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Growth, Yield, and Efficiency of Potassium Fertilizer Use in Burley Tobacco Production

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For many crops, band placement of fertilizer offers agronomic, economic, and environmental advantages over commonly used preplant broadcast applications. Drill banding most of the nitrogen (N) fertilizer 12 inches to both sides of the row for tobacco shortly after transplanting greatly alleviates manganese toxicity and other nutrient imbalances, improves early growth and yield, and offers increased efficiency of N use. Nitrogen fertilizers applied after transplanting are less likely to be leached during excess rainfall events that commonly occur in April and early May in Kentucky.

Another advantage of banding over broadcasting is that banded fertilizer reacts less with soil and remains in plant available forms for longer periods of time. This is particularly true for phosphorus (P) and potassium (K), nutrients which are relatively immobile in soil. These nutrients offer maximum plant benefits when placed in or near the root zone. Research has shown that the volume of soil fertilized (or width of band) affects the numbers of roots in contact with fertilizer. Although drill banding works well for N fertilizers, P and K fertilizer in drill bands may not be contacted by a sufficient number of roots for maximum nutrient uptake and yield. The current investigation was conducted to determine the effect of placement of P and K fertilizer in or near the row on growth, yield, and efficiency of K fertilizer use by burley tobacco.

Methods

A field experiment was conducted during 1986 and 1987 at Lexington, KY, on Maury silt loam soil. The plow layer soil had a pH of 6.2 and P and K tested very high and low to medium, respectively. The experimental area had been in alfalfa the two years prior to plowing. Treatments consisted of four rates of complete fertilizer (grade 6-24-32) totaling 0, 200, 400, and 800 lbs/acre and four placements: (a) broadcast, (b) 16 inch wide bands applied directly under and parallel to the row, (c) 4 inch wide bands placed 32 inches apart and perpendicular to the row, and (c) drill bands 4 inches to each side of the row. The fertilizer was formulated from ammonium nitrate, triple super phosphate, and potassium sulfate to produce a 1-1.8-4.5 ratio of N-P-K (1-4-5.4 N-P_2O_5-K_2O) at each rate. The fertilizer was applied on plowed and disced soil and incorporated before transplanting. Seven days after transplanting cultivar KY 14, additional ammonium nitrate was drilled in two bands each 12 inches from the row for uniform rate of 235 lbs. N/acre for all plots. Plant samples were taken forty days after transplanting for growth and concentration of P and K and after curing for yield, price, and acre value. Grades assigned by an official government inspector were used to calculate price and acre value of cured leaf.

Results

Average concentration of K and plant dry weight at forty days increased with rate of fertilizer application (Tables 1a & 1b). Compared to the control, K concentration and dry weight were increased, respectively, 48 and 27% by the highest rate of fertilizer. With exception of plant dry weight for the drill band treatment, average dry weight and K concentration were 5 to 15% higher in band than broadcast treatments. This suggested greater efficiency of fertilizer use in band than broadcast treatments. Since neither method nor rate of fertilization affected plant P concentration (data not shown, soil at the study site is inherently high in available P), the response to fertilizer application is primarily a response to applied K.

Average leaf yield, price, and value were higher for the 16" band than broadcast treatment, while values for the other band treatments were intermediate to those of broadcast and the 16" band treatment (Tables 2a, b, and c). Since treatments affected leaf price only in one year, differences in value/acre primarily reflect treatment effects on cured leaf weight. As was the case with data of Table 1, the response to band applications, as compared to broadcast, resulted from differences at the two lowest rates of added fertilizer. The increased price during 1986 for band treatments resulted from greater length of leaves grown in upper stalk positions (data not shown). Average cured leaf yield, price (one yr.), and value increased with increasing rate of fertilizer. Cured leaf price was increased slightly by the first increment of fertilizer. No further increase in price was obtained with further additions of fertilizer.

To quantify the greater efficiency of band over broadcast methods, the rate of banded K required to give the same leaf yield as a given yield when the K was broadcast (Table 3), was calculated from regression equations. These regression equations were developed from the quadratic relationships of cured leaf yield data vs. rate of K application for each method. Rate of K added was used as the independent variable rather than rate of 6-24-32 since plant P concentration was unaffected by fertilizer rate or application method. In contrast, relative cured leaf yield was closely related to K concentration in cured leaf regardless of application method (Figure 1). The calculated amounts for banded K were divided by the broadcast K amounts required to produce the equal yield. This ratio (banded K/broadcast K) represents the relative efficiency of broadcast K in terms of banded K for each method of banding.

Broadcast K was less efficient than banded K regardless of method of band application or rate of K added (Table 3). Comparing broadcast K to the 16" band K using cured leaf data, broadcast K was only 50 to 55% as efficient as for 16" band K.

The ratios of banded K/broadcast K for the 4" band and drill band treatments were larger than for the 16" band treatment. This indicated that greatest efficiency was obtained when the K was placed in 16" wide bands beneath the row. Reasons for the greater relative efficiency of fertilizer use for the 16" band treatment are not known with certainty. It may be that too few plant roots intercepted the fertilizer in the more narrow bands. In similar studies with corn, researchers at Purdue University have suggested that at least 10 to 20% of the plant's roots should be in soil fertilized with K in order to maximize K uptake and yield. It is estimated that approximately 40%, 10%, and 5% of the surface soil volume was fertilized, respectively, by the 16 inch, 4 inch, and the drill band treatments in our study.

