RESEARCH

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xx. Effects of Organic Soil Amendments on Physiology and Pests

OBJECTIVES:

Nutrient Management:

- Evaluate approved organic amendments applied to wild blueberry soil and leaves at different times and rates on three organic wild blueberry farms in Maine.
- Quantify the effects of different organic amendments on wild blueberry physiology and morphology.

Pest Management:

- Evaluate disease, insect, and weed severity under organic amendments

LOCATIONS: Appleton, Surry, and Columbia Falls, ME
PROJECT TIMEFRAME: May 2019 – September 2022

INTRODUCTION

This study is the final report of the project discussed in the 2020 report, page 98, and the 2021 report, page 169, both entitled, "Effects of Organic Soil Amendments on Physiology and Pest Pressure".

Soil organic matter ("SOM") is of critical importance especially to organic growers of many crops, because SOM increases soil moisture, nutrient levels, provides habitat for micro and macro organisms, improving overall crop health. In organic wild blueberry production, growers should consider SOM to be a source of nutrients. Soil tests show SOM as a percentage, and for each 1% SOM the soil contains approximately 20 pounds of inorganic nitrogen and two pounds each of phosphorous, potassium, and sulfur available for plant use annually (Fernandez & Kaiser, 2021; McLean et al., 2021).

Wild blueberry growers prune the plant either by flail mowing or by burning, and both methods have advantages and disadvantages. Burning is an organic pest management tool for weeds, diseases and insects, yet can burn off organic matter in a hot, prolonged oil burn. Flail mowing allows for fallen material to accumulate SOM located in the organic pad layer, also known as the O horizon, yet mowing can spread pests (Warman, 1987; Ismail and Yarborough, 1981).

Currently, fertilizer is not typically applied to organic wild blueberry fields because fertilizer feeds weeds as well as the crop which leads to weed management issues. Weed presence is one of the factors impacting nutrient uptake in wild blueberry, along with soil pH, water availability, and nutrient availability (Drummond et al., 2009). Applying organic matter however, may boost crop productivity. Softwood mulch is now being applied across whole fields to increase SOM for water holding capacity. Mulching should be practiced by all organic growers to increase SOM for nutrient availability, soil water holding capacity, and for pest suppression (weeds and leaf spot disease). Until recently growers have applied applied mulch to suppress pests or aid wild blueberry rhizomes in colonizing bare patches caused by de-rocking or other disturbance (DeGomez and Smagula, 1990; Drummond et al., 2009) but ongoing research is exploring the benefits and practicality of mulching entire fields to improve soil moisture improvements and pest control (see page XX in this report, "Using Soil Amendments to Improve Wild Blueberry Soil Moisture"). Research by Kender and Eggert (1966) demonstrates that some of the greatest benefits to mulched lowbush blueberry are not seen in the year following the application of mulch but five years after application. However, the 2022 mulching study indicates that you can see improved soil moisture the year that mulch is applied (see page XX in this report…mulch). Mulches and soil amendments must decompose somewhat before their constituent nutrients and materials can become available to plants, and this decomposition process requires time.

This report summarizes four years of organic research into the rates and timing of applications, cost, physiological benefits to wild blueberry, and potential impacts on pest presence under four different organic soil amendments and one organic foliar spray.

METHODS

This project was replicated at three farm locations selected to represent three organic farm sizes (small, medium, large) and the three major Maine wild blueberry growing regions (Midcoast, Ellsworth, and Downeast). The experimental design per location is a randomized complete block replicated six times with nine treatments applied to 6' by 30' plots (Table 1). Soil was sampled at each location in 2019 and 2022. The foliar fertilizer and Cheep Cheep (chicken manure) were applied at the recommended time and rate according to the label's and company representative's instructions. The Coast of Maine Cobscook blend, mulch, and compost were applied according to recommendations from University of Maine Extension Educator Mark Hutchinson (personal communication, 2019). All products were applied one time except for foliar fertilizer which was applied three times as recommended by the manufacturer.

All products were applied during the 2019 prune-cycle except for one foliar fertilizer treatment applied in the 2020 crop year (Table 1). The foliar fertilizer (SeaCrop16) was applied three times per site at key growth stages throughout the season. Cheep Cheep was applied in Surry and Appleton the week of June 3 and in Columbia Falls the week of June 12. The Coast of Maine Cobscook blend was applied in Appleton the week of June 17, and in Columbia Falls and Surry the week of June 24. University compost was applied in Appleton (only) the week of June 17 and mulch was applied in Columbia Falls and Surry the week of July 22.

Table 1. Products tested at each of three organic farms in a randomized complete block design with six replicates.

Product	Location	Material	Rate	Rate Type	Crop Cycle	%N-P-K*
Control	ALL	None	N/A	N/A	N/A	N/A
North American Kelp Co. SeaCrop16 Foliar Fertilizer	ALL	Liquid Foliar Spray	1.2 L/242 gal. H_2O/A	N/A	Prune	0.18% N 6.37% P 4.89% K
				N/A	Crop	
North Country Organics Cheep Cheep 4-3-3	ALL	Granular Soil Applied	1089 lb/A	Low	Prune	4% N 3% P 3% K
			2178 lb/A	High	Prune	
Coast of Maine Cobscook Blend Garden Soil	ALL	Loose material Soil Applied	7.5 yd^3/A	Low	Prune	0.4% N 0.14% P 0.12% K
			15 yd^3/A	High	Prune	
Mark Wright Disposal Dark Brown Mulch	Columbia Falls & Surry	Loose material Soil Applied	7.5 yd^3/A	Low	Prune	N/A
			15 yd^3/A	High	Prune	
University of Maine Compost	Appleton Only	Loose material Soil Applied	7.5 yd^3/A	Low	Prune	0.41% N 0.11% P 0.10% K
			15 yd^3/A	High	Prune	

*N-P-K represented as total nitrogen, phosphorus as P_2O_5, and potassium as K_2O

<u>Data Collection</u>

Soil Moisture

Soil temperature (°C), volumetric water content (%), and electrical conductivity were recorded using a FieldScout TDR 150 soil moisture meter (FieldScout TDR 150, Spectrum Technologies Inc., Aurora, IL, USA) probe inserted 12 cm (4.8 inches) into the blueberry root zone soil. Six random readings were recorded per plot on June 10, 2022.

Physiology and Morphology
At each site, six stems from each plot were randomly selected to measure their leaf chlorophyll concentrations and photosynthetic electron transport rates on June 10 – 12, 2022. Chlorophyll concentration was measured by a CCM-200 plus chlorophyll content meter (Opti-Sciences, Inc., Hudson, NH, USA). Photosynthetic electron transport rates were measured in leaves from six stems in each plot by a Y(II) meter (Opti-Sciences, Inc., Hudson, NH, USA) on June 10 – 12, 2022 between 10:00 and 2:00pm.

Eight random stems from each treatment plot were collected to quantify the number of leaves on each stem, leaf size, dry biomass, and nutrients. Leaf area of three leaves at three different positions (top, middle, and bottom) from each of those stems was determined using a LI-3000A area meter (Li-Cor, Lincoln, NE, USA). All the leaves from those eight stems were combined with other leaves from those eight stems, oven-dried at 70°C to constant mass and weighed, then were ground and sent to the University of Maine Soil and Plant Tissue Testing Laboratory in Orono, Maine for nutrition analysis. Leaf mass per area (LMA) was calculated by dividing leaf dry mass by leaf area (g/m^{-2}).

Pest Presence
Insects, weeds, and disease were monitored in the same 0.37 m^2 quadrats (two per plot) throughout each field season. In the 2019 prune year, pest scouting occurred once each in July, August, and September at each of the three locations. In the 2020 crop year, pest scouting occurred once each in May, June, and July at each of the three locations. In 2021, pest scouting occurred once each in June, August, and September at each of the three locations. In 2022, pest scouting occurred in Appleton and Surry in May and June and at Columbia Falls in May and July.

Pest severity for weeds, insects, and disease were quantified as percent cover using equal interval ranks between 0 and 6, where: 0 = not present, 1 = ≤1%-17%, 2 = 17%-33%, 3 = 33%-50%, 4 = 50%-67%, 5 = 67%-83% and 6 = 83%-100%. In 2020 - 2022, the number of wild blueberry stems with insect or disease damage were also identified and counted in addition to ranking severity using the same equal interval ranks.

In 2019, weeds were classified into two categories (grass or broadleaf) and in 2020 - 2022, weeds were identified by genera and counted to obtain weed number per quadrat. Insects were counted when an individual or their distinctive damage was observed. Diseases were similarly identified by distinctive characteristics. Fruit flies (BMF and SWD) were not quantified.

