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Effect of Humic Acid Application on the Yield and Quality of Flue-Cured Tobacco

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Abstract

The field experiment was conducted to investigate the effect of of humic acid amount (600 kg/hm^2, 900 kg/hm^2, 1200 kg/hm^2) at different fertilization time (base fertilization, topdressing fertilization and both) on the potassium content and chemical quality of Yunyan 97. The results showed that humic acid can significantly increase the potassium content in tobacco leaves. The coordination of potassium content in upper, middle and lower leaves reached for 1.52%, 2.55%, 2.63% respectively in the treatment of humic acid (1200 kg/hm^2) at base fertilization and topdressing fertilization (1/2 respectively), The content of nicotine and total nitrogen remained in appropriate range in all treatments. Both base and/or topdressing fertilization of humic acid in high level leaded to a more reasonable Potassium/Chloride ratio, and the coordination chemical quality was better.

Keywords: tobacco, humic acid, potassium, quality

1. Introduction

Tobacco cannot grow without in potassium nutrition, the potassium is required for carbon and nitrogen metabolism and activates enzymes involved in carbohydrate metabolism and increases resistance of tobacco. Flue-cured tobacco with high potassium content has good burning quality, good aroma and is safer to smoke (Shu et al., 2007; Guo et al., 2006; Gao et al., 2013; Niu et al., 2009; Liu et al., 2007; Duan et al., 2013). Potassium is one of the most mineral elements in flue-cured tobacco. The potassium content in the good-quality tobacco is over 2% (Marchand et al., 1997). In the countries like the US and Zimbabwe, potassium content of tobacco is as high as 4%~6%. In Brazil, the level is 3%~4%. While in China, that number is normally lower than 2%, which constrained the improvement of flue-cured tobacco quality in China (Hu et al., 1997; Li et al., 2010).

Humic acid is a bioactive organic biological slow-release fertilizer and together with the chemical fertilizers, forms an organic-inorganic complex fertilizer which holds the humic acid as the core. This can effectively improve the supply of nutrition (Wang & Qin, 2009; Stern et al., 2014; Wang et al., 2008) and increase the percentage of highest-class tobacco (Luo et al., 2011; Zheng et al., 2007; Gao, 2006). The objective of this paper is to investigate the effect of humic acid combined with chemical fertilizers on the the potassium absorption and the quality characteristic in Yunyan 97, which planted in Xiao zhai Village, Daba Township, Xingwen County, Sichuan, China. With concentrated heavy rain in summer, the potassium leaching loss in the soil is stronger and the potassium content in tobacco is low.

2. Materials and Methods

2.1 Study Area and Soil Properties

The field experiments were carried out in the Xiaozhai Village, Da ba Township, Xingwen County, Yibin, Sichuan, China. It is located in east longitude 105°08′55″, north latitude 28°20′38″ at 929.3 m above sea level. The soil, classified as a typical neutral purple soil in China. The physical and chemical properties were as follows, the pH value 6.5, organic matter 18.85 g/kg, total nitrogen 1.48 g/kg, available nitrogen 92.07 mg/kg, available phosphate 10.01 mg/kg, and available potassium 209.48 mg/kg.

2.2 The Tested Materials

The tested tobacco variety was Yunyan 97 (Hybrid variety of Yunyan 85×CV87). The adaptability was stronger and suitable for the southern smoke zone planting. The average height of Yunyan 97 was about 115cm, effective leaves were over 22, leaf shape was long elliptic, and the field period was about 125 days. It's easy baked, and the smoke color was orange and the main chemical composition was proportion. The humic acid fertilizer was provided by Sichuan Jiahe Agriculture Co., Ltd. The humic acid content was 55%.

2.3 Experiment Design

There were ten treatments in this experiment, including the local fertilization application (no humic acid addition). Base fertilizers were applied through drilling holes in concentric circles one week before transplanting. Topdressing fertilizers were applied in the same way after transplanting for 35 days. The NPK ratio was 6:9:20. The field cultivation and management measures were followed as the technical specifications of good-quality tobacco production management.

