CROP GROWTH & PHYSIOLOGY

RESEARCH

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12. TITLE: Effects of Organic Soil Amendments on Physiology and Pest Pressure

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 amendment treatments.

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

INTRODUCTION

Give the significant market declines for wild blueberries in the U.S. conventional market (USDA NASS 2018), interest in organic production is growing. Growing wild blueberries under certified organic standards is challenging because there are a limited number of fertilizer and pest management tools approved for use.

The effects of various organic amendments applied in wild blueberry systems have been previously studied. These include manure (Warman 1987), papermill sludge (Gagnon et al. 2003), gypsum (Sanderson and Eaton 2004), biosolids (Lafond 2004), municipal solid waste (Warman et al. 2009) and seafood-waste compost (Mallory and Smagula 2014). However, these studies produced variable results regarding blueberry productivity and marketable yield with few significant effects on soil organic matter or leaf nutrient concentrations. These studies demonstrate the need to investigate other organic alternatives at different rates and timings to better understand their cost-effectiveness and ability to aid in water retention and nutrient availability.

Factors that affect nutrient uptake in wild blueberries include weed presence, soil pH, water availability, and the presence of soil nutrients (Drummond et al. 2009). Wild blueberries compete with weeds for space, water, and nutrients, which can result in reduced crop yields and limited blueberry spreading if left unmanaged. Insects and disease pests can also benefit from nutrients applied to wild blueberry and in turn increase damage caused in blueberry plants. The low soil pH (4.0-4.5) of commercial wild blueberry fields does not allow critical nutrients like nitrogen, phosphorus, and potassium to be readily available to wild blueberry plants (Peterson 1982). Therefore, organic growers must rely on soil biology to break down applied organic matter in order to increase nutrient availability in crop fields. This study aims to identify materials that improve soil water holding capacity and nutrient availability for wild blueberries.

In this study we evaluate the efficacy of four organic soil amendments and one foliar spray treatment for their impact on wild blueberry growth and pest presence. This study focuses primarily on enhancing nutrient availability in organic wild blueberry systems rather than applying methods to directly manage pest populations. Because the materials applied may benefit pests, pest monitoring is a key aspect of this study. We seek to develop a better understanding of the relationship between wild blueberry nutrient inputs and pest presence in order to aid future recommendations for organic wild blueberry growers.

METHODS

This project is replicated at three farm locations that were selected to represent three scales (small, medium, and large) and the three major wild blueberry growing regions (Mid-coast, Ellsworth, and Downeast) in Maine. The experimental design is a randomized complete block replicated six times. Each plot is 6' by 30' (180 ft^2). A total of 54 plots and 9 treatments are located at each site (Table 1). The foliar fertilizer and chicken manure were applied at the recommended time and rate according to the label and company representative instructions. The 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 the foliar fertilizer which was applied multiple times as recommended by the manufacturer.

All products were applied during the prune cycle of 2019. The foliar fertilizer was applied three times – once during the emergence, tip dieback, and bud development stages of wild blueberry growth at each site. It was applied on June 19th, July 15th, and August 27th in Appleton; June 24th, July 19th, and August 28th in Columbia Falls; and June 4th, July 18th, and August 30th in Surry. Chicken manure was applied on June 4th in Surry, June 5th in Appleton, and June 12th in Columbia Falls. The Cobscook blend was applied on June 20th in Appleton, June 24th in Columbia Falls, and June 26th in Surry. Mulch was applied on July 23rd and 24th in Columbia Falls and Surry, respectively. UMaine compost was only applied in Appleton on June 19th. See Table 1 for product details.

Table 1. Treatments tested at each of three organic farms in a randomized complete block design with 6 replicates.

Product	**Rate**	**Rate Type**	**Crop Cycle**	**% NPK**
Control	N/A	N/A	N/A	N/A
North American Kelp Co. Seacrop16 Foliar Fertilizer	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 Chicken Manure 4-3-3	1089 lbs./A	Low	Prune	4% N 3% P 3% K
	2178 lbs. /A	High	Prune	
Coast of Maine Cobscook Blend Garden Soil	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	7.5 yd^3/A	Low	Prune	N/A
	15 yd^3/A	High	Prune	

Product	Rate	Rate Type	Crop Cycle	% NPK
Control	N/A	N/A	N/A	N/A
**University of Maine Compost	7.5 yd^3/A 15 yd^3/A	Low High	Prune Prune	0.41% N 0.11% P 0.10% K

*Only applied at Columbia Falls and Surry locations, % NPK analysis not completed
**Only applied at Appleton location
NPK represented as total nitrogen, phosphorus as P_2O_5, and potassium as K_2O