Crop Productivity
Blueberry cover was quantified at the same time as each pest scouting by using the same 0-6 equal interval ranking. In the 2019 prune year, stem heights and the number of buds per stem were recorded for eight random stems per plot at all locations late August to early September. This was done again in the 2021 prune year, with measurements recorded in late September. In the 2020 crop year, fruit-set and fruit-drop were monitored with repeated measures on the same four stems per plot. In the 2022 crop year, bud development, fruit-set, and fruit-drop were monitored with repeated measures on the same three stems per plot. The stems monitored in 2022 were not the same stems as were monitored in 2020.

The 2020 harvest took place on August 3, 6, and 11 in Appleton, Surry and Columbia Falls, respectively. The 2022 harvest took place on July 26, 28, and August 3 in Appleton, Surry, and Columbia Falls, respectively. In both 2020 and 2022, yield weights, Brix measures, and 100 berry counts were collected.

Data Analysis

The effects of the applied organic treatments on soil moisture, physiology (chlorophyll concentration and photosynthetic electron transport rate), and morphology (leaf size and leaf mass per area) of wild blueberry plants were statistically compared using a general linear model followed by LSD (least significant difference) post-hoc test in SPSS software ($\alpha = 0.05$). In this model, the main effects of applied treatments were considered as a fixed factor, experimental blocks as a random factor, and a Bonferroni correction was also applied for confidence interval adjustment. Each site (Appleton, Surry, and Columbia Falls) was analyzed individually over 2 crop years (2020 and 2022).

Ranked blueberry cover and pest cover data were transformed to their corresponding percent mid-point. Ranked blueberry cover, pest cover and pest counts (#/m^2) were compared across all years (2019 – 2022) using a full-factorial repeated-measures mixed model design, followed by a Tukey's Pairwise Comparison in JMP (JMP®, Version 15.2, SAS, Cary, NC, USA). Here, the full factorial tested the effects of date, treatment, and any interaction between date and treatment for the ranked response variables. Additionally, crop phenology, harvest yield and berry quality measures were compared across the two crop years (2021 and 2022), full-factorial repeated-measures mixed model design.

Due to the nature of count data collected in the field (which often has a high number of zeros creating a skewed distribution) much of our data failed the assumptions of normality and equal variance often required to run parametric statistical tests. All data were transformed with a square root transformation prior to any statistical testing. Ranked data and pest count data, as well as harvest yield and phenology count data visually improved following transformation, but the data continued to statistically fail for normality. Statistical tests were carried out despite non-normality after establishing there were no serious problems with the data. Quality measures of sugar content (Brix) and 100 berry counts were normally distributed and did not require transformation prior to analysis.

RESULTS

Soil Moisture

Overall, no significant differences were found in soil moisture among the treatments in any location (Figure 1). At Appleton, soil moisture was higher in the high rate of Cheep Cheep treatment than the control and other treatments. At Surry, average soil moisture was higher in the mulch treatments compared to the control and other treatments. At Columbia Falls, average soil moisture was higher in the mulch and both Cheep Cheep treatments compared to the control and other treatments.

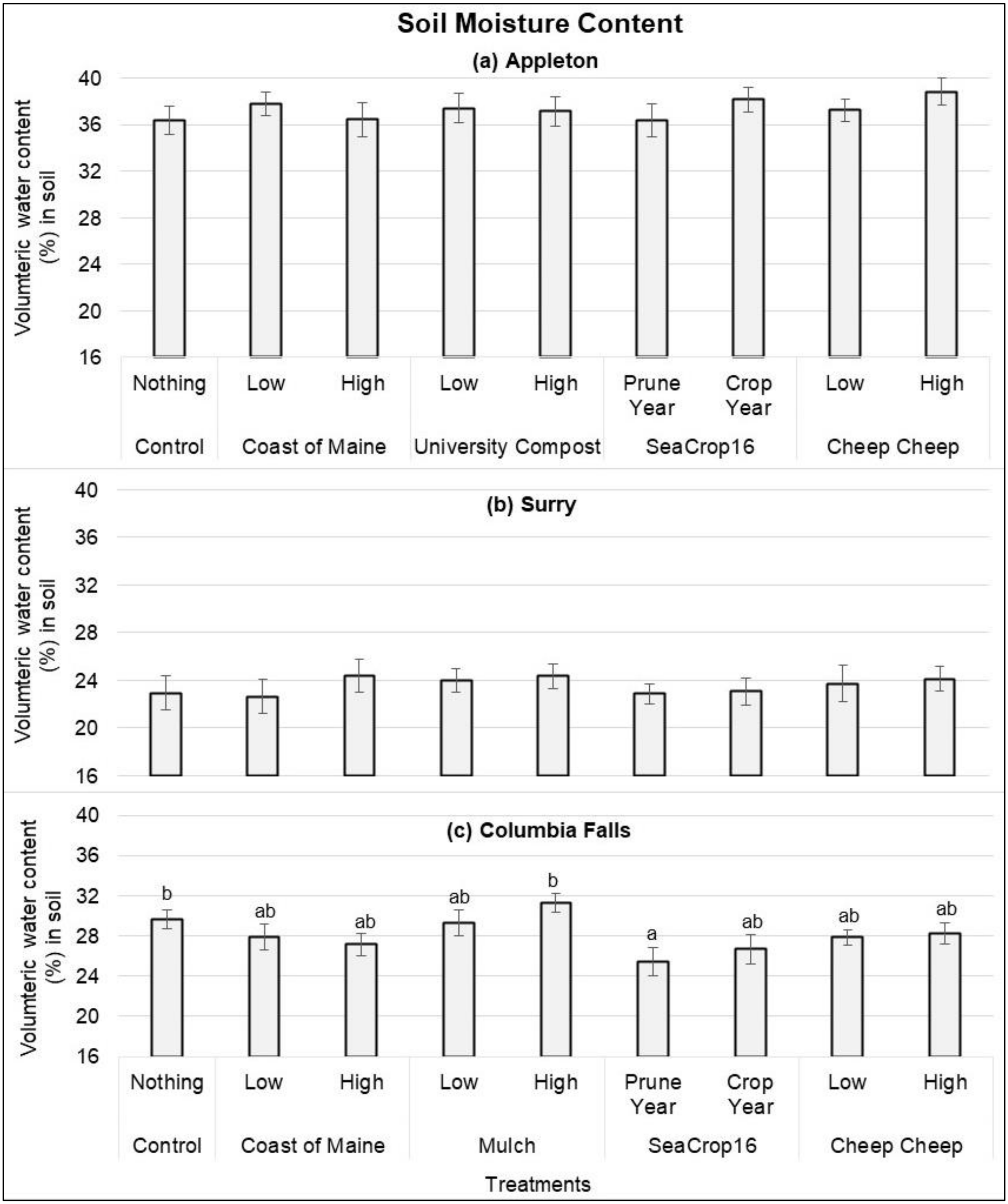

Figure 1. Comparison in soil moisture in June over two crop years (2020 and 2022) by treatments applied at: (A) Appleton, (B) Surry, and (C) Columbia Falls, Maine. Error bars indicate the standard error of the mean. No significant differences were observed at a significance level of $p < 0.05$.

Physiology and Morphology

Overall, no significant differences were found in leaf chlorophyll concentration among the treatments applied in any location (Figure 2). At Appleton and Surry, the average leaf chlorophyll concentration was higher in the high rate of Cheep Cheep compared to the control and other treatments. At Surry, average leaf chlorophyll concentration was lower in all treatments compared to the control. At Columbia Falls, average leaf chlorophyll concentration was higher in both rates of Cheep Cheep and the low rate of Coast of Maine compared to the control and other treatments.

