Original Research Article

RESULTS OF TESTING ON APPLICATION RATE OF THE SPECIALIZED ORGANIC BLENDED FERTILIZER ON FLUE CURED TOBACCO IN THE NORTH MOUNTAINS OF VIETNAM

ABSTRACT

Province Cao Bang is one of the dominant flue-cured tobacco (FCT) producing areas in the northern mountainous region of Vietnam. Here, a specialized organic mineral mixed fertilizer (OM-NPK), with analysis of N-P_2O_5-K_2O-organic matter-humic being 5-4-9.5-10-0.4 %, was tested on the application rate of this grade to FCT in the Spring crop of 2021 with 03 rates as follows: 1 ton/ha, 1.1 ton/ha and 1.2 ton/ha, compared with the control of specialized inorganic mixed fertilizer being named VTL: MN (analysis of N-P_2O_5-K_2O is 5.8-7.5-13.5 %) and the background treatment (no fertilizer). The experiment, including 05 treatment, was arranged in a randomized complete block design (RCBD) with 03 replications on the main tobacco-growing soil in the Cao Bang, which is heavy soil. The results of this study showed that all 03 treatments on the application rate of OM-NPK fertilizer met the requirements of the test based on the fertilizer use efficiency (beyond the control by 10%), in which the treatment with the application rate of 1-ton OM-NPK/ha gave the best performance (reliability 0.05). At the same time, the density of micro-organisms dissolving insoluble phosphorus in the soil was higher in treatments of the OM-NPK application than the control.

Keywords: *Flue cured tobacco, fertilizer, organic, humic acid, soil*

1. INTRODUCTION

The commonly cultivated tobacco plant is mainly of the species *Nicotiana tabacum*. FCT is the most produced of the four global commercially cultivated tobacco types (FCT, sun-cured, burley, and oriental tobacco). Tobacco is grown from 600 North to 400 South, but the quality of each tobacco type varies greatly between growing regions around the world and within a country. At each production area, tobacco cultivation techniques, especially fertilizer regimes, are developed only depending on soil type, climate, market, etc. but also are based on the relationship between the characteristics of nutrient absorption and capacity to produce the mass of a cultivated tobacco variety.

For the plant to produce the final product, which is raw tobacco, to achieve the highest possible yield and certain quality, it is first necessary to ensure the favorable growth of the plant, in which the plant's nutrient absorption needs are satisfied. For plants in general, tobacco in particular, each nutritional element has a specific role, thereby affecting the yield and quality of tobacco differently. The determination of the rate of essential nutrients is not only based on the needs of tobacco plants, but also on the current fertility of the soil and also on weather and climate conditions in the tobacco growing area …

The research work on macronutrient requirements in relation to dry matter yield of FCT has shown that in order to accumulate 4 tons of dry matter (whole plant), plants need to absorb the approximately amount of N-P_2O_5-K_2O being 67-12-134 kg/ha [6].

Most of the cultivated soil has an organic matter content of less than 5% [7]. Acidic and eroded soils are usually organic matter, including plant debris and fulvic acid, while that in neutral and alkaline soils is mainly in the form of humic acids and humin [5]. Humic compounds, dubbed "Black Gold" in agriculture, play a role in determining soil fertility [5]. Plants grown on soils, containing reasonable levels of humin, humic acid, and fulvic acid are healthier and more productive.

Soil organic matter has a specific role as follows [7]:

- Provide energy and carbon sources for soil microorganisms.

- Binds soil particles together, minimizing the risk of soil erosion. Increases the ability to retain moisture and provide water for plants. Assist structure for the soil, regulating the temperature and air regime in the soil, increasing the water permeability of the soil, facilitating the tillage.
- Store and gradually supply essential nutrients for plants and soil microorganisms; Increase the ex-

change of cations and anions between plants and soil.

- Minimizing the negative effect of pesticides, heavy metals, and many other environmental pollutants. Increase the buffering capacity of the soil.

