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Effects of the *Nicotiana debneyi* Black Root rot Resistance Factor on Agronomic and Chemical Traits in Burley Tobacco

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Summary. Lines isogenic or near isogenic for traits other than resistance to black root rot from *Nicotiana debneyi* were developed in eight cultivar backgrounds of burley tobacco (*N. tabacum* L.). For each cultivar background, a resistant and susceptible selection from the seventh backcross generation plus the recurrent parental cultivar were evaluated for ten agronomic and chemical traits. Resistant selections were statistically different from the susceptible entries for days to flower, total nitrogen content, and total alkaloid content. Also, resistant selections were consistently lower in yield, but the differences were statistically nonsignificant. Resistant selections were also taller in three families and in two families the resistant selections had wider leaves. Linkage of genetic material from *N. debneyi* with the resistance factor was suggested as the possible reason for differences between resistant and susceptible selections.

Key words: Disease resistance – Isogenic lines – Black root rot – *Thielaviopsis basicola* – *Nicotiana*

Introduction

Black root rot caused by *Thielaviopsis basicola* (Berk, and Br.) Ferr. is a soil-borne fungal disease that causes poor early growth and uneven stands. Reductions in yield from 5 to 7 percent are estimated to result from the occurrence of black root rot each year in the production of burley tobacco. Losses are most severe in the mountainous areas where the soil remains cool and wet following transplanting.

A single dominant factor for black root rot resistance was found in *N. debneyi* by Clayton (1969). The breeding research of Clayton (1969) and other scientists in Tennessee resulted in the development of 'Burley 49', the first burley cultivar with the *N. debneyi* resistance factor (Hoffleck et al. 1965). 'Burley 49' has not been grown extensively because of late maturity, small leaves, and low yields. Two recently released burley cultivars from Kentucky have combined the *N. debneyi* black root rot resistance with higher yields (Collins et al. 1978a, b).

Since the development of high yielding, multiple-disease resistant cultivars is a major objective of tobacco breeders, an understanding of the relationship between disease resistance and other important characteristics is extremely useful. The objectives of this study were to develop and compare lines of burley tobacco that were isogenic or near-isogenic for all traits except reaction to black root rot.

Materials and Methods

The black root rot resistance factor from *N. debneyi* was transferred from 'Burley 49' to eight genetically diverse, black root rot susceptible burley cultivars by the backcross method. The susceptible cultivars were 'Burley 2', 'Burley 21', 'Burley 37', 'Ky 5', 'Ky 10', 'Ky 61', 'Bell's Bourbon', and 'Casey's Yellow Twist Bud'.

A single F_1 plant from each of the eight cultivar × 'Burley 49' crosses was backcrossed to the appropriate recurrent cultivar. In the first backcross populations, seedlings were grown in the greenhouse and screened for reaction to a common strain of black root rot using procedures similar to those outlined by Litton et al. (1970). When the susceptible controls showed severe wilting or death, a single resistant plant in each population was randomly selected and crossed with the recurrent parent. This procedure was followed through six backcrosses. In each of the seventh backcross populations, a susceptible plant was selfed to obtain a susceptible selection and a resistant plant was selfed to produce a segregating population. After screening BC_7S_2 progenies of plants from the BC_7S_1 segregating population, a homozygous resistant selection was identified for further evaluation.

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For each of the eight cultivars, the susceptible selection, the resistant selection, and the recurrent parent were designated as a family and evaluated as a whole plot in a randomized split-plot design with four replications. Subplots were single rows consisting of 20 competitive plants, spaced 46 cm in the row, with a spacing between rows of 107 cm. Tests were conducted for three years at Lexington, Kentucky in fields relatively free of black root rot. Recommended fertilization, cultural, and curing procedures for burley tobacco were used. Data were collected for days from transplanting to flowering, number of harvestable leaves, plant height, leaf width, leaf length, cured leaf yield, total nitrogen, nitrate nitrogen, total volatile nitrogenous bases (TVNB), and total alkaloids. Data on all characters were obtained by previously described procedures (Legg et al. 1977; Legg and Collins 1971). Statistical analyses were performed using the methods for a split-plot experiment.

