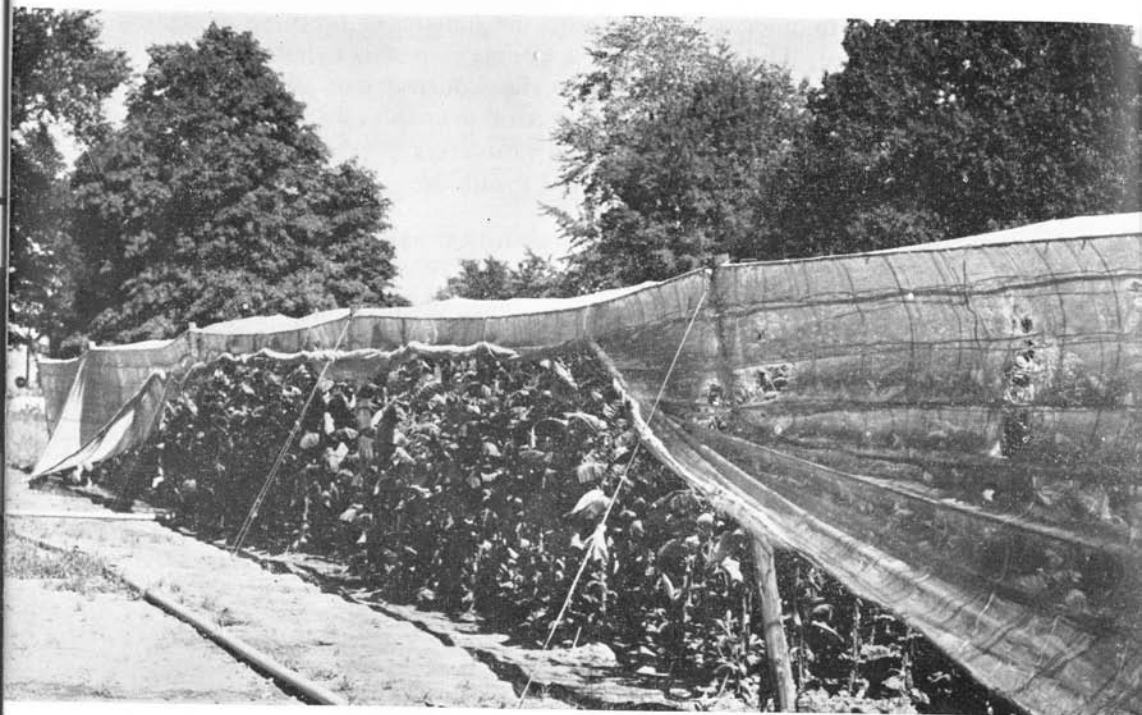


The Pedigree of Connecticut 49 Shade Tobacco

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FOREWORD

Connecticut 49 shade tobacco, both as a commercial cigar wrapper variety and as a basic pool of genes (in which only moderate alterations have resulted in continuing genetic improvements), is a major contribution to the Connecticut Valley tobacco industry. Consequently, the story of the development of Connecticut 49 warrants publication.

Acting as an historian, I have undertaken this task because the background pedigree information pertains to some of my current studies as geneticist working with tobacco at this Station. This information may also be useful to others concerned with the genetics or breeding of cigar wrapper tobacco. The development of Connecticut 49 is a classic example, continuing from the earliest days after the rediscovery of Mendel's work to the present, of the application of genetic principles to crop plant improvement, employing methods which now are a part of our scientific heritage in the realm of experimental evolution.

Seaward A. Sand

ACKNOWLEDGMENTS

The author expresses his sincere appreciation to Dr. D. F. Jones and Dr. P. J. Anderson for supplying from memory background information and details not elsewhere available on nearly 50 years of work in which they played major roles. Their suggestions as to content and their reading of the manuscript have been important aids in the quest for accuracy. The author also acknowledges the assistance of Dr. G. S. Taylor for his help in interpreting the available Station records and correspondence relating to the breeding history. From our integrative work the major pattern of the pedigree emerged. The plants for illustration were grown in 1959, some of the strains from seed that had been stored for 18 years at the Tobacco Laboratory. Credit is due to Mr. B. W. McFarland for original photographs of these plants and leaves and to Mr. Bruce B. Miner for editorial assistance.

