Improving Cotton Production Efficiency With Phosphorus and Potassium Placement At Multiple Depths in Strip Tillage Systems

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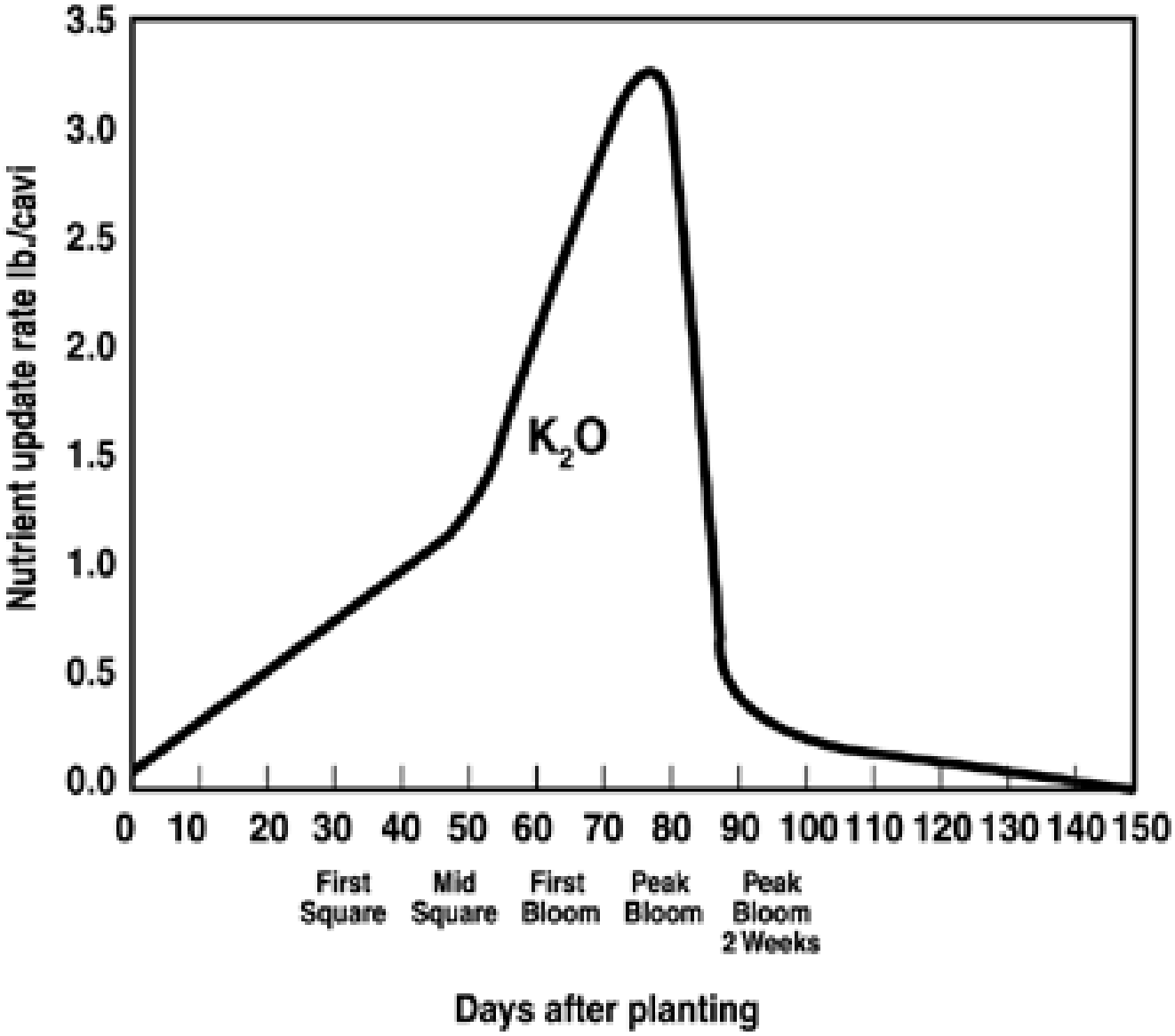
Introduction and Justification

- The primary preplant fertilization system in Virginia cotton (*Gossypium hirusutum*) production is a broadcast application prior to planting
- Limited data exists for using banded starter fertilizers in Virginia upland cotton
- Crozier et al. (2012) observed an average increase of 60 lbs lint per acre in North Carolina with the use of starters in soils testing high in soil phosphorus
  - Study indicated 2 x 2 placement was more consistent than surface banding over seed
- New high yielding and earlier maturing cotton varieties have created a greater demand for nutrients during bloom and boll set
  - Phosphorus and potassium must be available >6 weeks after application to maximize yields



Courtesy of Mullins and Burmester (1990)

Keeping Phosphorus and Potassium Plant Available

- Banded zones remain plant available longer due to a zone of high phosphorus concentration
  - Minimizes percent of applied phosphorus and potassium adsorbed to soil colloids
- Strip-tillage is the predominant tillage system utilized in southeast Virginia
- Strip-tillage gives growers the capability to place nutrients at multiple depths
- Having multiple bands throughout the rooting zone may increase phosphorus and potassium uptake/utilization by cotton

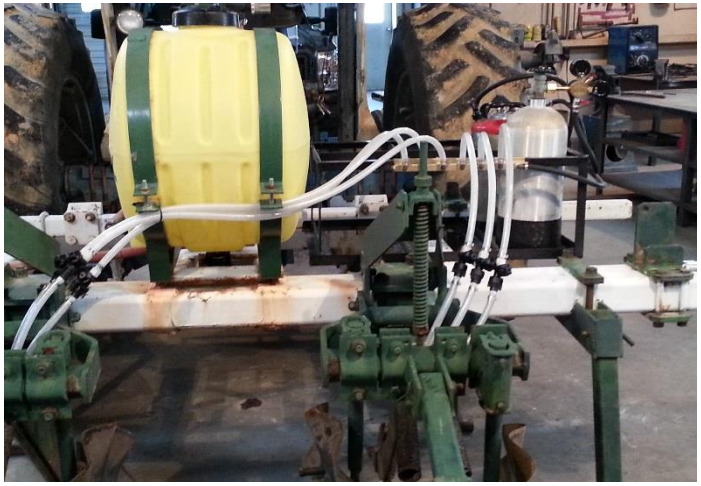
Research Objectives

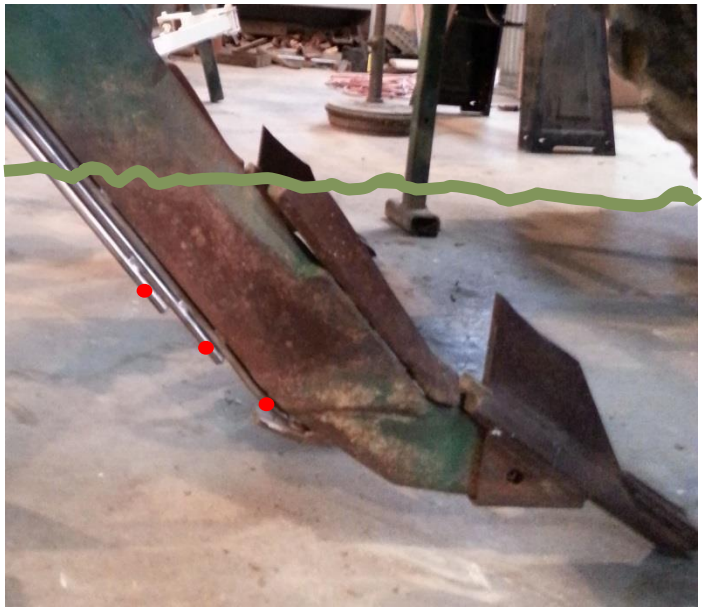
1. Determine the impact on early season development of upland cotton (*Gossypium hirsutum)* through first square, nutrient status throughout the bloom period, and lint yield and quality of placing a fluid P & K fertilizer at multiple depths below the seed during strip-till cultivation.