Effects of humic substances on plant growth [5] are as follows:

- Humic substances affect plants directly and indirectly. Indirect effects related to soil fertility. Direct effects include changes in the plant's metabolism. When humic substances enter the cell, several biochemical changes occur in the membrane and other components of the cell. Humic substances stimulate the absorption of macronutrients by plants.

- Humic substances are absorbed by plant roots and concentrated in plant roots. The large molecule humic acid is passively absorbed by the roots, while the smaller molecule fulvic acid is metabolized. After the amount of humic acid and fulvic acid reaches a certain concentration in plant roots, a proportion (5 - 30%) of the total concentration will transport to the branches and leaves. Humic acids increase the permeability of mineral nutrients across cell membranes, thereby increasing the ability to transport nutrients to the points required for synthesis. Humic affects both hydrophilic and hydrophobic sites on the cell membrane surface. In addition, the scientists also believe that the phosphorus-lipid components of the membrane will change the charge through humic. As a result, the cell membrane surface becomes more active in transporting trace minerals from the outside of the cell into the cytoplasm.

- Humic acid and fulvic acid both inhibit the enzyme indole acetic acid oxidase (IAA oxidase), leading to constrain IAA destruction. The growth regulator IAA has essential functions in various parts of the plant. IAA will continue to stimulate growth. Unfractionated humic acids are most effective in regulating plant growth hormones.

- Humic substances increase the ability to produce ATP energy molecules in plant cells, being the source of biological energy in most biological reactions of metabolic processes in plants.

Ways to protect and enhance soil humic [5] are as follows:

- Humic substances occur commonly in soil water, compost, peat, and carbon minerals such as brown coals, low-grade lignites, and leonardite. Most soil and water on the global surface contain some humic substance, being as humin, humic acid, or fulvic acid. However, the concentration of humic substances in agricultural soil is extremely low. Humic substances, used to produce the fertilizers, can be extracted from carbon mineral deposits in many zones. Within the United States, there are several mines and seams of carbon mineral deposits suitable for obtaining good humic substances in agricultural production. Humic substances also can be extracted from peat to apply crops in different product forms.

- Humic substances also can be formed naturally in properly cultivated soil. Activities such as crop rotation, balanced fertilization, legume cultivation, green manure application, composting, and the application of optimal farming practices can help form humic substances. However, such humus building practices are very slow and costly. To quickly return damaged soils to high yields, growers need to consider alternatives. An analysis of this situation indicates that the most rapid and practical solution to improving soil fertility is the addition of humates (mined humic substances) directly to the soil or as foliar fertilizers. Humic supplements will maximize the effectiveness of available nutrients as well as help release the insoluble nutrient bonds in the soil while reducing fertilizer costs for plants.

Table 1. Some meteorological factors in the spring FCT crop in Cao Bang

Year	Factors	January	February	March	April	May	June
2008 - 2020	Temperature (^{0}C)	13.9	16.4	19.4	23.3	26.4	27.7
	Sunshine (hrs)	57	77	81	116	167	156
	Rainfall (mm)	50	19	57	86	199	261
2021	Temperature (^{0}C)	13.3	18.5	21.3	23.3	28.3	28.6
	Sunshine (hrs)	90	92	63	88	227	198
	Rainfall (mm)	35	50	65	130	130	206

Province Cao Bang is a main FCT producing area in the North and produces the highest quality tobacco in the country. Previously, the fertilizer regime applied to FCT included specialized inorganic

mixed fertilizers (base rate was 1 ton of VTL:MN fertilizer per hectare) and the addition of manure. Recently, the rapid increase in mechanization (cultivator, transport machine) in the northern tobacco growing regions, the shortage of labor, etc. are the main reasons for the decrease in the cattle amount, thereby reducing the source of manure for tobacco crops, which will adversely affect soil fertility in the long term, especially reducing soil organic matter [2]. Therefore, it is necessary to research and apply specialized mixed fertilizers to supplement organic and humic substances for tobacco crops towards sustainable production, conserving the fertility of the soil.
The objective of this experiment was to determine the appropriate application rate of specialized organic blended fertilizer for FCT cultivation in Cao Bang, Vietnam.