Table 1. The experiment design and fertilization application

Treatment	Application rates (kg/hm^2)	Fertilization application mode
T0	No HA	-
T1	HA600	Base Fertilization
T2	HA900	Base Fertilization
T3	HA1200	Base Fertilization
T4	HA600	Topdressing Fertilization
T5	HA900	Topdressing Fertilization
T6	HA1200	Topdressing Fertilization
T7	HA600	Both base and topdressing fertilization（1/2 respectively）
T8	HA900	Both base and topdressing fertilization（1/2 respectively）
T9	HA1200	Both base and topdressing fertilization（1/2 respectively）

2.4 Analysis and Test Method

The tobacco leaves was named in different units and baked separately under the uniform way. Samples were collected for chemical analysis. The main indexes including, total sugar, reducing sugar, total nitrogen, nicotine, potassium and chlorine ion. These testing followed the methods of YC/T159, YC/T161, YC/T160, YC/T173, YC/T62, YC/T166 respectively. The sugar to alkali ratio, nitrogen to alkali ratio, and potassium to chloride ratio were calculated.

2.5 Data Analysis

The Excle2007 and SPSS 18.0 were used for the data analysis.

3. Results and Discussion

3.1 The Effect of Humic Acid on the Potassium Content of Yunyan 97 Leaves

According to Figure 1, a descending rank order of potassium content in different parts of tobacco leaves was lower, middle and upper leaves. Compare with the control group, after the humic acid treatment, the lower leaves had the higher potassium content of above 2%, reaching the standard of good-quality tobacco leaves. Middle leaves' potassium content was below 2%, except in the case of T9 treatment (both base and topdressing fertilization of humic acid), which leaded to 2.55% of potassium content. The upper leaves had a lower potassium content of less than 2%. Compared with the control group, topdressing humic acid could increase the potassium content of upper, middle and lower leaves and the T6 treatment (topdressing high-level humic acid) worked best. Both the base and topdressing fertilization of humic acid increased the potassium content in middle and lower leaves and T9 treatment was best, it' potassium content in middle and lower leaves higher than 2% and upper leaves higher than 1.5%.

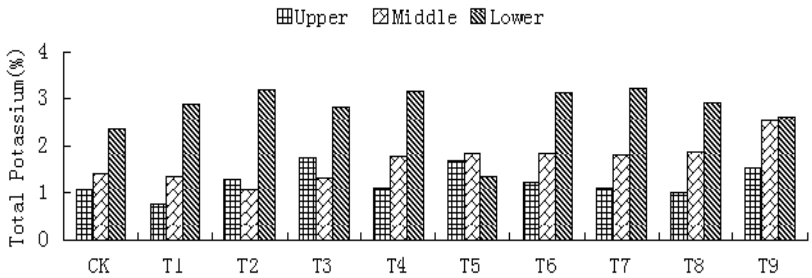

Figure 1. The effect of humic acid on potassium content of Yunyan 97 leaves

3.2 The Effect of Humic Acid on the Nicotine Content of Yunyan 97 Leaves

Nicotine was a type of pyridine alkaloid with strong irritating smell and taste spicy, which determines the physiological intensity of the smoke. Good-quality tobacco leaves must have a nicotine content of 1.5% to 3.5% and 2.5% at best (Fan, 2010). Figure 2 showed that humic acid increased the nicotine content in tobacco leaves by different levels, but the content after treatment was appropriate.

