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Effects of Biochar Based Fertilizer on Soil Nutrient Content and Maize Yield of Acidic Soil in Heilongjiang Province

Dawei Yin[1], Xiaohong Guo[1], Guohua Ding[2], Liang Jin[3], Xingchu Man[1], Kejun Yang[1], Yifei Zhang[1], Peng Zhang[1,4*]

[1]Agricultural College, Heilongjiang Bayi Agricultural University, Daqing, China
[2]Institute of Cultivation and Cultivation, Heilongjiang Academy of Agricultural Sciences, Harbin, China
[3]Institute of Soil and Fertilizer Research, Heilongjiang Academy of Agricultural Sciences, Harbin, China
[4]The Green Grassland Ranch, Heilongjiang Agricultural Reclamation Bureau, Daqing, China
Email: yindazhiyindawei@126.com, *lsnyk@126.com

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Abstract

Unreasonable fertilizer input and low fertilizer utilization seriously restrict the development of maize in Heilongjiang province. In this paper, the effects of biochar based fertilizer on the nutrient content of acidic soil and corn yield in Heilongjiang province were studied. The random block design was adopted, and seven treatments were set with four repetitions. The results showed that biochar based fertilizer increased the soil organic matter content in the mature stage of maize. The S1 (The biochar biobased fertilizer treatment 1 in acid soil), S2 (The biochar biobased fertilizer treatment 2 in acid soil), and S3 (The biochar biobased fertilizer treatment 3 in acid soil) treatments organic matter contents increased by 15.96%, 11.06% and 10.03% than SCK (The Acid Soil Control Check) respectively. The total nitrogen, total phosphorus, total potassium, total calcium of S1 treatment corn plants increased 16.81%, 15.34%, 31.20% and 22.96% than SCK. The S1 treatment increased the yield of corn, which was 1.94% higher than SCK. There was no significant difference between the yield of S2, S3 with SCK treatments, which achieved the effect of fertilization reducing.

Keywords

Biochar, Acid Soil, Nutrient, Maize, Yield

1. Introduction

Heilongjiang province is an important commodity grain base in China. At present, unreasonable fertilizer input and low fertilizer utilization are important factors restricting the development of corn in Heilongjiang province. Therefore, it is urgent to update the original fertilizer application mode with new fertilizers. As a new type of fertilizer, biochar base fertilizer can reduce the use of chemical fertilizer, improve soil physical and chemical properties, promote crop quality growth and yield increase, reduce agricultural production cost, and effectively increase soil fertility [1] [2].

Biochar and biochar base fertilizer have been researched and developed for nearly ten years in China. Biochar is praised as "black gold" by international academia [3]. China produces about 1.4 billion tons of agricultural and forestry wastes every year. The application of biomass carbonization to farmland technology can realize effective utilization of straw, carbon sequestration and emission reduction and sustainable agricultural development [1] [2] [3]. Biochar has large porosity, specific surface area, oxidation resistance and biodecomposition resistance, which can effectively improve physical and chemical properties and biological properties, and has the theoretical basis for improving acidic soil [4] [5] [6]. The results show that biochar can promote crop growth and increase crop yield [7] [8] [9]. In terms of promoting crop growth and yield, biochar base fertilizer is more stable and efficient than single application of biochar and conventional fertilizer. When biochar is mixed with mineral fertilizer, it has a significant synergistic effect on crop growth [10]. Liu Xiaohu's study showed that the yield of biochar based slow-release peanut special fertilizer was significantly higher than that of other fertilization treatments [11]. The development of biochar industry can effectively carbonize agricultural waste and then feed agriculture, which is a sunrise industry that benefits the country and people's ecology [12]. The application of biochar fertilizer in China is currently in the preliminary research and popularization stage, which plays a great role in low-yield soil improvement, weight and drug reduction, and organic green crop production.

Facing fertilizer input amounts big, low utilization rate of fertilizer series of Heilongjiang province. This paper mainly studied the alternative biochar basal fertilizer on a model of Heilongjiang province acidic soil nutrient content, corn plant nutrient content, the influence of the dry weight and yield of corn, a clear alternative biochar basal fertilizer effect. This paper aims to realize the zero growth fertilizer input, promote the acidification of soil improvement, and provide the reference basis in Heilongjiang province.

2. Materials and Methods

2.1. Test Materials

The test site is located in 854 farm science and technology park of Mudanjiang administration bureau, general bureau of agricultural reclamation, Heilongjiang province during 2017 year (46˚03'22.11"N, 132˚56'33.62"E). The soil type is Northeast meadow albic soil. The background values of basic nutrients of soil in the test area are organic matter content 30.55 g/kg, pH 5.96, alkali-hydrolyzed nitrogen content 164.10 mg/kg, available phosphorus content 32.07 m g/kg, and available potassium content 140.00 m g/kg. Corn biochar-based slow-release fertilizer is produced by longtai biochar engineering co., LTD., Faku county, Liaoning province (total nutrient content ≥ 45%, that is, N + P_2O_5 + K_2O ≥ 45%), and the maize variety in this study is 38P05 (general corn variety approved by Jilin province in 2004).

