Oak Woodland Artificial Regeneration Correlating Soil Moisture to Seedling Survival[1]

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Abstract: Broadleaf P4, an hydrogel soil amendment, was tested under field and greenhouse conditions to determine if it would increase the survival and growth of coast live oak (*Quercus agrifolia*) and blue oak (*Q. douglasii*) seedlings during periods of moisture stress. Broadleaf P4 had little positive effect on seedling survival in the field, and it actually appeared to reduce survival of blue oak. Low survival was not surprising, however, because of the unfavorable growing conditions during the late winter and spring 1989. Under greenhouse conditions, coast live oak grew twice as tall as blue oak. This growth differential was expected, and it is well documented in the literature. P4 enhanced coast live oak seedling height growth with biweekly and triweekly watering, but it inhibited blue oak at all levels.

A number of oak regeneration problems have been identified in California. Poor regeneration is attributed to factors ranging from poor acorn crops and unsatisfactory fall and winter weather conditions to predation by all sizes and types of wildlife and domestic animals, to summer drought (Griffin 1971; Plumb 1980; Plumb and McDonald 198 1). Poor oak seedling establishment and survival the last 4 years (1986-1990) can partly be attributed to inadequate rainfall.

Water-absorbing polymers, used as soil amendments, have been proposed to be an aid to plant growth under conditions of moisture stress (Johnson 1984; Johnson and Veltkamp 1985). Synthetic chemicals such as Broadleaf P4,[3] that can function as super absorbers, include polyvinylalcohols, starch co-polymers, and polyacrylamide compounds (Johnson 1984). Broadleaf P4 is a hydrogel soil amendment composed of polyacrylamide polymers. These gels have the capacity to absorb 200-400 times their weight in water (figure 1), and they can last 5-10 years in the soil. As the soil dries, the gel releases over 95 percent of the water back to the soil (Piper 1989). As the polymers absorb and release water, they expand and contract which improves soil structure and increases air spaces in the soil favoring root development, especially in fine-textured soils. Irrigation can be reduced, and a soil's increased water-holding capacity should help overcome periods of drought, especially with sandy soils that have low moisture-holding capacity.

The objective of this study was to enhance the survival and growth of coast live oak (*Quercus agrifolia*) and blue oak (*Q. douglasii*) by improving soil moisture conditions. Three concentrations of the soil amendment Broadleaf P4 were tested under field and greenhouse conditions. Increased seedling survival would be an important advance in the successful regeneration and survival of oaks on harsh sites or during dry years.

METHODS

Greenhouse Test

This test was conducted in the Natural Resources Management Greenhouse at Cal Poly, San Luis Obispo, California, in winter, 1989. Soil treatments included untreated controls and soils containing at the rates of 3.2, 4.0, and 5.8 g of P4 per 0.52 cubic foot of soil. The soils were collected from under coast live oak or blue oak trees on the Blythe Ranch near Paso Robles (Plumb and Hannah 1991). The soil-P4 mix was placed in 4 x 14-inch PVC pipes and seeded with pre-germinated coast live oak or blue oak acorns. Each P4 concentration was repeated forty-five times for a total of 360 plants. The plants were mist-watered until germination. After germination, 1/3 of the seedlings were watered weekly, 1/3 biweekly, and 1/3 triweekly. Seedling survival and height growth were monitored for several months. A small soil moisture trial was also run to determine how much water would remain in the different P4 soil mixes

