Effect of Potato Virus Y on Cultivars and Hybrids of Burley Tobacco

R. C. Sievert

Research Plant Pathologist, Agricultural Research Service, U.S. Department of Agriculture, Tobacco Experiment Station, Greeneville, TN 37743. Present Address: Tobacco Research Laboratory, Route 2, Box 16G, Oxford, NC 27565.

Cooperative investigation of the Agricultural Research Service, U.S. Department of Agriculture and the Tennessee Agricultural Experiment Station.

Accepted for publication 10 February 1978.

ABSTRACT

SIEVERT, R. C. 1978. Effect of potato virus Y on cultivars and hybrids of burley tobacco. Phytopathology 68: 974-978.

Eleven burley tobacco cultivars and hybrids infected with potato virus Y had lower yields, grade and crop indices, and market values. Tolerance to the virus was exhibited by some cultivars because its effect ranged from mild to severe. The value per hectare of tobacco from infected plants was reduced by 11 to 83%. The most tolerant cultivars were Kentucky (Ky) 10, Ky 12, and Ky 14; the least tolerant were hybrids involving L8 parentage. Cured leaf from diseased plants generally had significantly higher levels of total nitrogen, acid-insoluble nitrogen, and nitrate nitrogen, and produced a solution with a higher pH. Soluble nitrogen, total alkaloids, phenols, and water-soluble acids were generally significantly lower in infected material. Infected plants generally were shorter, and had fewer and smaller leaves than healthy plants.

Additional key words: *Nicotiana tabacum*, veinbanding.

The occurrence of potato virus Y (PVY) in tobacco, *Nicotiana tabacum* L., has increased in recent years and in some localities is a major disease. In tobacco, the disease is called veinbanding, with burley tobacco displaying a general yellowing and often premature death of lower leaves. In flue-cured tobacco, the symptoms are similar except that one strain of the virus causes necrosis in cultivars resistant to root knot and another strain causes necrosis on all flue-cured cultivars (3). Potato cultivars vary in susceptibility to PVY (1, 4) but little is known about how tobacco cultivars react other than that they are all susceptible (8).

The objectives of this experiment were to determine: (i) whether any of the currently grown commercial burley tobacco cultivars and hybrids are tolerant to PVY; (ii) the effect of PVY on yield and quality of burley tobacco; and (iii) the effect of PVY on selected chemical constituents of cured burley tobacco.

MATERIALS AND METHODS

Eleven cultivars and hybrids of burley tobacco were used in this study (Table 1). A split-plot design was used with inoculation treatments considered as the whole plots and cultivars as the subplots. Each subplot consisted of 27 plants of one cultivar or hybrid with the end plant not harvested; thus each subplot constituted 0.0010 ha (1/400 of an acre). Within the whole plots, each cultivar or hybrid was randomly replicated three times. The plants in one block were inoculated with PVY on 23 June 1970 and 29 June 1971, 32 and 28 days, respectively, after transplanting, using the method previously described (7). The plants in the other block were not inoculated and served as checks.

The tobacco was grown, harvested, and handled after harvesting in the manner normal for commercially grown burley tobacco. The cured tobacco was weighed and assigned a grade by Federal tobacco inspectors. The grade index, a measure of leaf quality, was calculated from the assigned grades; the crop index was determined by multiplying the yield (in lb/A) by the grade index.

Leaf number, length and width, and plant height for 10 plants in each plot were ascertained on 6 August 1970 and 12 July 1971. The number of plants flowering were counted on 24 and 28 July 1970.

Samples of the cured tobacco were dried, ground, and analyzed for selected chemical constituents. Each sample was a composite sample, that is, the sample for each plot consisted of leaf tissue from each stalk position in the same porportion that the leaf tissue from each stalk position contributed to the total weight for that plot. Chemical analyses were performed at the Tobacco Research Laboratory, Oxford, North Carolina and the Research Laboratory of Liggett and Meyers Tobacco Company using the procedures described previously (9).

The data were statistically analyzed by analysis of variance.

RESULTS

All inoculated plants developed PVY symptoms and the checks remained free of PVY symptoms. Table 1 gives the yield, quality, and values of the crop; Table 2 presents the results of the chemical analyses;and Table 3 indicates how the virus affected several physical characteristics of the plant.