2.2. Test Design

Field random block design was adopted. Seven treatments and four replicates were set in the experiment. The seven treatments were: SKB (acid soil blank treatment), namely, no fertilization. SCK (acid soil conventional fertilizer control), namely, 46% urea 225.00 kg/hm^2, 64% diammonium phosphate 225.00 kg/hm^2, 60% potassium chloride 150.00 kg/hm^2. S1 (acid soil biochar base fertilizer treatment 1), the amount of biochar application and the quality such as SCK, namely, the application of biochar base fertilizer is 600.00 kg/hm^2. S2 (acid soil biochar base fertilizer treatment 2), that is, the amount of biochar base fertilizer was reduced by 5%, and the amount of biochar base fertilizer was 570.00 kg/hm^2. S3 (acid soil biochar base fertilizer treatment 3), namely, biochar base fertilizer was reduced by 10%, and the application amount was 540.00 kg/hm^2. S4 (acid soil biochar base fertilizer treatment 4), that is, the amount of biochar base fertilizer was reduced by 15%, and the application amount was 510.00 kg/hm^2. S5 (acid soil biochar base fertilizer treatment 5), namely, biochar base fertilizer was reduced by 20%, and the application amount was 480.00 kg/hm^2. All the treated fertilizers are used as base fertilizer once, and no topdressing is required in the later stage. The other fertilizers are sown on May 3 and harvested on October 7 according to routine production management measures.

2.3. Determination Contents and Methods

2.3.1. Soil Nutrient Content Determination

"S" (soil sampling method) sampling was carried out at the key growth stage of maize, namely jointing stage, grouting stage and ripening stage. The soil was fully mixed and dried in dry. Soil organic matter content using potassium dichromate oxidation method, soil total nitrogen content is determined by kjeldahl determination, soil total phosphorus content in the sodium hydroxide melting-molybdenum antimony colorimetric method. The soil total potassium content, available potassium content, calcium and sodium content by atomic absorption spectrophotometry. Using diffusion method to determine soil alkaline hydrolysis N content. Soil available P content using the sodium bicarbonate leaching-molybdenum antimony colorimetric method. Soil pH value determination by pH meter [13].

2.3.2. Determination of Nutrient Content in Maize Plants

Plant samples were collected at the mature stage of maize, *i.e.*, 30 maize plants were successively taken from each plot. The plant sample was dried, crushed and sifted. The plant nutrient content was determined. The total nitrogen content in plants was determined by kjeldahl method, the total phosphorus content in plants was determined by sodium hydroxide melt-molybdenum antimony anticolorimetric method. The total potassium content, calcium content and sodium content in plants were determined by atomic absorption spectrophotometry.

2.3.3. Determination of Maize Plant Dry Quality, SPAD (Soil and Crop Analytical Instrument Development) Value and Yield

During the critical growth period of maize, namely, the three stages of elongation, grout and maturation, the variation rules of dry quality of maize were measured. Namely, the dry quality of maize stem, sheath and leaf, dry quality of ear and total dry quality of aboveground were measured. Drying method was adopted, that is, each part of the plant was killed at 105℃ for 30 min and dried to constant quality at 80˚C [7]. SPDA value of functional leaves of maize, namely inverted three leaves, was measured at the mature stage of maize, and spad-502 chlorophyll meter produced by minolta company of Japan was used for the measurement. At the mature stage of maize, the yield of each treatment area was measured when the safe water content of maize was reduced.

2.4. Data Analysis

SPSS (statistical products and services solution) 20.0 statistical software was used for analysis of variance, and Microsoft Excel (Microsoft superior spreadsheet) 2010 chart was drawn.

3. Results and Analysis

3.1. Effect of Biochar Base Fertilizer on SPAD Value of Maize

SPAD value can be used to measure the relative content of chlorophyll in crops. As shown in **Table 1**, S1 treatment increased the SPAD value at the mature stage of corn, which was 62.68, and increased by 7.47% compared with 58.32 of SCK. The S2, S4 and S5 reduced the SPAD value of corn, which were 52.67, 54.88 and

Table 1. Effect of biochar-based fertilizer on SPAD value of mature maize.

Treatment	SPAD Value
SKB	39.78d
SCK	58.32ab
S1	62.68a
S2	52.67c
S3	58.52ab
S4	54.88bc
S5	56.43bc

Note: The different letters in the same column indicate distinct difference ($p \leq 0.05$), The same as **Tables 5-7**.

56.43, respectively. The significant difference between S2 and SCK was p ≤ 0.05 (the probability ≤ 0.05 was statistically significant). This indicates that the quality application of biochar (S1) can promote the chlorophyll content of maize leaves.

3.2. Effects of Biochar on Soil Nutrient Content

Increasing the nutrient quantity in acidic soil is the key factor to promote the improvement of acidic soil. As shown in Table 2, biochar fertilizer treatment S1-S5 can increase the content of soil organic matter and alkal-hydrolyzed nitrogen in maize at the vegetative stage, and reach the maximum value in S1. The content of organic matter and alkal-hydrolyzed nitrogen in S1 increased by 15.56% and 5.75%, respectively, compared with SCK, and reached a significant level (p ≤ 0.05). Treatment with S1 increased the calcium content of acidic soil, and the calcium content of S1 increased by 9.38% compared with that of SCK, and reached a significant difference (p ≤ 0.05).

