# INFLUENCE OF MULCH MATERIALS ON GROWTH OF GREEN ASH

by Margaret Litzow and Harold Pellett[1,2]

**Abstract.** Six mulch materials applied to green ash were evaluated for effects on tree growth, soil moisture retention and temperature modification characteristics. The largest percentage increases in growth were observed on trees mulched with hay, black plastic and Turface mulches. In early spring, trees mulched with black plastic or nonmulched had higher soil temperatures but later in the season temperature differences among mulch treatments were much smaller. During the 1980 growing season moisture differences became apparent in late June when wood chip and redwood bark treatments had the highest soil moisture and nonmulched and Turface treatments had the lowest. Following a rainfall, the nonmulched, wood chip and redwood bark treatments had the highest soil moisture. Replacement of black plastic and hay mulches was necessary after two growing seasons.

Mulch materials are used widely in landscape plantings but little research has been done to compare the influence of various materials on shade tree establishment. The literature abounds with research work on mulches but work on woody plant species is limited primarily to tree seedlings in reforestation projects.

Materials recommended and used as mulches have varied from black plastic to corn cobs to sweet alyssum to porous blocks of pea gravel (12, 13, 22). A good mulch should help conserve moisture, control weeds, be economical, readily available, and aesthetically compatible with the surroundings. Mulches have been tested for their effect on soil moisture, fertility, temperature, and on plant growth, development and survival. Comparisons between plants that were not mulched or cultivated and mulched plants show not only increased growth and better root systems for mulched plants but increased survival as well (14, 15, 25, 27, 29, 37). As the mulched area around hardwood seedlings increased from 1 foot in diameter to 4 feet an 85% increase in growth was reported (1). Studies with Douglas-fir also show increased survival rates when comparing no mulch (10.4% survival) to 18-inch (40.3%) or 36-inch (78.2%) square sheets of Kraft paper (14). Although larger increases in diameter of trees grown in the nursery with Alsike clover compared with clean cultivation have been reported (12), it is generally agreed (17) that plant competition has detrimental effects on shade trees. Increased plant growth and survival have been reported for black plastic (2, 3, 8, 9, 11, 15, 16, 18, 19, 23, 25, 29, 31, 32, 33, 34, 36, 37), black plastic plus bark (31, 32, 33, 34, 35, 36), bark, (32, 33, 34, 35, 36), hay and straw (4, 19, 25, 26), wood chips (5, 10, 19), Kraft paper (14) and green plastic (26). Whitcomb (31, 32, 33, 34, 35, 36), however, found greater growth rates for Pfitzer juniper and Chinese pistache when they were not mulched. Increased plant mortality has been reported for plants mulched with spruce needle litter, white fiberglass batts (21), sawdust (20, 24), black plastic under bark (31, 32, 33, 34, 35, 36), and hay mulches (7). In cases where injury and/or death of mulched plants occurred, it was postulated that the cause was increased temperatures under the mulch in the summer (21, 24) or the increased temperatures that lengthened the growing season in the fall thereby making plants susceptible to freeze injury (7). In one study (20), trees mulched with sawdust suffered heavier rabbit damage than nonmulched trees. Whitcomb and coworkers (31, 32, 35, 36) postulate that injury to Chinese pistache mulched with black plastic under bark may have been caused by decreased soil oxygen with a high percentage of the resulting shallow root system being frozen longer during the winter. Top injury may have been due to dessication. However, they presented no supportive data.

Soil temperature measurements taken during

---

[1]Scientific Journal Series Paper No. *12,268* of the Minnesota Agricultural Experiment Station, St. Paul, MN. Mention of a trademark, proprietary product, or vendor does not consitute a recommendation or warranty by the University of Minnesota and does not imply approval of it to the exclusion of other products or vendors that may be suitable.

