CSCanada
Canadian Social Science
Vol. 11, No. 5, 2015, pp. 139-145
DOI: 10.3968/7005

ISSN 1712-8056[Print]
ISSN 1923-6697[Online]
www.cscanada.net
www.cscanada.org

Measurement and Analysis of the Scientific and Technological Contribution Rate of Chongqing City Tobacco Agriculture

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Received 6 February 2015; accepted 8 April 2015
Published online 26 May 2015

Abstract

The tobacco agriculture has an important economic and social significance in Chongqing. By relying on technological innovation, accelerating the development of modern tobacco agriculture has become an inevitable choice. This paper selects 1996-2012 year's Chongqing flue-cured tobacco input and output data, builds *C-D* functions, measures the flexibility and annual contribution of scientific and technological progress, capital, labor and land, and proposes the corresponding improvement measures and countermeasures, in order to enhance the scientific and technological efficiency and benefit of Chongqing tobacco agriculture.

Key words: Tobacco agriculture; *C-D* function; Scientific and technological progress

Li, J., Xiao, S. M., Xu, C., & Xiao, Y. C. (2015). Measurement and Analysis of the Scientific and Technological Contribution Rate of Chongqing City Tobacco Agriculture. *Canadian Social Science*, *11*(5), 139-145. Available from: http://www.cscanada.net/index.php/css/article/view/7005
DOI: http://dx.doi.org/10.3968/7005

INTRODUCTION

Chongqing has a long history of tobacco growing. There are currently a total of 12 main tobacco production areas, including Wulong and Pengshui which have been identified as the national tobacco favorable production areas, playing an important role in the national tobacco production. They are China's seventh largest flue-cured tobacco production area and the second largest burley production area. Until 2014 there have been almost 2.3 million tobacco peasants, and tobacco growing size has ranked the seventh in the country's 18 major tobacco-growing areas, the average growing size for each household has been 31.58 acres, ranking the fourth in the country and the first in west China (Fang, 2014, August 12).

Tobacco cultivation is the important industrial support in Northeast Chongqing ecological conservation area and in Southeast Chongqing ecological reserve area in Chongqing's five functional areas, is the important source of revenue in Chongqing City and its counties, is the important way to increase peasants' income in the Three Gorges Project reservoir area and Southeast Chongqing minority area, is the important source of employment for the rural population, and has an important demonstrative effect to Chongqing's modern agricultural development. Therefore, in order to speed up the tobacco scientific technological innovation, development of modern tobacco agriculture has become an inevitable choice. The National Tobacco Board has issued *The Tobacco Industry Middle and Long-Term Scientific and Technological Development Plan (2006-2020)*, putting forward the scientific and technological innovation strategy. Chongqing municipal government has also successively promulgated the *Chongqing City Speed up the Tobacco Industry Development Plan (2008-2012).* Chongqing Tobacco Monopoly Bureau has issued *Chongqing City Tobacco Industry Middle and Long-Term Scientific and Technological Development Plan (2006-2020)*, putting forward to use 5 years to build Chongqing tobacco industry as an innovative industry. Relying on scientific and technological innovation, developing a modern tobacco agriculture, playing the comparative advantage of middle flavored tobacco with mountainous characteristics, establishing a technological innovation system which is based on Chongqing municipal tobacco commercial enterprises, market-oriented, combined with industry and university research, is an inevitable choice for the development of Chongqing modern tobacco agriculture.

1. NATURAL CONDITIONS OF CHONGQING CITY TOBACCO AGRICULTURE CULTIVATION

Chongqing's tobacco cultivation history can be traced back to the Ming Dynasty, whose main species are flue-cured tobacco and burley tobacco. According to the division of the most suitable tobacco-growing areas by *China's Tobacco Planting Regionalization (2009)*, Chongqing is at the upper and middle Yangtze River tobacco planting area. Chongqing's landform is mainly mountainous, hills and low mountains accounting for 94% of the total area, and the mountainous areas whose slope are greater than 15 ° account for 85%. Eastern edge of Chongqing City and the southeastern mountainous region connects with Western Hubei and Hunan mountains, having a large area of mountainous temperate climate and a significant three-dimensional climate characteristics. The soil is mainly yellow soil, yellow brown soil and purple soil. The flue-cured tobacco is in golden to deep yellow color, having good appearance and physical characteristics, whose chemical composition is largely suitable. The flue-cured tobacco is intermediate flavored with a delicate aroma and soft smoke, having good compatibility and process ability, and is one of the main tobacco in China (Wang, Xie, & Li, 2010).