As shown in Table 3, is the soil nutrient content during grouting. Biochar fertilizer increased the pH value and organic matter content of the soil during maize filling period, among which S1 - S4 and SCK reached a significant difference level (p ≤ 0.05), and the organic matter content of S1-S4 increased by 18.55%, 14.42%, 10.98% and 7.57%, respectively, compared with SCK. Biochar fertilizer

Table 2. Effect of biochar based fertilizer on soil nutrient content at the jointing stage of maize.

Treatment	SKB	SCK	S1	S2	S3	S4	S5
pH Value	5.12c	5.33bc	6.00a	5.94a	5.81a	5.76a	5.68ab
OM content /(g/kg)	25.24d	26.41cd	30.52a	29.17ab	28.84ab	27.82bc	26.93cd
Avail N content /(mg/kg)	150.36d	155.22cd	164.15a	163.48ab	160.77abc	158.11bc	156.32c
Avail P content /(mg/kg)	28.33a	29.45a	32.08a	31.84a	31.22a	30.68a	29.89a
Avail K content /(mg/kg)	132.17d	134.20cd	140.33a	138.59ab	137.11abc	136.52bc	135.43bcd
Total N content /(g/kg)	1.01d	1.26ab	1.09cd	1.17bc	1.30a	1.11c	1.22ab
Total P content /(g/kg)	1.16cd	1.26a	1.22ab	1.12d	1.18bc	1.17bcd	1.14cd
Total K content /(g/kg)	18.49b	19.88a	20.36a	19.72a	19.81a	20.47a	18.05b
Ca content /(mg/kg)	21.23f	31.24b	34.17a	29.14c	27.39d	26.41e	27.43d
Na content /(mg/kg)	0.33b	0.38a	0.41a	0.33b	0.29c	0.24d	0.23d

Note: The different letters in the same line indicate distinct difference (p ≤ 0.05), The same as Table 3 and Table 4.

Table 3. Effect of biochar based fertilizer on soil nutrient content at the grouting stage of maize.

Treatment	SKB	SCK	S1	S2	S3	S4	S5
pH Value	5.26c	5.30c	6.02a	5.96a	5.80ab	5.71ab	5.57bc
OM content /(g/kg)	25.03e	26.15de	31.00a	29.92ab	29.02bc	28.13bc	27.11cd
Avail N content /(mg/kg)	150.19c	154.87bc	164.12a	163.77a	160.51ab	158.22b	156.14b
Avail P content /(mg/kg)	28.05a	29.11a	31.95a	31.80a	31.08a	30.37a	29.66a
Avail K content /(mg/kg)	132.02c	133.94bc	138.00a	138.17a	137.09ab	136.48ab	135.35abc
Total N content /(g/kg)	1.03d	1.27a	1.02d	1.15bc	1.28a	1.07cd	1.20ab
Total P content /(g/kg)	1.11b	1.25a	1.20a	1.09b	1.14b	1.11b	1.03c
Total K content /(g/kg)	18.44b	19.84a	20.31a	19.68a	19.75a	20.38a	17.96b
Ca content /(mg/kg)	24.51f	32.24c	35.62a	33.77b	28.48d	27.49e	28.15de
Na content /(mg/kg)	0.32c	0.36b	0.42a	0.32c	0.27d	0.26d	0.27d

increased the content of alkali-hydrolyzed nitrogen in soil, and the difference between S1 - S3 and SCK was significant ($p \leq 0.05$). Compared with SCK, the content of alkali-hydrolyzed nitrogen in S1 - S3 increased by 5.97%, 5.75% and 3.64%. Biochar base fertilizer increased the available potassium content of soil, among which S1 - S2 and SCK reached a significant difference ($p \leq 0.05$), and the available potassium content of S1 - S2 increased by 3.03% and 3.16% compared with SCK. S1 treatment increased the calcium and sodium content in the soil by 10.48% and 16.67%, respectively, compared with SCK, and reached significant differences ($p \leq 0.05$).

As shown in Table 4, is the content of soil nutrients in the mature stage. Biochar fertilizer increased soil pH value, S1 - S4 increased 12.62%, 11.11%, 9.04% and 8.29%, respectively, compared with SCK, and reached a significant level of difference ($p \leq 0.05$). Biochar base fertilizer increased the content of soil organic matter, and S1 - S3 increased by 15.96%, 11.06% and 10.03%, respectively, compared with SCK, and reached a significant level ($p \leq 0.05$). Biochar base fertilizer increased the content of alkalolytic nitrogen in soil, and S1 - S2 increased by 5.83% and 5.42%, respectively, compared with SCK, and reached a significant level ($p \leq 0.05$). Biochar base fertilizer increased the content of available potassium in soil, and S1 - S2 increased by 3.88% and 3.54%, respectively, compared with SCK, and reached the significant level of difference ($p \leq 0.05$). S1 treatment increased the calcium and sodium content in the soil by 7.53% and 22.86%,

Table 4. Effect of biochar based fertilizer on soil nutrient content at the mature stage of maize.