2. MATERIALS AND METHODS

2.1 The testing site

Nam Tuan commune, Hoa An distric, Cao Bang province, Viet Nam

2.2 The experimental soil

Table 2. Results of soil analysis for performing of OM-NPK fertilizer testing on FCT in Cao Bang, Spring 2021 crop

Mineral particles* (%)	Oganic matter (%)	pH_{KCl}	Cl (ppm)	Available macronutriment (mg/100 g)			Exchanges (meq/100g)			
				N	***P_2O_5***	***K_2O***	***CEC***	***Ca***	***Mg***	***H***
59.8	3.2	6.6	15	11.9	42.4	7.9	20.4	7.6	0.5	1.2

* *Clay and silt particles less than 0.01 mm in diameter*

The experiment was arranged on the main soil type for growing FCT in Cao Bang, which is fine texture, has a pH being in the neutral range, and has the following characteristics: organic matter has got being medium; rich both N as well as P2O5 in available; Total and available K_2O has got being both medium; rich in exchangeable Ca, but exchangeable Mg and cation exchange capacity (CEC) both has got being medium ...

2.3 Layout and Design of the Experiment

The experiment was laid out in randomized complete block design with three replications. The total numbers of unit plots were 15. The size of a unit plot was 2 m x 25 m. Each plot has two rows. Planting distance between two rows was 1 m and between two plant per row was 0.5 m.

2.4 Fertilizers, cultivar and treatments of the Investigation

The fertilizer OM - NPK (analysis of N-P_2O_5-K_2O-organic matter-humic is 5-4-9.5-10-0.4 %) was tested on FCT (cultivar GL7) for comparison with the control is a specialized inorganic mixed fertilizer VTL: MN (analysis of N-P_2O_5-K_2O is 5.8-7.5-13.5 %) and the background treatment (no fertilizer). The experiment consisted of 5 treatments as follows: (1) Control: apply 1 ton VTL:MN/ha; (2) Background: No fertilizer (symbol is Base); (3) Apply 1 ton OM-NPK/ha (symbol is 1 OM-NPK); (4) Apply 1.1 tons OM-NPK /ha (symbol is 1.1 OM-NPK); (5) Apply 1.2 tons OM-NPK/ha (symbol is 1.2 OM-NPK).

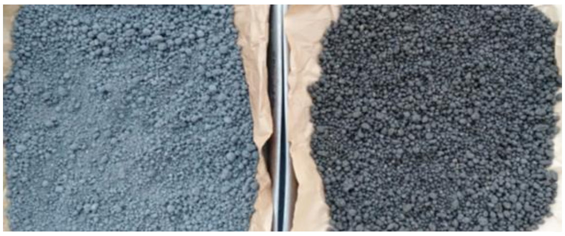
Figure 1. Fertilizer VTL: MN (left) and fertilizer OM-NPK (right)

2.5 Cultivation, harvesting and curing

Basal dressing of the experimental fertilizers has been carried out right before planting (planting date: January 20, 2021) with 50% of the fertilizer rate of each treatment and the remaining amount of fertilizer for each treatment at the time of 35 days after planting (before foliage of same row plants interspersed with each other). Lay-by were done at 35 days after planting. All 5-6 irrigations were given to the crop during the crop growth period.

Harvesting is done when the leaves are ripe, then they have been treated by flue cured.

2.6 The target surveillance

Establishing the fertilizer testing on the FCT according to the regulations on fertilizer testing of the Standard TCVN 12719-2019 - Testing of fertilizers for annual crops. Tested fertilizers that are registered for trading must have test results that meet the following requirements: Increased effectiveness compared to the control in terms of yield or economic efficiency or fertilizer use efficiency all is same rate, being equal or than 10%.

