Effects of Different Chemical Fertilizer Reduction Techniques on Flue-cured Tobacco Production

Longfeng GUI, Lei XIA, Jing YANG, Wei YAN, Yu ZHOU, Yuzhong ZHOU, Haohan GONG, Mengsheng ZHANG, Yeming FU, Xianyi ZENG, Xia NI*

Zhaotong Company, Yunnan Provincial Tobacco Company, Zhaotong 657000, China

Abstract [**Objectives**] This study was conducted to find out the most suitable special formula fertilizer for flue-cured tobacco production in tobacco-growing areas of Zhaotong City, so as to provide a basis for scientific fertilization and reduced application of inorganic fertilizers with improved efficiency in tobacco production in Zhaotong City. [**Methods**] Different formulas of special base fertilizer and special topdressing for tobacco were designed by optimizing and adjusting the application amounts and proportions of nitrogen, phosphorus, potassium and medium trace elements in fertilizer formulas, and the formulas of special base fertilizer and special topdressing for flue-cured tobacco production were selected through a field plot experiment. [**Results**] The combination of special base fertilizer and special topdressing was conducive to the early growth and rapid growth of tobacco plants under the condition of reduced fertilizer application, and the treatment using organic-inorganic compound fertilizer as the special base fertilizer was the most obvious, with an average growth period of two days increased. Compared with conventional fertilization, the yield, output value, average price, proportion of superior tobacco and proportion of medium and superior tobacco increased in the organic-inorganic compound fertilizer treatment, with the yield increasing by 5.96%, the output value increasing by 17.08%, the average price increasing by 10.49%, the proportion of superior tobacco increasing by 4.63%, and the proportion of medium and superior tobacco increasing by 2.44%. It was concluded from indexes including growth period, agronomic traits, disease incidence and economic traits, the fertilization mode of organic-inorganic compound fertilizer with the addition of trace elements (boron, magnesium and zinc) applied as the base fertilizer and nitrogen and potassium topdressing was most efficient and economic. [**Conclusions**] This study provides a basis for scientific fertilization and reduced application of inorganic fertilizers with improved efficiency in tobacco production in Zhaotong City.

Key words Fertilizer; Flue-cured tobacco production; Soil nutrient; Economic character; Quality of flue-cured tobacco; Zhaotong

DOI:10.19759/j.cnki.2164-4993.2023.06.010

Soil nutrient contents are important indicators to evaluate soil fertility, and their abundance and supply intensity directly affect the growth, yield and quality of tobacco[1-3]. With the continuous adjustment of agricultural industrial structure, agriculture in Zhaoyang District is developing in a diversified way. In some areas, problems such as the lack of awareness among tobacco farmers about farming and nurturing the land, extensive field management, one-sided pursuit of yield by tobacco farmers and the long-term use of large amounts of chemical fertilizers in tobacco fields exist, which leads to a decrease in soil organic matter content and pH value and a harsh growth environment for tobacco plant roots[4-5]. The excessive growth of tobacco plants and the decline of tobacco yield and quality are severe challenges for the production of flue-cured tobacco in Zhaoyang District. In addition, people pay close attention to the problem of "smoking and health", and the problem of tobacco production, quality and safety is becoming increasingly prominent.

He *et al.*[6] reported that when the fertilization level of Yunyan 87 in Dechang, Liangshan was medium, the agronomic and economic characters performed better, and the medium fertilization level was more conducive to increasing farmers' income and saving costs. Li *et al.*[7] found that compound fertilizer could obviously improve the internal and external quality of local tobacco leaves, and significantly improve the yield and quality of local tobacco leaves, leading to the highest average price. Li *et al.*[8] found that the treatment of application of 50% inorganic nitrogen compound fertilizer + 50% organic nitrogen organic fertilizer performed well in agronomic characters, economic characters and internal chemical quality. The normal growth and development of flue-cured tobacco and its yield and quality are not only determined by the application amount of nitrogen, phosphorus and potassium fertilizers, but also closely related to the reasonable ratio of nitrogen, phosphorus and potassium[9-11]. Improving the nutritional status of flue-cured tobacco and providing balanced nutrition for its growth are important measures to improve the quality of flue-cured tobacco[12]. Through the combination of environmental science and modern agricultural technology, combined with the investigation results of nutrients in tobacco-growing soil of the base unit in the early stage, according to the nutrient abundance and deficiency of tobacco-growing soil in the producing area, the quantities and proportions of nitrogen, phosphorus, potassium and medium trace elements in the fertilizer formula have been optimized and adjusted. The research on tobacco fertilizers focuses on the effects of applying the same special fertilizer on tobacco-growing soil and the yield and quality of tobacco[13-15], while there are few studies conducted on the fertilization mode of special organic-inorganic compound fertilizer for tobacco combined with nitrogen and potassium topdressing and its effects on tobacco production, and even