2. Evaluate selected combinations of P and K placed at multiple depths in the strip-till process in combination with 2x2 banding of P and K solutions at planting on early season development through first square, nutrient status throughout the bloom period, and lint yield and quality.

Materials and Methods

- Two Locations:
  - Suffolk, VA (TAREC)
  - Lewiston, NC
- Fertilizer Placement
  - Deep Placement with Strip-tillage
    - 6, 9, and 12 in. below the row
    - 1-2 weeks prior to planting
  - 2 X 2 Band at Planting





Materials and Methods

- Liquid Fertilizer Sources
  - Ammonium Polyphosphate (10-34-0)
  - Potassium thiosulfate (0-0-25-17S)
  - Soil Test Recommendations (100%):
    - 40 lbs. P_2O_5 ac^{-1}
    - 40 lbs. K_2O ac^{-1}
- Granular Fertilizer Sources
  - Diammonium phosphate (18-46-0)
  - Potassium Chloride (0-0-60)
- All preplant nitrogen and sulfur were balanced among treatments
  - Urea Ammonium nitrate (30-0-0)
  - Ammonium thiosulfate (12-0-0-26S)
  - 35 lbs N ac^{-1} and 41 lbs. S ac^{-1}

Treatment List

Trt	Placement	Description
1	Unfertilized Control	No P or K Fertilization
2	Broadcast Agronomic Control	P + K Broadcast – Soil test recommendation
3	Liquid Starter Agronomic Control	112 kg /ha of 10-34-0 in 2X2 band + K broadcast
4	2 X 2 Band	50%P + 50%K
5	2 X 2 Band	100%P + 100%K¶
6	2 X 2 Band	150%P + 150%K
7	Deep Placement	50%P + 50%K
8	Deep Placement	100%P + 100%K
9	Deep Placement	150%P + 150%K
10	2 X 2 + Deep Placement	(80%P + 80% K) + (20%P + 20%K)
11	2 X 2 + Deep Placement	(60%P + 60% K) + (40%P + 40%K)
12	2 X 2 + Deep Placement	(40%P + 40% K) + (60%P + 60%K)
13	2 X 2 + Deep Placement	(20%P + 20% K) + (80%P + 80%K)

¶ 100% rate equals 40 lbs. P_2O_5 and 40 lbs. K_2O per hectare based on soil test recommendations for producing cotton in Virginia

Materials and Methods

- Treatment were applied to 4 row plots
  - Row spacing = 3 ft.
  - Plot length = 40 ft

- In-season Plant Measurements
  - Plant Population
  - Plant Height (until 1st flower)
  - Total Nodes (from 1st square)
  - Nodes Above White Flower (NAWF)

Materials and Methods

- Petiole and Tissue Sampling
  - 1st through 9th week of bloom petiole sampling
  - 4th leaf down the main stem
  - 24 petioles per plot from the 1st and 4th rows
  - Petioles immediately detached from leaf
  - Petioles analyzed for nitrate-N, phosphorus, potassium, and sulfur
  - Leaf samples taken during 1st and 5th week of bloom
    - Complete nutrient analysis for leaf samples

Materials and Methods

- Lint Yield and Quality
  - Cotton harvested with two row cotton picker from center two rows
  - Lint will be ginned on 10 saw micro-gin for % lint
  - Lint will be sent to USDA for HVI analyses on lint quality

Unfertilized Check

40 lbs. P_2O_5 ac^{-1}

40 lbs. K_2O ac^{-1}

Statistical Design and Analysis

- Randomized Complete Block Design
  - 4 replications of each treatment
  - Analysis of variance was conducted at the $\alpha = 0.1$
    - Nutrient management systems tested at 45 kg P_2O_5 and 45 kg K_2O per hectare as single factors
    - Placement and rate analyzed as 2 X 3 factorial
    - Combination placement treatments tested as single factors (Data not shown)
    - Tukey-Kramer HSD used for mean separation at $\alpha = 0.1$

Treatment List

Trt	Placement	Description
1	Unfertilized Control	No P or K Fertilization
2	Broadcast Agronomic Control	P + K (Broadcast - Soil test recommendation)
3	Liquid Starter Agronomic Control	102 kg/ha of 10-34-0 in 2X2 band + K broadcast
4	2 X 2 Band	50%P + 50%K¶
5	2 X 2 Band	100%P + 100%K¶
6	2 X 2 Band	150%P + 150%K
7	Deep Placement	50%P + 50%K¶
8	Deep Placement	100%P + 100%K¶
9	Deep Placement	150%P + 150%K
10	2 X 2 + Deep Placement	(80%P + 80% K) + (20%P + 20%K)
11	2 X 2 + Deep Placement	(60%P + 60% K) + (40%P + 40%K)
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¶ 100% rate equals 40 lbs. P_2O_5 and 40 lbs. K_2O per hectare based on soil test recommendations for producing cotton in Virginia

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Mehlich I Soil Test Results

Depth	TAREC		Lewiston	
inches	P	K	P	K
		ppm		
0-3	49 (H+)¶	99 (H-)	30 (H)	126 (H)
3-6	31 (H)	86 (M+)	18 (H-)	59 (M)
6-9	20 (H-)	73 (M)	13 (M)	37 (L+)
6-12	19 (H-)	68 (M)	7 (M-)	33 (L+)

¶ Indicates the soil test level based on Virginia's soil test calibration

Nutrient Management Systems and Early Season Growth (TAREC)

Treatment	Plant Population (plants / 10 ft.)			
	17-May	21-May	24-May	31-May
Unfertilized Control	17.8	28.6	31.0	31.5
Broadcast Control	15.8	29.9	30.9	30.8
Starter Control	18.3	29.9	30.3	30.4
2X2 Band (100%)	20.0	31.4	30.4	31.8
Deep Placement (100%)	16.5	30.9	31.4	30.9
ANOVA (P > F)	NS*	NS	NS	NS

* The overall ANOVA was not significant at α =0.1

1st PGR application 28-Jun

Treatment	Plant Height (in.)					
	4-Jun	13-Jun	20-Jun	26-Jun	3-Jul	10-Jul
Unfertilized Check	4.8	7.4 c¶	9.4 c	13.2 d	18.0 c	22.0 b
Broadcast Control	4.8	8.5 ab	10.5 bc	15.4 c	22.4 b	29.6 a
Starter Control	5.0	9.6 a	11.1 ab	17.8 ab	24.1 ab	31.4 a
2 x 2 Band (100%)	5.2	9.4 ab	12.1 a	18.6 a	25.9 a	32.0 a
Deep Placement (100%)	4.9	8.7 ab	11.3 ab	16.9 bc	23.9 b	30.9 a
ANOVA (Pr > F)	NS*	0.0033	0.011	< 0.0001	< 0.0001	< 0.0001

