BLACK POLYETHYLENE MULCH INCREASES SURVIVAL AND GROWTH OF A JEFFREY PINE PLANTATION

NORBERT V. DE BYLE, [1] *Forest Ecologist*
Intermountain Forest and Range Experiment Station
Forest Service, USDA

Among site factors, available moisture is often most limiting to successful establishment of conifer plantations, especially in areas of the West where very little precipitation is received during the growing season. Several methods of reducing the critical first-year drought loss have been tested (Hunt 1963; George 1965) ; among these are mulches.

Mulches tested range from conventional materials, such as straw and sawdust, to rocks (Rotty 1958; Heidmann 1963), papers (Hunt 1963; Hermann 1964), and plastic (Walker 1961). The plastic films have several uses in agriculture (Spice 1963) ; .one of their most common uses is for mulching high-value row crops.

The microclimatic and edaphic effects of black plastic mulch were documented and compared to other mulch materials by Waggoner, Miller, and De Roo (1960). These workers found a dampened diurnal fluctuation in soil temperature; and they as well as Clarkson (1960), Black and Greb (1962), and Harris (1965) discovered that average soil temperatures were slightly higher under black plastic mulch than under the surface of bare soil. The nitrate content of plastic-covered soil also is much greater than that of bare soil (Waggoner et al. 1960; Clarkson 1960; Black and Greb 1962). Probably the most important value of the plastic for nonirrigated crops is that it retards evaporation (Lippert, Takatori, an Whiting 1964), thus conserving soil moisture for later use by the desired plants. The reflected or outgoing radiation is about the same, whether soil is bare or covered with black plastic, hay mulch, or dusty translucent plastic (Waggoner and Reifsnyder 1961) ; hence, the transpiration rate should not show any increase due to these coverings.

Only a few experiments with paper or plastic mulches in conifer plantations have been reported. Hermann (1964) greatly increased survival of Douglas-fir seedlings in Oregon by mulching with sheets of kraft paper. Walker (1961) used black plastic mulch around loblolly pine seedlings on the Georgia piedmont and improved survival over that of unmulched seedlings. Hunt (1963) tested several mulches in Oregon to improve plantation survival, and as a result recommended the application of an opaque mulch (black plastic was most durable) in the spring to shade out competing vegetation and reduce evaporation.

[1] Stationed at Forestry Sci. Lab., Logan, Utah, maintained in cooperation with Utah State University.

Methods

Site preparation in the 100-acre plantation area consisted of contour windrowing the manzanita *(Arctostaphylos patula* Greene) brush with a bulldozer, and cutting one or two small contour trenches about a foot deep in the cleared space between each windrow. In the following spring, May 1964, 2-0 and 3-0 Jeffrey pine *(Pinus jeffreyi* Grev. & Balf.) were hand planted in these trenches. The treated trees were mulched 2 weeks later, as described below.

Twenty pairs of trees at each of five sites in the plantation were selected for treatment. One tree in each pair was mulched with a 3- by 3-foot sheet of 4-mil black polyethylene. A 6-inch slit in the center of the sheet provided an opening for the tree (fig. 1). After the sheet was lowered into place, a small stone or dirt clod was placed at each end of the slit to hold down the mulch. The outer edges of the sheet were then buried in shallow trenches to prevent the sheet from blowing away. This reduced the exposed plastic surface to approximately 4 square feet around each tree.

The surface foot of soil was sampled and soil moisture content was determined at the time of mulching and again near the end of the first summer. The soil was also analyzed for texture and moisture content at 15 atmospheres.

Percent survival of both the treated and control trees was determined periodically during and at the end of the first and second growing seasons. The

Figure 1.—Jeffrey pine mulched with black polyethylene. A stone at each side of center slit holds plastic down. Edges are buried.

amount of terminal elongation was measured at the end of each year on the surving trees.

Site Description

The plantation was established in a moderately dense brush field on a gently rolling site at 6,000 feet elevation on the east side of the Sierra Nevada about 6 miles north-northwest of Verdi, Nev. Sites A, B, and D were on gentle northeast-facing slopes; site E was on a very rocky and practically level knoll top; and site C was on a steeper northeast-facing slope of approximately 30 percent.

The characteristics of the surface foot of soil varied only slightly among sites. The average composition for all sites is 57 percent sand, 28 percent silt, and 15 percent clay, with 10.6 percent water held at 15 atmospheres of tension. This somewhat rocky, sandy loam soil was probably developed in place from andesitic parent material.

The average annual precipitation is approximately 22 inches. The first growing season (1964) was very dry, and the second (1965) cooler and wetter than normal (table 1).