Received: August 30, 2023 Accepted: November 2, 2023

Supported by Science and Technology Program of Yunnan Company of China National Tobacco Corporation (2020530000241022).

Longfeng GUI (1971), female, P. R. China, assistant agronomist, devoted to research about tobacco cultivation and nutritional regulation.

*Corresponding author: Xia NI (1968), female, P. R. China, senior agronomist, devoted to tobacco cultivation, nutritional regulation and physiological and biochemical research. E-mail: ztnixia@163.com

less on the special formula fertilizer for flue-cured tobacco in the region. Therefore, a field plot experiment was conducted to study the effects of different compound fertilizers special for tobacco combined with special nitrogen and potassium topdressing on tobacco production, disease prevention and control, economic characters, *etc.*, and to select an economical and efficient formula fertilizer combination suitable for tobacco-growing areas in Zhaotong City. The application of special formula fertilizer had the characteristics of reasonable nutrient ratio, small fertilizing amount, reduced mutual inhibition between nutrients and reduced fertilization cost, providing a basis for scientific fertilization and reduced application of inorganic fertilizers with improved efficiency in tobacco production in Zhaotong City.

Materials and Methods

Experimental materials

Experimental variety The seeds of Yunyan 87 mainly planted locally were provided by Zhaotong Company, Yunnan Provincial Tobacco Company.

Experimental fertilizers Compound fertilizer special for tobacco (N-P_2O_5-K_2O = 11-15-22), potassium nitrate and potassium sulfate were supplied by Zhaotong Company of Yunnan Provincial Tobacco Company. Compound fertilizer special for tobacco (N-P_2O_5-K_2O = 9-15-22), special compound fertilizer for tobacco (N-P_2O_5-K_2O-b-mg-Zn = 9-15-22-1-3-1), organic-inorganic compound fertilizer (N-P_2O_5-K_2O-B-Mg-Zn = 6-9-15-1-3-1) and nitrogen and potassium topdressing (N-P_2O_5-K_2O = 10-0-36) were provided by Yunnan Microbial Fermentation Engineering Research Center Co., Ltd.

Methods

Experimental design The experiment was conducted from March to October, 2020 in a representative tobacco-growing area in Buga Township, Zhaoyang District, Zhaotong City, Yunnan Province. The plot experiment design was adopted and four treatments were set up: T_1, 11-15-22 compound fertilizer 750 kg/hm^2 + potassium nitrate 112.5 kg/hm^2 + potassium sulfate 225 kg/hm^2, T_2, 9-15-22 compound fertilizer 750 kg/hm^2 + nitrogen and potassium topdressing 300 kg/hm^2, T_3, 9-15-22 compound fertilizer (containing boron, magnesium and zinc) 750 kg/hm^2 + nitrogen and potassium topdressing 300 kg/hm^2, and T_4, 6-9-15 organic-inorganic compound fertilizer (containing boron, magnesium and zinc) 1 200 kg/hm^2 + nitrogen and potassium topdressing 300 kg/hm^2. The experiment was done in three replicates, each of which was one plot, forming a total of 12 plots. Four rows were planted in each plot, with a row spacing of 55 cm × 110 cm, and 60 tobacco plants were planted in each plot.

