CROP GROWTH & PHYSIOLOGY

RESEARCH

INVESTIGATORS: L. Calderwood and Y. Zhang

11. TITLE: Effects of Foliar Fertilizers on Wild Blueberry Physiology and Pest Pressure

OBJECTIVES

- Evaluate new fertilizer products and their impact on wild blueberry productivity, physiology, and morphology.
- Study the effect of fertilizer application on weed and insect pressure, and disease incidence.

LOCATION: UMaine Blueberry Hill Farm Experiment Station, Jonesboro ME
PROJECT TIMEFRAME: December 2018 – March 2021

INTRODUCTION

Several pesticide and fertilizer companies are now advertising and selling foliar fertilizer to wild blueberry growers. Studies that have investigated the impact of foliar fertilizers on crop yield have shown mixed results (Collins & Drummond 2018). Boron applied as a foliar spray was not found to increase fruit set in wild blueberry (Smagula 1993) yet consistent applications of foliar Boron throughout both summer and fall were found to reduce winter injury (Eaton et al. 2007). Iron (Fe) chelate and copper (Cu) were not shown to have any impact on stem measures or yield (Smagula 2008). When iron deficiency is observed, the long-term solution is to apply sulfur, which will bring the pH down, allowing iron to become available to the plant. Iron chelate is a “quick fix” but not the long-term solution.

Products for this 2019-2020 study were chosen based on interest from fertilizer companies to sell their product to wild blueberry growers in Maine. Products were donated by the companies, yet all other aspects of the project were funded by a State of Maine Specialty Crop Block Grant. Five of the products in this two-year study are foliar fertilizers from Agro-100 Global. Seacrop16 produced by North American Kelp Company and NanoGro produced by AquaYield are fertilizers with plant growth regulator (PGR) active ingredients. The active ingredient in Seacrop16 is kelp extract which naturally contains cytokinin, a growth hormone associated with enhanced plant growth and bud development (cell division), which may serve as an alternative to traditional fertilizers (Peltonen-Sainio, 1997; Zodape, 2008). NanoGro is a 7-10-1 mixed with gibberellic acid, another plant growth hormone known to promote and elongate cells. AquaYield claims that this product increases fruit set when applied during bloom.

Traditional fertilizers used in wild blueberry production are soil applied granular fertilizers, such as MAP (monoammonium phosphate, 12-61-0) and DAP (diammonium phosphate, 18-46-0). Plants require more than just nitrogen and phosphorous. To our knowledge there have been very few studies conducted on the effects micronutrients and plant growth regulators on wild blueberry. There is renewed interest in understanding micronutrient applications. Multiple studies have found foliar fertilizer to effectively correct leaf nutrient deficiencies and improve yield in highbush blueberries (*Vaccinium corymbosum* L.), (Hart et al. 2006; Karlsons & Osvalde 2019; Wach & Błazewicz-Woźniak 2012). The claim behind foliar fertilizers is that the nutrients applied to the leaves are simple, fast, and "readily absorbed" with less potential for soil problems or environmental contamination (Karlsons & Osvalde 2019). Physiologically, blueberry has a waxy leaf cuticle, making foliar fertilizer sprays ineffective when specific nutrients are applied or environmental conditions are unfavorable (Hart et al. 2006; Wach & Błazewicz-Woźniak 2012). Some foliar fertilizer products contain adjuvants that may aid in getting the fertilizer or PGR through the waxy leaf.

METHODS

In the fall of 2018, both soil and foliar samples were taken at the site location for this study at Blueberry Hill Farm in Jonesboro, ME. In 2019, products and controls were tested on a prune field in a randomized complete block design. Each treatment was replicated eight times in 6' by 30' plots. Products were applied at the recommended rate according to the label or company representative. DAP was included as the grower standard. It was applied at the rate recommended by the University of Maine Soil Testing Lab, Orono ME based on foliar test results from 2018. Product names, ingredients and rates are listed in Table 1.

Products that were recommended for vegetative and bud development were applied in 2019 as prune year products and will not be applied in 2020. Products that were recommended for flowering and fruit development will be applied in 2020 as crop year applications. In 2019, prune year products were applied on June 12th, July 9th, August 21st, and September 10th. The DAP fertilizer treatment was applied one time as a broadcast application by hand on June 12th, 2019.

Table 1. Products tested in a randomized complete block design with 8 replicates.

