Lingonberry Establishment on Soils Amended with Fish Waste and Wood Chips

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Abstract

Year old lingonberries (*Vaccinium vitis-idaea* subsp. *vitis-idaea*) were planted in Rabideau silt loam soils (Trapper Creek, Alaska) amended with five combinations of cannery fish waste (90% salmon, 10% halibut) as an organic fertilizer and wood chips recovered from rotting windrows of tree slash as a soil amendment. Control consisted of mineral soils. Treatments included fish waste only, 2:1 (v:v) fish waste:wood chips, 1:1 (v:v) fish waste:wood chips, 1:2 (v:v) fish waste:wood chips and wood chips only. Total volume of an amendment applied singly or a combination of amendments was 150 $l \cdot m^{-2}$. Each amendment was tilled into the plots, and planting occurred six weeks later. Plants were grown for one full season following the planting season to study establishment and vegetative growth on this organic mix. All treatments with fish waste showed the greatest overall plant growth. The treatment with fish waste only produced the greatest number and dry weight of stems and leaves (average 45 stems, 680 leaves, 8g per plant) of all treatments. Rhizome production varied widely among plants (0-13 rhizomes per plant) and did not differ among treatments. Vegetative growth was inhibited by addition of wood chips alone. Soil tests during the first growing season showed 2118-2749 $\mu g \cdot g^{-1}$ total available N, 255-281 $\mu g \cdot g^{-1}$ P and 787-880 $\mu g \cdot g^{-1}$ K for fish-amended soils, 106 $\mu g \cdot g^{-1}$ N, 25 $\mu g \cdot g^{-1}$ P and 235 $\mu g \cdot g^{-1}$ K for the control and 20 $\mu g \cdot g^{-1}$ N, 27 $\mu g \cdot g^{-1}$ P and 428 $\mu g \cdot g^{-1}$ K for the wood chip plots without fish. Lingonberries that normally require low nutrient levels grew best at the highest nutrient levels and showed no adverse effects from the fish waste. Wood chips did not provide any benefit for the establishment of lingonberries on mineral soils during the first year.

INTRODUCTION

Lingonberries, *Vaccinium vitis-idaea* grow wild throughout Alaska and are a common woodland ground cover. Plants grow best on acidic soils and are often most abundant on rotting tree stumps and logs. In forest communities, most of the roots and rhizomes of lingonberries occur in the organic litter horizon (Ritchie, 1955, Persson, 1983). Lingonberries are not heavy feeders and can often show poor growth and reduced fruit yield with high nutrient levels, especially nitrogen (Dierking et al., 1984, Holloway et al., 1982, Ingestad, 1973, Ipatov et al., 1977, Kruger et al., 1984, Tear, 1972, Trajkovski, 1987)

Under cultivation, acidic substrates high in organic matter increase vegetative growth (Dierking et al., 1984, Holloway et al., 1982, Lehmushovi et al., 1975). Cultivated soils may be mulched with a variety of locally available organic materials such as peat moss, pine bark and wood chips to improve the root and rhizome environment and increase growth (Gustavsson, 1999, Lehmushovi, 1977, Scibisz et al., 1989). Although not often recommended because of expense, amending soils with organic matter such as peat moss prior to planting has increased growth and fruit yield of lingonberries (Stang et al., 1993).

Typical cultivated field soils in southcentral Alaska are not suitable for lingonberry establishment. Soil pH often is higher than optimum, and organic matter content is low. Optimum nutrient levels are not known. Two readily available and economical waste products that have potential for use in lingonberry production are fish waste from coastal canneries and wood salvaged from decaying windrowed tree slash. Although wood chips have been used successfully as mulch (Gustavsson, 1999), no information is available on wood chips incorporated into field soils prior to planting. Fish waste has potential as an economical and abundant organic fertilizer. The purpose of this project was to evaluate vegetative growth and establishment of lingonberries on soils amended with wood chips and fish waste and to identify the combination that might provide a suitable environment for field cultivation of lingonberries.

MATERIALS, METHODS, EXPERIMENTS

One-year-old rooted lingonberry microshoots were planted in field plots on Rabideau silt loam soils amended with 150 $l \cdot m^{-2}$ wood chips, fish waste or a combination of the two. Application rates by volume were no amendments (control), 1:1 wood chips:fish waste. 2:1 wood chips: fish waste. 1:2 wood chips:fish waste, fish waste only, and wood chips only. A wooden frame was erected temporarily around each plot; wood chips and or fish waste were layered into the frame to the appropriate volume; the amendments were then tilled into the top 20 cm of soil. The wood chips were composed of approximately 70 % by volume paper birch (*Betula papyrifera*) and 30 % white spruce (*Picea glauca*) that had been windrowed during land clearing in the early 1980s. The partly rotted wood was chipped and unscreened. Fresh fish waste was obtained from Cook Inlet, Alaska. The waste consisted of 90 % (by volume) salmon and 10 % halibut carcasses.

Plots were planted in mid July, six weeks after incorporation of the wood chips and fish waste. Plots were harvested at the end of the following season. Plots were irrigated following planting and repeatedly through the growing seasons. Soil moisture was monitored with tensiometers at a 10cm depth, and plots were irrigated when moisture readings reached 20 centibars.