COVER PHOTOGRAPH

A small tobacco shade tent sheltering test plots of experimental breeding lines and hybrids being developed by the author at the Tobacco Laboratory of this Station. The picture was taken in August 1959 and shows plants that have been "primed" (leaves harvested successively, from the base of the plants, as the leaves ripen).

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Growing of tobacco under cloth in Connecticut began in 1900 with a small experimental plot in Poquonock under the combined direction of The Connecticut Agricultural Experiment Station and the Division of Soils of the U. S. Department of Agriculture. In the original tests seed of the Sumatra type grown in Florida was used. This variety proved unsuited to shade culture (see cover) for various reasons and seed brought from Cuba was tried. After a few years of selection, the Cuban type became established and its culture spread.

Occasionally, natural hybrids between different types of tobacco had been observed by growers, and these vigorous plants attracted considerable attention. With the rediscovery of Mendel's laws of heredity at the turn of the century there was much interest in the improvement of cultivated plants and domestic animals by cross breeding and selection. Naturally this interest included tobacco, then one of the most important crops in Connecticut. A department of plant breeding was established at this Station in 1905 under the direction of E. M. East. The U. S. Department of Agriculture stationed a number of tobacco specialists in the Connecticut Valley during the growing seasons. These men cooperated with the Connecticut and Massachusetts growers and experiment station workers on problems connected with the growing and processing of tobacco.

Growers themselves made selections of promising individual plants as they appeared in their fields. Consequently many growers had their own strains of various types of tobacco with certain distinctive characteristics.

In 1903 a program of crossing and recombining characters from different types of tobacco was begun by J. B. Stewart of the U. S. Department of Agriculture. One selection from a hybrid of Sumatra and Havana, called Halladay Havana because it was produced on the farm of Mr. Edmund Halladay, had promise and was grown on a considerable acreage for several years. It was not continued because it did not meet the requirements of the cigar manufacturers as well as did the standard varieties.

East, Hayes, and Beinhart made numerous crosses of different varieties and studied recombinations of these for many years. These experiments are described in the Proceedings of the American Breeders Association (1912) and Connecticut Station Bulletins 171 (1912), 176 (1913), and 180 (1914).

RESEARCH IN GENETICS OF CIGAR WRAPPER TOBACCO

The Development of Connecticut Round Tip, 1909-1920

The selection of Round Tip following a hybridization between Sumatra and broadleaf tobaccos has been described by East and Jones (1921) and Jones (1921). Essentially, desirable characteristics of Sumatra and broadleaf were recombined and fixed by 10 generations of selective inbreeding after the original cross in 1909. Valuable qualities of root rot resistance were also incorporated in Round Tip.

The small-leaved Sumatra parent (Figure 2A) typically grows over 6 feet in height and has about 27 leaves (Figure 3A) which are short, round-pointed, and erect. Its leaf length is somewhat less than twice its width, and under Connecticut conditions its cured leaf quality shows a papery texture which is considered inferior to Cuban. The Connecticut Broadleaf parent (Figure 2B) grows about 5 feet in height and has about 20 leaves (Figure 3B) which are long, pointed, and drooping. Its leaf length is somewhat more than twice its width, and its cured leaf has the heavy-bodied quality of cigar binder tobacco and is considered of excellent taste.