Fertilizer				**Application**		
Type	Material	Content	Rate	Crop Cycle	#/Season	Method
Control	None	N/A	N/A	N/A	N/A	N/A
DAP	Granular	Diammonium phosphate	80 lbs N/A	Prune	1	Hand broadcast
SeaCrop16	Liquid	Cytokinin (PGR)	41 oz/A	Prune	4	Backpack Sprayer
Salvador	Liquid	14-4-6	0.5 gal/A	Prune	4	Backpack Sprayer
Agro-Phos	Liquid	0-29-5 + 4% Mg	0.5 gal/A	Prune	4	Backpack Sprayer
Kali-T	Liquid	2-0-24 + Si	0.5 gal/A	Crop	4	Backpack Sprayer
NanoGro	Liquid	7-10-1 + PGR	4 oz/A	Crop	4	Backpack Sprayer
Poma	Liquid	0-0-0 + 6% Ca	0.5 gal/A	Crop	4	Backpack Sprayer

Data Collection

Physiology

Two locations within two different genets per plot were selected randomly to measure prune year percentage tip-die back within a 2'x2' quadrat. Six stems from each plot were randomly selected and marked to monitor stem length, chlorophyll content and anthocyanin content during June-October. Chlorophyll content was measured using a SPAD Chlorophyll Meter (SPAD 502; Minolta Corp., Osaka, Japan), anthocyanin content was measured by an ACM-200 (Opti-sciences, Hudson, USA). Photosynthetic rates (CO_2 assimilation) and photosynthetic electron transport rates were measured in leaves from two stems in each treatment plot by a portable photosynthetic measurement system (li-6800; Li-Cor Biosciences, Lincoln, NE, USA) on one sunny date, July 15, 2019 between 10:00 and 15:00 h solar time at a photosynthetic photon flux density of 1500 $\mu mol\ m^{-2}s^{-1}$. Twelve stems from each genet, 24 stems per plot, were collected in July 2019 (after

100% tip-die back) to measure leaf area, leaf dry biomass and leaf nutrition. 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. The dried leaf samples were ground and sent to the University of Maine Soil and Plant Tissue Testing laboratory in Orono, Maine for nutrition analysis.

Pest Pressure

Two 0.37 m^2 quadrats were placed and flagged for repeated pest and plant growth measurements taken throughout the season. Blueberry crop cover, presence of weed species, insect and disease pressure were recorded on August 21st, 2019. Pest severity was established using equal intervals 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%. Weeds were identified into two groups: grass and broadleaf, each of which were also given a severity rating on the same 0-6 scale.

Crop Productivity

Blueberry crop cover, stem height, and number of buds per stem were measured on September 20th, 2019 in the same quadrats after all product applications had been made. Height and bud count were both measured on the same 8 stems per quadrat. All measurements will be repeated in the 2020 crop year in addition to the collection of yield and crop quality.

<u>Data Analysis</u>

Physiology

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

Pest Pressure & Productivity

Blueberry crop cover and pest incidence (weeds, insect pressure and disease) were statistically compared using Chi-Squared test in JMP (JMP®, Version 14.3) across all fertilizer treatments ($\alpha = 0.05$). The effects of the fertilizer treatments on blueberry health, evaluated as a function of stem height and bud count were also statistically compared using a one-way ANOVA in JMP ($\alpha = 0.05$).

RESULTS- Preliminary

<u>Wild Blueberry Physiology</u>

Overall, no significant differences were observed in wild blueberry physiological characteristics (chlorophyll concentration, photosynthetic rate, electron transport rate, or leaf tissue nutrients) among different fertilizer treatments during the first year of application. DAP granular fertilizer showed the highest chlorophyll concentration (Figure 1) followed by Salvador and Agro-phos foliar treatments, which were higher compared to the control and SeaCrop16 foliar treatment. In contrast, SeaCrop16 and DAP treatments showed the highest photosynthetic rates and electron transport rates (Figure 2) which were similar to the control, whereas Salvador and Agro-phos foliar treatments showed lower photosynthetic and electron transport rates compared to the control. Leaf tissue analysis revealed no significant differences. However, the DAP treatment revealed slightly higher N, P, K concentrations in the leaves, while plants in some of the foliar spray treatments exhibited slightly higher Al, B, Cu, and Fe micronutrient concentrations (Figure 3).