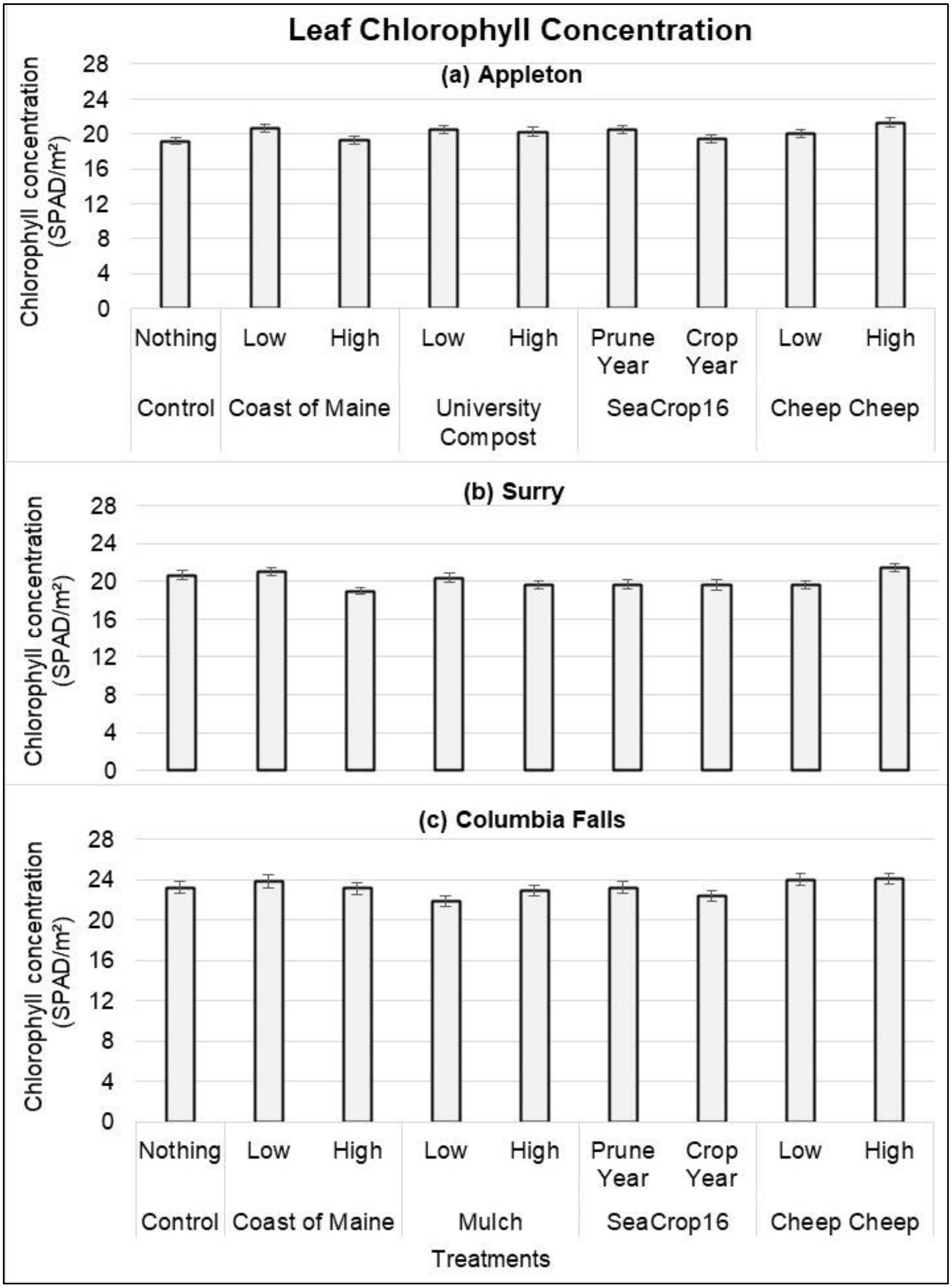

Figure 2. Comparison in chlorophyll concentration of leaves in June over two crop years (2020 and 2022) by treatments applied at: (A) Appleton, (B) Surry, and (C) Columbia Falls, Maine. Error bars indicate the standard error of the mean (averaged over replicated plots). No significant differences were observed at a significance level of $p < 0.05$.

Overall, no significant differences were found in leaf photosynthetic electron transport rates among the treatments applied in any location (Figure 3). At Appleton, average leaf electron transport rate was higher only in the low rate of Coast of Maine treatment compared to the control and other treatments. By contrast, at Surry, average leaf electron transport rate was higher in all treatments except SeaCrop16 applied in the crop year. At Columbia Falls, average leaf electron transport rate was lower in all the treatments compared to the control.

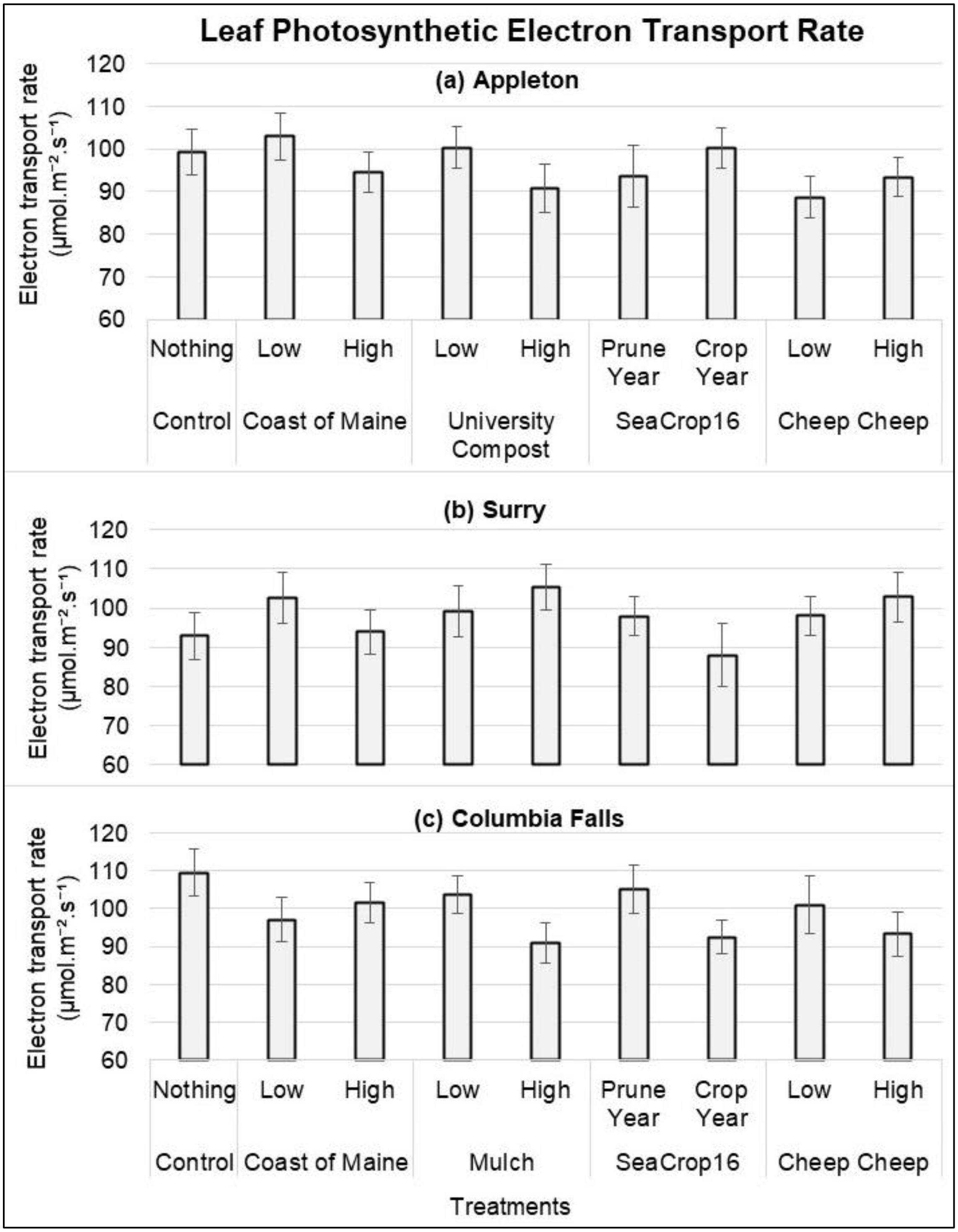

Figure 3. Comparison in photosynthetic electron transport rate of leaves in June over two crop years (2020 and 2022) by treatments applied at: (A) Appleton, (B) Surry, and (C) Columbia Falls, Maine. Error bars indicate the standard error of the mean (averaged over replicated plots). No significant differences were observed at a significance level of $p < 0.05$.

Overall, no significant differences were found in the wild blueberry leaf sizes among the applied treatments in any location (Figure 4). At Appleton, average leaf size was smaller in all treatments compared to the control. At Surry, both Cheep Cheep treatments had larger leaf sizes than the control and other treatments. At Columbia Falls, all treatments averaged larger leaf sizes than the control.