Results

Families were significantly different (P = .05) for all of the 10 traits. These differences were expected since the eight cultivars were independently developed in two breeding programs or selected by farmers. The family × year interaction was significant for plant height, leaf length, yield, and total alkaloids. However, interaction components were small relative to the family components.

Subplots (selections) were significantly different (P = .05) for days to flower, plant height, leaf width, leaf length, yield, total nitrogen, and total alkaloids (Table 1). The interaction component for selections with years was also different from zero for plant height, leaf length, leaf width, and yield. Again, the relative sizes of the interaction components were small compared to the main components. All comparisons between the susceptible cultivars and the susceptible selections were non-significant at the P = .05 level. When compared with susceptible entries, resistant selections, on the average, flowered later, were taller, had wider

Table 2. Performance of black root rot susceptible cultivars, susceptible selections, and resistant selections

Selections	Plant height, cm.	Leaf width, cm.	Leaf length, cm.	Yield/ plant, g.
'Casey's Yellow Twist Bud'	113.6	31.1	76.3	153.6
Sus. selection	119.6	32.6	77.8	142.2
Res. selection	115.5	35.1	77.9	128.7
'Burley 21'	143.6	34.0	73.8	145.0
Sus. selection	140.8	35.9	70.0	140.7
Res. selection	139.2	35.1	69.8	133.7
'Burley 2'	129.7	39.5	76.6	157.2
Sus. selection	139.3	38.4	74.6	153.9
Res. selection	141.3	38.0	74.1	142.8
'Ky 61'	116.9	32.6	72.8	149.2
Sus. selection	114.8	32.3	70.8	147.0
Res. selection	125.5	33.1	69.4	140.8
'Ky 5'	110.9	32.3	62.3	140.1
Sus. selection	96.2	33.2	63.9	132.4
Res. selection	122.3	36.3	66.6	120.9
'Ky 10'	122.4	34.3	68.9	166.4
Sus. selection	128.2	35.4	69.9	162.8
Res. selection	140.6	35.6	67.7	144.3
'Burley 37'	130.4	35.3	71.4	131.8
Sus. selection	131.7	34.6	70.1	125.7
Res. selection	142.6	36.4	72.0	122.6
'Bell's Bourbon'	100.5	35.5	72.2	145.8
Sus. selection	108.6	35.1	72.0	137.0
Res. selection	118.4	36.4	72.9	128.6
Within family LSD 0.05	8.7	2.0	3.1	20.6
0.01	11.4	2.7	4.1	27.2

Table 1. Three-year average performances of black root rot susceptible cultivars compared with backcross-derived susceptible and resistant selections

Entries	Days to flower, no.	Leaves/ plant, no.	Plant height, cm.	Leaf width, cm.	Leaf length, cm.	Yield/ plant, g.	Total N, %	Nitrate N, %	TVNB, %	Total alkaloids, %
Sus. cultivars	62.8	17.8	121.0	34.3	71.8	148.6	4.58	0.42	0.92	3.50
Sus. selections	62.1	17.3	122.4	34.7	71.3	142.7	4.65	0.41	0.96	3.45
Res. selections	65.2	17.6	130.8	35.8	69.2	132.8	4.27	0.44	0.91	3.05
L.S.D. 0.05	1.0	NS	3.1	0.7	1.1	7.3	0.28	NS	NS	0.36
L.S.D. 0.01	1.4	NS	4.0	0.9	1.5	9.6	0.37	NS	NS	0.48
Family × selection interaction	NS	NS	**	**	**	*	NS	NS	NS	NS

*, **, NS Denotes significance at $P \leq 0.05$, $P \leq 0.01$, and nonsignificant, respectively

but shorter leaves, and were lower in yield, total nitrogen, and total alkaloids. Since the family × selection interaction was significant for plant height, leaf width, leaf length, and yield, data for these traits are presented by families in Table 2.

