Fine-Tuning Organic Nitrogen Fertilizer Source, Rate, and Cut-off Timing in Organic Highbush Blueberry

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Washington Leads in Organic Blueberry Production

- Washington State is the **largest national producer** of organic highbush blueberries

~ 46% of nation's organic production
~ $38 million estimated value

(USDA NASS 2017)

Map constructed by H. Vogel and R. Rupp (Washington State University, Pullman

Washington Leads in Organic Blueberry Production

Variable	Requirements for blueberry	Native soil conditions in eastern Washington
pH	4.2-5.5	7.5-8.3
Organic matter	High (3-5%)	Low (<1%)
Predominate form of nitrogen	NH_4-N	NO_3-N

Dancer et al., 1973; Hart et al., 2006

- Blueberry cultivars **respond differently to organic N** fertilizer sources

- Rates of **N application varies with plant age** (Bryla and Strik, 2015)

Objective and Research Questions

- **Experiment #1 – Source and Rate**
  Evaluate the impacts of commercially available organic N fertilizer sources applied at low, medium, and high rates on blueberry plant growth, development, yield, and select soil characteristics

- **Research questions?**

  To find an **optimal organic N fertilizer source and rate** for northern highbush blueberry plants

Materials and Methods - Treatments

- Four organic N treatments

1. WISErganic (3N-0.9P-1.6K)
2. Blood meal (15N-0P-0K)
3. True fish emulsion (4N-0P-1.6K)
4. Combination (40% blood meal + 60% WISErganic)

- Three rates: 50 (**low**), 100 (**medium**), and 150 (**high**) lbs/acre N

Phosphorus (P) and Potassium (K) applied at 43 and 82 lbs/acre, respectively

ProPhos (0N-8.6P-0K) ProK (0N-0P-16.4K)

Materials and Methods – Experimental Design

- RCB design with plots split for different fertilizer rates

Main plot - **fertilizer source**
Sub-plot- **rate**

- Each treatment was replicated **4 times**
- 12 plants/plot –**10 plants** for data collection
- Orientation: N - S
- Experiment size: 0.2 acres

Materials and Methods – Fertilizer Applications

- Fertilizer applications began at **~5 to 10% bloom**
- Blood meal applied twice in the season

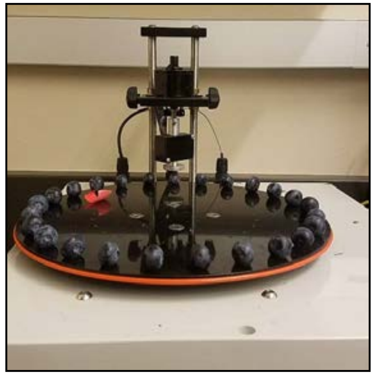
    - Four parts water with one-part blood meal **(4:1)**

- Liquid fertilizers (True fish emulsion, WISErganic) applied biweekly
- All fertilizers were applied around the **crown of the plants**

Data collection



- **Plant variables**
  - Cumulative shoot growth
    - June to September 2018
    - May to September 2019
  - Whip production
  - Average yield (lbs/bush)
  - Leaf tissue nutrients – mid August




- **Fruit quality**
  - Berry firmness and mass
  - Soluble solids concentrate (°Brix) and titrable acidity

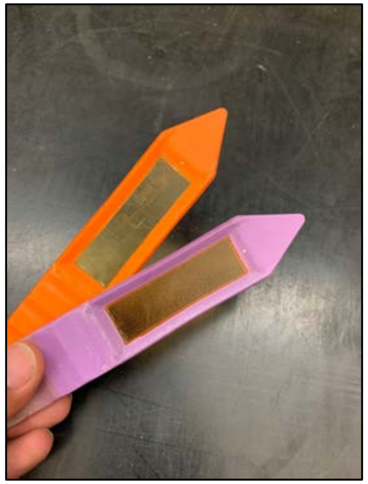
- **Soil properties**
  - Soil pH and Soil electrical conductivity (1:1)
  - NH_4-N and NO_3-N

Data Collection - Continued

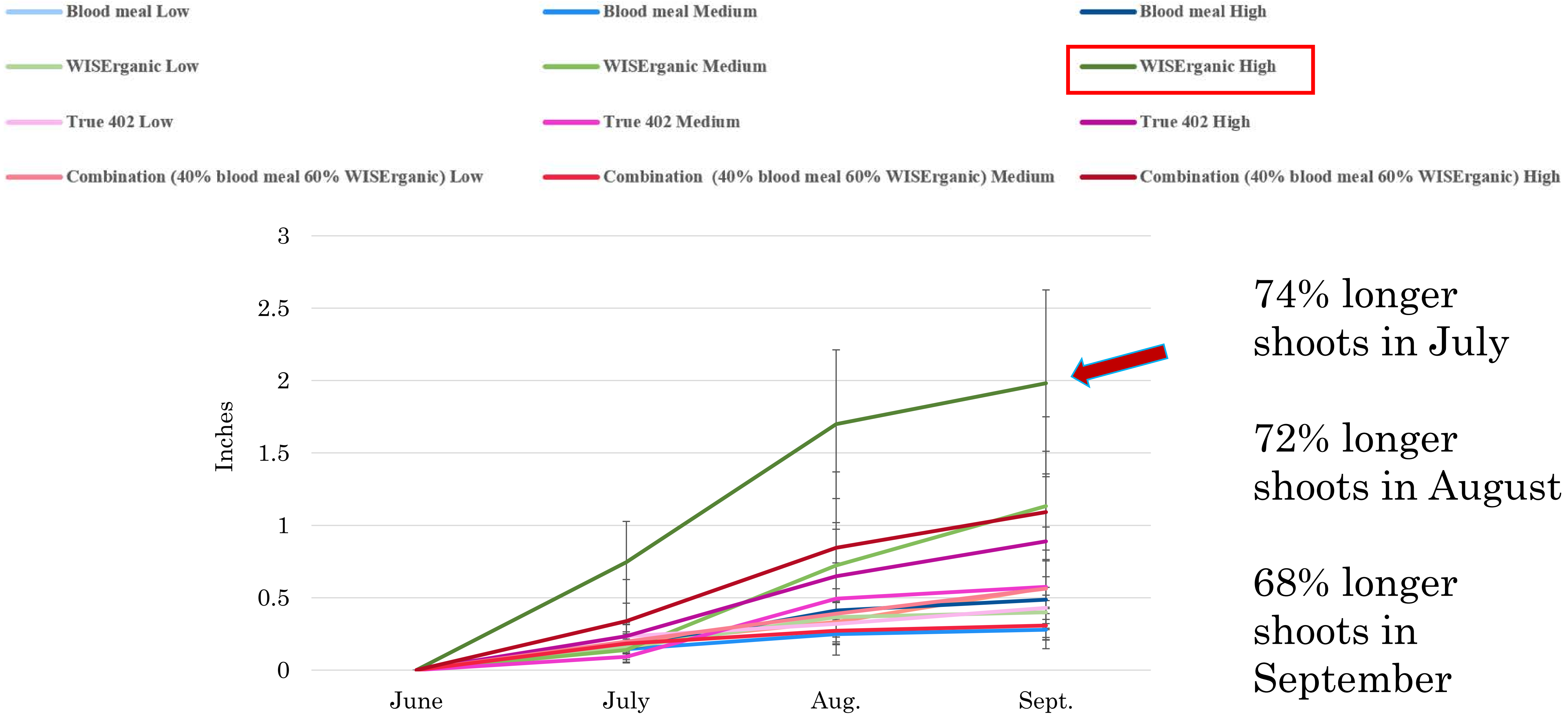
- Soluble N release from organic N fertilizers

