METERED APPLICATIONS OF CALCIUM NITRATE IN OVERHEAD IRRIGATION: EFFECTS ON YIELD AND QUALITY OF SHADE-GROWN CIGAR WRAPPER TOBACCO[1]

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The effects of metering $Ca(NO_3)_2$ as the sole source of N on shade-grown cigar wrapper tobacco by means of overhead irrigation were investigated. In 1980, N metered on at total rates of 134 and 202 kg/ha in eight equal installments throughout the growing season produced leaves with quality comparable to that fertilized with 252 kg/ha of N from conventional organic sources. While leaf quality was not affected, yields and crop indices increased linearly with increasing amounts of N applied. In 1981, metered and conventional treatments did not differ significantly in leaf quality, yield, or crop index at either 224 or 336 kg/ha of N and there were no significant differences between the two rates of N.

Additional Key Words: Nitrogen fertilization, NO_3 leaching.

INTRODUCTION

Cigar wrapper tobacco has been grown under shade in sandy loam soils of the Connecticut River Valley since the beginning of the century. Because nitrogen is easily leached from these soils, growers have traditionally used natural organic sources of N such as cottonseed or linseed meal and castor pomace as preplant fertilizers and as sidedressings during the first 30 days of growth (1,2,4,5,11). Growers, furthermore, have asserted that these organic meal sources of N improve both yield and leaf quality of tobacco despite evidence to the contrary (2,4,7,8,9,11).

DeRoo (6) found that nitrate concentrations in ground water beneath a continuously cropped shade tobacco field receiving annual applications of organic fertilizers ($\geq$ 224 kg/ha of N) can exceed the drinking water standard of 10 ppm. Barker (3) suggests that split applications of soluble inorganic N sources can duplicate leaf yields while contributing less nitrate to ground water. No previous work has been done on the effects of such a fertilization system on leaf quality and crop index of shade grown cigar wrapper tobacco. Recent advances in irrigation technology have provided semi-permanent overhead systems in nearly every shade field in the Connecticut Valley, but no grower presently depends on irrigation with soluble N as the major source of N.

The purpose of these studies was to grow shade tobacco on a sandy loam soil relying exclusively on a soluble, inorganic N source and to observe the effects on leaf quality, yield, and crop index compared with the same characteristics of a conventional, organically-fertilized crop.

MATERIALS AND METHODS

Cultural and evaluation techniques: Experiments were performed in 1980 and 1981 at the Valley Laboratory of the Connecticut Agricultural Experiment Station at Windsor, CT. The soil type was a Merrimac sandy loam (Entic Haplorthod). The shade area consists of 20 (10 m x 10 m) square blocks (bents) arranged in a 4 x 5 pattern (.2 ha) with 16 (4 x 4) bents used as the experimental area (0.16 ha). Each experiment consisted of four treatments replicated four times in a randomized complete block design. Shade was provided by standard orlon shade cloth, with new cloth on the tops of the shade area and used cloth on the sides.

All areas were treated before planting in 1980 with gypsum (358 kg/ha); and diazinon (DZN 14G, 22.4 kg/ha), oxamyl (Vydate L, 19 L/ha), and metalaxyl (Ridomil 2E, 4.7 L/ha). In 1981, the pretreatments were gypsum (448 kg/ha), diazinon (22.4 kg/ha), oxamyl (28 L/ha), and metalaxyl (4.7 L/ha).

In each experiment, 60-70 day old seedlings of shade tobacco (ACC-75) were planted by machine in nine rows per bent. Each bent row contained approximately 30 plants giving a population of 270 plants per bent. All plants were treated identically with respect to cultivation, suckering, and tying. At appropriate

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intervals (1980: 51, 58, 66, 73, 80, and 87 days; 1981: 49, 56, 63, 71, and 77 days), leaves from the same two rows in each treatment were harvested (3-4 leaves/plant), and placed in individual canvas baskets. Each treatment was assigned a randomly chosen number that also changed from one harvest to the next. Harvested leaves were taken to a commercial grower for post harvest curing and evaluation for quality, yield, and crop index. Evaluators knew only the numbers assigned to each treatment to avoid prejudice.

