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Results of a narrow field trial of promising Burley tobacco varieties in Dak Lak province in season 2023

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ABSTRACT
Burley tobacco has been growing popularly in the Ea Sup district of Dak Lak province. In 2021, the tobacco area reached 400 hectares and became the largest Burley tobacco growing area in Vietnam. Kentucky 14 variety (KY 14) popularly planted leads to some dangerous pest diseases are severely damaging, such as tobacco aphids (Myzus nicotinae), budworms (*Helicoverpa asulta*), caterpillars (*Spodoptera litura*), Granville wilt (*Ralstonia solanacearum*), especially the Granville wilt incidence from 5 - 30%, some tobacco fields are severely caused on tobacco yield and quality, with incidence > 60%. To identify suitable Burley varieties, diversify tobacco genetic resources and reduce the risks of pests, Vietnam Tobacco Institute tested five prospect varieties (Burley 49, Kentucky 14, Tenessee 90, Banket A1 and CSC) in 2023 in Easup - Dak Lak. The variety experiment was designed with a completely randomized block and repeated three times, with 54 m2/plot. Based on the study results, we collected the CSC Burley varieties that had fair quality, typical of the Burley group by aroma, taste, and heaviness, with aroma (9.6 points), taste (12.1 points), and total smoke point (36 points); excelled in growth, yield, grade of dried leaf; infected low some major pests and diseases, especially the bacterial wilt. Adding a new CSC variety for Dak Lak increases the diversified genetic resources, contribute to increase productivity, quality and income for tobacco growers, and reduces the risk of some important pests in the field.
Keywords*: Burley tobacco, Nicotiana tabacum L., nicotine and sugars content*

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INTRODUCTION

Burley tobacco is one of the four main types/groups of tobacco, including Flue-cured tobacco, Burley, Oriental and brown tobacco, with the second largest annual global production, just behind Flue cured tobacco. The annual demand for Burley tobacco in Vietnam is about 1.300 - 1.500 tons/year. Meanwhile, the annual domestic products of Burley are produced about 500 - 600 tons, only achieving nearly 50% of domestic demand. Forecast the next time, the demand for Burley tobacco materials for domestic cigarette production will increase quikly, both in production and quality.

In Vietnam, the provinces of Dak Lak, Dak Nong, and Gia Lai have suitable climatic conditions for growing burley tobacco, with the air temperature increasing gradually at the growth stages, from planting to harvesting and air curing, low rainfall and air humidity, which is favourable for the drying process of the tobacco leaves. In recent years, the Ea Sup district of Dak Lak province has strongly developed the Burley tobacco area, reaching 400 hectares in 2021 and becoming the largest Burley tobacco growing area in Vietnam, with Kentucky 14 variety (KY 14) popularly planted. Since the KY14 variety has been grown for many years in an ecological region leads to the risks of severe disease epidemics will occur in the coming years if no control measures and variety structure are appropriate. Some major pest diseases is severely harming here as tobacco aphids (*Myzus nicotinae*), budworm (*Helicoverpa asulta*), catepillar (*Spodoptera litura*), Granville wilt (*Ralstonia solanacearum*), especially the Granville wilt incidence from 5 - 30%, some tobacco fields are severely caused on yield and quality.

In order to identify suitable Burley varieties and diversify tobacco genetic resources for the growing area, in period of 2020 - 2021, Vietnam Tobacco Institute tested 11 Burley tobacco varieties which are stored, including some varieties of Burley 21, Burley 37, Burley 49, Burley 64, Kentucky 10, Kentucky 14, Tennessee 86, Tenessee 90, Va 528, Banket A1 and CSC. The results have identified 05 varieties (Burley 49, Kentucky 14, Tenessee 90, Banket A1 and CSC) with high yield, reaching from 2.55 to 2.93 tons/ha and good quality, with a yield rate 1 + 2: 87 - 94%; nicotine: 3.3 - 4.8%; reducing sugar: 0.3 - 1.1%; chlorine content: < 1.29%; are quite good smoke properties and is better than Burley samples imported from India

(Tran Thi Thanh Hao, 2021), the same to the research results of Burley varieties of Somchai Niyomdham, 1986; Jie Chen, 2021; Gupton, 1974 and Heggestad, 1960: Nicotine content: 3.16 - 5.89% and reducing sugar: < 5.9% and chlorine < 2.9%. To ensure safe and Burley tobacco sustainable growing, increase good yields and quality, minimize damage caused by pests and diseases, especially bacterial wilt, selecting the varieties with high yield, quality and low pest and disease infection plays an important role in tobacco production in Dak Lak region.