  - PRS (plant root simulators) – NH_4-N and NO_3-N

  - Installed in **medium rate** plots; on the slope of the bed



Results – Shoot Growth 2018



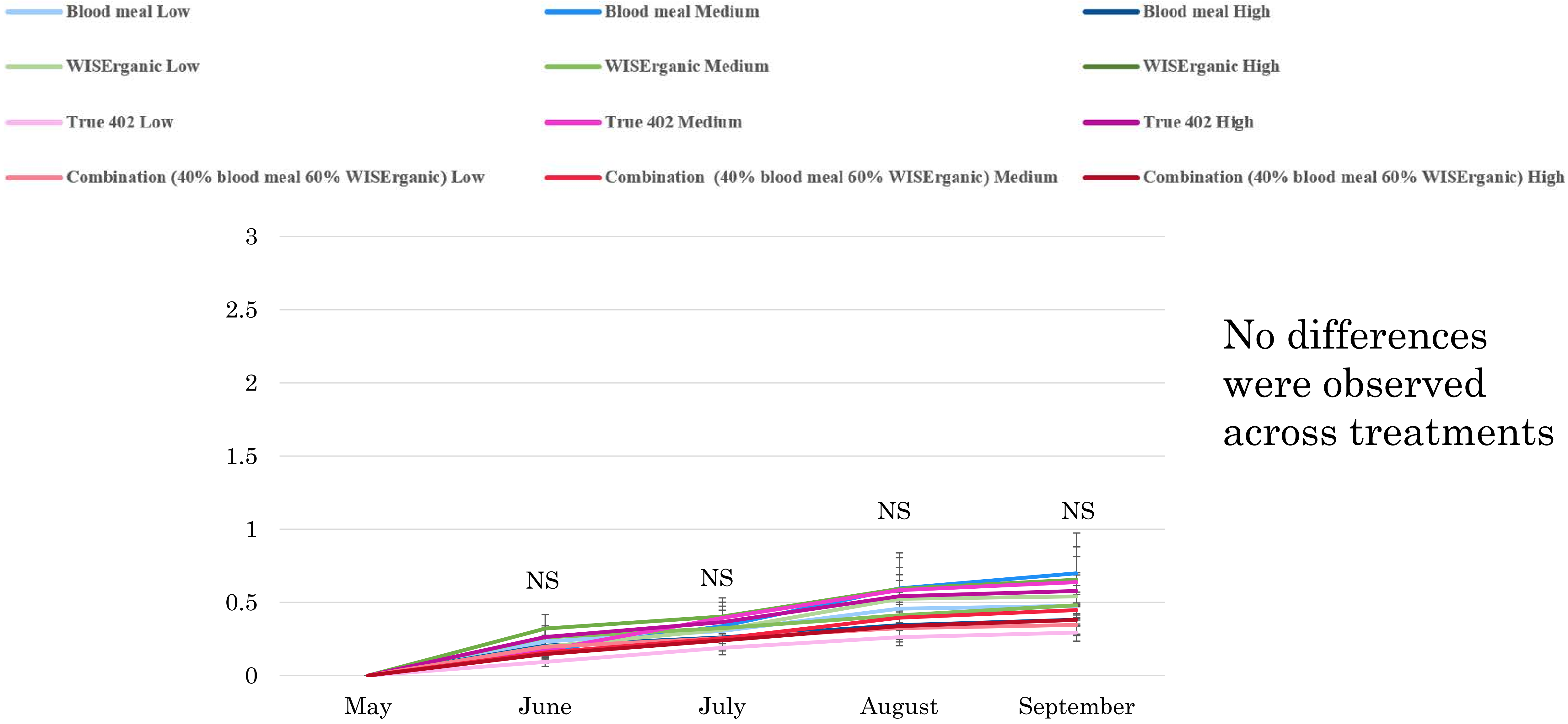
74% longer shoots in July

72% longer shoots in August

68% longer shoots in September

NS, *,**, and *** indicate nonsignificant or significant differences at $P \geq 0.05$, 0.001, or 0.0001, respectively.

Results – Shoot Growth 2019



No differences were observed across treatments

NS, *,**, and *** indicate nonsignificant or significant differences at $P \leq 0.05$, 0.001, or 0.0001, respectively.

Results – Whips Production and Average Yield

Treatments	No. of whips/bush	Average yield (lbs/bush)
Year (Y)		
2018	5 b[z]	10.93 b
2019	6 a	13.27 a
Rate (R) [y]		
Low	6	12.50
Medium	6	12.00
High	6	11.72
Source (S)		
True fish emulsion	5	13.60
Blood meal	6	11.50
Combination	6	11.80
WISErganic	6	11.48
Significance[x]		
Y	**0.0013**	**0.0001**
R	0.075	0.135
S	0.376	0.502

[z]Means followed by the same letter within a treatment or interaction are not statistically different ($P \geq 0.05$).
[y]Fertilizer rates were split within source at low, medium, and high rates (57, 112, and 168 kg·ha^{-1}).
[x]P-value with significance at $\alpha = 0.05$.