Irrigation system: The irrigation system utilized one circular pattern impulse sprinkler head (Rainbird 25 FP) positioned in the center of each bent on 2.7-m aluminum risers approximately 0.3 m above the shade cloth. Each sprinkler head was adjusted to deliver water at the rate of 15-19 L/min as far as the sides of each bent, but not to the corners. Each riser was served by a 1.3-cm plastic pipe running from a 7.5-cm aluminum irrigation pipe with four attachments allowing only four sprinklers (one treatment) to be connected at any one time. A 75 L sprayer was used to introduce 47 L of concentrated solution to the irrigation line in approximately 5-10 minutes, thus keeping injection time to a minimum. Each metering was preceded by a 5-60 minute irrigation depending on plant need and was followed by a 5-10 minute rinse. The conventional plots received plain water whenever metered plots received treatments.

Fertilization: 1980. The conventional (C) organic fertilizer was a cottonseed meal base with 5.9-2.8-6.1 (N-P-K). It was applied at a rate of 224 kg/ha of N preplant incorporated and as a 28 kg/ha of N sidedressing at 30 days for a total of 252 kg/ha of N, 118 kg/ha of P, and 266 kg/ha of K. Equivalent amounts of P and K were applied to each of the other plots in the form of triple superphosphate (0-21.4-0) and potassium sulfate (0-0-41.5). Fertilizer grade calcium nitrate (15.5-0-0) was metered in irrigation water at annual rates of 67.2 (Ml), 134.4 (M2), and 201.6 (M3) kg/ha of N. The total N was applied in eight separate applications of 8.4, 16.8, and 25.2 kg/ha of N, for M1, M2, and M3, respectively. The first application in each case was preplant incorporated. All remaining applications were applied through the irrigation system at 20, 30, 38, 45, 52, 59, and 67 days.

Fertilization: 1981. The conventional organic fertilizer was a cottonseed meal base wth 5.16-3.4-7.4 (N-P-K). It was applied at the rate of 224 kg/ha of N (160.8 preplant, 31.6 sidedressed twice at 18 and 25 days - C1) and 336 kg/ha of N (264.6 preplant, 35.7 sidedressed twice at 18 and 25 days - C2). Metered treatments received corresponding amounts of N as calcium nitrate (M1 = 224 kg/ha of N. M2 = 336 kg/ha of N). Meterings were equally divided into ten applications (M1 = 22.4 kg/ha of N, M2 = 33.6 kg/ha of N). The first preplant application was incorporated into the soil with the remaining nine applied through the irrigation system at 13, 19, 26, 35, 42, 49, 54, 60, and 68 days. Metered plots received P and K as triple superphosphate and potassium sulfate with M1 corresponding to C1 (150 kg/ha of P and 323 kg/ha of K) and M2 corresponding to C2 (225 kg/ha of P and 485 kg/ha of K).

RESULTS

1980: Leaf quality averaged over primings did not vary significantly among M2, M3 and C, but the quality of C was significantly higher than that of M1 (**Table 1**). Except for priming I, there was no significant differences in leaf quality among metered treatments either in individual primings or the overall mean. In all but priming III, the leaf quality of all metered plots, except M1, did not differ significantly from the quality of C.

Table 1. 1980. Leaf quality ($/Kg), yield (Kg/ha), and crop index ($/ha) of shade-grown cigar wrapper tobacco, by primings and totals.