Determination methods Soil nutrients: Before fertilization, basic soil samples were taken from the experimental plots, and after tobacco leaves were harvested and cured, one soil sample was taken from each treatment, totaling five soil samples (2 kg per soil sample). Soil pH, organic matter, available nitrogen, available potassium, available phosphorus and medium trace elements were determined.

Main growth stages: The transplanting date, resettling date, vigorous growing date, flower budding date, topping date, maturing date of foot leaf, maturing date of top leaf and the whole growth period of each treatment were recorded.

Agronomic traits: After topping, five representative tobacco plants were randomly selected from each plot. According to YC/T 142-2010 *Investigating and measuring methods of agronomical character of tobacco*, *various agronomic characters were observed or determined*, including plant height, stem girth, leaf number, and maximum leaf length and maximum leaf width of tobacco leaves in each part.

Occurrence of diseases: According to GB/T 23222-2008 *Grade and investigation method of tobacco diseases and insect pests*, common mosaic disease (TMV), potato virus Y (PVY), tomato spotted wilt virus, black shank disease and tobacco etch virus were investigated.

Economic character The economic characters such as yield, output value, average price, proportion of superior tobacco and proportion of medium and superior tobacco were investigated.

Data processing

The data were processed by SPSS.

Results and Analysis

Input of soil nutrients

As shown in Table 1, compared with T_1 (CK), the total nutrient input of T_2, T_3 and T_4 decreased by 54.6, 54.6 and 39.6 kg/hm^2, respectively, and the fertilizer reduction rates were 10.16%, 10.16% and 7.37%, respectively.

Table 1 Input of soil nutrients in various treatments kg/hm^2

Treatment	Input of soil nutrients			
	N	P_2O_5	K_2O	Total nutrient
T_1 (CK)	97.65	112.5	327.45	537.6
T_2	97.50	112.5	273.00	483.0
T_3	97.50	112.5	273.00	483.0
T_4	102.00	108.0	288.00	498.0

Main growth periods

It can be seen from Table 2 that compared with T_1, treatments T_2, T_3 and T_4 entered the resettling stage and vigorous stage one day, one day and two days earlier, respectively. The combined application of special base fertilizer and special topdressing was beneficial to the early growth and rapid development of tobacco plants, and the treatment using organic-inorganic compound fertilizer as the special base fertilizer was the most obvious. The growth periods of various treatments were basically the same from the budding stage to the end of harvesting and curing, indicating that the adjustment of the original fertilization mode had little effect on the growth period of flue-cured tobacco in the middle and late stage in the field.

Agronomic characters

As shown in Table 3, there were no significant differences in agronomic characters such as plant height, stem girth, and number of effective leaves per plant among the treatments. The plant height of treatment T_4 was 111.07 cm, the highest among all

treatments, but there were no significant differences from other treatments. The highest stem girth was 8.69 cm in treatment T_4, followed by treatment T_3, and lowest in treatment T_2. The number of effective leaves per plant, as well as the length and width of upper, middle and lower leaves, was highest in treatment T_4, followed by treatment T_3, and lowest in treatment T_2.

Table 2 Main growth periods of tobacco plants with different treatments

Treatment	Transplanting date	Resettling date	Vigorous growing date	Flower budding date	Topping date	Maturing date of foot leaf	Maturing date of top leaf	Growth period//d
T_1	Apr. 9	Jun. 24	Jun. 24	Jul. 12	Jul. 19	Jul. 28	Sept. 5	149
T_2	Apr. 9	Jun. 23	Jun. 23	Jul. 12	Jul. 19	Jul. 28	Sept. 5	149
T_3	Apr. 9	Jun. 23	Jun. 23	Jul. 12	Jul. 19	Jul. 28	Sept. 5	149
T_4	Apr. 9	Jun. 22	Jun. 22	Jul. 12	Jul. 19	Jul. 28	Sept. 5	149