Results – Leaf Macro and Micro Tissue Nutrients

- All tissue nutrient concentrations were **within the recommended range**; except Cu
- Leaf **N concentration increased with higher N** application rates
- No differences was observed among treatments
- **No signs of deficiency** was observed
- Leaf tissue nutrient concentration showed yearly differences

Results – Firmness and Berry Mass

Treatments	Firmness (g/mm of deflection)	Berry mass (g/berry)
Year (Y)		
2018	171.43 b[z]	2.27 a
2019	182.89 a	2.10 b
Rate (R)[y]		
Low	174.31 b	2.19
Medium	178.30 a	2.20
High	178.88 a	2.17
Source (S)		
True fish emulsion	177.24 b	2.18
Blood -meal	175.85 b	2.19
Combination	181.73 a	2.17
WISErganic	173.85 b	2.20
Significance[x]		
Y	**0.0001**	**0.0001**
R	**0.004**	0.828
S	**0.0001**	0.953

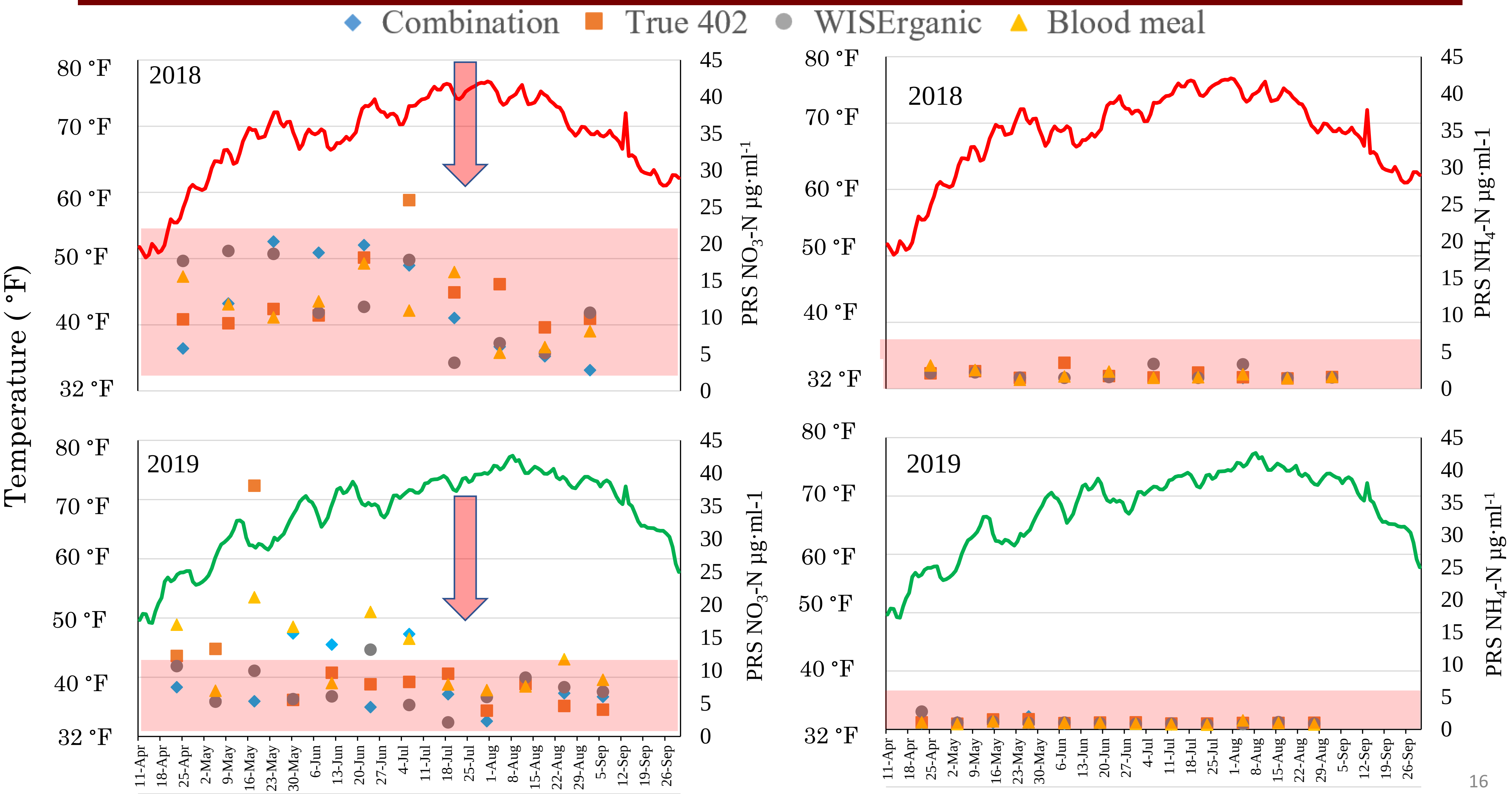
[z]Means followed by the same letter within a treatment or interaction are not statistically different ($P \geq 0.05$).
[y]Fertilizer rates were split within source at low, medium, and high rates (57, 112, and 168 kg·ha^{-1}).
[x]*P*-value with significance at $\alpha = 0.05$.

Results – Soil Properties

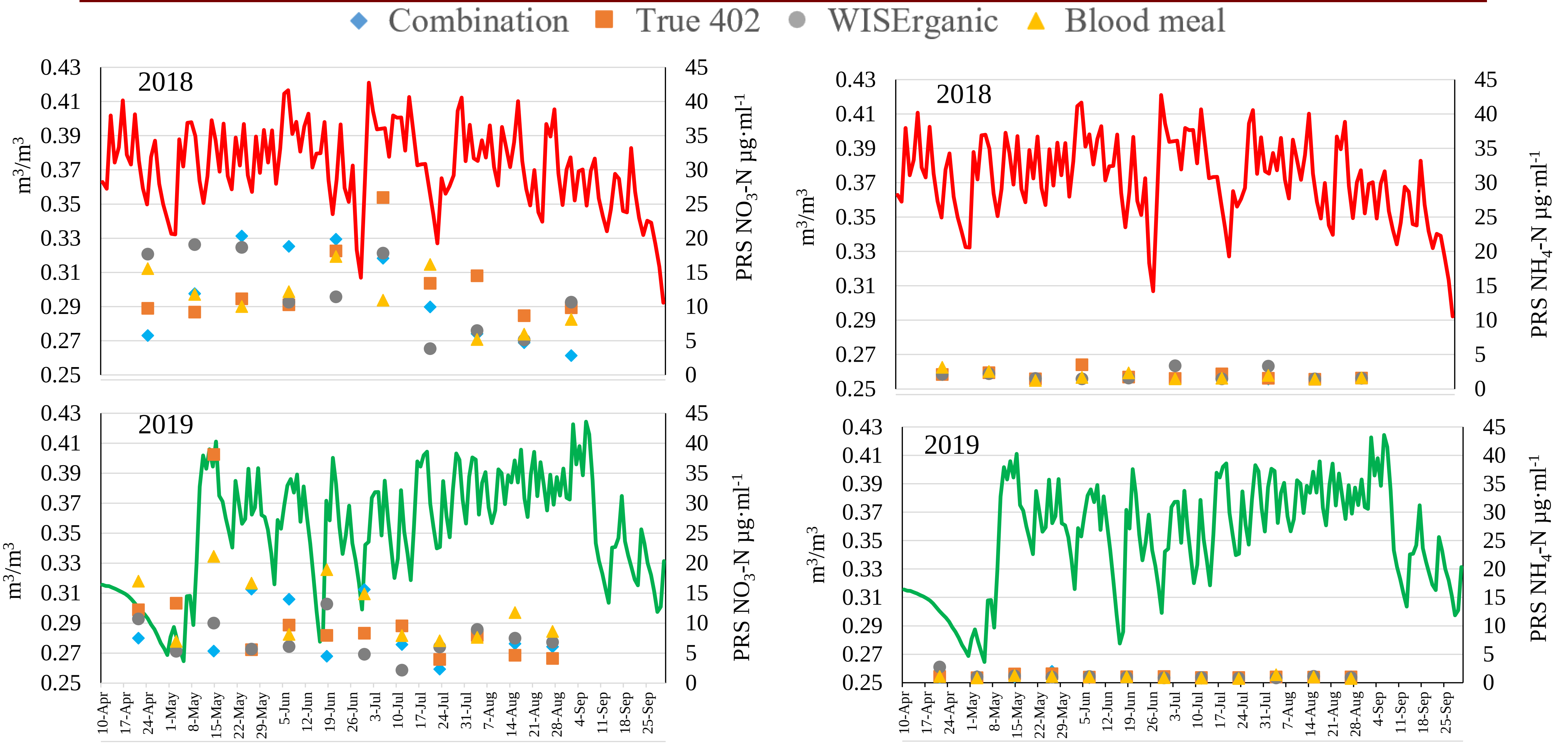
Treatments	Soil pH (1:1)	Soil NO_3-N ($mg \cdot kg^{-1}$)	Soil NH_4-N ($mg \cdot kg^{-1}$)	Electric conductivity EC ($dS \cdot m^{-1}$)
Baseline readings[z]	**5.08**	**4.63**	**11.83**	**0.33**
Rate (R)[y]				
Low				
Medium				
High				
Source (S)				
True fish emulsion				
Blood Meal				
Combination				
WISErganic				
Significance[w]				
R	0.014	0.005	<0.0001	0.465
S	0.241	0.0004	<0.0001	0.367
R × S	0.637	0.134	0.0003	0.544

