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Genetic Parameters in a *Ky* 14 × *Ky Ex* 42 Burley Population of *Nicotiana tabacum* L.[1]

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Summary. In the F_2 generation of the cross between burley varieties, *Ky* 14 and *Ky Ex* 42, estimates of additive genetic variance were significant for yield, days to flower, and number of leaves. All estimates of dominance variance, additive × additive variance, and interactions between genetic variances and years were smaller than twice their standard errors. The gain expected from selecting and recombining the best 10% of the F_2 plants ranged from 4% for number of leaves to 8.6% for yield. Additive genetic correlations between pairs of agronomic characters were positive. Yield and number of leaves were negatively correlated with total alkaloids.

Introduction

Plant breeders conduct genetic variability experiments to estimate the relative magnitude and type of genetic variation, to determine the magnitude of the genotype × environment interaction variance, and to evaluate the relationship among various characters. Once this information is available from a population, the breeder can compare the applicability of different breeding methods, calculate the progress expected from using certain selection procedures, and determine if selection in the population is likely to produce improved varieties or breeding lines at a reasonable expense.

In several populations of burley tobacco, the predominant genetic effects have been additive (Legg and Collins, 1971b, 1971c; Legg, Collins, and Litton, 1970; Matzinger, Wernsman, and Ross, 1971). However, in every population, estimates of one or more parameters indicated the presence of some nonadditive effects for one or more characters. Significant estimates of heterosis, inbreeding depression, and specific combining ability have been reported for days to flower, number of leaves, leaf width, and yield (Legg *et al.*, 1970; Matzinger *et al.*, 1971). In addition, significant heterosis and inbreeding depression estimates have been found for plant height, leaf length, and percent total alkaloids (Matzinger *et al.*, 1971). In our two experiments (Legg and Collins, 1971b, 1971c) which were designed to obtain specific estimates of additive, dominance, and additive × additive variances (σ_A^2, σ_D^2, and σ_{AA}^2, respectively), the only significant estimate of σ_D^2 or σ_{AA}^2 was σ_D^2 for days to flower in the Virginia *B*-29 × *Ky* 12 cross.

Additional evidence of dominance and additive × additive epistatic effects in burley tobacco was reported by Legg and Collins (1971a). In a two-locus system that is important in the control of alkaloid production, a significant effect for dominance was reported at one locus and the additive × additive epistatic effect was significant. To obtain more information on the genetic parameters in burley tobacco, the present study was designed to estimate variances and correlations in a cross between two high-yielding, morphologically different varieties.

Material and Methods

The two pure lines chosen for study were *Ky* 14 and *Ky Ex* 42. *Ky* 14 is a standup variety which produces a good yield of broad leaves of medium length. It is resistant to the wildfire, tobacco mosaic, black root rot and fusarium wilt diseases. *Ky Ex* 42 is an experimental line with long, narrow leaves that project from the plant in a semi-erect fashion. It is resistant to wildfire, tobacco mosaic, and fusarium wilt, but it is susceptible to black root rot.

Two plants, one from each of the pure lines, were crossed to give the F_1 generation, and a single F_1 plant was selfed to produce the F_2 generation. Within the F_2 generation, 13 sets of progenies were produced according to the mating design described by Matzinger and Cockerham (1963). Eight random F_2 plants were assigned to each set with four of the plants designated as males and four as females. Sixteen full-sib families were obtained by crossing each of the females by each of the males; and eight self progenies were produced by self-pollinating the eight parent plants.

The full-sib and self families in each set were planted in a randomized block design with two replications at Lexington, Kentucky during 1969 and 1970. *Ky* 14, *Ky Ex* 42, the F_1 generation, and F_2 generation were included in each replication of each set during 1969. In 1970, *Ky* 14 and *Ky Ex* 42 were included in each replication of each set.

All plots were single rows consisting of 25 plants spaced 46 cm in the row with a spacing between rows of 107 cm. Data were collected on number of days from transplant-

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ing to flowering, number of harvestable leaves, plant height, yield per plant, and percent total alkaloids. Further details on procedures used in the collection of data were given by Legg and Collins (1971b).

Genetic parameters were estimated by the basic computational procedures outlined by Matzinger and Cockerham (1963); Matzinger, Mann, and Cockerham (1966); and Matzinger (1968). Expected progress from selecting and recombining the best 10% of the parental plants on the basis of performance of both self and biparental progenies was calculated according to the simplified model of Cockerham and Matzinger (1966). Under this model, all interactions between genetic entries and environmental blocks are assumed to be zero and the genetic variance is assumed to be entirely additive.