2. INPUT AND OUTPUT OF CHONGQING TOBACCO AGRICULTURE

According to *Chongqing Survey Yearbook (2013)*, *Chongqing Yearbook (2013)*, *The National Agricultural Product Cost and Return Compilation (1986-2013)*, we organize the related input and output data of Chongqing last 30 years' tobacco agriculture, and make a preliminary analysis of the tobacco production level.

2.1 Tobacco Agricultural Output Status

Table 1
Chongqing Tobacco 1978-2012 Annual Output Level (unit: million tons)

Year	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Tobacco	2.25	1.02	0.81	2.07	3.72	1.96	2.41	3.62	4.67	4.50	6.89	6.21
Flue-cured tobacco	0.69	0.51	0.30	0.41	1.36	0.83	0.84	2.04	2.92	2.51	4.56	5.20
Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Tobacco	7.44	9.82	12.47	11.32	6.89	7.80	13.24	16.47	8.00	9.57	10.41	8.01
Flue-cured tobacco	4.89	7.45	9.60	8.63	5.02	5.74	11.04	13.42	5.75	7.20	7.69	5.32
Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Tobacco	8.71	8.60	8.50	9.02	9.19	7.15	8.55	9.99	8.10	9.36	10.29	
Flue-cured tobacco	6.44	6.84	6.45	7.17	7.26	4.86	6.90	8.23	6.39	7.59	7.61	

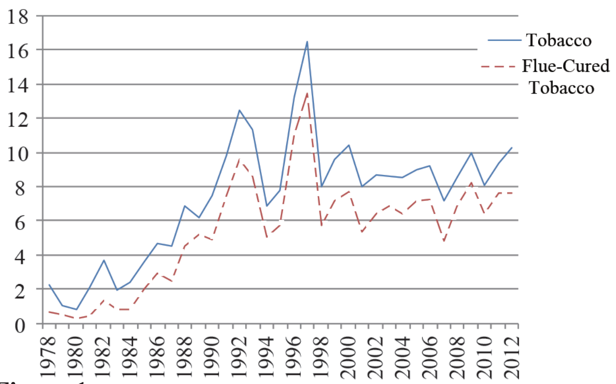

Figure 1
Chongqing City Tobacco Output (1978-2012)
Note. Data source: *Chongqing Survey Yearbook* (2013)

From Figure 1 it can be evidently seen that China's total tobacco production and flue-cured tobacco production remain essentially a same fluctuation, flue-cured tobacco accounting for about 80% of the total tobacco, hence taking the flue-cured tobacco data as the example to study Chongqing agricultural industry is reliable. Chongqing tobacco agricultural production can be distinctly divided into three phases: the first phase is Chongqing tobacco agriculture rapid growth phase. There is a rapid increase in tobacco production from 1978 to 1992 with an annual growth rate of 5%; the second is tobacco agriculture violent fluctuation phase. The tobacco production is in large fluctuations from 1992 to 1998. The third stage is a slow growth with small amplitude of fluctuations from 1998 to today, showing slight fluctuations in tobacco production, and the overall trend shows a growth but is very slow.

2.2 Land Input in Tobacco Agriculture

In the process of tobacco agricultural production, land is the most important productive factor. Table 2 and Figure 2 show the land input of Chongqing tobacco agriculture in recent years.

Table 2
Chongqing 1986-2012 Year Tobacco Land Investment (unit: 10 thousand mu)

Year	1986	1987	1988	1989	1990	1991	1992	1993	1994
Planting area	36.71	35.33	29.33	95.20	65.63	80.67	93.79	95.10	60.00
Year	1995	1996	1997	1998	1999	2000	2001	2002	2003
Planting area	66.15	95.79	64.80	84.57	65.10	71.70	54.90	63.15	69.92
Year	2004	2005	2006	2007	2008	2009	2010	2011	2012
Planting area	62.04	62.30	57.75	50.13	59.18	65.84	52.37	58.37	57.02

