Effect of Balanced Application of Potash Fertilizer on the Yield of Rice Yongyou 15 and Soil Nutrient Content

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Abstract By the field experiment, we set up the treatments of non-application of potash fertilizer, conventional fertilization, balanced fertilization and halved application of potash fertilizer, and studied the effect of different treatments on rice yield and soil nutrient content. The results showed that compared with non-application of potash fertilizer, conventional fertilization and balanced fertilization significantly increased the spike length, thousand kernel weight, yield and total potassium content of the stalk, as well as soil organic matter, total nitrogen and available phosphorus content; compared with conventional fertilization, the balanced fertilization did not significantly increase the rice growth and yield, but effectively increased rice grain total nitrogen, stalk total nitrogen and total phosphorus content, as well as soil available phosphorus and available potassium content. It could be found that potash fertilizer played a certain role in increasing rice yield and soil nutrient content, and the balanced fertilization had the most significant effect.

Key words Balanced fertilization, Potash fertilizer, Yield, Rice, Nutrients

1 Introduction

Potassium is one of the three necessary nutrients to maintain normal growth and development of plants[1], and its content accounts for 0.2% - 10% of crop dry matter weight. Potassium is second only to nitrogen for crop growth[2]. Studies have shown that potassium in plants has a variety of important physiological functions, such as participating in activation of enzymes, protein synthesis, material transport and enhancing plant resistance[3-4]. The application of potash fertilizer can significantly improve crop nutrient uptake capacity and photosynthetic rate[5]. However, with the crop yield improvement and cropping index increase, a lot of potassium drains away with the crop harvest, and it is not replenished in time, leading to serious soil potassium deficiency in farmland[2,6]. Data show that China's arable land deficient in potassium has increased year by year, accounting for 56% of total arable land, and potassium deficiency has become a major constraint for crop production[7]. In addition, the low self-sufficiency of potash fertilizer also seriously restricts the sustainable development of agriculture in the province[8]. The balanced application of potash fertilizer is an important measure to improve crop yield and quality, and also an effective way to alleviate the current grain production pressure and potassium resource shortage. In this paper, with rice as experimental material, we studied the effect of balanced application of potash fertilizer on rice yield and soil physical and chemical properties, in order to provide a theoretical basis for the rational application of potash fertilizer in the province.

2 Materials and methods

2.1 Materials The test site was in Siping Village (Tangxi Town, Development Zone, Jinhua City), and the pilot demonstration area was 3275 m^2. The test soil was yellow mud and the test rice variety was Yongyou 15. The potash fertilizer for test was the Canadian potash fertilizer provided by Zhejiang AMP International Co., Ltd. The basic physical and chemical properties of soil: organic matter 25.50 g · kg^{-1}; total nitrogen 1.64 g · kg^{-1}; available phosphorus 14.50 mg · kg^{-1}; available potassium 67.00 mg · kg^{-1}; pH 5.10.

2.2 Experimental design Experimental design was shown in Table 1, and there were a total of 4 potash fertilizer treatments. The test nitrogen fertilizer was urea (40% as basal fertilizer; 20% as tillering fertilizer; 40% as panicle-spikelet fertilizer). The test phosphate fertilizer was calcium superphosphate (all as basal fertilizer). The test potash fertilizer was potassium chloride (25% as basal fertilizer; 50% as tillering fertilizer; 25% as panicle-spikelet fertilizer). The basal fertilizer was applied twice, half in the day of machine-transplanting and half 5 - 6 days after transplanting. The seedlings with consistent growth were selected for machine-transplanting, with the spacing of 20 cm × 30 cm. There were 4 plants for each hole, and each treatment strictly controlled water and implemented single irrigation and single drainage. The field management was carried out in accordance with the local conventional rice production technology standards.

2.3 Data analysis Data were analyzed using DPS2000, and the mean significance difference was tested using Duncan's multiple range test.

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Table 1 Experimental design

Treatment	Application rate of fertilizer//kg/667m^2		
	N	P_2O_5	K_2O
CK(non-application of potash fertilizer)	16	3	0.0
FP(conventional fertilization)	16	3	12.0
OPT(balanced fertilization)	16	3	15.0
OPT-K(halved application of potash fertilizer)	16	3	7.5

Table 2 Effect of potash fertilizer on rice yield and traits

Treatment	Plant height//cm	Spike length//cm	Thousand kernel weight//g	Yield//kg/667m^2
CK	127.67 ±3.21 a	25.33 ±1.15 b	28.57 ±0.25 a	573.03 ±19.67 b
FP	127.00 ±6.24 a	26.67 ±2.89 ab	27.89 ±1.31 a	644.54 ±23.40 a
OPT	130.33 ±0.58 a	29.33 ±0.58 a	27.55 ±0.51 a	656.17 ±29.60 a
OPT-K	124.67 ±1.15 a	27.33 ±1.53 ab	27.65 ±0.50 a	625.11 ±18.12 ab

Note: Different letters in each column indicated significant differences at 5% level, the same below.