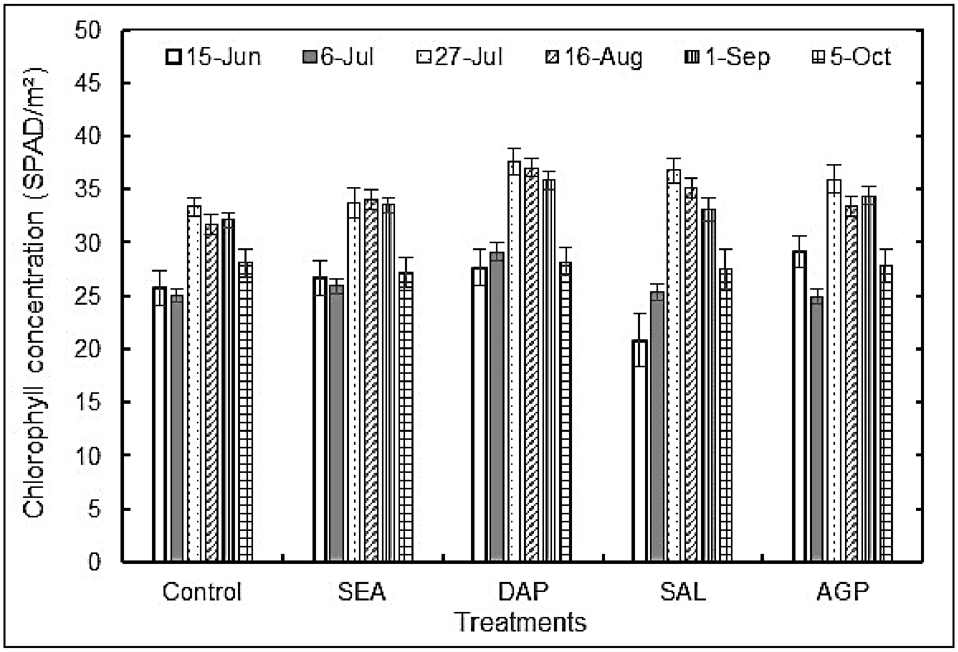


Figure 1. Comparison in chlorophyll concentration of wild blueberry leaves over time among different fertilizer treatments in a conventional wild blueberry field (Blueberry Hill Research Farm, Jonesboro, ME). No significant differences among different treatments were observed.

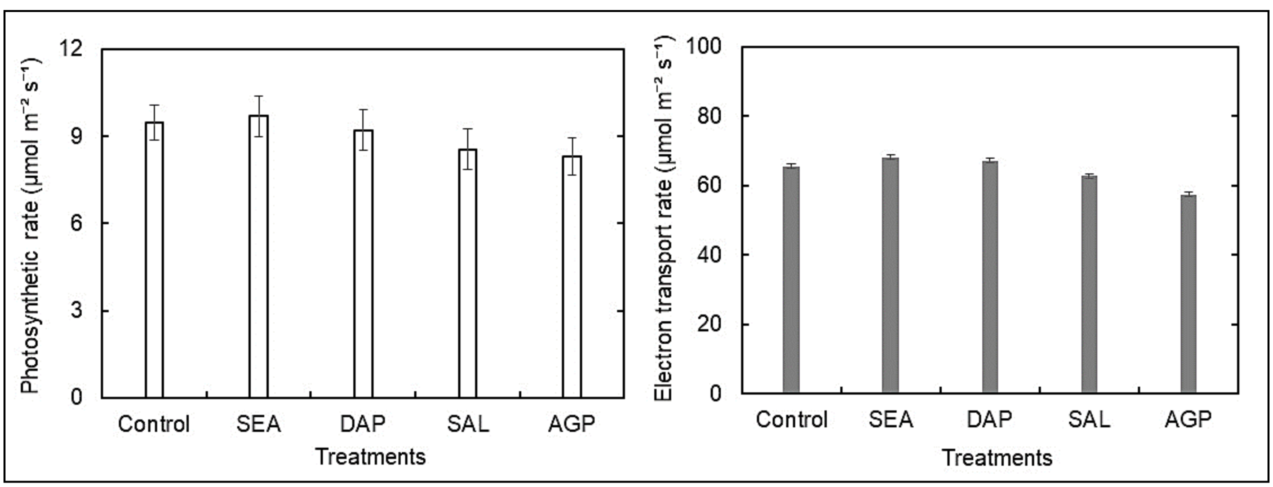


Figure 2. Comparison in leaf photosynthetic rate (CO_2 assimilation) and photosynthetic electron transport rate of wild blueberry leaves among different fertilizer treatments in a conventional wild blueberry field (Blueberry Hill Research Farm, Jonesboro, ME). No significant differences were observed.