Yield, quality, and value.—The yield of all cultivars and hybrids was reduced by PVY but the reductions were significant only for Burley 37 (Bu 37), Bu 49, Bu 21 × L8, and Bu 37 × L8. Yields of PVY-infected entries ranged

00032-949X/78/000 170$03.00/0

from 555 to 2,730 kg/ha (average 2,007 kg/ha). Healthy plants produced 2,705 to 3,339 kg/ha (average 2,932 kg/ha).

The disease significantly reduced the grade index of all cultivars and hybrids. Nondiseased plants produced cured leaf tobacco with grade indices from 0.491 to 0.617, averaging 0.552; cured leaf produced by tobacco plants infected with PVY had indices from 0.201 to 0.367 (average 0.309).

The crop index, a measure of both yield and quality, was lowered significantly by PVY. It varied from 1,192 to 1,780 for healthy tobacco and from 99 to 904 for diseased tobacco. The average for the tobacco from all healthy cultivars and hybrids was 1,451, whereas the average for all diseased cultivars and hybrids was 602.

The value/kg for inoculated tobacco also was reduced significantly by the virus. In noninoculated tobacco, the values ranged from 1.689 to 1.748 (mean 1.710). The mean for tobacco infected with PVY was 1.571 and ranged from 1.470 to 1.624.

The value per hectare of noninoculated cultivars and hybrids was significantly higher than for PVY-infected material for all entries. Values for healthy tobacco ranged from $4,593 to $5,837 (mean $5,015). Plants infected with PVY produced cured tobacco with a value that ranged from $816 to $4,421 (mean $3,183).

Chemical constituents.—The amount of nitrogen in tobacco from plants infected with PVY was significantly greater than that in tobacco from healthy plants. Total nitrogen in cured tobacco from diseased plants ranged from 4.50 to 5.06% by weight, whereas the range in healthy tobacco was 3.73 to 4.27%. The average for all diseased cultivars and hybrids was 4.77% and the mean for all healthy cultivars and hybrids was 3.96%.

Acid insoluble nitrogen also was significantly higher in PVY-infected tobacco than in healthy tobacco, averaging 2.12% in the former and 1.32% in the latter. The range in diseased tobacco was 1.77 to 2.50% and 1.21 to 1.49% in healthy tobacco.

Tobacco from plants infected with PVY had a significantly lower percentage of nitrogen that was soluble, ranging from 46.5 to 62.4% (mean 55.6%). The tobacco from healthy plants had an average of 66.6% of the nitrogen present as soluble nitrogen, and the amount ranged from 65.2 to 69.6%.

The effect of PVY on the amount of α-amino nitrogen was variable. Bu 49 had significantly less when infected with PVY, but there was no pattern for the other cultivars and hybrids - some had more when infected but others had less.

Nitrate nitrogen generally was higher in PVY-infected tobacco, but the differences were not significant for four cultivars: Ky 12, Ky 14, Bu 21 × L8, and Bu 37 × L8. Noninoculated tobacco had levels of nitrate nitrogen from 0.40 to 0.55% (mean 0.48%). Nitrate nitrogen in diseased tobacco from the 11 cultivars and hybrids ranged from 0.42 to 0.73% (mean 0.62%).

Generally, there was a reduction in the amount of phenols present in PVY-infected tobacco although the reductions were not significant for Bu 49, Ky 12, Bu 21 × L8, and Bu 37 × L8. The range in diseased tobacco was 0.29 to 0.74% (average 0.47%) and the range in healthy tobacco was 0.50 to 1.04% (mean 0.77%).

Diseased tobacco had less alkaloids than healthy

TABLE 1. Effect of potato virus Y on yield, quality, and value of 11 cultivars and hybrids of burley tobacco[y]

