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Full Length Article

Effects of Slow-release Compound Fertilizer on Eggplant (*Solanum melongena*) Quality

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Abstract

Egglant rutin is beneficial effect against oxidative damage of cells, moderate amount of solanine is good for the body, the anthocyanins have antioxidant functions. To investigate the effects of slow-release compound fertilizer (SRF) on compounds such as rutin, solanine, anthocyanins in eggplant (*Solamun melongena* L.) with a long growth period, the field experiments were conducted in neutral and slightly alkaline soils using the eggplant varieties called Heisheng and Zhuqie. Results showed that rutin content were higher with SRF treatment than with chemical fertilizer (CF) treatment at the second fruiting stage of Heisheng and Zhuqie eggplants grown in neutral and slightly alkaline soils. Furthermore, SRF increased solanine content of Zhuqie eggplant, which typically contains low levels of solanine, and decreased the solanine content of Heisheng eggplant, which typically contains high solanine levels. In the Zhuqie variety, anthocyanins levels were higher with SRF treatment than with CF and common compound fertilizer (CCF) treatments except at the second fruiting stage of eggplants grown in neutral soil. To sum up, slow-release compound fertilizer with one-time application could slowly supply nutrients to satisfied eggplant need, which will not only reduce labour costs but also improve eggplant qualities.

Keywords: Anthocyanins; Eggplant; Rutin; Slow-release compound fertilizer; Solanine

Introduction

Eggplant (*Solamun melongena* L.) is a good source of vitamins, amino acid, rutin, solanine and so on (Ayaz *et al.*, 2015; Gürbüz *et al.*, 2018). Rutin has been commonly used in human medicine because of its beneficial effects against many diseases (Ghiasi *et al.*, 2012; Wang *et al.*, 2017). Solanine, which is a compound particular to solanaceous plants, is beneficial for human health when found at appropriate levels in food, while excess solanine levels can be toxic to humans (Jensen *et al.*, 2007; Yamashoji and Matsuda, 2013).

Eggplant grows vigorously over a longer growing season and needs a continuous nutrient supply. This has made fertilizers one of the most important agricultural inputs for eggplant production. Different types of fertilizers have different release patterns over time. Consistent with the nutrient demands of eggplant and their long growth period, slow-release compound fertilizers (SRFs) release nutrients slowly and can continuously supply eggplant with multiple forms of nitrogen more effectively than chemical fertilizers and common compound fertilizers. Numerous studies have shown that slow release fertilizers could improve crop yield and quality (Guan *et al.*, 2014; Cheng *et al.*, 2015; Zareabyaneh and Bayatvarkeshi, 2015). Only limited studies have examined effect of slow release fertilizers on eggplant quality, and particularly its effects on rutin and solanine levels.

Soil microbial communities not only regulate plant productivity and diversity but can also indicate soil fertility, are regulated by biotic and abiotic factors such as nutrient availability and crop cultivars among others (Banks *et al.*, 2014; van der Bom *et al.*, 2018). Numerous studies have demonstrated that populations of bacteria and fungi are changed because of various fertilizers application (Montalba *et al.*, 2010; Zhang *et al.*, 2012), as well as the relationships between eggplant quality and soil microbial and the use of SRFs remain less well characterized.

A slow-release compound fertilizer (SRF) is unlike other fertilizers, and contains rich organic matter and various forms of nitrogen such as amide nitrogen, organic nitrogen, and ammonium nitrogen. Numerous studies have previously examined the effects of SRFs on nutrient release, biological and environmental effects (Dong and Wang, 2007; Li and Li, 2007; Hu *et al.*, 2009). To date, however, studies are rare on the effects of slow-release fertilizers on eggplant quality, particularly on rutin and solanine levels, on soil microbial communities, or the connections between these factors. Therefore, the purpose was to determine the effect of this fertilizer on quality attributes of Heisheng and Zhuqie eggplant varieties in neutral and slightly alkaline soils, focusing on changes in rutin and solanine levels.