Table 3 Agronomic characters of tobacco plants under different treatments

Treatment	Plant height//cm	Stem girth//cm	Number of effective leaves per plant//leaves	Lower part		Middle part		Upper part	
				Length//cm	Width//cm	Length//cm	Width//cm	Length//cm	Width//cm
T_1	104.27 a	8.24 a	17.27 a	62.73	27.97	71.10	30.67	55.10	15.50
T_2	103.73 a	8.22 a	17.00 a	62.52	27.53	69.00	32.40	54.77	15.27
T_3	108.33 a	8.26 a	17.73 a	62.90	28.23	71.35	33.90	54.20	15.20
T_4	111.07 a	8.69 a	18.60 a	67.62	30.47	79.80	33.20	64.93	17.27

Diseases

As shown in Table 4, the experimental treatments mainly suffered from common mosaic disease (TMV), potato virus Y (PVY), tomato spotted wilt virus, black shank disease, and tobacco etch virus. The incidence and disease index of black shank disease were consistent in various treatments. There were no significant differences in the incidence of TMV among treatments, and the incidence in treatment T_1 was higher. The incidence and disease index of PVY was lowest in treatment T_4, with significant differences from other treatments. Treatment T_3 showed lowest incidence and disease index of tomato spotted wilt virus, but there were no significant differences among the treatments. The incidence of tobacco etch was high in each treatment, so it was a typical disease in the experimental area. The incidence was highest in treatment T_1, which was significantly different from other treatments. On the whole, the incidence of diseases in each treatment was lower in T_3 and T_4, and higher in T_2 and T_1.

Table 4 Diseases of tobacco plants under different treatments

Treatment	TMV		PVY		Tomato spotted wilt virus		Black shank		Tobacco etch virus	
	Incidence//%	Disease index	Incidence//%	Disease index	Incidence//%	Disease index	Incidence//%	Disease index	Incidence//%	Disease index
T_1	5.56 a	3.11	3.89 a	3.10	1.67 a	1.51	1.67 a	1.67	18.33 a	9.60
T_2	4.44 a	3.56	3.89 a	3.25	1.67 a	1.67	1.67 a	1.67	14.44 b	8.25
T_3	5.00 a	3.00	4.44 a	3.81	1.11 a	1.48	1.67 a	1.67	13.33 b	6.83
T_4	4.89 a	2.77	1.67 b	1.51	2.22 a	1.51	1.67 a	1.51	14.44 b	8.89

Economic characters

It can be seen from Table 5 that the yield was highest in T_4, followed by T_3 and the lowest value was observed in T_2, and the yields of treatments T_4 and T_3 were significantly different from those of T_1 and T_2. The highest output value was observed in treatment T_4, which showed significant differences from other treatments. The average price, yield and output value exhibited similar laws, with the highest value in treatment T_4 and the lowest value in treatment T_1, and there were significant differences between the two. The highest proportion of superior tobacco was found in treatment T_4, followed by T_3, and the lowest was found in T_1, and there was a significant difference between treatments T_4 and T_1. The proportion of medium and superior tobacco was highest in T_4, followed by T_2 and T_3, and lowest in T_1, with no significant differences among the treatments. Comprehensively from the economic traits, it could be seen that the economic characters were highest in T_4 among various treatments, followed by T_3, and basically consistent in T_1 and T_2.

Table 5 Economic characters of tobacco plants under different treatments

Treatment	Yield//kg/hm^2	Output value//yuan/hm^2	Average price//yuan/kg	Proportion of superior tobacco//%	Proportion of medium and superior tobacco//%
T_1	2 184.0 b	58 509.30 b	26.79 b	55.49 b	87.59 a
T_2	2 110.8 b	57 983.70 b	27.47 ab	57.00 ab	87.60 a
T_3	2 268.3 a	62 945.40 b	27.75 ab	57.54 ab	88.34 a
T_4	2 314.2 a	68 500.35 a	29.60 a	58.06 a	89.73 a

Discussion

Related studies have shown that the mixed application of organic and inorganic fertilizers in a certain proportion can improve soil fertility and structure, increase soil microbial quantity and promote the growth and development of tobacco, thereby improving the quality of tobacco leaves[16-18]. In this study, organic-inorganic compound fertilizer was compared with inorganic fertilizer with the same nitrogen, phosphorus and potassium input. Under the condition of basically the same nutrient input, the agronomic and economic characters of tobacco leaves treated with organic-inorganic compound fertilizer were improved to varying degrees compared with the conventional fertilization control. The organic-inorganic compound fertilizer treatment in this study could reduce the incidences of common mosaic disease (TMV), potato virus Y (PVY), tomato spotted wilt virus, black shank disease, and tobacco etch virus to a certain extent, which is consistent with the research results of Li *et al.*[19] and Luo *et al.*[20]. It might be related to the increase of actinomycetes in the soil, which led to increasing the disease resistance of tobacco plants.