[z]Baseline average soil pH, NH_4-N, and NO_3-N before starting fertilizer N applications.
[y]Fertilizer rates were split within source at low, medium, and high rates (57, 112, and 168 $kg \cdot ha^{-1}$).
[x]Means followed by the same letter within a treatment or interaction are not statistically different ($P \geq 0.05$).
[w]*P*-value with significance at $\alpha = 0.05$.

Results – Soluble N by Temperature



Results – Soluble N by Moisture



Summary – Experiment 1

- **Few to no differences** due to **fertilizer source and rate**; vegetative growth variables followed yearly differences
- **No signs of nutrient deficiency** were observed; leaf macro- and micronutrients were within the sufficiency range
- Perennials can store nutrient; further year of data collection is required
- Both soil and PRS N data suggests **rapid nitrification**

Experiment 2- Timing of N Application

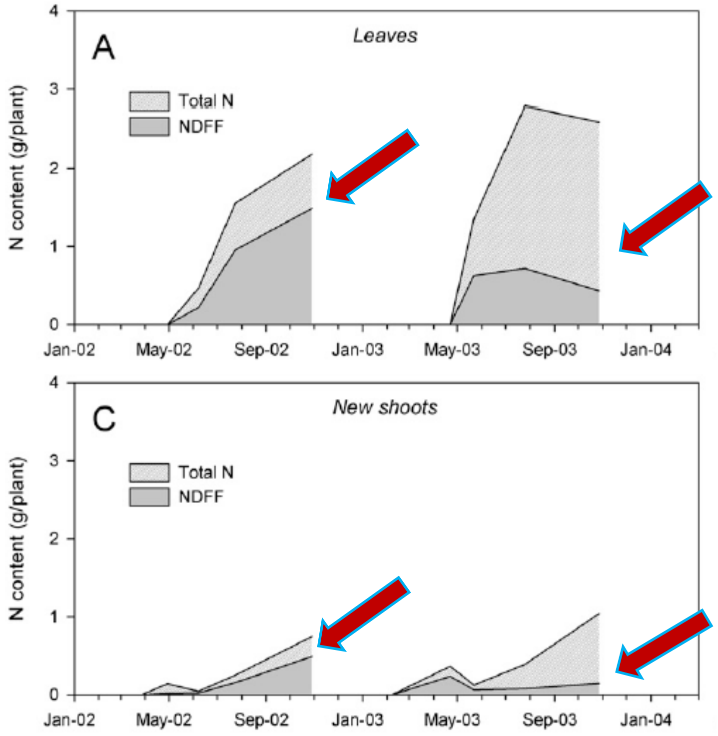
- Availability of nitrogen (N) is **critical**
- **Late bloom to fruit maturity;** rapid growth and maximum N uptake (Throop and Hanson, 1997)
- **Postharvest** applications of N is **not recommended**
- Late growth flushes can lead to **winter injury** by **delaying acclimation**
- N applied too late can **reduce fruit bud set**

Nitrogen Allocation

- Contribute to **N storage pool** in plant

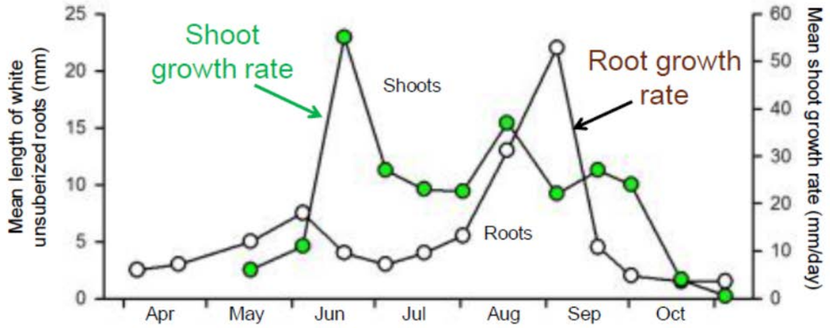
- Uptake of N derived from fertilizer **increased dry weight accumulation** and **N concentrations** in leaves and shoots past July
  (Bañados et al., 2012)

- Root growth flush postharvest (Abbot and Gough, 1987)



Potential Benefits:

- Postharvest N application may **encourage lateral shoot growth** and provide **additional fruiting wood** for the following season



Images adopted from Bañados et al., 2012 and Abbot and Gough 1987.

Objective and Hypotheses

- **Experiment #2 – Timing of Postharvest N Application**
  Study the impacts of postharvest N fertilization on plant growth, yield, fruit bud set, and cold hardiness in an early-fruiting blueberry 'Duke'

  Research question?

  Will postharvest N applications of N **increase fruit bud** set in early-fruiting 'Duke' ?

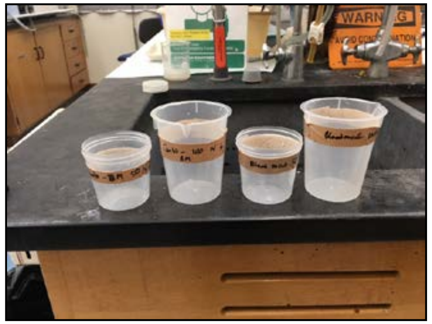
  Are they causing **cold injury** in fruiting buds?

