Aspen Wood Chip and Stone Mulches for Landscape Plantings in Interior, Alaska[1]

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Abstract

Five woody landscape plants were grown on five mulch treatments: 2.5 or 5 cm (1 or 2 in) crushed basaltic rock, 5 or 10 cm (2 or 4 in) of aspen wood chips and a non-mulched control, to determine the usefulness of these mulches in subarctic landscape plantings. Weed control was best, but growth and plant nutrition poorest on the wood chip mulches. White spruce, Siberian crabapple, Peking cotoneaster,, and rugosa rose had low levels of leaf nitrogen on the wood chip plots, and all species except cotoneaster and lodgepole pine showed significant N deficiency symptoms after 2 years. With the exception of the roses, all species grew best on the stone mulch plots. Roses grew vigorously on the stone mulches and the unmulched soil, but were subject to winter dieback. After 3 years, their total biomass did not exceed the recumbent, spindly and nitrogen deficient roses that were growing on the wood chip mulches. Plant growth, nutrition, and weed control were best achieved on the 5 cm (2 in) stone mulch plots.

Index words: plant nutrition, mulch, soil temperature

Species used in this study: Siberian crabapple (*Malus baccata* (L.) Borkh.); lodgepole pine (*Pinus contorta* Dougl. ex. Loud var. *latifolia* Engelm. ex. S. Wats.); white spruce (*Picea glauca* (Moench) Voss); Peking cotoneaster (*Cotoneaster acutifolius* Turcz.); rugosa rose (*Rosa rugosa* Thunb.); quaking aspen (*Populus tremuloides* Michx.).

Significance to the Nursery Industry

Nurserymen in interior, Alaska have questioned the use of organic mulches in perennial landscape plantings because temperature reductions beneath these mulches on existing cold soils might be harmful to plant growth. Despite this concern, bark and wood chip mulches routinely appear in landscape bid specifications. This research was conducted using common landscape plant materials to determine if a locally-available product, wood chips, would be detrimental to plant growth. As a comparison, another possible mulching material, crushed basaltic rock, was tested. The results of this study indicate that wood chips cannot be recommended in landscape plantings because of their effect on soil temperature and nitrogen availability. The stone mulch is a useful alternative to the wood chips and provides optimum growing conditions including good soil moisture levels and reduced weed growth. Additional studies are needed to determine if the detrimental effects of the wood chip mulches can be ameliorated by the use of greater amounts of nitrogen fertilizer.

Introduction

Cold soils during the growing season in subarctic Alaska are a significant factor in limiting plant growth, delaying maturity and reducing yields of fruits and vegetables. Many warm season vegetable crops and strawberry cultivars do not mature without the soil-warming benefits of clear polyethylene mulch (2, 3, 4, 8, 9). Organic mulches reduce soil temperatures, and their use in fruit and warm season vegetable crop production is not recommended. Similar recommendations have not been made for perennials such as landscape ornamentals. Nevertheless, bark and wood chip mulches are routinely specified in subarctic landscape plantings to reduce maintenance such as weeding and irrigation. The objective of this research was to study the effect of mulches on growth, nutrition and winter survival of native and introduced perennial landscape plants in interior, Alaska.

Materials and Methods

In June 1985, field plots were established at the Alaska Agricultural and Forestry Experiment Station, Fairbanks on Tanana silt loam soil with 1120 kg/ha (1000 lb/a) 10N- 8.6P-16.6K (10-20-20) fertilizer incorporated into the top 15 cm (6 in) of soil. Mulch treatments consisted of 10 m^2 (108 ft^2) plots of five mulches: a 2.5 cm (1 in) or 5 cm (2 in) layer of crushed black basaltic rock; a 5 cm (2 in) or 10 cm (4 in) layer of quaking aspen (*Populus tremuloides*) wood chips; and a non-mulched control. The rock consisted of a maximum 2.2 cm (0.87 in) aggregate for road surfaces. The aspen was chipped one week prior to mulching; 82% of the chips by weight were less than 2 cm (0.75 in) diameter.