Treatment	SKB	SCK	S1	S2	S3	S4	S5
pH Value	5.27b	5.31b	5.98a	5.90a	5.79a	5.75a	5.60ab
OM content /(g/kg)	25.18d	26.31cd	30.51a	29.22ab	28.95ab	28.06bc	27.08c
Avail N content /(mg/kg)	150.25d	155.11cd	164.15a	163.52ab	160.58abc	158.17bc	156.26c
Avail P content /(mg/kg)	28.22a	29.34a	31.98a	31.76a	31.18a	30.61a	29.82a
Avail K content /(mg/kg)	132.00c	133.81bc	139.00a	138.55a	137.12ab	136.51ab	135.29abc
Total N content /(g/kg)	1.00e	1.22ab	1.06de	1.13bcd	1.29a	1.09cde	1.18bc
Total P content /(g/kg)	1.14c	1.21a	1.19abc	1.20ab	1.15bc	1.16abc	1.08d
Total K content /(g/kg)	18.40b	19.81a	20.33a	19.70a	19.78a	20.44a	18.11b
Ca content /(mg/kg)	24.62e	33.21b	35.71a	33.78b	28.41c	27.51d	27.15d
Na content /(mg/kg)	0.33b	0.35b	0.43a	0.33b	0.27c	0.27c	0.27c

respectively, compared with SCK, and reached a significant level ($p \le 0.05$). From the perspective of the three key growth periods of corn, the application of biochar base fertilizer and other quality treatments S1 can significantly increase the content of organic matter in acidic soil, which is of great significance for promoting the improvement of acidic soil and improving the soil fertility of acidic soil.

3.3. Effect of Biochar Base Fertilizer on Dry Quality of Maize Plants

There is a close relationship between dry quality and yield of maize. As shown in **Table 5**, is the dry mass of maize at jointing stage. It can be seen that biochar base fertilizer S1 - S2 increases the dry weight of corn sheaths, and the dry weight of sheaths S1 - S2 increases by 9.30% and 4.14%, respectively, compared with SCK, and reaches a significant level ($p \le 0.05$). Biochar base fertilizer S1 - S3 increased the total dry mass of the upper part of corn field, and the total dry mass of the above-ground part of S1 - S3 increased by 6.31%, 4.88% and 2.67%, respectively, compared with SCK, and reached a significant difference level ($p \le 0.05$). This indicated that biochar base fertilizer S1 - S3 could positively promote the dry quality of maize at the jointing stage.

As shown in **Table 6**, is the dry mass of maize during grouting. It can be seen that biochar base fertilizer treatment S1 increased the quality of maize leaf stem, S1 increased by 13.25% compared with SCK, and reached a significant difference

Table 5. Effects of biochar based fertilizer on dry quality of maize during jointing period.

Treatment	Leaf dry weight /(g/plant)	Stem dry weight /(g/plant)	Sheath dry weight/(g/plant)	Overground part total dry weight/(g/plant)
SKB	23.01c	42.15d	40.75e	105.90f
SCK	43.82a	65.36bc	52.69c	161.87c
S1	44.85a	69.64a	57.59a	172.09a
S2	46.66a	68.25ab	54.87b	169.78a
S3	45.17a	67.24ab	53.76bc	166.17b
S4	37.06b	65.90bc	48.13d	151.09 d
S5	36.23b	62.60c	38.70f	137.53e

Table 6. Effects of biochar based fertilizer on dry quality of maize during grouting period.

Treatment	Leaf dry weight /(g/plant)	Stem dry weight /(g/plant)	Ear dry weight /(g/plant)	Sheath dry weight /(g/plant)	Overground part total dry weight /(g/plant)
SKB	23.98g	47.93f	159.15e	9.93g	240.99f
SCK	37.77b	49.68e	201.75bcd	12.61f	301.81d
S1	42.78a	64.27a	227.45a	18.54a	353.04a
S2	30.88e	62.09b	208.62b	16.12b	317.71b
S3	36.63c	55.43c	203.56bc	14.56c	310.18c
S4	33.17d	52.93d	200.91cd	13.50d	300.50d
S5	29.65f	55.33c	194.87d	12.84e	292.69e

level ($p \le 0.05$). Compared with SCK, S1 - S5 increased the stem quality of maize by 29.37%, 24.99%, 11.57%, 6.53% and 11.37%, respectively, and reached a significant difference ($p \le 0.05$). Biochar base fertilizer S1 increased the dry quality of ear of corn, which increased by 12.74% compared with SCK, and reached a significant difference level ($p \le 0.05$). Compared with SCK, S1 - S5 increased the dry weight of maize sheath by 47.04%, 27.81%, 15.46%, 7.06% and 1.86%, respectively, and reached a significant difference ($p \le 0.05$). Biochar base fertilizer treatment S1 - S3 increased the total dry mass of the upper part of corn field, and the total dry mass of the above-ground part of S1 - S3 increased by 16.97%, 5.27% and 2.77%, respectively, compared with that of SCK, and reached a significant difference ($p \le 0.05$). This shows that the quality application of biochar base fertilizer (S1) can promote the dry quality of maize during the grout period, and the dry quality of maize during the grout period can also be increased by reducing the amount of biochar base fertilizer by 5% (S2) and reducing the amount of biochar base fertilizer by 10% (S3).

As shown in Table 7, is the dry mass of corn at the mature stage. S1 increased the dry weight of maize leaves, which increased by 16.13% compared with SCK, and reached a significant difference level ($p \le 0.05$). The stem mass of S1 - S3 increased by 30.03%, 23.68% and 11.52% compared with that of SCK, and

Table 7. Effects of biochar based fertilizer on dry quality of maize during mature perio.