* The overall ANOVA was not significant at α =0.1

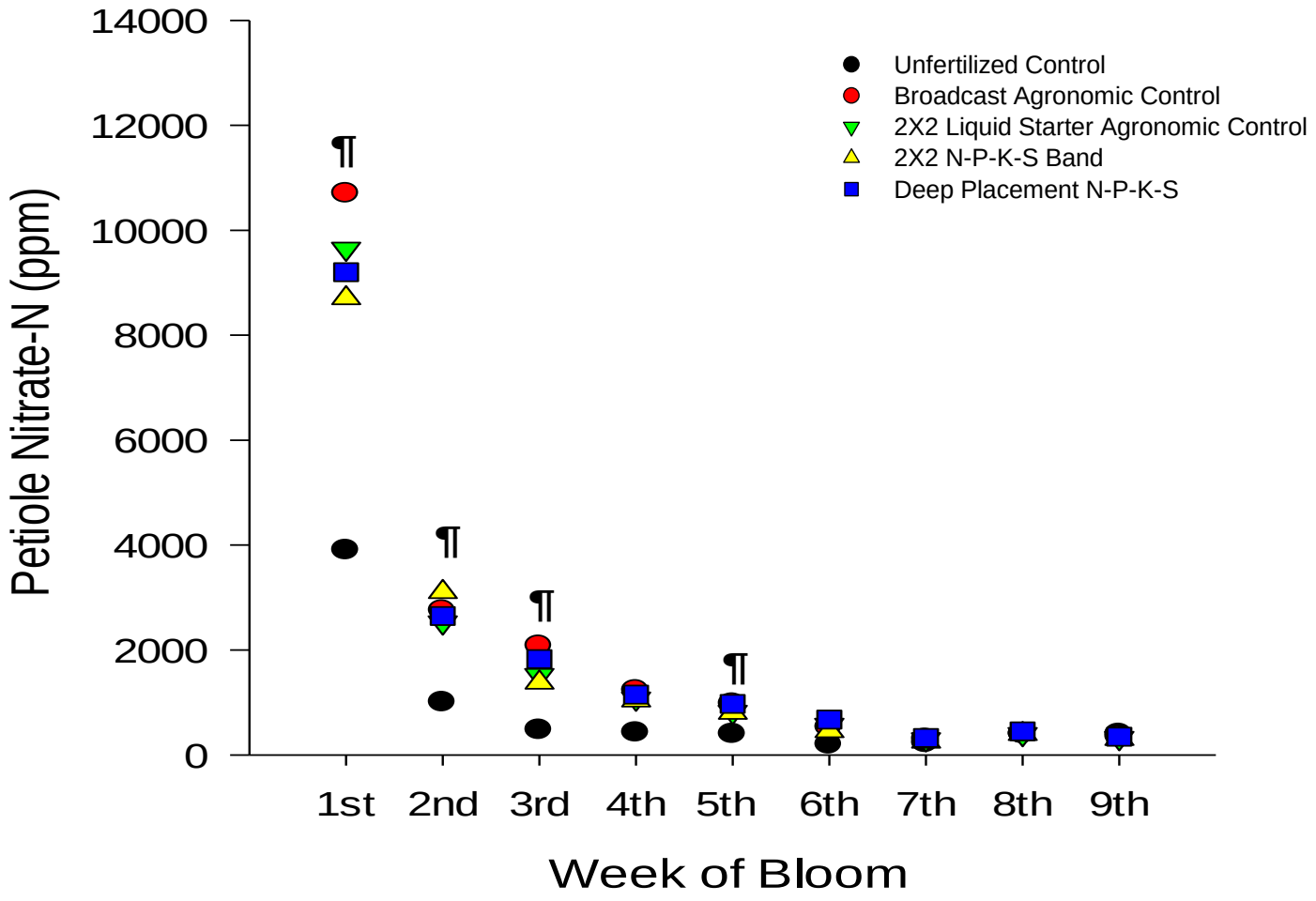
¶ Values with the same letter are not significantly different at α =0.1

Total Nodes and NAWF at TAREC for Nutrient Management Systems

Treatment	Total Nodes		Nodes Above White Flower (NAWF)			
	3-Jul	11-Jul	17-Jul	23-Jul	30-Jul	7-Aug
Unfertilized Check	9.8 b¶	10.1 b	6.6 b	4.8 b	3.2 b	1.8 b
Broadcast Control	10.5 ab	11.7 a	7.7 a	6.3 a	4.5 a	2.6 ab
Starter Control	11.1 a	11.9 a	7.3 a	5.8 a	4.0 ab	2.3 ab
2 x 2 Band (100%)	11.5 a	11.6 a	7.4 a	5.8 a	4.2 ab	2.8 a
Deep Placement (100%)	11.2 a	11.4 a	7.9 a	6.0 a	4.1 ab	3.0 a
ANOVA (Pr > F)	0.0059	0.0084	0.0025	0.0039	0.0555	0.0215

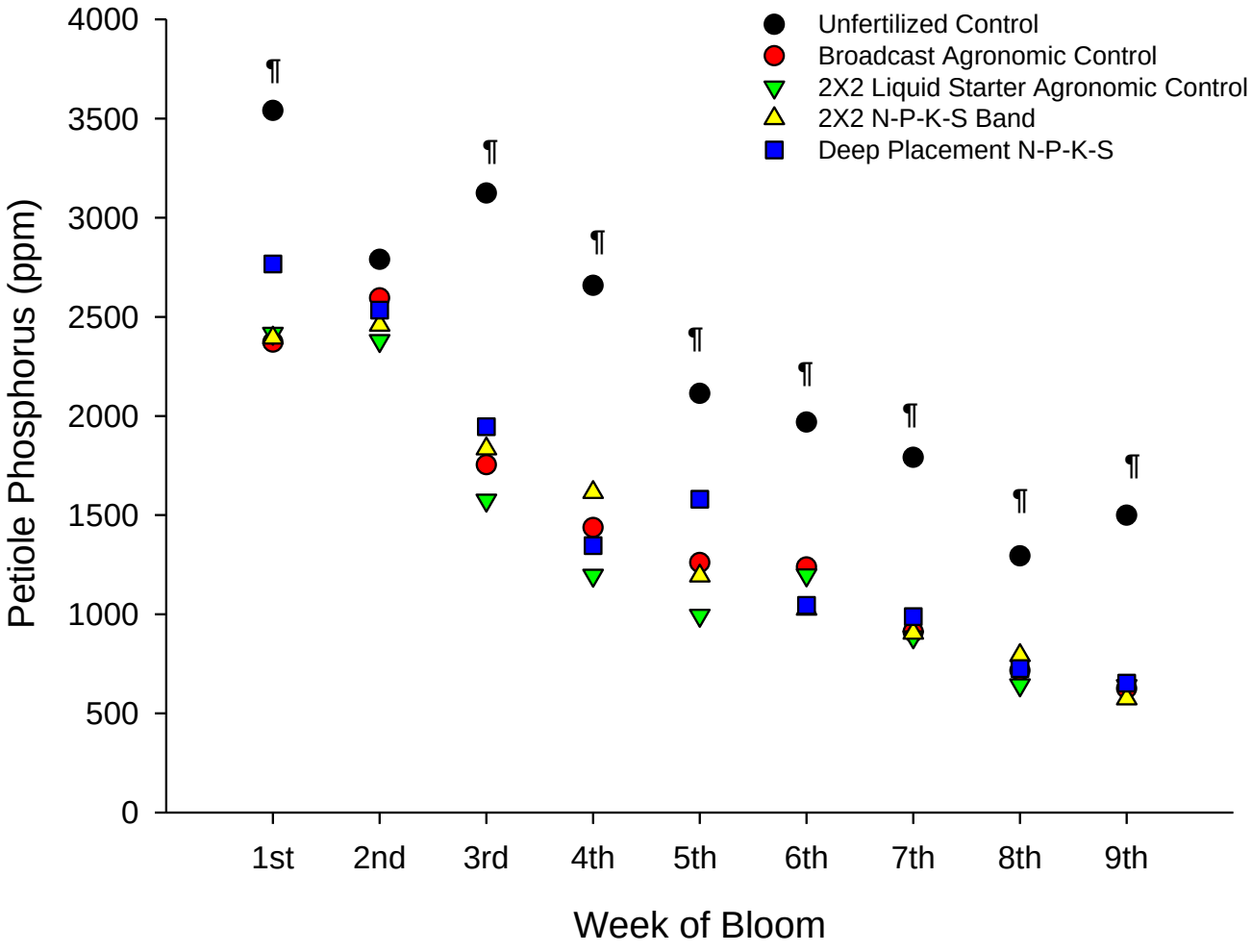
¶ Values with the same letter are not significantly different at α =0.1