Treatment	N applied (Kg/ha)	Method of application	I (51)	II (58)	III (66)	IV (73)	V (80)	VI (87)	Average
					Quality ($/Kg)				
M1	67.2	metered	10.34b[z]	11.58a	11.71b	15.99a	15.44a	11.58a	12.77b
M2	134.4	metered	11.71ab	12.81a	12.68b	15.30a	14.62ab	13.91a	13.52ab
M3	201.6	metered	13.10a	13.10a	13.23b	15.17a	15.30ab	12.81a	13.78ab
C	252	conventional	12.55a	14.07a	15.57a	16.27a	13.65b	13.10a	14.20a
					Yield (Kg/ha)				Total
M1	67.2	metered	221b	256c	252c	281c	271b	269a	1549d
M2	134.4	metered	225b	276c	282b	291b	297a	273a	1643c
M3	201.6	metered	244ab	305b	297b	310a	301a	277a	1733b
C	252	conventional	264a	329a	316a	330a	297a	272a	1809a
					Crop Index ($/ha)				Total
M1	67.2	metered	2288b	2985b	2958c	4487b	4183a	3116a	20015c
M2	134.4	metered	2637b	3526ab	3568b	4450b	4339a	3800a	22321b
M3	201.6	metered	3190ab	4001ab	3931b	4715b	4618a	3534a	24008b
C	252	conventional	3323a	4645a	4917a	5379a	4067a	3546a	25881a

z Mean separation within co umns by Duncan's Multiple Range Test - 5% level.

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Table 2. 1981. Leaf quality ($/Kg), yield (Kg/ha), and crop index ($/ha) of shade-grown cigar wrapper tobacco, by primings and totals.

Treatment	N applied (Kg/ha)	Method of application	Primings (days after planting) I (49)	II (56)	III (63)	IV (71)	Average
					Quality ($/Kg)		
M1	224	metered	13.52	16.82	17.64	16.96	16.52
C1	224	conventional	13.52	17.09	15.72	18.61	16.38
M2	336	metered	11.33	17.77	17.99	16.27	16.34
C2	336	conventional	12.62	17.93	16.82	17.64	16.60
					Yield (Kg/ha)		Total
M1	224	metered	198	278	343	340a[z]	1159
C1	224	conventional	196	290	334	315b	1155
M2	336	metered	198	302	330	326ab	1158
C2	336	conventional	207	298	330	335ab	1169
					Crop Index ($/ha)		Total
M1	224	metered	2686	4650	6029	5767	19130
C1	224	conventional	2651	4996	5221	5896	18765
M2	336	metered	2341	5382	5874	5310	18913
C2	336	conventional	2572	5305	5570	5930	19412

The yearly total yields of all treatments were significantly different from each other in the following decreasing order: C > M3 > M2 > M1. In the first five individual primings, C showed superior yields over all other treatments except M3 (primings I, IV, and V) and M2 (priming V). The crop index results resembled those of the yields with yearly totals differing significantly among treatments.

1981: Leaves from the fifth priming were misplaced in the evaluation process, thus totals shown in **Table 2** are from four primings only. In all treatments, neither leaf quality nor the crop index were significantly different, and yield differed only once (priming IV).

DISCUSSION

Results in 1980 indicate that calcium nitrate metered on throughout the growing season as the sole source of nitrogen at either 134.4 or 201.6 kg/ha of N can duplicate the leaf quality of shade-grown cigar wrapper tobacco receiving 252 kg/ha of N in conventional organic nitrogen forms. While leaf quality was unaffected, yield was directly proportional to the total amount of nitrogen applied (**Figure 1**). Consequently, the crop index was also proportional to the amount of nitrogen applied. The crop indices of M3 and C were significantly different by a margin of less than $0.25/ha. This narrow margin of difference suggests that slightly more than 201.6 kg/ha of N applied as $Ca(NO_3)_2$ metered on throughout the growing season, could produce a leaf quality, yield, and crop index comparable to conventional practice. This was the basis for choosing the rates used in 1981.

The lack of differences between metered and conventional treatments at 224 or 336 kg/ha of N in 1981 indicate that leaves with comparable quality and total yield may be grown with metered $Ca(NO_3)_2$ as the sole source of N. The lack of difference between the 224 kg/ha and the 336 kg/ha of N treatments suggests that 224 kg/ha is an approximate maximum level of N needed for shade-grown cigar wrapper tobacco as suggested by Anderson (2) and that the extra 112 kg/ha of N applied was not efficiently utilized by the crop.