By 1920, selection in generations after the cross had yielded a true-breeding tobacco type distinct from either of its original parents. In color and quality of cured leaves it was considered more nearly like Connecticut Havana Seed tobacco, but with some similarity to shade-grown Cuban. It was selected as an outdoor primed type. This variety, Connecticut Round Tip (Figure 2C), has a plant height and erect leaf aspect resembling Sumatra. It is intermediate between its Sumatra and Connecticut Broadleaf parents in leaf number and leaf size and in lightness of body of its cured leaves. It typically has about 22 leaves (Figure 3C) varying from 16 to 26 inches in length. The more nearly round shape and lighter body of the leaves of Round Tip permit it to yield more cigar wrappers per pound than either Havana Seed or Connecticut Broadleaf. Its several advantages resulted in Round Tip being grown commercially under shade cloth for several years both in Connecticut and in Florida, but it was considered to have an objectionable taste. Round Tip was no longer grown by 1934.

The Development of Experimental Strains I and M, 1926-1934

However, Round Tip had many desirable agronomic characteristics upon which further improvements could be built. Its modification in the direction of more adequate shade-grown quality was undertaken by Anderson in 1926 by a cross with regular Stewart Cuban Shade tobacco. This Stewart Cuban variety (Figures 2D and 3D) had been developed by J. B. Stewart from imported Cuban seed by selective inbreeding over a period of 20 years.

The F_1 generation of Stewart Cuban by Round Tip was grown in 1927, and was both self-pollinated and backcrossed (Figure 1) with Cuban. In 1928 thirteen selections from the F_2 generation and nine selections from the first backcross generation were made on the basis of field and cured leaf characteristics of individual plants. Testing and selection was continued in later generations from 1929 to 1934.

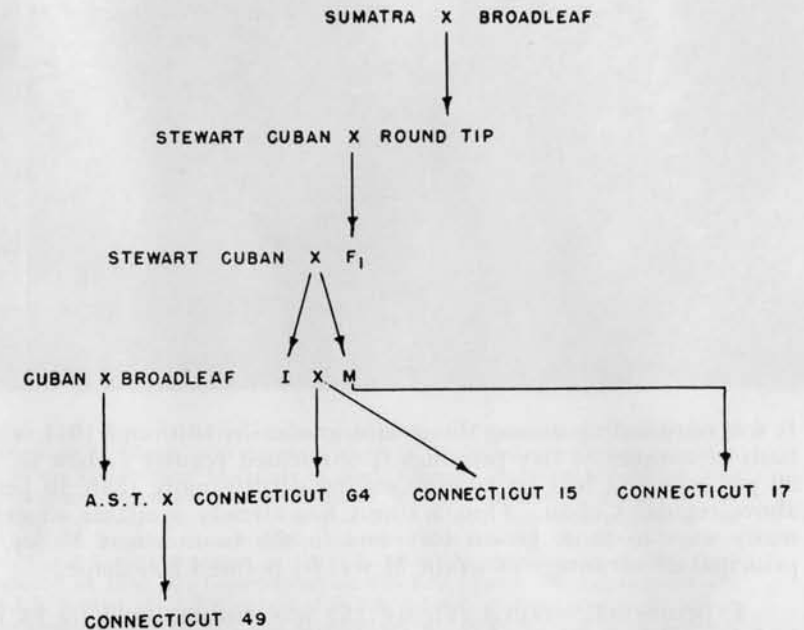


Figure 1. Connecticut shade tobacco pedigree: the main line of progress during 40 years of genetic studies after the original Sumatra \times broadleaf hybridization made by E. M. East at this Station in 1909.

The two experimental strains which ultimately contributed to the pedigree of Connecticut 49 were descended from two different plants of the first backcross generation. The M strain was isolated in 1931 as a third inbred generation following the first backcross. The I strain was isolated in 1934 as a sixth inbred generation after the first backcross. Thus both the I and the M strains represent genetic recombinations from Round Tip and Cuban tobaccos. Characteristics of these strains are described below.

The 1940 Survey

A survey of available shade tobacco material was conducted in 1940. This survey compared several imported types with strains of regular Cuban tobacco then grown in the Connecticut Valley and with Experiment Station strains developed during previous years.