Treatment	Leaf dry weight/(g/plant)	Stem dry weight/(g/plant)	Ear dry weight/(g/plant)	Sheath dry weight/(g/plant)	Overground part total dry weight/(g/plant)
SKB	23.79f	47.21e	159.21d	9.35g	239.56e
SCK	36.89b	49.53de	207.71b	12.37f	306.50bcd
S1	42.84a	64.41a	222.98a	18.12a	348.35a
S2	31.53d	61.76b	210.08b	16.04b	319.41b
S3	36.46b	55.23c	205.12bc	14.45c	311.27bc
S4	33.32c	52.12cd	202.20bc	13.45d	301.10cd
S5	30.04e	55.22c	197.79c	12.75e	295.79d

reached a significant difference ($p \le 0.05$). S1 increased the dry quality of ear, S1 increased 7.35% compared with SCK, and reached a significant difference level ($p \le 0.05$). S1 - S5 increased the dry weight of maize sheath, and S1 - S5 increased 46.48%, 29.67%, 1.79%, 8.71% and 3.08%, respectively, compared with SCK, and reached a significant difference ($p \le 0.05$). Biochar base fertilizer treatment S1 increased the dry mass of abovementis, and S1 increased the dry mass of abovementis by 13.66% compared with SCK, and reached a significant difference ($p \le 0.05$). As a whole, the quality application of biochar base fertilizer (S1) promoted the total dry quality of maize in the three growing stages. And biochar basal on a treatment S2 and S3 can increase the jointing stage and milking stage of corn plant total dry weight, the mature period of S2 and S3 plants there was no significant difference between the total dry weight and SCK, suggesting that biochar basal on a model in a certain extent, have the effect that reduce fertilizer inputs, but should be further verified between annual repeat.

3.4. Effects of Biochar Base Fertilizer on Nutrient Content of Maize Plants

As shown in **Figure 1**, S1 - S2 increased the total nitrogen content of corn leaves, and S1 - S2 increased 19.71% and 10.07% respectively compared with SCK, and reached a significant difference level ($p \le 0.05$). S1 increased the total nitrogen content of corn sheath by 7.13% compared with SCK, and reached a significant difference ($p \le 0.05$). S1 increased the total nitrogen content in the stalk of corn by 11.48% compared with SCK, and reached a significant difference ($p \le 0.05$). However, S2 - S5 reduced the total nitrogen content in the leaves, scabbard and stem of corn and reached a significant difference ($p \le 0.05$). This indicates that the application of biochar fertilizer (S1) can effectively increase the total nitrogen content in the leaves, scabbard and stem of maize plants.

As shown in **Figure 2**, the total phosphorus content of corn leaves was reduced by biochar fertilizer, and the total phosphorus content of S-S5 was reduced by 6.97%, 24.38%, 43.78%, 58.21% and 65.17%, respectively, compared with that of SCK. The difference between S2-S5 and SCK was significant ($p \le$

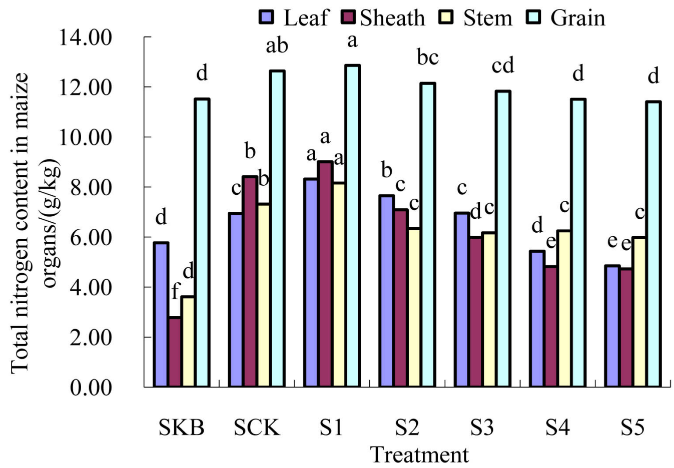

Figure 1. Effect of biochar based fertilizer on total nitrogen content of maize plants. Note: The different letters for treatments indicate distinct difference ($p \leq 0.05$), The same as **Figures 2-8.**

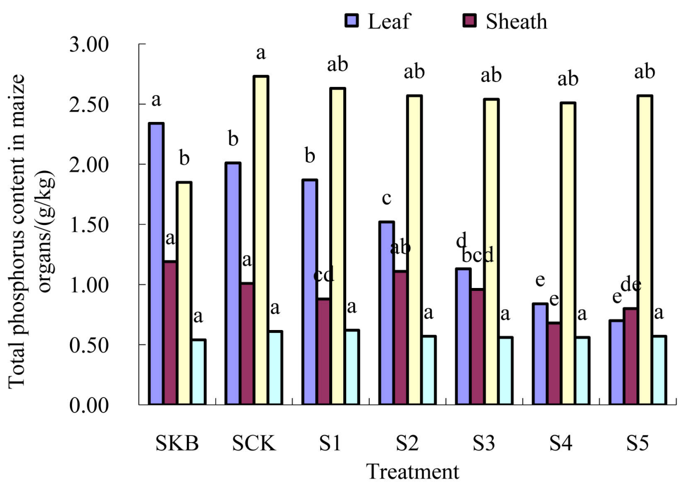

Figure 2. Effect of biochar based fertilizer on total phosphorus content of maize plants.