Density of microorganisms that degrade insoluble phosphate in soil was determined following the standard of Vietnam TCVN 6167:1996. Analysis of blended fertilizers following standards of Vietnam as total nitrogen: TCVN 5815:2015, available phosphorus: TCVN 5815:2015, available potassium: TCVN 8560:2018, organic matter: TCVN 9294:2012 and humic: TCVN 8561:2010. Analysis of chemical components of FCT following standards of Vietnam as Nicotine: TCVN 7103:2002 (ISO 2881:1992), sugar: TCVN 7102:2002 (CORESTA 38:1994) and Chlorua (Cl): TCVN 7251:2003, total nitrogen: TCVN 7252:2003, total phosphorus: TCVN 7254:2003, total potassium: TCVN 7255:2003.

Analysis of the experimental data: Use statistical analytical software STATISTIX.

Sensory evaluation of tobacco ingredients according to Interim Standard TC 01 - 2000 of Viet Nam Tobacco Corporation based on the total point of the smoker: less 20 points are poor smoking; 25-28 points are medium smoking; 31 - 38 points are good smoking; 43 - 50 points is exellent smoking.

Figure 2. Newly planted experimental FCT (left) and after finishing lay-by (right); Signboard: CT1 - CT5 corresponds to treaments (1) - (5); Roman numerals for repetitions

3. RESULTS AND DISCUSSION

3.1 Leaf ripening characteristics and major pests

Table 3. Effect of the treatments on ripening characteristics and powdery mildew disease index of experimmental FCT in Spring 2021 in Cao Bang

Treatments	Days to		Harvested leaves mass (%)		Powdery mildew index* (%)
	Mature primings	Finished harvesting	Priming N_0 1 to N_0 3	The last four picks	
Base	65	153	30.5	30.5	7.8
Control	67	158	29.0	32.5	9.7
1 OM-NPK	67	158	28.4	35.2	8.3
1.1 OM-NPK	69	158	26.5	36.1	11.1
1.2 OM-NPK	70	158	24.2	38.8	13.9

* *The disease appeared at the end of March 2021*

The difference in time from planting to first ripening of the FCT among 05 treatments was significantly different. The results have shown that the FCT of the treatment Base in the earliest maturing; Increasing the rate of OM-NPK application tended to slow down the ripening of the FCT, while the treatment of 1 ton OM-NPK/ha has got matured primings at the same time as the control. The effect of each treatment on the duration from planting to matured primings of the FCT was similar to the data on the percentage of harvested leaves mass for the first 3 harvest times of each treatment. However, after the early primings, the ripeness of the FCT depends not only on treatment but also on the great influence of the weather patterns in the northern mountainous provinces of Vietnam (often have heavy rain, prolonged and hot weather; Table 1). This weathering type causes FCT to not reach full maturity, morphological ripening often occurs faster than physiological ripening of leaves and is called “false ripening” (due to a combination of reasons: heavy and prolonged rain causes leaching and drowning; high temperature). In this case, the slow ripening of FCT has good holding ability, which may help the plant accumulate more dry matter or mature leaves more fully. The better holding ability of FCT can be proved through a higher percentage of last some primings. The FCT in the OM-NPK fertilizer treatments has proved better holding ability than the control (VTL: MN application), especially in the treatments with the increased amount of OM-NPK fertilizer. However, extended duration from reaching maturity to technical ripe for an FCT left is often associated with excess nitrogen (N) nutrition at the harvest stage. The slow maturity of an FCT left will adversely affect both the quality and smoking properties. FCT in the non-fertilized treatment ripened early due to lack of nutrients, especially nitrogen.

Experimental data showed that the time from planting to final harvest (table 3) of the FCT was not different between 4 treatments with fertilizer application, except that the FCT in the background treatment finished harvesting earliest.

Powdery mildew disease has appeared in late March to early April 2021 when the weather has was more humid and warmer (Table 1). The disease has caused damage to the bottom leaves of all experimental and local FCT, and the disease index of experimental FCT tended to increase when increasing the amount of fertilizer application.