[2]This research was supported by a grant from the Minnesota State Department of Agriculture Shade Tree Program.

spring and summer at depths of 2 inches or more have shown that temperatures are higher under black plastic (16, 18, 23), and green plastic (26) and lower under cinder and wood chip mulches (10, 23) than nonmulched plots. Soil temperatures under black plastic can, however, be equal to or lower than in bare soil (19, 26, 28). In a Canadian study, soil temperatures under a sawdust mulch were lower than in check plots until the fall when the soil temperatures became higher under the sawdust because of a slower heat loss (30). Fine textured mulch materials and deeper mulches have better insulative properties (13).

Soil moisture studies have reported higher moisture levels under black plastic (2, 23), coarse, medium and fine bark (13), corn cobs (13, 19), hay (7), cinder (23), bark, plastic under bark (31, 32, 35, 36) and wood chips (10, 19) than under nonmulched areas. Other studies (16) have reported no differences in moisture between nonmulched plots and plots mulched with black plastic.

There have been reports of increased levels of calcium, magnesium and potassium under hardwood bark mulch (13), increased potassium levels under wood chips (10), and increased nitrate levels below black plastic covered soil (28). A recent study (10) also found that wood chip mulches had neither an effect on population levels of *Pythium* spp. and *Fusarium* spp., two potential disease-causing fungi, nor on plant parasitic nematodes.

As cities and other agencies and institutions continue their tree planting programs, planting practices that maximize survival and growth rates are critical. A mulch study was initiated in spring, 1979, at the University of Minnesota Landscape Arboretum to determine the effectiveness of various mulch materials for shade tree establishment.

**Materials and Methods**

During spring, 1979, ninety 4′ branched green ash (*Fraxinus pennsylvanica* Marsh.) were planted 3.3 m between rows and 2.1 m between plants within rows. The soil texture was a clay loam. The following treatments were applied May 1-7:

1. Weed - Chek fiberglass landscape mat
2. wood chips 5 cm deep
3. hay 15 cm deep
4. Turface (Calcined Clay) 5 cm deep over 4 mil black plastic
5. redwood bark 5 cm deep over 4 mil black plastic
6. 4 mil black plastic
7. control — no mulch

The soil surface around each tree was modified to direct rainfall toward the plant's base. An area 1.8 m by 1.8 m was mulched around each tree. A completely random design with 10 replications was used. Tree growth (tree circumference 30 cm up from the mulch) was measured at the end of each of three growing seasons. Soil moisture (tensiometer readings at a 15 cm depth) and temperature (potentiometer readings from thermocouples at a 15 cm depth) were monitored approximately every 10 days throughout the first two growing seasons. Soil temperature was monitored on five trees per treatment and tensiometer readings on three trees per treatment. Fall, 1981, all trees were cut at the soil line and the leaves removed. The trees were weighed and the mulches removed to determine surface root growth if any. Two trees per treatment were dug with a tree spade and vertical root distribution was observed.

**Results and Discussion**

Table 1 summarizes the yearly and final growth data. The greatest final increases in growth were observed with the hay, black plastic and Turface mulches in that order. Treatment rank based on yearly growth increase measurements remained consistent from year to year and correlated well with the final fresh weight.

Soil moisture and temperature data for each mulch varied with the time of year. In general, the black plastic and no mulch treatments had higher soil temperatures during the growing season. These differences in soil temperature were most pronounced in early spring differing by as much as 11 °C immediately after soil thaw (Table 2 — temperatures for April 21). From late spring to fall these differences were much smaller. In the spring warmer soil temperatures would be an advantage for early

**Table 1. Yearly % trunk caliper increase and final top fresh weight (leaves removed) of green ash mulched with various materials.**

| | GROWING SEASONS | | | | | | Average fresh weight | |
|---|---|---|---|---|---|---|---|---|
| | 1979 | | 1980 | | 1981 | | | |
| Mulch | % caliper increase | rank | % caliper increase | rank | % caliper increase[z] | rank | kilogram | rank |
| Weed-Chek fiberglass | 12 | 3 | 56 | 6 | 159[b] | 7 | 3.2 | 6 |
| Wood chips | 9 | 5 | 63 | 5 | 172[b] | 4 | 4.2 | 3 |
| Hay | 16 | 2 | 84 | 2 | 246[a] | 1 | 5.4 | 1 |
| Turface | 12 | 3 | 82 | 3 | 209[a,b] | 3 | 4.0 | 4 |
| Redwood bark | 10 | 4 | 64 | 4 | 171[b] | 5 | 3.4 | 5 |
| Black plastic | 18 | 1 | 96 | 1 | 225[a] | 2 | 4.9 | 2 |
| No mulch | 9 | 5 | 48 | 7 | 162[b] | 6 | 3.2 | 6 |

[z]Mean separation by Duncan's multiple range test, 1% level. Means not followed by the same letter differ significantly at the 1% level.