MATERIAL AND METHODS

The study area

The experiment was conducted in the Ea Sup district, Dak Lak province, Vietnam, from December 2022 to May 2023. This area had suitable climate and soil conditions for producing Burley tobacco, with every year average temperature was 24^{o}C, a max average temperature of 34^{o}C, and min average temperature of 18 - 20^{o}C. From December 2022 to May 2023, it was dry, hot, and sunny, with little rain and low air humidity, with average air humidity ranging from 35 - 78% and rainfall of 1.6 - 14.8 mm, which was favourable for growth and air curing of Burley tobacco.

The soil analysis data in Ea Sup district - Dak Lak province in 2023: Total nitrogen (N): 0.96 mg/g, phosphate (P_2O_5): 0.06%, and potassium (K_2O): 0.16%. The available substance (mg/100g soil) of N was 5.03, P_2O_5: 2.46 and K_2O: 4.12. The total organic was 1.78%, pH_{KCL}: 4.24, chlorine (clo): 27 ppm, Ca^{2+}: 3.38, and Mg^{2+}: 0.53.

Material and Object

Five burley tobacco varieties collected from 11 burley varieties tested in 2021 in the Ea Sup district - Dak Lak province included: Burley 49, Kentucky 14, Tenessee 90, Banket A1 và CSC, with fertilizer types: N: NH_4NO_3 and Ure, P: $Ca(H_2PO_4)_2$, and K: K_2SO_4. Kentucky 14 variety was popularly planted in the field.

Experimental Field

Tobacco seeds were sown on a free pathogen nursery. The seedlings reaching 4 - 6 leaves were transplanted in the experimental field, with a specified distance from plant to plant: 45 cm and space between lines: 90 cm. Rate of fertilizers: Based on soil analysis data and experimental field in 2021 Dak Lak province, the fertilizer formula was: 190N: 110P_2O_5: 260K_2O kg/ha. Fertilized 1st time after planting about 9 days, with 40% N + 50% P_2O_5 + 50% K_2O (120 kg Ure + 115 kg DAP + 250 kg K_2SO_4) and 2nd time: 23 days after tranplanting, with 60% N + 50% P_2O_5 + 50% K_2O (115 kg DAP + 290 kg NH_4NO_3 + 250 kg K_2SO_4 kg/ha). The variety experiment was designed with a completely randomized block, repeated 3 times, with 54 m^2/plot. The experiments were tranplanted on December 5th 2022.

The air curing barn was built with a size: length: width: height was 9 x 5 x 2,5 m, with tow floors for air curing and a dark tarpaulin covering all around. The technical mature leaves were picked and skewered with sticks with a length of 80 cm. The space between the tobacco skewers was 15 cm.

The Target Surveillance

The cultivatable technique of Burley tobacco is based on the technical process of Vietnam Tobacco Institute and Hoa Viet company limited; Evaluation of growth, the number of leaves, plant height, and yield parameters follows the National Technical Regulation on testing the value of cultivation and use of dried yellow tobacco varieties following QCVN 01- 85: 2012/BNN & PTNT, Vietnam; Rate of grade: Standard of Hoa Viet company limited, Vietnam; Leaf tobacco - Sensory evaluation by scoring method: Vietnam national standard, TCVN 13583: 2022.

Analysis of chemical components follows the standard of Vietnam as Nicotine: TCVN 7103: 2002 (ISO 2881:1992), total nitrogen: TCVN 7252: 2003, sugar: TCVN 7102: 2002 (CORESTA 38: 1994) and chlorine (clo): TCVN 7251: 2003.

Data collection was treated by Software of Excel and Statistics 8.2.

RESULTS AND DISCUSSION

Narrow field trial of some Burley tobacco varieties in Dak Lak

Growth and development levels of Burley tobacco varieties

The results of monitoring the growth and development time of Burley tobacco varieties grown in Dak Lak province in the season 2023 are in Table 1.