Material and Methods - Treatments

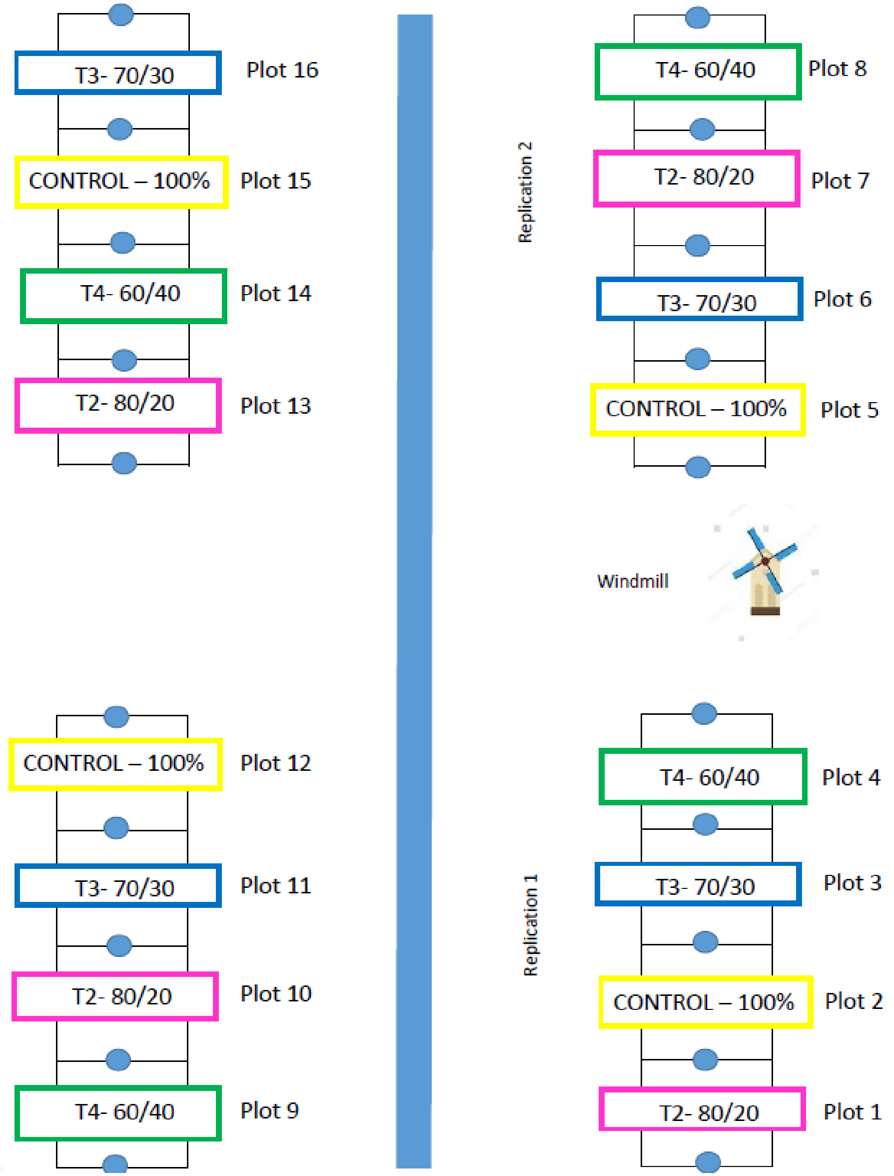
Treatments

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

- 4 treatments applied @ 116 lbs/acre N
- Fertilizer source is WISErganic (3N-0.9P-1.6K)
- Fertilizer applied weekly from mid-Apr. to late Aug. 2018 & 2019



Material and Methods – Experimental Design

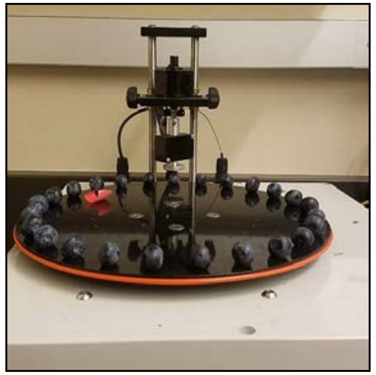


- Randomized complete block design
- 16 plants/treatment – **12 plants** for data collection
- Each treatment was replicated **4 times**
- Orientation: S-N
- Experiment size: 0.05 acres

Data collection

- **Plant variables**
  - Cumulative shoot growth
    June to September 2018
    May to September 2019
  - Whip production
  - Average yield (lbs/bush)
  - Leaf tissue nutrients – mid August

- **Fruit quality**
  - Berry firmness and mass
  - Soluble solids concentrate (°Brix) and titrable acidity



- **Soil properties**
  - Soil pH and Soil electrical conductivity (1:1)
  - NH_4-N and NO_3-N

Data collection – Fruit Bud Set and Cold Hardiness

- $$\% \text{ Fruit bud set per lateral} = \frac{\text{Fruiting buds}}{\text{Total buds per lateral}} \times 100$$

