2018 PROGRESS REPORT

Year Initiated: 2018 **Current Year:** 2018 **Terminating Year:** 2019

Title: Impacts of Post-Harvest Nitrogen Cut-Off times in 'Duke' Blueberry

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OBJECTIVES:
The overall objective of this study is to evaluate the impacts of post-harvest nitrogen applications on plant growth, yield, fruit bud set, and cold hardiness in early fruiting 'Duke' blueberry grown in eastern Washington.

PROCEDURES:
An on-farm study was established in Prosser, WA in February 2018 in a commercially managed organic 'Duke' field. Plants were in their eighth growing season and grown on raised beds mulched with wood chips. The experimental design was a randomized complete block with each treatment replicated four times. Plants were spaced 2.5 feet apart within the row with 16 plants in each treatment plot. All treatments were applied using one fertilizer source, WISErg (3-2-2; WISErg Corporation, Redmond, WA). Fertilizer was applied at a constant rate (125 lbs/A N) but varied with the timing of application. Treatments include:

1) Control (100% of N applied pre-harvest; standard grower practice)
2) 80/20 (80% of N applied pre-harvest, remaining 20% applied post-harvest)
3) 70/30 (70% of N applied pre-harvest, remaining 30% applied post-harvest)
4) 60/40 (60% of N applied pre-harvest and remaining 40% applied post-harvest)

Fertilizer application began at ~5 to 10% bloom on 17 April and continued through 22 August 2018 with fertilizer being applied every week around the crown of the plants and near the root zone under the drip line. Fertilizers amount was first calculated for each treatment and applied using marked beakers. The control treatment received a total of 10 fertilizer applications (all pre-harvest); the 80/20 treatment received 12 fertilizer applications (10 pre-harvest, 2 postharvest); the 70/30 treatment received 14 fertilizer applications (10 pre-harvest, 4 post-harvest); and the

60/40 treatment received 16 fertilizer applications (10 pre-harvest, 6 post-harvest).

Data collection:
Vegetative growth was assessed from the center 8 plants per plot by counting the number of whips arising from latent buds and suckers per plant. Cumulative lateral shoot growth was also measured monthly from June through September from one flagged shoot per plant at mid-canopy level. An Unmanned Aerial Vehicle (UAV; ATI AgBot™, Oregon City, Oregon) was used to capture aerial images using MicaSense® (RedEdge.MX, MicaSense®, Seattle, WA) multispectral cameras at a height of 50 and 100 feet. The acquired images were processed using various indices including NDVI (Normalized Differential Vegetative Index) and GDVI (Generalized Difference Vegetative Index) on Pix4D software (Pix4D SA, Lausanne, Switzerland). These indices were used to estimate biomass and serve as a proxy for N concentration.

Total yield (lbs/plant) was determined by harvesting all of the fruit from the center three plants in each plot on 26 June 2018. A random sample of 50 fully ripe berries were sampled from each plant for analysis of fruit quality parameters. Average berry mass and firmness were evaluated within 48 hours of harvesting from 30 fully ripe berries from each treatment plot using a FirmTech II (Bioworks, FirmTech II, Bioworks, Wamego, KS). All berries were then frozen at -9.4˚F (-23˚C) and will be thawed to determine fruit soluble solids concentrations (SSC), pH, and titratable acidity by end of December 2018. Soluble solids concentration will be determined from juice collected from 50 berries per plot using a digital refractometer (H19680 Refractometer, Hanna Instruments, Woonsocket, RI). Initial juice pH and titratable acidity will be measured using a digital autotitrator (HI84532 Minititrator and pH Meter, Hanna Instruments, Woonsocket, RI).

Leaves were collected for tissue nutrient analyses in mid-August from each plant within a treatment. Two fully expanded leaves, one from each side of the plant, were collected from mid-canopy height. Collected leaves were oven-dried at 140 °F (60º C) for 48 hours and ground to <40 mesh with a Wiley Mill (Thomas Scientific, Swedesboro, NJ). Soil pH, NO_3-N, and NH_4-N were determined from a bulk sample collected from the entire field before treatment application in March 2018. Samples were collected at a 12-inch depth. Samples were collected again in August 2018 from each treatment plot. Soil was air dried and sieved to <2 mm. Both dried soil and ground leaf samples were sent to a commercial lab for analysis(Soiltest Farm Consultants, Inc., Moses Lake, WA).