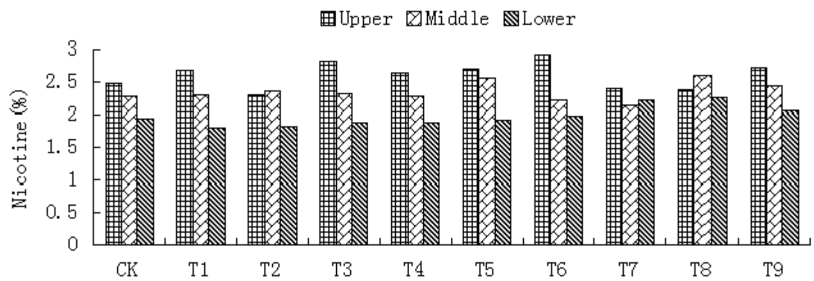

Figure 2. The effect of humic acid on nicotine content of Yunyan 97 leaves

3.3 The Effect of Humic Acid on the Content of Total Sugar in Yunyan 97 Leaves

The content of carbohydrate in tobacco has a great influence on the quality of tobacco leaves. An appropriate level can produce satisfying aroma and taste, concealing the smoke of impurities, but too high level leads to insipid taste and much tar after combustion. Figure 3 showed that the overall total sugar content after each treatment was relatively low. Humic acid reduced the content of total sugar in upper leaves. For middle and lowe leaves, T6 and T9 treatment work well to increase their content of total sugar.

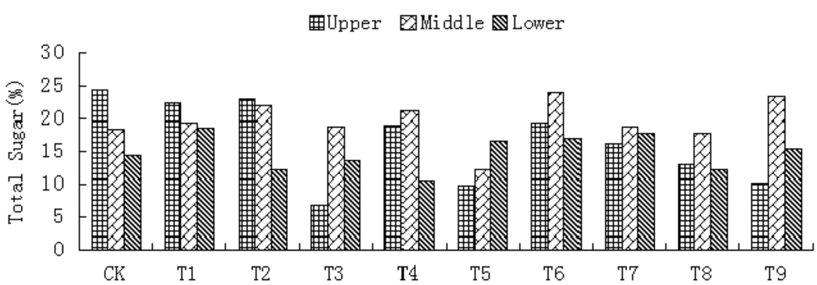

Figure 3. The effect of humic acid on total sugar of Yunyan 97 leaves

3.4 The Effect of Humic Acid on Other Chemical Indexes in Yunyan 97 Leaves

Table 2 indicated that there was no apparent change in the content of total nitrogen after different treatments, which remained in an appropriate range. Humic acid reduced the content of reducing sugar in lower leaves. The content of reducing sugar in middle and lower leaves after all treatments remained in an appropriate range. The appropriate content of chloride ion in tobacco leaves is between 0.3% and 0.8% (Hu et al., 2010). In the control group, the content of chloride ion in upper, middle and lower leaves was below 0.1%. After using humic acid, the content in them increased by different levels and the after-treatment content remained in an appropriate range.

Table 2. Effect of humic acid on other chemical components of Yunyan 97

Treatment	Total nitrogen (%)			Reducing sugar (%)			Chloride ion (%)		
	Upper	Middle	Lower	Upper	Middle	Lower	Upper	Middle	Lower
T0	1.84	1.70	1.72	13.51	13.87	16.18	0.08	0.03	0.10
T1	1.89	1.39	1.68	23.29	13.07	11.91	0.15	0.15	0.10
T2	1.90	1.88	1.64	15.83	15.65	12.98	0.09	0.16	0.15
T3	1.54	2.22	1.79	3.56	7.65	9.25	0.15	0.08	0.05
T4	1.51	1.87	1.41	11.02	16.21	5.51	0.11	0.19	0.76
T5	1.96	2.13	1.71	9.25	11.74	12.62	0.1	0.17	0.09
T6	1.55	2.00	1.80	10.31	14.58	13.27	0.12	0.05	0.15
T7	1.83	1.81	1.91	17.6	14.31	9.6	0.15	0.76	0.26
T8	1.95	1.66	1.7	10.49	7.73	11.24	0.11	0.10	0.22
T9	1.88	1.72	1.86	15.47	17.51	13.87	0.12	0.08	0.08

3.5 Effect of Humic Acid on the Degree of Coordination of Chemical Components of Flue-Cured Tobacco

The degree of coordination of chemical components of tobacco is an important criterion to assess the quality of tobacco leaves. The ratio of sugar to alkali examines tobacco momentum, which is between 6 and 10 (Hu et al., 2010). The ratio of nitrogen to alkali of tobacco of high quality is about 1 (Li, 2008; Ling, 2008). The ratio of sugar to alkali after humic acid was applied had slightly decreased while the ratio of nitrogen to alkali was hardly affected (Table 3). In terms of the degree of coordination of chemical components, it was optimal to dress or dress and bottom apply at the same time high-level humic acid. When the ratio of potassium to chlorine is less than 4, ash content and combustibility of tobacco will be heavily affected and unnecessary smells will come out. It could be seen from the analysis result that the ratio of potassium to chlorine of the middle and lower parts of tobacco was higher when tobacco treated with T3, T6 and T9, which indicated that the use of high-level humic acid could coordinate the ratio of potassium to chlorine.