Table 1. Growth time of Burley tobacco varieties grown in Dak Lak province in 2023

No	Variety	Growth time from planting to (days)		
		50% buds	First ripe leave	Last ripe leave
1	Burley 49	57.3	61.0	110.0
2	Kentucky 14 (KY14)	58.7	61.0	112.0
3	Tenessee 90 (TN90)	62.0	61.0	112.0
4	Banket A1	59.3	61.0	112.0
5	CSC	59.7	61.0	112.0

Planting to budding time: All varieties of Burley tobacco grown in Dak Lak province, in 2023 had a budding time of 50% of the plants ranging from 57.3 to 62.0 days after planting (DAP). Tenessee 90 variety had the latest budding time, at 62.0 DAP; then Banket A1 and CSC (59.3 - 59.7 DAP); and the earliest variety was Burley 49 (57.3 DAP). Meanwhile, Kentucky 14 (KY14) popularly grown, had a budding time of 50% of the plants with 58.7 DAP.

The time of the first ripe leaf and final harvest of most varieties were the same each other, with 61.0 DAP and 112.0 DAP, respectively, except Burley 49 had a faster ripe leaf rate than other varieties, with a final harvest time of 110 DAP.

Thus, five varieties of Burley tobacco grown in Dak Lak are not much difference in growth time, first leaf ripening and final harvest compared with the KY14 variety, so these varieties are suitable for crop variety structure here.

Results of the experiment showed that the flowering time of most Burley varieties grown in Dak Lak region is relatively consistent with the characteristics of the variety type announced by the variety producer. According to the results of C. A. Wilkinson et al., 1996, the KY14 variety had a flowering time of about 57 DAP, TN 90: 60 DAP, Burley 49: 73.4 DAP (C. L. Gupton M. and O. Neas, 1974).). Varieties KY14, TN90, Banket A1 (O.L.P. Mulekano et al., 2003) and CSC had a moderate mature leaf, except Burley 49 was the late ripe variety (University of Kentucky, C. L. Gupton M. and O. Neas, 1974). However, when planted in Vietnam in 2023, Burley 49 variety had a faster ripe leaves rate, but the difference was not much compared to other varieties, only two days earlier. According to the evaluation results of 11 Burley gene sources of the Vietnam Tobacco Institute in Dak Lak region in 2021, these five gene sources were also not much different in the percentage of ripe leaves, ranging from 121 to 124 DAP. The early mature time and leaf maturity of Burley 49 grown in Vietnam may be due to the variety's response to regional ecological conditions.

Some growth parameters of Burley tobacco varieties

Table 2. Some growth parameters of Burley tobacco varieties grown in Dak Lak region

No	Variety	Topping height (cm)	Stem diameter (cm)	Harvesting leaf number (leaf)	Leaf size of middle leaves	
					Length (cm)	Width (cm)
1	Burley 49	107,0 ^{c}	3,24 ^{b}	26,8 ^{a}	69,9 ^{a}	27,0 ^{d}
2	Kentucky 14	113,7 ^{c}	3,34 ^{ab}	27,4 ^{a}	70,3 ^{a}	31,1 ^{b}
3	Tenessee 90	155,2 ^{a}	3,35 ^{ab}	23,3 ^{b}	65,7 ^{b}	32,9 ^{a}
4	Banket A1	123,9 ^{b}	3,26 ^{b}	26,3 ^{a}	63,6 ^{b}	32,4 ^{ab}
5	CSC	111,6 ^{c}	3,46 ^{a}	22,9 ^{b}	71,1 ^{a}	29,6 ^{c}
CV(%)		*4,29*	*2,29*	*3,6*	*2,07*	*2,4*
$LSD_{0,05}$		*9,9*	*0,14*	*1,7*	*2,7*	*1,4*

Note: Same letter are not significantly different at 95% confidence level

The topping height of plants, the diameter of the stem, the harvesting leaf number and the size of the leaves are the growth indicators that affect the tobacco yield, quality, and tolerance of the variety to environmental conditions, such as wind, sun, drought, etc. The results of monitoring the growth parameters of Burley varieties grown in Dak Lak region are in Table 2.

The topping height of five promising Burley tobacco varieties grown in Dak Lak province in the season 2023 had a length of 107.0 - 155.2 cm. The Tenessee 90 variety had the longest topping height, reaching 155.2 cm, then Banket A1 (123.9 cm), and the lowest was Burley 49, with 107.0 cm. Statistically, there is no significant difference between Burley 49, Kentucky 14 and CSC varieties.