**Table 2. Average soil temperature (in Celsius degrees) under various mulch materials.**

| | 1980 | | | | | |
|---|---|---|---|---|---|---|
| Mulch | Apr. 21 | May 19 | June 18 | July 18 | Aug. 25 | Oct. 8 |
| Weed-Chek fiberglass | 8 | 11 | 19 | 23 | 21 | 13 |
| Wood chips | 2 | 11 | 19 | 24 | 21 | 14 |
| Hay | 6 | 11 | 19 | 23 | 21 | 14 |
| Turface | 8 | 11 | 19 | 24 | 21 | 13 |
| Redwood bark | 6 | 12 | 20 | 23 | 22 | 14 |
| Black plastic | 12 | 11 | 21 | 25 | 23 | 15 |
| No mulch | 13 | 12 | 21 | 24 | 22 | 14 |

**Table 3. Average soil moisture under various mulch materials. Soil moisture is tensiometer readings (the lower the value, the greater the soil moisture).**

| | 1980 | | | | | |
|---|---|---|---|---|---|---|
| Mulch | June 25 | July 9 | July 24 | July 31 | Aug. 25 | Sept. 4 |
| Weed-Chek fiberglass | 32 | 100 | 29 | 33 | 6 | 0 |
| Wood chips | 6 | 85 | 17 | 60 | 14 | 0 |
| Hay | 22 | 100 | 52 | 100 | 45 | 0 |
| Turface | 51 | 100 | 50 | 62 | 24 | 0 |
| Redwood bark | 9 | 100 | 14 | 64 | 23 | 0 |
| Black plastic | 41 | 90 | 32 | 92 | 33 | 0 |
| No mulch | 63 | 100 | 16 | 100 | 36 | 0 |

root growth. During spring the nonmulched trees and the trees grown with black plastic broke bud and had leaf expansion earlier than trees with the other mulches. This correlates with the higher soil temperatures observed with these two treatments.

During the 1980 growing season, soil moisture differences became apparent in late June (Table 3). The wood chip and redwood bark treatments had the highest soil moisture and the nonmulched and Turface treatments had the lowest. By early July (July 9) the soil moisture was low on all treatments. Following a mid-July rainfall, the nonmulched, wood chips and redwood bark treatments had the highest soil moisture (July 24), but by the end of July (July 31) the nonmulched, hay and black plastic treatments had the lowest soil moisture levels. Soil moisture differences were small during August through mid-October (August 25 and October 8).

Replacement was necessary after two growing seasons on all black plastic mulches because the plastic was torn and brittle, on all hay mulches because of decomposition, and on two of the fiberglass mulches because of rodent damage. Limited durability has been reported for black plastic (8), white plastic (15), green plastic (25), and petroleum (water emulsion of petroleum resins sprayed on the ground), wood chip, and clear plastic mulches (23). These reports are not consistent as other researchers have found black plastic very durable for three (23, 25) and five (15) years.

The fibrous feeder roots under all mulches were concentrated in a narrow band in the top three inches of soil. Larger roots were found throughout the soil ball. When the mulches were removed, some surface roots were found only with the Turface and redwood bark but not nearly to the extent that has been previously reported (5, 31, 32, 34, 35, 36).

When considering mulching woody ornamentals no one mulch will satisfy all requirements. One must consider cost, availability, longevity of the mulch, appearance, ease of application, water retention and percolation traits, soil temperature modification, maintenance practices and overall plant growth. The requirements of each situation and of the plant materials will determine the appropriate mulch.