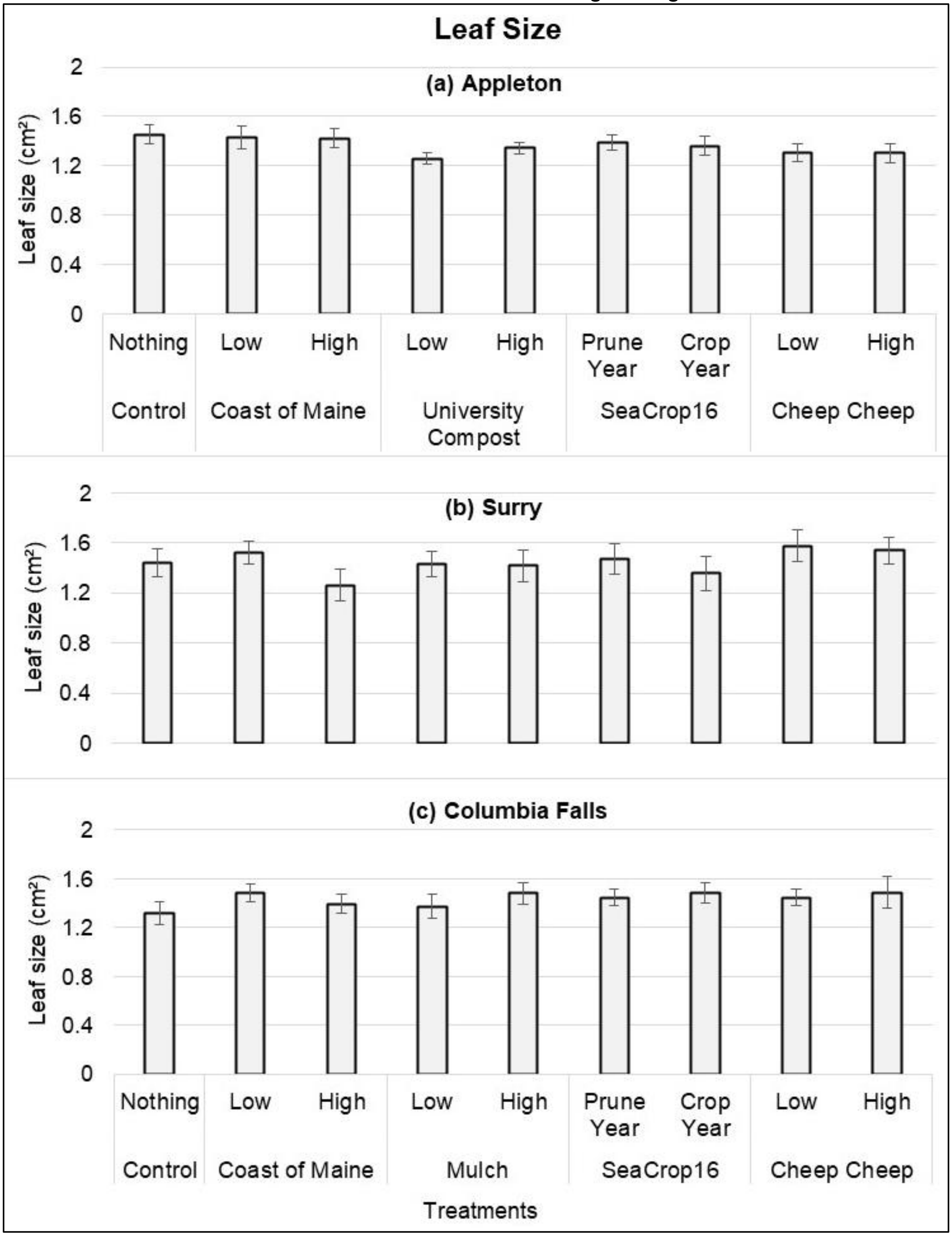

Figure 4. Comparison in leaf size in July over two crop years (2020 and 2022) by treatments applied at: (A) Appleton, (B) Surry, and (C) Columbia Falls, Maine. Error bars indicate the standard error of the mean (averaged over replicated plots). No significant differences were observed at a significance level of $p < 0.05$.

Overall, no significant differences were found in leaf mass per area (LMA) of the wild blueberry plants among the applied treatments in any location (Figure 5). At Appleton, average LMA was higher in the high rate of University Compost and high rate of Cheep Cheep compared to the control and other treatments. However, at Surry, average LMA was lower in all treatments compared to the control. At Columbia Falls, average LMA was higher in all treatments compared to the control.

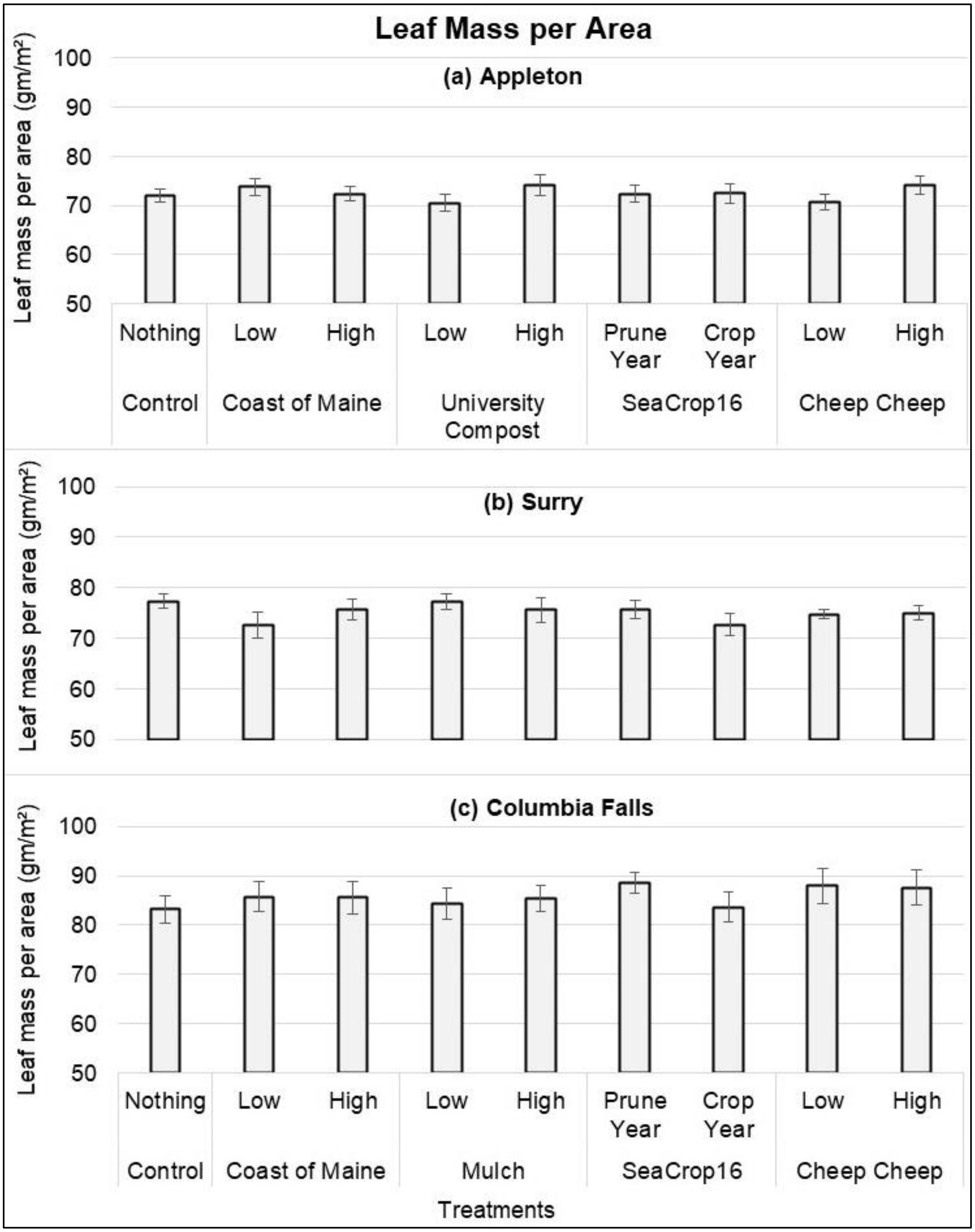

Figure 5. Comparison in leaf mass per area in July over two crop years (2020 and 2022) by treatments applied at: (A) Appleton, (B) Surry, and (C) Columbia Falls, Maine. Error bars indicate the standard error of the mean (averaged over replicated plots). No significant differences were observed at a significance level of $p < 0.05$.

Tables 2A-C. Soil characteristics among different soil amendment treatments compared to the optimum range in August 2022 at (A) Appleton, (B) Surry, and (C) Columbia Falls in Maine.

Table 2A. Appleton soil characteristics by treatment, as sampled on August 10, 2022.

Soil Characteristics	Optimum range	Control (No treatment)	Coast of Maine (Cobscook blend)		University compost		SeaCrop16		Cheep Cheep (Chicken manure)	
			Low	High	Low	High	Prune year	Crop year	Low	High
pH	4.0-4.5	4.8	4.8	4.7	4.7	4.8	4.3	4.3	4.5	4.3
Organic matter (%)	5-8	8.4	7	8.7	10	9	22.7	22.9	15	24.2
CEC (me/100 g)	>5	3	2.9	3.4	3.8	2.6	6.9	7	5.6	7.5
Nitrate-N (ppm)	20-30	1	1	1	1	1	1	1	1	1
Ammonium-N (ppm)	<10	2	3	2	2	2	6	6	4	6
Phosphorous (lb/A)	10-40	10.3	6.3	6.1	8.7	7	29.3	26.8	20	32.1
Potassium (% saturation)	2.1-3.0	3.9	4.4	2.6	4.1	5.2	4.8	5	3.9	4.6
Calcium (% saturation)	20-30	16.4	10.5	15.5	14	10.4	21.4	25.5	18.4	26
Magnesium (% saturation)	5-10	5.3	5.4	4.3	5.9	5.6	8.2	7.4	6.7	8.6
Sulfur (ppm)	>50	187	134	165	168	136	51	53	67	62
Copper (ppm)	0.25-0.6	0.2	0.13	0.18	0.20	0.18	0.4	0.27	0.31	0.59
Iron (ppm)	6-10	39	28	32	37	26	73	57	66	67
Manganese (ppm)	4-8	15	19	20	28	15	88	78	42	93
Zinc (ppm)	1-2	1	0.9	1.2	1.3	1.1	3.2	3.3	2.2	3.8
Boron (ppm)	0.5-1.2	0.6	0.5	0.5	0.6	0.5	0.8	0.7	0.5	0.8

Table 2B. Surry soil characteristics by treatment as sampled on August 4, 2022.