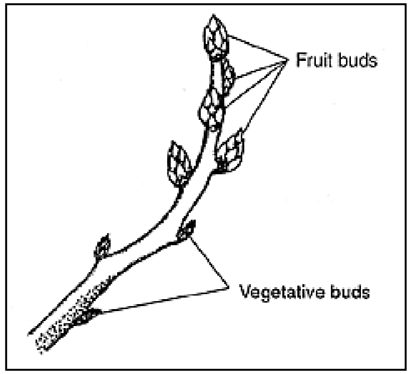
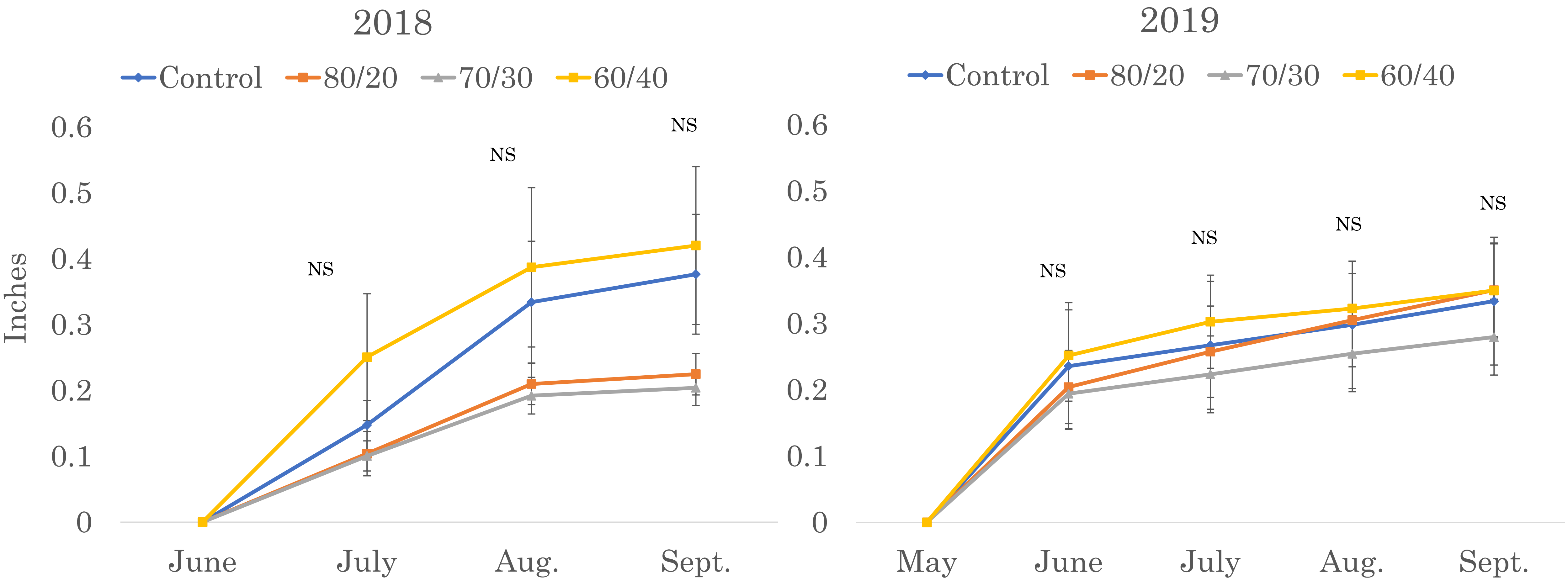


Diagram: U. Maine

- Cold hardiness (measured monthly in October, November, and December) using Polar pod method

Results – Shoot Growth 2018 & 2019



NS denotes not statistically significant at α = 0.05.

Results – Whip Production, Average Yield, and Fruit Bud Set

	No. of whips/bush	Average yield (lbs/bush)	Fruit bud set (%)
Year (Y)			
2018	8	14.53	54
2019	9	15.54	54
Treatment (T)			
Control	5	14.00	54
80/20	6	13.66	55
70/30	6	16.00	53
60/40	6	16.47	54
Significance[x]			
Y	0.420	0.341	0.881
T	0.722	0.157	0.579
Y X T	0.756	0.595	0.630

[x]*P*-value with significance at $\alpha = 0.05$.

Results – Leaf Macro and Micro Tissue Nutrients

- All tissue nutrient concentrations were **within the recommended range**; except Cu
- No differences was observed among treatments
- **No signs of deficiency** was observed
- Leaf tissue nutrient concentration showed yearly differences

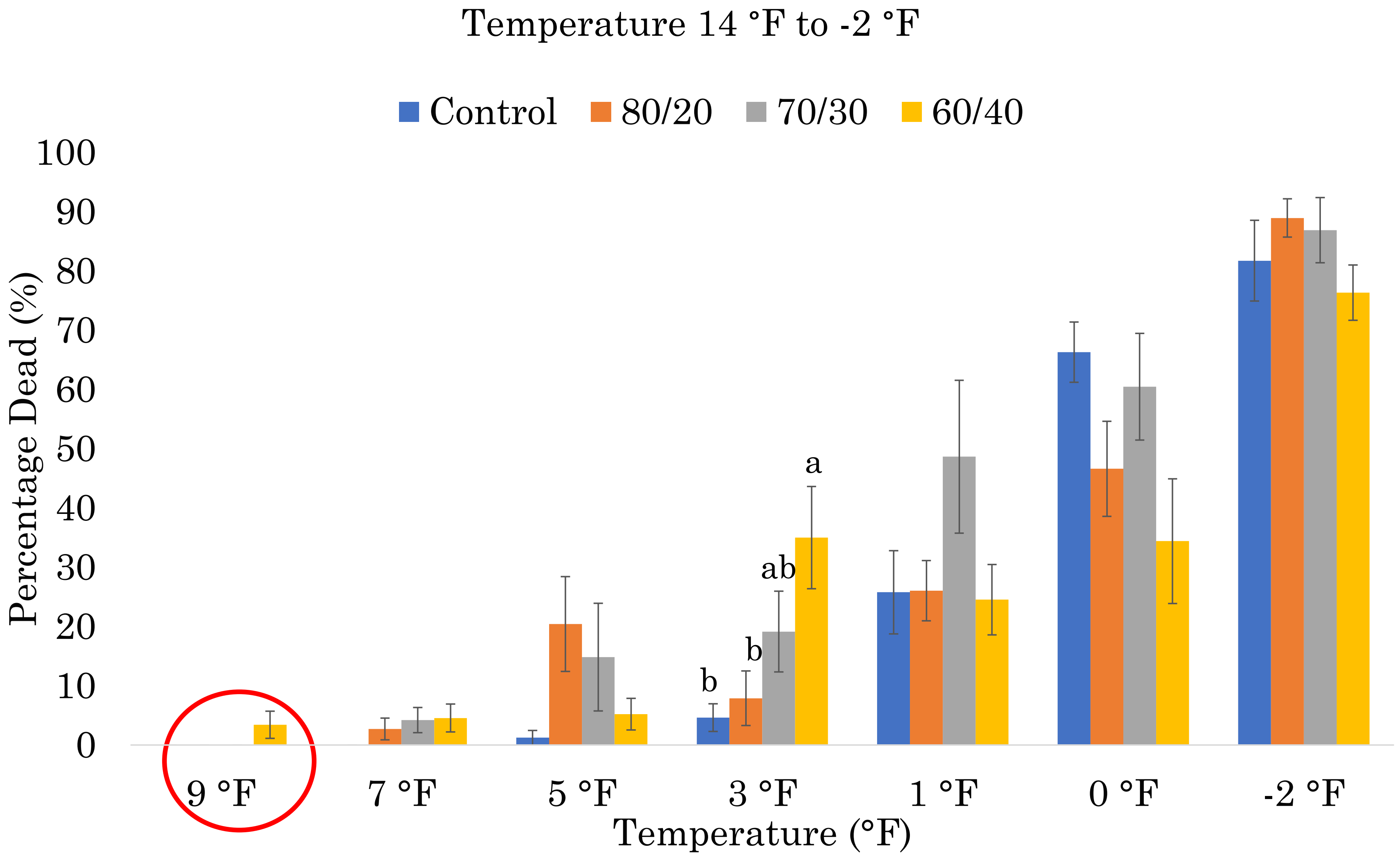
Results – Firmness and Berry Mass

Treatments	Firmness (g/mm of deflection)	Berry mass (g/berry)
Year (Y)		
2018	198.72 a[z]	2.86
2019	155.71 b	2.77
Treatment (T)		
Control	171.41	2.89
80/20	163.91	2.83
70/30	170.05	2.82
60/40	174.70	2.72
Significance[y]		
Y	0.0001	0.155
T	0.0001	0.290
Y X T	0.246	0.619