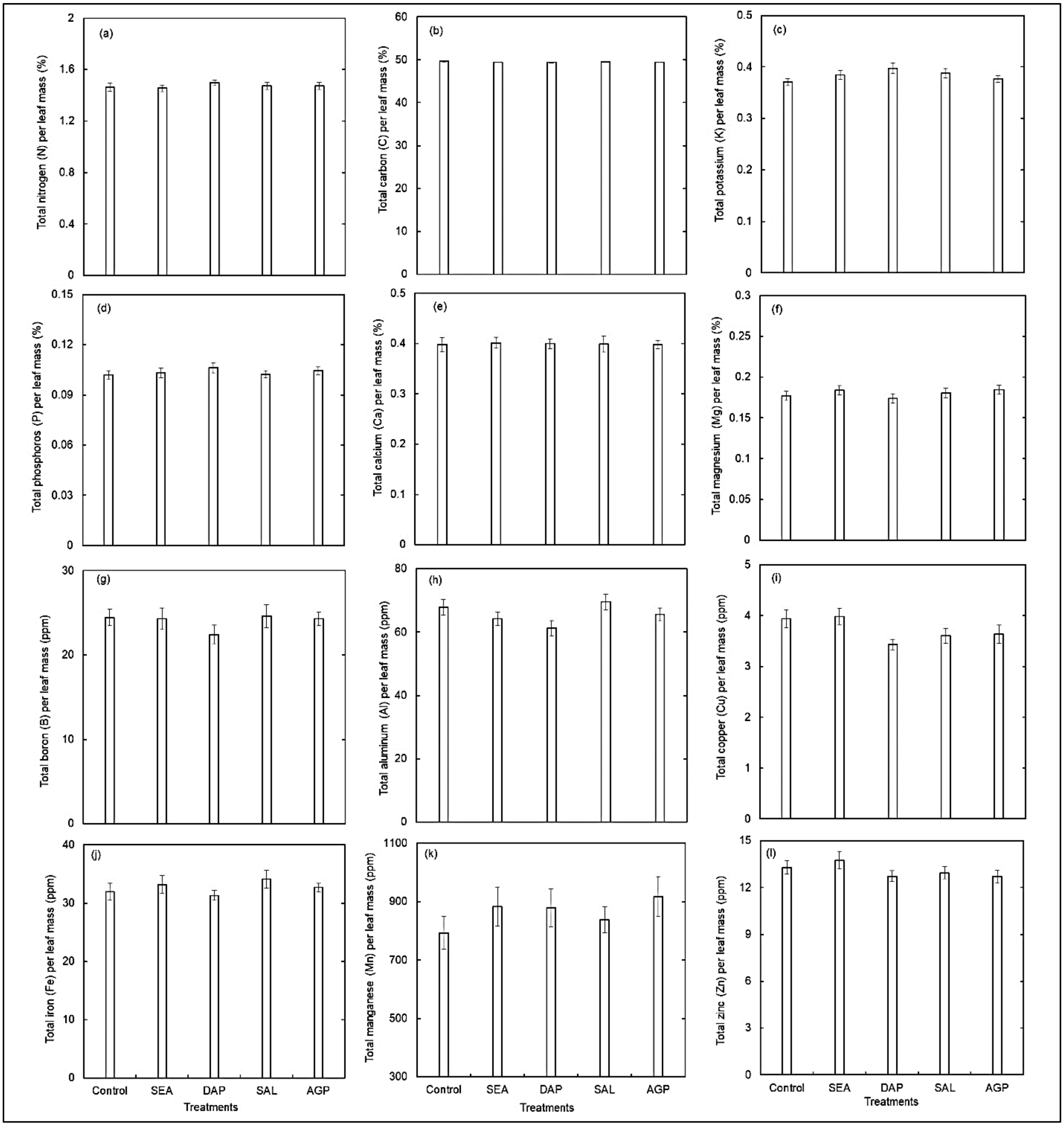


Figure 3. Leaf nutrient concentrations per leaf biomass including (a) Total nitrogen (N), (b) Total carbon (C), (c) Total potassium (K), (d) Total phosphorous (P), (e) Total calcium (Ca), (f) Total magnesium (Mg), (g) Total boron (B), (h) Total aluminum (Al), (i) Total copper (Cu), (j) Total iron (Fe), (k) Total manganese (Mn), and (l) Total zinc (Zn) by treatment. Data are averages ± S.E.; n=16. No significant differences were observed among the treatments.