0.05). Biochar fertilizer reduced the total phosphorus content of sheaths, and the difference between S1, S3 - S5 and SCK was significant ($p \leq 0.05$). Compared with SCK, the total phosphorus content of S1 - S5 decreased by 3.66%, 5.86%, 6.96%, 8.06% and 5.86% respectively, but the difference was not significant. Biochar fertilizer had no significant effect on the total phosphorus content of corn.

As shown in **Figure 3**, S1 - S2 treated with biochar increased the total potassium content in corn leaves, and S1 - S2 increased by 27.79% and 14.22%, respectively, compared with SCK, and reached a significant difference ($p \leq 0.05$). Treatment S1, S3 - S5 reduced the total potassium content of corn sheaths to a significant level ($p \leq 0.05$). S1 increased the total potassium content of corn stalks by 6.13% compared with SCK, and reached a significant difference ($p \leq 0.05$). Treatment with S5 reduced the total potassium content of corn kernels, which was 13.37% lower than that of SCK, and reached a significant difference level ($p \leq 0.05$).

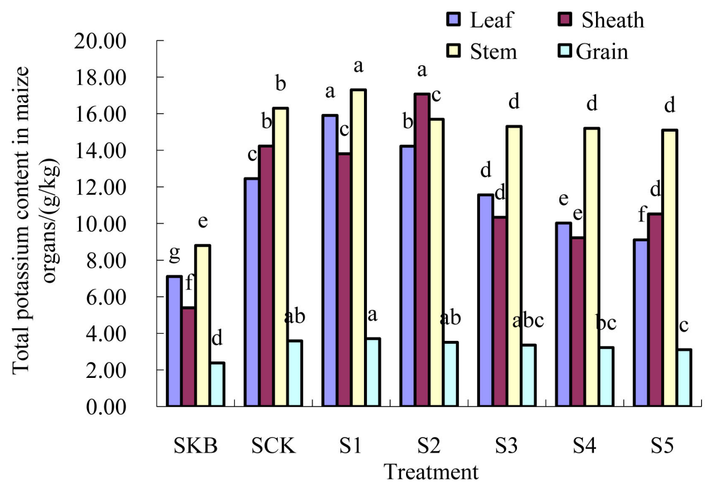

Figure 3. Effect of biochar based fertilizer on total potassium content of maize plants.

As shown in **Figure 4**, S2-S5 treatment reduced the calcium content in corn leaves by 6.45%, 9.68%, 9.68% and 12.90%, respectively, compared with SCK, and reached a significant difference level ($p \le 0.05$). Biochar base fertilizer has no obvious effect on the calcium content of maize sheath. Treatment with S2 - S5 reduced the calcium content of corn stalks by 7.32%, 9.76%, 9.76% and 12.20% respectively compared with SCK, and reached a significant level ($p \le 0.05$). Biochar base fertilizer has no obvious effect on the calcium content of corn.

As shown in **Figure 5**, S3-S5 treatment reduced the sodium content of corn leaves, and the sodium content of S3-S5 decreased by 9.68%, 9.68% and 12.90% respectively compared with SCK, and reached a significant level ($p \le 0.05$). Treatment S1 - S5 reduced the sodium content of corn sheath, but not to a significant level ($p \le 0.05$). Compared with SCK, S3 - S5 reduced the content of sodium in stalk of maize by 23.27%, 23.27% and 36.36%, and the difference was significant ($p \le 0.05$). Biochar-based fertilizer treatment had no significant effect on the sodium content of corn seeds.

As shown in **Figure 6** and **Figure 7**, S1 treatment increased the total nitrogen content of corn plants, which increased by 16.81% compared with SCK, and reached a significant difference level ($p \le 0.05$). Treatment S1 increased the total phosphorus content of maize plants, which was 15.34% higher than that of SCK, and reached a significant difference ($p \le 0.05$). Treatment with S1 - S2 increased the total potassium content of maize plants, which increased by 31.20% and 10.92%, respectively, compared with SCK, and reached a significant level ($p \le 0.05$). Treatment with S1 increased the total calcium content of corn plants by 22.96% compared with that of SCK and reached a significant difference ($p \le 0.05$). Treatment with S1 increased the total sodium content of corn plants to a significantly different level than that of SCK ($p \le 0.05$). This indicates that the application of biochar base fertilizer (S1) can increase the content of total nitrogen, total phosphorus, total potassium, total calcium and total sodium in maize plants, which plays an important role in promoting the formation of maize yield.

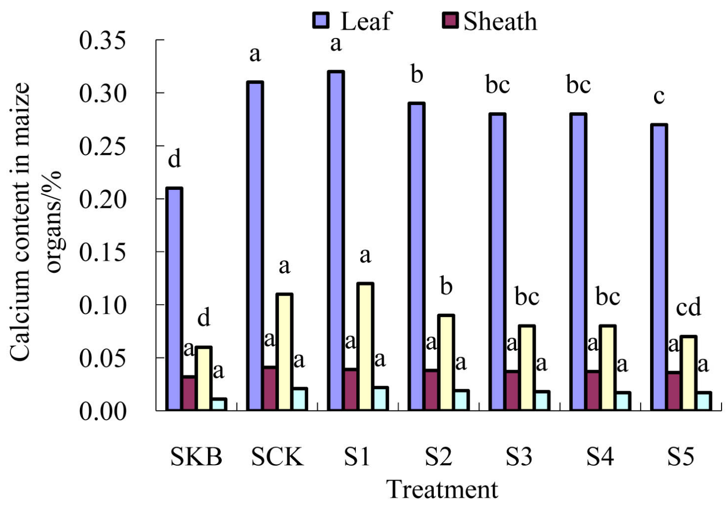

Figure 4. Effect of biochar based fertilizeron calcium content of maize plants.

