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EFFECT OF ELECTRIC FERTILIZER ON SOIL PROPERTIES

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ABSTRACT: Electric fertilizer, i. e. exerting electric field on plants during growing season instead of chemical fertilizer, is a kind of physical fertilizer, and the third kind of fertilizer with developmental prospect after inorganic fertilizer and organic fertilizer. For the purpose of studying the changes of physical and chemical properties of soil after exerting electric field, five treatments with different applications of chemical fertilizer were arranged on the black soil in Yushu City of Jilin Province by randomized block method, and electric field was exerted on plants every ten days during the growing season. Through sample analysis the paper arrives at following conclusions: 1) Exerting electric field can make soil′s granular structure increase, bulk density decrease, moisture capacity increase, thus improving the perviousness of soil. 2) Exerting electric field can make microorganism′s number increase and activity strengthen, thus activating nutrient and increasing organic matter content. 3) Exerting electric field with 0.1A medium has the best effect. So the chemical fertilizer can be saved. Therefore, we can say that the application of electric fertilizer is favorable for decreasing chemical poison, improving soil, relaxing the contradiction between the supply and demand of chemical fertilizer, and decreasing production cost of agriculture and forestry.
KEY WORDS: electric fertilizer; soil property; rival action; black soil

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1 INTRODUCTION

Electric fertilizer, i. e. exerting electric field on plants during growing season instead of chemical fertilizer, is a kind of physical fertilizer, and the third kind of fertilizer with developmental prospect after inorganic fertilizer and organic fertilizer. Though organic fertilizer has good effect, it cannot be widely used due to its limited amount and inconvenient application. As for inorganic fertilizer, NH_4^+ in N fertilizer is a stronger dispersing agent, so the more the inorganic fertilizer is applied, the more hardened and impervious the soil is (LIU, 1983). Meanwhile, many remaining poisonous matters from chemical fertilizer, such as Cl^-, PH_3, H_2S, CH_4 and some heavy metal ions, can get into soil along with water, which not only causes the reduction of output, but also does serious harm to plants, animals and mankind through the chain of soil-plant-animal-mankind (YAN, 2000).

Many researchers at home and abroad indicated that under the effect of electric field, the growth of plants speeds up and the output of plants increases (LI, 2003; WANG, 1993). A Russian horticulturist found that all the plant cells are special electric fields; weak electricity unceasingly goes through every plants. Therefore, it will be beneficial to exerting electric field on plants: 1) promoting metabolism and heightening photosynthesis; 2) controlling the amount and direction of Ca^{2+} getting in and out plant body; 3) increasing the speed of absorbing CO_2, and providing materials for photosynthesis. If electric fertilizer can be widely used for cultivating nursery stocks and crops, chemical fertilizer will be replaced or saved on condition that base fertilizer is applied. Therefore, it can be said that the application of electric fertilizer is favorable for decreasing chemical poison, improving soil, relaxing the contradiction between the supply and demand of chemical fertilizer, and decreasing production cost of agriculture and forestry. Many researches have been done on the physiological and biochemical reaction of plant after exerting electric field in China and abroad, so this paper will focus on the changes in physical chemical properties of soil after exerting electric field.

2 MATERIALS AND METHOD

The experiment on the changes of physical and chemical properties of soil after exerting electric field on

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plants was conducted in the black soil of Wukeshu Seedling Nursery and Balipu Flower Nursery in Yushu City of Jilin Province. Randomized block method was adopted, five treatments and eight repeats for each treatment were arranged (Table 1), the area of each plot is 5m×16.5m.

During the growing season (from 16 June to 16 September), electric field was exerted on the seedlings of *Pinus sylvestris* var. *Mongolica*, *Larix olgensis* and *Picea koraiensis* every ten days. The Electric Fertilization Apparatus DFY-1 (its voltage is 2kV, and pulse frequency 200Hz), developed by Jilin Institute of Forestry, was used for exerting electric field. Its positive electrode was connected to the nozzle of sprayer when sprinkling different mediums, and its negative electrode was tied to an iron block on the ground. The time of exerting electric field on an individual plant was 0.5s. On 16 September, all soil samples were collected, and then tested by the laboratories of Shenyang Institute of Applied Ecology, Chinese Academy of Sciences, and Jilin Agricultural University. Finally, the average tested results of each treatment were analyzed to study the changes of physical and chemical properties of soil.