Soil Characteristics	Optimum range	Control (No treatment)	Coast of Maine (Cobscook blend)		Mulch		SeaCrop16		Cheep Cheep (Chicken manure)	
			Low	High	Low	High	Prune year	Crop year	Low	High
pH	4.0-4.5	5.1	4.6	4.8	4	4.3	4.6	5	3.8	4.3
Organic matter (%)	5-8	3.9	4.1	4.7	13.9	16	3	5.4	16.7	19.5
CEC (me/100 g)	>5	2.3	3.1	3.5	7	7.2	3.7	2.4	7.4	10.6
Nitrate-N (ppm)	20-30	1	1	1	1	1	1	1	1	1
Ammonium-N (ppm)	<10	1	1	1	2	4	1	1	3	5
Phosphorous (lb/A)	10-40	4.7	6.8	5.5	13	18.9	7.9	6.1	15.1	18.5
Potassium (% saturation)	2.1-3.0	2.5	1.9	2	3.1	3	1.9	2.4	2.9	2.5
Calcium (% saturation)	20-30	27.6	8.7	19.1	24.5	30.3	17.8	10.1	21	43.3

Magnesium (% saturation)	5-10	4.6	2.3	4.2	5	5.2	3.2	2.8	3.6	7.5
Sulfur (ppm)	>50	80	57	78	43	59	23	165	32	27
Copper (ppm)	0.25-0.6	0.04	0.09	0.09	0.21	0.2	0.09	0.09	0.13	0.22
Iron (ppm)	6-10	13	21	26	28	25	33	20	19	28
Manganese (ppm)	4-8	5.3	5	7.7	34	39	4.6	3.1	19	59
Zinc (ppm)	1-2	1.1	1.2	2.2	3.5	6.6	1.7	1	2.6	7.2
Boron (ppm)	0.5-1.2	0.4	0.4	0.4	0.6	0.6	0.4	0.4	0.6	0.6

Table 2C. Columbia Falls soil characteristics by treatment as sampled on August 4, 2022.

Soil Characteristics	Optimum range	Control (No treatment)	Coast of Maine (Cobscook blend)		Mulch		SeaCrop16		Cheep Cheep (Chicken manure)	
			Low	High	Low	High	Prune year	Crop year	Low	High
pH	4.0-4.5	4.8	4.7	4.9	4.9	4.7	5	4.8	5.1	4.7
Organic matter (%)	5-8	5.4	12.4	7.5	13.2	5.1	4.4	7.5	5	11.1
CEC (me/100 g)	>5	3.7	6.2	3.7	5.8	3.7	2.3	2.6	2.6	6
Nitrate-N (ppm)	20-30	1	<0.5	<0.5	1	<0.5	<0.5	1	1	<0.5
Ammonium-N (ppm)	<10	1	3	3	3	2	2	2	2	3
Phosphorous (lb/A)	10-40	8.5	12.1	13.7	7.9	6.3	6.9	8.8	9.4	12.2
Potassium (% saturation)	2.1-3.0	2.9	2.5	4.2	3.1	2.7	3.4	3	3.7	3
Calcium (% saturation)	20-30	14.4	27.7	19.1	33.1	13.3	5.6	5.6	8.6	33.6
Magnesium (% saturation)	5-10	5.9	10.4	12.5	9	6.1	3.4	3.7	5.2	8.1
Sulfur (ppm)	>50	84	67	88	45	91	74	80	112	51
Copper (ppm)	0.25-0.6	0.11	0.14	0.13	0.14	0.28	0.10	0.12	0.11	0.13
Iron (ppm)	6-10	30	27	31	42	26	22	39	21	28
Manganese (ppm)	4-8	4.2	9	4.6	22	4.7	1.8	1.8	2.9	11
Zinc (ppm)	1-2	1	3.7	1.5	2.9	1.3	0.6	0.8	0.6	3.2
Boron (ppm)	0.5-1.2	0.4	0.5	0.5	0.5	0.4	0.4	0.4	0.3	0.4

Treatments including all rates and timings of Cheep Cheep, Coast of Maine Compost, and SeaCrop16 improved blueberry cover more than did the control (Figure 6). Blueberry cover ranged from 64% in the control to 68% in the treatments where SeaCrop16 had been applied (both prune and crop). Blueberry cover in treatments where Cheep Cheep had been applied (67% at both rates) was close to the cover under SeaCrop16, 68%.

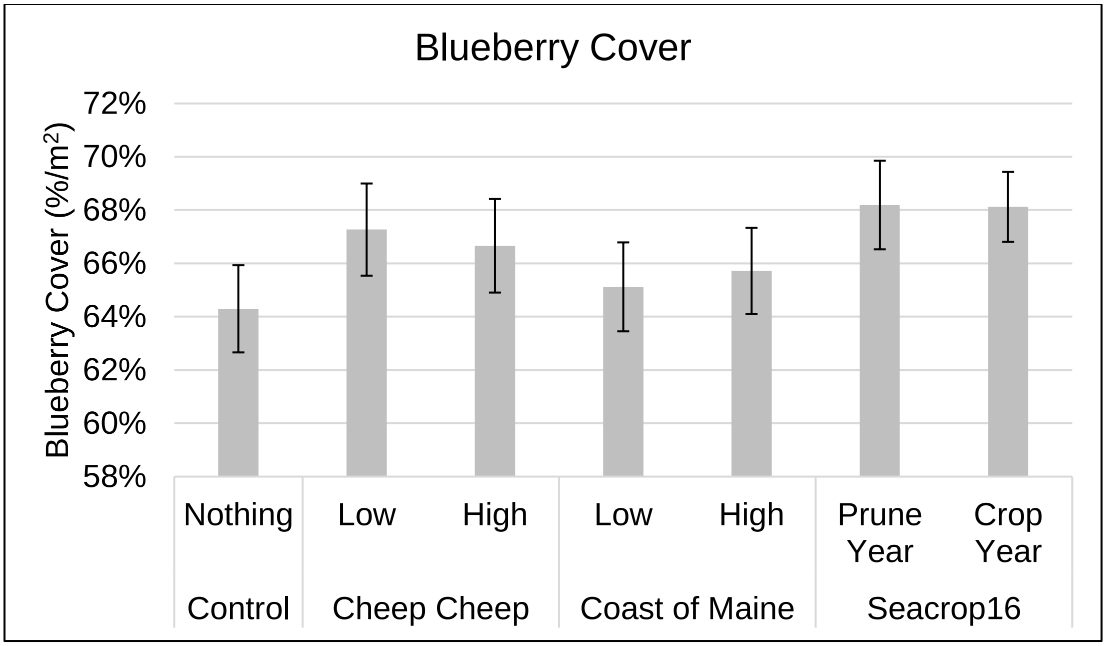

Figure 6. Average blueberry cover (%/m^2) measured across all three locations (Appleton, Surry and Columbia Falls) over four years (2019 – 2022) by treatments. Treatment differences were not significant. Error bars indicate the standard error of the mean.

The average number of green fruit per stem was averaged across both crop years, 2020 and 2022. The most green fruit were observed in the high rate of Cheep Cheep (8.13 green fruit/stem), and the fewest green fruit were observed in the high rate of Coast of Maine (7.00 green fruit/stem). The control averaged 7.62 green fruit/stem, which was only slightly higher than the crop year application of SeaCrop16, the low rate of Cheep Cheep, and the high rate of Coast of Maine.