The statistical results of nutrient input for various treatments showed that compared with conventional fertilization, the total nutrient input of the special formula fertilization treatments was reduced by 39.6 – 54.6 kg/hm^2, and the fertilizer reduction rates were in the range of 7.37% – 10.16%. The results of field experiment showed that under the condition of reduced fertilizer application, the combination of special base fertilizer and special topdressing was beneficial for the early growth and rapid development of tobacco plants, with the treatment using organic-inorganic compound fertilizer as the special base fertilizer showing the most significant performance. The application of organic-inorganic compound fertilizers could also promote the growth and development of tobacco plants in the middle and later stage in the field, and improve the agronomic characters of tobacco after topping.

The results of a systematic investigation of common diseases during the field growth period of tobacco showed that the addition of boron, magnesium and zinc to the base fertilizer resulted in slightly lighter disease occurrence. It indicated that the addition of trace elements could improve the disease resistance of tobacco plants and reduce the occurrence of diseases.

The statistical results of the economic characters of tobacco showed that compared with local conventional fertilization, the treatment of adding boron, magnesium and zinc to the base fertilizer improved the yield, output value, average price, proportion of superior tobacco and proportion of medium and superior tobacco. Among them, the best performance was achieved with organic-inorganic compound fertilizer as the base fertilizer.

According to the growth period, field performance, disease incidence and economic traits of tobacco plants, the most efficient and economical combination of special formula fertilizer for flue-cured tobacco in Zhaoyang tobacco-growing area of Zhaotong was: organic-inorganic compound fertilizer (N-P_2O_5-K_2O = 6-9-15, boron 1%, magnesium 3%, zinc 1%) applied as the base fertilizer and nitrogen and potassium topdressing (N-P_2O_5-K_2O = 10-0-36).

Conclusions

The tobacco specific formula fertilizer reduced nutrient input, and the combination of organic and inorganic fertilizers could promote early growth and rapid development of tobacco plants, accelerate the growth and development of tobacco plants in the middle and later stage in the field, and improve the agronomic traits of tobacco plants in the field.

Adding trace elements such as boron, magnesium and zinc to the base fertilizer special for tobacco could effectively reduce common tobacco diseases and improve resistance in tobacco plants.

The fertilization mode of organic-inorganic compound fertilizer with the addition of trace elements as the base fertilizer and nitrogen and potassium topdressing achieved the highest economic benefits for flue-cured tobacco in Zhaoyang tobacco-growing area in Zhaotong City.

References

[1] ZHAO X, LIU WQ, ZHANG WL, *et al.* The present situation and prospect of balanced fertilization technology of tobacco in China[J]. Chinese Journal of Tobacco 2003(Supplements): 30 – 35. (in Chinese).

[2] XIAO HQ, LUO JX, WANG GB, *et al.* Analysis of nutrient abundance and deficiency of tobacco-growing soil in Hunan Province[J]. Journal of Hunan Agricultural University (Natural Science Edition), 2003, 29(2): 150 – 153. (in Chinese).

[3] XU ZC, WANG L, WANG JP, *et al.* Relationships between chemical components of flue-cured tobacco leaf and soil organic matter content in Hunan Province of China[J]. Chinese Journal of Ecology, 2006, 25(10): 1186 – 1190. (in Chinese).

[4] GUO SL, ZHOU YD, ZHANG WJ, *et al.* Effects of long-term application of chemical fertilizer on grain production and soil quality[J]. Research of Soil and Water Conservation, 2003, 10(1): 16 – 22. (in Chinese).

