CHLOROPHYLL, AGRONOMIC AND CHEMICAL CHARACTERISTICS OF YELLOW TOBACCOS[1]

By G. R. GWYNN and A. G. HAYES[2]

A collection of 30 varieties of tobacco (**Nicotiana tabacum**) with growth characteristics similar to pale yellow Tobacco Introduction 1372 was studied for chlorophyll content, ripening characteristics, and agronomic and chemical properties. The yellow tobaccos had a higher proportion of leaves removed in the first and second harvests than did flue-cured varieties indicating their tendencies toward early maturation. Chlorophyll content did not seem to be related to starch or sugar content and was only slightly related to yield. The entries varied from each other in all characters measured and most entries were below the flue-cured checks in yield and value characters. The total chlorophyll content for the yellow tobaccos was below that of the flue-cured checks.

INTRODUCTION

Some varieties of tobacco, *Nicotiana tabacum*, exhibit leaf appearances that are more yellow than other varieties when grown under flue-cured cultural conditions (1). Certain of these, such as Tobacco Introduction (T.I.) 1372, have been called "pale yellow" but specific chlorophyll characteristics of all representatives of this type of tobacco have not been established. The color characteristics of burley and yellow-green (e.g. 'Consolation') are more familiar and outwardly different from these tobaccos. Most of the reported leaf-color variants in tobacco are controlled by a few genes (2, 3, 4, 5), but the interrelationships between chlorophyll characteristics and agronomic and chemical characteristics of yellow tobaccos are not well known. This paper deals with the type of tobaccos in which the green coloring disappears more rapidly during the growth cycle than ordinary flue-cured tobaccos and which are obviously neither burley nor 'Consolation' types. They are called *yellow tobaccos*.

Producers of flue-cured tobacco are interested in tobaccos that might be harvested earlier in the growing season and harvested in fewer harvests. Because color is an important requisite of harvesting, it might be possible to obtain germ plasm from the yellow tobaccos that would permit earlier harvests and/or fewer harvests. The purposes of this study were 1) to evaluate all the known yellow tobaccos in the Tobacco Introduction (T.I.) collection to see if their yellow color would permit earlier harvests and 2) to measure certain of their agronomic and chemical characteristics.

MATERIALS AND METHODS

Thirty T.I.'s were grown in a replicated field trial at Oxford, North Carolina under flue-cured cultural conditions in 1974. The T.I. entries used, their country of origin, local name and comments from T.I. notes are shown in **Table 1.** These entries were compared to flue-cured varieties 'North Carolina (N.C.) 2326' and 'N.C. 88,' to burley varieties 'Burley 21' and 'Barnett Special,' to yellow green types 'Consolation,' 'Yellow Green (Y.G.) Coker 139,' 'Y.G. South Carolina 58,' to dark tobacco varieties 'Kentucky (Ky.) 160' and 'Little Crittenden' and to a light green Japanese variety 'Ensu.'

Characters measured were total chlorophyll, sampled at mid-season, using the method of Main et al. (6); pounds per acre; dollar value per 100 pounds; index value per 100 pounds; percent starch, percent reducing sugars; and percent total alkaloids. To further characterize the entries, data were taken on number of ground suckers, leaf number, and days to flower.

Single row plots 45 inches apart with plants spaced 22 inches were used and fertilization was according to recommended levels for flue-cured tobacco. Twenty harvested plants comprised each plot and the plants were harvested as the leaves yellowed. Three replications were used in the field in a randomized complete block

[1] *Cooperative investigations of the Oxford Tobacco Research Laboratory, Southern Region, Agricultural Research Service, U. S. Department of Agriculture, and the Department of Crop Science, North Carolina State University at Raleigh, N. C. 27607. Paper No. 4880 of the Journal Series of the North Carolina Agricultural Experiment Station, Raleigh, N. C. Contribution received Feb. 2, 1976; Tob. Sci. XX: 77-79, 1976.*

[2] *Research Agronomist, Oxford Tobacco Research Laboratory, Southern Region, Agricultural Research Service, U. S. Department of Agriculture, Oxford, North Carolina and Associate Professor of Crop Science; and Graduate Assistant, Crop Science, North Carolina State University.*

Table 1. Tobacco Introductions Tested for Yellowing Characteristics.