3 Results and analysis

3.1 Effect on plant height and yield traits Compared with the non-application of potash fertilizer, the application of Canadian potash fertilizer increased the rice yield, and the rice yield under FP (conventional fertilization), OPT (balanced fertilization) and OPT-K(halved application of potash fertilizer) increased by 12.48%, 14.51% and 9.09%, respectively, but the Canadian potash fertilizer treatment had no significant effect on rice plant height and thousand kernel weight (Table 2). The results showed that the balanced fertilization had the best effect, and the rice yield and spike length were better than those without applying potash fertilizer.

3.2 Effect on rice grain and stalk nutrient content Compared with the control, the application of Canadian potash fertilizer increased the content of total nitrogen and total phosphorus in rice grain, and OPT (balanced fertilization) played the most significant role in enhancing the content of total nitrogen and total phosphorus in grain (increasing by 33.21% and 8.61%, respectively), but Canadian potash fertilizer had no significant effect on the content of total potassium in rice grain (Table 3). Table 3 showed that the application of Canadian potash fertilizer increased the content of total nitrogen, total phosphorus and total potassium in rice stalk, OPT played a prominent role in increasing the rice stalk nutrients, and the content of total nitrogen, total potassium and total phosphorus increased by 36.63%, 31.42% and 38.90%, respectively. The field record during test process showed that when the potash fertilizer was not applied, there was lodging phenomenon in rice, while there was no lodging phenomenon in rice under Canadian potash fertilizer treatment, possibly because the application of potash fertilizer increased the total potassium content of rice stalk and improved the mechanical strength of stalk.

Table 3 Effect of potash fertilizer on the content of nutrients in rice grain and stalk

Treatment	Grain			Stalk		
	Total nitrogen g·kg^{-1}	Total phosphorus mg·g^{-1}	Total potassium mg·g^{-1}	Total nitrogen g·kg^{-1}	Total phosphorus mg·g^{-1}	Total potassium mg·g^{-1}
CK	10.81 ±0.75 b	2.67 ±0.13 b	3.35 ±0.01 a	4.75 ±0.30 c	1.05 ±0.02 b	27.92 ±1.95 c
FP	11.62 ±0.70 b	2.82 ±0.23 ab	3.68 ±0.59 a	5.18 ±0.41 bc	1.10 ±0.07 b	33.69 ±3.87 ab
OPT	14.40 ±1.54 a	2.90 ±0.06 a	3.35 ±0.01 a	6.49 ±0.13 a	1.38 ±0.03 a	38.78 ±0.63 a
OPT-K	12.10 ±1.47 b	2.99 ±0.10 a	3.39 ±0.02 a	5.82 ±0.54 ab	0.66 ±0.03 c	32.90 ±4.00 bc

Table 4 Effect of balanced fertilization on soil physical and chemical properties

Treatment	Organic matter//g·kg^{-1}	Total nitrogen//g·kg^{-1}	Available phosphorus//mg·kg^{-1}	Available potassium//mg·kg^{-1}	pH
Basic value	25.50	1.64	14.50	67.00	5.10
CK	19.65 ±2.19 c	1.44 ±0.09 c	15.53 ±3.08 c	57.13 ±9.38 b	5.50 ±0.30 a
FP	27.96 ±3.30 ab	2.02 ±0.14 a	27.48 ±3.93 b	62.75 ±3.75 b	5.40 ±0.10 a
OPT	31.29 ±0.88 a	2.01 ±0.08 a	52.22 ±4.28 a	89.00 ±7.50 a	5.50 ±0.17 a
OPT-K	24.37 ±1.81 b	1.67 ±0.14 b	13.98 ±3.23 c	65.25 ±7.81 b	5.40 ±0.00 a

3.3 Effect on soil nutrient content Table 4 showed that the application of Canadian potash fertilizer increased the content of soil organic matter, total nitrogen, available phosphorus and available potassium, and balanced fertilization played the most significant role in increasing soil nutrients; compared with the control, the content of organic matter, total nitrogen, available phosphorus and available potassium increased by 59.26%, 39.56%, 236.30% and 55.79%, respectively, but the application of Canadian potash fertilizer did not affect soil pH. Compared with the basic value of soil nutrient content before test, the content of soil organic matter, total nitrogen and available potassium declined under non-application of potash fertilizer (Table 4), and Canadian potash fertilizer played a certain role in increasing soil nutrient content.

3.4 Differences in contribution rate and uptake and utilization rate of rice potash fertilizer Table 5 showed that the contribution rate of rice potash fertilizer under conventional fertilization, balanced fertilization and halved application of potash fertilizer was 12.49%, 14.48% and 12.48%, respectively, but there were no significant differences between treatments; the uptake and utilization rate under conventional fertilization, balanced fertilization and halved application of potash fertilizer was 39.21%, 41.96% and 42.35%, respectively, but there were no significant differences between treatments.