Wild Blueberry Morphology:

Similarly, no significant differences were observed in morphological characteristics (leaf area and leaf dry biomass per stem) between treatments. DAP granular fertilizer and SeaCrop16 foliar treatment showed the highest leaf area and dry biomass per stem (Figure 4). While, Salvador and Agro-Phos treatments had lower leaf area and leaf dry biomass per stem compared to the control and other treatments (DAP and SeaCrop16).

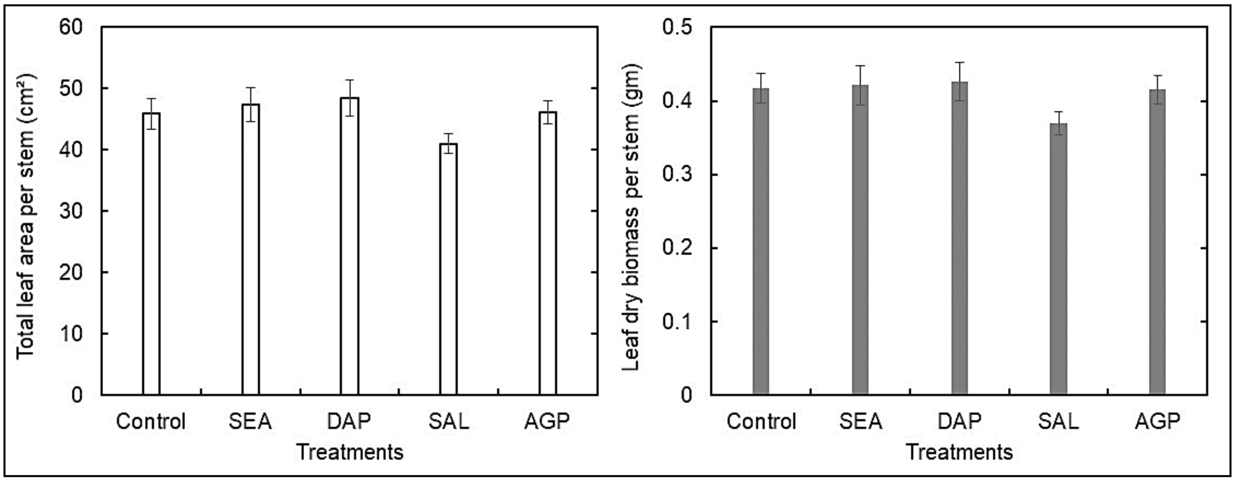
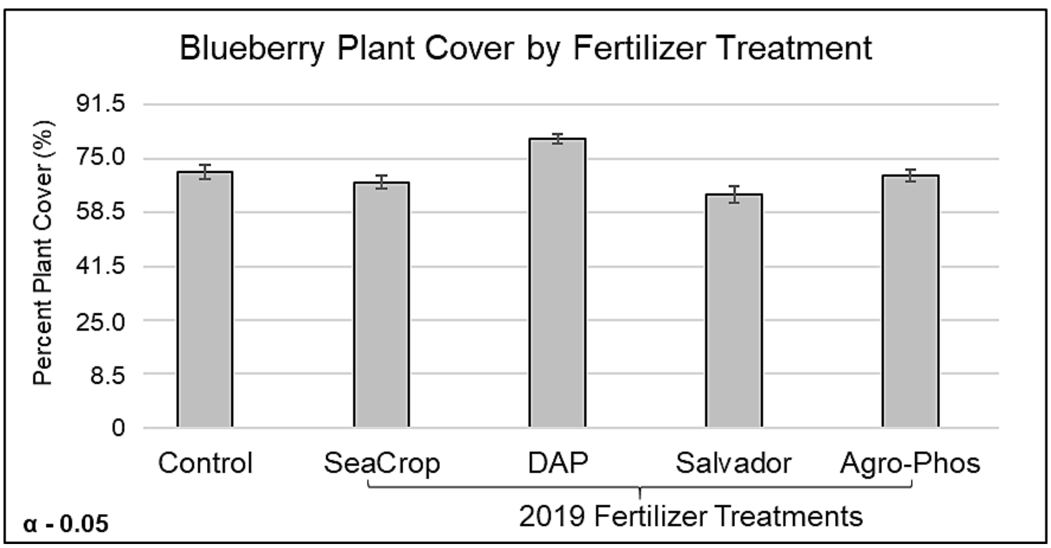