Data Collection

Physiology

Two 0.37 m^2 quadrats were placed in each plot to monitor percent tip-die back and physiological measures in the vegetative year (2019). Within each plot, each of the two quadrats were placed in separate genets (plants). Six stems from each plot were randomly selected and marked to monitor stem length, chlorophyll content and anthocyanin content during June-October on a vegetative year (2019). Chlorophyll content was measured by a SPAD Chlorophyll Meter (SPAD 502; Minolta Corp, Osaka, Japan), anthocyanin content was measured by an ACM-200 anthocyanin meter (Opti-sciences, Hudson, USA). Photosynthetic electron transport rates were measured in leaves from 6 stems in each plot by a Y(II) meter (Opti-sciences, Hudson, USA) in August on a vegetative year (2019) between 10:00 and 14:00 h solar time. Ten random leaves from each genet in each plot (20 leaves as 2 samples in each plot) were collected in September of 2019 to measure leaf area and their dry biomass. Leaf area was determined using LI-3000A area meter (Li-Cor, Lincoln, NE, USA), then the leaves were oven-dried at 70ºC to constant mass and weighed.

Pest Pressure

Insects, weeds, and disease were monitored in the same 0.37 m^2 quadrats as pant physiology throughout the season. Two quadrats were marked and measured per plot on 3 separate dates in July, August, and September at each location. This was done on: July 15, August 9, and September 6 in Appleton; July 19, August 6, and September 13 in Columbia Falls; and July 18, August 7, and September 5 in Surry. Percent blueberry cover, grass cover, broadleaf cover, insect presence, and disease presence were measured in each quadrat. Each category was rated based on a 1-6 scale ranking system representing even intervals of 100%, where: 0 = not present, 1 = ≤1%-17%, 2 = 17%-33%, 3 = 33%-50%, 4 = 50%-67%, 5 = 67%-83% and 6 = 83%-100%. Stem heights and number of buds per stem for 8 stems in each plot were also recorded on August 27 in Appleton, August 30 in Surry, and September 13 in Columbia Falls after all treatments were applied.

Crop Productivity

One soil sample was taken at the site location before treatments were applied in spring 2019. Each plot will be soil sampled in the spring of 2022, the final year of the project. Leaf samples were taken from each plot in all locations for foliar analysis at the tip-dieback stage on July 25 date in Appleton, August 1 in Surry, and August 6 in Columbia Falls. Leaf samples were taken by stripping all leaves from 40 stems/plot. In each plot, leaves collected were placed in a labeled paper bag and brought to the University of Maine Rogers Farm Forage and Crop Research Facility in Stillwater, ME where they were dried at approximately 43°C for at least one week. Leaves were then ground for leaf nutrient analysis at the University of Maine Soil Testing Service in Orono, ME. The same foliar analysis will be taken in 2021. Yield and quality data will be collected in the crop cycle (2020 and 2022) of this project.

Data Analysis

Physiology

The effects of the fertilizer treatments on physiology (chlorophyll concentration, electron transport rate) and morphology (leaf area and leaf dry biomass per stem) of wild blueberry plants, were statistically compared using a one-way ANOVA in SPSS ($\alpha = 0.05$).

Pest Pressure & Productivity

Percent blueberry cover, grass cover, broadleaf cover, insect presence, and disease presence were statistically compared in JMP (JMP®, Version 14.3) across all treatments at the 0.05 level of significance. The effects of the treatments on blueberry health, evaluated as a function of stem height and number of buds per stem were statistically analyzed using a randomized block design where location was a random effect. Blueberry cover and pest incidence (ranked data) were statistically analyzed using a logistic regression. Sites with unique treatments were analyzed individually to correct for sample sizes of mulch and compost. Significant differences were only detected for pooled sites with common treatments (Figure 6).

RESULTS

Wild Blueberry Physiology

The preliminary observation (chlorophyll concentration in Figure 1 and electron transport rate in Figure 2) showed no significant differences among different fertilizer treatments in all three organic wild blueberry fields. In the Appleton and Surry field (Figure 1a and 1b), chlorophyll concentrations were the highest in the Cheep Cheep fertilizer treatments (CC1 and CC2) during end of July to September compared to the control and other fertilizer treatments. In the Columbia Falls field, chlorophyll concentrations were higher in the lower rate of Cobscook Blend (CR1), Cheep Cheep (CC1), and Seacrop16 (SEA1).

