The Effect of Potassium Rate, Application Method and Timing on the Yield and Quality of Flue-cured Tobacco

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Introduction

Potassium (K) is an essential plant nutrient that has a profound effect on crop yield and crop quality. As with all other crops, K is essential to the production of high yielding, high quality flue-cured tobacco with a healthy crop typically requiring about 100 kg K_2O ha^{-1} from the soil for optimum growth (Raper and McCants, 1966). Tobacco is known to be a luxury consumer of K (Raper and McCants, 1966), and K application is typically two to three times that needed for maximum yield (Sims, 1985).

In recent years, input costs have increased dramatically, with potassium prices nearly doubling in 2008 alone (Fig. 1). With smaller profit margins as a result of increasing production costs, producers must be more efficient in fertilizer application.

One benefit tobacco producers in North Carolina have is that roughly 85% of all traditional tobacco soils in North Carolina have a high to very high phosphorus index (Smith, 2010) (Fig. 2). Soils with a high phosphorus index do not need additional applications of phosphorus fertilizer, thus providing producers with the option of not applying the amendment. The decrease in need for phosphorus has promoted the idea of not applying blended fertilizers, which allows producers to apply N and K independently of each other. By decoupling traditional, complete fertilizers producers now have the option of exploring alternative sources of K as well as alternative application methods.

Overall, with rising input costs, growing environmental concerns, and new higher yielding cultivars, potassium fertilizer recommendations must be accurate.

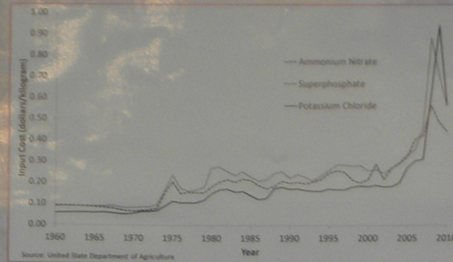

Fig. 1-Trend of macro nutrient input costs over the last half century. Input costs of macro nutrients were fairly stable until the late 2000's when the price for all three increased, with potassium becoming the most expensive.

Fig. 3-Potassium deficiency across plots on a Norfolk Loamy Sand soil series.

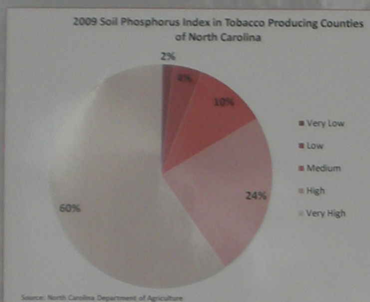

Fig. 2-Soil phosphorus index in traditional tobacco producing counties of North Carolina. Phosphorus is not easily leached from a system and years of over application have resulted in high indices.

Fig. 4-Common K deficiency symptoms on an individual plant.

Location	Soil Series	Transplanting Date	Soil pH	Soil P and Corresponding Nutrient Status	Soil K and Corresponding Nutrient Status	Total Rainfall
				-----mg P/dm³-----	-----meq K/100cc-----	-----cm-----
UCPRS-09	Goldsboro Loamy Sand	April 29, 2009	6.2	45.6 (Medium)	0.25 (Medium)	69.8
OTRS-09	Helena Sandy Loam	May 21, 2009	5.8	49.2 (Medium)	0.19 (Medium)	62.8
UCPRS1-10	Norfolk Loamy Sand	April 27, 2010	5.8	162 (Very High)	0.30 (High)	86.0
UCPRS2-10	Goldsboro Loamy Sand	April 27, 2010	6.0	112.8 (High)	0.45 (High)	86.0

Fig. 5-Field conditions for both studies at all four locations.

Objectives

- Determine optimum potassium rate for yield and quality using newer, higher yielding cultivars
- Determine if alternative potassium application methods affect application rate
- Determine feasibility of alternative fertilizer plans

Methods and Materials

- Randomized Complete Block Design
- Potassium applied, by hand, according to protocol
- Tissue samples collected from each plot at layby, at topping, and after curing
- Tissue samples were dried and ground at NCSU
- Lab analysis was conducted for N,P,K, & Mg in the leaf tissue and soil
- Soil samples were collected prior to transplant and when K fertilizer was applied in both studies

Statistical Analysis

Experiments were repeated in time and data were subjected to an analysis of variance (ANOVA) and means were separated using Fisher's protected LSD at P=0.05.