Petiole Nitrate-N Concentrations During Bloom Period (TAREC)



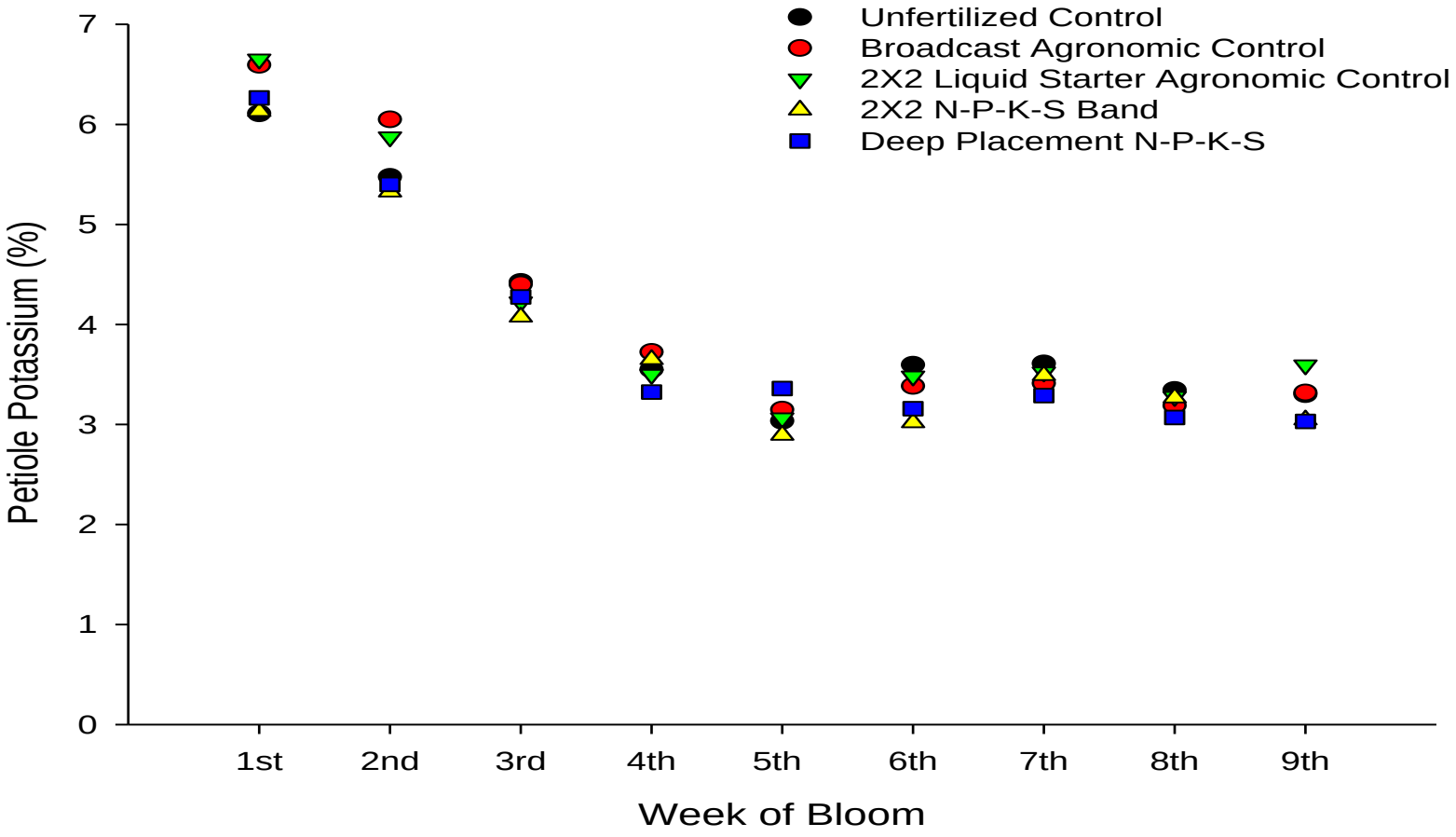
¶ Atleast two treatments are significantly different at α = 0.1

Petiole Phosphorus Concentrations During Bloom Period (TAREC)



¶ Atleast two treatments are significantly different at α = 0.1

Petiole Potassium Concentrations During Bloom Period (TAREC)