Three different organic fields showed contrasting results in photosynthetic electron transport rate (ETR) among different fertilizer treatments compared to the control. All the fertilizer treatments resulted in higher ETR in the Appleton field (Figure 2a) compared to the control. Only wild blueberries in the low rate of Cobscook Blend (CR1) showed higher ETR in the Surry field (Figure 2b), and only those under the high rate of Cheep Cheep (CC2) showed higher values in the Columbia Falls field (Figure 2c) compared to the control.

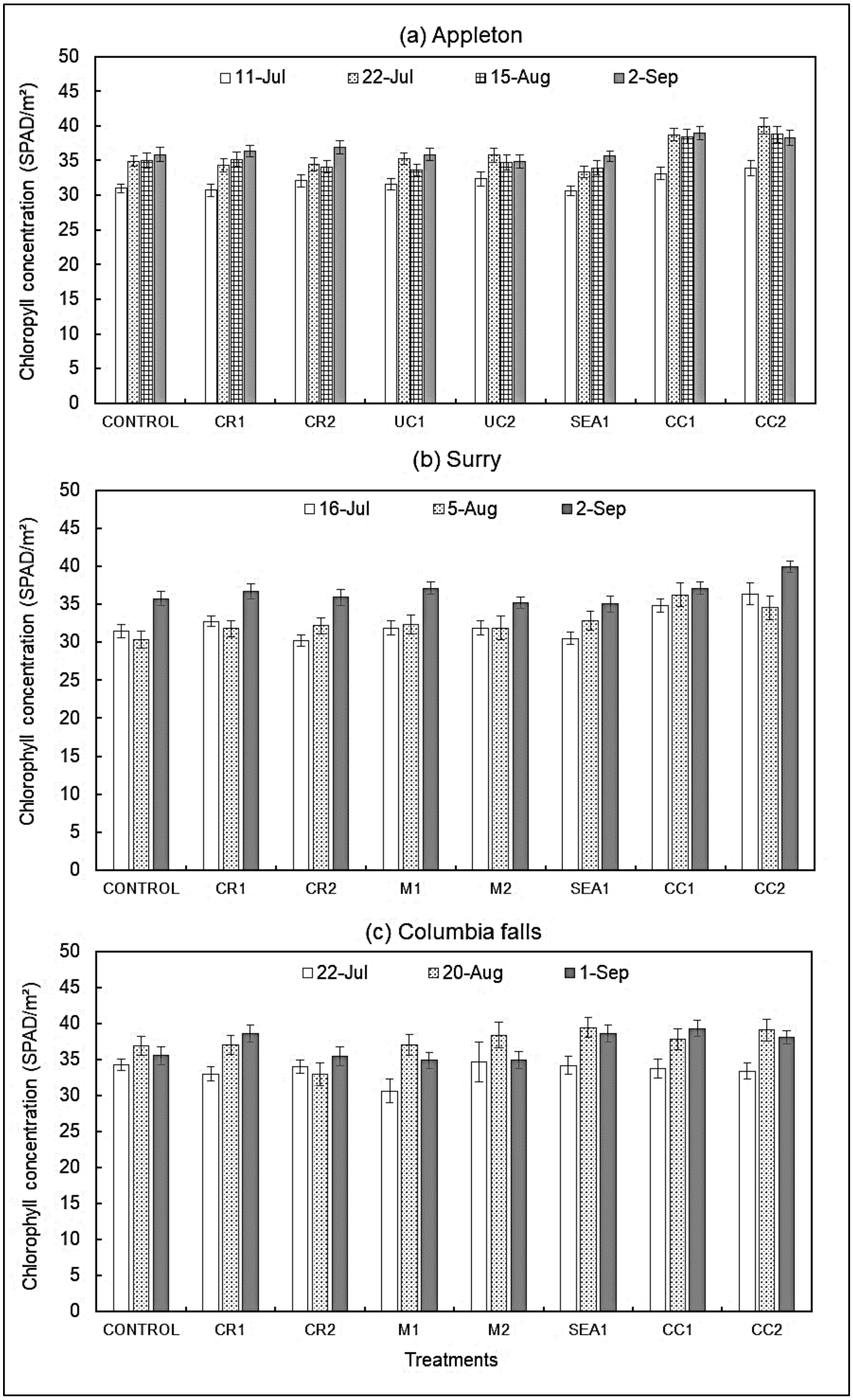

Figure 1. Comparison in chlorophyll concentration of wild blueberry leaves over time among different fertilizer treatments in the organic wild blueberry fields at (a) Appleton, (b) Surry, and (c) Columbia falls. No significant differences were observed.