Table 3. Effect of humic acid on quality indicators of Yunyan 97

Treatment	Ratio of sugar to nicotine			Ratio of potassium to chlorine			Ratio of nitrogen to alkali		
	Upper	Middle	Lower	Upper	Middle	Lower	Upper	Middle	Lower
T0	9.85	8.09	7.47	13.02	46.26	24.3	0.74	0.75	0.89
T1	8.34	8.44	10.27	5.14	9.18	29.68	0.70	0.60	0.93
T2	9.94	9.29	6.74	14.45	6.75	21.81	0.82	0.80	0.90
T3	2.42	8.11	7.28	11.89	17.46	60.79	0.54	0.95	0.95
T4	7.20	9.28	5.67	9.68	9.40	4.16	0.57	0.82	0.75
T5	3.60	4.75	8.68	17.18	10.94	15.06	0.72	0.83	0.89
T6	6.64	10.82	8.60	9.93	34.32	21.31	0.53	0.90	0.91
T7	6.75	8.78	8.04	7.69	2.37	12.36	0.76	0.84	0.86
T8	5.49	6.86	5.47	8.60	19.43	13.29	0.82	0.63	0.75
T9	3.79	9.60	7.50	12.26	30.95	31.93	0.69	0.70	0.90

4. Conclusion

First, as application amount of humic acid was increased: the amount of potassium in all parts of tobacco was increased, especially of the upper and middle parts. Treatment T9 that was to dress and bottom apply high-level humic acid best coordinated the amount of potassium in the upper, middle and lower parts, the ratio of which was respectively 1.52%, 2.55% and 2.63%. Humic acid could increase the amount of potassium of tobacco, which was similar with that of the former researchers (Liang et al., 2005). Humic acid could improve cation exchange capacity, reduce the fixed amount of external potassium and promote the release of potassium of soil. With storability and validity of potassium increased, the amount of potassium in tobacco is increased. However, the amount of potassium in the upper part of tobacco was low, which was probably because that the accumulation amount of dry matter was larger than the absorptive amount of potassium, leading to attenuation of potassium (Zhao et al., 2010).

Second, dressing and bottom application of high-level humic acid could coordinate the ratio of potassium to chlorine, increase the amount of sugar in the middle and lower parts of tobacco and realize the highest degree of coordination of chemical components. This result was similar with that of Liu et al. (2010) and other researchers (Huang et al., 2008), that was, applying humic acid could coordinate chemical components better and improve the indexes of flavor and other chemical components.

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References

Duan, B. B., Li, Y. F., Rong, H., Ma, D. P., & Ning, X. (2013). Effects of chloride ions content on combustibility of reconstituted tobacco. *Modern Food Science and Technology, 29*(4), 752-755.

Fan, L. H. (2010). Effects of applying rapeseeds cake on growing of tobacco plants and quality of tobaccp leaf. *Southwest University*.

Gao, C. L., Zhou, J. H., Qiu, Y., Li, Q., Zhang, Z., & Huang, T. (2013). Effect of nitrogen and potassium stress on physiological properties and nicotine of flue-cured tobacco after topping. *Crop Research, 27*(5), 449-452.

Gao, J. H. (2006). Effect of humic acid on growth of flue-cured tobacco. *Chinese Agricultural Science Bulletin, 22*(8), 328-330.

Guo, Z. K.,Yang, Q., Yao, Q. H., Wan, X. Q., & Yan, P. Q. (2006). Study on HAL1 modified tobacco with high leaf potassium content. *Acta Tabacaria Sinica, 12*(5), 46-51.