## Literature Cited


1. Anonymous. 1946. *Scalping and mulching increases the growth of hardwood seedlings planted in Iowa prairies.* Rep. Cent. St. For. Exp. Sta. 1945. pgs. 11-13.
2. Bowersox, T.W. and W.W. Ward. 1968. *Juvenile growth and yield of hybrid poplar clone NE-388.* Res. Briefs Sch. For. Resour. Pa. St. Univ. 3: 2-6.
3. Bowersox. T.W. and W.W. Ward. 1970. *Black polyethylene mulch — An alternative to mechanical cultivation for establishing hybrid poplars.* Tree Planters' Notes 21: 21-24.
4. Buller, G.B. and J.A. Gibbs. 1952. *Planted loblolly pines respond to mulching.* J. For. 50: 317-318.
5. Champagne, E.G. 1954. Wood chip mulch improves red pine survival. Sta. Note Cent. St. For. Exp. Sta. 86. 2 pp.
6. Cooper, G.R. and J.M. Aikman. 1950. *Some responses of black locust to planting site treatment.* Proc. Iowa Acad. Sci. 57: 73-90.
7. Creech, J.L. and W. Hawley. 1960. *Effects of mulching on growth and winter injury of evergreen azaleas.* Proc. Am. Soc. Hort. Sci. 75: 650-657.
8. DeByle, N.V. 1969. *Black polyethylene mulch increases survival and growth of a Jeffrey Pine plantation.* Tree Planters' Notes 19: 7-11.
9. Fortney, W.R. 1959. *The effects of black plastic on the growth rates of four species of nursery plants.* Ill. St. Flor. Assoc. Bull. No. 199: 14.
10. Fraedrich, S.W. and D.L. Ham. 1982. *Wood chip mulching around maples: Effect on tree growth and soil characteristics.* J. Arboric. 8: 85-89.
11. Gabriel, W.J. 1962. *Experience with black polyethylene film for mulching hardwood transplants.* Tree Planters' Notes No. 51: 25-28.
12. Galle, F. and L.C. Chadwick. 1948. *The effect of mulches and companion crops on soil aggregation and porosity and on the growth of some woody ornamental plants in the garden and nursery.* Proc. Am. Soc. Hort. Sci. 52: 517-524.
13. Gartner, J.B. 1978. *Using bark and wood chips as a mulch for shrubs and evergreens.* Am. Nurseryman 147: 9, 53-55.
14. Hunt, L.O. 1963. *Evaluation of various mulching materials used to improve plantation survival.* Tree Planters' Notes No. 57: 19-22.
15. Loewenstein, H. and F.M. Pitkin. 1970. *Ponderosa pine transplants aided by black plastic mulch in Idaho plantation.* Tree Planters' Notes 21: 23-24.
16. Lopushinsky W. and T. Beebe. 1976. *Effect of black polyethylene mulch on survival of Douglas-fir seedlings, soil moisture content, and soil temperature.* Tree Planters' Notes. 27: 7-8.
17. Messenger, A.S. 1976. *Root competition: Grass effects on trees.* J. Arboric. 2: 228-230.
18. Nilov, V.N. 1975. *Use of black plastic film as a mulch in growing trees and shrubs in nurseries.* Lesnoe Khozyaistvo 4:12-14.
19. Pellett, H. 1971. *Influence of various mulch materials on soil environment and growth of Zabel honeysuckle.* Misc. Report 104. Agric. Exp. Sta., Univ. of Minn., pgs. 12-14.