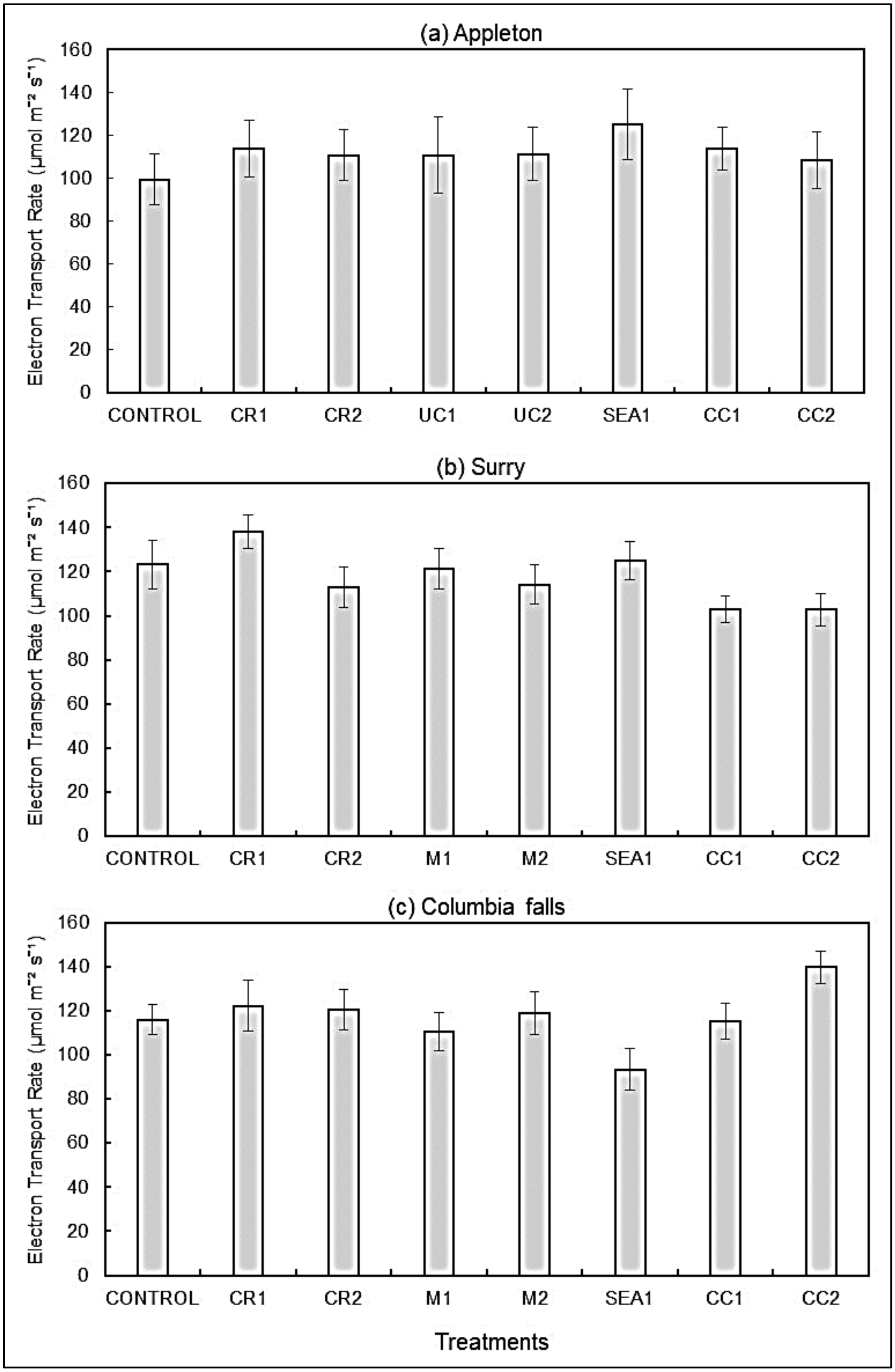

Figure 2. Comparison in photosynthetic electron transport rate of wild blueberry leaves among different fertilizer treatments in the organic wild blueberry fields at (a) Appleton, (b) Surry, and (c) Columbia Falls. No significant differences were observed.

<u>Wild Blueberry Morphology</u>
Similar to the physiology results, no significant differences in leaf morphology were observed among different fertilizer treatments in all three organic wild blueberry fields (Figure 3). However, in all the three organic fields (Appleton in Figure 3a, Surry in Figure 3b, and Columbia falls in Figure 3c), both leaf area and leaf dry biomass were higher only in both high and low rates of Cheep Cheep (CC1 and CC2) compared to the control and other fertilizer treatments.