Hu, G. S., Zhao, Y. K., Cao, Z. H., Zhao, X., Zhao, Z. S., Chen, J. H., … Li, Z. L. (1997). China's main flue-cured tobacco element composition and chemical quality evaluation. *Acta Tabacaria Sinica, 3*(3), 36-43.

Hu, W. D., Zhang, Y. Z., Li, H. B., Yang, Q. L., & Zhang, H. (2010). Effects of different fertilization ratios on yield and quality of tobacco. *Hunan Agricultural Science, 23*, 63-66.

Huang, Y. J., Zhang, Y., Zhang, X., Liu, G. S., & Mao, J. W. (2008). Effects of humic acid and cake fertilizer on soil microbe and flue－cured tobacco yield and quality. *Acta Tabacaria Sinica, 14*(B12), 25-28.

Li, D. D. (2008). *Sichuan tobacco potassium and chlorine content condition and the relationship with other quality indicators*. Henan Agricultural University.

Li, W., Zhou, J. H., Zhang, Y. Y., Deng, J. H., Deng, Y. L., Yang, R. S., … Tang L.T. (2010). Spatio-temporal variability of potassium content in flue-cure tobacco leaf in Yunnan province. *Acta Tabacaria Sinica, 16*(5), 24.

Liang, C. H., Luo, L., Du, L. Y., & Pan, D.W. (2005). Effect of humic acids on fixation and release of potassium in cultivated brown soil. *Acta Pedologica Sinica, 42*(3), 468-4.

Ling, A. F. (2008). *Effect of different humic acid levels on soil characteristics and leaf quality of flue-cured tobacco*. Henan Agricultural University.

Liu, Q., Ma, F. Y., Yu, J. J., Wei, P. P., Ye, X. W., & Yan, D. (2010). The research advance of the effect of humic acid to the soil and tobacco. *Chinese Agricultural Science Bulletin, 26*(4), 132-136.

Liu, W. X., Yan, H. H., Zhou, Y., Lin, L. T., & Lin, Z. L. (2007). Research progress of potassium nutrition of tobacco improving k content in flue-cured tobacco leaves. *Crop Research, 21*(B12), 736-740.

Luo, J. X., Guo, W., Yan, H., Yang, Q., Dong, X. L., & Yang, W. Q. (2011). Adsorption desorption properties of three types of agricultural humic acids for K^+. *Journal of Agricultural University (natural science editor), 37*(1), 103-106. http://dx.doi.org/10.3724/SP.J.1238.2011.00103

Marchand, M., Etourneaud, F., & Bourrrie, B. (1997). Influence of different varieties of potash fertilizer on tobacco production and chemical composition. *Chinese Tobacco Science, 18*(2), 6-11.

Niu, R. B., & Nie, Z. (2009). Study on the potassium content distribution regular pattern of different position within the flue-cured tobacco leaf. *Crop Research, 23*(3), 194-196.

Shu, H. Y., Yang, T. Z., Cao, G. Q., Ling, H., & Tian, B. M. (2007). The relationship between tobacco economic characters, nicotine content and potassium content. *China Agricultural Science Bulletin, 23*(2), 275-278.

Wang, R. J., Wang, Z. G., Liang, T. B., Zhang, X. D., Liu, L. L., & Shi, C. Y. (2008). Influence of potassium humate to eat sweet potato varieties potassium uptake, utilization and the tuber yield. *Plant Nutrition and Fertilizer Science, 14*(3), 520-526.

Wang, Y. X., & Qin, H. J. (2009). Function of humic acid to control the release of nitrogen and potassium and to activate phosphorus. *Humic Acid, 4*, 27-32.

Zhao, Z. X., Li, C. J., Yang, Y. H., & Zhang, F. S. (2010). Why does potassium concentration in flue-cured tobacco leaves decrease after apex excision? *Field Crops Research, 116*(1), 86-91.

Zheng, X. B., Liu, G. L., Xing, G. Q., Wei, Y. W., Ye, X. F., & Wang, T. Y. (2007). Effects of humic acid on chemical constituents and economic of flue-cured tobacco. *Henan Agricultural Science, 12*, 43-45.

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