Metering nitrogen is easily adaptable to the shade fields of the Connecticut Valley. Many growers presently supplement organic fertilizations with small amounts of $Ca(NO_3)_2$ (22.4-33.6 kg/ha of N). The rapid injection system used in these experiments can apply N in a short time during rainy periods or can apply N at the end of lengthy irrigations during droughty periods. Furthermore, the likelihood of leaching of nitrate by heavy rains in the early part of the growing season can be reduced by a metered N program. An additional benefit may be realized because $Ca(NO_3)_2$ needed to supply N levels comparable to those from organic sources is less expensive.

In 1935, Morgan and Street (10) suggested an ideal fertilization scheme for Havana seed tobacco, a crop with similar agronomic characteristics to shade-grown varieties. Their plan was to provide N to the plants in nitrate form only as it was needed, which meant a very small amount (22.4 kg/ha of N) during the first 30 days of growth followed by succeeding applications of larger amounts during the period of exponential growth. They postulated that a crop could then be grown using 179 kg/ha or 20% less N than the normal 224 kg/ha. The difficulty was that tobacco fields then lacked the irrigation capabilities that exist now. A technique such as that used in these experiments may be a means of actually reducing the amounts of N applied to shade-grown tobacco fields while maintaining comparable leaf quality and yield.

Tobacco Science, 1984, 28-2, p. 3-6, ISSN. 0082-4523.pdf

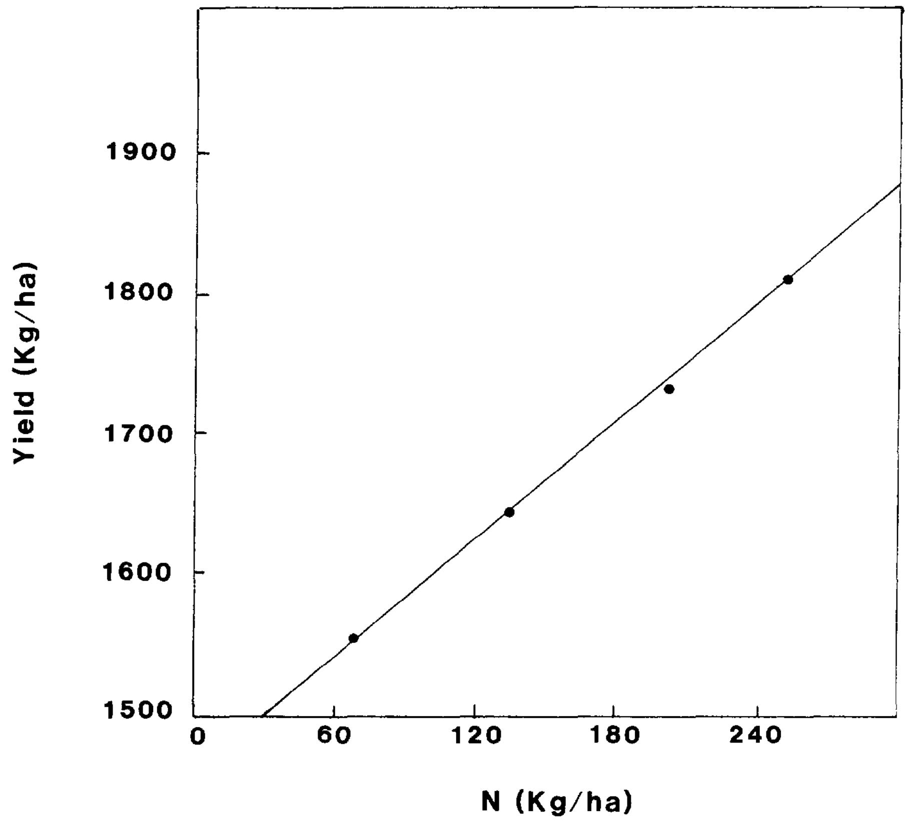

Figure 1. 1980. Yield in kg per ha of shade-grown wrapper tobacco versus nitrogen applied.

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