T.I. No.	Country	Name	Comments
14	Uruguay		Like burley
58	Argentina	Lampazo	
74	Uruguay		Like burley
108	Brazil	Americano draelataena	Yellow color
130	Brazil	Paraense	
132	Brazil	Mineiro	
368	Uruguay	Nacional	
544	Ecuador		
946	Venezuela		
964A	Brazil		
999	Argentina		
1067	Argentina	Lampazo	
1068	Argentina	Hoja Parado	
1082	Argentina	Criollo Saltono	
1085	Argentina	Chileno Colorado Hoja Angosta	
1088	Argentina	Lampazo	Very tall
1089	Argentina	Hoja Parado	
1091	Argentina	Criollo Colorado	
1095	Argentina	Chileno Grande Colorado	Very late
1141	Brazil	Amarellinho	
1143	Brazil	Chinese x Amarellinho	
1300	Bolivia	S.E. Concepcion	Small flower, flue-cured type
1304	Argentina	Aurea	
1305	Argentina		
1372	Argentina	Chicoane #1	Very good variety under Argentina conditions
1419	Brazil	Tiete V-380	
1423	Brazil	Va. V-192	
1425	Brazil	R.S.E.	
1498	Brazil	Rippel	
1499	Brazil	Amarelao	

design. Harvested leaves were flue-cured with no attempt made to vary the cure because of differing leaf appearance. Chemical analyses other than chlorophyll were conducted on the cured leaf. A government grade was assigned to each lot of cured leaf and the average market price was then used in determining value per 100 pounds. An index value was computed by using the government grade and an assigned schedule of values for each grade rather than using market price. This involved assigning low numerical values for poorer grades of tobacco and higher values for better grades (7).

RESULTS

The yield, dollar value per 100 pounds, and index value per 100 pounds are shown in **Table 2.** Yields varied considerably (542–2483 lbs/acre) as one might expect considering the diverse nature of the entries. Although the flue-cured checks had the highest average yield, there were several T.I. entries that were higher. In value per 100 pounds, the flue-cured checks were highest. Other entries with fairly high dollar values were T.I. 1372 and Y.G. 139. Value per 100 pounds was rather low for all entries because the assigned set of values is quite low for any tobacco in the lower quality classes or in certain grades such as the N grades; for example, N2 has a value of 0. The flue-cured varieties were highest in dollar value and value index and the other entries were considerably lower **(Table 2).** Those entries with 0 index values produced leaf which received government grades N2, N1GG, or NOG tobacco throughout. The yellow tobacco entries with highest index values were T.I. 1372, T.I. 1143, T.I. 999 and T.I. 74.

Earliness may be expressed in several ways. One of these is days from transplanting until flowering. Another criterion of earliness is how rapidly the leaves attain an appearance considered to be ripe enough for harvesting. The latter is influenced by the judgement of the harvester and not all entries are treated in the same manner in a group as they would be when grown individually in a commercial planting. Therefore, the measurements we have relative to maturity, particularly rate of harvest, are preliminary. For days-to-flower, the yellow tobaccos fell into four general classes. The earliest group generally took about 45 days to flower and T.I.s 58, 130, 946, 964A, 999, 1067, 1091, 1300, 1372, 1419, and 1425 fell in this group. The second group took approximately 55 days to flower and these included T.I.s 74, 108, 132, 368, 544, 1082, 1088, 1089, 1095, 1143, 1304, NC 2326, and NC 88. The third group took from 65 to 75 days to flower and T.I.s 14, 1068, 1085, and 1423 were in this group. The fourth group was very late and resembled mammoth tobaccos in being late in flowering, tall and with high leaf numbers. T.I.s 1141, 1498, and 1499 were in this group.

Early ripening may be indicated by the amount of tobacco removed in early harvests. In this experiment, the amount of tobacco removed in the first two harvests was expressed as a percentage of the total yield. This indicates how much of the total was removed in the early stages of harvest and thereby indicates the earliness of the entry as far as harvesting is concerned. Although there was some variation among replications, the means across replications are shown in **Table 2.** The amount removed in the first and second harvestings ranged from 30 percent for the dark green Little Crittenden to 75 percent for Burley 21. The flue-cured checks had a mean of 37.5 percent removed in the first two harvests, while the yellow group averaged 53.8 percent. This difference was significant at the .01 level. There were differences among entries in number of ground suckers per plant (range: 0–6.4), days to flower (range:

Table 2. Mean Values for Agronomic Measurements.