The material was judged for experimental promise from this comparison when grown and handled under similar conditions. No important differences were found among the different growers' strains of regular Cuban tobacco, one of which was thereafter used as a standard by which to determine progress in the breeding program. Seven crosses involving promising strains were made in 1940. These were tested for varying lengths of time, as were their parents and in later years other strains and hybrids. However, attention will be paid here mainly to those strains and hybrids that contributed to the pedigree of Connecticut 49.

Experimental strain M (Figures 2F and 3F), later called Connecticut 17 (Figure 1), was distinguished for the light, uniform color of its leaves.



It was outstanding among the strains graded in 1940 and 1941. On the basis of samples of five primings it outyielded regular Cuban by about 20 per cent and had an average sorting quality more than 30 per cent above regular Cuban. Thus a strain was already available superior in many ways to those grown for years in the Connecticut Valley. The principal disadvantage of strain M was its pointed leaf-shape.

Experimental strain I (Figure 2E) was distinguished by its round leaf-shape (Figure 3E) maintained to the top of the plant and by its large number of leaves (25 to 30). Its major disadvantage was the dark, non-uniform color of its leaves. On the basis of samples of five primings in 1940, strain I was similar to regular Cuban in yield, but its sorting quality was inferior to regular Cuban by nearly 15 per cent.

The Development of Connecticut G4 and Connecticut 15, 1940-1945

The cross (Figure 1) between strains I and M was made in 1940 with the aim of combining the light, uniform color and sorting quality of strain M with the better leaf-shape and larger number of leaves of strain I. Selection in later generations following this cross led directly to both Connecticut G4 and Connecticut 15.

F₁ plants of I × M were grown in the greenhouse during the winter of 1940-41, and an F₂ family was observed in the field in 1941. Twelve individual F₂ plants were selected for well-shaped leaves of light color, and their F₃ progenies were grown in 1942 under the letter designations A through L. Selection G (which led to Connecticut G4) was noted in the field to be uniform with a heavier bodied leaf of deep green color and 2 to 4 more leaves than the other selections. Selection I (which led to Connecticut 15) was considered outstanding in the field for its good leaf shape and light color. Selection I should be distinguished from strain I (Figures 2E and 3E) which was one of its parents. In sorting, the G selection was observed to have a greenish cast and the I selection was noted for its light colors. Both the G and I selections were similar to parental strain M in yield for the same number of primings, but were judged to be slightly inferior to strain M in their average sorting quality.

Figure 2. A 40-year Connecticut tobacco lineage. Mature plants photographed at Windsor in August 1959 represent stages in the breeding program culminating in the Connecticut 49 variety of shade tobacco. A, Sumatra wrapper, like the original Sumatran parent. B, John Williams broadleaf, similar to the original broadleaf parent. C, Round Tip, inbred line maintained at the C.A.E.S. D, Regular Cuban shade, inbred of the C.A.E.S. E, Strain I, grown from C.A.E.S. seed produced in 1941. F, Strain M, grown from C.A.E.S. seed produced in 1946. G, Connecticut 15, C.A.E.S. inbred. H, Connecticut G4, C.A.E.S. inbred. I, A.S.T. strain, C.A.E.S. inbred. J, Connecticut 49, grown from seed produced in 1952 and supplied by Mr. B. B. Barwell of the General Cigar Company. A yardstick is photographed with each pair of plants.

F₄ generations from both the G and I selections were grown in 1943. Six single plant selections were made in each line, and their F₅ progenies were grown in 1944 under the designations G₁ through G₆, and I₁ through I₆. In both 1943 and 1944 the I lines were considered generally superior to the G lines in uniformity, height, number of leaves of good shape and size, and light color. The G lines were judged better in both years for their fineness of veins and smoking taste. However, both selections were consistently better than regular Cuban in yield, sorting quality, and total acre value. In 1944 G₃, G₄, and G₆ were chosen as best of the G's on the basis of sorting quality and total acre value. On the same basis I₃ and I₅ were chosen as best of the I's.