Five perennial landscape species commonly used under Alaska conditions were planted through each of these mulch treatments. Three species were purchased from a commercial nursery in Montana: *Cotoneaster acutifolius*, Peking cotoneaster, as 46–61 cm (18–24 in) bareroot seedlings; *Malus baccata*, Siberian crabapple, as 61–91 cm (2–3 ft) bareroot seedlings; and *Rosa rugosa*, rugosa rose, purchased as seed and planted as six-month greenhouse-grown seedlings. Native *Picea glauca*, white spruce seed was collected near Fairbanks and planted as six-month, greenhouse-grown seedlings. *Pinus contorta* var. *latifolia*, lodgepole pine, seeds were collected from the Ethel Lake area, Yukon Territory, Canada and planted as six-month, greenhouse-grown seedlings. These species were planted in June and July, 1985 and hand watered once to aid plant establishment. The four, single-plant replicates of the 5 mulch treatments were completely randomized in the field.

[1]Received for publication September 13, 1991; in revised form November 14, 1991. Journal article no. 217 from the Alaska Agricultural and Forestry Experiment Station, Fairbanks.

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Soil moisture was recorded weekly during the growing season using tensiometers inserted to a 15 cm (6 in) depth. Temperature was recorded hourly during the three-month growing season using portable Grant recorders and thermistors located 10 cm (4 in) beneath the soil surface and 30 cm (12 in) above the mulch surface. Daily maximum and minimum temperatures were used to obtain cumulative soil and air thaw degree days. An accurate base temperature was not known particularly for the native species, therefore the 0°C (32°F) base was used in order to provide a comparison among treatments of heat unit accumulation during the growing season. In addition, the length of the frost free season was recorded along with dates of first budbreak.

Beginning in 1986, plots were fertilized using the same type and rate of fertilizer as in 1985, but the fertilizer was injected into the soil to a depth of 15 cm (6 in) in a uniform pattern across plots. Soil tests were conducted annually during the third week of July by collecting four samples selected at random per plot. These samples were combined into one composite sample per plot. Soils from the 5–10 cm (2–4 in) depth were analyzed for pH and available N, P and K. Soils were air dried, ground, and extracted with KCL for analysis of available N and with Mehlich-3 extractant for available P using an auto analyzer. Soils treated with Mehlich-3 extractant were analyzed for available K using atomic absorption spectrophotometry.

Weeds were harvested during the last week of each month during the three-month growing season, washed, divided by species and dried in a forced-draft oven at 65°C (149°F) for 24 hr. Monthly and total seasonal biomass accumulation for each weed species were recorded.

Plots were monitored for three complete growing seasons beginning in 1986. On July 20, 1987, #25 leaves were harvested from each plant by stratified random sampling. Leaves were dried for 24 hr in a forced-draft oven at 65°C (149°F), ground, wet-digested, and analyzed for percent N and P using an auto analyzer and K by atomic absorption spectrophotometry. In August 1988 plants were measured for maximum height and spread, then excavated carefully to retain as many roots as possible. Plants were divided into roots, shoots, leaves and fruit, and each was coarsely-shredded to hasten drying. Plants were dried in a forced-draft oven for 24 hr at 149°F (65°C), then weighed.

Results and Discussion

Soil temperatures at the 10-cm (4 in) depth were consistently lower for the wood chip treatments than the stone or control treatments for every month of the growing season. The soil thaw degree day accumulation was 20% lower for the 5 cm (2 in) wood chip plots and 24–27% lower for the 10 cm (4 in) wood chip plots when compared to the non-mulched control (Table 1). I anticipated warmer soil temperatures beneath the black stone mulches, but cumulative thaw degree days were similar to the control plots for all three years of the study. Air temperatures 30 cm (12 in) above the soil surface were similar for all mulch treatments during each year of the study.

Spring soil thaw (continuous above freezing temperatures at the 10 cm (4 in) depth) occurred during the last week of April or first week of May, 36–44 days after snowmelt. During all years, spring thaw on the non-mulched control and stone mulch treatments occurred within 1–2 days of

Table 1. Air and soil thaw degree days, soil moisture and budbreak dates on wood chip, stone and non-mulched plots.

	Treatment				
Measurement	Control (non-mulched)	2.5 cm stone	5 cm stone	5 cm wood chip	10 cm wood chip
Air thaw degree days[z]					
1986	1021	1125	1073	1009	1083
1987	1231	1196	1252	1229	1241
1988	1492	1470	1407	1454	1398
Soil thaw degree days[z]					
1986	893	846	888	711	680
1987	1034	1064	1118	831	752
1988	1204	1122	1129	954	880
Soil moisture, 1986[y] (centibars)					
June	59 ± 7	38 ± 2	42 ± 4	33 ± 6	25 ± 9
July	46 ± 13	42 ± 11	42 ± 9	38 ± 8	33 ± 6
August	22 ± 8	24 ± 8	22 ± 7	22 ± 6	23 ± 13
Date of first budbreak, 1986					
Peking cotoneaster	5/23	5/22	5/23	5/22	5/22
White spruce	5/26	5/26	5/26	5/26	5/26
Lodgepole pine	6/1	6/1	5/31	6/1	6/1
Siberian crabapple	5/25	5/27	5/25	6/7	6/7
Rugosa rose	5/14	5/14	5/14	5/18	5/20

[z]Three-month growing season and 0°C (32°F) base temperature. Air temperature recorded 30 cm (12 in) above mulch surface and soil temperature recorded 10 cm (4 in) below soil surface.