Entry	Yield lbs/acre	Value/ 100 lbs. $/cwt	Value Index $/cwt	% Harvested in 1st & 2nd Harvest
Yellow T.I.s				
14	2252	76	7	53
58	588	70	0	67
74	2147	78	10	45
108	1184	77	6	50
130	1349	70	0	55
132	1086	72	3	63
368	1854	78	6	54
544	1354	73	7	62
946	543	70	0	53
964A	542	70	0	68
999	1312	78	14	34
1067	1075	71	2	55
1068	1681	71	1	61
1082	1233	70	0	59
1085	1732	70	1	49
1088	1525	71	1	50
1089	1518	70	0	48
1091	1227	73	3	49
1095	1703	71	2	55
1141	2483	74	5	42
1143	1421	80	15	62
1300	668	72	3	51
1304	1930	71	1	55
1305	1156	71	1	50
1372	2025	91	23	50
1419	1621	71	1	57
1423	1609	71	1	52
1425	607	70	0	56
1498	1915	70	0	55
1499	2233	70	0	52
Mean	1452	73	4	54
Consolation				
Consolation	1188	78	8	43
YG 139	1945	91	20	30
YG SC 58	1418	79	8	36
Mean	1517	83	12	36
Burley				
Burley 21	1376	72	3	75
Barnett Special	1663	71	2	69
Mean	1520	72	3	72
Dark Green				
Ky. 160	1717	80	11	40
Little Crittenden	1376	73	3	30
Mean	1547	76	7	35
Flue-Cured				
NC 2326	1748	96	36	33
NC 88	1483	95	41	42
Mean	1616	96	38	38
Light Green				
Ensu	1304	70	0	38
L.S.D. (.05)*	559	7	8	16
(.01)**	740	9	11	21

*, ** *Differences necessary for significance at the .05 and .01 levels, respectively.*

52–67) and leaf number (range 13.4–32.7) **(data not shown).**

Percentages of starch, total reducing sugars, and total alkaloids were determined on the cured leaves from the lower, middle and upper stalk positions. The averages across stalk positions are shown in **Table 3.** In addition, total chlorophyll for the lower and middle stalk positions as measured at mid-season (56 days after transplanting) is shown in the **same Table.** Statistical analysis revealed an interaction of genotype with stalk position for all characters in **Table 3** with the exception of total alkaloids. This is to be expected for chlorophyll because there were obvious differences in rate of loss of chlorophyll among entries. Some entries were yellow at the lower stalk position and green at the upper stalk position, while others were yellow at both positions; still others were green at both positions. All entries appeared to be green at the extreme upper position at the mid-season sampling. The inconsistencies of varieties over stalk positions followed a varied pattern. Some of these involved differences in degree, while others were clearly differences in rank. If such differences are not due to variation in environment and/or technique, one must conclude that the T.I.s were diverse in their characteristic attributes for starch, sugar and chlorophyll. Although not reported, similar cured-leaf inconsistency existed among entries at different stalk positions for starch and sugars; because these were not characters of primary consideration, only the overall means are presented. Starch levels ranged from 0.20 to 1.20 percent, sugar ranged from 1.42 to 13.15 percent, and total alkaloids ranged from 1.57 to 5.72 percent. Chlorophyll ranged from 1.25 mg chlorophyll per gram of freeze-dried tissue to 7.88 mg at the lower positions and from 4.21 to 10.98 mg at the middle positions.

One of our objectives was to compare the yellow tobaccos as a whole with the flue-cured checks. This comparison was made for all characters and it was found that the flue-cured checks had higher dollar values per 100 pounds, higher index values per 100 pounds, less percent leaves removed in the first two harvests, higher starch levels, higher sugar levels, and higher chlorophyll levels than did the average of the yellow tobaccos. Differences existed among the yellow tobaccos for yield, dollar and index values per 100 pounds as well as in the total alkaloids percentage and chlorophyll content. The comparison between burley and yellow tobaccos indicated that yellow tobaccos and burley tobaccos were not different for any character measured. The 1974 season was generally adequate at Oxford but not exceptional. This together with soil variation common at this station must be considered in a single season comparison such as reported here.

An overall appraisal of the yellow tobaccos does not single out a particular one that is desirable for all characteristics. T.I. 1143 had relatively high quality, early maturity, and an alkaloid level similar to the flue-cured checks. T.I. 1372 showed good yielding ability, relatively good quality but lacked early maturity. T.I. 1419 had a fair yield, reasonably early leaf removal and a level of total alkaloids similar to those of flue-cured tobacco. It would appear that none of the entries are usable for commercial production *as such,* and hybridization with flue-cured varieties followed by selection must be the means whereby the yellow characteristic can be incorporated into flue-cured tobacco varieties. The most promising feature of the yellow tobaccos seems to be the tendency for chlorophyll to disappear more rapidly than in flue-cured tobacco. If this can be managed or manipulated in such a way as to maintain yield, chemical levels, and quality, it may be possible to use these tobaccos in a breeding program that would ultimately develop a variety that could be harvested earlier.

