

# NC STATE UNIVERSITY

## Evaluation of Nitrogen Application Timings on Yield, Quality, and Sucker Control in Flue-cured Tobacco

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# Current Practices: Nitrogen Application

- Growers are applying fertilizer in two applications.
- The first fertilizer application is applied as either a band or a broadcast before transplanting or just after transplanting. 50% of N and 100% of P and K.
- The second application is made just before the lay-by growth stage of the plant (three to five weeks after transplanting or 15-20 inches tall), banded. Remainder of N.
- Nutrients are not normally added after lay-by as field implements cannot pass over plants without damaging.

# Potential Complications with Split Application

- Amount of nitrogen applied is based on extension recommendations and field experience.
- Estimation based on soil type and expected rainfall.
- End up with too much N in a dry year and not enough in a wet year.

# Justification of Research

- With the use of liquid nitrogen (Urea ammonium nitrate, UAN) becoming popular, later applications are now possible with high clearance equipment.
- According to NC Extension 50% of tobacco acreage receives at least some of its nitrogen from UAN.

# Justification of Research

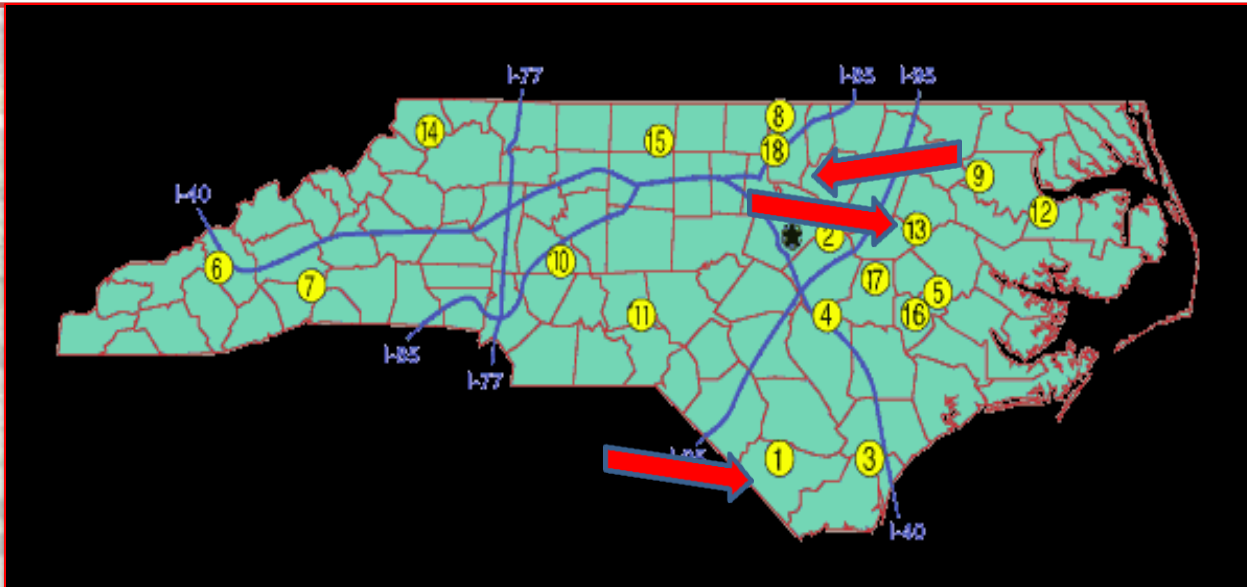
- Benefits of UAN include
  - Ease of handling
  - Less fill-ups
  - More flexibility in application timing
  - Cost savings

# Justification of Research

- Applying nitrogen in more than two applications would allow growers to base nitrogen rates on current growing conditions in **ADDITION** to previous field experience.
- Rainfall amounts, soil texture, estimated water percolation, and crop condition would determine need for additional nitrogen.
  - Drought conditions vs. excess rainfall.

# Enviroments

- Border Belt Tobacco Research (BBTRS) in Whiteville, NC. (2012 & 2013)
- Oxford Tobacco Research Station (OTRS) in Oxford, NC (2012 & 2013)
- Upper Coastal Plain Research Station (UCPRS) Rocky Mount, NC (2013)
- Representative of Coastal Plain & Piedmont (major tobacco producing regions in NC)



# Methods & Materials

- Nitrogen applications were made two to four times per season.
- Possible application timings evaluated were at planting, at *6 in.* plant height, at *15-20 in.* plant height (layby), at *24-30 in.* plant height and at *48 in.* plant height (topping).
- Timings corresponded with approximately 0, 2, 4, 6, and 8 weeks after transplanting.
- Base rates of nitrogen were based on recommended rates for each location.
- Within each environment, rates of nitrogen applied were 75% of the total nitrogen recommended rate, 100% of the total nitrogen recommended rate, or 125% of the total nitrogen recommended rate.



