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Screening of Low Tar Flue Cured Tobacco Varieties

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Abstract The main agronomic traits, economic traits, appearance quality, main chemical components, gas composition and physical parameters of 10 flue cured tobacco varieties were investigated in the experiment. And the field natural incidence of the main diseases was investigated. The results showed that main agronomic characters of the 10 varieties were in line with the breeding objectives, among which 5 varieties have good economic characters; 5 varieties have good appearance quality; 6 varieties have coordinated chemical composition and high potassium content; 9 varieties have good smoke components and physical indicators.

Key words Flue cured tobacco, Varieties, Low tar, Screening

1 Introduction

At present, tobacco safety has become a hot spot in the international tobacco industry. The amount of tar produced during tobacco smoking is closely related to the amount of tar released when the tobacco is smoked. The use of low tar flue cured tobacco leaves in the cigarette formula can reduce the amount of cigarette tar and improve the cigarette safety. Due to the different structure and chemical composition of tobacco leaves of different origins, types, varieties, parts and grades, the density and flammability are quite different, and the amount of tar after combustion is obviously different. In the relationship between the amount of tar produced and the content of inorganic nutrients in tobacco leaves, potassium has the greatest effect on the amount of tar produced in the tobacco leaves^[1–3]. Low tar low harm tobacco leaves can promote the sustainable development of tobacco production in Jilin Province. Establishing high-quality low tar filled low harm tobacco production technology and standard system has important realistic significance for improving market competitiveness of tobacco leaves in Jilin Province and ensuring demands of tobacco industry for high quality filled tobacco.

2 Materials and methods

2.1 Materials In this experiment, ten varieties were tested, namely, CF220 (experimental plot No. 7001), CF222 (No. 7002), CF223 (No. 7003), CF224 (No. 7004), Zhongyan 203 (No. 7005), 0408 (No. 7006), NC89 (No. 7007), Jiyuan No. 9 (No. 7011), Jiyuan No. 10 (No. 7012), and 9407 (No. 7013).

2.2 Management of experimental field The experiment field had uniform fertility and flat terrain. Ploughing, harrowing, and ridging were carried out in autumn. On April 20, 2016, the experimental field was sprayed with 3000 times deltamethrin, to prevent underground pests such as *Agrotis ypsilon*. Fertilization standard was pure N 5.5 kg/667 m², N:P₂O₅:K₂O = 1:1.5:3. Besides, we carried out timely weeding, intertillage, prevention

and control of tobacco aphids and tobacco budworms, and active prevention and control of PVY, TMV, CMV and other virus diseases. In the field growth period, we took agronomic measures such as two times of shoveling, one time of earthing up, and one time of pulling up weeds. Besides, the tobacco top was removed in time. After removing the top, buds were inhibited by proper method.

2.3 Experiment design The experiment was carried out in a randomized block arrangement in the field without any repetition. Each variety was planted with 200 m² and the row spacing was 0.5 m × 1.2 m, and the protection line was set up. We made a record of the phenophase of the tested varieties^[4], and investigated the main agronomic traits of the tested varieties and the natural incidence of major diseases in the field. After harvesting, we made statistics of the main economic traits, took 5 kg of the middle leaves of each variety and sent to Tobacco Research Institute of Chinese Academy of Agricultural Sciences for evaluation of main appearance quality, chemical composition analysis, smoke component detection and physical indicator determination.

3 Results and analyses

3.1 Phenophase The results of the field phenology survey of ten flue cured tobacco varieties were listed in Table 1. As can be seen from Table 1, the rosette stage of all varieties was during June 28 and July 4, flower-bud appearing stage was during July 8 and July 17, central flower blooming stage was during July 14 and July 21, and the fly maturity stage was during July 28 and August 5. According and the phenological survey, the experimental varieties were basically suitable for planting during the tobacco area of Jilin Province.