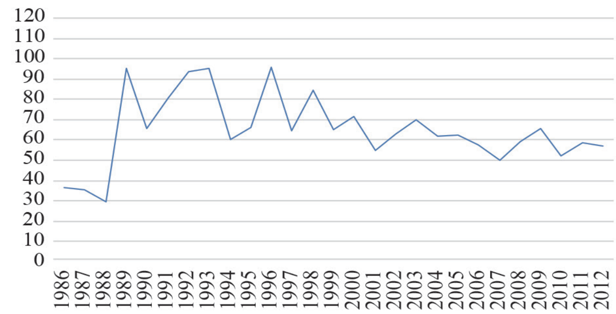

Figure 2
Chongqing Tobacco Land Investment (unit: 10 thousand mu)
Note. Data source: as per data conversion from Chongqing Survey Yearbook (2013), Sichuan Statistical Yearbook (1987-1997) and Chongqing Statistics Yearbook (1989-1996)

The trend of Chongqing City tobacco growing land investment has changed from violent fluctuations to a smoothness, and within the decade from 1986 to 1996, there have been double M type of violent fluctuations in planting area, twice reaching the highest acreage in history. Afterwards despite of the fluctuations, the planting area is basically around 600 thousand mu and remains stable.

2.3 Labor Input in Tobacco Agriculture

Chongqing's tobacco is suitable for planting in the regions between 1,400 m below sea and 800 m above sea. Chongqing tobacco growing areas are mainly distributed in 12 counties in Southeast Chonqging Wuling Mountainous area and Northeast Chongqing Three Gorges reservoir area. Mountainous agriculture demands for more labor, and with the agricultural machinery innovation and promotion, mountainous agricultural machinery's substitution effect for labor is obvious, plus the guidance of the "less labor and more efficiency" principle by Chongqing Tobacco Board, Chongqing city tobacco labor input shows a significant downward trend. Despite of this, in 2012 and 2013 out of the total Chongqing tobacco production costs, labor cost is more than two-thirds of the total, so speeding up a large-scale, mechanized and intensive production is imperative.

Table 3
Chongqing 1986-2012 Year Flue-Cured Tobacco Production Labor Investment (unit: 10 thousand days)

Year	1986	1987	1988	1989	1990	1991	1992	1993	1994
Labor input	1766.97	2015.19	1851.17	6216.59	4239.71	4197.28	4292.88	4242.41	2892.07
Year	1995	1996	1997	1998	1999	2000	2001	2002	2003
Labor input	2388.68	3707.01	2799.36	4768.06	2825.34	3427.26	2009.34	2304.98	2530.92
Year	2004	2005	2006	2007	2008	2009	2010	2011	2012
Labor input	2208.00	2005.28	1982.56	1793.65	2195.98	2429.97	1828.80	1829.80	1762.93

Note. Data source: As per the data conversion from *China Agricultural Product Cost-Return Compilation* (1987-2012) and *Chongqing Survey Yearbook* (2013).

2.4 Capital Investment in Tobacco Agriculture

According to the statistics of *China Agricultural Product Cost-Return Compilation* (1987-2012), capital investment in tobacco agriculture is mainly divided into the direct production costs (seed and seedling expense, manure expense, fertilizer expense, plastic sheeting expense, pesticide expense, animal power expense, machinery work expense, irrigation expense, fuel and power expense, scaffolding material expense and other direct costs) and other flowing capital investment and fixed capital investment. Taking 1986 as the base year, the production material price indices of agricultural products show a constant rise in the fluctuations.

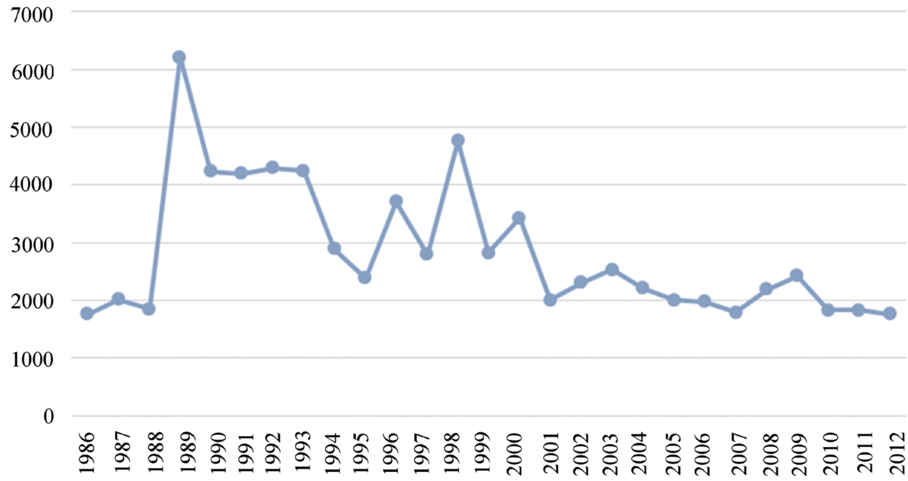

Figure 3
Chongqing 1986-2012 Year Flue - Cured Tobacco Production Labor Input (10 thousand days)
Note. Data source: As per data conversion from *China Agricultural Product Cost-Return Compilation* (1987-2012) and *Chongqing Survey Yearbook* (2013)