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Materials and Methods

Location of Field Experiments and Plot Design

Field experiments were conducted from March 10 to August 27, 2015. Neutral soil experiments were conducted at Bishan (29°47'N, 106°18'E) and experiments with slightly alkaline soil at Tongliang (29°46'N, 106°1'E), Chongqing, China. Soil physico-chemical properties were measured: soil pH is 6.7 and 7.9 in neutral and slightly alkaline soil, and two soils organic matter is 13.8 and 21.8 g kg^{-1}, available nitrogen, available phosphorus, and available potassium were 99.7, 22.6, 134 mg kg^{-1}, respectively, in neutral soil and 93.1, 19.1, 97.7 mg kg^{-1}, respectively, in slightly alkaline soil. Main plots were split into three randomized subplots arranged three fertilizer treatments, and each treatment replicated three times. The area of each subplot was of 16.8 m^2 for neutral soil and 18 m^2 for slightly alkaline soil. Row spacing of 1.4 m and 1.5 m between eggplants was used for neutral and slightly alkaline soil, respectively.

Plant Material

Heisheng and Zhuqie eggplants were provided by the Chongqing Academy of Agricultural Sciences, China. Both eggplant varieties were of the long rod type, with Heisheng having purple-black skin and Zhuqie having purple-green skin.

Fertilizer and Treatments

SRF was produced by our team in this research, which had N, P_2O_5, K_2O in the ratio of 14: 8: 8, contained a variety of nitrogen (N) forms such as ammonium-N, nitrate-N and dissolvable organic-N (Wang *et al.*, 2005). Additionally, Organic matter content (15.7%) of the fertilizer was rich. Chemical fertilizer (CF) consisted of urea (N, 46%), ammonium dihydrogen phosphate (N, 11% and P_2O_5, 44%) and potassium sulfate (K_2O, 50%). Common compound fertilizer (CCF) was composed of CF that had urea, ammonium dihydrogen phosphate and potassium sulfate, and the ratio of N, P_2O_5, K_2O was the same as that of SRF.

Application rates were the same for three fertilizer treatments and N, P_2O_5, K_2O were 350, 200, and 200 kg hm^{-2}. On March 10, 2015, the blocks were prepared and treated with a one-time application of phosphorus and potassium fertilizer, CCF, or SRF as the base manure. Forty percentage of urea nitrogen fertilizer was basally applied and the remainder was applied from the top twice.

Yield Statistics and Quality Analysis of Eggplants

Eggplant yield was measured by harvesting from May to August 2015, fruit from each subplot were weighted and cumulatively analyzed at different harvest stages.

Ready to harvest eggplant fruits were taken on June 25 and July 18, 2015, to determine eggplant quality. Amino acid and soluble sugar levels were determined by spectrophotometry using the chromogenic method with ninhydrin for amino acid determination and 3, 5-dinitrosalicylic acid for soluble sugar determination (Yemm and Cocking, 1955; Lu, 2000). Rutin was extracted from fruit as previously described by Han *et al.* (2002) and rutin levels were determined using aluminum nitrate. Solanine was extracted and analyzed by HPLC as described by Mäder *et al.* (2009). Anthocyanins and chlorophyll levels were determined by spectrophotometry using the chromogenic method with vanillin and hydrochloric acid for anthocyanins and ethanol and acetone as the extracting agents for chlorophyll (Spagna *et al.*, 2003; Ye, 2007; He *et al.*, 2008).

Soil Collection and Analysis

Soil microbial extraction and Phospholipid Fatty Acid (PLFA) analysis were carried out using a gas chromatography (GC) as described by Bligh and Dyer (1959), Schutter and Dick (2000).

Statistical Analysis

Analysis of variance (ANOVA) and Duncan's mean grouping were used to determine significant differences between treatment means. All statistical analyses containing correlation analysis were executed using SPSS (Statistical Package for Social Science) 13.0 statistical software.