Figure 4. Comparison in leaf area per stem and leaf dry biomass per stem of wild blueberry plants among the fertilizer treatments in a conventional wild blueberry field (Blueberry Hill Farm, Jonesboro, ME). No significant differences were observed.

Wild Blueberry Productivity

Blueberry plant cover, stem height and bud count were used to best represent blueberry health and productivity in the 2019 prune-cycle. In the first year of application, blueberry plant cover did not exhibit significant differences between fertilizer treatments (Figure 5). **Figure 5.** Percent



blueberry plant cover by fertilizer treatment. No significant differences were observed.

When evaluating stem height and bud count by treatment, blueberry plants in DAP plots were significantly taller than those that received the Salvador or Agro-Phos foliar spays (Figure 6).

However, the plants that received DAP did not show substantial deviation from the SeaCrop treatment or the Control. While no significant differences were detected in the number of buds formed per stem between treatments, the SeaCrop fertilizer treatment presented the highest average number of buds relative to average stem height (Figure 6).

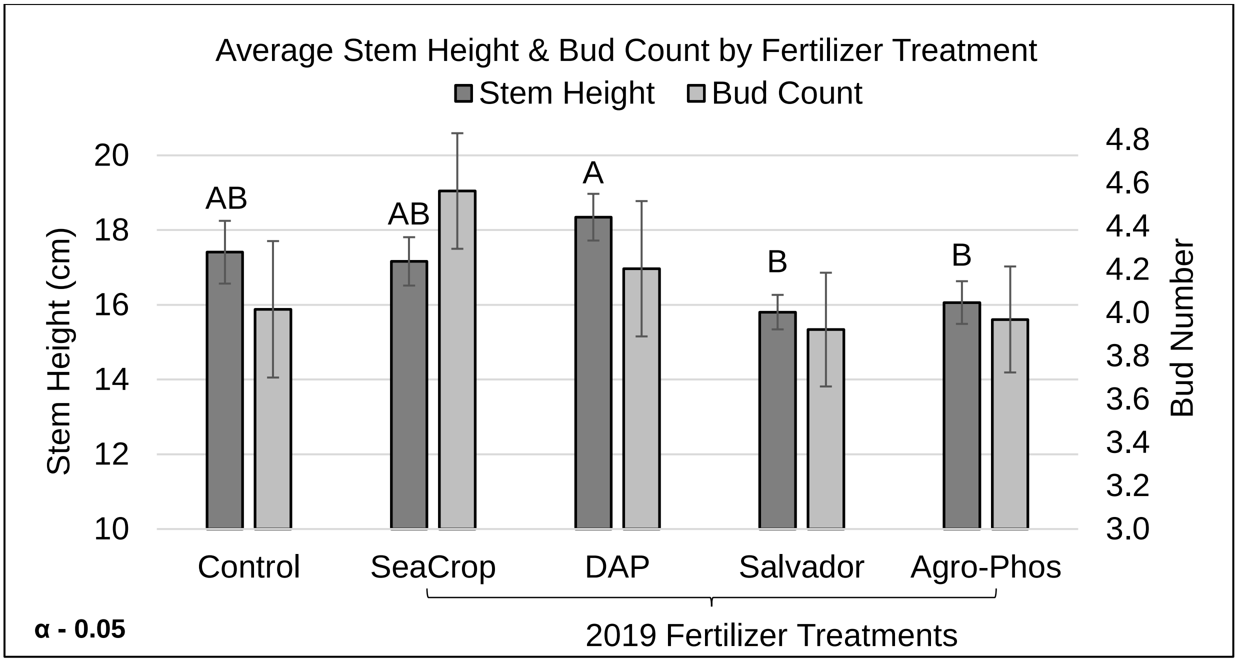


Figure 6. Blueberry stem height and bud count by fertilizer treatment as a representation of overall blueberry plant heath. No significant differences in bud counts were detected. DAP plots had a significantly higher stem height than Salvador and Agro-Phos.