Table 1 Design of experiment

Plot No.	1	2	3	4	5
Treatment	CK	EFF with 0.1A medium	EFF with 0.5A medium	EFF with water	Routine topdressing(A)

Notes: EEF means exerting electric field; A stands for routine topdressing amount of NH_4NO_3 (250kg/ha).

3 RESULTS AND ANALYSIS

The electric field produced by Electric Fertilization Apparatus can affect plant as well as soil colloid. As a result, such cations as Fe^{3+}, Ca^{2+} and Mg^{2+} are desorbed from soil colloids, then close to negative electrode, and finally enter into soil solution under the effect of eletrostatic attraction (QIN, 2003). In addition, under the effect of electric field, the atomization of water medium makes the polarization of water be strengthened. So the ions in diffuse layer become loose and are easily desorbed from colloids. All the phenomena mentioned above cause a series of changes of physical and chemical properties of soil (ZENG, 1987).

3.1 Improving Physical Properties of Soil

When electric field is exerted, some ions enter into soil solution, thus make the free nutrients of soil increase (Table 2). On the one hand, plants can directly use these free nutrients; on the other hand, Ca^{2+} can act with humic acid to form calcium humate, which is a best cementing agent of granular structure. Under the effect of Ca^{2+}, calcium humate can make organic and inorganic colloids be glued together, which provides a good condition for the formation of aggregates. The experimental results show that the aggregates of $0.25mm<\Phi<10mm$ increase obviously (Table 3).

As a result of the increase of aggregates, the perviousness of soil is improved, thus makes soil moisture content increase and soil bulk density decrease (Table 4).

3.2 Activating Nutrients and Increasing Organic Matter Content

The improvement of the physical properties of soil creates favorable conditions for the activities of microbes. From the experimental results, it can be seen that the number of nitrifying bacteria and ammonifying bacteria obviously increase after exerting electric field (Table 5). At the same time, the activities of such enzymes as catalase, urease and phosphatase, which par-

Table 2 Test result of cations in soil (mg/kg)

Cation	Plot No.				
	1	2	3	4	5
Ca^{2+}	4492	5446	4781	4548	3413
Fe^{3+}	24220	28540	26400	23282	17920
Mg^{2+}	4878	5572	5373	4992	3350

Table 3 Test result of aggregate ($0.25mm<\Phi<10mm$) in soil (%)

	Plot No.				
	1	2	3	4	5
Aggregate	81.75	82.61	82.33	82.22	80.34

Table 4 Test result of soil moisture content and bulk density

Item	Plot No.				
	1	2	3	4	5
Moisture content (%)	16.16	17.67	16.36	16.21	15.70
Bulk density (g/cm^3)	1.60	1.51	1.57	1.57	1.62

Table 5 Test result of nitrifying bacteria and ammonifying bacteria ($\times10^5$/g)

Bacteria	Plot No.				
	1	2	3	4	5
Nitrifying bacteria	105.65	578.25	500.00	200.40	58.35
Ammonifying bacteria	46.24	606.10	388.22	288.81	136.08

Table 6 Test result of enzyme activity

Enzyme	Plot No.				
	1	2	3	4	5
Hydrogen peroxidase (0.1 NMON, ml/g)	3.39	8.67	5.21	3.48	3.50
Ureas (NO_3-N, μg/g·12h)	9.45	22.05	16.50	20.50	21.50
Phosphatase (phenol, mg/g·24h)	2.52	2.98	2.85	2.67	2.32

ticipate in the transformation of azotic substance, are evidently strengthened (Table 6). Under the effect of nitrifying bacteria, ammonifying bacteria and catalase, protein is degraded to amino acid.