# Methods & Materials

- Nitrogen was soil applied using a simulated soil directed application technique and was then incorporated with a Danish tine rolling cultivator.
- Applications after layby were done to simulate drop nozzles used by high clearance sprayers to apply nitrogen to the soil surface.

# Nitrogen application timing and amount applied relative to recommended nitrogen rates at each environment.

Treatment Number	-----Nitrogen Application Timing-----				
	At Transplanting	2 Weeks after transplanting <sup>1</sup>	At layby <sup>2</sup>	2 Weeks after layby <sup>3</sup>	At Topping
<b>1 (Control)</b>	50%	-	50%	-	-
<b>2</b>	50%	25%	-	-	-
<b>3</b>	25%	25%	25%	25%	-
<b>4</b>	25%	25%	25%	-	-
<b>5</b>	25%	-	25%	25%	25%
<b>6</b>	25%	-	25%	25%	-
<b>7</b>	25%	25%	-	-	50%
<b>8</b>	25%	-	25%	-	25%
<b>9</b>	50%	-	50%	-	25%
<b>10</b>	50%	-	25%	-	25%

**P values for yield, quality, value, total alkaloids, reducing sugars, leaf nitrogen content at layby, leaf nitrogen content at topping, and SPAD measurements.**

Variable	Pr>F Env* Rate/Timing	Pr>F Rate/Timing
Yield	0.7037	0.3448
Quality	0.9803	0.5747
Value	0.8286	0.3988
Total Alkaloids	0.0618	<0.0001*
Total Reducing Sugars BBTRS-12	---	0.1201
Total Reducing Sugars OTRS-12	---	<b>0.0026*</b>
Total Reducing Sugars BBTRS-13	---	0.3415
Total Reducing Sugars OTRS-13	---	0.574
Total Reducing Sugars UCPRS-13	---	0.1585
Leaf nitrogen content at layby	0.1454	<b>0.0038*</b>
Leaf nitrogen content at topping BBTRS-12	---	0.0917
Leaf nitrogen content at topping OTRS-12	---	<b>0.0250*</b>
Leaf nitrogen content at topping BBTRS-13	---	<b>0.0039*</b>
Leaf nitrogen content at topping OTRS-13	---	0.8992
Leaf nitrogen content at topping UCPRS-13	---	<b>0.0090*</b>
SPAD BBTRS-12	---	0.0558
SPAD OTRS-12	---	<b>0.0461*</b>
SPAD BBTRS-13	---	<b>0.0012*</b>
SPAD OTRS-13	---	0.8946
SPAD UCPRS-13	---	<b>0.0187*</b>

# Yield, quality, and value response to nitrogen rate and timing combined over environments.

Treatment Number	-----Nitrogen Application Timing-----					Yield ---Lbs/ac---	Quality Index <sup>1</sup>	Value --\$/ac--
	At Transplanting	2 WAT	At layby	2 WALayby	At Topping			
<b>1 (Control)</b>	50%	-	50%	-	-	2,567 a	80 a	4,248 a
<b>2</b>	50%	25%	-	-	-	2,591 a	82 a	4,376 a
<b>3</b>	25%	25%	25%	25%	-	2,463 a	82 a	4,245 a
<b>4</b>	25%	25%	25%	-	-	2,481 a	83 a	4,345 a
<b>5</b>	25%	-	25%	25%	25%	2,771 a	80 a	4,633 a
<b>6</b>	25%	-	25%	25%	-	2,525 a	82 a	4,292 a
<b>7</b>	25%	25%	-	-	50%	2,474 a	78 a	3,977 a
<b>8</b>	25%	-	25%	-	25%	2,488 a	79 a	3,979 a
<b>9</b>	50%	-	50%	-	25%	2,542 a	78 a	4,051 a
<b>10</b>	50%	-	25%	-	25%	2,632 a	84 a	4,603 a

<sup>1</sup>Bowman *et al.* Revised North Carolina grade index for flue-cured tobacco. 1988