These selections, in the F₆ generation following the cross of strains I × M, were grown in 1945. A summary from sorting data for that year is shown in Table 1. Selections from the parental strain M were called Connecticut 17 (Figure 1). From the hybridization, selection G₄ was called Connecticut G4, and selection I₃ was called Connecticut 15. The advance over regular shade was clear. The principal advantages of Connecticut G4 (Figures 2H and 3H) and Connecticut 15 (Figures 2G and 3G) over Connecticut 17 were their larger number of leaves and improved leaf-shape. These characteristics from parental strain I had been combined with the light, uniform leaf colors of strain M, so that a major goal of the breeding program had been realized.

Connecticut 17, Connecticut G4, and Connecticut 15 have been grown commercially. By 1948 the latter two were being used on more than 1,000 acres in the Connecticut Valley.

The Development of Connecticut 49, 1945-1949

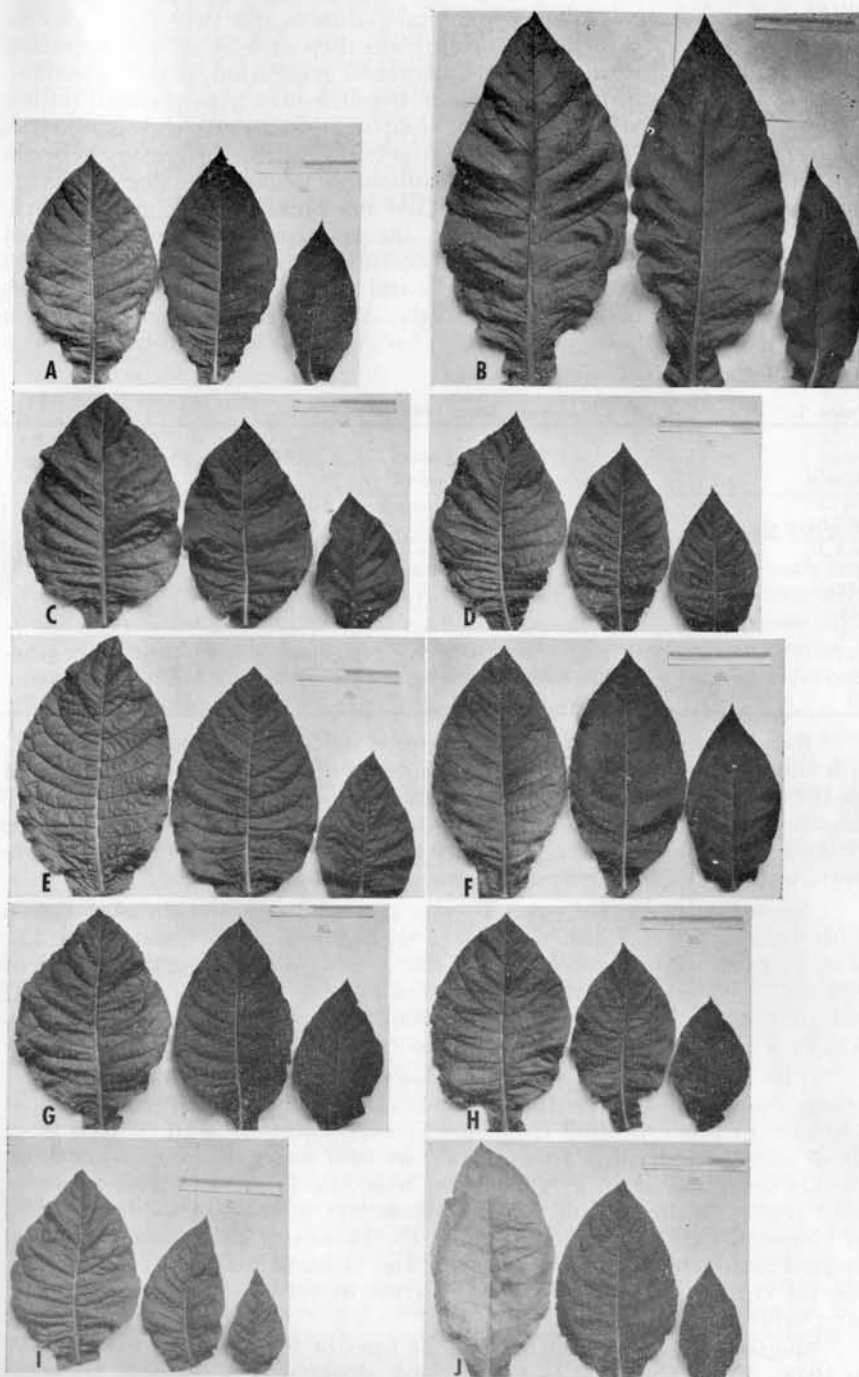
Although Connecticut 15 was a desirable agronomic type of superior sorting quality, it had been criticized by some of the packers and users of shade tobacco for two main reasons. It was considered to have (1) a poorer smoking taste than the regular Cuban strains, and (2) a leaf without enough elasticity or stretch. Improvement was undertaken by crossing with A.S.T.