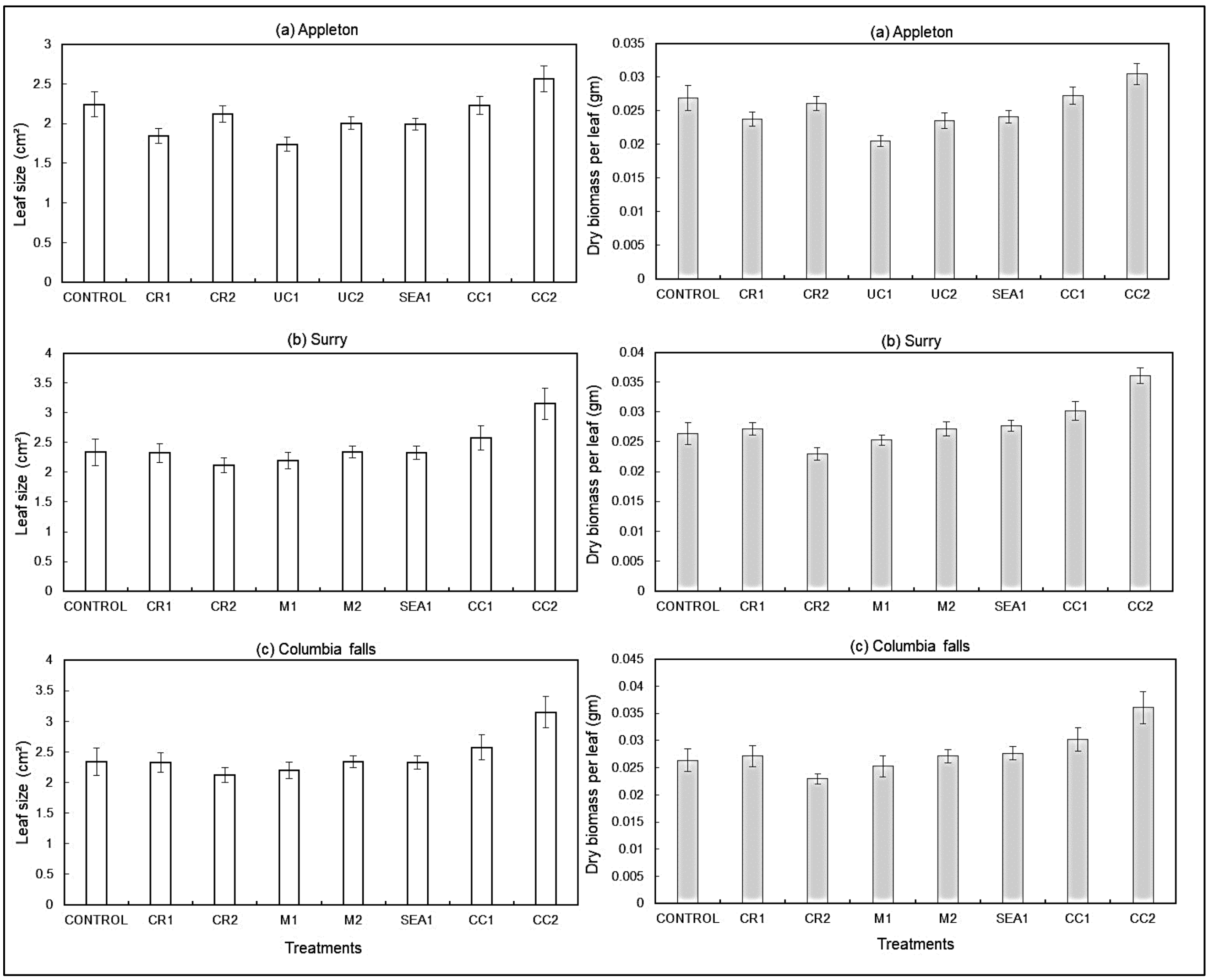

Figure 3. Comparison of leaf size and dry biomass per leaf from wild blueberry plants among different fertilizer treatments in the organic wild blueberry fields at (a) Appleton, (b) Surry, and (c) Columbia falls. No significant differences were observed.

<u>Wild Blueberry Productivity</u>
Blueberry plant cover, stem height and number of buds per stem were used to indicate treatment effects on blueberry health related to vegetative and reproductive growth during the 2019 prune-cycle. However, these indicators did not show any significant differences among treatments (Figures 4 and 5).