# Total alkaloids and leaf nitrogen content at layby responses to nitrogen rate and timing combined over environments.

Treatment Number	-----Nitrogen Application Timing-----					Total alkaloids -----%-----	Nitrogen content at layby
	At Transplanting	2 WAT	At layby	2 WALayby	At Topping		
<b>1 (Control)</b>	50%	-	50%	-	-	2.65 cde	4.34 ab
<b>2</b>	50%	25%	-	-	-	2.49 ef	4.61 a
<b>3</b>	25%	25%	25%	25%	-	2.54 def	4.15 bc
<b>4</b>	25%	25%	25%	-	-	2.41 f	4.17 bc
<b>5</b>	25%	-	25%	25%	25%	2.76 abc	4.10 bc
<b>6</b>	25%	-	25%	25%	-	2.43 f	4.00 c
<b>7</b>	25%	25%	-	-	50%	2.85 ab	4.23 bc
<b>8</b>	25%	-	25%	-	25%	2.56 cdef	4.04 bc
<b>9</b>	50%	-	50%	-	25%	2.95 a	4.29 bc
<b>10</b>	50%	-	25%	-	25%	2.72 bcd	4.34 ab

# Discussion

- The highest total alkaloid percentages were from treatments that had 100% or 125% of the recommended rate of nitrogen.
- The four highest total alkaloid percentages also had a late season nitrogen application at the “at topping” timing interval.
- Differences in N content at layby likely because not all of the treatments had all nitrogen applied at the time of sampling.
- There were treatments that had 50% of the nitrogen applied after the layby stage, these treatments had less leaf nitrogen content than treatments that had already had 100% of the recommended rate applied when the samples were taken.

# Discussion

- Higher reducing sugar levels observed at 75% of the total recommended nitrogen rate.

# Leaf nitrogen content at topping in response to nitrogen rate and timing by environment.

Treatment	-----Nitrogen Application Timing-----					BBTRS-12	OTRS-12	BBTRS-13	OTRS-13	UCPRS-13
	At Transplanting	2 WAT	At layby	2 WALayby	At Topping					
<b>1 (Control)</b>	50%	-	50%	-	-	2.11a	3.88 abc	1.54 cd	2.93 a	2.48 a
<b>2</b>	50%	25%	-	-	-	1.87 a	4.19 ab	1.43 d	2.84 a	1.79 c
<b>3</b>	25%	25%	25%	25%	-	1.91 a	4.30 a	1.73 cd	3.04 a	2.00 bc
<b>4</b>	25%	25%	25%	-	-	1.85 a	3.61 c	1.52 cd	2.87 a	2.07 bc
<b>5</b>	25%	-	25%	25%	25%	2.15 a	3.50 c	2.56 a	2.85 a	2.03 bc
<b>6</b>	25%	-	25%	25%	-	1.99 a	3.73 bc	1.97 bc	2.91 a	2.05 bc
<b>7</b>	25%	25%	-	-	50%	2.57 a	3.79 bc	2.26 ab	2.76 a	1.83 c
<b>8</b>	25%	-	25%	-	25%	1.84 a	4.13 ab	1.72 cd	2.88 a	2.33 ab
<b>9</b>	50%	-	50%	-	25%	2.18 a	4.20 ab	1.75 cd	3.16 a	2.46 a
<b>10</b>	50%	-	25%	-	25%	1.97 a	3.83 abc	1.76 cd	2.86 a	2.03 bc



# Discussion

- The highest nitrogen levels “at topping” were generally in plots where later nitrogen applications were made.

# Conclusion

- Rate of nitrogen and timing had very little affect on leaf quality.
- Leaf chemistry was affected by nitrogen rate and timing.
- Current nitrogen rate recommendations appear to be adequate for optimum yield and quality.
- **Weather played a major role in this study.**
- Had less rainfall occurred some of the late season applications may have resulted in a decreased leaf quality.
- Further research is still needed to determine if a late season application would not harm quality due to delayed ripening of the leaf.

# Rainfall Table by month for individual environments

Month	BBTRS-12 <sup>1</sup>	OTRS-12 <sup>2</sup>	BBTRS-13 <sup>3</sup>	OTRS-13 <sup>4</sup>	UCPRS-13 <sup>5</sup>
	-----Inches-----				
<b>April</b>	2.32	3.90	2.28	4.57	2.68
<b>May</b>	8.98	6.14	22.64	4.57	2.87
<b>June</b>	2.28	2.24	25.79	10.35	9.96
<b>July</b>	8.11	11.06	12.32	9.49	4.92
<b>August</b>	14.37	6.50	6.65	4.21	4.53
<b>September</b>	4.17	5.43	4.72	1.93	4.84
<b>October</b>	4.49	2.48	1.06	2.32	3.27
<b>Total</b>	44.72	37.76	75.47	37.44	33.07
<b>Average</b>	31.50	27.56	31.50	27.56	27.56
<b>Percent above average</b>	41%	37%	140%	37%	20%

# Objective

- Evaluate Soil Applied and Stalk Run-down methods for late season N application.