Each treatment consisted of 1.2 m x 1.2 m plots with 20 plants spaced 30 cm apart. Plots were replicated four times in a randomized complete block design. Five plants were randomly harvested from each plot. They were separated into stems, leaves, roots, rhizomes and daughter shoots (shoots arising from rhizomes) and dried in a force draft oven at 65°C. Data consisted of stem, leaf, rhizome and daughter shoot numbers and dry weight. Data were analyzed using analysis of variance followed by mean separation with Waller-Duncan K-ratio T-test, 5 % level of significance.

Soil samples within the 20 cm-treatment depth were taken at the time of planting and one year later. Soils were air dried, sieved to a maximum 2 mm particle size, extracted with 2N KCL for nitrate analysis, Bray-1 phosphate and Mehlich-3 for available phosphorus and potassium, respectively. Nitrate analysis was completed by Autoanalyzer colorimetric analysis and phosphorus and potassium by Inductively Coupled Plasma-Atomic Emission Spectroscopy.

RESULTS

Above ground growth as shown by number and dry weight of stems and leaves was greatest on treatments with fish waste incorporated into the soil (Table 1). Wood chips alone inhibited above ground growth since stem and leaf numbers and dry weight were lower than the control. Growth of rhizomes and roots showed no statistical difference among treatments. Numbers of rhizomes varied from 0 to 13 rhizomes per plant within all treatments. Biomass of roots ranged from 1.72 g to 3.74 g per plant across treatments. The number and dry weight of daughter shoots from rhizomes was greatest on combined wood chip and fish treatments. The addition of fish waste either alone or in combination with wood chips promoted above ground growth, but had no effect on roots or rhizomes.

Nutrient levels, especially nitrogen were very high compared to control plots during the first year (Table 2). Soil pH also increased above 7.0 on treatments where fish waste consisted of half or more of the total volume of amendments applied. Measurements in year two showed a significant drop in nutrient levels, especially in plots amended with fish waste. Wood chip plots showed reduced available nitrogen levels when compared to the control plots at planting as well as one year later.

DISCUSSION

We expected the addition of partly rotted wood chips would provide a better growing environment for lingonberries as opposed to the existing silt loam soils. We also predicted that fish waste might have excessive nutrients and high total salts causing temporary burning of young microshoots. On the contrary, soils amended with fish waste with or without wood chips provided the best environment for the vegetative growth of lingonberries. It appears the very high nutrient levels were readily leached from the root zone and posed no short-term problems for plant establishment.

The growth on plots treated with wood chips alone was the poorest of all treatments. The increased decomposition of the partly rotted wood chips probably reduced nitrogen to levels below that necessary for dry matter gains during the first full season. Growth of rhizomes and daughter shoots on all treatments was inconclusive because of the short duration of the experiment.

These results show that fish waste may be used to amend soils for the production of lingonberries in Alaska. The high nutrient levels did not burn the young microshoots, but promoted above ground vegetative growth. Wood chips did not have a significant effect on plant growth during establishment but may have benefits in subsequent years or as mulch for weed control. Amending soils with wood chips did not have the same benefits as reported for incorporation of peat moss (Stang *et al.*, 1993).

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Tables

Table 1. Vegetative growth and dry matter accumulation of lingonberries grown on soils amended with wood chips and fish waste applied alone or in combinations with a total volume of 150 $l \cdot m^{-2}$.

Treatment	Stems	Leaves	Daughter shoots
		Number	
Control	25.5b*	343c	0.0b
1:1 wood chips:fish waste	38.2ab	556ab	0.2b
1:2 wood chips: fish waste	37.7ab	446bc	3.7a
2:1 wood chips:fish waste	30.5ab	326c	0.0b
Fish waste only	45.2a	680a	0.0b
Wood chips only	9.7c	84d	0.0b
		Dry weight (g)	
Control	2.01NS	3.34b	0.0 NS
1:1 chips:fish	1.92	5.65a	0.0
1:2 chips:fish	1.85	5.20ab	0.1
2:1 chips:fish	1.32	3.36b	0.0
Fish waste	2.21	5.80a	0.0
Wood chips	0.93	0.80c	0.0

*Mean separation within columns and measurement type by Waller-Duncan K-Ratio T Test, 5 percent level, NS = not significant

Table 2. Soil analysis of Rabideau silt loam amended with wood chips and fish waste applied alone or in combinations with a total volume of 150 $l \cdot m^{-2}$.

Treatment	Available Nutrients ($\mu g \cdot g^{-1}$) N	P	K	pH
Year one- at planting				
Control	106	25	235	4.52
1:1 chips:fish	2467	255	880	7.18
1:2 chips:fish	2749	281	854	7.44
2:1 chips:fish	106	56	375	5.07
Fish waste	2118	259	787	7.05
Wood chips	20	27	428	5.36
Year two- midseason				
Control	27	77	172	4.30
1:1 chips:fish	78	492	179	4.80
1:2 chips:fish	113	255	241	4.89
2:1 chips:fish	46	551	249	5.38
Fish waste	92	488	195	5.04
Wood chips	13	88	393	5.38