A.S.T. (Figures 2I and 3I) is a shade tobacco strain first grown and commercially tested by the American Sumatra Tobacco Corporation in 1944. Subsequently, according to Mr. Irving Polumbaum, A.S.T. was widely grown commercially by the Corporation until the advent of Connecticut 49 as an adequately proven new variety in 1952.

The origin of the A.S.T. strain is genetically uncertain. Mr. Polumbaum says that it was first observed in 1941 occurring as six plants consecutively located in one row and noticed at "topping time" in a field of regular Cuban shade tobacco growing in Bloomfield, Connecticut. He further recalls that bagged seed of these six plants was pooled and grown for observation in 1942. According to Polumbaum, this 1942 family showed no visible segregation but was true to the type of the six parental plants. On the other hand, Mr. Lamar Monroe believes A.S.T. to have come from selection after a cross between regular Cuban shade and broadleaf. This also has been the view of P. J. Anderson, who emphasizes, however, that it is for him little more than a notion based upon the characteristic crinkling shown between the veins of A.S.T., its leaf elasticity and its good smoking taste, which are reminiscent of broadleaf characters. Therefore, although definitive information on the pedigree origin of the A.S.T. strain would be of fundamental genetic interest, its origin remains obscure despite the cooperation of these observers.

This obscurity may have arisen because of past commercial secrecy in a competitive field, or because A.S.T. was a chance discovery and not a part of a planned breeding program, or because the early breeding record was not documented.

Figure 3. Typical leaves of the tobacco strains shown in Figure 2 representing stages in the 40-year breeding program outlined in Figure 1. The ruler shown in each photograph is $8\frac{1}{4}$ inches long. The leaves shown for each strain are, from left to right, lower, middle, and upper leaves (highest harvestable) from one typical plant of the strain. Lower and middle leaves were taken at about $\frac{1}{3}$ and $\frac{2}{3}$ the distance from the base of the plant to the upper leaf node. The exact leaf-node position from which each leaf was picked on August 19, 1959 is recorded below. A, Sumatra wrapper, leaves 8, 14, and 21. B, John Williams broadleaf, leaves 5, 10, and 15. C, Round Tip, leaves 8, 16, and 24. D, Cuban, leaves 7, 14, 22. E, Strain I, leaves 8, 16, and 26. F, Strain M, leaves 7, 14, and 21. G, Connecticut 15, leaves 8, 16, and 26. H, Connecticut G4, leaves 8, 16, and 26. I, A.S.T. strain, leaves 8, 16, and 21. J, Connecticut 49, leaves 8, 16, and 24.