Results

Nutritional Quality of Eggplants

As shown in Table 1, application of fertilizer had an obvious effect on eggplant amino acid levels. In neutral soil, amino acid content in Heisheng eggplants was greatly higher with SRF treatment compared with CF and CCF treatments at the first fruiting stage. However, at the second fruiting stage, amino acid content with SRF did not differ obviously with CCF treatment and was greatly decreased compared with CF treatment. To Zhuqie eggplant, amino acid content was higher with SRF than with CF and CCF treatment at the two fruiting stages. In the slightly alkaline soil, the amino acid content of Zhuqie eggplants with SRF treatment was significantly higher than with CF treatment, no obvious differences were found in amino acid content between SRF and CF treatment at the two fruiting stages for Heisheng eggplant. Across the two eggplant fruiting stages in neutral and slightly alkaline soil, the amino acid content of Zhuqie eggplant at the first fruiting stage was higher than at the second fruiting stage, although this trend was not observed in Heisheng eggplant.

At the first fruiting stage, the soluble sugar content of SRF-treated Heisheng eggplant increased by 11.54 and 6.53% compared with CF and CCF in neutral soil, respectively, and by 8.62 and 4.56% in slightly alkaline soil, respectively (Table 1). SRF treatment resulted in an 8.27 and 6.34% increase compared with CF in soluble sugar content of Heisheng eggplant in neutral and slightly alkaline soil, respectively, at the second fruiting stage (Table 1). The soluble sugar content of Zhuqie eggplant in neutral soil increased by 9.79 and 3.40% with SRF treatment compared with CF and CCF treatment, respectively at the first fruiting stage, and by 12.71 and 12.09% at the second fruiting stage (Table 1). The soluble sugar content of SRF-treated Zhuqie eggplant increased by 14.69 and 2.11% compared with CF at the two fruiting stages in slightly alkaline soil (Table 1).

Health Quality of Eggplants

In neutral soil, rutin levels in Heisheng eggplant increased significantly with SRF treatment compared with CCF treatment but did not differ significantly compared with CF treatment. In Zhuqie eggplant, there were no remarkable differences in rutin levels between the three fertilization treatments at the two fruiting stages. In slightly alkaline soil, SRF treatment increased rutin levels significantly in Zhuqie eggplant by 34.62 and 15.38% compared with CF and CCF treatment, respectively, at the first fruiting stage. In Heisheng eggplant, SRF treatment increased rutin levels by 24.27 and 15.56% compared with CF and CCF treatment, respectively, at the second fruiting stage (Table 2). In summary, SRF increased eggplant rutin content play a role in softening blood vessels and avoiding cerebrovascular disease, improved eggplant qualities and is good for human health.

Table 2 shows that solanine levels in Heisheng eggplant were higher than in Zhuqie eggplant under all conditions except for at the second fruiting stage in neutral soil. Regardless of the fruiting stages or soil conditions, solanine levels were lower with SRF treatment than CF and CCF treatment in Heisheng eggplant. Conversely, in Zhuqie eggplant, solanine levels were higher with SRF treatment than with CF and CCF treatment under all conditions except for at the first fruiting stage in neutral soil. This suggested that SRF increased solanine content of Zhuqie eggplant, which typically has low solanine levels, and decreased the solanine content of Heisheng eggplant, which typically contains a higher level of solanine. SRF had a balancing effect on solanine levels in eggplant that may help to improve the flavor of Heisheng eggplant and increase the solanine-associated health benefits of Zhuqie eggplant. So moderate solanine level in Zhuqie eggplant may be beneficial for human health, and Heisheng eggplant with solanine reducing may have a good taste to diet.

Eggplant Pigmentation

Great differences in anthocyanins content were observed between two eggplant varieties, with the Heisheng eggplant having higher anthocyanins content than Zhuqie eggplant, regardless of the fruiting stages or soil types (Table 3). anthocyanins levels in Zhuqie eggplant with SRF treatment were higher than with CF and CCF treatment except at the second fruiting stage in neutral soil when SRF treatment resulted in lower anthocyanins levels. In Heisheng eggplant grown in slightly alkaline soil, anthocyanins levels were significantly lower with SRF treatment than with CF treatment and increased compared with CCF treatment regardless of the fruiting stages.

