

## Tobacco Stunt, a Disease of Burley Tobacco Controlled by Soil Fumigants

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### ABSTRACT

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Burley tobacco in Kentucky is affected by a stunt disease caused by a soilborne pathogen. Characteristic symptoms include stunting, delay in flowering, and reduced yield and quality. Plants are seldom killed, and transplant survival is little affected. The disease is usually more severe in some portions of fields than in others, and the result is uneven growth and maturity. Severely stunted plants frequently appear beside vigorous ones. Snap bean, lima bean, and corn were not affected by the pathogen, and tomato was less affected than tobacco. The pathogen was controlled by fumigation with methyl bromide-chloropicrin or ethylene dibromide-chloropicrin.

Burley tobacco in Kentucky is affected by a disease that inhibits growth and often reduces yields. The disease has been particularly noticeable in recent years, when cultivars highly resistant to the black root rot pathogen, *Thielaviopsis basicola* (Berk. & Br.) Ferraris (= *Chalara elegans* Nag Raj & Kendrick), have been widely planted. The disease came to the attention of extension tobacco specialists when poor crops were produced in situations that should have been productive: soils usually well suited for tobacco, proper crop rotation, optimum pH, absence of the black root rot pathogen, and adherence to other recommended cultural practices.

In etiological studies to be reported elsewhere, the endogonaceous mycorrhizal fungus *Glomus macrocarpum* (Tul. & Tul.) Gerd. & Trappe was implicated as the primary pathogen (1,6). In the experiments described in this paper, we investigated control of the disease by soil fumigants. Our purpose was to characterize the disease and to distinguish it from other diseases that result in stunting of tobacco.

### MATERIALS AND METHODS

A field experiment was conducted on the University of Kentucky South Farm. The soil type was Maury silt loam, normally highly productive for tobacco. The land had been in tobacco a number of

years, with yields progressively decreasing.

The land was fertilized with 2,240 kg of 5-10-15 fertilizer per hectare and 336 kg of  $\text{NH}_4\text{NO}_3$  per hectare. The fertilizer was broadcast and incorporated with a disc harrow immediately before fumigation. Two soil treatments and the untreated control were arranged in a randomized complete block design with four replicates. Each treatment was applied to plots 4.27 m wide and about 53 m long. Methyl bromide-chloropicrin (2:1, w/w) (MB-C) was injected at a rate of 300 kg/ha with a plastic-laying fumigation apparatus. The 36% ethylene dibromide-30% chloropicrin (EDB-C) was injected at 187 L/ha with the same apparatus, but plastic was not laid on these or the nonfumigated plots. The plastic was removed from the methyl bromide-chloropicrin plots 3 days after fumigation.

Tobacco was planted in four rows spaced 1.07 m apart in the middle 37 m of each soil treatment. Two rows were transplanted to cultivar KY 10, and the other two, to cultivar KY 14. Data were taken from 30.5 m of the two middle rows; the two outer rows served as guard rows. On the west end of each soil treatment, tomato (cultivar Jet Star) was transplanted on 7.7 m of one of the two central rows; and bush lima bean (cultivar Henderson Bush) and bush snap bean (cultivar Top Crop) were each planted on 3.8 m of the other central row. Data were taken on the middle 3.05 m for the beans and 6.10 m for the tomatoes. On the east end of each soil treatment, sweet corn (cultivar Illini Xtra Sweet) was planted on 7.7 m of all four rows, and data were taken from 6.10 m of the two central rows. All crops were seeded or transplanted 3 wk after fumigants were applied. Tomato plants were staked. Each bean crop was harvested twice, the corn once, and the tomatoes weekly.

