Implications of Chloride Application Rate and Nitrogen Fertilizer Source on Flue-Cured Tobacco

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Introduction – Cl^- Overview

- Chloride (Cl^-) uptake can be deleterious to tobacco growth and development.
  - ≤33 kg/ha is typically appropriate for production
- Presence influenced by:
  - Fertilizer application (KCl, muriate of potash)
    - Misapplication or blending error in southern USA
  - Soil fumigation
  - Precipitation/Irrigation
- 1% tissue concentration is a general tolerance limit

Introduction – Nitrogen Overview

- Nitrogen (N) fertilizer source is widely debated topic.
  - >33% NO_3^- historically recommended
  - 100% NH_4^+ based sources currently used in some scenarios
- Transition to liquid UAN and 24S due to low cost
  - >50% of the North Carolina crop receives some of it's N in this form
- Limited information regarding nutrient uptake following UAN application

Introduction – Cl^- and N Interactions

- Nitrogen form may also influence Cl^- assimilation
  - Toxicity may be related to N source as well
- Issues more apparent within the first 45 days of transplanting
- Most of what we know is based on greenhouse studies from the 1960's and 1970's
- Research is needed that reflects the inclusion of UAN in a modern production system

Objectives

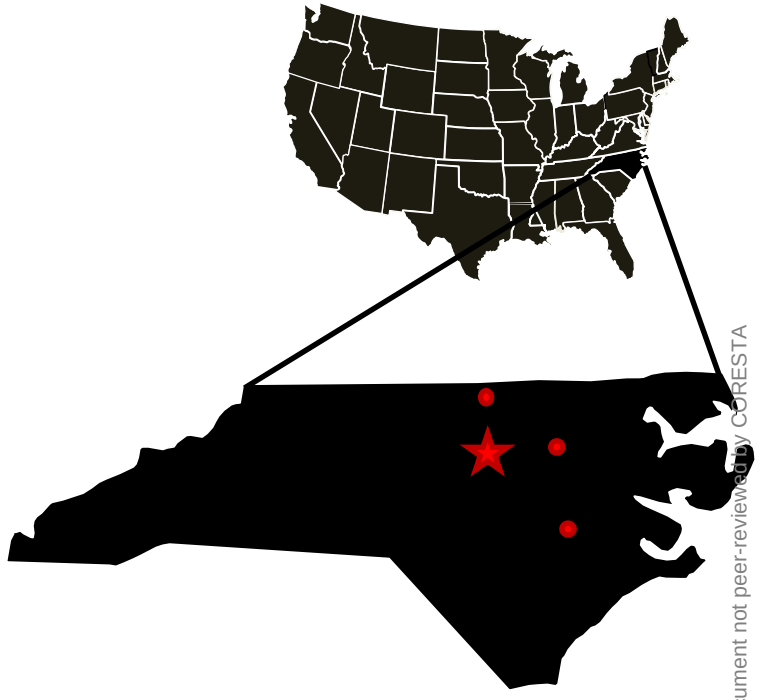
1. Quantify the impact of Cl^- in a modern system
2. Identify potential interactions of Cl^- and N source
3. Evaluate a range of N sources to further refine Extension recommendations
    -Identify management strategies following misapplication

Methods & Materials

- Four growing environments
  - RCBD w/factorial treatment arrangement
  - Four replications per environment
  - Cultivar was NC 196 in each environment

- Cl applied 10 days after transplanting (DAT)
  - Sidedress in a band (10 cm x 10 cm)
  - 0, 34, 67, & 101 kg Cl^{-} ha^{-1}
  - K_2SO_4, KCl, and $CaSO_4$ blended to ensure 168 and 60 kg ha^{-1} of K_2O and SO_4^{2-}, respectively, in all treatments

- Nitrogen split-applied 10 DAT and at layby
  - Sidedress in a band (10 cm x 10 cm)
  - Calcium Nitrate (100% NO_3^{-}), Calcium Ammonium Nitrate (50% NO_3^{-}, 50% NH_4^{+}), UAN (25% NO_3^{-}, 75% NH_4^{+}), Ammonium Sulfate (100% NH_4^{+})