Table 1. *Mean performance of parents, F_1, F_2, full-sib families, and self families for five characters*

	Yield, g/plant	Total alkaloids, %	Days to flower	Leaves, no/plant	Plant height, cm
1969					
Ky 14	160.58	4.53	72.58	22.32	110.40
Ky Ex 42	145.17	4.93	72.77	21.77	108.60
Midparent	152.88	4.73	72.68	22.04	109.50
F_1	145.89	4.63	72.73	21.77	110.94
F_2	150.72	4.67	72.04	21.89	110.38
Full-sib families	151.69	4.67	71.61	21.73	107.91
Self families	150.61	4.63	72.12	21.81	106.46
1969–70					
Ky 14	140.65	4.22	70.16	22.42	109.80
Ky Ex 42	126.94	4.64	71.04	22.15	106.36
Midparent	133.80	4.43	70.60	22.28	108.08
Full-sib families	131.03	4.41	70.04	21.84	107.06
Self families	130.55	4.35	70.53	21.97	106.07

Table 2. *Estimaltes of additive genetic (σ_A^2), dominance (σ_D^2), and additive × additive (σ_{AA}^2) variances, their interactions with years, plot error variances for self (σ_{1e}^2) and full-sib (σ_{2e}^2) families, and standard errors*

	Yield		Alkaloids		Days to flower		No. of leaves		Plant height	
	σ^2	*SE*	σ^2	*SE*	σ^2	*SE*	σ^2	*SE*	σ^2	*SE*
σ_A^2	64.12	21.42	0.026	0.022	4.77	1.31	0.43	0.18	13.31	6.92
σ_D^2	− 7.01	32.70	0.028	0.041	0.07	1.42	−0.10	0.30	3.85	12.98
σ_{AA}^2	− 35.69	33.02	−0.006	0.038	−0.51	1.72	−0.35	0.30	−11.06	11.79
σ_{AY}^2	− 19.08	21.70	0.024	0.028	0.03	0.84	0.07	0.24	− 6.09	8.15
σ_{DY}^2	18.25	53.26	0.017	0.064	−0.54	1.90	0.08	0.52	13.11	19.99
σ_{AAY}^2	35.13	41.35	−0.010	0.050	0.31	1.58	0.29	0.45	15.72	15.09
σ_{1e}^2	196.12	20.36	0.209	0.021	8.16	0.86	1.66	0.16	64.33	6.67
σ_{2e}^2	188.53	13.97	0.198	0.016	7.35	0.52	1.58	0.13	66.68	5.13

Results

Mean performances of the parents, F_1, F_2, full-sib families, and self families are given in Table 1. When differences among these generations were tested by the t statistic, *Ky* 14 and *Ky Ex* 42 differed for yield and percent total alkaloids in both the 1969 data and the data combined over years. *Ky* 14 yielded about 13 grams per plant more than *Ky Ex* 42 and had approximately 9% less total alkaloids. All comparisons among the midparent, F_1, F_2, full-sib families, and self families were nonsignificant at $P = 0.05$.

There were significant amounts of variability among full-sib families for all five characters and among half-sib families for days to flower, yield, and percent total alkaloids. The variances of half-sib family means for parents used as males in crosses versus those used as females in crosses did not differ for any character. There was no interaction of male × female parents in the full-sib families. Significant estimates of genotype × year interactions were found for number of leaves and plant height. The variance among male parents within sets × years was significant for number of leaves in the analysis of full-sib families. In the self-family analyses, the selfs within sets × year interactions were significant for number of leaves and plant height.

Estimates of additive genetic (σ_A^2), dominance (σ_D^2), additive × additive (σ_{AA}^2), additive genetic × years (σ_{AY}^2), dominance × years (σ_{DY}^2), and additive × additive × years (σ_{AAY}^2) variances, standard errors, and plot error variances for self (σ_{1e}^2) and full-sib families (σ_{2e}^2) are presented in Table 2. Estimates of additive genetic variance were significant for yield, days to flower, and number of

Table 3. *Heritabilities of self (h_S^2), half-sib (h_{HS}^2), and full-sib (h_{FS}^2) families for two replications and two years*

Character	Family reference		
	h_S^2	h_{HS}^2	h_{FS}^2
Yield	0.38	0.34	0.23
Alkaloids	0.14	0.13	0.08
Days to flower	0.37	0.37	0.29
No. of leaves	0.33	0.29	0.19
Plant height	0.25	0.22	0.14

leaves. Estimates of σ_D^2, σ_{AA}^2, and components of variance for interactions between genetic variances and years were smaller than twice their standard errors.

Heritabilities, in the narrow sense, are given in Table 3 for family means from two replications and two years. The estimates ranged in magnitude from 0.08 for percent total alkaloids in the full-sib families to 0.38 for yield in the self lines.

Table 4. *Additive genetic (γ_A), self error (γ_{1e}), and full-sib error (γ_{2e}) correlations and phenotypic correlations of self (γ_{1p}), half-sib (γ_{h2p}), and full-sib (γ_{f2p}) families*

Characters	Correlations					
	γ_A	γ_{1e}	γ_{2e}	γ_{1p}	γ_{h2p}	γ_{f2p}
Yield-alkaloids	−0.44*	−0.15	−0.09	0.12	−0.15	−0.14
Yield-flowers	0.47*	−0.49*	−0.41*	−0.01	0.18	−0.06
Yield-leaves	0.54*	0.37*	0.30*	0.29*	0.40*	0.36*
Yield-height	0.28	0.49*	0.52*	0.40*	0.33*	0.45*
Alkaloids-flowers	−0.04	−0.05	0.13	0.03	−0.11	−0.06
Alkaloids-leaves	−0.22*	−0.10	−0.05	−0.03	−0.06	−0.02
Alkaloids-height	0.32	−0.13	−0.21*	−0.07	0.03	−0.02
Flowers-leaves	0.21*	−0.35*	−0.22*	0.18	0.10	−0.01
Flowers-height	−0.17	−0.65*	−0.36*	−0.12	−0.20	−0.33*
Leaves-height	0.43*	0.37*	0.33*	0.19	0.28*	0.28*

* Covariance or mean product larger than twice its standard error.