Heights of the tobacco and tomato plants were measured 44 days after transplanting. Elongation of stems of tobacco caused by initiation of inflorescences had not begun at this time. Tobacco was considered mature when 50% of the plants in a plot had at least one floret open. When tobacco in all plots for a treatment was mature, inflorescences were broken off and the plots sprayed with maleic hydrazide to inhibit secondary bud development. Treatments were harvested 3 wk later and air-cured in a barn by the usual commercial procedure. When cured, the leaves were removed from the stalks and divided into three grades, and U.S. official grades in effect in 1976 were assigned. A quality evaluation was computed by multiplying the weight of leaves for each grade by the official support price for 1976 and dividing the total for the three grades per plot by the total weight per plot. The relative quality index was obtained by expressing each treatment quality value as a decimal fraction of the highest treatment quality value.

The persistence of the effect of fumigation with MB-C in the spring was evaluated. In October, a composite sample of soil was collected randomly with a shovel from the root zones of tobacco plants grown on the four plots fumigated in the spring with MB-C. A similar sample was collected from the control plots. Portions of the two soil samples were either not treated further, steam-pasteurized, or fumigated with methyl bromide. Soil to be steamed was potted (400 g wet wt/10-cm-diam. clay pot), and the pots were stacked in a 75-L metal can, covered with a piece of canvas, and steamed for 30 min by introducing steam into the bottom of the can. Soil to be fumigated was spread in shallow pans, and 90-mm petri dish bottoms were placed on the surfaces. Pans were sealed in polyethylene bags with tape. Cans of MB-C (98:2, w/w) were placed in a freezer overnight, then packed in ice before puncturing. Methyl bromide was pipetted into the petri dish bottoms through slits in the plastic bags at the rate of 30 ml/4 kg of soil, and the slits were sealed with tape. After 24 hr at room temperature, the bags were removed and the pans of soil aerated for 24 hr before potting. One tobacco seedling (KY 14) was transplanted to each pot, with five

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**Table 1.** Effects of soil fumigants on survival, growth, maturity, yield, and quality of tobacco cultivars KY 10 and KY 14 grown on land with a history of tobacco stunt disease

Fumigant <sup>a</sup>	Transplant survival (%)		Height (cm) at 44 days		Days to maturity		Days first flower to maturity		Quality index <sup>b</sup>		Yield (kg/ha)	
	KY 10	KY 14	KY 10	KY 14	KY 10	KY 14	KY 10	KY 14	KY 10	KY 14	KY 10	KY 14
MB-C	95.7	94.5	40	45	66	64	11	9	1.00	0.99	2,449	2,466
EDB-C	92.0	94.5	32	34	80	76	22	19	0.93	0.95	2,140	1,998
None	92.0	93.5	26	14	86	89	20	20	0.90	0.91	1,471	1,176
LSD ( $P = 0.05$ )	2.60		5.1		3.4		4.5		0.027		236	
( $P = 0.01$ )	3.51		6.9		4.6		6.2		0.038		320	

<sup>a</sup> MB-C = methyl bromide-chloropicrin injected at 300 kg/ha and covered with plastic. EDB-C = ethylene dibromide-chloropicrin injected at 187 L/ha and not covered with plastic.

<sup>b</sup> Value (U.S. official support price) per unit weight, expressed as a fraction of the treatment with the highest value.

**Table 2.** Effects of soil fumigants on stand, growth, and yield of vegetable crops grown on land with a history of tobacco stunt disease<sup>a</sup>

Fumigant <sup>b</sup>	Snap bean		Lima bean		Corn			Tomato		
	Stand	Yield (kg)	Stand	Yield (kg)	Stand	Height (cm)	Yield (kg)	Stand	Height (cm)	Yield (kg)
MB-C	29.0	2.08	20.3	3.45	72.5	64.6	8.22	18.0	69.3	37.4
EDB-C	28.8	2.40	17.0	2.86	56.3	63.9	8.35	17.0	66.2	27.5
None	28.6	2.34	14.0	2.50	48.4	58.6	7.22	16.8	64.5	30.3
LSD ( $P = 0.05$ )	9.5	1.20	6.5	1.51	26.8	10.2	3.06	1.9	2.5	4.3
( $P = 0.01$ )	...	...	...	...	...	...	...	...	3.6	6.0

<sup>a</sup> Stand (no. plants) and yield data are on a per plot basis. Plot lengths were 3.05 m for snap bean and lima bean and 6.10 m for corn and tomato.