Stem diameter: CSC variety had the largest stem diameter, reaching 3.46 cm and had a statistically significant difference from other tobacco varieties. The Burley 49, Tenesee 90, Kentucky 14 and Banket A1 had smaller stem diameters, ranging from 3.24 to 3.35 and are not significantly different between them.

The harvesting leaf number: Among the 5 experimental tobacco varieties, KY14, Burley 49 and Banket A1 had the highest harvesting leaf number, reaching 26.3 to 27.4 leaves/plant and there was no statistically significant difference between them. Similarly, Tenesee 90 and CSC varieties had the lowest harvesting leaf number, only achieving 22.9 - 23.3 leaves/plant.

The length and width of tobacco leaves play an important role in affecting yield, quality, leaf shape, leaf thickness, field cover measure, etc., leading to a decrease or increase in the photosynthetic efficiency of plants, and pest diseases. With leaf length, CSC, Kentucky 14, and Burley 49 varieties were the long leaf group, ranging from 69.9 to 71.1 cm, and there was no statistically significant difference. Other varieties, such as Tenesee 90 and Banket A1 had shorter leaf lengths, with long leaf ranging from 63.6 to 65.7 cm. Leaf width, Tenessee 90 variety was the largest leaf width, reaching 32.9 cm, and significantly different from other varieties, then Kentucky 14 and Banket A1: 31.1 - 32.4 cm, CSC: 29.6 cm and the narrowest leaves was Burley 49 (27.0 cm). When considering each length or width separately, it only partially determines the yield and quality of tobacco. The leaf shape will determine the main because it helps maximise photosynthesis, create ventilation and reduce pests in the field. Therefore, in the five experimental varieties, Kentucky 14 and CSC varieties had leaf shapes in accordance with the above requirements. For varieties, Burley 49 had long and narrow leaves that reduced the photosynthetic efficiency of the plant, affecting yield and fresh/dry ratio; Tenessee 90: short leaves and broad leaf plate when planted will increase field cover, especially at high densities, resulting in reduced photosynthetic efficiency, thin leaves, reduced fresh/dry ratio and increased levels of pest infestation. Through the experiment of 5 burley varieties in Season 2023, the topping height and stem diameter of these varieties are consistent with the results of the experimental evaluation of 11 tobacco gene sources in 2021 in Dak Lak, in which the TN90 variety had the highest topping height and stem diameter and the lowest is Burley 49.

Figure 1. Burley tobacco Varieties: G1: Burley 49, G2: Kentucky 14, G3: Tenesee 90, G4: Banket A1, and G5: CSC. G3II: After spaying leaf nutrients, upper young leaf symtompt with Calcium deficiency; G3: The new young and bud is severely deformed

The pest infested ratio of Burley tobacco varieties

The investigation results in Table 3 showed that there are six main pests in the field, including Tobacco aphids (Myzus nicotinae), budworm (Helicoverpa asulta), catepillar (Spodoptera litura), Granville wilt (Ralstonia solanacearum) and nutritional deficiency disease (Ca^{2+}).

- Tobacco insects

Tobacco aphids appeared a lot on Burley 49 and caused moderate damage, with a damage rate of 100% and high aphid density, over 50 insects/upper leaves. For other tobacco varieties, aphids appeared from 9.8 to 11.3% and caused insignificant to mild damage, with aphid density on the upper leaves less than 20 individuals/leaf.

Caterpillars appeared with a frequency from common to many on burley tobacco varieties in the season of 2023, with a damage rate of 7.9 - 26.7% and a density of about 20 caterpillars on the tobacco plants. They appeared a lot on Kentucky 14, Tenesee 90, Banket A1 and CSC varieties, with the damage rate ranging from 16.2 to 26.7% and appeared commonly on the Burley 49 (7.9%). The caterpillars caused damage mainly on the lower leaves at the stage of the plant' bud. Due to the spraying of insecticides, insects caused only mild harm. Based on the characteristics of the variety, Kentucky 14, Tenesee 90, Banket A1 and CSC varieties with many leaves, large leaf sizes are often more severely damaged than varieties with small leaf sizes. Burley 49 variety has a small leaf blade leads to a well-ventilated plant, with more sunlight shining on the lower leaves, lead to being less suitable for Caterpillars to thrive. Because they only thrive at high humidity, from 85-95%, the fields are luxuriant and scattered with lots of light (Nguyen Van Chin, 2021), so the tree has many leaves, especially the too-large leaf blades is favourable conditions for harmful Caterpillars.