Estimates of additive genetic, phenotypic, and environmental correlations are shown in Table 4. Most of the significant additive genetic and phenotypic correlations between pairs of the agronomic characters (yield, days to flower, plant height, and number of leaves) were positive. An increase in one of the traits by selection would also increase the others. The additive genetic correlation between yield and alkaloids was −0.44, and number of leaves was negatively correlated with total alkaloids (−0.22).

For environmental factors, the error correlations indicated that positive and significant relationships existed among yield, plant height, and number of leaves. Negative relationships were found between days to flower and yield, number of leaves, and plant height. Plant height was negatively correlated with alkaloids in the full-sib families.

The progress expected from selecting and recombining the best 10% of the F_2 plants is given in Table 5.

Table 5. *Expected progress from selecting and recombining the best 10% of the F_2 plants*

Character	Expected progress expressed in	
	Original units	% of biparental progeny mean
Yield	11.33	8.65
Alkaloids	0.19	4.31
Days to flower	3.35	4.78
No. of leaves	0.89	4.08
Plant height	4.69	4.38

These estimates apply when the F_2 plants are selected on the basis of performance of both self and biparental progenies in replicated tests in two environments. For yield, the average performance of a population generated by recombining the selected F_2 plants would be expected to be 8.65% higher than the original F_2 population (the F_2 and biparental progenies were comparable in performance). For the other characters, the expected progress would be 4 to 5%.

Discussion

The two varieties chosen for this study show wide difference in plant morphology. *Ky* 14 has a wide leaf of medium length whereas *Ky Ex* 42 has a long, narrow leaf. Also, the angle between the leaf midrib and the stalk is much wider for *Ky Ex* 42. This gives the droopy characteristic of *Ky Ex* 42 contrasted with the semi-upright position of the leaf on *Ky* 14. In addition to these morphological differences which can be attributed primarily to qualitative factors (Humphrey, Matzinger, and Mann, 1965), the varieties differed in yield and % total alkaloids.

The mean performance of the F_1, F_2, and full-sib families were similar to each other and to the midparent for all characters. This indication of an absence of nonadditive variance was also reflected in estimates of genetic variances where all significant values were caused by additive gene action.

The presence and/or importance of nonadditive genetic variance in populations of burley tobacco is questionable. Diallel studies with released varieties have indicated the presence of some significant estimates of specific combining ability, heterosis, and inbreeding depression. However, the relative magnitude of specific combining ability to general combining ability and the magnitude of heterosis and inbreeding depression have been small. In the present study and two other experiments (Legg and Collins, 1971b, 1971c) designed to estimate σ_A^2, σ_D^2, and σ_{AA}^2, dominance and additive × additive variances have been nonsignificant. These latter studies were conducted with crosses involving varieties and a breeding line from the three major burley breeding programs in the United States. *Ky* 10, *Ky* 12, *Ky* 14, and *Ky Ex* 42 are three recently released varieties and an advanced breeding line from the Kentucky breeding program. Burley 21 represents one of the more widely used varieties from Tennessee, and *Va B*-29 is a recent release from Virginia. The three experiments have been conducted with populations from *Ky* 10 × Burley 21, *Va B*-29 × *Ky* 12, and *Ky* 14 × *Ky Ex* 42. These particular crosses were used to represent crosses between two Kentucky lines, a Kentucky line and a Tennessee line, and a Kentucky line and a Virginia line. Thus, data from these populations should provide conclusive information about genetic variances in crosses between advanced breeding lines. The importance of nonadditive genetic variance for quantitative characters in such populations appears to be nil.

The predominance of additive genetic variance in burley populations suggests the use of breeding methods that lead to the production of pure lines. Under these conditions, the critical factor becomes the choosing of populations with sufficient genetic variance to permit good progress from selection. In selecting a population for improvement, the amount of variance is most important, but the level of performance is also important. If one can choose a highly variable population with good performance, progress toward improved varieties is expected to be highest. If one must choose a lower level of performance, then a large amount of the variation may have to be used to achieve the performance level of advanced varieties.

The expected progress in the present population from one cycle of selection among the F_2 plants ranged from 4.0% for number of leaves to 8.6% for yield. These values are intermediate in relation to those reported for other crops. If this amount of progress could be realized in the initial cycle of selection and if further cycles could be conducted with comparable progress, then the population would be a valuable source of germplasm from which to obtain improved varieties.

The general lack of genotype × environmental interaction in this population is in general agreement with other studies conducted in Kentucky. It would appear that maximum information can be obtained by testing a maximum number of progenies rather than increasing testing environments or replications.

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