Fruit bud set was determined from 10 laterals per treatment plot in November 2018 using the formula: Fruiting buds/Total buds per lateral X 100 = % Fruit bud set per lateral.

Cold hardiness of fruit buds was determined in October and November 2018 and will be measured again in December 2018 using the polar pod machine at WSU IAREC.

2018 PRELIMINARY RESULTS AND CONCLUSIONS:
Vegetative growth: We observed no statistically significant differences in shoot length between treatments over the period of June to September. However, the shoots were actively growing past August with the longest shoot growth observed in the 60/40 treatment whereas the 70/30 treatment had the least growth (Fig. 1). Similarly, no difference in the production of whips and

suckers was observed among treatments (Table 1). Fruit bud set (%) for 2018 was the same for all treatments in 2018.

Yield and fruit quality. We did not observe any statistically significant yield differences among the treatments (Table 1). Numerically, the highest yield was observed among plants grown in the 60/40 treatment plots whereas the lowest yield was associated with 80/20 treatment. Average berry mass was not significantly impacted by the treatments. However, firmness was affected with the most firm fruit observed in the 60/40 treatment and the least firm fruit in the 80/20 treatment. Similarly, no statistical differences were observed in whip and sucker production between the treatments. UAV data collected on 18 Aug. showed no significant differences in mean NDVI values between the treatments (Table 2 and Figure 2). GDVI data is currently being processed and analyzed.

Nutrient analyses: Nitrogen concentrations in leaf tissues did not significantly differ with treatment (Table 3). Tissue nitrogen concentrations in our experiment were below the recommended range of 1.76-2.0% N (Hart et al., 2006). However, no indications of nitrogen deficiency have been observed in the plants. The level of nitrogen is consistent with those found in previous studies in eastern Washington (Davenport and DeVetter, unpublished data). Analysis of other macro- and micro-nutrients is underway.

Average soil pH (1:1), NO_3-N, and NH_4-N before the fetilizer treatments were applied were 6.1, 13.6 mg/kg, and 3.1 mg/kg, respectively. No statistical differences were observed for soil pH, NO_3-N, and NH_4-N in Aug. 2018 (Table 3). Soil pH decreased but was within the recommended range of 4.2-5.5 except for the 70/30 treatment (Hart et al., 2006). Nitrate was numerically highest in the 80/20 treatment, whereas the 60/40 treatment was lowest. Ammonium was numerically highest in the control treatment (100/0) and lowest in the 80/20 treatment.

Overall, there were few to no differences observed in the first year of this experiment. The variability in the yield data and other fruit quality parameters is likely explained as a carryover effect from previous year's fertilizer applications. Treatment differences are expected in the following years as the plants respond to this year's treatment applications. The active growth of shoots in plants fertilized with 60/40 treatment past August could be related to late season N applications. Repetition of the experiment in 2019 will allow us to discern how plants are responding to postharvest N fertilizer applications.

ANTICIPATED BENEFITS AND INFORMATION TRANSFER:
The results from this experiment will provide information that allows for the creation of data-driven management guidelines. This will help growers and crop advisors create informed nutrient management plans and addresses some of the basic questions of organic nutrient management in this unique blueberry production area.

This project will be part of Amit Bhasin's MS thesis. Results will be shared with grower cooperators, at regional horticulture events (e.g. Small Fruit Conference), and at national horticulture meetings (e.g. American Society for Horticultural Sciences). Information will also be published online on the Small Fruit Horticulture Website (http://smallfruits.wsu.edu/) and in peer-reviewed journals. Data will also be used to generate extension fact sheets on organic blueberry nutrient management for eastern Washington.

OUTPUTS:

- A. Bhasin. 2018. Fine-tuning organic nitrogen fertilizer sources, rates, and cut-off times in organic highbush blueberry. Washington Small Fruit Horticulture Conference. Lynden, WA.