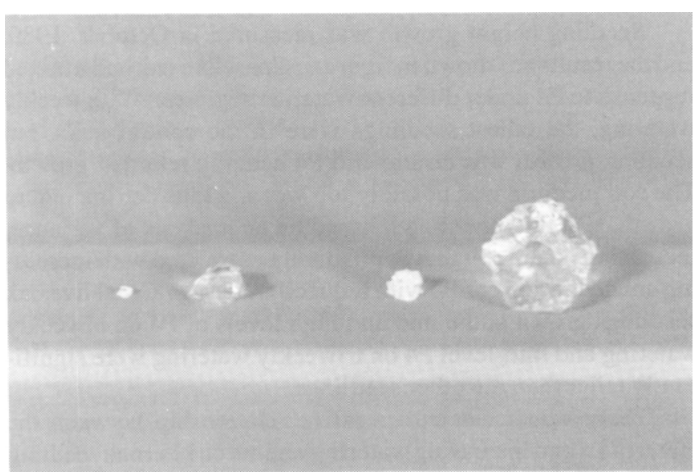

Figure 1—The massive water absorbing capacity of P4 is illustrated above with large and small granules of hydrated and unhydrated P4.

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[3]Broadleaf P4 is a trade name for polyacrylamide co-polymer. Its name is mentioned for information and does not imply endorsement by the authors.

when no plants were present. Two to three planting tubes of coast live oak and blue oak soils containing the three concentrations of P4 were watered to saturation and then sampled at weekly intervals.

Field Study

The same concentrations of P4 were evaluated at the Blythe Ranch. The soil from each seed spot was removed with a 4-inch power auger, mixed with P4, and returned to the planting hole. Two acorns were planted horizontally below the soil surface at each seed spot during the period from February to March, 1989. The seed spots were protected with a 4-inch diameter small mammal exclosure made of 1/4-inch hardware cloth. The seed spots were then watered with a quart of water to ensure that the P-4 was hydrated. The seed spots were located both in the open and under the canopy of five coast live oak and five blue oak trees. The P4 treatments were replicated four times and randomly assigned to seed spots in a 4 by 4 grid for a total of 160 spots per species.

RESULTS AND DISCUSSION

Greenhouse Test

Several of the oak seedlings were excavated to determine the distribution of roots and P4 in the soil medium. Figure 2 illustrates a coast live oak seedling grown in the high concentration of P4. Both large and small roots readily grow through the globules of hydrated P4. The effect of P4 on soil moisture after three weeks of drying (figure 3) graphically illustrates the increased level of potentially available water with the increasing concentrations of P4. The coast live oak soils were sandier than those associated with blue oak and, therefore, had lower moisture holding capacity and should benefit the most from P4 water enhancement.

Seedling height growth was measured in October, 1989, and the results are shown in figure 4. Coast live oak had a mixed response to P4 under different watering regimes. With weekly watering, the tallest seedlings were in the control soils, but seedling growth was erratic and P4 actually retarded growth. The soil medium was possibly too wet and thus detrimental to growth. On the other hand, based on an analysis of variance, increasing plant growth was positively correlated with increasing concentrations of P4 with reduced watering. Coast live oak seedlings grown at the mid and high levels of P4 on biweekly watering and mid-level P4 on triweekly watering were significantly taller than the other seedlings.

There was a clearcut negative relationship between the effect of P4 and increasing watering regime on blue oak seedling growth. Because blue oak is generally believed to grow on more xeric sites than coast live oak (Matsuda and McBride 1986), it is possible that the P4 soils were too moist for satisfactory blue oak growth.