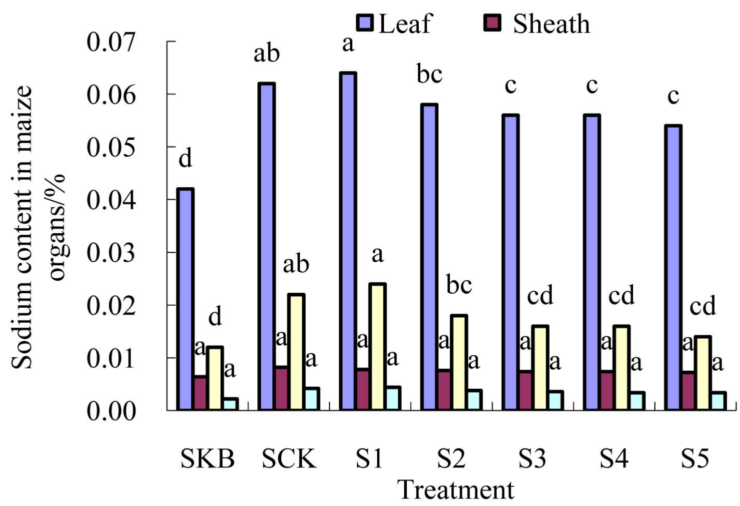

Figure 5. Effect of biochar based fertilizer on sodium content of maize plants.

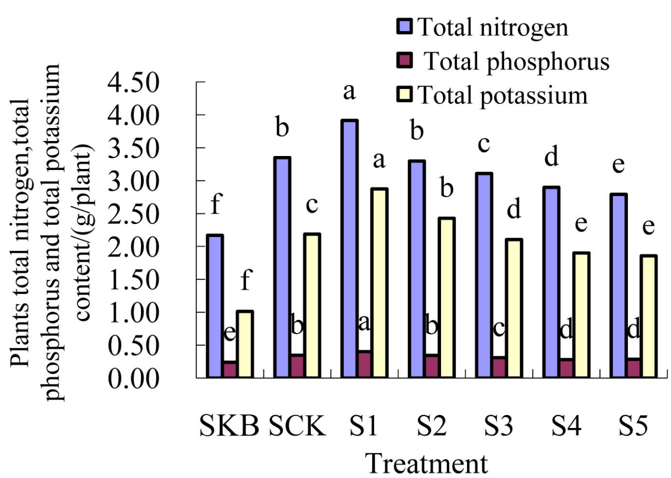

Figure 6. Effect of biochar based fertilizer on total nitrogen, total phosphorus and total potassium content of maize plants.

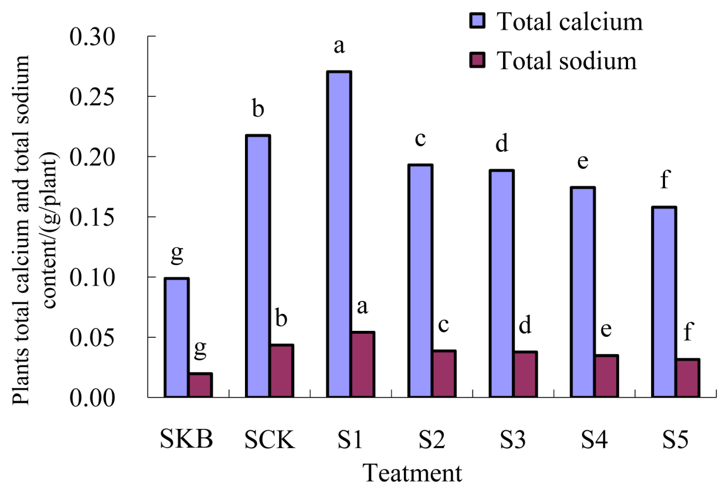

Figure 7. Effect of biochar based fertilizer on total calcium and total sodium content of maize plants.

3.5. Effects of Biochar on Maize Yield

Figure 8 shows the measured yield of corn. Biochar base fertilizer S1 increased the yield of corn, which was 9491.00 kg/hm^2, 1.94% higher than that of SCK (9310.5 kg/hm^2), but it did not reach a significant difference ($p \leq 0.05$). S2-S5 treatment with biochar reduced the yield of corn, the yield of S2-S5 was 9 210.00 kg/hm^2, 9 168.00 kg/hm^2, 8 882.50 kg/hm^2, and 8 484.00 kg/hm^2, respectively, which was 1.08%, 1.53%, 4.60% and 8.88% lower than that of SCK, among which S4-S5 reached a significant difference compared with SCK ($p \leq 0.05$). The reduction of biochar base fertilizer by 5% (S2) and 10% (S3) had no significant impact on the yield of corn, indicating that the fertilizer reduction effect had been achieved, but further inter-annual verification was needed.