From the above statistical data and trend analysis it can be seen that, Chongqing flue-cured tobacco acreage basically keeps stable at around 600 thousand mu, the output fluctuates around 75,000 tons, the output value keeps growing during the fluctuations, the output per unit area rises during the fluctuations, the output per worker also grows, and the output per unit capital shows great fluctuations.

Table 4
Chongqing City 1986-2012 Flue-Cured Tobacco Production Capital Investment (unit: 10 thousand yuan)

Year	1986	1987	1988	1989	1990	1991	1992	1993	1994
Capital input	1885.19	2164.12	2228.22	7214.13	5788.67	8311.91	12632.57	9911.22	8255.15
Year	1995	1996	1997	1998	1999	2000	2001	2002	2003
Capital input	8718.77	27121.17	27903.84	26371.18	17005.70	20711.58	17919.19	20035.79	21820.05
Year	2004	2005	2006	2007	2008	2009	2010	2011	2012
Capital input	19462.67	28532.44	28825.06	23879.09	31274.59	51765.98	35286.73	40483.35	49681.13

Note. Data source: As per the data conversion from *China Agricultural Product Cost-Return Compilation* (1987-2012) and *Chongqing Survey Yearbook* (2013)

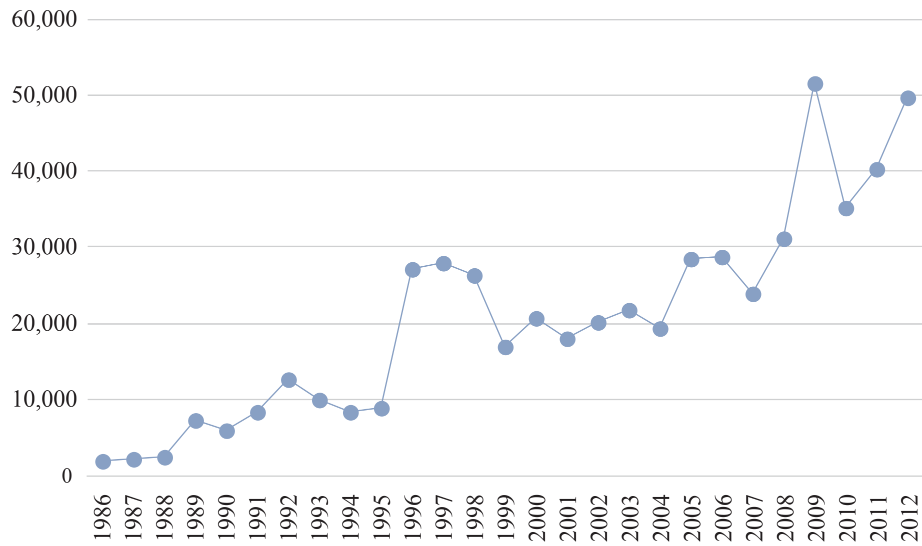

Figure 4
Chongqing City 1986-2012 Flue-Cured Tobacco Production Capital Investment (unit: 10 thousand yuan)