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REFERENCES :

Hart, J., B. Strik, L. White, and W. Yang. 2006. Nutrient management for blueberries in Oregon. Ore. State Univ. Ext. Serv. EM 8918.

Davenport. J.R. and L.W. DeVetter. 2019. Blueberry Tissue Nutrient Standards for Washington Production. *In progress*.

TABLES AND FIGURES

Table 1. Number of whips and suckers per bush, yield, average berry mass, fruit firmness, and fruit bud set in 'Duke' blueberry treated with different fertilizer nitrogen cut-off times. The treatments were: 1) Control (100% of N applied pre-harvest; standard grower practice); 2) 80/20 (80% of N applied pre-harvest, remaining 20% applied post-harvest); 3) 70/30 (70% of N applied pre-harvest, remaining 30% applied post-harvest); and 4) 60/40 (60% of N applied pre-harvest and remaining 40% applied post-harvest). Data were collected in 2018.

Treatment	No. whips/bush	No. suckers/whips	Yield (lbs/bush)	Average berry mass (g/berry)	Firmness (g/mm of deflection)	Fruit bud set (%)
100/0 (Control)	7	2	32.3	1.8	196.8ab[z]	54
80/20	7	2	27.2	1.8	191.7b	54
70/30	7	1	33.6	1.7	200.3ab	54
60/40	7	2	35.1	1.7	206.2a	54
P-Value	NS	NS	NS	NS	0.0143	NS

[z]Means separations were performed with Tukey's Honest Significant Difference (HSD) test; means with the same letter are not different at $P \leq 0.05$; NS denotes not statistically significant.

Table 2. Mean NDVI values of 'Duke' blueberry treated with different fertilizer nitrogen cut-off times. The treatments were: 1) Control (100% of N applied pre-harvest; standard grower practice); 2) 80/20 (80% of N applied pre-harvest, remaining 20% applied post-harvest); 3) 70/30 (70% of N applied pre-harvest, remaining 30% applied post-harvest); and 4) 60/40 (60% of N applied pre-harvest and remaining 40% applied post-harvest). Data were collected in 2018.
[z]Means separations were performed with Tukey's Honest Significant Difference (HSD) test; NS denotes not statistically significant.

Treatments	Mean NDVI Values
100/0 (control)	0.82
80/20	0.83
70/30	0.83
60/40	0.83
P-value	NS[z]

[z]Means separations were performed with Tukey's Honest Significant Difference (HSD) test; NS denotes not statistically significant

Table 3. Leaf tissue nitrogen, soil pH, NO_3-N, and NH_4-N concentrations in soil growing 'Duke' blueberry treated with different fertilizer nitrogen cut-off times. The treatments were: 1) Control (100% of N applied pre-harvest; standard grower practice); 2) 80/20 (80% of N applied pre-harvest, remaining 20% applied post-harvest); 3) 70/30 (70% of N applied pre-harvest, remaining 30% applied post-harvest); and 4) 60/40 (60% of N applied pre-harvest and remaining 40% applied post-harvest). Data were collected in 2018.

Treatment	Nitrogen (%)	Soil pH (1:1)	NO_3-N (mg/kg)	NH_4-N (mg/kg)
100/0 (Control)	1.55	5.1	21.5	8.7
80/20	1.54	5.4	33.8	4.8
70/30	1.54	5.5	13.3	5.0
60/40	1.49	5.2	11.5	5.5
P-value	NS[z]	NS	NS	NS

[z]Means separations were performed with Tukey's Honest Significant Difference (HSD) test; NS denotes not statistically significant.