Data Collection & Analysis

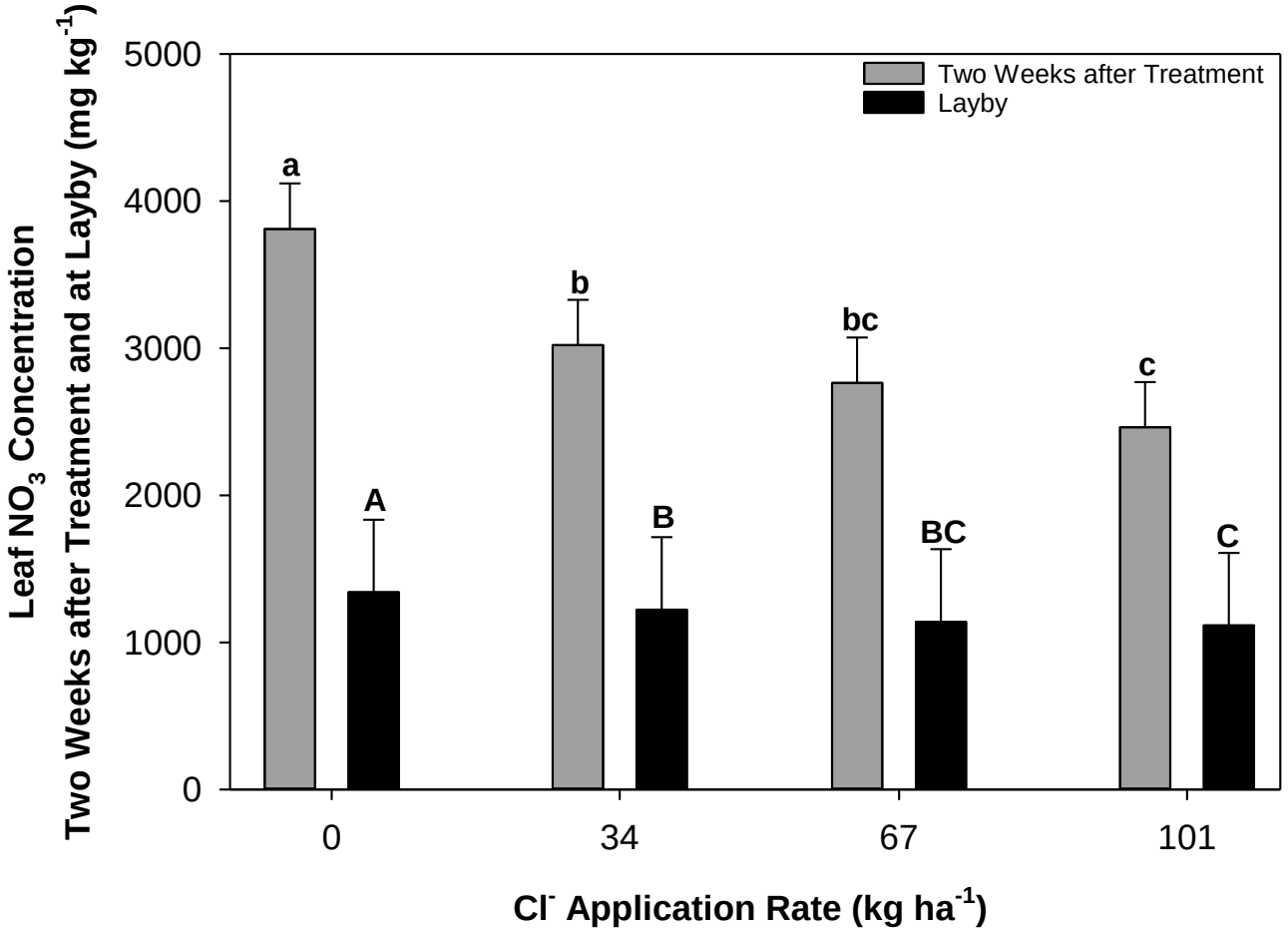
- Soil Samples (0-15 & 15-30 cm)
  - Prior to treatment application
- Tissue Samples
  - Two Weeks After Fertilizer App.
  - Layby
  - Two Weeks After Layby
  - At Flowering
  - After Curing (Final Priming Only)
- Analyzed by NCDA & CS:
  - N, P, K, Mg, Cl, and NO_3^-
- Cured leaf yield, quality, value, and chemistry
- PROC GLIMMIX procedure
  - SAS version 9.4, $LSD_{0.05}$
  - Random Effects: Env. & Rep
  - Fixed Effects: Cl^- rate & N Source
- Main effect interactions further analyzed using two-way ANOVA
- Sigma Plot ver. 14.0

Growing Environment Descriptions

Parameter	Soil Depth (cm)	LCPRS-16	LCPRS-17	OTRS-17	UCPRS-17
Soil Series		Norfolk	Norfolk	Appling	Norfolk
Texture		Loamy-Sand	Loamy-Sand	Sandy-Loam	Loamy-Sand
OM (%)	0-15	0.48	0.57	0.66	0.67
	15-30	0.79	0.60	0.51	0.65
pH	0-15	6.3	5.7	5.7	6.0
	15-30	5.7	5.8	5.7	6.1
		kg ha^{-1}			
Cl^-	0-15	5	1.8	115	81
	15-30	2	0.4	52	5

* Soil samples analyzed by Waters Agricultural Lab, Warsaw, NC using the Mehlich-1 Extraction Method and proprietary extraction methods for Cl^-

Nitrate



Nitrate

Table 1. Leaf NO_3^- concentration two weeks after layby as influenced by the interaction of N fertilizer source and Cl^- application rate[a]. Data are pooled across four growing environments.