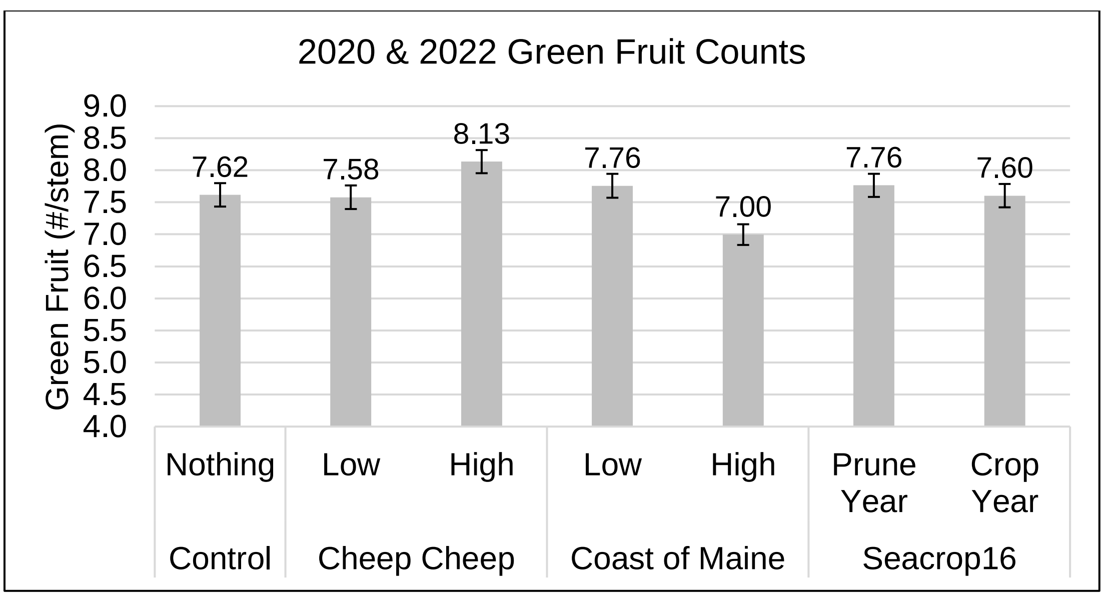

Figure 7. Average green fruit number (#/stem) measured across all three locations (Appleton, Surry, and Columbia Falls) over both crop years (2020 and 2022) by treatments. Treatment differences were not significant. Error bars indicate the standard error of the mean.

Pest Presence

Treatment differences in weed presence (#/m^2) over three years of this study (2020 – 2022) were not significant, however, interesting trends were present (Figure 8). Weed presence was highest under high rate of Cheep Cheep (#/m^2), followed by low rate of Cheep Cheep (#/m^2), and low rate of Coast of Maine (#/m^2). Weed presence was lowest where SeaCrop16 was applied during the crop year.

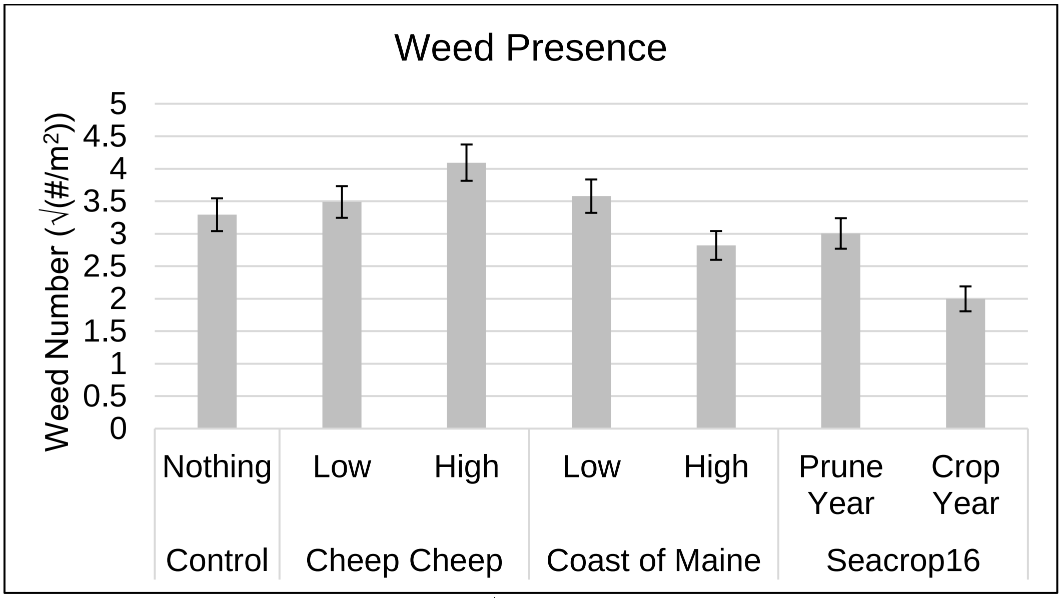

Figure 8. Average weed number (transformed; $\sqrt{(\#/m^2)}$) measured across all three locations (Appleton, Surry, and Columbia Falls) over three years (2020 – 2022) by treatments. Treatment differences were not significant. Error bars indicate the standard error of the mean.

Site-specific differences were analyzed to compare the efficacies of University Compost (only applied at Hope) and mulch (applied at Columbia Falls and Surry; Figure 9). At Hope, the high rates of Coast of Maine and University Compost both had significantly lower weed cover than the control. Interestingly, at the Columbia Falls and Surry locations, the SeaCrop16 applied in the crop year and high rate of mulch had significantly lower weed cover than the control.

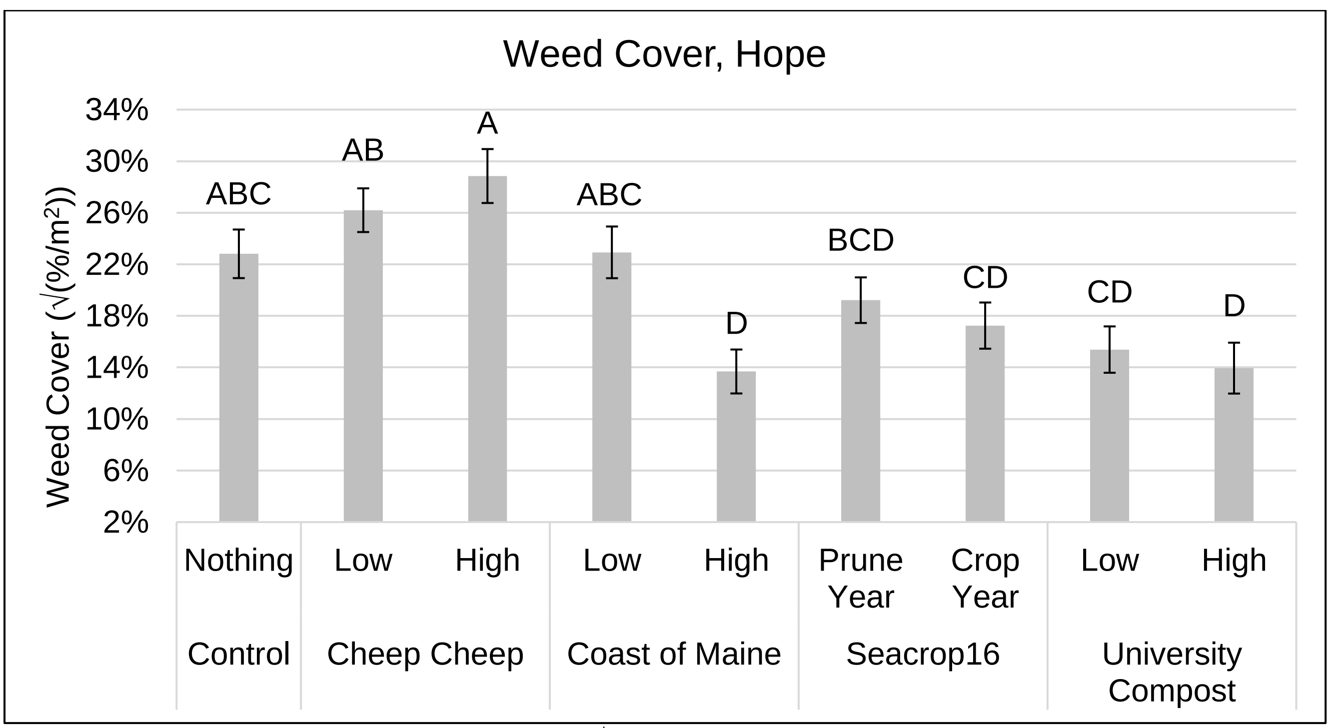

Figure 9. Average weed cover (transformed; $\sqrt{(\%/m^2)}$) measured in Hope, ME over four years (2019 – 2022) by treatment. Letters indicate significance at the 0.05 level of significance. Error bars indicate the

standard error of the mean. University Compost treatment included for comparison to all treatments per location.