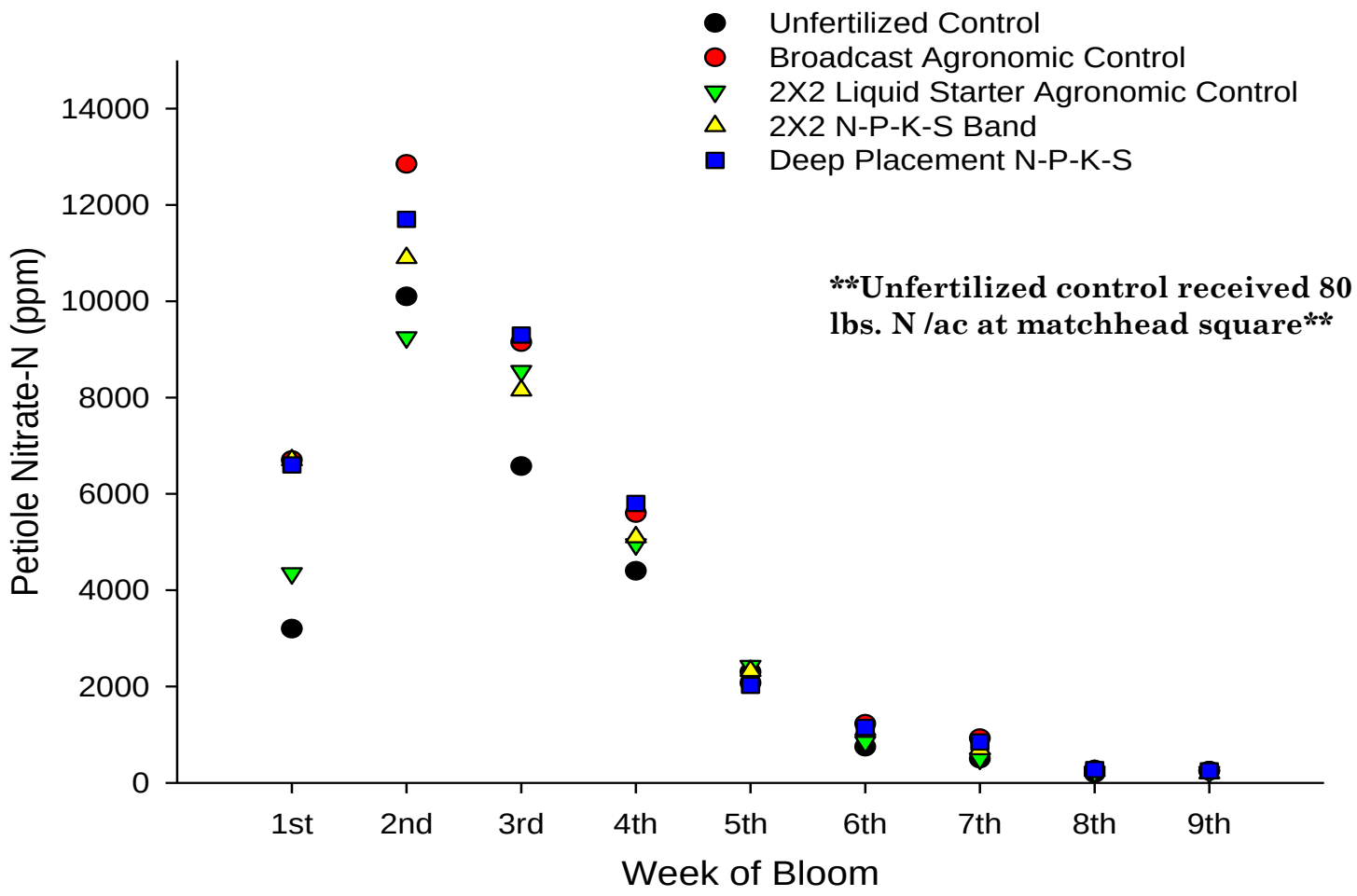
Sand-burn Damage at Lewiston

June 17, 2013

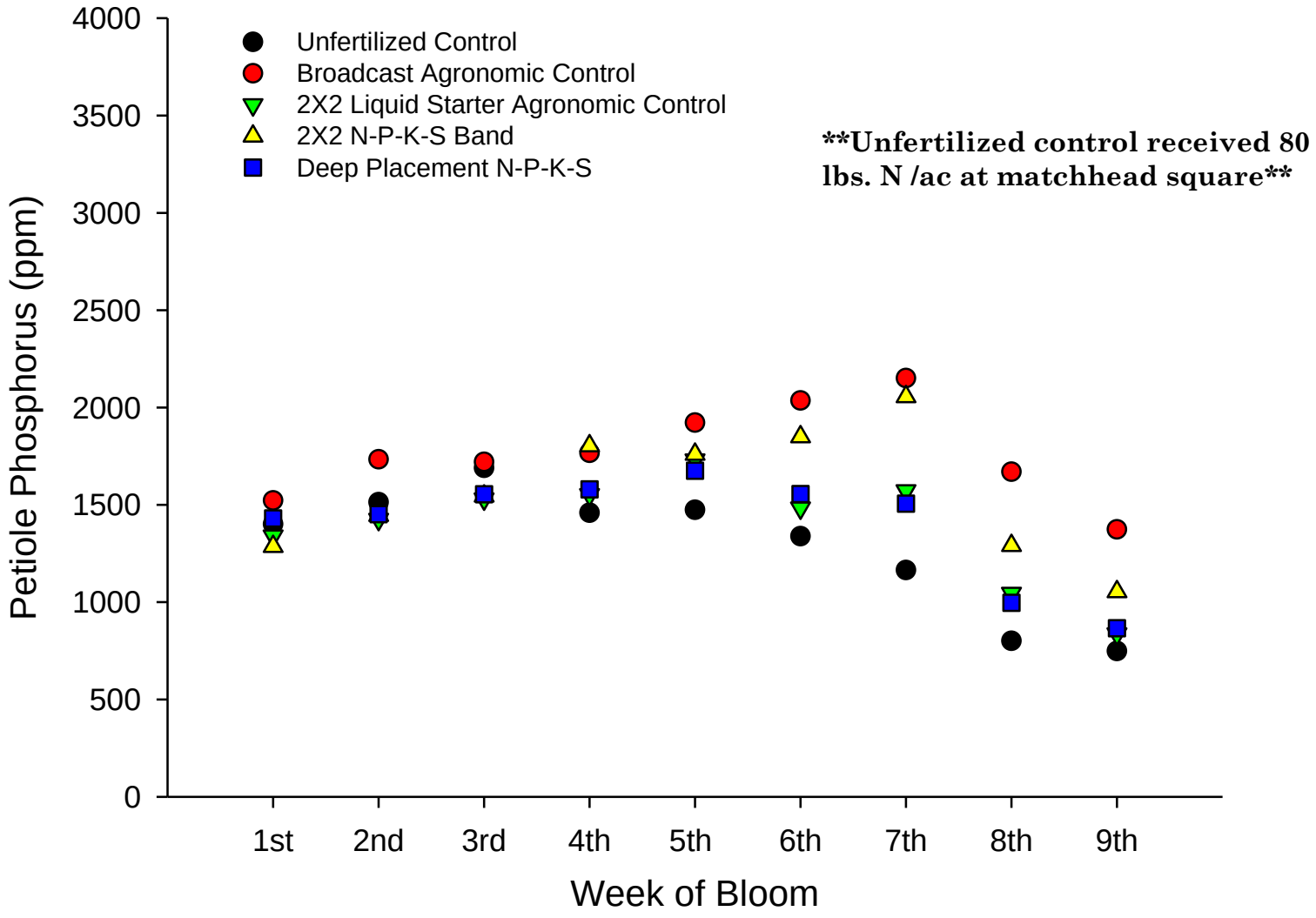
July 2, 2013

Sept.17, 2013

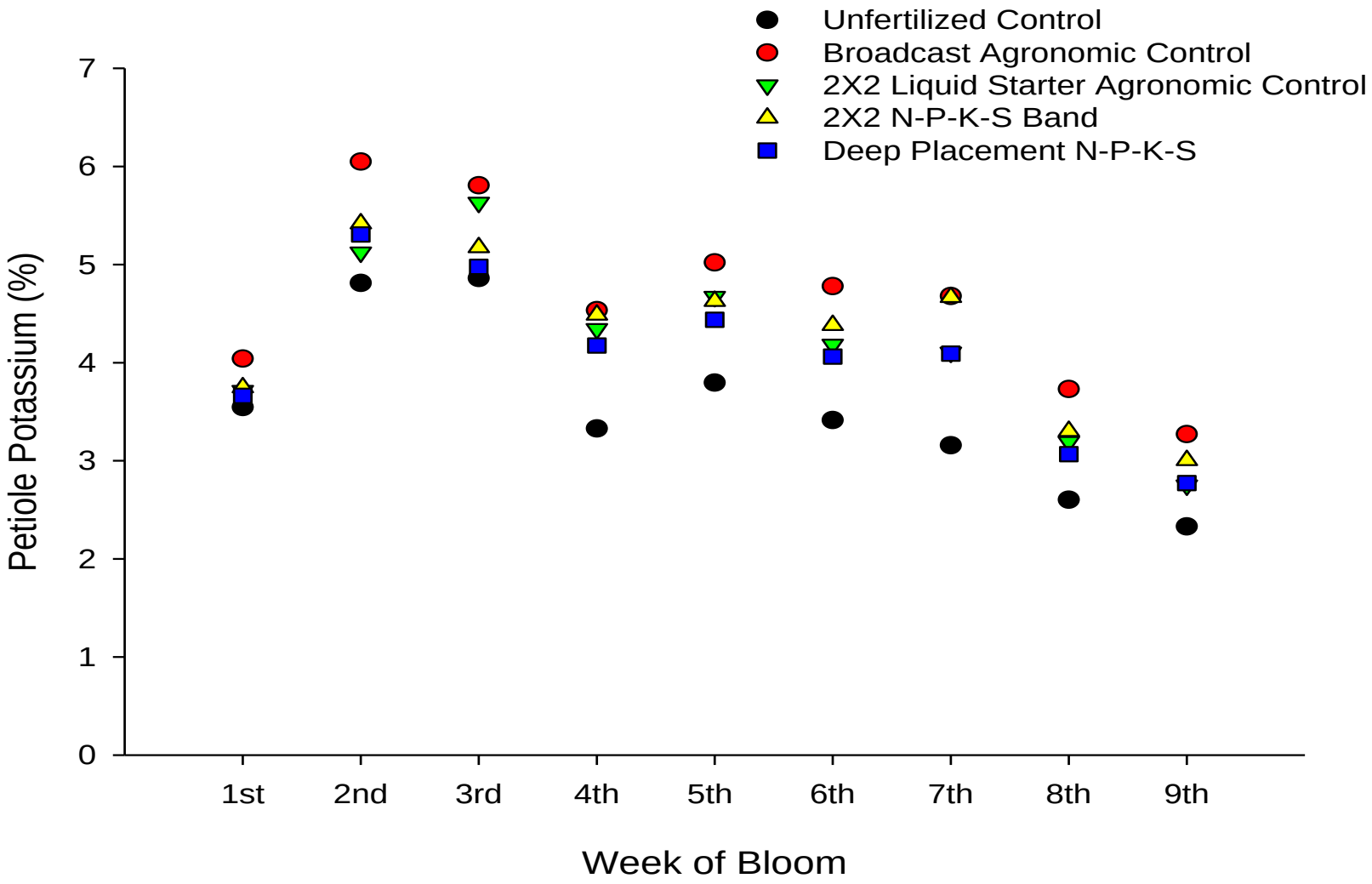