<sup>b</sup> MB-C = methyl bromide-chloropicrin injected at 300 kg/ha and covered with plastic. EDB-C = ethylene dibromide-chloropicrin injected at 187 L/ha and not covered with plastic.

replicates per treatment. Plants were fertilized weekly with 20-20-20 soluble fertilizer.

## RESULTS

Fumigation of soil with MB-C had little effect on survival of tobacco transplants. Survival of one cultivar but not the other was improved by a small but statistically significant amount (Table 1).

A dramatic effect of soil fumigation on plant growth was evident as soon as transplants began growing. By 6 wk after transplanting, plants grown on fumigated soil were 23–221% taller than those grown in nonfumigated soil (Table 1). Plants in fumigated soil were uniform in size, whereas those in nonfumigated soil were extremely variable, with large vigorous plants often occurring beside severely stunted ones. The variability in height of stunt-affected plants was indicated by the magnitude of the standard error of the mean, which expressed as percentage of the mean, averaged 12.2% for the two cultivars growing in nonfumigated soil and 2.6% for plants growing in soil fumigated with MB-C.

Some severely stunted plants developed chlorosis and necrosis of leaf margins similar to symptoms of manganese toxicity or potassium deficiency (7). With time, small areas of laminae became necrotic and eventually fell out. Less affected plants appeared normal except for subnormal size. Roots of stunted plants in the growth stage appeared normal. Nematodes or spores of *T. basicola* were not found on or in roots.

Fumigation with MB-C dramatically reduced the time required for plants to

**Table 3.** Effects of methyl bromide fumigation or steaming of soil collected in October from field plots either not fumigated or fumigated the previous spring with a methyl bromide-chloropicrin mixture (2:1, w/w) on growth of tobacco plants in the greenhouse<sup>a</sup>

Fall soil treatment	Height (cm)		Stem diameter (cm)	
	Not fumigated previous spring	Fumigated previous spring	Not fumigated previous spring	Fumigated previous spring
Fumigated <sup>b</sup>	18.1	14.8	0.87	0.73
Steamed	12.7	12.3	0.81	0.75
None	8.4	13.4	0.65	0.79
LSD ( $P = 0.05$ )	5.5		0.15	
( $P = 0.01$ )	7.5		0.21	

<sup>a</sup> Plants were grown 45 days in 10-cm pots containing 400 g of soil (five replicates per treatment).

<sup>b</sup> Fall fumigation at 30 ml of methyl bromide-chloropicrin (98:2, w/w) per 4 kg of soil, applied for 24 hr.

flower (mature) (Table 1). Once flowering began, the time required to reach maturity was halved by fumigation.

The quality of the cured leaf was reduced about 10% by the disease (Table 1). Reductions in quality were primarily due to a higher proportion of the leaf occurring in the red grades, which are less desirable commercially. Tobacco stunt disease reduced yields of cured leaf to about half (Table 1), even though nonfumigated plots had about 3 wk more growing time because of delayed maturity. Both cultivars were affected by the disease; however, growth and yield were suppressed more in KY 14 than in KY 10.

In nearly all parameters measured, the effect of EDB-C on tobacco was intermediate between the MB-C and control treatments (Table 1). Soil fumigation had no observable effect on snap bean (Table 2). Although not significant at  $P = 0.05$ , fumigation with MB-C tended to improve stands and yields of lima bean and corn. These trends were not present when the data were

computed on the basis of yield per plant. Height and yield of tomato were improved significantly by soil fumigation with MB-C; however, the magnitude of increases was less than that of tobacco.