Results and Discussion

In 2009 tobacco was grown on soils with medium K-indices and growing conditions at both locations were nearly ideal. As a result, a response to supplemental K was not observed and both yield and quality were unaffected. In 2010 tobacco was grown on soils with high K-indices, but under poor growing conditions (Fig. 5). Potassium deficiencies were observed on the Norfolk soil series (Fig. 3, 4), but disappeared around 134 kg K_2O ha^{-1}. Yield and quality were unaffected on deficient plants. A response to potassium application was not observed on the Goldsboro soil series. In both years application timing and method had no effect on rate response.

Conclusion

Increasing rates of K_2O above 84 kg/ha did not significantly improve yield, quality, crop value, or any chemical constituents (Fig. 6, 7, 8). Research indicates that current K recommendations are accurate and may even be higher than necessary on finer-textured soils with medium to high K indices. Alternatively, recommendations appear to be correct for coarse soils with lower K levels.

Application rate and timing had no effect on cultivars, under conditions of adequate soil moisture and moderate depth to clay. Under the environmental conditions of these experiments, 84 kg K_2O ha^{-1} applied broadcast one month before planting, broadcast at planting, banded at planting, or applied in split applications, provided adequate amounts of potassium to ensure sufficient yield and quality. It is likely that early broadcast applications of K_2O with current rate recommendations would only be of concern with combinations of conditions that included coarse soil textures, low potassium indices, and/or excessive leaching rainfall.

Acknowledgements

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Sources

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Potassium Application Rate Study

Overview

Two Locations: Oxford Tobacco Research Station in Oxford, NC (2009)
Upper Coastal Plain Research Station near Rocky Mount, NC (2009 & 2010)
Variety: NC 71 (UCPRS) & NC 297 (OTRS)
Potassium Source: 0-0-22 (Sulfate of Potash Magnesia/K-Mag)
Rates: 0, 84, 112, 140, 168, 196, 224, & 252 kg K_2O ha^{-1} Banded at Transplant
Nitrogen Source: Liquid Nitrogen (30% UAN) or Calcium Nitrate (15.5-0-0)
Control: 747 kg K_2O ha^{-1} 6-6-18 (134 kg K_2O ha^{-1}) at UCPRS
560 kg K_2O ha^{-1} 8-8-24 (134 kg K_2O ha^{-1}) at OTRS

Variable	P>F Env*K_2O Rate	P>F K_2O Rate
Yield	0.4033	0.0923
Grade Index	0.3581	0.3391
Crop Value	0.0159	0.0257
Crop Value-UCPRS-2009	----	0.0679
Crop Value-OTS-2009	----	0.3589
Crop Value-UCPRS1-2010	----	0.0393
Crop Value-UCPRS2-2010	----	0.0224
Total Alkaloids	0.5316	0.1639
Reducing Sugars	0.6457	0.3941
Nitrogen-Layby	0.8998	0.0004
Nitrogen-Topping	0.6391	0.3827
Nitrogen-After Curing	0.4171	0.0054
Phosphorus-Layby	0.8510	0.0119
Phosphorus-Topping	0.3925	0.1402
Phosphorus-After Curing	0.3353	0.9368
Phosphorus-No P-Layby	0.7564	0.1176
Phosphorus-No P-Topping	0.5944	0.1148
Phosphorus-No P-After Curing	0.2076	0.8992
Potassium-Layby	0.6610	0.0356
Potassium-Topping	0.3208	0.0033
Potassium-After Curing	0.8228	<.0001
Magnesium-Layby	0.2778	0.0024
Magnesium-Topping	0.0860	0.2939
Magnesium-After Curing	0.8735	0.4169

Fig. 6-P values for yield, quality, value, total alkaloids, reducing sugars, and elemental leaf content in potassium application rate study.

