil amendment in seed spots to increase soil moisture retention remains plausible, however.

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