Cultivar[z]	Yield (kg/ha)	Grade index	Crop index	Value ($/kg)	Value ($/ha)
Not inoculated					
Burley 21	2,719 abcd	.527 cd	1,280 def	1.699 b	4,620 de
Burley 37	2,705 abcd	.563 bc	1,359 cde	1.716 ab	4,640 cde
Burley 49	2,720 abcd	.498 d	1,215 ef	1.692 b	4,603 de
Kentucky 10	3,122 ab	.578 abc	1,619 ab	1.716 ab	5,358 b
Kentucky 12	2,934 abc	.563 bc	1,485 bc	1.715 ab	5,032 bcd
Kentucky 14	3,339 a	.597 ab	1,780 a	1.748 a	5,837 a
Virginia 509	3,061 abc	.617 a	1,679 a	1.719 ab	5,262 b
Bu 21 × Ky 10	2,957 abc	.569 abc	1,499 bc	1.712 ab	5,062 bc
Bu 21 × Ky 12	3,014 abc	.541 cd	1,447 c	1.703 b	5,134 b
Bu 21 × L8	2,719 abcd	.491 d	1,192 f	1.689 b	4,593 de
Bu 37 × L8	2,959 abc	.533 cd	1,410 cd	1.696 b	5,019 bcd
Inoculated					
Burley 21	2,084 de	.303 gh	569 jk	1.616 c	3,366 i
Burley 37	1,715 e	.283 h	464 k	1.557 e	2,670 j
Burley 49	1,766 e	.315 efgh	552 jk	1.571 de	2,775 j
Kentucky 10	2,578 abcd	.362 ef	852 gh	1.603 cd	4,131 fg
Kentucky 12	2,716 abcd	.361 ef	888 g	1.624 c	4,411 ef
Kentucky 14	2,730 abcd	.367 e	904 g	1.619 c	4,421 ef
Virginia 509	2,298 cde	.323 efgh	679 hij	1.586 cde	3,643 hi
Bu 21 × Ky 10	2,470 bcd	.344 efg	772 ghi	1.586 cde	3,917 gh
Bu 21 × Ky 12	2,504 bcd	.312 fgh	703 hij	1.545 e	3,868 gh
Bu 21 × L8	664 f	.228 i	140 l	1.501 f	996 k
Bu 37 × L8	555 f	.201 i	99 l	1.470 f	816 k

[y]Two-yr means based on three replications per year; means in the same column followed by the same letter are not significantly different ($P = 0.05$) according to Duncan's multiple range test.

[z]Abbreviations: Bu = Burley; Ky = Kentucky.

tobacco but the amount was significantly less in only 10 of the 11 entries. The amount ranged from 2.63 to 4.21% when PVY was present and from 3.90 to 4.80% in the absence of the virus. The means were 3.48 and 4.40% for diseased and healthy plants, respectively.

Less water-soluble acids were present in PVY-infected tobacco than in healthy tobacco, ranging from 1.92 to 3.27% (mean 2.58%). In virus-free tobacco it ranged from 2.86 to 3.33% (mean 3.18%). Although 10 of the 11 cultivars and hybrids had reduced water soluble acids when infected with PVY, the reductions were significant for only three cultivars and three hybrids.

The pH of a solution prepared from ground cured leaf was higher for all diseased tobacco except Ky 14, but the increases were significant only for Bu 49, Bu 21 × L8, and Bu 37 × L8. The average pH for all healthy entries was 5.90 and ranged from 5.83 to 5.95. The average for PVY-infected tobacco was 6.06 and ranged from 5.83 to 6.35.

Physical characteristics.—Plants containing PVY were shorter than healthy plants, with the exception of inoculated Ky 10 which was 3.3 cm taller than noninoculated plants of the same cultivar. The reductions in plant height were significant only for Bu 37, Bu 49, Ky 14, and the two L8 hybrids.

Generally there were fewer harvestable leaves on plants inoculated with PVY than on noninoculated plants although the differences usually were not significant. Only three entries had significantly fewer leaves. These were Bu 37, Bu 21 × L8, and Bu 37 × L8 which had 15, 31, and 43%, respectively, less leaves per plant.

Leaves on plants infected with PVY were significantly shorter and narrower than leaves on healthy plants. Leaf length of infected plants decreased from 6 to 41%; the width was reduced by 11 to 44%.

The percentage of plants flowering generally was higher among plants inoculated with PVY than among healthy plants. Only Bu 49 and the hybrid Bu 37 × L8 averaged fewer plants flowering when infected with PVY but the differences were not significant. Cultivars Bu 21, Bu 37, Ky 10, Virginia 509, and Bu 21 × Ky 12, infected with PVY, had a significantly greater number of plants flowering than healthy plantings of the same cultivars.