Table 5 Effect of potash fertilizer on contribution rate and uptake and utilization rate of rice potash fertilizer

Treatment	Contribution rate//%	Uptake and utilization rate//%
CK	–	–
FP	12.49 ± 1.78 a	39.21 ± 1.35 a
OPT	14.48 ± 1.32 a	41.96 ± 3.49 a
OPT-K	12.48 ± 1.26 a	42.35 ± 1.93 a

4 Discussions

The application of potash fertilizer is an important agronomic measure to achieve high yield of crops. The studies of Lei Wanjun *et al.* [9] showed that an appropriate increase in application of potash fertilizer could significantly increase the setting percentage and improve rice production. Suitable application of potash fertilizer had some positive effects on corn and buckwheat production, and when the application rate of potash fertilizer was 100 kg · ha, the yield was highest for Zhengdan 958 and Xianyu 335. When applying 22.5 – 45 kg · ha potassium oxide, the buckwheat could get high potash fertilizer use efficiency and yield[10-11]. In addition, the application of potash fertilizer could effectively increase rape yield, but the growth rate varied under different forms of potash fertilizer[12]. The results of this study showed that compared with non-application of potash fertilizer, the application of potash fertilizer could significantly increase the rice yield (Table 2), the content of total nitrogen, total phosphorus and total potassium in rice stalk (Table 3), and the content of soil organic matter and total nitrogen (Table 4). The application of potash fertilizer could not only increase yield, but also significantly improve the quality of crops[2, 13], for example, after application of potash fertilizer, cucumber vitamin C, soluble sugar and fruit potassium content increased significantly[14], and potash fertilizer treatment effectively reduced the lettuce nitrate content, and improved lettuce vitamin C and soluble sugar content[15]. By spraying different potassium fertilizers on leaves, kiwi vitamin C content increased by 1.43% – 9.60%, titratable acid content decreased by 10.92% – 15.05%, and sugar acid ratio increased by 5.03% – 16.64%[16]. The results of this experiment showed that the application of potash fertilizer significantly increased the content of available phosphorus in rice grain, and the balanced application of potash fertilizer played the most significant role in increasing the content of available phosphorus in grain. In addition, the potash fertilizer treatment effectively increased the content of total potassium in rice stalk, significantly increased the mechanical strength of rice stalk, and enhanced the rice lodging resistance[17-18]. The application of potash fertilizer had a certain influence on soil physical and chemical properties, and the content of tobacco soil available potassium increased with increasing potash fertilizer application[19]. The application of different potash fertilizer did not significantly affect the content of organic matter, nitrogen, phosphorus and potassium in paddy soil after harvesting. This study confirmed that the application of potash fertilizer effectively increased the content of soil organic matter, total nitrogen and available phosphorus, and the balanced application of potash fertilizer played the most significant role in increasing soil nutrients (Table 4). In conclusion, the application of potash fertilizer in rice production could effectively improve yield, mechanical resistance of rice, quality of rice grain and content of soil nutrients, and the balanced application of potash fertilizer had the most significant effect. Therefore, the balanced application of potash fertilizer an effective way to achieve high yield of crops and improve soil quality.

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Table 8 Microbial index

Items	Index	Measured index	Detection method basis
Total number of colony//CFU/g	≤1000	15	GB 4789.2 -2010
Coliform group count// MPN/g	≥0.4	<0.3	GB 4789.3 -2010
Mold count//CFU/g	≤25	<1×10	GB 4789.15 -2010
Yeast count//CFU/g	≤25	<1×10	GB 4789.15 -2010
Salmonella	Negative	Not detected	GB 4789.4 -2010
Shigella	Negative	Not detected	GB 4789.5 -2012
Staphylococcus aureus	Negative	Not detected	GB 4789.10 -2010
Hemolytic streptococcus	Negative	Not detected	GB/T GB 4789.11 -2003

4 Conclusions and discussions

Through the study on processing methods, raw material extract preparation and product index detection, the processing technology and product quality standards of *Millettia speciosa* Champ. instant tea were explored in order to provide a theoretical basis for its development and application. Through the detection of sensory index, physical and chemical index and microbiological index, they were all within the normal range, and did not exceed the standard, indicating that the processing technology had a certain degree of stability and maturity, and could provide scientific basis for industrializing organisms. The existing instant tea seldom takes the herbal extract as the main component, and due to taste and solubility problems, the herbal ingredients will lead to poor taste, color and solubility. This study developed a kind of instant tea with *Millettia speciosa* Champ. extract as the main component, and designed technical scheme for the production of *Millettia speciosa* Champ. instant tea. The water decoction for raw material extraction, combined with concentration and dry production process, caused the effective components of product to have high purity, good taste, good solubility, and good health care effect. *Millettia speciosa* Champ. instant tea had low production costs and simple process, and there was perfect combination of color, aroma, taste and appearance in instant tea. Long-term drinking would produce good health effects, such as fatigue resistance, endurance and immunity enhancement and blood lipid reduction. The technical method could help to achieve industrial production and increase the added value and resource utilization rate of *Millettia speciosa* Champ. Therefore, the development of *Millettia speciosa* Champ. instant tea expanded the market for *Millettia speciosa* Champ. raw material, and filled the market gap of *Millettia speciosa* Champ. instant tea.

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