Petiole Nitrate-N Concentrations During Bloom Period (Lewiston)



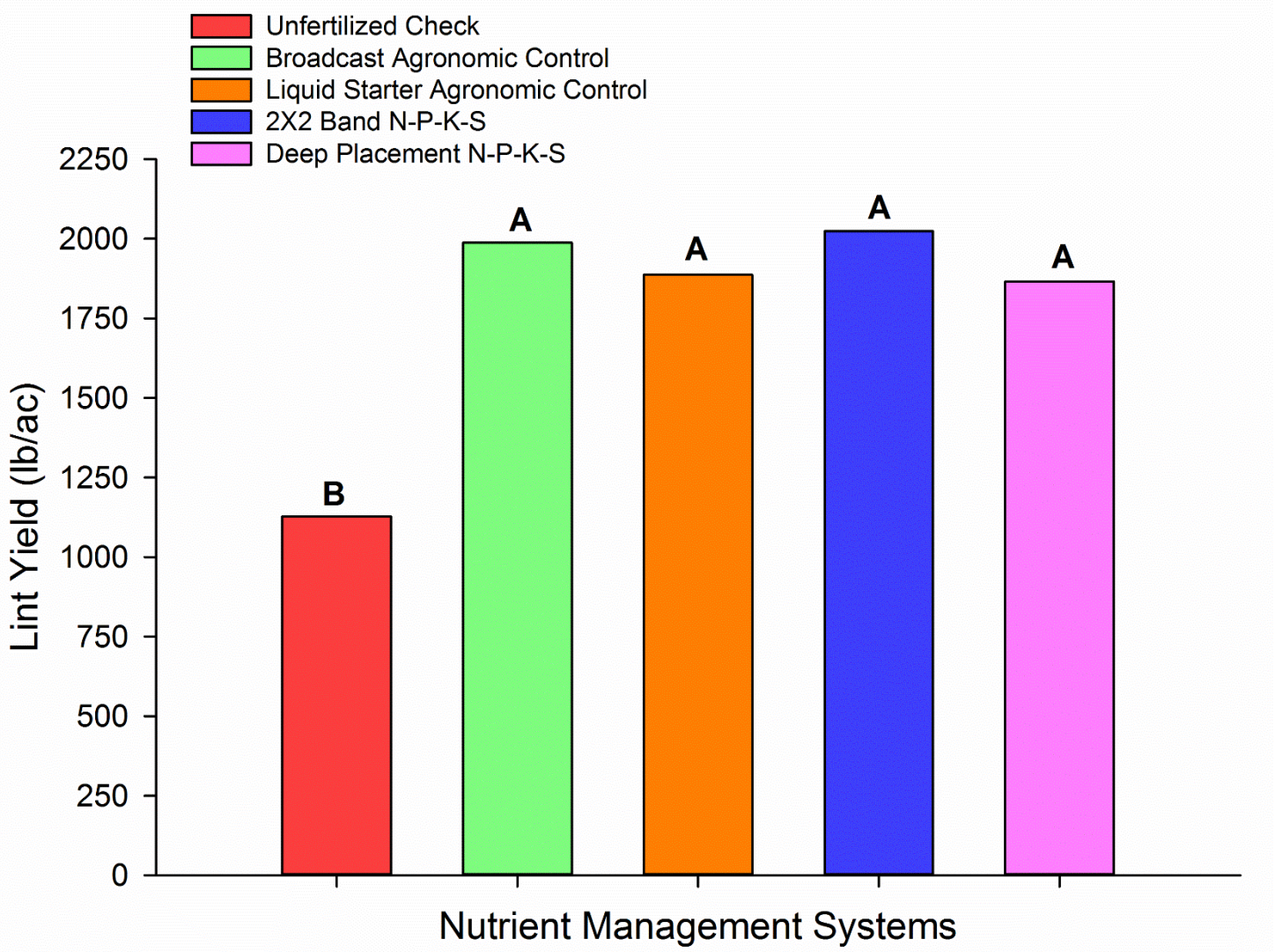
Petiole Phosphorus Concentrations During Bloom Period (Lewiston)



