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Effects of straw incorporation and reduction of chemical fertilizer on soil nutrients and crop yield in farmland

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Abstract

It's adopted the method of field experiments studied the effects of straw incorporation and reduction of chemical fertilizer on soil nutrients and crop yield, through the treatments of no fertilizer + straw (NS), optimized fertilization with straw to field the full amount (SF), optimization by providing optimization of biological humic acid fertilizer + basal was applied without straw (NSC), optimization of nitrogen and phosphorus fertilizer by 20% + total amount of straw to field ($S_{0.8}F$), optimization of fertilizer nitrogen and phosphorus by 40% + total amount of straw to field ($S_{0.6}F$) process. The results showed that, rape - rice rotation crop yield under both conditions showed NSC > SF > NS > $S_{0.8}F$ > $S_{0.6}F$, wherein the NSC has the significant differences compared with NS, $S_{0.8}F$ and $S_{0.6}F$ ($P < 0.05$) and has no significant differences compared with SF ($P > 0.05$). Rapeseed - rice rotation field soil organic matter content are expressed as: SF > $S_{0.8}F$ > $S_{0.6}F$ > NSC > NS, and straw treatments significantly improve the soil organic matter ($P < 0.05$). Changing trend of total nitrogen content in rice season is: NSC > $S_{0.8}F$ > SF > NS > $S_{0.6}F$, and soil nitrogen content trends: NSC > SF > $S_{0.8}F$ > $S_{0.6}F$ > NS. Rapeseed season paddy soil total nitrogen content trends: NSC > SF > $S_{0.8}F$ > NS > $S_{0.6}F$, and soil nitrogen content trends: NSC > $S_{0.8}F$ > SF > $S_{0.6}F$ > NS. Among them, the difference between treatments was significant ($P < 0.05$). Rapeseed season and trends of soil potassium content in rice season performance: NSC > SF > $S_{0.8}$F > NS > $S_{0.6}$F, also, the SF, soil potassium content NSC, $S_{0.8}$F processing, such as processing and NS showed significant difference ($P < 0.05$). Crop yield trends were showed as: NSC > SF > NS > $S_{0.8}$F > $S_{0.6}$F. It concluded that the implementation of straw would help to improve the carbon and nitrogen content of the soil and to increase the crop yields. To a certain extent, taking the reduction of chemical fertilizers would reduced the soil nutrient content and crop yield. But The implementation of straw can replace a certain amount of fertilizer. This study could provide the technical basis for the green agriculture and increase agricultural environmental action.

keywords: Returning straw into field; Less fertilizer; Chaohu; Soil Nutrients; Crop Yields

Introduction

In China, a large number of crop straw are produced annually. Straw is an important source of organic manure. It can be directly returned to the field because of it's convenient for drawing and has rich organic fertilizer[1]. Effective use of straw is an important measure to raise soil and crop yield. Irrational use of straw can lead to waste of resources, decline of soil quality, reduction of crop yield and risk of environmental pollution[2]. Therefore, it is of great significance to study the effective ways of returning straw to field for the development of sustainable agriculture. Straw is a component of farmland crops, including rice crop stalks and rape crop stalks, etc.They are renewable resources. It can be used as low-cost organic fertilizer due to it's rich in N, P, K and other nutrients, as well as trace elements and rich in organic matter[3]. In addition, straw returning can improve soil nutrient supply[4-5], increase soil temperature and increase soil moisture content[6]. It also can help to reduce the soil bulk density and beneficial to increase soil porosity[7]. It is suggested that the efficiency of straw incorporation in different soil types is different for soil nutrient content[9]. But the effects of multi - season crop straw return on farmland soil nutrient and crop yield were less. Therefore, in this study, the main paddy soils in Chaohu region were used as experimental soils, and the effects of straw returning with chemical fertilizers on crop yield To effectively carry out the straw return to the field and rational application of fertilizer to effectively explore.

Materials and Methods

Overview of observation sites

The experiment was carried out in TongYang Town, Chaohu City, north of Chaohu Lake. The land is located in the coastal polder plain, belonging to subtropical transitional climate. Chaohu has four distinct seasons, rain and heat over the same period, and abundant rainfall. The annual precipitation between 610 ~ l500mm. The lowest and highest temperatures are in January, the average temperature of 2 ℃, and in July, the average temperature of 28 ℃. The frost-free period is about 240 days, the average accumulated temperature of 5623 ℃. The average sunshine duration is about 2106 hours, and the highest sunshine hours months are in June and August. The experiment was conducted on a rice-oil tanker.

Test materials

Test soil: soil type is paddy soil and the soil properties in Table l.