DISCUSSION

Infection by PVY had deleterious, and in some instances, severe effects on the quantity and quality of cured tobacco produced by 11 burley tobacco cultivars and hybrids. The reductions in value per hectare averaged 36%, but ranged from 11% for Ky 12 to over 80% for the hybrid Bu 37 × L8. The reduced per-hectare values were due to both lowered yields and tobacco of lower quality. The yield reduction ranged from 7 to 81%, averaging 32% less, and the grade index was lowered from 36 to 62%, averaging 44% less than tobacco from comparable healthy cultivars and hybrids. The reduction in yield was

TABLE 2. Effect of potato virus Y on selected chemical constituents of air-cured leaf from 11 cultivars and hybrids of burley tobacco[w]

Cultivar[x]	Total nitrogen (%)	Acid-insoluble nitrogen (%)	Soluble nitrogen[y] (%)	α-Amino nitrogen (%)	Nitrate nitrogen (%)	Total phenols (%)	Total alkaloids (%)	Water-soluble acids[z] (ml)	pH
Not inoculated									
Burley 21	3.81 gh	1.30 ef	65.8 b	.453 efg	.51 defg	.80 abc	4.08 def	2.86 cde	5.91 cdef
Burley 37	4.08 ef	1.41 ef	65.3 bc	.429 fgh	.43 fg	.75 bcd	4.80 a	3.26 ab	5.95 cdef
Burley 49	4.27 e	1.49 def	65.2 bc	.510 cde	.52 defg	.50 defgh	4.45 bc	3.20 ab	5.87 def
Kentucky 10	4.09 ef	1.24 f	69.6 a	.551 abc	.50 defg	1.04 a	4.77 a	3.33 a	5.89 def
Kentucky 12	4.08 ef	1.33 ef	67.2 ab	.589 a	.50 defg	.73 bcdef	3.90 ef	3.09 abc	5.83 f
Kentucky 14	3.88 fgh	1.21 f	68.4 ab	.532 abc	.49 defg	.88 ab	4.17 cde	3.22 ab	5.87 def
Virginia 509	4.01 fg	1.32 ef	67.1 ab	.444 efgh	.55 cdef	.66 bcdefg	4.78 a	3.32 a	5.84 ef
Bu 21 × Ky 10	3.88 fgh	1.25 f	67.5 ab	.466 defg	.50 defg	.83 ab	4.64 ab	3.18 abc	5.90 def
Bu 21 × Ky 12	3.91 fgh	1.34 ef	65.7 b	.524 bcd	.46 efg	.90 ab	3.95 ef	3.09 abc	5.93 cdef
Bu 21 × L8	3.73 h	1.28 f	65.4 bc	.447 efg	.40 g	.72 bcdef	4.35 bcd	3.24 ab	5.95 cdef
Bu 37 × L8	3.86 fgh	1.31 ef	65.9 b	.428 fgh	.42 g	.66 bcdefg	4.63 ab	3.20 ab	5.93 cdef
Inoculated									
Burley 21	4.74 c	2.11 abc	55.5 fg	.452 efg	.70 ab	.42 gh	3.56 gh	2.47 fg	6.05 cd
Burley 37	4.98 ab	2.23 abc	55.3 fg	.451 efg	.70 ab	.29 h	3.52 gh	2.63 ef	6.08 bc
Burley 49	4.83 bc	2.31 ab	52.6 gh	.421 fgh	.71 a	.34 h	2.94 i	2.09 hi	6.29 ab
Kentucky 10	4.86 abc	1.96 bc	59.9 de	.542 abc	.64 abc	.46 efg	4.21 cde	3.10 abc	5.96 cdef
Kentucky 12	4.70 cd	1.90 bcd	59.6 de	.546 abc	.61 abcd	.52 cdefgh	3.41 h	2.95 bcd	5.83 f
Kentucky 14	4.68 cd	1.77 cde	62.4 cd	.579 ab	.58 bcde	.54 cdefgh	4.03 ef	3.27 ab	5.83 f
Virginia 509	5.06 a	2.16 abc	57.6 ef	.497 cde	.73 a	.33 h	4.07 def	3.02 abcd	5.88 def
Bu 21 × Ky 10	4.80 bc	2.18 abc	55.1 fg	.496 cde	.67 abc	.38 h	3.81 fg	2.87 cde	6.02 cde
Bu 21 × Ky 12	4.63 cd	2.03 abc	56.3 e	.486 cdef	.64 abc	.46 efgh	3.33 h	2.75 def	5.94 cdef
Bu 21 × L8	4.50 d	2.22 abc	50.8 h	.411 gh	.45 fg	.74 bcde	2.76 ij	2.23 gh	6.22 ab
Bu 37 × L8	4.65 cd	2.50 a	46.5 i	.381 h	.42 g	.71 bcdef	2.63 j	1.92 i	6.35 a