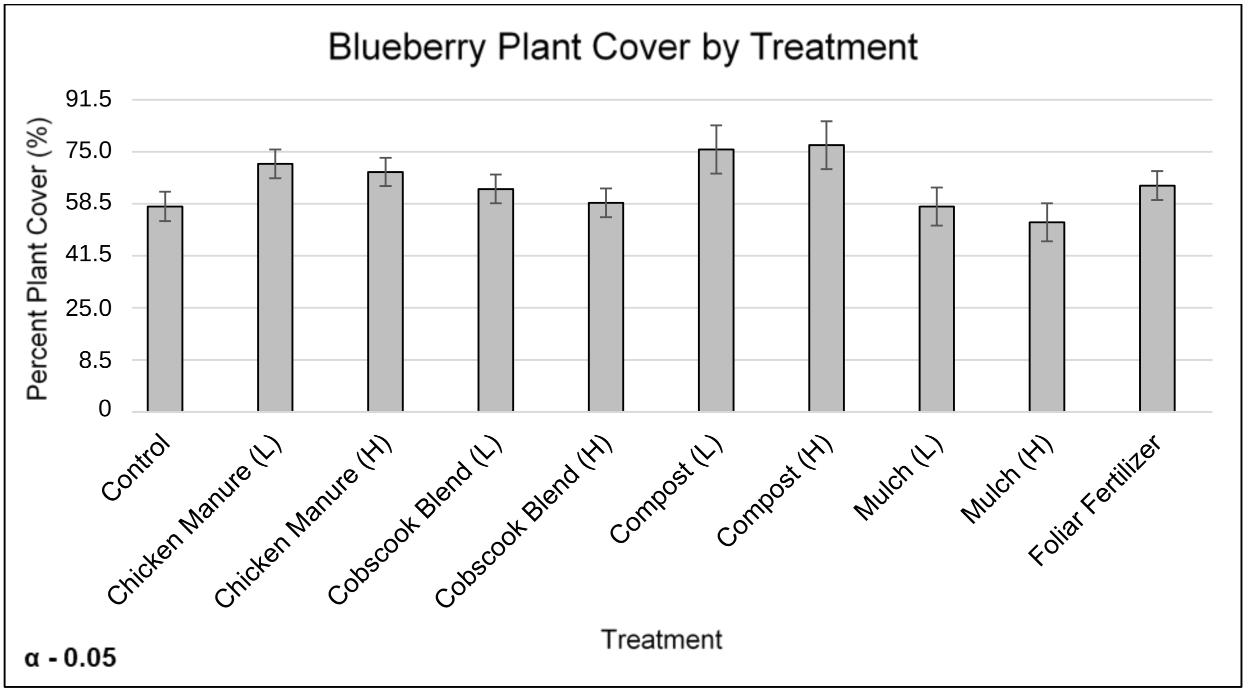

Figure 4. Average blueberry plant cover (%) by 2019 prune-cycle treatments. Error bars indicate ± 2.0 standard error, the 95% confidence interval. L = Low Rate, H = High Rate. No significant differences were detected at the 0.05 level of significance.