We interpret the events described from memory by Polumbaum, including the absence of phenotypic segregation in the 1942 family, to indicate that A.S.T. (if of hybrid origin) was then at least an F_3 generation and almost certainly an even more advanced generation, if the hypothetical cross were with broadleaf. Such an hypothesis of hybrid origin (either chance or controlled) for A.S.T. is compatible with the segregant types recoverable in current experiments involving controlled crosses between broadleaf and shade varieties. Polumbaum's description does not rule out the possibility that A.S.T. originated as a mutant in the genetic background of Cuban shade. However, the relatively large magnitude of genetic and phenotypic differences presently observable between inbred lines derived from the original A.S.T. and Cuban shade types makes this simple mutational origin seem unlikely. We tentatively conclude that a Cuban \times broadleaf origin (Figure 1) for A.S.T. is more probable than a mutational origin.

Table 1. Summary from 1945 sorting data

Strain	Name	Leaves	Yield	Average	Acre
		picked	per acre	Price	
		Number	Pounds	Dollars	Dollars
Regular shade		16	1116	4.01	4480
A.S.T.		17	1165	4.33	5040
17C	Conn 17	20	1711	4.81	8220
17D	Conn 17	20	1466	4.89	7170
G3		22	1830	4.87	8910
G4	Conn G4	22	1557	5.25	8170
G6		22	1768	4.79	8470
I3	Conn 15	22	1712	4.91	8410
I5		22	1764	4.56	8040

Regardless of its origin, Table 1 shows that the performance of A.S.T. was somewhat better than regular shade, as judged from samples sorted in 1945. In addition A.S.T. had a good smoking taste, and a crinkly fullness between the veins contributing to leaf elasticity. To transfer these characteristics of taste and elasticity into the Connecticut G4 and Connecticut 15 background types became a breeding goal.

Accordingly, in 1945 A.S.T. was crossed by Anderson and Green with Connecticut G4 and with I5 (a sister selection of Connecticut 15). The F_1 generations were grown in the greenhouse during the winter of 1945-46. Selection in later generations of the A.S.T. \times G4 cross (Figure 1) led to the development of Connecticut 49, while progenies from the A.S.T. \times I5 cross were judged later to be less desirable.

The F_2 generations of both crosses were grown in 1946, and tall plants showing characteristics of Connecticut G4 and Connecticut 15 in addition to leaf crinkling from A.S.T. were selected. Bulk seed from these selected individuals was grown in 1947 as an F_3 generation from the G4 cross and as an F_3 generation from the I5 cross. Performance of both crosses in the F_2 and F_3 generations was inferior in sorting quality to Connecticut G4 and Connecticut 15. However, preliminary tests indicated satisfactory smoking taste for the crosses. In the F_3 generation the G4 cross was superior to the I5 cross in yield, sorting quality, and acre value.

Single plants were selected and 24 lines of F_4 progenies were grown in 1948. These consisted of 8 selections (designated A through H) from

the A.S.T. \times G4 cross, and 16 selections (designated A through P) from the A.S.T. \times I5 cross. Again, the average sorting quality and acre values were higher for the G4 cross. And in addition, the estimates of smoking taste favored the G4 cross over the I5 cross and over Connecticut 15. The selection (A.S.T. \times G4)A was particularly promising. It ranked next to Connecticut 15 in average sorting quality, and was noted for its fineness of veins, adequate burn, and satisfactory taste. On the basis of taste and sorting quality four selections from the G4 cross and two selections from the I5 cross were continued into the F_5 generation.