[y]Tensiometer depth, 15 cm (6 in); n = 4 per month.

each other. Thaw on the wood chip treatments was delayed by 5–7 days. Despite the delay in spring thaw on the wood chip mulches, both conifers and the Peking cotoneaster had very uniform budbreak across treatments (Table 1). The Siberian crabapple and rugosa rose, on the other hand exhibited at least a four-day delay in budbreak on the wood chip mulches. This pattern was consistent for all three years of the study, therefore only the 1986 data are presented.

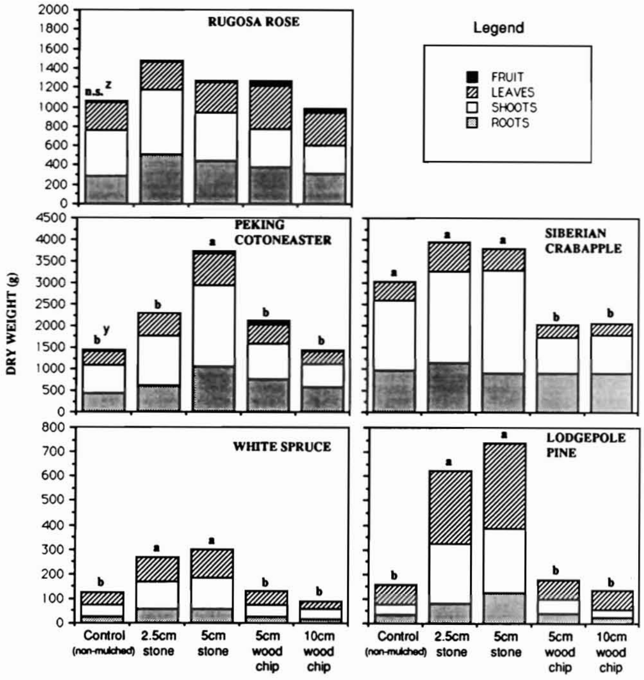
Continuous soil freezing temperatures at 10 cm (4 in) level began during the first or second week of October for all mulch plots. Mulch plots and the non-mulched control did not differ by more than 2 days in the onset of continuous soil freezing temperatures for any year.

Soil tests for available nutrients and pH did not differ significantly among mulch treatments during each year. For instance, in 1987 soil test results were: pH, 6.96 (range, 6.94–7.05); total N, 44 ppm (range, 40–47 ppm); P, 108 ppm (range 99–119 ppm); and K, 34 ppm (range, 32–38 ppm). In 1986, soil moisture was highest on the wood chip plots followed by the stone mulches and the non-mulched control during June and July. In August, all treatments showed similar moisture levels. Typically, August is cloudy and rainy, therefore moisture differences became negligible late in the season.

Weed growth was curtailed by all mulch treatments, but especially by the wood chips (Table 2). During the first growing season, one or two hand weedings on both the stone and wood chip mulch plots would suffice to maintain these plantings. Weeds were so prolific on the non-mulched control plots though, that continual maintenance would be necessary to retain an attractive ornamental landscape. Most weeds were annuals with the most common species being rapeseed (*Brassica campestris*), shepherd's purse (*Capsella bursa-pastoris*), and knotweed (*Polygonum aviculare*). The most common herbaceous perennials were dandelion (*Taraxacum officinale*) and yellow-flowering alfalfa (*Medicago falcata*).

During 1987 and 1988 the non-mulched control plots continued to dominate in total weeds harvested, but weeds on the 2.5 cm (1 in) stone mulch had also increased to unacceptable levels. Herbaceous perennials dominated the populations on the wood chip and stone mulches with fireweed (*Epilobium angustifolium*), dandelion, and yellow-flowering alfalfa being the most conspicuous. Annuals composed the majority of weeds on the non-mulched control and 2.5 cm (1 in) stone plots with the most common being shepherd's purse, knotweed and common groundsel (*Senicio vulgaris*).