Compared with CF treatment, SRF treatment resulted in a decrease in chlorophyll content at the first fruiting stage and an increase at the second fruiting stage in Heisheng eggplant grown in neutral soil. In slightly alkaline soil, SRF treatment only increased chlorophyll content by 10.32% (Table 3) compared with CCF treatment at the second fruiting stage of Heisheng eggplant. In Zhuqie eggplant, chlorophyll content at the first fruiting stage was higher with SRF treatment than with the other treatments in both neutral and slight alkaline soil. Compared with CF and CCF treatment, the chlorophyll level in Zhuqie eggplant at the second fruiting stage treated with SRF increased significant 4.84 and 4.84% in neutral soil and by 23.97 and 16.50% in slightly alkaline soil, respectively (Table 3).

Correlations between Eggplant Yield and Quality

According to Pearson's correlation analysis, significant differences were recorded on between the yield of Heisheng and Zhuqie eggplants with different fertilizer treatments in neutral and slightly alkaline soils. In particular, eggplants yield was higher with SRF treatment than with the CF and CCF treatments. Compared with CF and CCF treatment, SRF treatment significantly increased the yield of Heisheng eggplant by 10 and 6.7%, respectively and the yield of Zhuqie eggplant by 11.63 and 5.13%, respectively in neutral soil (Table 4). Additionally, in slightly alkaline, SRF treatment significantly increased the yield of Heisheng and Zhuqie eggplant by 10.53 and 14.17%, respectively compared with CF treatment, and by 9.42 and 5.14%, respectively, compared with CCF treatment (Table 4). Therefore, there existed significant differences in eggplant yield among different treatments, although application of SRF showed a significant positive effect on eggplant yield in both soil types.

As shown in Table 5, yield was positively correlated with solanine levels in Heisheng eggplant ($r=0.838^*$, at $P<0.05$), while no correlation were found between yield and other Heisheng eggplant qualities. In Zhuqie eggplant, yield and soluble sugar content levels were positively correlated ($r=0.903^*$, at $P<0.05$), as were yield and chlorophyll ($r=0.933^{**}$, at $P<0.01$). No correlation was found between yield and anthocyanins levels in Zhuqie eggplant, but the correlation coefficients were relatively large.

Table 1: Amino acid and soluble sugar levels in eggplant (g kg^{-1})

Soil type	Eggplant variety	Treatment	Amino acid		Soluble sugar	
			First fruiting stage	Second fruiting stage	First fruiting stage	Second fruiting stage
Neutral soil	Heisheng	CF	3.75±0.04c	3.34±0.03a	23.4±0.32c	25.4±0.47b
		CCF	3.85±0.03b	3.25±0.02b	24.5±0.38b	27.8±0.25a
		SRF	3.93±0.03a	3.28±0.01b	26.1±0.30a	27.5±0.71a
	Zhuqie	CF	2.11±0.04b	1.52±0.03a	19.4±0.41c	18.1±0.55b
		CCF	2.18±0.02a	1.46±0.04b	20.6±0.29b	18.2±0.35b
		SRF	2.21±0.01a	1.53±0.02a	21.3±0.34a	20.4±0.36a
Slightly alkaline soil	Heisheng	CF	3.83±0.02a	3.27±0.02b	23.2±0.30c	20.5±0.46b
		CCF	3.78±0.03a	3.34±0.03a	24.1±0.67b	21.5±0.48a
		SRF	3.81±0.03a	3.31±0.01ab	25.2±0.32a	21.8±0.22a
	Zhuqie	CF	1.94±0.04b	1.41±0.02b	21.1±0.32b	19.0±0.18b
		CCF	2.05±0.02a	1.46±0.04b	22.2±0.29a	19.9±0.20a
		SRF	2.00±0.02a	1.55±0.02a	24.2±0.37a	19.4±0.34a

Means with same letter differ non-significantly

Table 2: Rutin and solanine levels in eggplant (mg g^{-1})