Pest Incidence

Pest pressure identified in the 2019 prune-cycle included: 2 general groups of weeds (grass and broadleaf), 5 insects (Red Stripe Fire-worm, Tip Midge, Flea Beetle, Gall Wasp and Trips), and 2 diseases (grouped as: leaf spot and blight). New fertilizer products did not significantly impact pest pressures in this initial year. However, it is interesting to see trends of increased disease and weed pressure with certain products and decreased insect pressure for almost all products relative to the control (Figure 7). Subsequent years of this experiment will reveal any indirect effects of these fertilizer treatments on pest pressure.

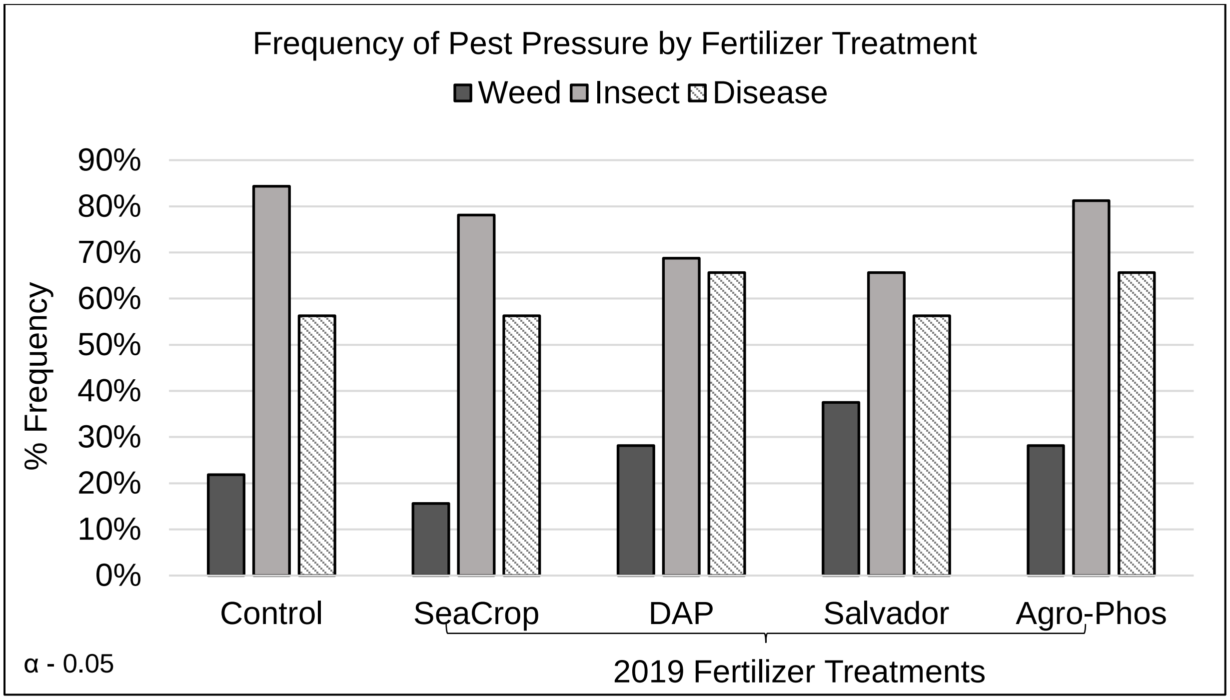


Figure 7. Pest frequency in a low-input, conventionally managed wild blueberry field relative to applied fertilizer treatments in the 2019 prune-cycle. No significant differences were observed.

DISCUSSION

<u>Wild Blueberry Physiology</u>

The preliminary results showed some effects of fertilizer products on physiological and morphological characteristics of wild blueberry plants, yet the differences were not significant in the first year (vegetative year; 2019). Since plants need time to absorb nutrients from the applied fertilizers and respond slowly in terms of their growth and development, the crop year, 2020, might reveal significant differences among the treatments.