Both conifers, white spruce and lodgepole pine, grew best on the stone mulch treatments as shown by total plant dry weight, plant height and spread (Fig. 1, Table 3). Root, shoot and leaf dry weight were greatest on plants growing in the stone mulch treatments. No difference in total growth was measured between the wood chip and non-mulched control plots. Lodgepole pine did not show visible evidence of nutrient disorders, and needle nutrient concentration did not differ significantly among treatments. The range of needle nutrient concentration for all treatments was: N, 1.22–1.49%; P, 0.14–0.17%, and K, 0.40–0.53%.



z n.s. = not significant, p = .05.
y total dry weight separation by Duncan's New Multiple Range Test, p = .05.

Fig. 1. Root, shoot, leaf, fruit and total biomass of woody landscape plants grown on mulched and non-mulched soils.

White spruce showed significant needle yellowing and lower needle N concentrations on the wood chip plots when compared to the stone and non-mulched control plots (Table 4). Needle P levels did not differ among treatments (range 0.18–0.22%), but K levels were significantly higher on the wood chip plots than the stone and non-mulched control treatments (Table 4).

Plant dry weight of Siberian crabapple was significantly lower on the wood chip mulch plots than the non-mulched control and stone mulches especially in the weight of shoots and leaves (Fig. 1). Although dry weight of plants grown on the stone mulches was greater than the non-mulched

Table 2. Total seasonal weed biomass on mulched and non-mulched plots.

	Weed biomass (g)[z]				
Year	Control (non-mulched)	2.5 cm stone	5 cm stone	5 cm wood chip	10 cm wood chip
1986	852.1	348.3	100.8	17.6	4.0
1987	2117.3	735.0	286.4	87.2	8.6
1988	2554.7	1421.3	165.3	114.7	21.3

[z]Three-month growing season, June through August.

Table 3. Height and spread of woody landscape plants after 3 years of growth on mulched and non-mulched plots.

Mulch treatment	Peking cotoneaster	White spruce	Lodgepole pine	Rugosa rose
		Height (cm)		
Control (non-mulched)	115 b[z]	60 b	43 b	84 n.s.[y]
2.5 cm stone	122 ab	81 a	106 a	75
5 cm stone	144 a	90 a	102 a	94
5 cm wood chip	111 b	60 b	67 b	68
10 cm wood chip	101 b	52 b	57 b	67
		Spread (cm)		
Control (non-mulched)	143 n.s.	36 b	56 b	130 n.s.
2.5 cm stone	152	52 a	92 a	123
5 cm stone	135	54 a	93 a	135
5 cm wood chip	156	40 b	61 b	137
10 cm wood chip	122	37 b	60 b	126

[z]Mean separation by Duncan's New Multiple Range Test, p = .05.

[y]n.s. = not significant, p = .05.

control, differences were not significant. Differences did not occur among treatments for plant height (159–180 cm) and spread (132–157 cm).

Of all the plants studied, the Siberian crabapple showed the most severe nutrient deficiency symptoms including leaf yellowing and early season leaf drop. Leaf nutrient samples from the wood chip plots revealed significantly lower levels of N than the non-mulched control and stone plots (Table 4). Leaf K levels were significantly higher on the wood chip plots than the other treatments.

Peking cotoneaster had the greatest dry weight accumulation on the 5 cm stone treatments especially in shoot and leaf dry weight (Fig. 1). Plant height also was significantly greater on the stone mulch treatments (Table 3) when compared to the wood chip and non-mulched control plots. Plant spread did not differ among treatments. Although no visible symptoms were evident, leaf N was significantly lower on the wood chip plots than the other mulch treatments (Table 4). Leaf P did not differ among treatments (range, 0.22–0.26%), and leaf K was significantly higher on the wood chip plots than the stone mulch and non-mulched control treatments.

Rugosa roses were the only plants tested that did not show a significantly lower dry weight on the wood chip plots (Fig. 1). The dry weight data, along with the plant height and spread, indicated that the rose grew fairly well on all mulch treatments (Table 3). Visual observations, however, did not support this information. The rose seedlings grew very differently on the wood chip mulches as opposed to the non-mulched control and stone mulch treatments. The initial year's growth on the wood chip mulches was limited to small amounts of shoot growth on existing above-ground stems and no suckering. Plants were spindly, weak, and tiny.