# Nitrogen application timings, rates, and method.

Treatment Number	-----Nitrogen Application Timing-----					Method of Application
	At Transplanting	2 Weeks after transplanting	At layby	6 Weeks after transplanting	At Topping	
<b>1 (Control)</b>	50%	-	50%	-	-	SA
<b>2 (Control)</b>	50%	25%	-	-	-	SA
<b>3</b>	25%	-	25%	25%	25%	SA/SR
<b>4</b>	25%	-	25%	25%	25%	SA
<b>5</b>	-	25%	25%	-	50%	SA/SR
<b>6</b>	-	25%	25%	-	50%	SA
<b>7</b>	50%	-	50%	-	25%	SA/SR
<b>8</b>	50%	-	50%	-	25%	SA

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1 (Control)	50%	-	50%	-	-	SA
2 (Control)	50%	25%	-	-	-	SA
3	25%	-	25%	25%	25%	SA/SR
4	25%	-	25%	25%	25%	SA
5	-	25%	25%	-	50%	SA/SR
6	-	25%	25%	-	50%	SA
7	50%	-	50%	-	25%	SA/SR
8	50%	-	50%	-	25%	SA

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<b>1 (Control)</b>	50%	-	50%	-	-	SA
<b>2 (Control)</b>	50%	25%	-	-	-	SA
<b>3</b>	25%	-	25%	25%	25%	SA/SR
<b>4</b>	25%	-	25%	25%	25%	SA
<b>5</b>	-	25%	25%	-	50%	SA/SR
<b>6</b>	-	25%	25%	-	50%	SA
<b>7</b>	50%	-	50%	-	25%	SA/SR
<b>8</b>	50%	-	50%	-	25%	SA

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<b>1 (Control)</b>	50%	-	50%	-	-	SA
<b>2 (Control)</b>	50%	25%	-	-	-	SA
<b>3</b>	25%	-	25%	25%	25%	SA/SR
<b>4</b>	25%	-	25%	25%	25%	SA
<b>5</b>	-	25%	25%	-	50%	SA/SR
<b>6</b>	-	25%	25%	-	50%	SA
<b>7</b>	50%	-	50%	-	25%	SA/SR
<b>8</b>	50%	-	50%	-	25%	SA



**P values for yield, quality, value, total alkaloids, reducing sugars, leaf nitrogen content at layby, leaf nitrogen content at topping, and SPAD measurements.**

Variable	Pr>F Env*Ntime*Nmeth	Pr>F Env*Ntime	Pr>F Env*Nmeth	Pr>F Ntime*Nmeth	Pr>F Ntime	Pr>F Nmeth
Yield	0.1417	0.3806	0.3801	0.8075	0.2457	<b>0.0456*</b>
Quality	0.0658	0.0822	0.2719	<b>0.0008*</b>	0.3654	0.9720
Value	<b>0.0344*</b>	0.2361	0.7458	0.0362	0.6047	0.1931
Total Alkaloids	0.9540	0.3982	0.9408	0.9242	0.2022	0.0973
Total Reducing	0.6334	0.5110	0.4165	0.7215	<b>0.0439*</b>	0.1496
Leaf nitrogen content at layby	0.6924	<b>0.0058*</b>	0.5272	0.1005	0.2924	0.5611
Leaf nitrogen content at topping	0.3820	0.8992	<b>0.0041*</b>	0.4308	0.2077	<b>&lt;.0001*</b>
SPAD	0.8877	0.7962	<b>0.0160*</b>	0.7421	0.2947	0.0629

# Yield response to application method combined across all environments.

Application Method	Yield
	-----lbs/ac-----
Soil Applied	2,592 a
Stalk Run-down	2,480 b

# Grade index response to nitrogen application rate, timing, and method combined across all environments.

-----Nitrogen Application Timing-----					Method of Application	Quality Index
At Transplanting	2 Weeks after transplanting	At layby	6 Weeks after transplant	At Topping		
25%	-	25%	25%	25%	SA/SR	81 ab
25%	-	25%	25%	25%	SA	76 b
-	25%	25%	-	50%	SA/SR	74 b
-	25%	25%	-	50%	SA	84 a
50%	-	50%	-	25%	SA/SR	83 a
50%	-	50%	-	25%	SA	79 ab