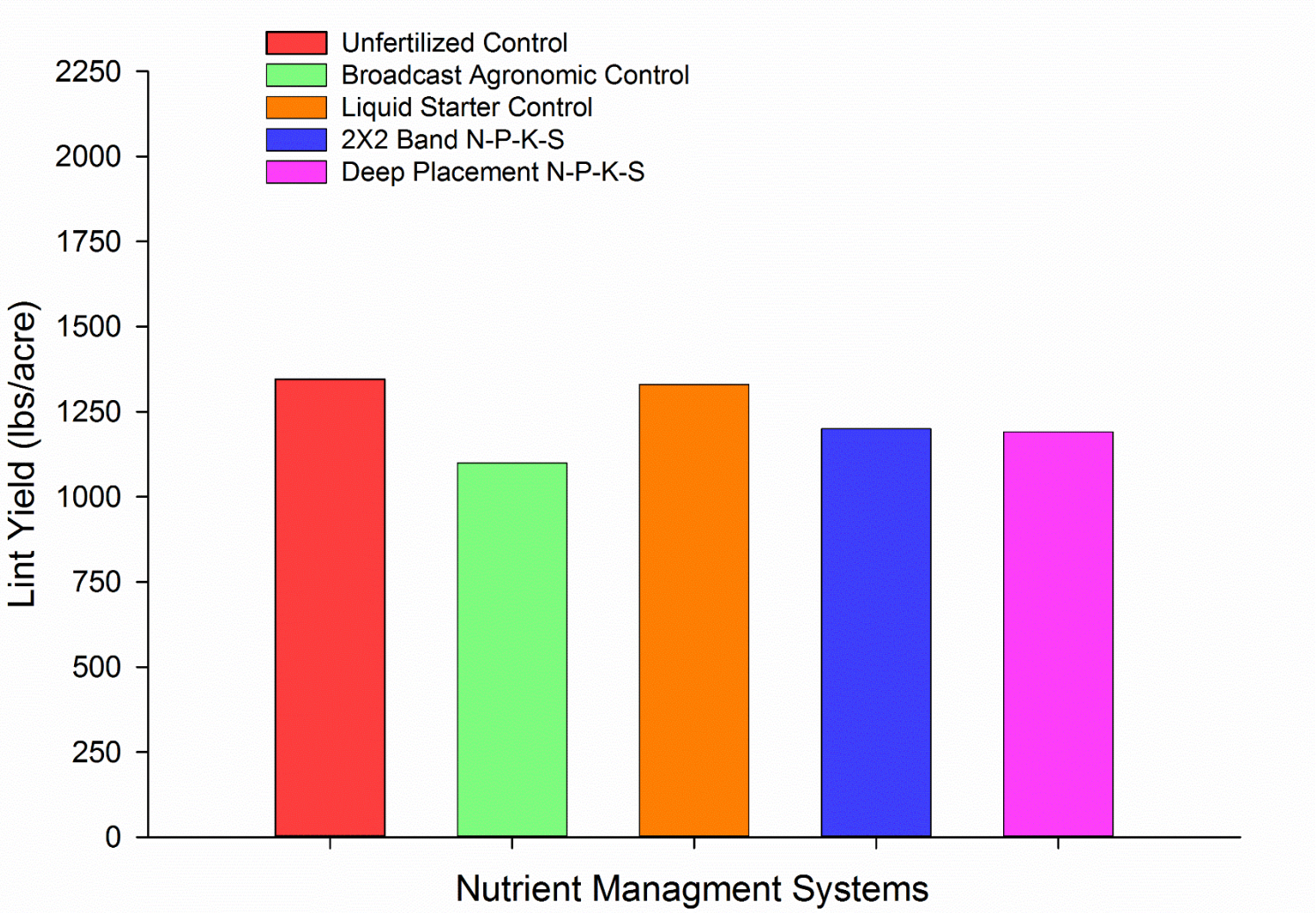
Petiole Potassium Concentrations During Bloom Period (Lewiston)



Lint Yield and Nutrient Management Systems (TAREC)



Lint Yield and Nutrient Management Systems (Lewiston)



Placement and Rate on Early Season Plant Height (TAREC)

Placement	P and K Rate†	Plant Height (in.)					
	%	4-Jun	13-Jun	20-Jun	26-Jun	3-Jul	10-Jul
-	50	5.0	8.7	11.0	16.5 b	24.1	31.2
-	100	5.1	9.1	11.7	17.7 ab	24.9	31.5
-	150	5.1	9.3	11.6	18.1 a	25.0	31.9
2X2 Band	-	5.1	9.2	11.5	17.9 a	25.5 a	32.0 a
Deep Placement	-	5.0	8.8	11.4	17.0 b	23.9 b	30.9 b
2X2 Band	50	4.9	8.7	10.6	16.4	24.8	31.3
2X2 Band	100	5.2	9.4	12.1	18.6	25.9	32.0
2X2 Band	150	5.2	9.5	11.7	18.7	25.8	32.8
Deep Placement	50	5.1	8.7	11.3	16.7	23.5	31.0
Deep Placement	100	4.9	8.7	11.3	16.9	23.9	30.9
Deep Placement	150	5.0	9.1	11.6	17.4	24.2	30.9
		ANOVA (Pr > F)					
P and K Rate		NS	NS	NS	0.0591	NS	NS
Placement		NS	NS	NS	0.0919	0.0009	0.0214
Rate*Placement		NS	NS	NS	NS	NS	NS

¶ Values with the same letter are not significantly different at α =0.1
* The ANOVA for that fixed effect in the model was not significant at α =0.1
† 100% of the recommended rate is equal to 40 lbs P_2O_5 and 40 lbs K_2O per acre

Leaf Nutrient Concentrations using different P and K Rate and Placement (Lewiston)