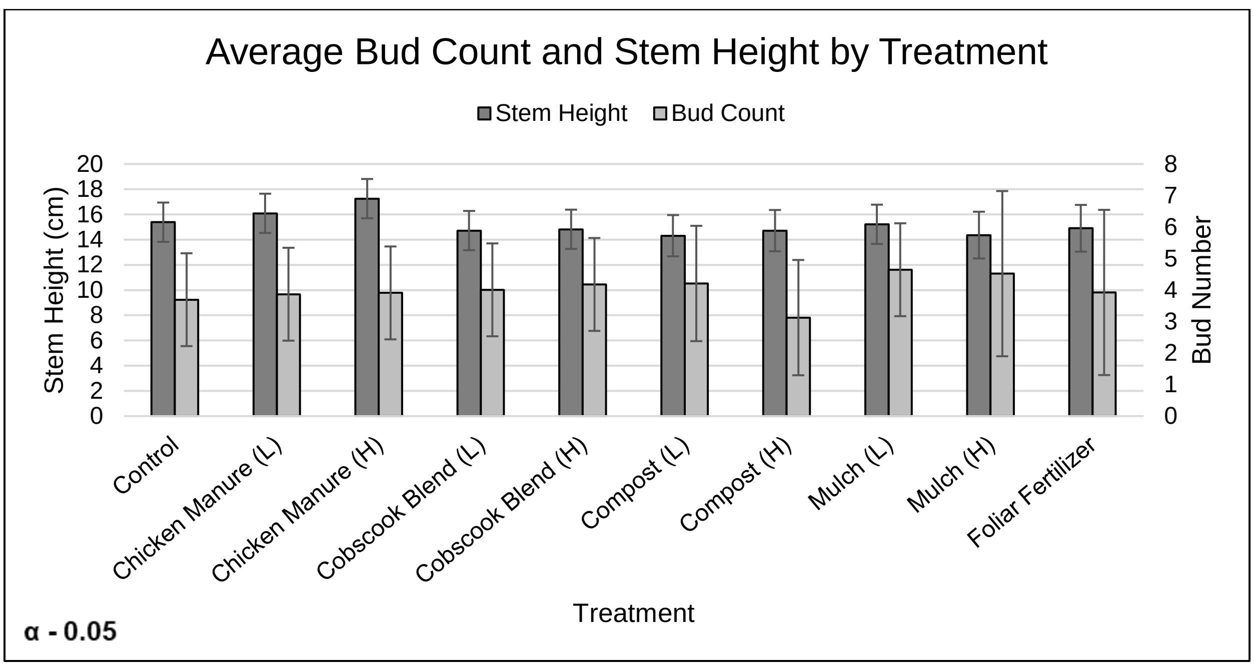

Figure 5. Average blueberry stem height and bud number (per stem) by 2019 prune-cycle treatments. Error bars indicate ± 2.0 standard error, the 95% confidence interval. L = Low Rate, H = High Rate. No significant differences in stem height or bud number were detected at the 0.05 level of significance.

Pest Incidence

Pest pressure identified in the 2019 prune-cycle were divided into three categories: weeds, insects, and disease. Each category included several groups: two groups of weeds (grass and broadleaf), five groups of insects (tip midge, red-striped fireworm, flea beetle, gall wasp and thrips), and two groups of disease (leaf spot and blight). Treatments did not significantly impact insect or disease pressures. However, incidence of grasses was significantly higher in both treatment rates of chicken manure than other treatments regarding weed pressure (Figure 6).

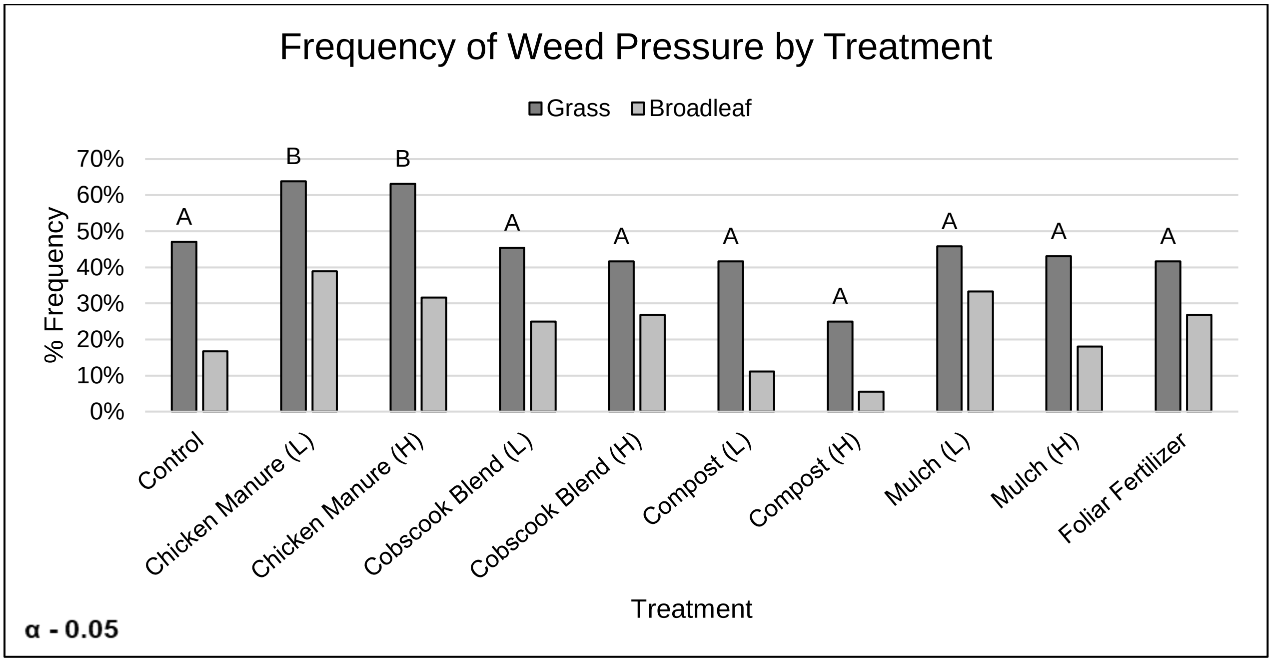

Figure 6. Frequency of grass and broadleaf weeds by 2019 prune-cycle treatments. L = Low Rate, H = High Rate. Chicken manure plots had higher incidence of grasses than all other treatments at the 0.05 level of significance.