Table 1 soil nutrient content of paddy in TongYang

Soil type	pH	OM	TN	Alkaline hydrolysis N	Available P	Available k
		$g•kg^{-1}$	$g•kg^{-1}$	$mg•kg^{-1}$	$mg•kg^{-1}$	$mg•kg^{-1}$
Paddy soil	6.18	15.78	1.25	98.00	21.64	279.79

Test straw: Rape straw was harvested in October 2014, and rice straw was harvested in May 2015. The tested rapeseed varieties: qin optimal number 10. For tested rice varieties: Hui Liang 996. The humic acid fertilizer and biological agents: The urea nitrogen (N46%), phosphate ($P_20_5$46%), and using superphosphate potassium chloride potassium selection (K_2O60%). The biological humic acid agent for the oasis in Zhaoan County of Fujian province Biochemical Co. Ltd. production of "Tianjia brand agricultural biological humic acid bacteria". The biological humic acid mainly contains bacteria inoculum ($2*10^8$ / g), the organic matter is more than 60%, more than 20% water soluble humic acid. It can produce a large number of cellulase, hemicellulase, lignin enzymes and other substances. The lignin, cellulose, hemicellulose and other components of straw had good ability to decompose. Used as crop rooting agent, soil conditioner, fertilizer synergistic agent, disease inhibitor.

The experiment design

It was tooked randomized block design and 5 treatments: NS treatment: optimized fertilization + no straw return; SF treatment: optimizing the fertilization + straw returning to the whole field; NSC treatment: optimizing fertilization + bio humic fertilizer base fertilizer application + no straw returning to field ; $S_{0.8}F$ treatment: optimization of fertilizer nitrogen and phosphorus reduced by 20% + straw to field; $S_{0.6}F$ treatment: optimization of nitrogen and phosphorus reduction by 40% + straw return to the field, each treatment 3 times, the plot area of $30m^2$. The results showed that N356.8kg / hm^2, $P_20_5$166.7kg / hm^2 and K 200.1 kg / hm^2 were the best fertilization results. Rice season: N490.2 kg / hm^2, P 230.1 kg / hm^2, K200.1 kg / hm^2.

Straw return to field for the full amount of crushing (length of about 5-10cm) tillage, in which the crop season for the straw stalks crop straw that is 10050 kg / hm^2 and the rice season straw applied for the last season crop rape stalks 7200 kg / hm^2.Biological humic acid bacteria agent according to the amount of 300 kg / hm^2 and fertilizer mixed evenly spread to the field. Straw, phosphorus, potassium as basal fertilizer one-time application, nitrogen fertilizer basal urea 75 kg / hm^2, and the rest in turn green and jointing topdressing.

The trial began in 2010, continuous. The soil samples were collected in May 2015 and October 2015 respectively, and the data were obtained in May 2015 and October 2015 respectively.

Sampling and analysis

At the maturity of the crop, soil samples (0-20 cm) were sampled in each plot with soil drill. Soil organic matter and nutrient contents were determined after air-sieving.

The soil organic matter was determined by potassium dichromate oxidation-external heating method. The total nitrogen was determined by semi-micro Kjeldahl method. The alkali-hydrolyzed nitrogen was determined by diffusion absorption method. The available phosphorus was determined by sodium bicarbonate extraction-molybdenum antimony colorimetry. Potassium was extracted with 1mol / L ammonium acetate (NH_4OAc) - flame photometric method. At harvest time, crop yields were measured using a single-crop approach.

The statistical data of WPS 10.1 software were used and the chart was drawn. SPSS 22.0 was used to analyze the variance and significance of the test data.

Research and results

Straw returned with reduced fertilizer effect on chaohu paddy soil organic matter and nitrogen content

From Table 2, the content of organic matter in the treated paddy field after rice-oil tanker cultivation was 10.2% higher than that of NS treatment, and the content of organic matter in NSC treated with NS treatment was lower than that in NS treatment ($P < 0.05$). The change trend of soil organic matter was SF> $S_{0.8}$F> $S_{0.6}$F> NSC> NS, and that of SF and NSC was significant ($P < 0.05$) The content of organic matter in straw mulch treated with SF was increased by 5.5% compared with that in NS treatment, and the content of organic matter in NSC treated by NS treatment was increased by 1.8% (Table 2), and the effect of straw on the content of organic matter in straw was also similar The soil organic matter was significantly increased by treatments ($P < 0.05$).

Table 2 soil organic matter under different treatments($g \cdot kg^{-1}$**)**

Different processing	Rape season	The rice season
NS	9.407±0.060c	14.578±0.098d
SF	10.542±0.043a	15.425±0.100a
NSC	10.038±0.098b	14.848±0.085c
$S_{0.8}$F	10.422±0.078a	15.317±0.035ab
$S_{0.6}$F	10.152±0.058b	15.172±0.089b

Note: the data between the different letters within the same column reached significant difference ($P < 0.05$), the table below.