Table 3. Mean Values for Chemical Constituents.

Entry	Starch % Dry Wt.	Sugar % Dry Wt.	Total Alkaloids % Dry Wt.	Chlorophyll† Lower Stalk Positions	Chlorophyll† Middle Stalk Positions
Yellow T.I.s					
14	.37	3.63	3.22	2.34	8.99
58	.52	1.67	2.80	3.16	7.34
74	.30	2.35	3.28	2.61	9.15
108	.43	3.26	3.86	1.65	5.06
130	.28	2.75	3.77	4.28	7.08
132	.37	1.72	3.75	1.29	7.89
368	.35	3.05	3.38	4.76	10.34
544	.52	2.21	4.39	2.39	9.56
946	.62	1.87	4.27	1.34	4.21
964A	.35	1.72	4.37	1.45	6.73
999	.63	4.17	4.27	3.82	7.89
1067	.58	1.78	3.96	2.41	10.60
1068	.37	2.38	2.63	3.39	8.32
1082	.40	1.53	2.91	2.72	9.95
1085	.38	2.03	2.06	2.64	7.27
1088	.78	2.45	4.65	2.39	10.29
1089	.40	2.43	4.48	2.43	10.33
1091	.55	1.97	4.28	4.31	10.56
1095	.43	1.62	2.39	1.60	7.71
1141	.57	2.77	2.77	1.25	8.86
1143	1.05	1.98	2.83	2.61	7.51
1300	.50	1.93	5.72	2.17	5.52
1304	.52	2.02	3.19	1.96	9.34
1305	.55	2.10	5.07	2.87	9.03
1372	.65	4.53	3.59	2.93	8.74
1419	.82	2.35	2.92	2.86	9.93
1423	.47	2.35	3.67	2.79	10.98
1425	.50	1.75	4.07	1.45	5.31
1498	.38	2.53	2.15	3.34	9.36
1499	.38	1.98	2.39	2.59	8.51
Mean	.50	2.36	3.57	2.59	8.41
Consolation					
Consolation	.33	3.62	3.51	1.56	4.46
YG 139	.75	8.53	1.57	2.39	6.66
YG SC 58	.60	2.58	5.73	3.93	7.33
Mean	.56	4.91	3.40	2.63	6.15
Burley					
Burley 21	.33	1.42	2.87	2.07	8.16
Barnett Special	.20	1.53	3.56	1.30	7.30
Mean	.27	1.48	3.22	1.69	7.73
Dark Green					
Ky. 160	.66	6.90	3.84	6.69	9.06
Little Crittenden	1.20	6.33	3.42	7.88	9.51
Mean	.93	6.62	3.63	7.29	9.29
Flue-Cured					
NC 2326	.98	8.08	3.01	5.84	10.56
NC 88	1.13	13.15	2.65	5.95	9.40
Mean	1.06	10.62	2.83	5.90	9.98
Light Green					
Ensu	.40	3.27	3.88	7.16	8.29
L.S.D. (.05)*	.29	3.60	1.56	1.90	2.33
(.01)**	.38	4.76	2.06	2.52	3.09

*, ** *Differences necessary for significance at the .05 and .01 levels, respectively.*
† *Expressed as mg chlorophyll per gm of freeze-dried tissue.*

ACKNOWLEDGMENT

The authors wish to express appreciation for analytical services and advice from Dr. W. W. Weeks, North Carolina State University.

LITERATURE CITED

1. Chaplin, J. F. Inheritance and possible use of pale yellow character in tobacco. **Crop Sci.** 9(2):169–172. 1969.
2. Clausen, R. E. and D. R. Cameron. Inheritance in *Nicotiana tabacum.* XXIII. Duplicate factors for chlorophyll production. **Genetics** 35:4–10. 1950.
3. Henika, F. A. The inheritance of the white burley character in tobacco. **J. Agr. Res.** 44:477–493. 1932.
4. Nolla, J. A. B. Inheritance of *Nicotiana.* I. A study of the glaucous and yellow character in *N. tabacum.* **L. J. Agr. Univ. Puerto Rico** 18:443–462. 1934.
5. Valleau, W. D. Yellow Crittenden—a new mutant in dark tobacco. **Tob. Sci.**:91–92. 1957.
6. Main, C. E., J. F. Chaplin and F. W. Elliott, Jr. Sampling and storage technique for determination of chlorophyll content using green punch samples. **Tob. Sci.**:105–106. 1972.
7. Wernsman, E. A. and E. L. Price. North Carolina Grade Index for flue-cured tobacco. **Tob. Sci.**:74. 1975.