In contrast to this pattern, the roses grown on the stone mulches and the non-mulched control had strong, robust suckers which quickly dwarfed the original seedling shoot. After the second year of growth, these stiff, upright shoots were subject to significant winter dieback. Only buds located beneath the snow and close to the crown produced new shoots in subsequent seasons. Consequently, plants growing on the non-mulched control and stone mulches were subject to significant losses of above-ground biomass because of winter injury. Plants on the wood chip mulches however, did not exhibit this dieback and continued to grow

Table 4. Leaf nitrogen and potassium levels for woody landscape plants grown on mulched and non-mulched plots.

Mulch treatment	Peking cotoneaster	Siberian crabapple	White spruce	Rugosa rose
		Leaf N (%)		
Control (non-mulched)	2.97 a[z]	2.78 a	1.53 a	3.06 a
2.5 cm stone	2.64 ab	2.43 a	1.43 ab	3.30 a
5 cm stone	2.45 b	2.74 a	1.35 b	2.88 a
5 cm wood chip	1.75 c	1.25 b	1.06 c	2.23 b
10 cm wood chip	1.83 c	1.37 b	0.90 c	2.11 b
		Leaf K (%)		
Control	0.65 c	0.61 c	0.32 c	0.88 n.s.[y]
2.5 cm stone	0.74 c	0.74 b	0.40 bc	1.14
5 cm stone	0.91 b	0.88 ab	0.37 bc	1.05
5 cm wood chip	1.26 a	0.95 a	0.52 a	1.04
10 cm wood chip	1.32 a	0.97 a	0.45 ab	0.93

[z]Mean (n = 4) separation by Duncan's New Multiple Range Test, p = .05.

[y]n.s. = not significant, p = .05.

annually. The thinner, recumbent shoots were buried annually by snowfall and were protected from winter injury. The plants growing on the non-mulched control and stone mulch plots recovered to their previous years's size, but after 3 full growing seasons total growth had not exceeded the visibly poorer growth on the wood chip mulches.

Rugosa roses growing on the wood chip plots were a uniform pale yellow-green color and had significantly lower leaf N levels than the stone and control plots (Table 4). Leaf P (range, 0.32–0.40%) and K (range, 0.88–1.14%) did not differ among treatments.

On average, the five species grew best on the stone mulch treatments. Considering the effectiveness of the weed control, the most acceptable mulch for subarctic landscapes is 5 cm stone. Although the plants growing on wood chip mulches appeared similar in size and shape to the non-mulched control plots, visually they were unsightly because of N deficiency symptoms that began to appear at the end of the second growing season. Although all plots showed similar levels of available nutrients in the soil, rugosa rose, white spruce and Siberian crabapple plants grown on the wood chips plots were visibly deficient.

Cooler soil temperatures could have reduced N uptake on the wood chip plots (7, 11), but also the location of plant roots could have influenced nutrient availability. When the wood chip mulches were removed just prior to plant excavation, large quantities of roots were visible at the root/mulch interface. A similar mat of roots was not evident beneath the stone mulches. A similar root distribution pattern was noted for maples grown on wood chip-mulched soil (6) where improved water relations and temperature conditions in the upper soil strata resulted in significant root growth at the root/mulch interface. Organic mulches can also tie up soil available nitrogen as they decompose (5, 7, 10) but the soil tests showed little difference in available N among treatments in this experiment.

Some organic mulches leach toxic substances into the soil that will limit plant growth (5, 7). Although growth was visibly poorer on the wood chip plots as opposed to the stone and non-mulched control plots, except for Siberian crabapple, plant dry matter accumulation did not differ significantly between wood chip and non-mulched control treatments.

Three of the five species showed higher levels of leaf K on the wood chip plots which is a common occurrence on organic mulches (6, 7). This K could have leached from the wood chips (6) and remained readily available to the plants because of a better, more consistent moisture regime (7).

The black-colored stone mulches did not increase soil temperature over non-mulched control plots, but the combination of reduced competition from weeds and greater moisture availability probably provided a better growing environment than the unmulched plots.

Organic mulches such as wood chips provide a favorable environment for a variety of plants growing in more southern latitudes (i.e. 1, 5, 6, 7). However, in subarctic Alaska wood chip mulches cannot be recommended. Additional studies are required to determine if the detrimental effects of wood chips can be ameliorated with higher levels of N fertilizer. Stone mulches, on the other hand, provide an acceptable mulch for perennial landscape plantings in interior, Alaska.

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