Tobacco budworms are an important insect in tobacco cultivation in Vietnam and many countries in the world, and harm to many tobacco types such as Flue-curing tobacco, Burley, cigars, etc. In the Burley tobacco varieties grown in Dak Lak, in 2023, tobacco budworms appeared from little to common levels, with a damage rate of 1.8 - 7.4%. Tenessee 90 and Banket A1 varieties' large leaf sizes were severely damaged, with a damage rate of 6.7 - 7.4%, while Burley 49 with small leaf sizes was few infected, with a damage rate of 1.8%.

- Tobacco diseases

Bacterial wilt disease: Some burley tobacco varieties selected for experiment in Dak Lak are high resistance to tobacco mosaic virrus, black shank, root rot and yellow wilt, but are susceptible to the bacterial wilt caused by *Ralstoria solanacearum* (G C. A. Wilkinson et al., 1996 and O.L.P. Mulekano et al., 2003). The survey results in Table 3 showed the burley tobacco varieties infected with bacterial wilt, with disease rates ranging from 1.3 to 2.3%. In that, Kentucky 14 and Banket A1 varieties had high disease rates of 2.3%; then CSC and Burley 49 varieties (1.8%); and the lowest infection rate was Tenessee 90 (1.3%). According to field investigation results in Dak Lak, KY14 popularly planted in the field, was infected with heavy bacterial wilt and stem rot (*Erwinia* sp), with a disease rate of 10 - 30%; some severely infected fields was over 60%. Therefore, the selection of low infectious varieties is neccesary to prevent the bacterial wilt.

Tobacco leaf curl virus: Currently, most types of tobacco, such as Flue curing tobacco, burley, etc. do not have resistant varieties to tobacco leaf curl virus caused by Begomovirus. Therefore, the burley varieties in Dak Lak were all infected with the disease, with disease rate from 0.5 to 6.4%. Tenesee 90 variety had the highest rate of infected plants, with a disease rate of 6.4%; then Kentucky 14 was 3.6%, and the lowest infection was the CSC variety (0.5%).

Calcium deficiency disease (Ca): The burley tobacco varieties tested in Dak Lak showed calcium deficiency, with a 100% infection rate, and caused by mild to severe damage. In that, Tenesee 90 had the most severe symptoms of calcium deficiency, with heavily curled leaf edges down, young leaves and deformed tops; Burley 49 and Banket A1 had moderate damage, the young leaves had curled margins downwards, and the tops and young leaves were slightly deformed; Kentucky 14 and CSC varieties were the mild symptoms of damage. After spraying once times with calcium-rich leaf nutrients, Burley 49 and Banket A1 varieties showed mild calcium deficiency, only slightly affecting leaf development; Kentucky 14 and CSC cultivars had no symptoms after spraying. Particularly for the Tenesee 90 variety, after spraying, the leaves developed later still had moderate calcium deficiency symptoms and affected development of leaf. Ca deficiency symptoms caused moderate damage, and some tobacco fields were severely damaged on the variety KY14 popularly grown in Dak Lak, as well as some fields planted with flue-curing tobacco, K326 variety. Symptoms of Ca deficiency on tobacco leaf in Dak Lak are caused by acidic soil and poor Ca^{2+}. Based on the soil analysis data, tobacco growing soil in Dak Lak have pH_{KCL} = 4.2 and Ca^{2+}: 3.3 mgđl/100g soil. Meanwhile, tobacco growing soil in other areas with no symptoms of Ca deficiency has pH_{KCL}: 5.4 - 7.7 and Ca^{2+}: 5.4 - 11.3 mgdl/100g of soil. Thus, acidic soil with pH_{KCL} < 5 causes symptoms of Ca deficiency in tobacco plants. According to Matthew Vann et al., [15], soil pH ranges from 5.8 to 6.2, and the amount of

easily digestible Ca and Mg in the soil is high enough to provide for plant growth and development. When pH < 5.5, have to fertilize Ca by dolomite limestone, with 45 - 55kg/ha.
Thus, through the levels of pest infestation of Burley tobacco varieties grown in Dak Lak, in 2023, it is possible to select CSC varieties to add to the variety structure to diversify genetic resources and limit some majorly pests and diseases.