3. MEASURE OF THE SCIENTIFIC AND TECHNOLOGICAL PROGRESS RATE OF CHONGQING CITY TOBACCO AGRICULTURE

3.1 Measuring Method of the Flue-Cured Tobacco Scientific and Technological Progress Rate

For the quantitative research on agricultural scientific and technological progress, the main research methods are Cobb - Douglas production function method, Solow residual method, transcendental logarithmic production function method, TFP method and data envelopment analysis (DEA) method. Liu (2009), Wang (2011) and Cao (2014) make empirical analysis and calculate the Chongqing city agricultural scientific and technological progress contribution ratio and the production elasticity of respective output factors, finding that science and technology's contribution to agriculture shows an overall upward trend, but there are fluctuations among years. Wang (2007), Su, Cai, and Zhang (2009), Tian (2010, 2011) and Cui (2011), etc. make empirical calculations on the scientific and technological progress rate of China's flue-cured tobacco, compare the efficiency among main production areas, cities and provinces, finding that the overall scientific and technological progress rate of China's flue-cured tobacco is relatively higher. By summarizing the results of above studies we find that, by building a production function to calculate the elasticity of the elements is the main method to estimate the scientific and technological progress rate of tobacco agriculture. The common method is to build the measuring model of Cobb-Douglas production function. The general form of CD function model is $Y=cM^{\alpha}L^{\beta}S^{\gamma}e^{\delta t}$, wherein Y is the total output value of tobacco agriculture (10 thousand yuan), M, L and S are the respective corresponding input factors to Y, i.e. material cost (10 thousand yuan), labor (10 thousand days) and planting land (10 thousand mu). c is a constant term, t is a time variable. Theory can prove that α, β, γ are the elasticity coefficients of material cost, labor and planting land respectively, and δ is the rate of technological progress. By taking the logarithms on both sides of the formula can be transformed into the following form:

$$\text{LOG}(Y) = \text{LOG}(c) + \alpha\text{LOG}(M) + \beta\text{LOG}(L) + \gamma\text{LOG}(S) + \delta t$$

3.2 Data Source and Measuring Model Estimation

3.2.1 Data Source

Due to the statistical factors and Chongqing's municipality, in order to ensure data consistency, the paper discards the converted data from 1986 to 1996, and selects 16 years of data of flue-cured tobacco production in China from 1997 to 2012, whose data amount is generally small. All data are from *Chongqing Survey Yearbook* (2013) and *Chinese Agricultural Product Cost-Return Compilation* (1997-2013). To avoid collinearity among the explanatory variables, labor and material costs adopt the labor number and material costs per 0.0067 hm^2 (Liu, 2009), wherein the material costs include seed cost, fertilizer cost, pesticide cost, plastic sheeting cost, lease operation cost, fuel and power cost, technical service cost and other indirect costs associated with the production. Taking 1996 as the base year, we divide the material costs that year by the agricultural productive material price index that year to eliminate the impacts of price fluctuation. Use the selling price per 50 kg tobacco as the selling price, and divide the selling price of flue-cured tobacco that year by the agricultural producer price index that year to eliminate the impacts of price fluctuation.

3.2.2 Estimation Results

By using the econometric software Eviews7.0 to estimate production model data, after repeated fitting, the results are shown in Table 5: It can be learned from the econometric model that the effect of the adjusted model is preferable, wherein the correlation coefficient is 0.92, indicating that 92% changes in production can be explained by the main production factors; *F* test and T test at the 5% confidence level are both through, *D-W* value also shows that there is no multiple co-linear problems, the overall model fitness is high.

From 1996 to 2012 Chongqing flue-cured tobacco production elasticity coefficient is 0.74 (<1), indicating that flue-cured tobacco in Chongqing is at a production scale return decreasing stage. For each 1% increase in input, output increases only 0.74%, wherein the capital elasticity is 0.53, indicating that infrastructure construction in Chongqing city, especially tobacco water supporting projects, basic tobacco field construction, flue-curing barn construction and use of mechanization have remarkable effects to improve yield and quality. The output elasticity of land is 0.27, indicating that the basic position of land in the flue-cured tobacco production is unshakable. In the process of urbanization, assuring the number of tobacco fields, reducing soil pollution, improving soil quality of tobacco fields, and enhancing mechanized operations in contiguous tobacco fields to increase land yield is a necessary requirement of modern tobacco agriculture green production. The output elasticity of labor is -0.10, indicating that the number of labor engaged in Chongqing tobacco production is a surplus, the quality is not high, less labor and higher efficiency has a greater potential and space. The annual scientific and technological progress rate of Chongqing tobacco production is 4.2%, with an average contribution rate of 47.89%. Similarly the contribution rate of the production factors can be derived and shown in Table 6.