[5] GONG W, YAN XY, WANG JY. Effect of long-term fertilization on soil fertility[J]. Soils, 2011, 43(3): 336 – 342. (in Chinese).

[6] HE YY, HAN LH, HE ZH, *et al.* Effects of different fertilizer formulations on agronomic and economic characters of flue-cured tobacco in Dechang[J]. Sichuan Agricultural Science and Technology, 2009(11): 46 – 47. (in Chinese).

[7] LI W, JIANG XY, WANG HJ, *et al.* Effects of different fertilizer formulas on growth, yield and quality of flue-cured tobacco[J]. Modern Agricultural Science and technology, 2019(11): 3 – 4. (in Chinese).

[8] LI HG, LI JP, FU YL, *et al.* Effects of different fertilization formulas on growth, yield and quality of flue-cured tobacco[J]. Journal of the Yunnan Agricultural University, 2015, 30(2): 271 – 276. (in Chinese).

[9] ZHOU KY. Experiment on ratio of nitrogen, phosphorus and potassium fertilizer application in flue-cured tobacco[J]. Northwest Tobacco, 1991(4): 29 – 33. (in Chinese).

[10] LI GX, JIA XJ, ZHANG ZF. Preliminary study on the ratio of nitrogen, phosphorus and potassium in tobacco leaves[J]. Tobacco technology, 1990(4): 28 – 29. (in Chinese).

[11] GAO TZ. A special high nitrogen-phosphorus-potassium fertilizer for flue-cured tobacco[J]. Yunnan Chemical Industry, 1995(3): 56 – 59. (in Chinese).

(Continued on page 61)

production and management. In terms of "management", it is recommended to strengthen the supervision of input products of Chinese chives. The first is to strengthen the inspection of input product production and operation. It is necessary to intensify inspections on Chinese chive pesticide production enterprises, business units and online platforms, and strictly investigate and deal with illegal production and business activities that occur to ensure the quality and safety of Chinese chive input products. The second is to strengthen the traceability management of restricted agrochemicals in Chinese chives. For restricted agrochemicals in Chinese chives, fixed-point management and real-name purchase of restricted agrochemicals should be further implemented, and the traceability management system of agrochemicals should be improved to prevent prohibited input products from entering the circulation link. The third is to strengthen inspections, spot checks and inspections, especially during the peak application period of agrochemicals in Chinese chives in winter and spring and the centralized marketing period in spring and autumn, and increase the inspection intensity and sampling frequency for the use of banned agrochemicals, the failure to implement safety intervals for conventional pesticides and the expansion of dosage, so as to find hidden problems in time.

References

[1] YANG G. Poisonous Chinese chives reappear in the Jianghu: Investigation reveals that farmers have doubled their use of low-toxicity pesticides [J]. Pesticide Market News, 2011(19): 14. (in Chinese).

[2] LOU SQ, QU YL. Investigation on suspected "poisonous Chinese Chives" in Jinan: Initially identified as organophosphorus and related pesticide poisoning[N]. Qilu Evening News, 2012-05-05. (in Chinese).

[3] Ministry of Agriculture and Rural Affairs of the People's Republic of China. The seventh department including the Ministry of Agriculture and Rural Affairs have deployed a three-year action plan to promote the improvement of illegal, drug and residue control measures for edible agricultural products[EB/OL]. (2021-06-12)[2022-05-27]. http://www.gov.cn/xinwen/2021-06/12/content_5617356.htm. (in Chinese).

[4] The Science, Technology and Education Department of the Ministry of Agriculture and Rural Affairs. Report on the Development of Agricultural Industry Technology in China 2020[M]. Beijing: China Agricultural Science and Technology Press, 2021. (in Chinese).

[5] YANG GD, CUI LW, LIU AQ. General situation of Chinese chive industry development in Liaoning Province[J]. Liaoning Agricultural Sciences, 2020(4): 53-55. (in Chinese).