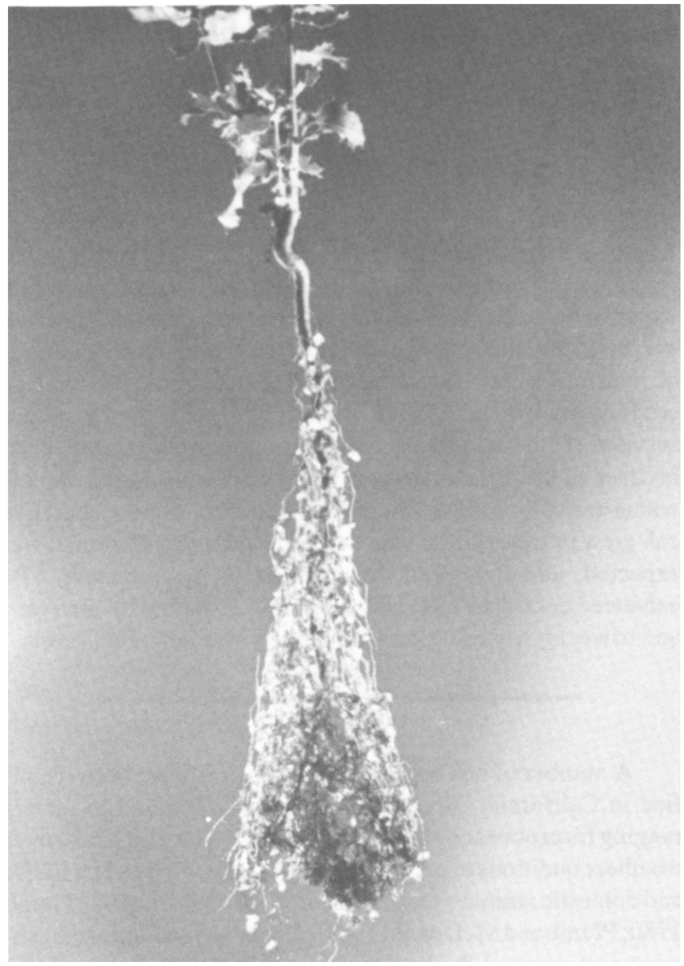

Figure 2—Both large and small roots readily grow through the globules of hydrated P4. This is illustrated here where the soil has been removed and only the gelatin-like P4 and roots remain.

Field Study

The results of P4 on seedling survival are shown in figure 5. There was no significant difference in seedling survival for any of the treatment variables including species, P4 concentration, and light exposure. If anything, P4 had somewhat of an inhibiting effect on survival. These results do not match the positive response that others have obtained. Also, they do not support the positive results obtained with coast live oak in the greenhouse test.

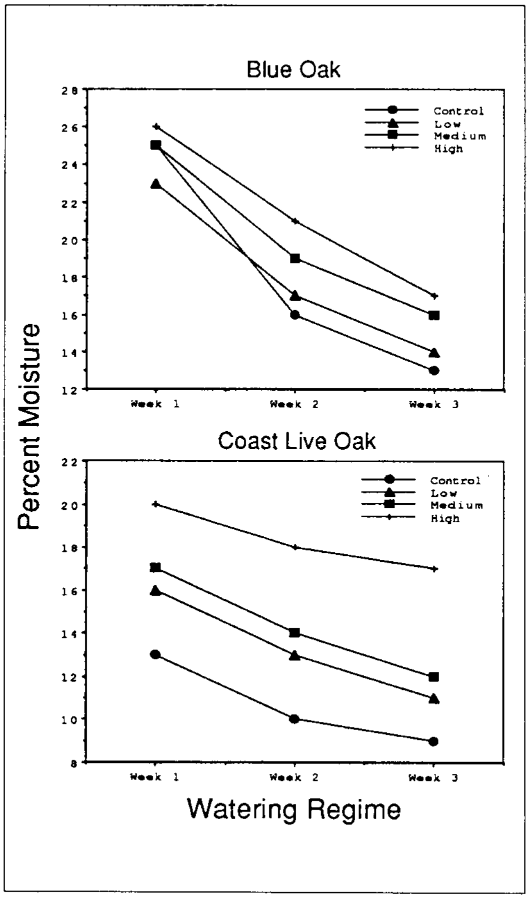

Figure 3—These graphs represent changes in percent soil moisture over a three week drying period for blue oak and coast live oak soils for different P4 concentrations.