DISCUSSION

Wild Blueberry Physiology

Crops need time to absorb nutrients from the applied granular fertilizers on the soil surface (Terman & Hunt 1964) and respond slowly in terms of their growth and development. Therefore, investigation in the subsequent years will be necessary to detect effects of different soil amendments. Based on the preliminary results, Cheep Cheep fertilizer showed a clear response, while not significant, compared to all other treatments. It could be because Cheep Cheep has 40% of both essential macro and micro (N-P-K: 4-3-3, Fe, Cu, S, Ca, Mg, Zn, Mn) nutrient elements. Wild blueberry plants have been shown to take up nitrogen, phosphorous, and potassium (Smagula 2011; Starast et al. 2005; Percival et al. 2002; Percival & Sanderson 2004). Additionally, Cheep Cheep also contains 60% organic matter, which helps to hold water and nutrients so that plants can easily take up the nutrients consistently over time (Barber 1995, Jungk 1996).

Pest Pressure and Plant Productivity

Analysis of the first year of blueberry plant cover, stem height, and bud number per stem data did not indicate any significant trends.

Both rates of chicken manure applied resulted in significantly higher incidence of grass presence. This may be an example of the effect that added nutrients have on weed competition when weeds are left unmanaged. This already indicates the importance of proper weed management before and after fertilizer application (Yarborough 2012). The chicken manure was also applied at generous rates: 1089 lbs./A and 2178 lbs./A, which is the equivalent of 44 lbs. nitrogen/A and 88 lbs. nitrogen/A, respectively. The high amount of nitrogen applied in chicken manure plots may have encouraged growth of grasses already present. We know that high rates of fertilizer result in more weeds that compete with wild blueberry (Drummond et al. 2009).

While no significant differences were measured for blueberry health parameters amongst treatments, it will be interesting to evaluate future potential effects as this study continues. Analysis of leaf nutrient concentrations and crop year data (blueberry yield and quality) may also be useful in differentiating indirect effects of each treatment once that data is analyzed.

Cost of Products

The cost of products used plays a critical role in implementation by wild blueberry growers (Table 2). The Coast of Maine Cobscook Blend was the most expensive product, followed by North Country Organics Cheep Cheep. Both the North American Kelp Seacrop 16 foliar fertilizer and Mark Wright Disposal mulch had lower costs per unit and were also applied at lower rates compared to the chicken manure, 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 2. Cost comparison of 2019 prune-cycle treatments. Cost is based on one application. Prices may vary based on quantity purchased, grower size, and retailer.

Product	**Rate**	**Cost ($/acre)**	**Cost/unit**
Control	N/A	N/A	N/A
North American Kelp Co. Seacrop16 Foliar Fertilizer	1.2 L/242 gal. H_2O/A	$14.70	$245/5 gal.
North Country Organics Cheep Cheep Chicken Manure 4-3-3	1089 lbs./A 2178 lbs. /A	$814 $1628	$37/50 lb.
Coast of Maine Cobscook Blend Garden Soil	7.5 yd^3/A 15 yd^3/A	$2025 $4050	$270/$yd^3$
Mark Wright Disposal Dark Brown Mulch	7.5 yd^3/A 15 yd^3/A	$240 $480	$32/$yd^3$
*University of Maine Compost	7.5 yd^3/A 15 yd^3/A	N/A N/A	N/A

***Cost unknown, provided by university for study

CURRENT RECOMMENDATIONS

None at this time.

NEXT STEPS

- Evaluate leaf nutrient analysis results.
- Apply crop year foliar fertilizer applications (SeaCrop16).
- Continue monitoring plant growth (blueberry cover, stem height, buds per stem).
- Continue monitoring pest pressure (weed, insect, disease).
- Monitor chlorophyll content, anthocyanin content, and photosynthetic electron transport rate every 2 weeks on 6 marked stems in each plot during June to August 2020 (until harvesting).
- Mark 8 random stems in each plot to quantify winter damage (damaged stem length/ total stem length), leaf number, leaf area, leaf dry biomass, leaf nutrition, fruit drop and fruit yield in August 2020. Quantify the number of fruit drop, green fruits per stem (via counting) in June 2020 (on the marked 8 stems) and again the ripe fruits per stem will be counted during harvest in August 2020 (on the same marked stems). The counted ripe fruits will be weighed afterwards using a precision balance (0.001 gm).
- Measure soil moisture.
- Collect crop year blueberry yield and quality data.

ACKNOWLEDGEMENTS

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