In late September, roots and soil from tobacco and corn plots were examined for stilet-bearing nematodes. Techniques were employed to induce migratory nematodes, notably *Pratylenchus* spp., to leave roots. Few stilet-bearing nematodes were found in either soil or roots of either crop.

The persistence of the effect of fumigation with MB-C in the spring was evaluated by collecting soil in late autumn and conducting a growth test in the greenhouse. Steaming or fumigation with methyl bromide increased the height and/or stem diameter of plants grown in soil not fumigated in the spring, but similar benefits were not obtained with soil fumigated in the spring (Table 3).

## DISCUSSION

The major difficulty in diagnosing tobacco stunt disease is the lack of

distinguishing symptoms. At present, tobacco stunt is identified by eliminating other diseases characterized by reduced growth. Aboveground symptoms of stunt-affected plants are similar to those of black root rot caused by *T. basicola*, manganese toxicity, brown root rot caused by *Pratylenchus* spp., and stunt caused by tobacco stunt virus.

Tobacco stunt is distinguished from black root rot by the lack of root lesions early in the growing season. In this experiment, KY 14, rated as having higher resistance to black root rot than KY 10, was more severely affected by stunt than KY 10 in most parameters measured (Table 1). Subsequent experiments demonstrated that cultivars such as KY 15 and KY 17 with high resistance to black root rot (7) are susceptible to stunt (J. W. Hendrix and W. C. Nesmith, unpublished).

Stunt differs from brown root rot (5,8,9) in the absence of necrotic roots early in the season. Although brown root rot occurs in Kentucky (10), it is not widespread. *Pratylenchus* spp. were not found in roots or rhizospheres of tobacco or corn in this experiment. Corn was included because it promotes the buildup of high populations of *Pratylenchus* spp. (8).

Stunt differs from manganese toxicity in not being pH-dependent (J. W. Hendrix and W. C. Nesmith, unpublished). Manganese toxicity also does not respond to soil fumigation (J. W. Hendrix and A. C. McGraw, unpublished).

Viruses usually reduce growth of tobacco plants (5). Unlike most virus diseases, that caused by tobacco stunt virus in Japan is controlled by soil fumigants including chloropicrin (2), which control the fungal vector (4). Tobacco stunt virus causes vein-clearing, necrotic spots, and rings; stem necrosis is common (2,5). The Kentucky disease has

none of these symptoms. The virus also causes premature flowering (2,5), whereas the Kentucky pathogen delays flowering (Table 1). Attempts to isolate a virus, using chelators successful with tobacco stunt virus (3), failed (K. J. Jones and J. W. Hendrix, unpublished). Tobacco stunt virus has not been reported in the United States.

Tobacco stunt disease appears to be universal in the central Kentucky region where burley tobacco is produced. Subsequent to this experiment, more than 20 fumigation experiments, some on land thought not to have a production problem, were conducted in six counties. Acceleration of growth and flowering was obtained with soil fumigation at each location, but at some locations, yield increases were not observed. Disease intensity is greater in some locations than in others (J. W. Hendrix and W. C. Nesmith, unpublished).

Invariably, tobacco stunt disease is more severe in some portions of fields than others. Since harvesting procedures must be applied simultaneously to all the tobacco in a field, farmers must decide whether to proceed when the better plants are mature or to wait until stunted plants mature. If the former choice is made, the effect on yield and quality of the stunted plants is more severe than in our experiment, because the less mature stunt-affected plots in this experiment were harvested later. If the decision is made to delay harvest to allow greater maturity of stunt-affected areas, the faster-growing plants become overmature, and weight loss frequently occurs. The disease also increases production costs per unit weight of tobacco, because costs of fertilizer, planting, harvesting, and market preparation per unit of land are similar whether or not stunt occurs. Because burley tobacco production is controlled on a weight basis, losses

resulting from quality reductions cannot be retrieved.

Vegetable crops in this experiment did not respond to soil fumigation to the extent that tobacco did (Table 2). This experiment suggests that the pathogenicity of the tobacco stunt agent is host-specific.

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