Within family differences were found in five families for plant height. For the 'Burley 2' and 'Ky 5' families, the susceptible selection differed from the recurrent parent indicating that backcrossing may not have restored the genotype of the recurrent parent for plant height. Thus, we concluded that a comparison of the resistant selection with the susceptible cultivar for plant height in these two families would not necessarily reflect effects of the resistance factor. In the 'Ky 10', 'Burley 37', and 'Bell's Bourbon' families, the susceptible selection and the cultivar were comparable and differed from the resistant selection. For leaf width, the resistant selection had wider leaves than the susceptible entries for 'Casey's Yellow Twist Bud' and 'Ky 5'. Differences for leaf length were significant within the 'Burley 21', 'Ky 61', and 'Ky 5' families; however, the resistant selection was not different from the susceptible selection in any of these families. For yield, within families differences were found for 'Casey's Yellow Twist Bud' and 'Ky 10'. Within these two families, the resistant selection was significantly lower yielding than the susceptible cultivar, but was not different from the susceptible selection.

Discussion

The development of disease-resistant cultivars continues to be a major objective of burley tobacco breeders. The use of disease-resistant cultivars not only reduces yield losses and need for chemical control, but also helps to produce good quality leaf. When plants become diseased, the appearance, quality, and chemical content of the leaves are often changed in an undesirable direction. However, the incorporation of disease-resistant factors into cultivars can alter the plant in an undesirable way. The attempt to use the *N. glutinosa* factor for mosaic resistance in flue-cured and dark-fired tobaccos is a prime example (Chaplin and Mann 1978; Chaplin et al. 1961; Litton et al. 1972).

Burley cultivars with the *N. debneyi* resistance factor for black root rot have not been grown extensively. The two releases from Tennessee, 'Burley 49' and 'Burley 64', are later maturing and low yielding. The two Kentucky cultivars, 'Ky 15' and 'Ky 17', are better yielding and earlier, but are still not comparable to other cultivars under disease-free conditions. Their greatest value is for production on land infested with diseases.

This study indicated that later maturity, increased plant height, broader leaves, shorter leaves, reduced yield, reduced total nitrogen content, and lower total alkaloids were associated with the *N. debneyi* resistance. Changes in maturity, total nitrogen, and total alkaloids were consistent over cultivars and appeared to be independent of the recipient genotype. For the other four traits, the association is not as consistent and varied by families. Plant height differences were present in only three families and one can assume that selection against taller genotypes during the incorporation of resistance would eliminate any increase in plant height. For yield, the comparison of susceptible and resistant selections was nonsignificant in all families, but the resistant selection was always lower in yield. Thus, lower yield may have been directly associated with black root rot resistance.

The four possible explanations for the influence of a qualitative factor on quantitative traits are linkage, position effect, elimination of favourable factors by segmental chromosome substitution of certain factors of the host genotypes, and pleiotropism. Although the exact reason for the differences that we observed cannot be given, we suspect linkage of undesirable genes with the resistance factor might be involved. This conclusion is based on the fact that continued breeding and selection have improved cultivars and lines carrying the *N. debneyi* resistance factor (Collins et al. 1978a, b).

If the influence of a qualitative factor on quantitative traits is due to chromosomal linkage of genetic material, then a reduction or even elimination of the influence should be possible through genetic recombination. However, tight linkage would require extensive recombination and might be practically impossible to break. In the present study, a single resistant plant from each family was randomly selected in each backcross generation for advancement to the next generation. The extent to which this program maintained linkage blocks around the resistance factor cannot be determined from present information. The use of more backcrosses or larger populations with intense selection in the early generations might have altered the observed results. However, the results do indicate that breeding cultivars with the *N. debneyi* black root rot resistance, high yields, and good quality requires extensive efforts and expense.

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