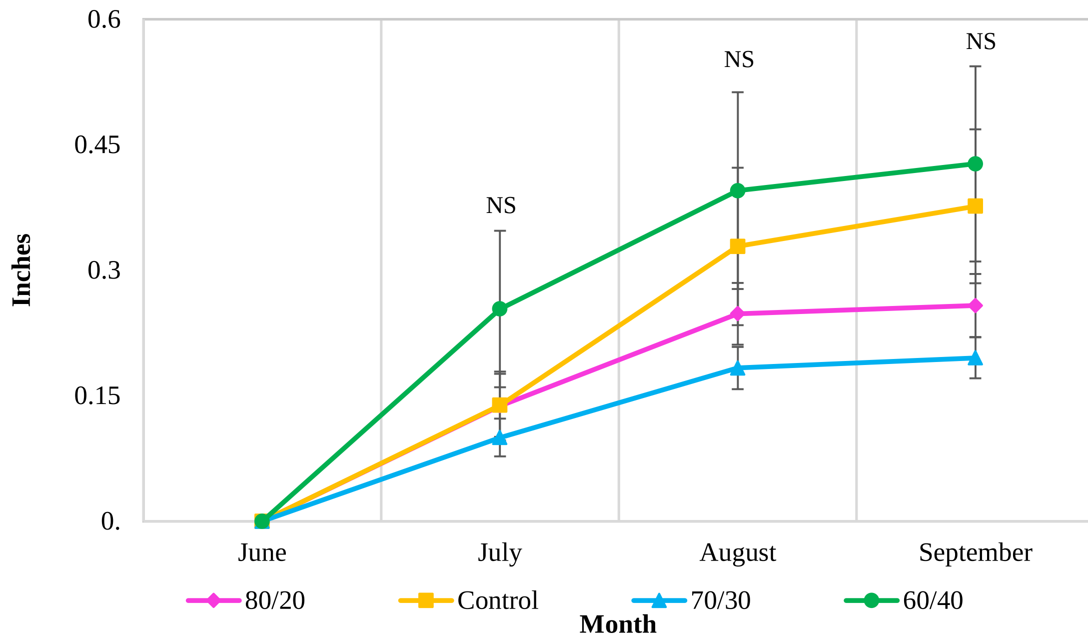

Figure 1. Cumulative shoot length measured in ‘Duke’ blueberry treated with different fertilizer nitrogen cut-off times. The treatments were: 1) Control (100% of N applied pre-harvest; standard grower practice); 2) 80/20 (80% of N applied pre-harvest, remaining 20% applied post-harvest); 3) 70/30 (70% of N applied pre-harvest, remaining 30% applied post-harvest); and 4) 60/40 (60% of N applied pre-harvest and remaining 40% applied post-harvest). Data were collected in 2018.
[z]NS denotes means within a sampling date are not statistically significant due to treatment at $P \leq 0.05$.

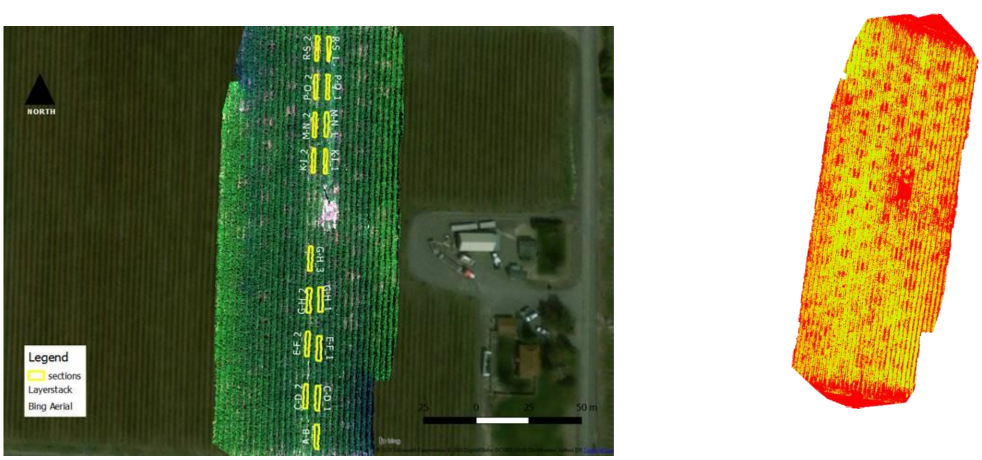

Figure 2. Aerial images of experimental ‘Duke’ field site treated with different fertilizer nitrogen cut-off times, 2018.