Soil type	Eggplant variety	Treatment	Rutin		Solanine	
			First fruiting stage	Second fruiting stage	First fruiting stage	Second fruiting stage
Neutral soil	Heisheng	CF	2.73±0.14a	3.92±0.12a	1.56±0.05b	2.60±0.03a
		CCF	2.36±0.05b	3.58±0.07b	1.80±0.09a	2.21±0.02b
		SRF	2.69±0.06a	4.00±0.02a	1.52±0.10b	1.86±0.06c
	Zhuqie	CF	4.09±0.12a	4.41±0.25a	0.307±0.01a	2.05±0.05b
		CCF	4.00±0.13a	4.16±0.15a	0.224±0.02c	1.47±0.04c
		SRF	3.59±0.41a	4.50±0.03a	0.266±0.01b	2.23±0.07a
Slightly alkaline soil	Heisheng	CF	2.65±0.26a	2.39±0.08c	2.43±0.02b	2.38±0.07a
		CCF	1.98±0.09b	2.57±0.05b	2.72±0.08a	2.36±0.02a
		SRF	2.40±0.07a	2.97±0.08a	2.35±0.03c	1.58±0.05b
	Zhuqie	CF	3.12±0.02c	2.76±0.04b	0.297±0.01b	0.559±0.03b
		CCF	3.64±0.05b	3.31±0.22a	0.307±0.04b	0.573±0.02b
		SRF	4.20±0.28a	3.08±0.22ab	0.343±0.02a	0.612±0.04a

Means with same letter differ non-significantly

Table 3: Anthocyanins and chlorophyll levels in eggplant (mg g^{-1})

Soil type	Eggplant variety	Treatment	Anthocyanins		Chlorophyll	
			First fruiting stage	Second fruiting stage	First fruiting stage	Second fruiting stage
Neutral soil	Heisheng	CF	553.7±1.15a	408.0±2.65c	0.132±0.04a	0.131±0.02b
		CCF	561.0±9.70a	516.1±3.75a	0.113±0.07b	0.152±0.06a
		SRF	482.5±1.85b	489.1±6.90b	0.106±0.04b	0.145±0.07a
	Zhuqie	CF	202.6±0.60c	313.8±5.65b	0.103±0.06a	0.124±0.06b
		CCF	247.2±7.70b	349.8±5.55a	0.0942±0.08b	0.124±0.08b
		SRF	311.8±0.40a	312.8±4.00b	0.104±0.05a	0.130±0.04a
Slighlyt alkaline soil	Heisheng	CF	571.4±4.70a	481.5±3.80a	0.103±0.01a	0.152±0.04a
		CCF	333.3±0.30c	407.0±3.75c	0.101±0.03a	0.126±0.03c
		SRF	530.9±2.30b	453.9±0.701b	0.103±0.01a	0.139±0.01b
	Zhuqie	CF	199.3±19.20b	134.4±1.10c	0.0795±0.04b	0.0968±0.03c
		CCF	235.8±11.00a	261.2±10.00b	0.0904±0.06a	0.103±0.07b
		SRF	246.8±12.80a	292.6±2.60a	0.0953±0.03a	0.120±0.03a

Means with same letter differ non-significantly

Correlations between Eggplant Quality and Soil Microbiota

Soil microbial community is given in Table 6. SRF treatment resulted in an increase in soil bacteria when compared with CF and CCF treatment in Heisheng eggplant grown in neutral soil. In Zhuqie eggplant grown in neutral soil, SRF treatment increased soil bacteria significantly by only 3.55% as compared to CCF treatment. When Compared with CF treatment in slightly alkaline soil, however, soil bacteria was significantly decreased with SRF treatment. While no obvious differences were found in actinomyccetes population in neutral soil among the three fertilizer treatments, the actinomyccetes content was higher with SRF treatment than with CCF treatment. Compared with CF and CCF treatment, SRF treatment significantly decreased the actinomyccetes content of slight alkaline soil. Regardless of soil type or eggplant variety, fungi population increased with SRF treatment compared with CF and CCF treatment.