3.2 Main agronomic traits The survey results of main agronomic traits of ten flue cured tobacco varieties were listed in Table 2. As can be seen from Table 2, the plant height of experimental varieties was in the range of 81.8 cm – 121.0 cm, No. 7004 had the shortest plant height (81.8 cm), while No. 7001 had the highest plant height (121.0 cm). The stem girth of experimental varieties was in the range of 9.5 cm – 11.4 cm, No. 7005 had the thinnest stem girth (9.5 cm), while No. 7006 had the thickest stem girth (11.4 cm). The internode length of experi-

mental varieties was in the range of 4.6 cm – 6.8 cm, No. 7004 had the shortest internode length (4.6 cm), while No. 7006 had the longest internode length (6.8 cm). The number of leaves of experimental varieties was in the range of 13.7 – 21.2, No. 7006 had the fewest leaves (13.7), while No. 7001 had the largest number of leaves (21.2). The leaf length of experimental varieties was in the range of 59.8 cm – 71.1 cm, No. 7005 had the

longest leaf (71.1 cm), while No. 7004 had the shortest leaf (59.8 cm). The leaf width of experimental varieties was in the range of 24.6 cm – 28.0 cm, No. 7003 had the widest leaf (28.0 cm), while No. 7004 had the narrowest leaf (24.6 cm). According to the survey results, the main agronomic traits of all varieties conformed to requirements of breeding objectives^[5].

Table 1 Phenophase

Experimental plot No.	Seeding time	Transplantation stage	Rosette stage	Flower-bud appearing stage	Central flower blooming stage	Fly maturity stage
7001	Mar. 15	May 22	Jul. 2	Jul. 17	Jul. 20	Aug. 4
7002	Mar. 15	May 22	Jul. 2	Jul. 16	Jul. 20	Aug. 2
7003	Mar. 15	May 22	Jun. 28	Jul. 9	Jul. 18	Jul. 28
7004	Mar. 15	May 22	Jul. 2	Jul. 8	Jul. 17	Aug. 4
7005	Mar. 15	May 22	Jun. 30	Jul. 10	Jul. 18	Jul. 29
7006	Mar. 15	May 22	Jul. 4	Jul. 15	Jul. 21	Aug. 5
7007	Mar. 15	May 22	Jul. 3	Jul. 19	Jul. 17	Aug. 1
7011	Mar. 15	May 22	Jul. 2	Jul. 9	Jul. 14	Jul. 30
7012	Mar. 15	May 22	Jun. 29	Jul. 13	Jul. 18	Jul. 28
7013	Mar. 15	May 22	Jun. 30	Jul. 12	Jul. 18	Jul. 28

Table 2 Main agronomic traits of tobacco

Experimental plot No.	Plant height//cm	Stem girth//cm	Internode length//cm	Leaf length//cm	Leaf width//cm	Number of leaves
7001	121.0	10.1	5.2	64.30	26.50	21.2
7002	93.7	10.0	5.1	65.40	26.50	16.9
7003	92.1	9.7	5.7	66.80	28.00	14.6
7004	81.8	9.6	4.6	59.80	27.90	15.3
7005	91.6	9.5	5.4	71.10	26.50	14.7
7006	104.7	11.4	6.8	65.50	25.60	13.7
7007	100.5	10.2	6.3	62.80	24.60	15.5
7011	94.8	10.7	6.2	64.70	25.50	14.4
7012	87.7	11.1	5.5	66.70	25.50	13.9
7013	94.7	10.7	6.0	62.80	25.00	13.8

3.3 Main natural disease incidence in the tobacco field The survey results of main natural disease incidence in the tobacco field of ten flue cured tobacco varieties were listed in Table 3. From Table 3, we can know that the PVY and CMV disease index of No. 7004 was the highest (up to 25.00), while the PVY and CMV disease index of other 9 varieties were lower than 5. This showed that except No. 7004 variety was moderately resistant to PVY and CMV, other varieties were resistant to PVY and CMV.

3.4 Analysis of main economic traits The survey results of main economic traits of ten flue cured tobacco varieties were listed in Table 4. From Table 4, it can be known that the output of No. 7001 ranked first (3052.80 kg/ha), and No. 7002 and No. 7003 occupied the second and third position. No. 7006 had the highest output value (26300.93 yuan/ha), while No. 7003 and No. 7005 ranked second and third in the output value. The high quality ratio of No. 7013 ranked first, being 13.74%, and No. 7006 and No. 7004 had the high quality ratio ranked second and third. The high-middle quality ratio of No. 7013 ranked first, being 83.26%, and No. 7006 and No. 7005 had the high quality ratio ranked second and third. The average price of No. 7012

ranked first (14.74 yuan/kg), while No. 7013 and No. 7006 ranked second and third in the average price. In sum, No. 7006 had the best economic traits, the next was No. 7013, then was No. 7003, No. 7005, and No. 7012.