TABLE 1.—*Precipitation and mean temperatures by months for 1964 and 1965 growing seasons*

Months	Mean temperature		Total precipitation	
	1964	1965	1964	1965
	Degrees F.	*Degrees F.*	*Inches*	*Inches*
May	52	50	0.81[1]	0.07[2]
June	56	54	0.80	1.88
July	66	61	0.00	1.06
August	64	60	0.10	3.28
September	54	50	0.00	0.53
October	52	—	0.34	—

[1] For May 18-31 period only.
[2] For May 11-31 period only.

Results

On all sites the survival of mulched trees was better than that of the controls. There was a marked difference in survival by August 20, about 3 months after planting, when 95 percent of- the mulched trees were alive as compared to 75 percent of the controls (fig. 2). By October 30 the survival per-

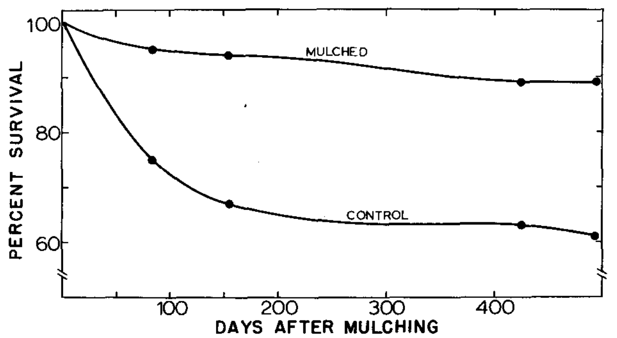

Figure 2.—Survival of mulched and control Jeffrey pine.

centages were 94 and 67, respectively. Site E, the rocky knoll, made the poorest showing; here only 15 of the 20 mulched trees and 12 of the 20 controls were alive on October 30.

The little mortality that did occur during the winter and second growing season was about equally divided between mulched and control trees. By October 5, near the end of the second growing season, 89 percent of the mulched trees and 61 percent of the control trees were still alive.

Growth of the surviving mulched and control trees was similar during the first season (table 2). By application of a "t" test on paired replicates, the second season terminal elongation of mulched trees was significantly greater than that of the controls. The average elongation was 7.89 cm. on mulched trees as compared to 4.44 cm. on controls. As a result of this second-year elongation, the total growth for both years was significantly more on the mulched trees. The average mulched tree grew 8.9 cm. in 2 years, whereas the average control tree grew only 5.5 cm.

By August 21 of the first season, the surface foot of soil under the plastic mulch contained an average of 4.1 percent more moisture than did the bare soil near the control trees, where the soil was at or near the wilting point (fig. 3).

By the end of the second season, many of the mulch sheets had become so perforated that they probably had lost their effectiveness. Other mulch sheets had by then become almost entirely buried.

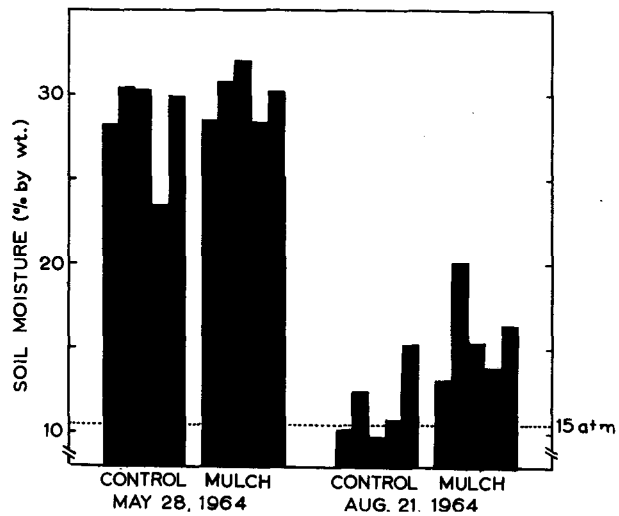

Figure 3.—Moisture depletion in the surface foot of soil under mulched and control Jeffrey pine during the first growing season. Each of the five sites, A through E, is represented from left to right by individual bars within each group.

TABLE 2.—*Average terminal growth of surviving seedling pairs, 1964 and 1965*

Sites	1964 Mulched	1964 Control	1964 Diff.	1965 Mulched	1965 Control	1965 Diff.	Total[1] Mulched	Total[1] Control	Total[1] Diff.
	Cm.	*Cm.*	*Cm.*	*Cm.*	*Cm.*	*Cm.*	*Cm.*	*Cm.*	*Cm.*
A	1.96	1.80	0.16	8.05	4.41	3.64*	10.00	6.21	3.79*
B	0.81	0.79	0.02	9.65	4.75	4.90**	10.52	5.62	4.90**
C	0.30	0.13	0.17	4.11	2.15	1.96	4.42	2.26	2.15
D	0.99	1.17	—0.18	9.49	6.13	3.36*	10.52	7.38	3.14
E	0.84	1.02	—0.18	5.69	3.10	2.59	6.48	4.34	2.15
All	0.94	0.95	—0.01	7.89	4.44	3.45**	8.90	5.51	3.39**

[1] Only those pairs surviving both years are used in the total analysis. Since the number of surviving pairs did not remain the same, the 1964 and 1965 average growth values cannot be added to show total growth.