K_2O Rate	Yield	Grade Index	Total Alkaloids	Reducing Sugars
-------------kg/ha-------------			------------%------------	
0	3077	81	4.20	11.89
84	3449	83	4.25	12.37
112	3408	82	4.20	11.60
134	3403	80	4.40	10.70
140	3335	81	4.28	11.89
168	3407	81	4.17	12.27
196	3353	81	4.14	12.26
224	3400	81	4.00	12.38
252	3466	79	4.18	11.75
LSD	NS	NS	NS	NS

Fig. 7-Yield, quality, alkaloid content, and sugar content response to increasing rates of K_2O.

K_2O Rate	Layby	Topping	Cured Leaf
----kg/ha----		----------%----------	
0	3.76	2.47	1.85
84	4.14	2.93	2.18
112	3.99	2.75	2.41
134	4.13	3.31	2.55
140	4.13	2.96	2.28
168	4.07	2.90	2.24
196	4.15	2.93	2.26
224	4.04	2.94	2.50
252	3.87	3.01	2.58
LSD	0.25	0.34	0.22

Fig. 8-Potassium content at layby, topping, and after curing in potassium application rate study.

Potassium Application Rate and Method Study

Overview

Two Locations: Oxford Tobacco Research Station (2009)
Upper Coastal Plain Research Station near Rocky Mount, NC (2009 &2010)
Variety: NC 71 (UCPRS) & NC 297 (OTRS)
Potassium Source: 0-0-22 (Sulfate of Potash Magnesia/K-Mag)
Rates: 84, 140, 196, 252 kg K_2O ha^{-1}
Method: Broadcast One Month before Planting, Broadcast One Week before Planting, Banded At Transplant, and Banded Split Application (One-Half Rate at Transplant and One-Half Rate at Layby)
Nitrogen Source: Liquid Nitrogen (30% UAN) or Calcium Nitrate (15.5-0-0)
Control: 102 L ha^{-1} 30% Liquid Nitrogen at Rocky Mount
217 kg ha^{-1} 15.5-0-0 at Oxford
0 kg ha^{-1} supplemental K_2O

Variable	Env*Rate*Application	Rate*Application	Env*Rate	Env*Application	Rate	Application
Yield	0.8211	0.8304	0.0226	0.9799	0.0385	0.9902
Grade Index	0.5767	0.5937	0.7826	0.6930	0.5629	0.5972
Crop Value	0.9437	0.8980	0.2387	0.9075	0.4595	0.6347
Total Alkaloids	0.5567	0.4561	0.0669	0.1223	0.9226	0.6890
Reducing Sugars	0.3668	0.8070	0.2756	0.0905	0.0216	0.4227
Nitrogen-Layby	0.8917	0.1248	0.4251	0.4899	0.1499	0.5744
Nitrogen-Topping	0.9739	0.9819	0.4025	0.3904	0.9583	0.0678
Nitrogen-After Curing	0.7716	0.5382	0.3177	0.5562	0.0961	0.9101
Phosphorus-Layby	0.5516	0.6587	0.2092	0.9233	0.1369	0.1111
Phosphorus-Topping	0.3678	0.2215	0.7722	0.0270	0.5213	0.1405
Phosphorus-After Curing	0.9525	0.5640	0.5456	0.6059	0.3254	0.0361
Potassium-Layby	0.7551	0.1071	0.5835	0.0011	0.0518	0.2884
Potassium-Topping	0.4633	0.5977	0.6622	0.0439	0.4991	0.2013
Potassium-After Curing	0.4649	0.7530	0.0334	0.3953	<.0001	0.1873
Magnesium-Layby	0.3119	0.3707	0.1869	0.1567	0.0038	0.0073
Magnesium-Topping	0.4212	0.4885	0.6442	0.1367	0.6237	0.2331
Magnesium-After Curing	0.2080	0.5925	0.5374	0.2086	0.0114	0.1437

Fig. 9- P values for yield, quality, value, total alkaloids, reducing sugars, and elemental leaf content in potassium rate and application method study.