3.2 Some agronomical characteristics, yield and good grade

Table 4. Effect of the treatments on some agronomical characteristics, cured leaf yield and total grade 1&2 of the FCT in Spring 2021 in Cao Bang

Treatments	Height of topped stalk (cm)	Diameter topped stalk (cm)	Leaves per Plant	Cured leaf yield* (ton/ha)	Percent Yield compared with control	Percentage of grade 1+2*
Base	62.2	2.3	27.8	2.57^{B}	70	69.5^{A}
Control	95.3	2.8	27.8	3.67^{A}	100	68.7^{A}
1 OM-NPK	99.8	2.7	27.9	3.80^{A}	104	71.4^{A}
1.1 OM-NPK	99.8	2.8	27.9	3.73^{A}	102	66.9^{AB}
1.2 OM-NPK	99.3	2.8	27.9	3.80^{A}	104	63.5^{B}

* *Values with the same letter are not statistically significant*

Experimental tobacco planted at the end of January 2021, plus the weather patterns of the Spring 2021 crop (Table 1) made the plant had reached the calibrated rate of leaves for harvest (maximum 28 leaves per plant) but have not yet reached button stage, including in the treatment Base. Therefore, it was not possible to determine the time of 50% of the plants to bud and the total number of leaves per plant in the experiment. Regarding other parameters, the test results showed that FCT in the treatment Base had the worst performance in growth, shown in the height of the topped stalk and the lowest diameter of the topped stalk in the 5 tested treatments. Increasing the rate of OM - NPK fertilizer application tended to increase the growth of FCT and the treatment of 1.2 ton/ha gave the highest performance among the three application rates of tested OM - NPK as well as compared with the control.

Statistical analysis showed that all 03 OM - NPK fertilizer treatments gave cured leaf yield (3.73 - 3.8 tons/ha) that was not a statistically significant difference (reliability $\alpha = 0.05$) compared with the control (3.67 tons/ha). In addition, the test results showed that the fertilizer's tobacco yield-enhancing effect is estimated at 30% under experimental conditions.

The results of the trial showed that increasing the level of OM - NPK fertilizer application tends to reduce the quality of FCT, specifically: FCT in the treatment 1.2 ton/ha gave a significantly lower percentage of grade 1+2 being statistical significance (reliability 0.05) compared with the treatment 1 ton/ha and the control.

3.3 Chemical composition and sensory evaluation

In addition to the trend of increasing the rate of OM - NPK fertilizer applying for FCT leading to a slight decrease in reducing sugar content, all 03 OM - NPK application treatments and the control made no significant difference in nicotine component, chlorine in FCT materials. Therefore, the difference in the smoking point between 04 tobacco samples corresponding to 03 OM - NPK treatments and control is not significant. All four samples of FCT materials tested through the sensory evaluation gave good aroma (above 10 scores). It is possible that the weather in the second half of the Spring 2021 harvest period, which had a higher number of sunny hours than usual (Table 1), had got a positive effect on the ripening of FCT leaves, leading to an increase in the aroma of tobacco [6]. Also, the favorable weather of the Spring 2021 crop, especially in the second half of the harvest period, has increased the accumulation of dry matter of the plants. Therefore, the cured leaves yield of the four fertilized treatments, excluding the treatment Base, has reached a very high level, so it has markedly decreased nicotine in raw materials compared to previous years in this growing area, reaching an average of 1.5% in years 2017 - 2020 [4]. Therefore, the high ratio of reducing sugars/nicotine of FCT materials tested in 2021 may have adversely affected the taste of tobacco. However, the tobacco samples of testing were assessed to have good smoking quality (total smoker score from 39 to 43), which is typical of FCT materials of Cao Bang growing area.