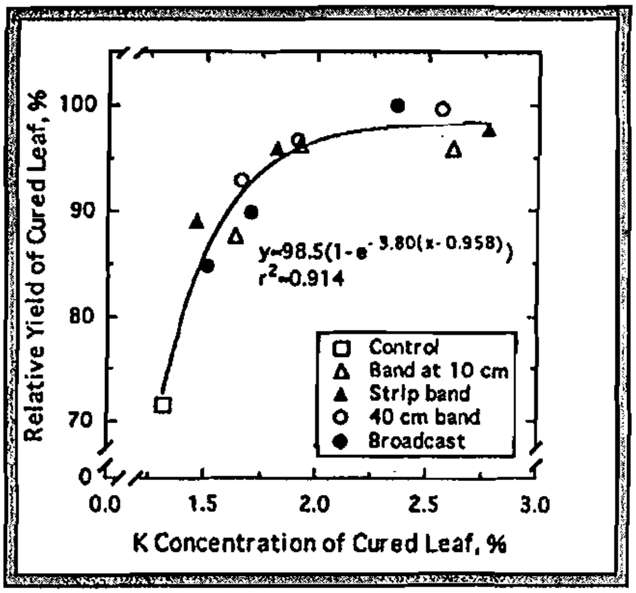

Figure 1. Relative cured leaf yield as a function of K concentration of cured leaf.

Summary

The current investigations were conducted to determine the effect of placement of P and K fertilizer in or near the row on growth, yield, and efficiency of K fertilizer use by burley tobacco. The study was conducted on a soil testing very high in P but low to medium in K. As contrasted to broadcast applications (control), placement of grade 6-24-32 fertilizer in 16 inch wide bands directly under and parallel to the row resulted in greatest increases in plant K, plant dry weight, and cured leaf yield and value. Using cured leaf data, broadcast placements of K were only 50 to 55% as efficient as placement of K in 16 inch wide bands under the row. Efficiencies for placements in 4 inch bands (applied 32 inches apart and perpendicular to the row) or in two drill bands each 4 inches to the side of the row were intermediate to those of broadcast and the 16 inch band treatment.

Generally, the cured leaf yield and value efficiencies gained by banding over broadcast applications decreased at the highest rate of fertilizer application. Additionally, it is known that applying high rates of N or K fertilizers in bands increases the salt concentration in the soil solution, as compared to broadcasting. This suggests that increased production efficiencies are likely to be realized only in conjunction with careful attention to the rates and kinds of fertilizer applied.

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Table 1. Effect of rate and method of fertilizer application on K concentration and dry weight of Burley Tobacco at 40 days post-transplant.

Rate of grade 6-24-32 fertilizer	Application Method: Broadcast	16" Band	4" Band	Drill Band	Mean
Lbs/acre	a. Concentration of K, %				
0	1.80	1.80	1.80	1.80	1.80d*
200	2.14	2.33	2.21	2.51	2.30c
400	2.51	3.02	2.68	3.08	2.82b
800	3.31	3.38	3.51	3.72	3.48a
Mean***	2.63c*	2.91ab	2.80b	3.11a	
	b. Plant dry weight, g/plant				
0	51	51	51	51	51c**
200	62	62	60	59	61b
400	64	70	70	61	66ab
800	63	75	71	70	70a
Mean***	63b**	69a	67ab	63b	

* and ** Means not followed by the same letter or letters are significantly different, respecively, at the 0.05 and 0.10 probability levels.Mean of fertilized plots only.

*** Mean of fertilized plots only.

Table 2. Effect of rate and method of fe.tilizer application on cured leaf yield, price and value.

Rate of grade 6-24-32 fertilizer	Application Method: Broadcast	16" Band	4" Band	Drill Band	Mean
Lbs/acre	a. Cured leaf yield, lbs/acre				
0	1950	1950	1950	1950	1950d*
200	2309	2525	2422	2388	2411c
400	2444	2631	2610	2622	2577b
800	2722	2713	2663	2613	2678a
Mean***	2492b*	2623a	2565ab	2541ab	
	b.** Cured leaf price, $/cwt				
0	138	138	138	138	138b*
200	139	139	140	143	140a
400	139	142	140	139	140a
800	138	143	140	141	141a
Mean***	139b*	141a	140ab	141a	
	c. Cured leaf value, $/acre				
0	2691	2691	2691	2691	2691d*
200	3210	3510	3391	3415	3382c
400	3397	3736	3654	3645	3608b
800	3756	3880	3728	3684	3762a
Mean***	3464b*	3709a	3591ab	3581ab	

* Means not followed by the same letter or letters are significantly different at the 0.05 probability level.

** Cured leaf price for 1986 only.

*** Mean of fertilized plots only.

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Table 3. Rate of banded K (Kb) required to produce the same leaf yield as a given rate of broadcast K (KB), and the efficiency of broadcast K in terms of banded K (Kb/KB).

Broadcast K	16" Banded K		4" Banded K		Drill Banded K	
Lbs/A	Lbs/A	Kb/KB	Lbs/A	Kb/KB	Lbs/A	Kb/KB
55	30	0.55	33	0.60	35	0.64
110	60	0.55	65	0.59	70	0.64
165	87	0.53	95	0.58	110	0.67
220 (200)*	110	0.50	125	0.57	(155)*	(0.78)*

* The ratio of Kb/KB was determined at the broadcast rate of 200 since this rate produced maximum calculated yields for the regression equation of the drill-band treatment.