# Value response to nitrogen application rate, timing, and method at individual environments.

-----Nitrogen Application Timing-----					Method of Application	BBTRS-12	OTRS-12	OTRS-13	UCPRS-13
At Transplanting	2 Weeks after transplanting	At layby	6 Weeks after transplant	At Topping		-----\$/ac-----			
25%	-	25%	25%	25%	SA/SR <sup>1</sup>	5,373 a	4,996 a	4,043 a	2,381 a
25%	-	25%	25%	25%	SA <sup>2</sup>	4,675 a	5,246 a	4,345 a	2,245 ab
-	25%	25%	-	50%	SA/SR <sup>1</sup>	4,130 a	4,835 a	3,614 a	2,050 abc
-	25%	25%	-	50%	SA <sup>2</sup>	5,254 a	5,145 a	5,709 a	1,806 bc
50%	-	50%	-	25%	SA/SR <sup>1</sup>	5,194 a	5,155 a	5,417 a	1,525 c
50%	-	50%	-	25%	SA <sup>2</sup>	5,632 a	4,981 a	4,403 a	1,836 bc

# Discussion

- For value, the only environment with a significant treatment effect was the Upper Coastal Plains Research Station in 2013.
- The three treatments that received the highest value per acre were treatments that had only 100% of the recommended rate of nitrogen applied.
- The increase in yield from the soil applied nitrogen method when evaluating yield combined with the differences in quality index likely led to differences in crop value.

# Reducing sugar percentage in response to application timing combined across all environments and method of application.

-----Nitrogen Application Timing-----					Reducing Sugars
At Transplanting	2 Weeks after transplanting	At layby	6 Weeks after transplant	At Topping	-----%-----
25%	-	25%	25%	25%	15.22 a
-	25%	25%	-	50%	13.66 b
50%	-	50%	-	25%	14.26 ab

# Discussion

- Treatments with a portion of their nitrogen applied at transplant had less nitrogen applied late in the season allowing for starch to accumulate earlier.

# Leaf nitrogen content at layby in response to nitrogen application timing by individual environment and combined over application method.

-----Nitrogen Application Timing-----					Leaf Nitrogen Content at layby			
					BBTRS-12	OTRS-12	OTRS-13	UCPRS-13
At Transplanting	2 Weeks after transplanting	At layby	6 Weeks after transplanting	At Topping	-----%-----			
25%	-	25%	25%	25%	3.75 a	4.04 a	3.72 b	4.11 a
-	25%	25%	-	50%	3.72 a	4.78 a	4.34 a	3.59 b
50%	-	50%	-	25%	3.61 a	4.04 a	4.63 a	4.15 a



# Leaf nitrogen content at topping in response to nitrogen application method combined over timings of application.

Application Method	Leaf Nitrogen Content at topping			
	BBTRS-12	OTRS-12	OTRS-13	UCPRS-13
	-----%-----			
<b>Stalk rundown</b>	2.68 a	4.90 a	3.63 a	2.01 a
<b>Soil applied</b>	2.50 a	4.00 b	3.14 b	1.77 a

# Conclusions

- Can use later season applications of nitrogen with the use of high clearance sprayers and UAN with more flexibility than once thought.
- Growers have been doing this to make leaching adjustments, but with lower rates than evaluated in this study.
- Soil applied nitrogen appears to be more efficient from a plant use standpoint than stalk rundown method of application.
- Because of excessive rainfall in both years we were not able to determine how late is too late and what amount of N is too great. The theory was verified, but not the practice.
- Would prefer to deal with excessive N applied early than late, but delaying a portion of the N applied until 6-8 weeks after transplanting (total of 3 applications) would provide for better N management flexibility with minimal risk.

# Rainfall Table by month for individual environments

Month	BBTRS-12 <sup>1</sup>	OTRS-12 <sup>2</sup>	BBTRS-13 <sup>3</sup>	OTRS-13 <sup>4</sup>	UCPRS-13 <sup>5</sup>
	-----Inches-----				
<b>April</b>	2.32	3.90	2.28	4.57	2.68
<b>May</b>	8.98	6.14	22.64	4.57	2.87
<b>June</b>	2.28	2.24	25.79	10.35	9.96
<b>July</b>	8.11	11.06	12.32	9.49	4.92
<b>August</b>	14.37	6.50	6.65	4.21	4.53
<b>September</b>	4.17	5.43	4.72	1.93	4.84
<b>October</b>	4.49	2.48	1.06	2.32	3.27
<b>Total</b>	44.72	37.76	75.47	37.44	33.07
<b>Average</b>	31.50	27.56	31.50	27.56	27.56
<b>Percent above average</b>	41%	37%	140%	37%	20%