[w]Two-year means based on three replications per year; means in the same column followed by the same letter are not significantly different ($P = 0.05$) according to Duncan's multiple range test.

[x]Bu = Burley; Ky = Kentucky.

[y]Percent of total nitrogen that is soluble in water.

[z]Milliliters of 0.1 N NaOH required to neutralize 1.0 g of oven-dried and ground tobacco.

caused by a combination of fewer harvestable leaves and also smaller leaves; there was a reduction in both length and width of leaves on plants infected with PVY. The reduction in harvestable leaves resulted from a tendency of leaves on infected plants to yellow prematurely. Thomson and Wright (10) also found that PVY reduced plant height, leaf area, and leaf weight of flue-cured tobacco in New Zealand.

The presence of the virus affected the amounts of several chemical constituents in the cured leaf. Total nitrogen was higher in PVY-infected tobacco and was due largely to an increase in acid insoluble nitrogen. Nitrate nitrogen also was higher, but the increases were not significant for four cultivars. Samples from PVY-infected plants had higher pH's, but the increases generally were not significant. Total alkaloids were lower in PVY-infected tobacco although the reduction was not significant for Ky 14. Total phenols and water soluble acids were also lowered by the virus, but the reductions were not always significant. The changes in the chemical constituents caused by PVY in this study agree closely with those reported in another type of study (9) and follow the same pattern reported for tobacco vein mottling virus (TVMV) (5).

There were definite differences in the magnitude of the effect of PVY on the yield and value per ha of the cultivars and hybrids included in this study. A number of available cultivars are tolerant of the virus and will produce good yields even when infected with PVY early in the season. Ky 12 was the least affected cultivar in this test. The percent decrease in yield, grade index, value per kg, and value per ha due to PVY was less for Ky 12 then for any of the other cultivars or hybrids tested. Although the yield was reduced when Ky 12 was inoculated with PVY, the reduction was not significant. There was, however, a significant reduction in the quality as measured by the grade index, and consequently significant reductions in the crop index as well as the values per kg and ha. Cultivars Ky 10, Ky 14, Bu 21 × Ky 10, and Bu 21 × Ky 12 also were tolerant to PVY. The lowest yields were produced by Bu 37, Bu 49, and the two L8 hybrids. Generally, the effect of PVY on the yield of burley cultivars is similar to the effects of tobacco etch virus (TEV) and TVMV on burley tobacco (2, 6). Two exceptions are Virginia 509, which was severely affected by TVMV but only moderately affected by PVY and TEV, and Ky 12, which had a significant reduction in yield due to TEV, but was tolerant to PVY and TVMV.

Caution should be exercised in selecting a cultivar tolerant to the potyvirus complex to insure that it is not at the expense of resistance to another disease. Those cultivars and hybrids with resistance to black shank generally were affected more by PVY, TEV, and TVMV than cultivars and hybrids that do not have black shank resistance. The two hybrids involving L8 as one parent were severely affected and probably could not be profitably grown in an area where the potyviruses are endemic. Further studies are needed to determine whether black shank resistance is genetically linked with resistance to the PVY group.

TABLE 3. Effect of potato virus Y on physical characteristics of 11 burley tobacco cultivars and hybrids[y]