Table 3 Natural incidence of PVY and CMV

Experimental plot No.	PVY disease index	CMV disease index
7001	4.12	1.72
7002	4.80	0.13
7003	3.59	0.25
7004	25.00	25.00
7005	5.55	1.53
7006	3.76	2.10
7007	3.94	0.39
7011	1.72	0.24
7012	2.63	0.50
7013	1.18	0.31

3.5 Evaluation of appearance quality of original tobacco The evaluation results of appearance quality of ten flue cured tobacco varieties were listed in Table 5. From Table 5, it can be known

that No. 7002, No. 7003, No. 7005, No. 7011, and No. 7013 had better appearance quality, their color intensity (gloss) was medium or strong, they had tobacco tar, their colors were deep and

uniform (lemon-orange) , and leaf structure was loose , and leaf thickness was high or moderate; other varieties were general in the appearance quality.

Table 4 Economic traits

Experimental plot No.	Output kg/ha	Output value yuan/ha	High quality ratio//%	High-middle quality ratio//%	Average price yuan/kg	Economic score
7001	3052.80	16533.31	0.00	67.72	13.28	20
7002	2933.40	18203.50	7.70	70.90	13.26	27
7003	2676.15	26185.10	11.22	70.26	14.05	34
7004	2608.05	16722.25	11.91	68.30	12.94	22
7005	2347.20	22153.01	9.95	73.74	14.20	34
7006	2273.10	26300.93	12.30	77.91	14.62	41
7007	2266.95	15652.66	7.53	66.28	12.50	11
7011	2255.55	16975.60	7.48	61.87	14.43	17
7012	2188.20	19905.94	9.65	71.50	14.74	30
7013	1292.25	21592.42	13.74	83.26	14.72	37

Table 5 Appearance quality of original tobacco

Experimental plot No.	Color of original tobacco	Color intensity of original tobacco	Structure of original tobacco	Thickness of original tobacco	Original tobacco tar
7001	Lemon yellow	Medium	Slightly loose	Moderate	Slight
7002	Lemon-orange	Strong	Loose	Moderate	Yes
7003	Lemon-orange	Strong	Loose	Thick	Yes
7004	Lemon-orange	Medium	Slightly loose	Moderate	Slight
7005	Lemon-orange	Strong	Loose	Thick	Yes
7006	Lemon-orange	Strong-medium	Very loose	Thick	Yes
7007	Lemon-orange	Medium	Slightly loose	Moderate	Slight
7011	Lemon-orange	Medium	Loose	Moderate	Yes
7012	Lemon-orange	Medium	Slightly loose	Moderate	Slight
7013	Lemon-orange	Strong-medium	Very loose	Moderate	Yes

3.6 Chemical composition of original tobacco The evaluation results of chemical composition of ten flue cured tobacco varieties were listed in Table 6. According to Table 6, except No. 7011 with the total sugar content in the appropriate range, the total sugar content of other varieties was slightly higher than the standard value; the protein content of all varieties was lower than the standard value^[6]; No. 7005, No. 7011, No. 7012, and No. 7013 had

chlorine content within the appropriate range, while other varieties had chlorine content slightly lower than the standard value^[7]; all varieties had the reducing sugar, K, and starch content within the appropriate range, No. 7003, No. 7011, No. 7012, No. 7004, No. 7002, and No. 7001 had high content of K. The above results indicated that, except No. 7005, the chemical composition of other varieties was relatively coordinated.

Table 6 Chemical composition of original tobacco

Experimental plot No.	Total sugar//%	Reducing sugar//%	Total alkaloid//%	Total N//%	Protein//%	K//%	Cl//%	Starch//%
7001	27.5	21.9	2.24	1.87	4.14	2.04	0.26	3.78
7002	27.6	23.0	2.20	1.84	4.28	2.08	0.29	3.77
7003	27.8	22.4	2.17	1.82	4.34	2.26	0.24	2.79
7004	27.0	21.8	2.16	1.81	4.64	2.10	0.25	3.24
7005	31.0	24.8	2.32	1.95	4.43	1.84	0.30	3.99
7006	27.4	22.7	2.25	1.92	4.46	1.95	0.26	3.67
7007	27.8	22.3	2.45	1.82	3.93	1.90	0.28	3.85
7011	23.7	20.1	2.65	2.05	4.69	2.17	0.36	2.44
7012	28.2	24.4	2.07	1.78	4.25	2.17	0.42	3.60
7013	26.4	20.4	2.38	1.90	4.40	1.87	0.44	2.68

3.7 Smoke components The detection results of smoke components of ten flue cured tobacco varieties were listed in Table 7. From Table 7, it can be known that the total particulate matter,

moisture content, nicotine content and tar content of all varieties were within the appropriate range^[7], indicating that the smoke components of each variety were relatively coordinated.