Under the action of deamination of ammonifying bacteria, amino acid changes into ammonia (NH_3). Some of NH_3 transforms to NH_4^+, which is combined with base ion to form various amino salts for plant use; some of NH_3 take part in nitrification to form nitric acid, which is combined with various base ions to form different nitrates for plant use. Due to the improvement of ventilation condition of soil, the activity of phosphate is rose. Furthermore, the organic matter containing P is gradually decomposed into phosphoric acid, which acts with inorganic salt to form phosphate for plant use.

The strengthening of activity of nitrifying bacteria, ammonifying bacteria and various enzymes is also favorable for the mineralization of organic matter in soil, thus making the organic relict that is difficultly mineralized be decomposed. Furthermore, rapidly available nutrients (Table 7) and cations of Ca^{2+}, Mg^{2+} and Fe^{3+} (Table 2), which are indispensable for plant growth, increase.

Owing to exerting electric field, aggregates obviously increase in soil, which promotes the humification of organic matter. From the analysis results, it can be seen that total N and total P of soil do not change greatly, but organic matter and cation exchange capac ity increase to some extent (Table 8), indicating that fertility preserving capacity of soil heightens somewhat after exerting electric field.

3.3 Effect Analysis of Exerting Electric Field with Different Media

Through SD analysis, it can be seen that the effect of exerting electric field with 0.1A medium is better than that with 0.5A medium and water. The more the chemical fertilizer is applied, the greater the concentration of soil solution is, and the greater the ion density in the diffuse layer of colloid is. Therefore, the ions on colloid are not easily to be adsorbed by electrostatic attraction. In addition, the ion density in colloid can cause rival action, i. e. one ion can inhibit the effect of other ions (JIN, 2003). For these reasons, the effect of exerting electric field with 0.1A medium is the best.

In routine topdressing treatment, ammoniun nitrate mainly contains monovalent ammoninium ion with smallest coagulating power and stronger dispersion force. So routine topdressing for a long time will make soil be hardened, then influence microbes′ activity and nutrient release.

While exerting electric field only with water for a long time, the nutrients in soil will decrease, because the organic relict returned to soil from above ground part and the basal manure dressed in spring is limited. Hence, it can be said that exerting electric field with 0.1A medium can not only supplement rapidly available nutrients in soil, but also preserve the granular structure of soil, which solve the contradiction between fertilizer supply and demand both in a short time and in a long time.

Compared to the routine topdressing, exerting electric field with 0.1A medium can save 90% of topdressing amount of chemical fertilizer. In accordance with

Table 7 Test result of nutrients

Plot No.	Total N (g/kg)	Total P (g/kg)	Total K (g/kg)	Rapidly available N (mg/kg)	Rapidly available P (mg/kg)	Rapidly available K (mg/kg)
1	1.0	28.0	1.6	135.0	115.6	151.8
2	1.4	33.5	2.4	173.7	181.1	258.9
3	1.2	28.1	2.0	165.3	139.6	156.6
4	1.1	31.2	2.1	154.8	137.5	154.1
5	1.3	33.1	1.8	149.0	171.5	204.0

Table 8 Test result of organic mater and cation exchangeable capacity

	Plot No.				
	1	2	3	4	5
Organic matter (g/kg)	18.80	30.50	21.60	19.20	21.10
Cation exchangeable capacity (cmol/kg)	14.48	16.38	15.69	15.18	15.16

the area of growing seedlings in Jilin Province (about 32 899.4ha/a), the application of electric fertilizer will proximately save production cost of 626 216.4 yuan (RMB) per year.

4 CONCLUSIONS

Through the experimental study, it is indicated that exerting electric field can improve soil physical and chemical properties, which is benefit for plant growth. Through the experimental study and analysis, the paper reaches at the following conclusions:

1) Exerting electric field can make soil granular structure increase, bulk density decrease, moisture capacity increase, thus can improve perviousness of soil.

2) Exerting electric field can make microbes number increase and activity strengthen, thus activating nutrient and increasing organic matter content.

3) Exerting electric field with 0.1A medium has the best effect. By so doing, 90% of topdressing amount of chemical fertilizer can be saved, and the production cost of agriculture and forestry can be decreased.

4) The physical and biochemical effect of exerting electric field on microbes group remains to be further studied.

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