N Source	Cl Application Rate (kg ha^{-1})			
	0	34	67	101
	NO_3^- (mg kg^{-1})			
$CaNO_3$	1,842 aA	1,453 aB	1,455 aB	1,451 abB
NH_4NO_3	1,617 aA	1,340 abA	1,294 aA	1,240 bcA
UAN	1,565 aA	1,175 bcB	1,534 aA	1,515 aA
NH_4SO_4	1,292 aA	1,119 cA	1,345 aA	1,061 cA

[a] Treatment means followed by the same lowercase letter within the same column are not significantly different at the α=0.05 level. Treatment means followed by the same uppercase letter within the same row are not significantly different at the α=0.05 level.

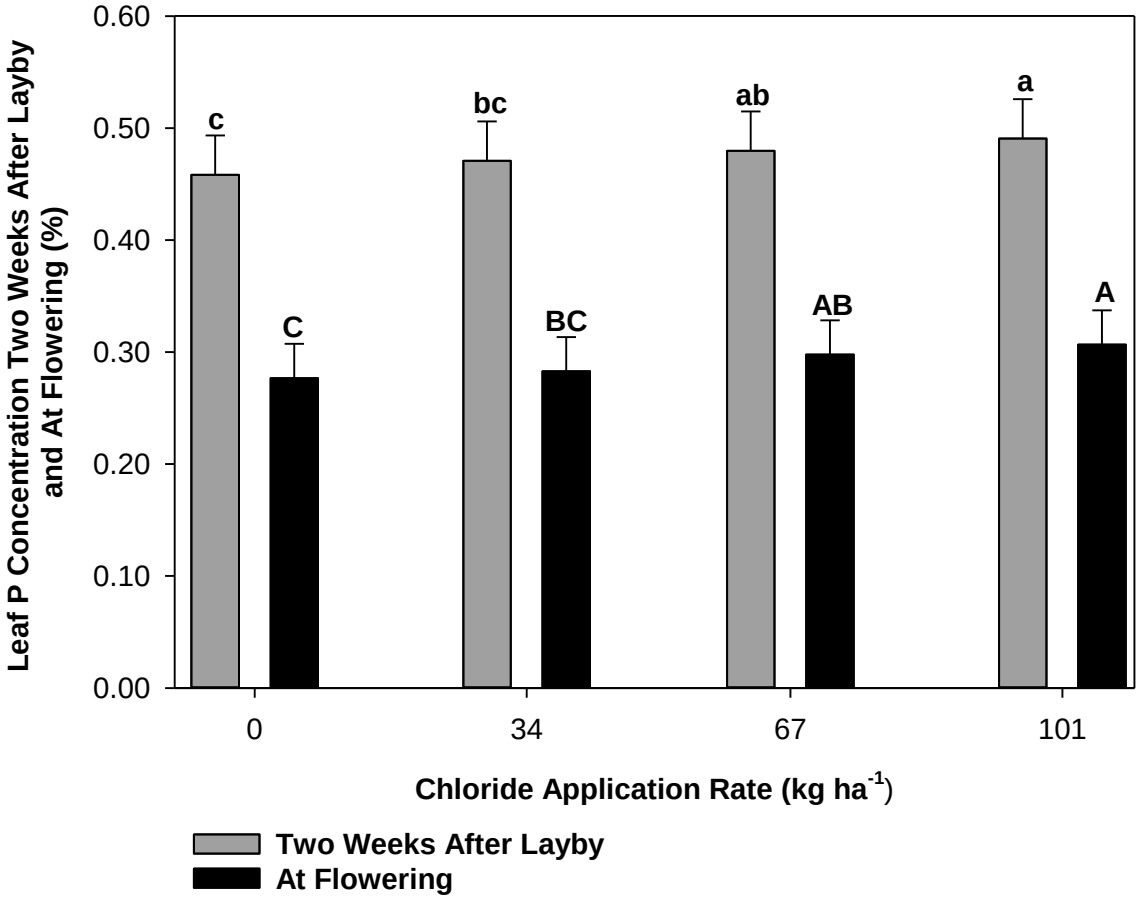
Total Nitrogen

Table 2. Leaf total nitrogen concentration two weeks after chloride application, two weeks after layby, and after curing as influenced by the main effect of chloride application rate[a]. Data are pooled across four growing environments.