Cultivar[z]	Plant height (cm)	Leaves (no.)	Leaf length (cm)	Leaf width (cm)	Flowering (%)
Not inoculated					
Burley 21	127.7 ab	19.8 efghi	58.2 bcde	25.4 def	13.0 efgh
Burley 37	124.6 abcd	20.8 cdefg	57.7 cdef	26.1 cde	36.3 c
Burley 49	118.1 bcdef	21.4 bcdef	56.6 ef	26.4 bcde	18.7 defg
Kentucky 10	114.0 efg	20.7 cdefgh	62.9 a	27.5 abc	13.0 efgh
Kentucky 12	124.6 abcd	23.0 ab	59.9 abcd	27.0 abcd	2.7 h
Kentucky 14	127.3 ab	21.5 bcde	61.8 a	28.3 a	11.5 fgh
Virginia 509	125.6 abc	21.0 cdefg	62.3 a	28.0 ab	11.0 gh
Bu 21 × Ky 10	127.0 ab	19.5 ghi	60.9 ab	27.2 abc	17.5 defg
Bu 21 × Ky 12	131.6 a	23.4 a	60.1 abcd	26.9 abcd	11.7 fgh
Bu 21 × L8	119.4 bcde	17.7 j	61.1 ab	25.3 def	47.8 b
Bu 37 × L8	118.4 bcdef	19.0 hij	60.4 abc	27.4 abc	60.8 a
Inoculated					
Burley 21	121.8 abcde	18.9 ij	53.0 gh	22.2 hi	28.8 cd
Burley 37	108.4 fg	17.6 j	49.0 i	21.0 i	55.7 ab
Burley 49	104.0 g	19.8 efghi	50.7 hi	22.8 gh	18.2 defg
Kentucky 10	117.3 bcdef	21.0 cdefg	57.3 cdef	24.1 fg	27.2 cd
Kentucky 12	119.9 bcde	22.0 abcd	55.2 efg	24.0 fg	12.8 efgh
Kentucky 14	112.9 efg	19.5 ghi	57.5 cdef	25.0 ef	24.2 cdef
Virginia 509	115.1 cdef	20.4 defghi	54.6 fg	22.9 gh	26.0 cd
Bu 21 × Ky 10	117.0 bcdef	19.7 fghi	57.1 def	23.7 fgh	30.5 cd
Bu 21 × Ky 12	121.9 abcde	22.4 abc	54.7 fg	23.9 fgh	25.7 cde
Bu 21 × L8	77.5 h	12.1 k	39.2 j	16.0 j	50.8 ab
Bu 37 × L8	73.2 h	10.9 k	35.7 k	15.3 j	55.2 ab

[y]Each figure is the mean of six replications (three in each of 2 yr, 1970 and 1971) except for percent flowering which is the mean of counts made on 24 and 28 July 1970. Means in the same column followed by the same letter are not significantly different ($P = 0.05$) according to Duncan's multiple range test.

[z]Abbreviations: Bu = Burley; Ky = Kentucky.

LITERATURE CITED

1. BAWDEN, F. C., and B. KASSANIS. 1946. Varietal differences in susceptibility to potato virus Y. Ann. Appl. Biol. 33:46-50.
2. GOODING, G. V., JR., and M. ROSS. 1970. Effect of tobacco etch virus on yield and market value of commercial cultivars of burley tobacco in North Carolina. Tob. Sci. 14:55-57.
3. GOODING, G. V., JR., and S. A. TOLIN. 1973. Strains of potato virus Y affecting flue-cured tobacco in the southeastern United States. Plant Dis. Rep. 57:200-204.
4. JONES, L. K. 1937. The susceptibility of potatoes to the vein-banding virus. J. Agric. Res. 55:69-79.
5. PIRONE, T. P., and D. L. DAVIS. 1977. Modification of the chemical composition of burley tobacco by infection with tobacco vein mottling virus. Tob. Sci. 21:83-84.
6. PIRONE, T. P., and G. V. GOODING, JR. 1973. Effect of tobacco vein mottling virus on field-grown burley tobacco varieties. Plant Dis. Rep. 57:845-847.
7. SIEVERT, R. C. 1971. Effect of time of inoculation with potato virus Y on yield and quality of burley tobacco. Phytopathology 61:588-589.
8. SIEVERT, R. C. 1972. Sources of resistance to potato virus Y in the genus Nicotiana. Tob. Sci. 16:92-94.
9. SIEVERT, R. C. 1978. Effect of early harvest of burley tobacco infected with potato virus Y on yield, quality and chemical constituents. Tob. Sci. 22:51-53.
10. THOMSON, A. D., and D. S. C. WRIGHT. 1966. Incidence and some effects of potato virus Y on New Zealand flue-cured tobacco. N. Z. J. Agric. Res. 9:886-893.