Table 7 Smoke components

Experimental plot No.	Total particular matter mg/pcs	Moisture mg/pcs	Nicotine mg/pcs	Tar mg/pcs
7001	28.1	1.4	0.8	25.9
7002	28.1	1.5	1.0	25.6
7003	26.8	1.5	0.9	24.4
7004	26.6	1.2	0.9	24.5
7005	29.4	1.6	1.0	26.8
7006	29.0	1.5	1.0	26.5
7007	27.2	1.5	1.0	24.7
7011	26.4	1.2	0.8	24.4
7012	24.8	1.2	0.7	22.9
7013	26.6	1.5	0.9	24.2

3.8 Physical indicators The detection results of physical indi-

Table 8 Physical indicators

Experimental plot No.	Cellulose %	Lignin %	Leaf thickness mm	Single leaf weight//g	Foliar density g/m ²	Filling value cm ³ /g	Equilibrium moisture content//%
7001	7.59	1.26	160.47	13.88	65.21	2.16	13.69
7002	7.40	1.15	159.67	15.21	76.05	2.21	13.35
7003	7.49	1.68	158.53	15.28	76.39	2.25	12.57
7004	7.71	1.29	159.53	12.67	74.35	2.34	12.24
7005	6.94	1.06	161.30	17.93	90.51	2.14	13.14
7006	8.09	1.05	153.63	19.81	78.58	2.21	12.51
7007	7.51	1.11	161.77	16.18	70.85	2.32	12.63
7011	8.66	1.11	191.93	13.92	75.22	2.49	12.73
7012	8.29	1.15	156.10	16.70	73.99	2.31	13.34
7013	8.20	1.01	144.27	15.23	71.73	2.53	12.44

4 Conclusions and discussions

The experimental results indicated that phenological performance of all ten flue cured tobacco varieties are suitable for planting in tobacco area of Jilin Province, agronomic traits also conform to the requirements of breeding objectives, and all have high or moderate resistance to PVY and CMV. For the economic traits, No. 7006 has the best economic traits, the next is No. 7013, then is No. 7003, No. 7005, and No. 7012.

In the aspect of appearance quality, No. 7002, No. 7003, No. 7005, No. 7011, and No. 7013 have better appearance quality, their color intensity (gloss) is medium or strong, they have tobacco tar, their colors are deep and uniform (lemon-orange), and leaf structure is loose, and leaf thickness is high or moderate. As for the physical indicators, No. 7001 has the most coordinated physical indicators, and other varieties (except No. 7005) have relatively coordinated physical indicators.

From the analysis results of the chemical composition of the original smoke, the total sugar content of No. 7011 is within the appropriate range, the reducing sugar, K, and starch content of all varieties are within the appropriate range, and varieties No. 7003, No. 7011, No. 7012, No. 7004, No. 7002, and No. 7001 have high K content. Except No. 7005, the chemical composition of other varieties is relatively coordinated. In the aspect of smoke components, the total particulate matter, moisture content, nicotine content and tar content of all varieties are within the appropriate range, indicating that the smoke components of each variety are

relatively coordinated. The detection results of physical indicators of ten flue cured tobacco varieties were listed in Table 8. As can be seen from Table 8, the cellulose content of each variety was lower than the standard value^[8,9], but the leaf thickness was appropriate; except the leaf density of No. 7001 was more suitable for 65.21 g/m², the leaf density of other varieties were larger than the standard value; the filling value of each variety was smaller than the standard value; however, the equilibrium moisture content was within the appropriate range. Generally speaking, the equilibrium moisture content of tobacco leaves should be higher than 13.5%. In this experiment, the best equilibrium moisture content of No. 7001 was 13.69%. The above results showed that physical indicators of No. 7001 had the most coordinated physical indicators, while other varieties except No. 7005 had relatively coordinated physical indicators.

relatively coordinated.

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