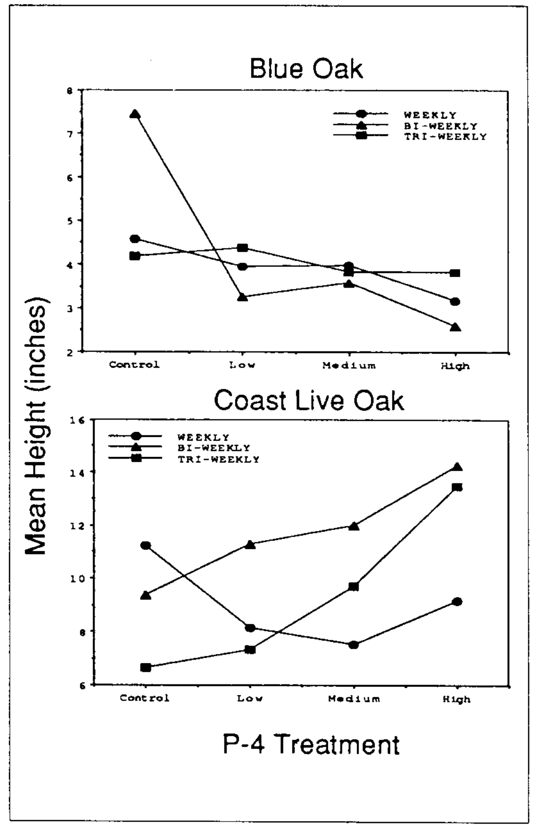

Figure 4—The effect of different concentrations of P4 on coast live oak and blue oak seedling height growth under three watering regimes are illustrated above. Coast live oak, but not blue oak, responses were significantly different, from the control treatment.

CONCLUSION

Although coast live oak responded favorably to P4 under greenhouse conditions, this positive effect did not carry over to the field study. The drought conditions in 1989 may have been too severe to have allowed any advantage of P4 to be demonstrated. More field testing should be done with coast live oak to further explore the effects of P4 on seedling survival. Some of the results of this work indicate that P4 may have kept the soil too moist for good blue oak growth; but this is contradicted by other results in this study where the available soil moisture was low, and there was still no positive effect of P4 on blue oak survival.

Finally, P4 shows enough promise that further testing should be done to determine if it can be used to enhance seedling survival.

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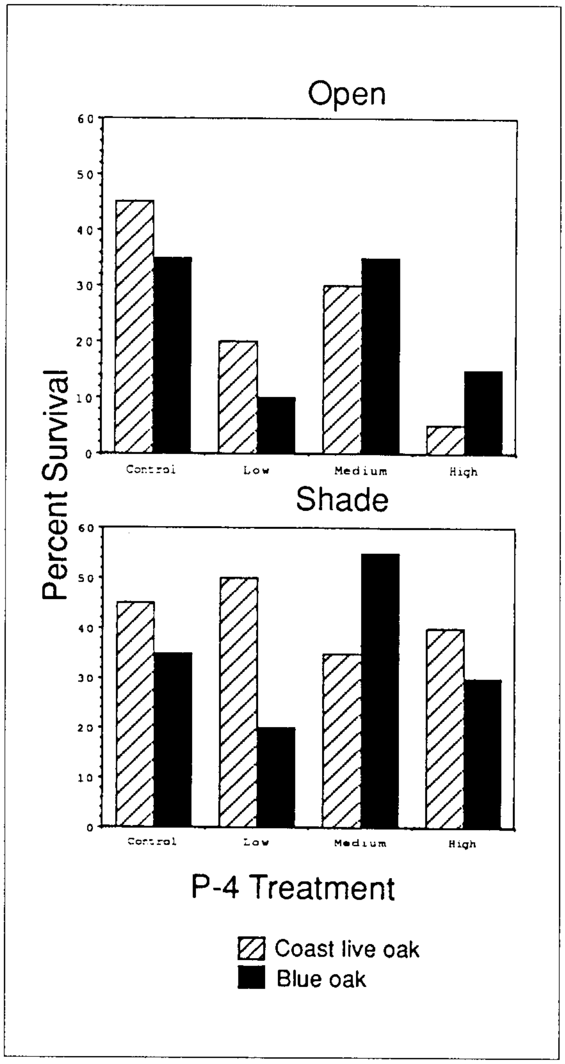

Figure 5—Blue oak and coast live oak pre-germinated acorns were planted in the ground in shaded and open areas. Seedling survival was determined for the first growing season. These graphs represent percent seedling survival for each Broadleaf P4 treatment in shaded and open exposures.

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