[6] Ministry of Agriculture and Rural Affairs: The overall quality and safety of agricultural products in China remained stable in 2021, and the qualified rate of routine quality and safety monitoring was 97.6%[EB/OL]. (2021-12-28)[2022-05-27]. http://m.people.cn/n4/2021/1228/c125-15370044.html. (in Chinese).

[7] Four batches of "poisonous Chinese chives" were found in Sichuan Province. What is the problem? The disposal situation has been announced![EB/OL]. 2020-06-30)[2022-05-27]. https://baijiahao.baidu.com/s?id=1670920901960028418&wfr=spider&for=pc. (in Chinese).

[8] Chinese chives are already a "regular guest"! Jiangsu exposed five batches of unqualified food. [EB/OL]. (2020-06-04)[2022-05-27]. http://k.sina.com.cn/article_6755570082_192a9d1a200100y0bs.html. (in Chinese).

[9] National health commission of the People's Republic of China, Ministry of Agriculture and Rural Affairs of the People's Republic of China, State Administration for Market Regulation. GB 2763-2021 National food safety standard—Maximum residue limits for pesticides in food[S]. Beijing: China Agriculture Press, 2021. (in Chinese).

[10] National health commission of the People's Republic of China, Ministry of Agriculture and Rural Affairs of the People's Republic of China, State Administration for Market Regulation. GB/T 2763-2019 National food safety standard—Maximum residue limits for pesticides in food[S]. Beijing: China Agriculture Press, 2019. (in Chinese).

[11] HE ZQ, CHEN DX, HU XL, *et al.* Occurrence and control of gray mold of Chinese chives[J]. Sichuan Agricultural Science and Technology, 2012(5): 36. (in Chinese).

Editor: Yingzhi GUANG Proofreader: Xinxiu ZHU

(Continued from page 51)

[12] NIE XB, JIN ZL. Effect of harmonization of medium and trace elements on growth, yield and quality of flue-cured tobacco[J]. Chinese Tobacco Science, 2003, 24(4): 30-34. (in Chinese).

[13] QIU BR, ZHOU JH, ZHENG KQ, *et al.* Effects of nitrogen application rate on yield, quality and nicotine content of flue-cured tobacco [J]. Tobacco Technology, 2003(11): 41-43. (in Chinese).

[14] LI CJ, ZHANG FS, LI WQ, *et al.* Nitrogen management and its relation to leaf quality in production of flue-cured tobacco in China[J]. Plant Nutrition & Fertilizer Science, 2007, 13(2): 331-337. (in Chinese).

[15] YANG YG, WANG SL, LIU G, *et al.* Effects of bio-organic fertilizer on yield and quality of flue-cured tobacco and soil improvement[J]. Chinese Tobacco Science, 2012, 33(4): 70-74. (in Chinese).

[16] DING W, YE JP, JIANG W, *et al.* Effects of long term fertilization on microorganisms in flue cured tobacco grown soil[J]. Plant Nutrition & Fertilizer Science, 2012, 18(5): 1168-1176. (in Chinese).

[17] CHEN YG, LI XJ, WANG HT, *et al.* Effects of application of organic fertilizer combined with chemical fertilizer on disease resistance and quality of flue-cured tobacco[J]. Henan Agricultural Science, 2015, 44(6): 38-42. (in Chinese).

[18] WANG L, ZHOU JH, HE W, *et al.* Effect of different fertilization measures on soil enzyme activities and soil nutrition supplying abilities of flue-cured tobacco field[J]. Soils, 2012, 44(2): 302-307. (in Chinese).

[19] LI J, LIU GS, GAO Q, *et al.* Effect of application of different bio-organic fertilizer with tobacco specific chemical fertilizer on the amount of microbe and enzyme activities in the rhizosphere soil of flue-cured tobacco[J]. Journal of the Henan Agricultural University, 2013, 47(2): 132-137. (in Chinese).

[20] LUO SQ, YANG XO, LIN JQ. Effects of fertilization on diversity of microbial community structure and invertase activities in flue-cured tobacco grown soil[J]. Guizhou Agricultural Science, 2013, 41(7): 124-128. (in Chinese).

Editor: Yingzhi GUANG Proofreader: Xinxiu ZHU