High nitrogen content in the DAP (80 lb N/acre) and Salvador (N-P-K: 14-4-6) might be the reason for the higher chlorophyll concentrations (Figure 1) compared to the control and other treatments (SeaCrop16 and Agro-Phos). N-P-K and DAP fertilizers have proved to be efficient for wild blueberries (Smagula 2011; Starast et al. 2005; Percival et al. 2002; Percival & Sanderson 2004). Photosynthetic rates and electron transport rates (Figure 2) were expected to follow the same trend as the chlorophyll concentration, since chlorophyll concentration is a strong determinant of photosynthetic rate and electron transport rate (Evans 1985; Seemann et al. 1987). Interestingly, the control (where no fertilizer was applied) showed similar photosynthesis and electron transport rates, leaf area and biomass per stem to the SeaCrop16 and DAP treatments, and showed higher electron transport rate, leaf area and biomass compared to the Salvador and Agro-Phos treatments. Leaf surface areas per stem were higher in SeaCrop16 and DAP treatments which could be because of the cell division regulator hormone cytokinin in SeaCrop16 and high nitrogen supply from the DAP fertilizer (Taiz et al. 2015). These trends will be further justified by the leaf nutrition concentration analyses and the results of the 2020 crop-cycle.

<u>Pest Pressure & Productivity</u>

The lack of response in overall blueberry plant coverage to the first year of fertilizer treatments may be a function of the spatial variability in the growth and coverage of wild blueberry (Zaman, Schumann, Percival & Gordon 2008), or the relatively slow establishment of the plant (Yarborough 2012). Indirect responses such as pest pressure also did not exhibit significant responses to the fertilizer treatments in this initial year of application. The continuous monitoring of blueberry health and pest pressure in response to these new fertilizer applications in the 2020 crop-cycle is essential prior to drawing final conclusions and recommendations on the use of these products on wild blueberry.

Additionally, the cost of these products plays a crucial role for Maine wild blueberry growers (Table 2). While DAP yielded the tallest plants, DAP also required a generous application to the soil (440 lbs/acre) based on leaf nutrient analysis making DAP the most expensive fertilizer treatment applied in 2019. In contrast, SeaCrop, Salvador and Agro-Phos had relatively small application rates when applied directly to the leaves, with more frequent applications, resulting in a lower cost per acre.

Table 2. Cost comparison of fertilizer products tested in 2019/2020. Foliar fertilizers are based on a minimum purchase of 5 gallons. Prices may vary based on the quantity purchased, grower size and retailer. Estimates do not include labor costs.

Type	Rate	Cost/unit	Cost ($/acre/app.)	Cost Season* ($/acre/season)
DAP	80 lbs N/A	$ 18.00/50lb bag	$158.00	$158.00
SeaCrop16	41 oz/A	$ 49.00/Gal	$10.57	$42.28
Salvador	0.5 gal/A	$ 15.38/Gal	$7.69	$30.76
Agro-Phos	0.5 gal/A	$ 33.95/Gal	$16.98	$67.92
Kali-T	0.5 gal/A	$ 26.12/Gal	$13.06	$52.24
NanoGro	4 oz/A	$ 48.00/Gal	$6.00	$24.00
Poma	0.5 gal/A	$ 17.98/Gal	$8.99	$35.96

**Cost per season estimates are based on 4 applications/season for foliar sprays, DAP is one application per season.*

After the first year of this study, it is clear that more research into the role of plant hormones in wild blueberry production is warranted. Additionally, the age of leaves at the time of application may impact foliar fertilizer uptake. Petiole sap testing may provide a more real-time picture of the nutrients available in wild blueberry plants, which may improve the accuracy of fertilizer application timing.

CURRENT RECCOMENDATIONS

None at this time.

NEXT STEPS

2020 Field Season:

- Apply crop-cycle fertilizer applications (Kali-T, NanoGro, Poma).
- Chlorophyll content, anthocyanin content, and electron transport rate will be monitored every 2 weeks on the 6 marked stems in each plot during June to August 2020 (until harvesting).

- Monitor overall plant health (plant cover, stem height and bud count).
- Monitor pest pressure (weed, insect, disease).
- Eight random stems in each plot will be marked 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.
- The number of fruit drop will additionally be quantified by counting the number of green fruits per stem in June 2020 (on the marked 8 stems) and again counting the ripe fruits per stem in August 2020 on the same marked stems. The counted ripe fruits will be weighed afterwards using a precision balance (0.001 gm).
- Harvest the blueberries from each plot to compare fertilizer effects on crop yield and quality.

ACKNOWLEDGEMENTS

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