20. Pruett, E. 1959. Mulch around newly planted trees can be detrimental. Sta. Note Cent. St. For. Exp. Sta. No. 132. 2 pp.
21. Richards, N.A. 1970. *Adverse effects from mulching spruce seedlings.* Tree Planters' Notes 21:11-12.
22. Richards, S.J. 1965. *Porous block mulch for ornamental plantings.* Calif. Agric. 19: 12-14.
23. Rietveld, W.J. and L.J. Heidmann. 1974. Mulching planted ponderosa pine seedlings in Arizona gives mixed results. U.S.D.A. For. Ser. Res. Note, Rocky Mt. For. and Range Exp. Sta. No. RM-257. 3 pp.
24. Salisbury, P.J. and J.R. Long. 1959. *High temperature damage to Douglas fir seedlings.* Bi-m. Progr. Rep. Div. For. Biol. Dep. Agric. Can. 15: 3.
25. Stephens, G.R. 1965. *Accelerating early height growth of white spruce.* J. For. 63: 671-673.
26. Stephens, G.R. 1965. *Yellow-poplar seedlings respond to soil temperature.* J. For. 63: 701-703.
27. Stuckey, I.H. 1961. *Root growth of taxus.* Am. Nurseryman 114: 14, 117, 118.
28. Waggoner, P.E., P.M. Miller and H.C. De Roo. 1960. Plastic mulching: Principles and benefits. Conn. Agri. Exp. Sta. Bull. 634. 44 pp.
29. Walker, L.C. 1961. *Black plastic "mulch" for pine plantings.* Tree Planters' Notes. No. 45: 1.
30. Webster, G.R. and R.M. Adamson. 1960. *Effects of sawdust used as a mulch and as a soil amendment on soil temperatures under irrigated and unirrigated conditions.* Can. J. Soil Sci. 40: 207-211.
31. Whitcomb, C.E. 1977. *Effects of black plastic and mulches on growth and survival of landscape plants.* Research Report P-760. Ok. Ag. Exp. Sta., pgs. 14-17.
32. Whitcomb, C.E. 1978. *Effects of black plastic and mulches on growth and survival of landscape plants.* Research Report P-777. Ok. Ag. Exp. Sta., pgs. 13-17.
33. Whitcomb, C.E. 1979. *Factors affecting the establishment of urban trees.* J. Arboric. 5: 217-219.
34. Whitcomb, C.E. 1979. *Factors affecting the establishment of urban trees.* Research Report P-791. Ok. Ag. Exp. Sta., pgs. 3-7.
35. Whitcomb, C.E. 1979. *Effects of black plastic and mulches on growth and survival of landscape plants.* Research Report P-791. Ok. Ag. Exp. Sta., pgs. 8-11.
36. Whitcomb, C.E. 1980. *Effects of black plastic and mulches on growth and survival of landscape plants.* J. Arboric. 6:10-12.
37. Yawney, H.W. and C.M. Carl. 1970. A sugar maple planting study in Vermont. U.S.D.A. For Ser. Res. Pap. Ntheast For. Exp. Sta. No. NE-175. 14 pp.

*University of Minnesota Landscape Arboretum*
*3675 Arboretum Drive*
*Box 39, Chanhassen, MN 55317*

---

## ABSTRACT

Smith, E.M. and S.A. Treaster. 1982. **Sodium chloride phytotoxicity to sugar maple.** OARDC Research Circular 268. pp. 7-8.

Sodium chloride (NaCl), the most commonly used salt for de-icing streets, may affect plant growth by: 1) increasing osmotic pressure differences and causing desiccation, 2) accumulating specific ions in toxic concentrations within plant tissues, and 3) altering mineral nutritional balances. High salt concentrations are manifested in sugar maple as marginal necrosis, small or pale green leaves, premature defoliation, and terminal twig dieback which leads to tree decline. The usefulness of sugar maple planted along streets is limited due to its habit of developing leaf necrosis beginning in early to mid-summer and continuing throughout summer and autumn. In many instances, the condition is related to stress from lack of adequate soil moisture. However, in certain situations, de-icing salts may be a significant contributor to the necrosis and early leaf defoliation. Sodium chloride was applied over a 3-year period under 10-year-old sugar maple trees isolated from highways to correlate foliar injury with known rates of application to the soil surface. Increasing foliar necrosis and defoliation were tested with increasing rates and times. The most severe phytotoxicity was observed at foliar sodium levels of 82-452 ppm, which corresponded to sodium chloride treatments of 8-20 lb/100 sq. ft.