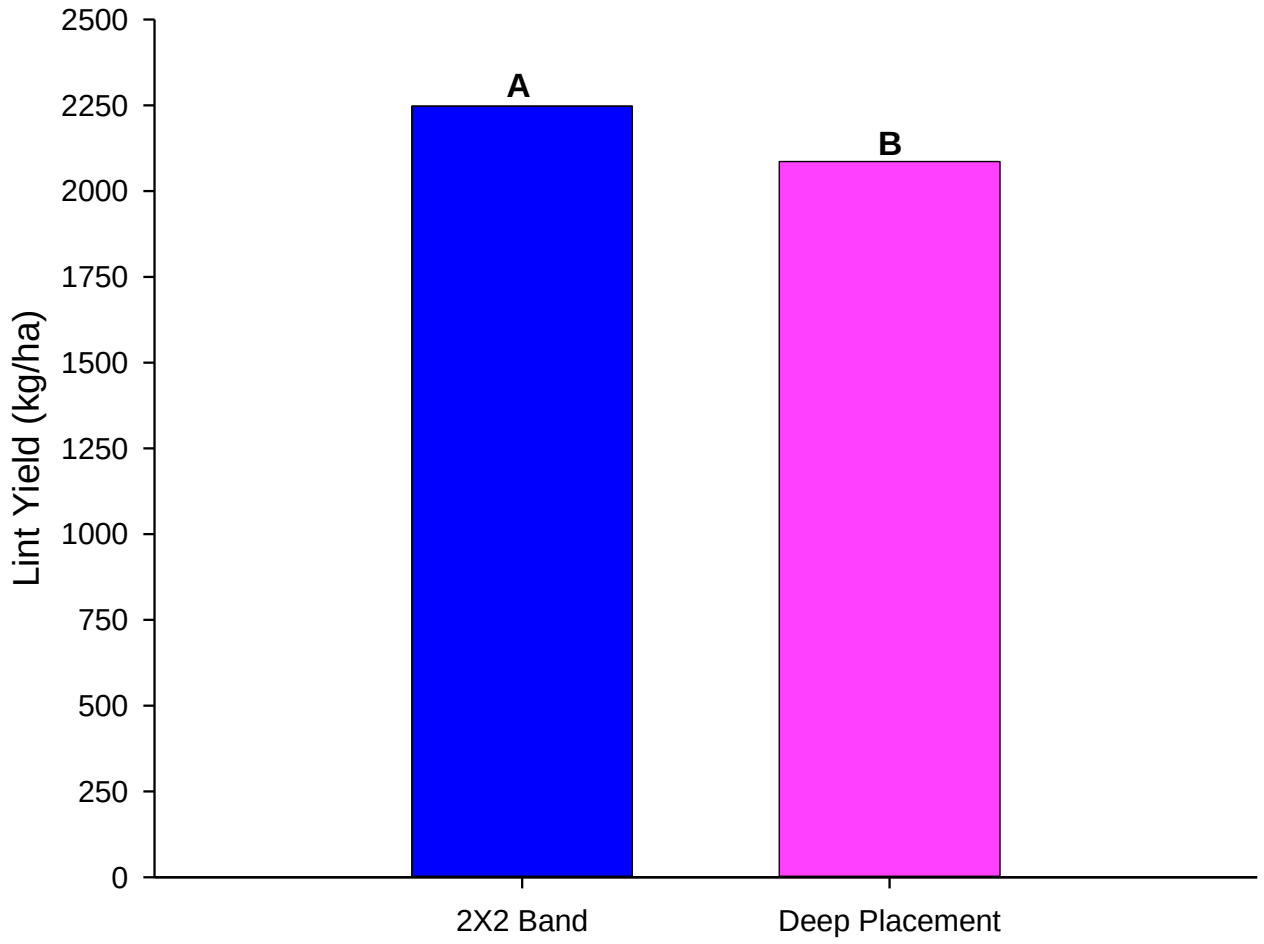
Placement	P and K Rate†	Nitrogen		Phosphorus		Potassium		Sulfur		Boron	
	%					Week of Bloom					
		1st	5th	1st	5th	1st	5th	1st	5th	1st	5th
		----------				%				ppm	
-	50	4.12	4.07	0.27	0.28	1.10 b¶	1.18 b	0.86	0.73	25.0	46.6
-	100	4.21	3.81	0.27	0.29	1.19 b	1.24 ab	0.88	0.75	25.6	50.1
-	150	3.93	3.87	0.25	0.26	1.32 a	1.31 a	0.89	0.73	25.2	51.4
2X2 Band	-	4.08	3.99	0.25 b	0.28	1.26 a	1.29 a	0.95 a	0.76	25.1	49.8
Deep Placement	-	4.10	3.85	0.28 a	0.27	1.15 b	1.19 b	0.81 b	0.72	25.4	48.9
2X2 Band	50	3.98	4.39 a	0.26	0.27	1.15	1.24	0.86	0.69 a	24.3	48.0
2X2 Band	100	4.29	3.71 b	0.26	0.30	1.25	1.26	0.98	0.80 a	25.1	50.1
2X2 Band	150	3.98	3.87 ab	0.24	0.27	1.40	1.37	1.00	0.79 a	25.9	51.3
Deep Placement	50	4.27	3.75 b	0.23	0.28	1.07	1.12	0.85	0.78 a	25.8	45.1
Deep Placement	100	4.13	3.92 ab	0.28	0.28	1.13	1.22	0.79	0.70 a	26.1	50.2
Deep Placement	150	3.89	3.88 ab	0.27	0.25	1.24	1.25	0.79	0.67 a	24.4	51.4
						ANOVA (Pr > F)					
	P and K Rate	NS*	NS	NS	NS	0.0003	0.0337	NS	NS	NS	0.0276
	Placement	NS	NS	0.0331	NS	0.002	0.0186	0.0289	NS	NS	NS
	Rate*Placement	NS	0.0367	NS	NS	NS	NS	NS	0.0943	NS	NS

* The overall ANOVA was not significant at α =0.1

¶ Values followed by the same letter are not significantly different at α =0.1

† 100% of the recommended rate is equal to 40 lbs P_2O_5 and 40 lbs K_2O per acre

Lint Yield and Placement (TAREC)



2x2 Band and Deep Placement Combinations on Early Plant Height (TAREC)

Placement Combinations†	Plant Height (in)					
% / %	4-Jun	13-Jun	20-Jun	26-Jun	3-Jul	11-Jul
100 / 0	5.2	9.4	12.1	18.6 a¶	25.9 a	32.0
80 / 20	5.2	9.3	12.1	18.3 ab	25.6 a	31.7
60 / 40	5.0	9.0	11.8	17.7 ab	24.9 ab	30.0
40 / 60	5.0	8.8	11.8	17.4 ab	24.7 ab	31.0
20 / 80	5.1	9.1	11.5	17.5 ab	24.6 ab	31.4
0 / 100	4.9	8.7	11.3	16.9 b	23.9 b	30.9
ANOVA (Pr > F)	NS*	NS	NS	0.0457	0.0172	NS

* The overall ANOVA was not significant at α =0.1

¶ Values followed by the same letter are not significantly different at α =0.1

† Combinations of deep placement and 2X2 band of the P and K applied at the 100% (40lbs /acre) rate

2013 Conclusions

- 2x2 P and K band produced significantly taller plants than the broadcast control in 3 out of 6 sampling intervals at TAREC

- Early season growth is very important in Virginia cotton production as weather can be variable during May
  - Cool Temperatures
  - Heavy Rainfall Events

- Nitrogen deficiency increased phosphorus concentrations in cotton petioles throughout the bloom period
  - When petiole sampling is used in cotton, N status will be important when making decisions about in-season phosphorus management

- Sand-burn injury delayed the peak nutrient levels in cotton petioles 1-2 weeks for N and K, and up to 4-5 for P
  - If early season injury has occurred, petiole samples during early bloom may not be a good indicator of the crop nutrient status

Conclusions (cont.)

- Leaf tissue analysis was more sensitive than petioles to treatments when monitoring K in cotton despite early season injury
- All nutrient management systems produced similar lint yields when P and K were applied at the soil test recommended rates
- 2X2 Band produced significantly higher lint yield than the deep placement at TAREC when analyzed over rates and placement
- Environmental conditions in 2013 may have reduced the risk of salt injury with the 2x2 band
  - Wet cool early season conditions
  - Important not to extrapolate data to other environments!!!
  - Potential for salt injury on higher rates in 2x2 band placement during dry years.

Acknowledgements

- Fluid Fertilizer Foundation
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Questions?