The contents of total N and available N in soil after harvest were shown in Table 3. The trend of total soil N content in paddy soil was: NSC> $S_{0.8}$F> SF> NS> $S_{0.6}$F, The trend of content is: NSC> SF> $S_{0.8}$F> $S_{0.6}$F> NS. The trend of soil total nitrogen content in rapeseed paddy soil was: NSC> SF> $S_{0.8}$F> NS> $S_{0.6}$F, and the trend of soil N content was NSC> SF> $S_{0.8}$F> $S_{0.6}$F> NS. Among them, the differences among the treatments were significant ($P < 0.05$).

Table 3 soil nitrogen contents under different treatments

Different processing	TN（g•kg^{-1}）		Alkaline hydrolysis N（mg•kg^{-1}）	
	Rape season	The rice season	Rape season	The rice season
NS	0.969±0.003bd	1.116±0.009c	94.137±0.394d	93.920±1.199d
SF	0.990±0.005bc	1.130±0.005bc	111.620±0.962bc	96.267±0.785c
NSC	1.153±0.055a	1.205±0.005a	117.240±0.527a	101.233±0.729b
$S_{0.8}F$	0.986±0.005cd	1.145±0.005b	111.830±0.430b	95.197±0.604cd
$S_{0.6}F$	0.921±0.003d	1.061±0.007d	110.097±0.267c	95.183±0.180d

Straw returned with reduced fertilizer effect on chaohu paddy soil phosphorus and potassium content

Table 4 shows the effects of different treatments on soil phosphorus and potassium. SF> S>$S_{0.8}F$> SF> NS> $S_{0.6}F$. The trend of soil available phosphorus under different treatments was: NSC> SF> $S_{0.8}F$> NS> $S_{0.6}F$. The content of soil available phosphorus in SF treatment, NSC treatment and $S_{0.8}F$ treatment was significantly different from NS treatment ($P < 0.05$).

Table 4 Soil phosphorus and potassium contents under different treatments

Different processing	Available P（mg•kg^{-1}）		Available k（mg•kg^{-1}）	
	Rape season	The rice season	Rape season	The rice season
NS	10.300±0.267c	34.003±1.519b	113.940±0.564c	85.313±0.916c
SF	10.875±0.087b	41.050±2.097a	128.345±1.301a	90.125±0.637b
NSC	11.567±0.085a	41.414±0.882a	128.627±0.658a	94.612±0.548a
$S_{0.8}F$	11.187±0.065b	39.699±0.368a	124.487±0.990b	83.067±0.161d
$S_{0.6}F$	9.833±0.076d	33.019±1.593b	112.213±0.509c	78.967±0.301e

The trend of soil available K in the rape season was NSC> SF> $S_{0.8}F$> NS> $S_{0.6}F$. The change trend of soil available K in each season was similar to that in rape season. The contents of soil available K in soils treated with SF, NSC and $S_{0.8}F$ were significantly different from NS treatments ($P < 0.05$).

Straw returned with the influence of fertilizer on crop yield reduction

The results of different treatments on rice-oil tank crop yield are shown in Table 5. There were significant differences in crop yield between different treatments in different cropping soils. The results showed that NSC> SF> NS> $S_{0.8}F$> $S_{0.6}F$, and SF treatment increased by 1.1% and 2.5%, respectively. Compared with NS treatment, NSC treatment and NS treatment (P <0.05).

Table5 Rice and cole yields under different treatments(kg•hm-2)

Different processing	Rape season	The rice season
NS	1889.900±63.095c	8139.502±24.845c
SF	2062.142±58.554b	8216.218±49.377ab
NSC	2188.767±47.332b	8348.300±26.943a
$S_{0.8}F$	1789.633±41.964c	8111.984±68.598c
$S_{0.6}F$	1584.492±49.982d	7819.016±106.541d

The trend of crop yield in the rape season was: NSC> SF> NS> $S_{0.8}F$> $S_{0.6}F$, SF treatment increased by 8.4% compared with NS treatment, while $S_{0.8}F$ treatment and $S_{0.6}F$ treatment decreased more than NS treatment 5.3% and 16.2% respectively. There was no significant difference between SF treatment and NSC treatment (P> 0.05), and there was significant difference (P <0.05) with NS treatment, $S_{0.8}F$ treatment and $S_{0.6}F$ treatment.

Discussion

The results of field experiment showed that the functional humic acid bacteria, organic matter, water-soluble humic acid and so on can produce large amounts of cellulase, hemicellulase, ligninase and other substances. It can play an important role in crop rooting, soil improvement, fertilizer efficiency, disease inhibition and so on. So that the soil fertility of the farmland can be promote and the crop yield can be promote. The effect of humic acid base fertilizer application was similar to that of soil nutrient after harvesting in two seasons, and the increase of humic acid base fertilizer was improved after rape season and rice season.