Table 5. Effect of the treatments of applied fertilizers on some chemical components and some smoking characteristics of the FCT materials in Spring 2021 crop in Cao Bang

Treatments	Component (%)			Sensory evaluation (score)					
	Nicotine	Reducing sugar	Cl	Smoking flavor	Tastes	Irritability	Combustionability	Colour	Sum
Control	1.0	18.1	0.1	10.6	9.3	6.9	7.0	7.0	40.8
No (3)	1.0	16.6	0.1	10.5	9.1	7.0	7.0	7.0	40.6
No (4)	0.9	16.5	0.1	10.3	9.2	7.0	7.0	7.0	40.5
No (5)	1.0	15.2	0.1	10.4	9.0	7.0	7.0	7.0	40.4

3.4 Density of useful microorganisms in soil and accumulation of macronutrient of the FCT

Table 6. Density of microorganisms that degrade insoluble phosphate in soil and macronutrient accumulation of experimental FCT in Spring 2021 crop in Cao Bang

Treatments	Density of microorganisms (CFU/g)	macronutrient element (%)		
		N	P	K
Control	4.2×10^6	1.4	0.31	2.5
1 OM - NPK	1.4×10^7	1.5	0.34	2.5
1.1 OM -NPK		1.5	0.34	2.5
1.2 OM -NPK		1.6	0.35	2.7
Sufficient range [1]		1.6 - 2.0	0.13 - 0.3	1.5 - 2.5

Except for the FCT in the treatment 1.2 OM - NPK, which showed sufficient accumulation of N nutrients, the FCT in the remaining 03 fertilizer treatments was a slight accumulation of N deficiency. The concentration of P and K in the leaves of FCT in the four fertilizing treatments was at or slightly above the upper limit of the plant's P and K nutrient enough range. Although, the phosphorous application rate of all the 03 OM - NPK fertilizing treatments was significantly lower than the control (Table 7). Applying OM - NPK for the FCT can increase the density of insoluble phosphorus degrading microorganisms compared with the control, the study results obtained are as follows: the density of this microorganism in the merged soil sample of 03 OM - NPK fertilizing treatment increased more than 3 times compared to the control (Table 6). The results of this study are similar to the results of previous studies on supplementing humic bioorganic fertilizer for FCT in Cao Bang [3].

3.5 Fertilizer use efficiency (FUE)

Table 7. Calculation fertilizer use efficiency of fertilizer treament in the trial on FCT plants in the Spring crop of 2021 in Cao Bang

Treatments	Amount of converted macronutrient (kg/ha)				Fertilizer use efficiency	
	N	P_2O_5	K_2O	Sum	kg cured leaves/ kg macronutrient *	Percentge compared with control
Control	58	75	135	268	4.1^{C}	100
1 OM - NPK	50	40	95	185	6.6^{A}	161
1.1 OM -NPK	55	44	105	204	5.7^{B}	139
1.2 OM -NPK	60	48	114	222	5.6^{B}	137

** FUE of a fertilizer experimental treatment is calculated by the difference between the yield of the that treament and the yield of the base treament (no fertilizer) divided by the total amount of converted nutrients of the fertilizer experimental treatment; Values with the same letter are not statistically significant.*

All three application rates of the promising specialized organic blended fertilizer have provided higher FUE than the control (reliability 0.05) and achieved a minimum excess of 10% according to the requirements set out in the Standard TCVN 12719-2019 - Test of fertilizers for plants annually. Among the 03 levels of application of OM - NPK fertilizer tested, the treatment 1 OM - NPK gave the highest FUE and the difference was statistically significant with the tested together 02 treatments.

4. CONCLUSION

The specialized organic blended fertilizer (proportion N-P_2O_5-K_2O-organic matter-humic is 5-4-9.5-10-0.4 %) with the application rate of 1 ton/ha is the most advantageous for FCT cultivation in Cao Bang.

EXISTENCE OF THE STUDY

According to the TCVN 12719-2019 Standard, this organic blended fertilizer needs to be further tested on a large scale on FCT in Cao Bang in the Spring 2022 crop. In addition, the long-term effect of increasing the fertility of tobacco cultivating soil by this organic blended fertilizer application also needs to be further evaluated.

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COMPETING INTERESTS DISCLAIMER:

Authors have declared that no competing interests exist.

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