[z]Means followed by the same letter within a treatment or interaction are not statistically different ($P \geq 0.05$)

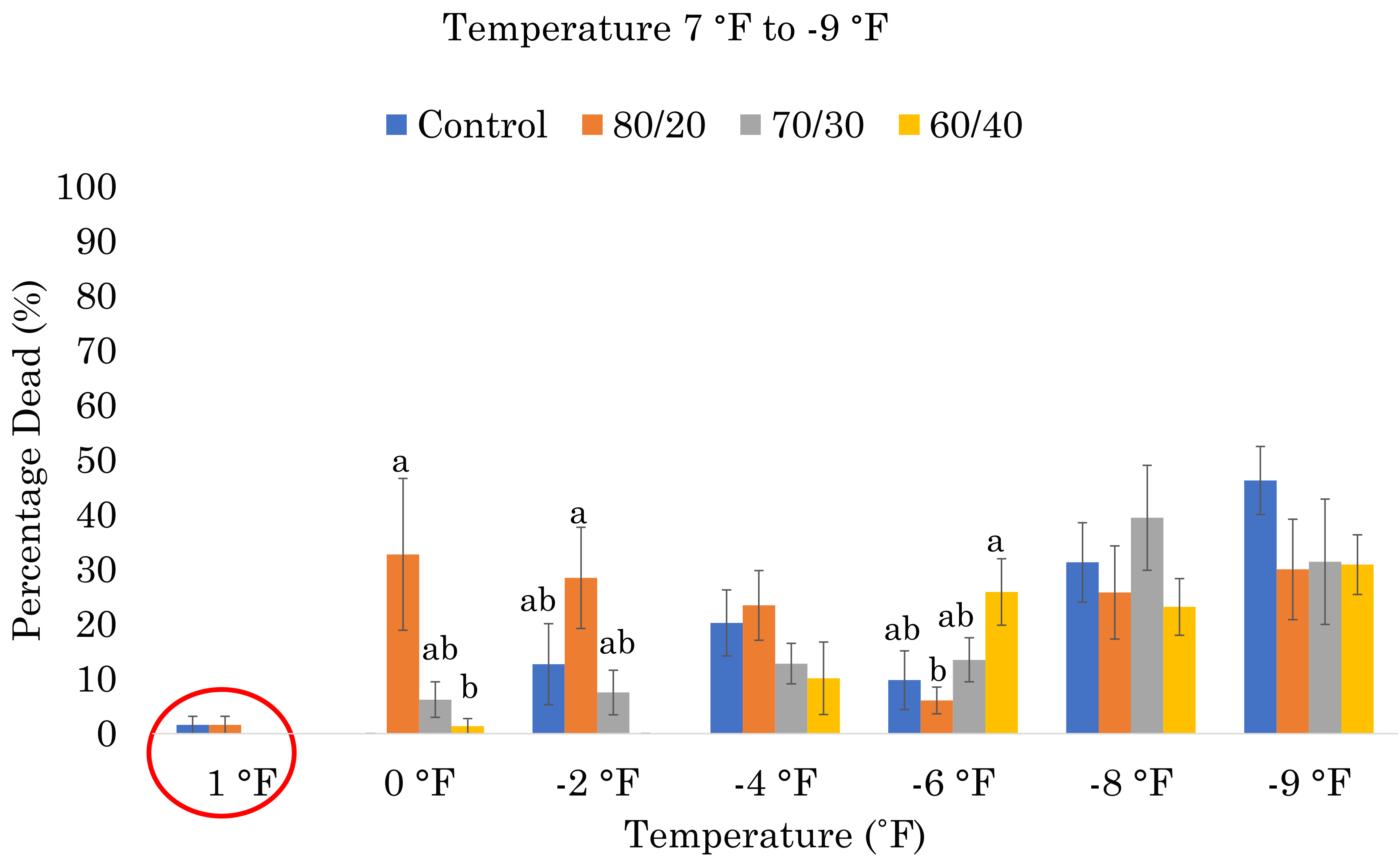
[y]*P*-value with significance at $\alpha = 0.05$

Results – Cold Hardiness (October)



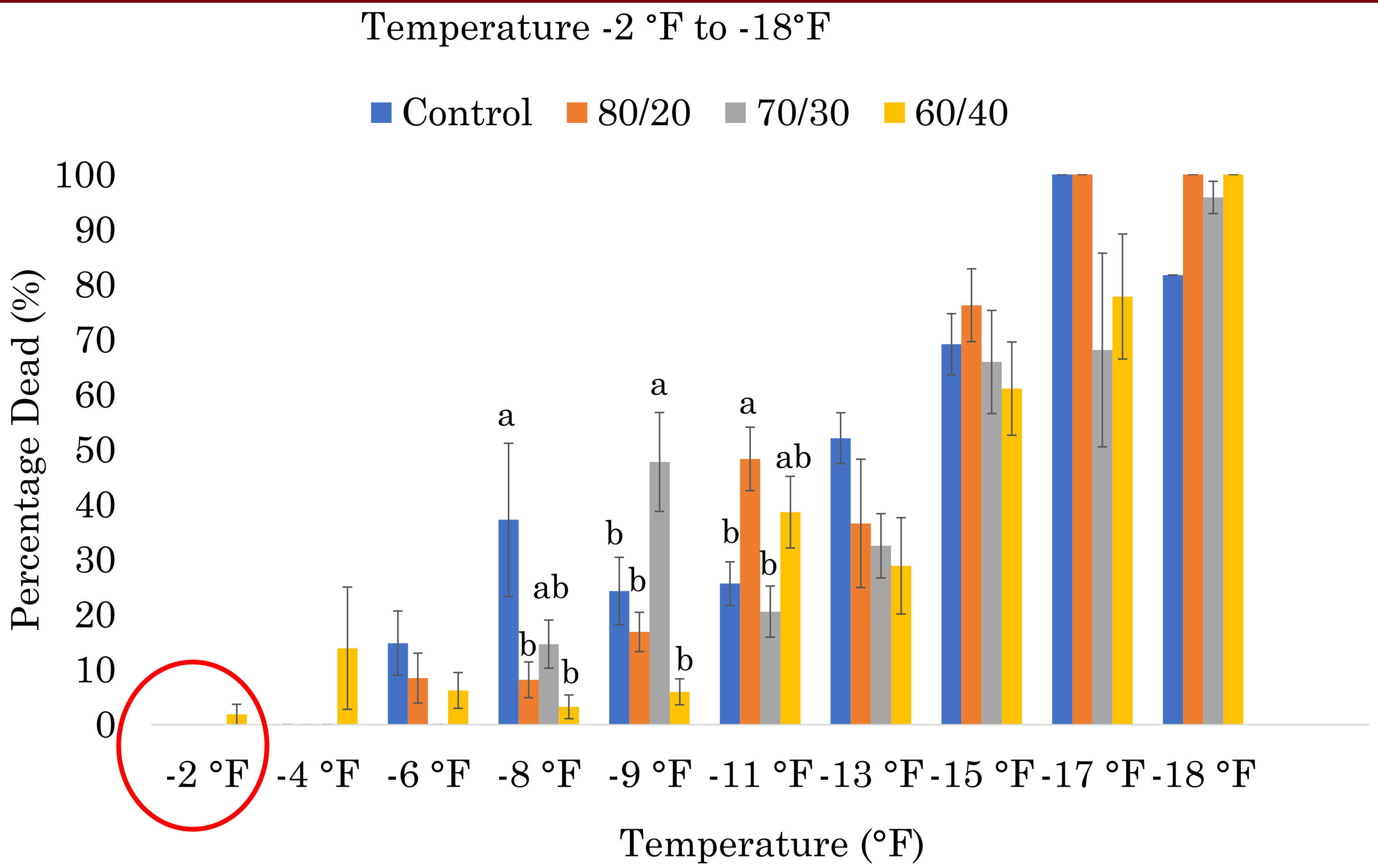
Means with same letter within a temperature treatment are not different due to treatment at α = 0.05