4. Discussion and Conclusion

4.1. Effects of Biochar on Soil Nutrient Content and Plant Nutrient Absorption

Studies show that biochar can increase the content of ammonium nitrogen and nitrate nitrogen in the soil, and improve the content of available nutrients in the soil better than the common NPK fertilizer [14]. Application of biochar base fertilizer is better than other treatments in improving the content of soil organic matter, total potassium and available potassium [15]. The results of this study showed that the total phosphorus content, calcium content and sodium content of soil S1 treated with biochar fertilizer in the mature stage of corn increased by 2.62%, 7.53% and 22.86%, respectively, compared with that of SCK. The content of total nitrogen, phosphorus, potassium and calcium in S1 increased by 16.81%, 15.34%, 31.20% and 22.96% compared with that in SCK. The application of biochar fertilizer can increase the content of organic matter in different growth stages of maize. This is basically consistent with previous research results [14] [15]. This is because biochar itself contains rich nutrient content, rich porous

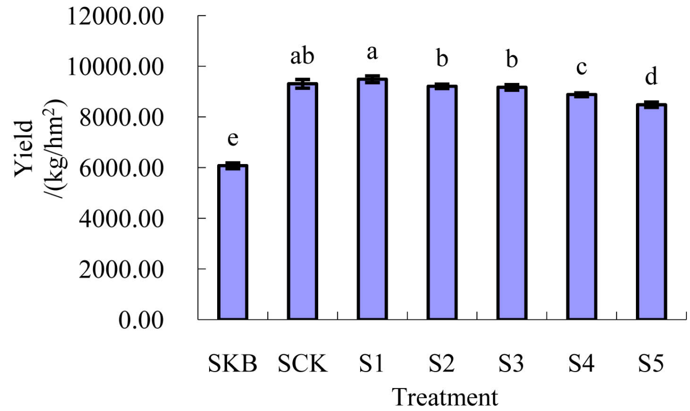

Figure 8. Effect of biochar based fertilizer on maize yield.

structure and strong adsorption capacity, so it has a strong adsorption capacity for nutrient ions in the soil [16] [17]. As a "habitat" for microbial growth and reproduction, biochar can promote soil microbial activity, thereby promoting soil cation exchange and improving and maintaining soil fertility [18] [19]. Applying biochar quality such as basal can increase corn acidic soil organic matter content at different development stages, that is because the carrier of biochar basal biochar is a kind of chemical and biological "inertia", is not easy to be mineralized, biochar can through the surface adsorption inhibit its instability in soil organic carbon mineralization, and promote the adsorption of organic matter, organic molecules polymerization degree of its effect [2] [6].

4.2. Effect of Biochar Fertilizer on Maize Yield

Studies have shown that biochar can promote dry matter accumulation and yield of maize plants [20]. Mixed application of biochar and organic fertilizer is more beneficial to crop growth than single application of biochar [21]. The results of this study showed that, at the mature stage, the abovementioned dry weight of S1 - S3 treated with biochar increased by 13.66%, 4.21% and 1.56% respectively compared with that of SCK, and the yield of S1 treated with biochar increased by 1.94% compared with that of SCK, which was basically consistent with previous research results. This indicates that biochar base fertilizer has obvious advantages over conventional fertilization in promoting corn yield. This is because the biochar basal can have the effect of slow release of nutrients, at the same time can be dissolved nutrients in soil solution. The biochar has a certain adsorption and biochar itself with abundant pore structure, which can effectively improve soil physical structure. The biochar can promote the breeding of microorganism and soil nutrients activation.

4.3. Application Prospects of Acid Soil Improvement and Biochar Fertilizer in Heilongjiang Province

Soil acidification is a serious problem in Heilongjiang province, mainly due to the continuous planting of crops for many years, and the large amount of organic acids secreted by crops promotes soil acidification. At the same time a large number of physiological acid fertilizer overinvestment is also an important cause of soil acidification. Biochar basal by biochar made with conventional fertilizer after the special craft processing, including alkaline biochar carrier, with abundant porosity, large specific surface area, adequate amounts of nutrients, can effectively improve acidic soil pH value, improving the structure of the acidic soil nutrient content, physical and biological properties, promote restoration of the acidic soil fertility. The author since 2010 in Heilongjiang province agricultural reclamation administration of Mudanjiang, Sanjiang administration building and Fuyuan city, the biochar have good adjustment function on acid soil improvement. At present this technology still needs to further popularization and application, It will further promote Heilongjiang province grain production potential [22].

Heilongjiang province's cultivated land area is 239 million mu, and the annual straw yield is about 130 million tons. Shenyang agricultural university, professor of Wen-Fu Chen biochar take the lead input forward on the basis of simple carbon technology, suggest biochar fertilizer and soil conditioner as the main development direction. A ton of straw can be made about 0.30 tons of biochar, that alone can be more than 60% lower transportation costs. At the same time, the scattered carbon production points are small in scale, and straw collection within a radius of five kilometers around them can meet the needs of biochar processing [2]. Therefore, it is of great significance to further realize the development of green agriculture and guarantee the national food security by arranging straw carbonization equipment in a certain range in the reclamation area of Heilongjiang province, realizing the preparation of biochar and returning farmland, and then realizing the dual effects of straw treatment and increasing farmland fertility. At the same time, how to develop the efficient carbon production equipment suitable for the promotion of Heilongjiang reclamation area, and reduce the cost of biochar and biochar base fertilizer are urgent problems to be solved at present. Biochar is a strategic and emerging initiative with great achievements in the contemporary era, which will play a key role in Heilongjiang province's agricultural barrier soil improvement, drug reduction, and organic green crop production.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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