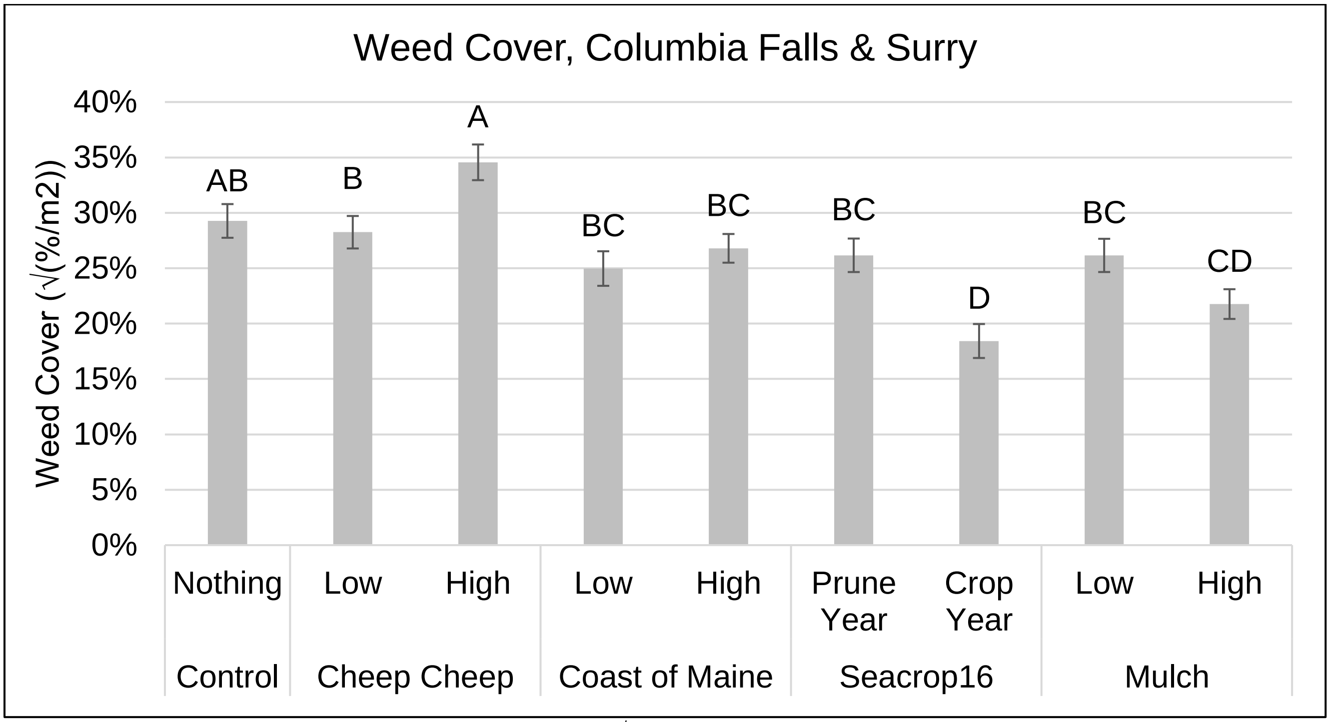

Figure 9. Average weed cover (transformed; $\sqrt{(\%/m^2)}$) measured in Columbia Falls and Surry, ME, over four years (2019-2022) by treatment. Letters indicate significance at the 0.05 level of significance. Error bars indicate the standard error of the mean. Mulch treatment included for comparison to all treatments per location.

Insect coverage, a spatial measure of insect presence generally indicated by pest damage to leaves or observation of the actual culprit, was significantly higher in the low rate of Cheep Cheep (13%/m^2) relative to the control (10%/m^2; Figure 10). Over the four years of study, all other treatments were not significantly different from one another. Top insects included: tip midge, red striped fireworm, and flea beetle. Disease coverage, including leaf spot species, mummy berry, and phomopsis, as indicated by a spatial measure of disease presence, was relatively similar across all treatments except for the high rate of Cheep Cheep (12%/m^2), which exhibited significantly less disease presence than the control (14%/m^2; Figure 11).

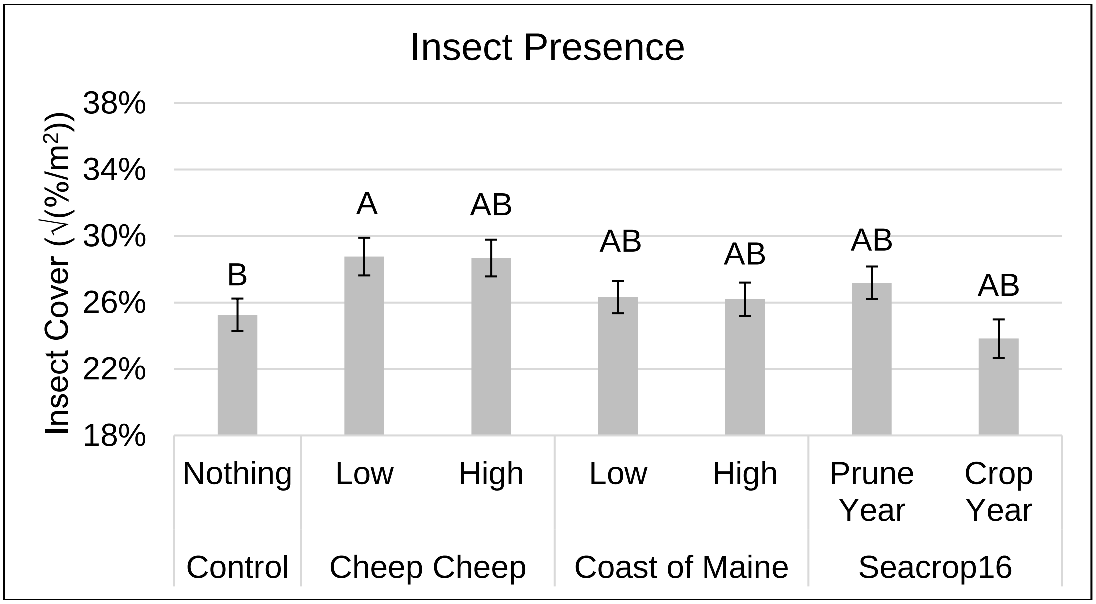

Figure 10. Average flea beetle, red striped fireworm, and tip midge insect pest coverage (transformed; $\sqrt{(\%/m^2)}$) measured across all three locations (Appleton, Surry, and Columbia Falls) over four years (2019 – 2022) by treatment. Letters indicate significance at the 0.05 level of significance. Error bars indicate the standard error of the mean.

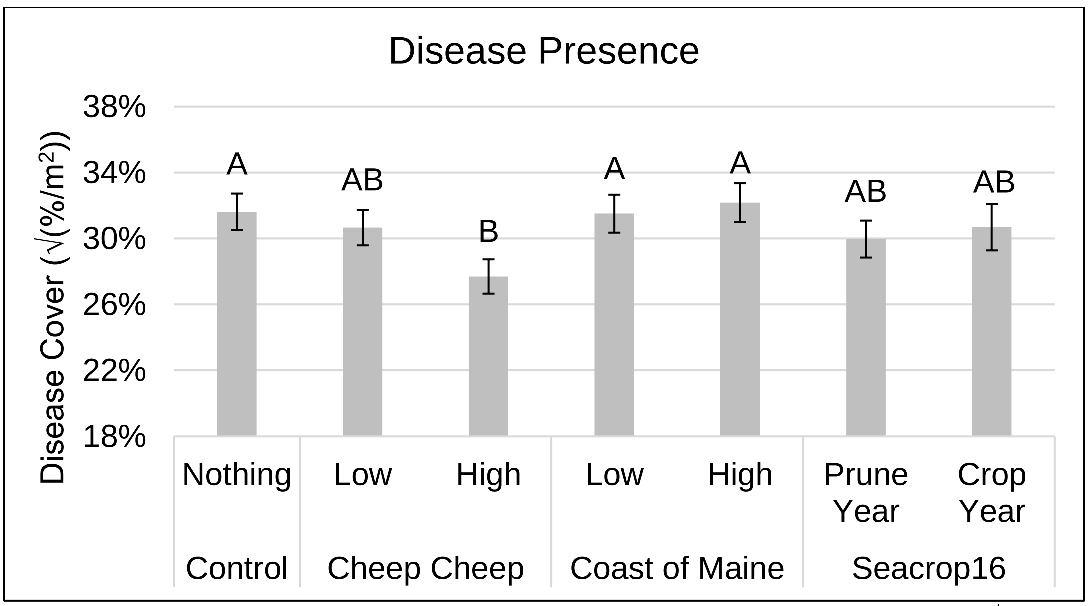

Figure 11. Average mummy berry and leaf spot disease cover (transformed; $\sqrt{(\%/m^2)}$) measured across all three locations (Appleton, Surry, and Columbia Falls) over four years (2019 – 2022) by treatment. Letters indicate significance at the 0.05 level of significance. Error bars indicate the standard error of the mean.

Crop Productivity

Treatment differences in harvest yield were not significant across both crop years (2020 and 2022) and all locations, however, there are interesting trends worth noting (Figure 12). Blueberry yields were higher in the quadrat subsamples compared to whole plot yields. Whole plot yields are more susceptible to variation between clones and the physical loss that occurs when harvesting a larger area (16.7 m^2). The quadrat yields are more representative of the crop potential by thoroughly capturing a small area (0.37m^2).