Straw return had an effect on soil nutrients, and it could also affect crop yield in different cropping seasons. After nitrogen and phosphorus were reduced by 20% in rice season(by P_20_5 and K_20 account) can reduce soil organic matter. But there was no significant difference (P> 0.05) in organic matter content compared with the optimized fertilization.Since the organic matter in the soil without fertilization was mainly supplied by the roots and residues, it could keep the soil organic matter level low[8]. The soil organic matter could be compensated by the application of chemical fertilizers combined with straw returning to field content of the problem[9]. In the rape season, the total amount of straw returned to soil can increase the content of soil organic matter. The treatment of adding humic acid base fertilizer was significantly higher than that of the treatment without addition of nitrogen, phosphorus, nitrogen, phosphorus and straw. ($P < 0.05$), which was probably due to the effect of returning straw to the soil. Soil organic matter is an important index for evaluating soil fertility. It has been shown that crop stalks are rich in nutrients and organic components[10], which can promote the mineralization, decomposition, formation and accumulation of soil organic matter, and then increase soil organic matter content[11]. Straw return can also increase soil microbial content, which is due to plant growth process of straw on microorganisms have an important impact[12]. In this study, it was found that straw incorporation with chemical fertilizers could effectively increase the content of organic matter in the plow layer. This is consistent with previous studies.

The total amount of nitrogen in farmland soil is dynamic, and fertilization is an important factor that can affect the soil nitrogen. The results showed that straw incorporation had an important effect on soil nitrogen content. Straw return to field with the optimized fertilization and straw return with nitrogen and phosphorus reduced by 20% of the treatment of soil nitrogen has improved, but the straw return with nitrogen and phosphorus treatment by 40% failed to show the promotion of soil nitrogen The trend of element content. The application of biological humic acid base fertilizer could significantly increase the soil nitrogen content. The effects of 20% N and P fertilization (P_2O_5 and K_2O) on the content of nitrogen in farmland soil were not affected by the decrease of N, There was no significant difference between straw and chemical fertilizers. More fertilizer in the planting conditions, nitrate leaching and ammonia volatilization are more likely to occur[14]: Straw returned to the crop in addition to supply the season, there are some remain in the soil. In addition, the return of straw to inorganic nitrogen, so that the soil nitrogen cycling, indicating that straw with the optimal formulation of fertilization is to improve soil nitrogen content of one of the effective measures[15].

Because the effect of phosphate fertilizer can last for several years after a single application[16], a large number of studies have suggested that the phosphorus content of soil is mainly determined by the amount of phosphate fertilizer applied. At the same time, the return of straw can increase the leaching of phosphorus in soil. It has been reported that phosphorus content in soil is increased by reducing the amount of phosphorus that is fixed by the soil[17]. The results showed that straw incorporation with chemical fertilizers could increase available phosphorus in soil and increase available potassium in farmland soil. Straw return can improve the efficiency of soil potassium content in farmland[18].

The results also showed that the application of biological humic acid base fertilizer hadsignificant effect on soil nutrient and had a positive effect on crop yield. In this experiment, straw fertilizer was added to soil fertilizers to increase the nutrient content in farmland soil, and at the same time to reduce the risk of pollution to the environment and the economic loss. It can be seen from the straw return to field with different treatment of chemical fertilizers. Adding humic acid fertilizer base fertilizer and chemical fertilizers. Humic acid fertilizer for the future development and development of ecological agriculture has a crucial role. The effect of bio - humic acid on the bio - chemical properties of farmland soils and microbiological indicators of farmland soil was further studied, and the farmland soil should be regarded as a complex ecological system. The above conclusions have positive significance for the study on the reduction of farmland straw in the Chaohu Lake area. Field experiment should continue to improve and strengthen the straw to the field and with the effect of reducing chemical fertilizers and the objective laws of further exploration, to better serve the actual and efficient use of farmland crop stalks, and agricultural green production and agriculture Environmental protection action to provide technical basis.

Conclusions

(1)The effect of humic acid base fertilizer application was improved after rape season and rice season.(2)Straw return had an effect on soil nutrients, and it could also affect crop yield in different cropping seasons.(3)The return of straw to inorganic nitrogen, so that the soil nitrogen cycling, indicating that straw with the optimal formulation of fertilization is to improve soil nitrogen content of one of the effective measures.(4)Straw fertilizer was added to soil fertilizers to increase the nutrient content in farmland soil, and at the same time to reduce the risk of pollution to the environment and the economic loss, it can be seen from the straw return to field with different treatment of chemical fertilizers, adding humic acid fertilizer base fertilizer and chemical fertilizers.

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