Table 3. The pest infested levels of Burley tobacco varieties in Dak Lak province in 2023

No	Variety	Insects and diseases incidence (%)						
		Aphid	Caterpillar	Budworm	Bacterial wilt	Tobacco leaf curl virus	Ca deficiency	Severe levels
1	Burley 49	100	7,9	1,8	1,8	1,5	100	++
2	Kentucky 14	10,6	24,2	3,6	2,3	3,6	100	+
3	Tenessee 90	10,5	26,7	6,7	1,3	6,4	100	+++
4	Banket A1	11,3	20,0	7,4	2,3	1,8	100	++
5	CSC	9,8	16,2	3,4	1,8	0,5	100	+

Yield and quality of Burley tobacco

The Burley tobacco yield
The results of monitoring some indicators constituting yield, yield and quality of Burley tobacco varieties are in Table 4.

Table 4. Yield and quality of Burley tobacco in Dak Lak province in 2023

No	Variety	Fress weight (g/leaf)	Fresh/dry ratio	Yield (tons/ha)	Grade 1+2 (%)	Leaf stem ratio (%)
1	Burley 49	62,0	8,5	2,79 ^{b}	83,2	34,0
2	Kentucky 14	66,0	7,5	3,49 ^{a}	93,2	34,7
3	Tenessee 90	67,7	8,6	2,91 ^{b}	85,6	33,3
4	Banket A1	57,0	7,6	3,37 ^{a}	93,8	35,3
5	CSC	67,3	8,4	3,46 ^{a}	92,4	39,3
CV(%)		-	-	*6,78*	-	-
$LSD_{0,05}$		-	-	*4,09*	-	-

Note: Fress weight by middle leaves

Fresh leaf weight is one of the indicators affecting tobacco yield, especially the fresh yield of the plant. In the five burley tobacco varieties tested in Dak Lak, the average fresh leaf weight of all varieties ranged from 57.0 to 67.7 g. The variety with the highest yield of fresh leaves was Tenessee 90, reaching 67.7 g; then CSC: 67.3 g, Kentucky 14: 66.0 g; and the lowest was Banket A1 (57 g). The fresh yield of the variety was positively related to the dry yield of the plant, but this was not enough but closely related to the dry matter accumulation capacity of the plant. The variety with high fresh yield and good dry matter accumulation will achieve the highest commercial yield value.
Fresh/dry ratio influences the dry yield and tobacco quality, as reflects the photosynthetic efficiency and the ability to transport and accumulate dry matter in the plant. Most varieties with a low fresh/dry ratio will have high yield potential and good quality, and vice versa. Experimental results in Table 4 showed that Kentucky 14 and Banket A1 varieties had the highest dry matter accumulation capacity, with a fresh/dry ratio from 7.5 to 7.6; then to CSC (8.4); The lowest are varieties Burley 49 and Tenesee 90, with fresh/dry ratios of 8.5 and 8.6, respectively.
Yield and grade of tobacco: The Burley tobacco varieties tested in Dak Lak in 2023 had high yield, ranging from 2.79 to 3.49 tons/ha. The two highest yield burley varieties are Kentucky 14 and CSC, reaching 3.46 - 3.49 tons/ha. But with statistical significance, Kentucky 14, CSC and Banket A1 were the highest yield and did not differ significantly, with yields ranging from 3.37 to 3.49 tons/ha. Burley 49 variety had the lowest yield and grade 1+2: 2.79 tons/ha and 83.2%, respectively.

The grade of tobacco, the experimental varieties had a high rate of grade of dried leaves, with grades 1+2 ranging from 83.2 to 93.8%. The Kentucky 14, Banket A1 and CSC had the highest percentage of grade 1+2 dried leaves, reaching 92.4 - 93.8%. Other varieties, such as Tenesee 90 and Burley 49, had the lowest percentage of grade 1+2, below 85%.

Leaf stalk rate: The rate of leaf stalk affects the yield of product recovery of tobacco leaves in processing. If the stalk ratio is too high, it reduces the recovery yield and causes economic losses to tobacco material production. The leaf stalk rate of the five experimental tobacco varieties was from 33.3 to 39.3%. The Burley 49, Kentucky 14, Tenesee 90 and Banket A1 varieties had low leaf stalk rates, from 33.3 - 35.3%. The CSC variety had the highest stalk rate, up to 39.3%.