Table 2. Summary from 1949 sorting data

Strain	Name	Leaves	Yield	Average	Acre
		picked	per acre	Price	
		Number	Pounds	Dollars	Dollars
Regular shade		19	1068	2.78	2970
Conn 15, 1942		19	1349	3.44	4640
Conn 15, 1948		19	1332	3.55	4730
(AST \times G4)A	Conn 49	19	1431	3.57	5110
(AST \times G4)D		19	1450	3.00	4350
(AST \times G4)F		19	1441	3.39	4890
(AST \times G4)G		19	1323	3.63	4800
(AST \times I5)K		19	1313	3.63	4770
(AST \times I5)P		19	1205	3.61	4350

These families were grown in 1949 and may be compared with controls in the summary from sorting data shown in Table 2. These selections were very similar in grading to Connecticut 15, with some indication that selections from the G4 cross were superior in acre value to selections from the I5 cross. Since previous taste tests had also favored the G4 cross, its selections were considered more promising.

Variation was present in certain field characters among the four selections from A.S.T. \times G4 in this F_5 generation. Although relatively uniform in plant height and in number of leaves of medium-dark color, the four selections varied in leaf shape, vein-coarseness, and amount of leaf crinkle. Considering these factors in conjunction with the sorting data, the selection (A.S.T. \times G4)A was judged most promising and became known as Connecticut 49.

Connecticut 49 (Figures 2J and 3J), with a grading performance similar to Connecticut 15 but with leaves of greater elasticity and with finer veins and an improved smoking taste, represented realization of the major breeding goal. It was favorably received by growers. While segregating for certain plant characters, (A.S.T. \times G4)A was the basic pool of Connecticut 49 germ plasm, which remains today the fundamental gene pool of Connecticut shade tobacco.

Currently, shade tobacco in the Connecticut Valley is mainly of strains derived from Connecticut 49, and to a lesser extent, the related strains derived from Connecticut G4 or Connecticut 15. The major exception is the limited planting of derivatives from a Cuban selection called Fowler Special. Individual grower selections (largely from Connecticut 49) have been carried under different names or numbers, intended to improve the shade tobacco type in ways each grower considered most valuable. Our breeding program at this Station has likewise used the primary Connecticut 49 genotype for continuing experiments in hybridization and selection having many different goals.

SUMMARY

The purpose of this report is to record the pedigree history leading to development of the shade tobacco variety Connecticut 49, now the most widely grown shade type in this area. This pedigree is outlined in Figure 1, which summarizes a main line of progress in selection and breeding experiments at this Station extending through nearly half a century. Figures 2 and 3 illustrate typical mature plants and leaves, respectively, representing plants at ten critical stages (A through J) in the breeding history.

Genetically, the accomplishment represents recombination of characteristics from broadleaf, Sumatra, and Cuban tobaccos into a single inbred type. Initiated by early work on quantitative character inheritance by E. M. East (Hayes, East, and Beinhart, 1913), the program evolved in four principal stages, each building upon previous results. These stages can be described as (1) the development of Round Tip from a cross between Sumatra and broadleaf, (2) the development of experimental strains I and M from a cross between Round Tip and Cuban, (3) the development of Connecticut G4 from a cross between strains I and M, and (4) the development of Connecticut 49 from a cross between Connecticut G4 and an inbred derived probably from a Cuban by broadleaf hybrid. Into the recombination of Sumatra and broadleaf germ plasm produced in stage (1) were introgressed Cuban genes during stages (2) and (3) and additional broadleaf genes in stage (4).

Only those persons principally responsible for direction of the work are mentioned here, but it should be recognized that numerous other individuals contributed to the program. Work leading to development of Round Tip was started by E. M. East, continued by H. K. Hayes and E. G. Beinhart, and completed by D. F. Jones. Subsequently, strains I and M were developed by P. J. Anderson. More recent work was begun in 1940 at the suggestion of and in cooperation with the Research Committee of the Connecticut Valley Shade Growers Association. Major credit for these later projects leading to Connecticut 15 and Connecticut 49 is owed also to P. J. Anderson of The Connecticut Agricultural Experiment Station, and to Allen Green of the Imperial Agricultural Corporation. However, it should be emphasized that the active assistance of many organizations and men in the tobacco industry was essential to success of the program at all stages in its development.

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