In addition to the yield differences by sampling methods (quadrat vs. whole plot), there were notable yield differences by treatment. Both whole plot and quadrat yields were highest for the SeaCrop16 applied in the crop year (2552 lbs/A and 3988 lbs/acre), followed by the SeaCrop16 applied in the prune year (2391 lbs/A and 3762 lbs/A), with the third highest yield occurring with high rate of Cheep Cheep (2283 lbs/A and 3585 lbs/A). Quadrat yields from plots treated with SeaCrop16 crop year, SeaCrop16 prune year and the high rate of Cheep Cheep were 24%, 17% and 12% greater than the quadrat yields in the control (3214 lbs/A).

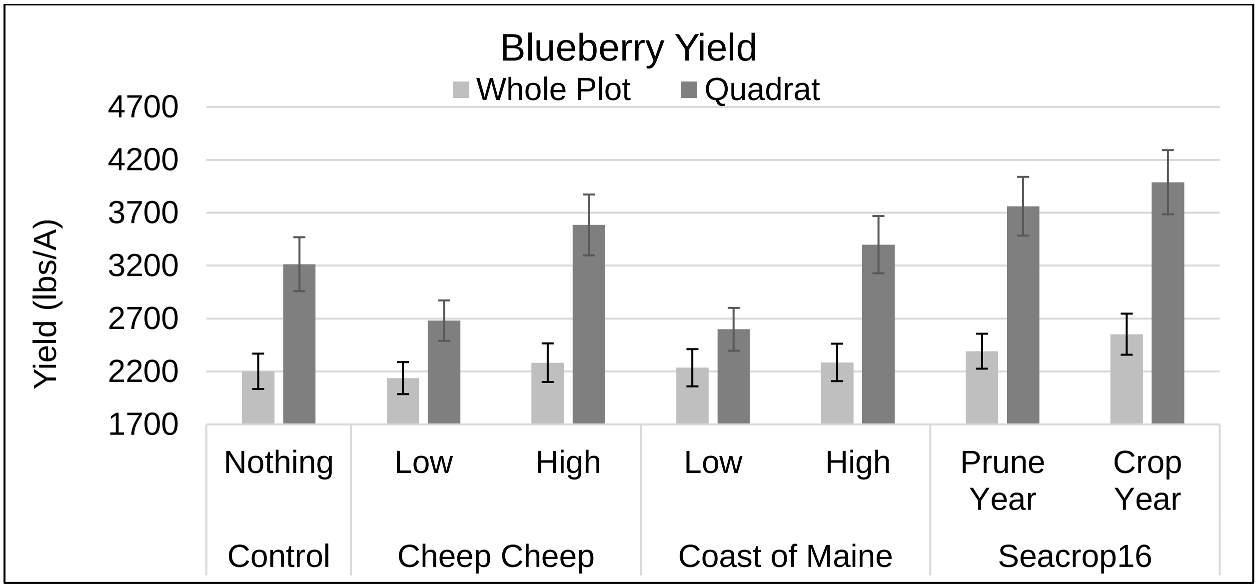

Figure 12. Average blueberry yield (lbs/A) of whole plot and quadrat subsample, measured across all three locations (Appleton, Surry and Columbia Falls) over two crop years (2020 and 2022) by treatment. Treatment differences were not significant. Error bars indicate the standard error of the mean.

DISCUSSION

While not significant, all treatment rates and timings of Cheep Cheep, Coast of Maine, and SeaCrop16 had greater blueberry coverage than the untreated control, indicating that the additional nutrients provided by each of the treatments was successful in increasing plant health and vigor. The treatments did not indiscriminately "feed the weeds”, as the weed coverage varied by location and treatment. Low weed coverage at Surry and Columbia Falls under high rates of mulch reinforce the knowledge that mulch applications confer many benefits, particularly the suppression of weeds (Gumbrewicz & Calderwood, 2022).

While all treatments saw a trend towards increased blueberry cover, not all treatments saw an increase in green fruit numbers. The high rate of Cheep Cheep produced the greatest number of green fruit across both crop years, indicating there may be a relationship between the high rate of nitrogen in this treatment (4%, the highest of all treatments) and the resulting green fruit produced. The forthcoming foliar nutrient analysis may prove or disprove this.

Higher insect presence in both rates of the Cheep Cheep and Coast of Maine treatments compared to the control indicates the wild blueberry plants were appealing to the insects, indicating a fairly healthy plant. The slightly lower rates of disease in the treated plots compared to the control indicate that the soil or mulch treatments provided a barrier to spores splashing from the ground to the plants. The rates of both insect and disease as observed in this study may be limited by identification methods. Structures such as tip midge galls on the tips of stems and mummy berry spores allowed for easy identification of the perpetrators. More general damage, such as chewed segments of leaves, was likely not attributable to a specific pest and so that pest’s presence may not be appropriately recorded.

Based on the four years of data collected during this study, some soil amendments such as Cheep Cheep and mulch may be able to improve soil moisture availability and physiological performance of wild blueberry plants. Cheep Cheep and mulch treatments accumulated comparatively higher levels of soil organic matter ("SOM") and major nutrients (N, P, K, Ca) in soil at the studied sites as found from the soil testing results in the fourth and final year of this study (Tables 2A-C). Hence, Cheep Cheep and mulch applications appear to have increased water holding capacity in the soil by adding and protecting SOM (Gould, 2015; Bot and Benites, 2005).

This increase in water-holding capacity and SOM might have contributed to the slightly higher leaf chlorophyll concentrations that were observed in Cheep Cheep treatments. The higher nitrogen content in Cheep Cheep products may also have increased soil nitrogen levels, thereby benefitting the wild blueberry plants (Tables 2A-C). As nitrogen is the most important nutrient for building leaf chlorophyll, increasing the availability of this nutrient improves plants' photosynthetic performance and improves crop production (Taiz et al., 2015). Cheep Cheep had the highest macro- and micronutrient concentrations where N-P-K is 4-3-3 and Fe, Cu, S, Ca, Mg, Zn, and Mn are present. These ten nutrients comprise 40% of the product and the remaining 60% is organic matter. Despite the available nutrients from the applied treatments, photosynthetic electron transport rates showed rather contradictory responses from leaf chlorophyll concentration responses to the applied treatments. The reasons behind such contradictory results can be better explained with the leaf nutrient concentration information from this season which are still being tested (data forthcoming).

In 2022, the final year of this study, the effects of treatments seemed to wane somewhat as there were declines in soil moisture and there were no significant differences in wild blueberry physiology and morphology across treatments. This could mean that treatments applied at the rates described here should be applied every few years to achieve consistent improvements in plant physiology, morphology, and yield.

<u>Product Costs</u>

The cost of products used plays a critical role in implementation by wild blueberry growers (Table 3). The Coast of Maine Cobscook Blend was the most expensive product, followed by North Country Organics Cheep Cheep. Both the North American Kelp SeaCrop16 foliar fertilizer and Mark Wright Disposal mulch had lower costs per unit and were also applied at lower rates compared to the Cheep Cheep, thus resulting in overall lower costs compared to all other treatments. No cost was given for compost because it was donated by the University of Maine for this study.

Table 3. 2021 costs of a single application of the organic amendments used in this trial. Prices may vary based on quantity purchased, grower size, retailer and year. Prices do not include labor.

Product	Rate Type	Rate Applied	Rate Unit	Cost ($/acre)	Unit Cost
Control	N/A	N/A	N/A	N/A	N/A
North American Kelp Co. SeaCrop16 Foliar Fertilizer	Prune or Crop	1.2 /242	L /gal H_2O/A	$14.70	$49/gal
*North Country Organics Cheep Cheep Cheep 4-3-3	Low	1000.0	lbs/A	$814	$0.74/lb
	High	2000.0	lbs/A	$1628	
Coast of Maine Cobscook Blend Garden Soil	Low	7.5	yd^3/A	$2025	$270/$yd^3$
	High	15.0	yd^3/A	$4050	
Mark Wright Disposal Dark Brown Mulch	Low	7.5	yd^3/A	$240	$32/$yd^3$
	High	15.0	yd^3/A	$480	

**University of Maine Compost	Low	7.5	yd³/A	N/A	N/A
	High	15.0	yd³/A	N/A	

**Rate applied is total amount of material per acre to achieve the target 'low' rate of 40 lbs. N/acre and the target 'high' rate of 80 lbs. N/acre.*
*********Cost unknown, provided by the University of Maine for this study*

CURRENT RECOMMENDATIONS

- Organic growers should apply any affordable and available source of organic matter as this benefitied wild blueberry
- Chicken manure can be applied at a rate of 700lbs/a (see page XX SCBG ground fertility) **IF** good weed management practices are already in place. 2,000 lbs/a increased weed presence.
- The effects of fertilizer waned in year four. Consider this when scheduling applications.

ACKNOWLEDGEMENTS

We are very thankful to Northeast SARE for funding this research. Thanks to Ava Ardito, Abby Cadorette, Charles Cooper, Julian LaScala, and Jordan Ramos for data collection and analysis assistance.

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