Table 5
Chongqing City Flue-Cured Tobacco Production Function Estimation Results
***Y*=*C*(1)+*C*(2)*S+*C*(3)*L+*C*(4)*M+*C*(5)*T**

	Coefficient	Std. Error	*t*-statistic	Prob.
C(1)	1.939382	0.084812	22.86683	0.0000
C(2)	0.268593	0.114281	10.14576	0.0000
C(3)	-0.104311	0.197952	-3.002300	0.0120
C(4)	0.529198	0.180248	3.490730	0.0051
C(5)	0.042127	0.004462	1.373113	0.0196
R-squared	0.919550	Mean dependent var	-697.1024	
Adjusted *R*-squared	0.969387	S.D. dependent var	2576.110	
Sum squared resid	3.11E-06	Schwarz criterion	-11.75077	
F-statistic	6111.210	Durbin-Watson stat	2.279740	
Prob(*F*-statistic)	0.000000	Weighted mean dep.	4.808628	

Table 6
The Annual Contribution Rate of Each Input Element of Chongqing City Flue-Cured Tobacco

	Technological progress	Capital	Labor	Land	Others
Elasticity	0.042	0.63	-0.1	0.26	
Element annual growth rate(%)		2.57	-1.14	0.4	
Output value annual growth rate(%)	8.77	8.77	8.77	8.77	
Contribution share(%)	47.89	18.46	1.30	1.19	31.16

The highest contribution rate belongs to scientific and technological progress, the next is for others, the third is for capital, and the fourth is for labor and land. These results are mainly due to the rapid growth rate of output value and low growth rate of labor and land. The relevant factors in other elements' contribution may include the influence of price index by the excessive price fluctuation in some special years (such as 1998), the influence by Chongqing climate of rains alternated with droughts, the influence of pests and diseases, as well as the influences of taxes and subsidies to tobacco cultivation, agricultural cooperative construction and other institutional arrangements.

4. COUNTERMEASURES AND SUGGESTIONS

4.1 Stabilize the Plant Size and Strictly Control the Production Red Line

As a special agricultural product, tobacco is characterized by the single use and hierarchical complexity, its cultivation and purchase are carried out in strict accordance with the national plan. Meanwhile, the Third Plenary Session of the Eighteenth Central Committee has proposed to further improve the market mechanism, make the market play a better and decisive role in allocating resources, and gradually liberalize tobacco prices. In the "transition" process of tobacco price, we need to ensure a stable development in tobacco production, protect a rational planting structure of arable lands, strictly control the production scale and purchase price, prevent the tobacco economy from sharp price fluctuations, and in the premise of a stable planting scale, optimize planting structure, improve management and improve the quality of tobacco.

4.2 Optimize the Industrial Structure and Strengthen the Infrastructure Construction

The changes of Chongqing tobacco main growing areas reflect that the industrial layout has adjusted toward the optimum planting areas, based on which, we need to continue to optimize the industrial structure, accelerate the construction of high-quality contiguous tobacco fields, enhance the average planting scale for each household, and achieve intensive management. Accelerate tobacco-water supporting projects, road construction in tobacco planting areas, farm tractor road construction, infrastructure constructions including modern equipment, breeding sheds, high-quality flue-curing barns, etc., and lay a solid foundation for the development of modern tobacco agriculture.

4.3 Change the Production Methods and Achieve Less Labor and Higher Efficiency

As for Chongqing tobacco production in recent years, the output elasticity and contribution rate of the input labor are relatively lower compared to the surplus labor number. Labor qualities are generally not high, labor costs keep rising. In 2012 and 2013 the labor costs accounted for more than 2/3 of the entire costs of flue-cured tobacco. To build a modern tobacco agriculture, we need to change the petty peasant operation model to intensive management, continue to reduce labor and increase efficiency. Promote tobacco scale cultivation, intensive management, specialization and information management, vigorously promote the construction of tobacco peasant professional cooperatives, strengthen technical management training to the peasants, improve the overall quality and productivity of peasants.

4.4 Increase Scientific and Technological Research Investment, Promote Scientific and Technological Progress

The scientific and technological progress contribution rate of Chongqing tobacco planting has reached 47.89%, but there is still more room for development compared with the national average level and advanced level abroad. Scientific and technological progress needs to play the basic role of tobacco fields, the decisive role of high-quality tobacco varieties and the supporting role of other important elements in the industrial chain. Increase research investment, improve capital use efficiency, make good use of the scientific and technological innovation platform of industry-university-research, strengthen soil improvement, tobacco variety breeding, nutrition, fertilizer, pest control, tobacco technical equipment and other key technological research and development, strengthen incentives for technological innovation, accelerate tobacco technological innovation and technology promotion service system construction, and shorten the cycle of transforming new achievements into practical productivity.

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