Based on the biological characteristics of the Burley varieties, such as plant height, number of leaves, and leaf size, especially the leaf width, leaf shape, etc., we can initially predict the yield and fresh/dry rate of the plant. For exmple, the Burley 49 variety, with a low topping height (107 cm), many leaves (26.8 leaves) and leaves are too close together on the stem, and narrow leaf width will give a low yield (2.79 tons/ha) and a high fresh/dry ratio (8.5). In contrast to Burley 49, Tenessee 90 is the tallest plant height, reaching 155.2 cm and little leaves number (23.3 leaves), short leaf length, and too wide leaf plate (32.9 cm) will be low yield and high fresh/dry ratio, with 2.9 tons/ha and 8.6, respectively. Meanwhile, varieties with reasonable height, leaf number, leaf shape and internode length will have high yield potential and a low fresh/dry ratio. The proper technical measures and good biological characteristics of the variety that make all leaves the best photosynthetic ability will give high yield and good quality.

Experimental results in Dak Lak show that the yield and grade 1+2 of burley varieties are high, equivalent to or higher than the average yield of many countries in the world. For example, the average yield of varieties in Season 2023 reach 3.2 tons/ha and grade 1+2 (good grade) is approximately 90%. Similarly, in 2021, yield and grade 1+2 are 2.8 tons/ha and 92%, respectively (Tran Thi Thanh Hao, 2021). According to the results of the burley tobacco variety trial from 1991 to 1995 by the Southwest Virginia Agricultural Research and Extension Center, USA, the average yield and grade 1+2 ratio of Kentucky 14 are 2.99 tons/ha and 73.6%, respectively; Tenesee 90: 2.96 tons/ha and 80.8% (C. A. Wilkinson et al., 1996); Tested results at the University of Tennessee, Burley 49 has an average yield (1969 - 1972): 2.43 tons/ha and grade 1+2: 55.5% (C. L. Gupton M and O. Neas, 1974); Banket A1: 3.1 tons/ha (By D. F. LAPHAM; O.L.P. Mulekano, 2003); and CSC: 2.4 - 2.6 tons/ha and 68 - 71% (SYED MEHAR ALI SHAH et al., 2009).

Chemical compositions and smoking properties of Burley tobacco varieties

Chemical composition

Table 5. Chemical composition of Burley tobacco varieties in Đak Lak province in 2023

No	Variety	Chemical composition (%)			
		Nicotine	Total nitrogen	Reducing suger	Clo
1	Burley 49	4,50	3,43	0,9	0,99
2	Kentucky 14	4,56	3,98	0,5	1,11
3	Tenessee 90	4,38	3,34	0,4	0,53
4	Banket A1	4,90	3,28	3,0	0,73
5	CSC	3,87	3,11	2,2	0,65

The results of the chemical composition analysis of burley varieties in Table 5 showed:

Nicotine content: Burley tobacco varieties had too high nicotine content, ranging from 3.87 to 4.9%. The Banket A1 variety had the highest nicotine content, reaching 4.9%; then to Burley 49 and Kentucky 14: 4.5 - 4.56%; The lowest is the CSC variety, with a nicotine content of 3.78%.

Reducing sugar of Burley tobacco varieties was low compared to dried yellow tobacco, ranging from 0.4 to 3.3%. The Tenessee 90 and Kentucky 14 had low sugar content, only 0.4 - 0.5%; Then Burley 49: 0.9%; Banket A1 and CSC varieties had the highest reducing sugar content, reaching 3.0% and 2.2%, respectively.

The chlorine content of burley tobacco in the season 2023 is low, from 0.53 to 1.11%, an average of 0.8% and lower than in 2021 (chlorine content: 0.92 - 1.29%, an average of 1.2%) leading to good quality of burning material, improving quality and aroma.

Burley tobacco had a high nicotine content and low reducing sugars are characteristic of this group's tobacco. The results of testing 11 genetic resources of the Tobacco Institute in the season 2021 in Dak Lak also showed that the burley had high nicotine and low reducing sugar content, respectively from 3.31 to 4.65% and reducing sugar: 0.3 - 1.6%. Compared with the published research results, the nicotine content of the varieties tested in 2023 in Dak Lak is consistent with the characteristics of the variety. According to the research of Gupton (1974), the nicotine content of Burley 64: 3.16 - 3.47%, Burley 49: 3.12 - 3.25%, Burley 21: 3.56 - 4.72% (Heggestad, 1960); Kentucky14: 5.89%, Burley 1: 5.49% (Somchai Niyomdham, 1986); Banket A1: 4.11% [10], 1.75 - 3.56 (D. F. LAPHAM. 1976); Tennesse 90: 4.3 - 4.8% (Lewis, 2020), Yunbai 3: 4.84% [6]; CSC: 2.3 - 2.5% [9]. Reducing sugar content of Kentucky 14: 5.89%, Burley 1: 5.49% [12], Yunbai 3: 4.38 (Jie Chen, 2021); CSC: 1.3 - 1.8% [11].