Cl^- Application Rate	Two Weeks After Treatment	Two Weeks After Layby	After Curing[b]
kg ha^{-1}	% Total N		
0	4.64 a	5.49 b	2.58 a
34	4.52 ab	5.64 a	2.47 b
67	4.37 bc	5.66 a	2.39 b
101	4.22 c	5.66 a	2.37 b

[a] Treatment means followed by the same letter within the same sampling interval are not significantly different at the α=0.05 level.
[b] Tissue samples collected after curing represent the uppermost stalk position only.

Phosphorus



Chloride

Table 3. Leaf chloride concentration as influenced by the main effect of chloride application rate[a]. Data are pooled across four growing environments.

Cl^- Application Rate	Two Weeks After Treatment	At Layby	Two Weeks After Layby	After Curing[b]
kg ha^{-1}		% Cl^-		
0	0.68 c	0.35 d	0.49 d	0.77 c
34	1.34 b	0.73 c	0.72 c	1.02 b
67	1.75 a	0.90 b	0.89 b	1.40 a
101	1.74 a	1.09 a	1.04 a	1.60 a

[a] Treatment means followed by the same letter within the same sampling interval are not significantly different at the α=0.05 level.
[b] Tissue samples collected after curing represent the uppermost stalk position only.

Chloride

Table 4. Leaf Cl^- concentration at flowering as influenced by the interaction of N fertilizer source and Cl^- application rate[a]. Data are pooled across four growing environments.

N Source	Cl Application Rate (kg ha^{-1})			
	0	34	67	101
	% Cl^-			
$CaNO_3$	0.50 aD	0.68 bC	1.01 aB	1.13 aA
NH_4NO_3	0.47 aD	0.83 aC	0.96 aB	1.10 aA
UAN	0.53 aD	0.77 abC	1.00 aB	1.15 aA
NH_4SO_4	0.51 aD	0.81 aC	0.96 aB	1.19 aA

[a] Treatment means followed by the same lowercase letter within the same column are not significantly different at the α=0.05 level. Treatment means followed by the same uppercase letter within the same row are not significantly different at the α=0.05 level.

Post-Harvest Performance

Table 5. Cured leaf yield, quality, value, and chemistry as influenced by the main effects of chloride (Cl^-) application rate and nitrogen fertilizer source[a]. Data are pooled across four growing environments.

Main Effect	Yield	Quality[b]	Value	Total Alk[c]	Red Sugars[c]
Cl^- Application	**kg ha^{-1}**		**$US ha^{-1}**	**%**	
0 kg ha^{-1}	3,158 a	75 a	10,908 a	2.70 a	16.12 b
34 kg ha^{-1}	3,323 a	76 a	11,249 a	2.46 b	17.73 a
67 kg ha^{-1}	3,280 a	75 a	11,070 a	2.53 b	17.52 a
101 kg ha^{-1}	3,310 a	74 a	11,034 a	2.43 b	18.14 a
Nitrogen Source					
$CaNO_3$	3,341 A	77 A	11,546 A	2.55 AB	16.76 A
NH_4NO_3	3,232 A	75 B	10,956 A	2.60 A	16.86 A
UAN	3,279 A	75 B	11,143 A	2.47 C	17.56 A
NH_4SO_4	3,218 A	73 C	10,617 A	2.50 BC	18.33 A

[a] Treatment means followed by the same lowercase or uppercase letter within the same column and main effect are not significantly different at the α=0.05 level.
[b] Quality is assessed on a scale of 1-100, with 100 being of the highest quality.
[c] Total alkaloid and reducing sugar concentration quantified from composite cured leaf samples representing each of the four harvested stalk positions.

Conclusions

- Cl^- toxicity symptoms not observed
- Cl application rate had few practical effects to nutrient assimilation after layby.
  - NO_3^- was suppressed prior to layby
- Foliar concentration >1% as Cl rates >34 kg ha
- Limited effect of N source to Cl uptake
  - Where conditions promote nitrification

Practical Application of Research

- Limit Cl^- to no more than 33 kg ha^{-1}
  - Possibly less if using soil fumigation
  - Yield response is unlikely due to prevalence of fumigation
- NO_3^- should account for ≥25% of the total applied N
  - Do not use NH_4^+ for 100% of N fertility plan
- Consider having soil tested for residual Cl^-
- Following misapplication of Cl^-, use NO_3^- N sources

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Questions??

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