Results – Cold Hardiness (November)



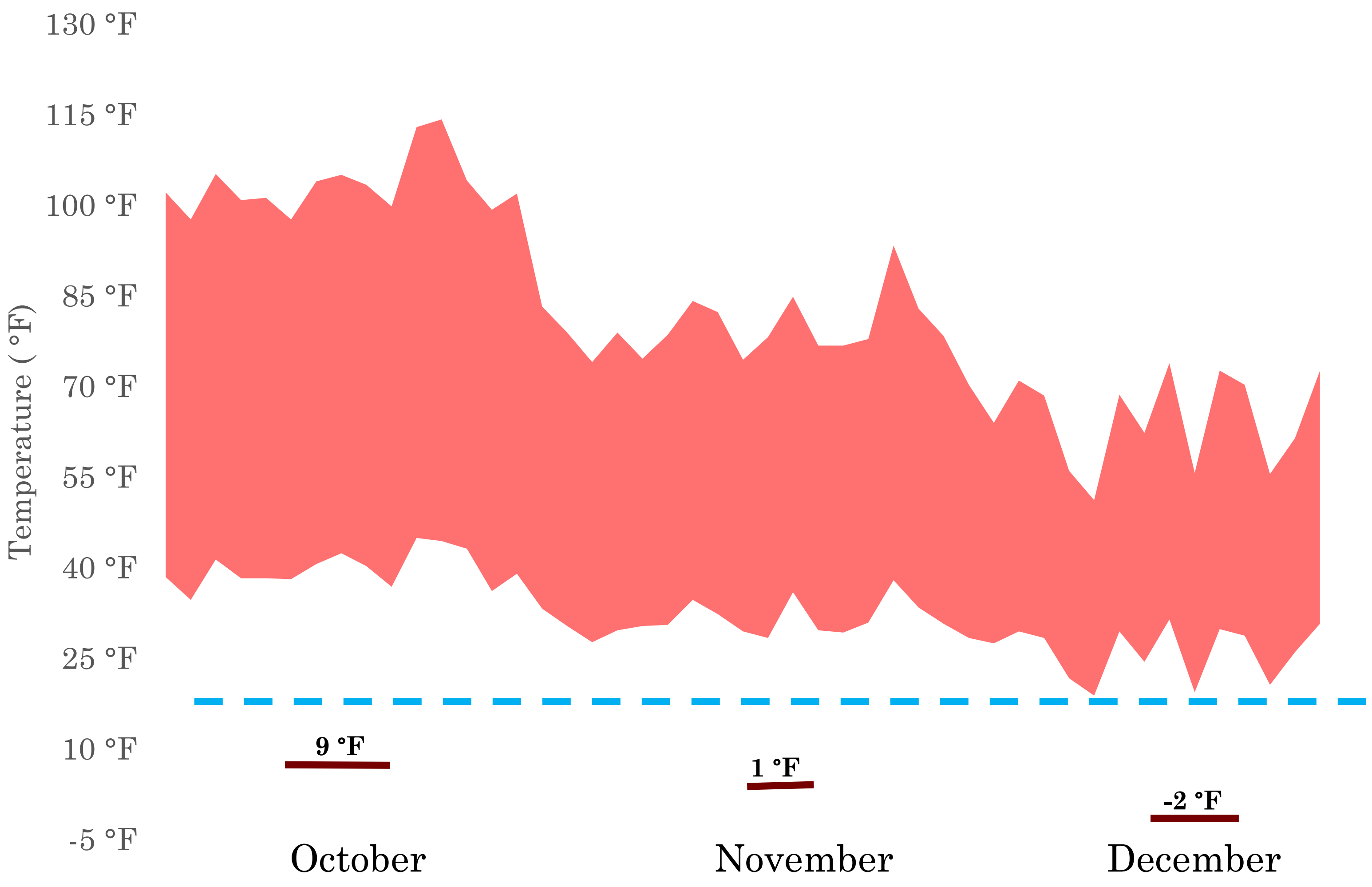
Means with same letter within a temperature treatment are not different due to treatment at α = 0.05

Results – Cold Hardiness (December)



Means with same letter within a temperature treatment are not different due to treatment at α = 0.05

Average 28- Year Minimum and Maximum Temperatures (°F) from Oct. -Dec. (1990 – 2018)



AgWeathernet -WSU

Summary

- We observed **no signs of nutrient deficiency**
- No increment in fruit bud set
- Yield tended to increase with the **later fertilizer application** treatment
- Further years of data collection is necessary considering the **slow response of perennials** to fertilizer applications
- Postharvest N application had **no detrimental effect on bud acclimation** process
- Further research is needed to see if postharvest application can affect **deacclimation** process in spring

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Northwest Center for Small Fruits Research

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Thank you!
Questions?

For more information
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SFH Website: https://smallfruits.wsu.edu/

	True 402[z] (4N-0P-1.6K)	WISErganic[y] (3N-0.9P-1.6K)	Blood meal[x] (15N-0P-0K)
Organic N (%)	3.8%	2.8%	14.9%
Ammonium (NH_4-N)	0.15%	0.0009%	0.038%
Nitrate (NO_3-N)	0.05%	0.12%	0.001%
pH	4.2-5.7	4.2	7