* Significant at the 5-percent probability level.

** Significant at the 1-percent probability level.

and still others were exposed along the edges and could easily be blown away. Apparently this disturbance was mostly caused by rodent action, and to a much lesser extent' by erosion. That more than half of the mulch sheets would be very effective during the third growing season is doubtful.

Discussion

Mulching with black plastic may improve survival and growth in plantations and therefore aid establishment of Jeffrey and ponderosa pine on sites near the lower elevational limit for these species and on xeric sites anywhere. The principal benefit of the plastic as revealed in this study was probably its ability to prevent evaporation from the soil. It made more water available to the seedling trees and extended the availability of water later into the critically dry growing season. The added moisture was probably responsible for the dramatically different survival records of mulched and control trees during the first summer.

The mulched trees not only survived better, but also grew much more during the second season than did the unmulched controls. This increased growth is perhaps attributable to their better establishment and greater buildup of stored food reserves during the first year. The increased food reserves at the end of the 1964 growing season would have resulted in greater terminal elongation of the mulched trees in the 1965 season. The slight increase in soil temperatures and the possible increase in available nitrogen due to plastic mulching (not tested in this study) also may have contributed to the greater growth of the mulched trees.

Black plastic will help suppress competing vegetation. However, in this study, competition from other plants developing within a few feet of the seedlings did not appear to be limiting for either the mulched or control trees. The scalping and furrowing prior to planting eliminated existing vegetation, and only a sparse cover of forbs, especially mullein *(Verbascum thapsus L.),* became established on this bared soil during the subsequent two growing seasons.

Although it is evident that increased survival and better growth can be realized by mulching pine plantations on sites similar to those described in this paper, the question remains, is it worth the cost?

Hand placement of mulch sheets, as used in this study, is time consuming and may double the cost of planting. More efficient methods of mulching could, no doubt, be developed if it is deemed worthwile as a management practice. Tractordrawn or mounted machines are now available to apply plastic mulch in continuous bands in row crops. These might be modified for tree planting and make mulching an economically feasible practice in the timber growing process.

On the other hand, vegetation is badly needed on many harsh sites, which are frequently xeric sites, for soil or watershed protection. There the use of hand-applied black plastic mulch is recommended if it will significantly improve survival or growth of the planted stock. Successfully establishing vegetation on these areas is usually difficult and expensive. Here mulching may actually reduce the cost by making other expensive practices and replanting unnecessary.

Literature Cited

Black, A. L., and Greb, B. W.
1962. Nitrate accumulation in soils covered with plastic mulch. Agron. J. 54: 366.

Clarkson, V. A.
1960. Effect of black polyethylene mulch on soil and microclimate temperature and nitrate level. Agron. J. 52: 307-309.

George, Ernest J.
1965. Methods of improving conifer survivals. Tree Planters, Notes 71: 6-13.

Harris, R. E.
1965. Polyethylene covers and mulches for corn and bean production in northern regions. Amer. Soc. Hort. Sci. Proc. 87: 288-294.

Heidmann, L. J.
1963. Effects of rock mulch and scalping on survival of planted ponderosa pine in the Southwest. U.S.D.A. Forest Serv. Res. Note RM-10.

Hermann, Richard K.
1964. Paper mulch for reforestation in southwestern Oregon. J. Forest. 62: 98-101.

Hunt, Lee O.
1963. Evaluation of various mulching materials used to improve plantation survival. Tree Planters' Notes 57: 19-22.

Lippert, L. F., Takatori, F. H., and Whiting, F. L.
1964. Soil moisture under bands of petroleum and polyethylene mulches. Amer. Soc. Hort. Sci. Proc. 85: 541546.

Rotty, Roland.
1958. Three rocks-for better planting survival. Tree Planters' Notes 33: 3-5.

Spice, H. R.
1963. Polyethylene films in agriculture. World Crops 15: 239-245, 249.

Waggoner, Paul E., Miller, Patrick M., and De Roo, Henry C. 1960. Plastic mulching-principles and benefits. Conn. Agr. Exp. Sta. Bull. 634, 44 p.

Reifsnyder, W. E.
1961. Difference between net radiation and water use caused by radiation from the soil surface. Soil Sci. 91: 246-250.

Walker, L. C.
1961. Black plastic "mulch" for pine planting. Tree Planters' Notes 45: 1.