Smoking properties of Burley tobacco varieties

Table 6. Results of smoking properties of Burley tobacco varieties in Đak Lak province in 2023

No	Variety	Flavor	Taste	Heavy degree	Burning degree	Colourful fibers	Total points
1	Burley 49	9.8	11.4	6.0	3.0	5.0	35.2
2	Kentucky 14	9.5	11.8	6.1	3.6	4.8	35.8
3	Tenessee 90	9.1	11.3	6.2	2.8	4.5	33.9
4	Banket A1	9.2	11.7	5.8	3.4	5.0	35.1
5	CSC	9.6	12.1	6.2	3.4	4.8	36.0

Flavor: All burley varieties had a fair scent, reaching 9.1 - 9.8 points (thresholds of good aroma: 10 - 12.5 points). The varieties with the highest flavour points were Burley 49 and CSC, reaching 9.6 - 9.8 points and close to being good; then Kentucky 14: 9.5 points; and the lowest was the Tenessee 90 and Banket A1: 9.1 - 9.2 points.

The taste was fair, with 11.3 - 12.1 points (good threshold: 13 - 16.25 points), especially the CSC variety had the best taste, reaching 12.1 points.

Heavy degree of most Burley tobacco varieties is fair, with scores ranging from 6.0 to 6.2 points, especially the heavy degree points of Banket A1 were moderate levels (5.8 points) because the nicotine content was too high (4.9%) leads to causing too strongly stimulation.

Burning degree of most varieties was a fair threshold, from 3 - < 4. The Tenessee 90 had a moderate burn level, from 2 - < 3, but it does not affect the flavour and taste of tobacco.

Evaluating the quality of Burley tobacco varieties

Burley 49: Fairly aroma, fairly intense, with floating smoke, very uniform; good taste, quite characteristic, quite dark aftertaste; moderate weight, strongly stimulation; fair burn, grey ash; dark brown, light brown.

Kentucky 14: Fairly fragrant and intense, the fair uniform; good taste, good aftertaste; moderate heavy degree, strongly stimulation; Fairly burnt, greyish ash, dark brown, light brown colour.

Tenesee 90: Fairly fragrant, medium intensity; good taste, good aftertaste; moderate weight, strongly stimulation; medium burn, grey and black ash, light brown colour.

Banket A1: Fairly fragrant, medium intensity; good taste, good aftertaste; moderate weight, strongly stimulation; Fairly burnt, greyish ash, dark brown, light brown colour.

CSC: The fragrance is quite typical, the aroma intensity is too, the smoke is floating, very uniform; good taste, good aftertaste; moderate weight, strongly stimulation; fair burn, grey ash; dark brown, light brown.

So burley variety quality of CSC had the best quality, reaching 36.0 points > Kentucky 14 variety (35.8 points) > Burley 49 (35.2 points) > Banket A1 (35.1 points) points) > Tenessee 90 (33.9 points).

CONCLUSION

The Burley tobacco varieties experimented in Dak Lak had fair quality, typical of the Burley group by aroma, taste and heaviness. The CSC variety excelled in growth, yield, grade of dried leaf and had the best smoke properties, with aroma (9.6 points), taste (12.1 points), and total smoke point (36 points).

The infection levels of the major pests and diseases of the CSC variety were lower than other varieties, such as tobacco aphids, budworm, bacterial wilt and tobacco leaf curl caused by Begomovirus, and less susceptible to Ca deficiency.

KY 14 variety has been growing popularly in Dak Lak for a long time that is susceptible to major diseases, especially bacterial wilt. Adding a new CSC variety for Dak Lak is necessary, has practical significance, increases the diversified genetic resources, contribute to increase productivity, quality and income for tobacco growers, and reduces the risk of some important pests in the field.

COMPETING INTEREST

Authors have declared that no competing interests exist.

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