Table 4: Eggplant yield in different soils

Soil type	Varieties	Treatment	Yield (kg hm^{-2})
Neutral soil	Heisheng	CF	101643±2277.6b
		CCF	104790±1762.8b
		SRF	111806±1063.9a
	Zhuqie	CF	102560±1287.2c
		CCF	108905±1300.4b
		SRF	114492±977.7a
Slightly alkaline soil	Heisheng	CF	129861±2872.4b
		CCF	131185±5361.1b
		SRF	143537±472.5a
	Zhuqie	CF	131111±3329.2c
		CCF	142370±2583.4b
		SRF	149685±409.5a

Means with same letter differ non-significantly

Table 5: Pearson's correlation analysis between eggplant yield and quality

	Amino acid	Soluble sugar	Rutin	Solanine	Anthocyanins	Chlorophyll
Yield of eggplant that Heisheng	-0.128	0.070	-0.429	0.838*	-0.586	0.689
Yield of eggplant that Zhuqie	-0.701	0.903*	-0.257	0.661	0.808	0.933**

**, * indicated Significance are 0.01 and 0.05 level, respectively

Table 6: Microbial community in soil planted with eggplant (nmol g^{-1})

Soil	Eggplant varieties	Treatment	Bacteria	Actinomyccetes	Fungi
Neutral soil	Heisheng	CF	10.1±0.22b	0.565±0.03a	0.884±0.01b
		CCF	9.88±0.05b	0.598±0.01a	1.18±0.06a
		SRF	11.6±0.05a	0.636±0.07a	1.27±0.07a
	Zhuqie	CF	15.0±0.04a	0.840±0.02a	1.91±0.05b
		CCF	14.1±0.27c	0.779±0.08a	1.72±0.04b
		SRF	14.6±0.10b	0.786±0.05a	2.18±0.21a
Slight alkaline soil	Heisheng	CF	11.0±0.09a	0.574±0.02a	0.953±0.03b
		CCF	7.51±0.07c	0.437±0.03b	0.591±0.01c
		SRF	8.16±0.06b	0.338±0.04c	1.02±0.02a
	Zhuqie	CF	12.1±0.10a	0.680±0.04a	0.948±0.04b
		CCF	10.6±0.18b	0.610±0.03a	0.856±0.04c
		SRF	9.77±0.29c	0.452±0.04b	1.36±0.03a

Means with same letter differ non-significantly

Table 7: Pearson's correlation analysis between eggplant quality and soil microbiota

	Amino acid	Soluble sugar	Rutin	Solanine	Anthocyanins	Chlorophyll
Bacteria	-0.599*	-0.769**	0684*	-0.723**	-0.465	-0.181
Actinomycetes	-0.530	-0.774**	0.564	-0.671*	-0.448	-0.131
Fungi	-0.500	-0.522	0.667*	-0.617*	-0.351	-0.031

**, * indicated Significance are 0.01 and 0.05 level, respectively

As shown in Table 7, solanine population was negatively correlated with soil actinomyccetes and fungi. A significant negative correlation was also observed between solanine levels and soil bacteria. Except for soil actinomyccetes, rutin was positively correlated with soil bacteria and fungi. Soluble sugar content was negatively correlated with soil bacteria and anthocyanins levels. Additionally, there was no correlation between eggplant quality indicators such as anthocyanins and chlorophyll levels and soil microbiota populations such as bacteria, actinomyccetes fungi.

Discussion

Azeem *et al.* (2014) concluded that most controlled release fertilizers released nutrients at the same rate. However, SRF used in this study was prepared to satisfy eggplant need (Dong and Wang, 2007; Wang *et al.*, 2015). CF and CCF are kind of fertilizer that only contain nitrogen, phosphorus, and potassium, while SRF has many forms of nitrogen such as NH_4^+-N, NH_3^--N, amide-N and organic-N. Organic-N is important as it can decrease nutrient loss and satisfy the nutrient needs of eggplant evenly because of the uniform nitrogen mineralization and nitrification and the effect of humic acid retaining nitrogen. Additionally, SRF comprises rich organic matter that could improve the crop growth environment, further increase in yield and improved eggplant quality (Radicetti *et al.*, 2016). This study showed that the influence of different treatments on eggplant yield and quality depended on soil fertility. Indeed, SRF had a significant influence on eggplant yield and quality in both the eggplant varieties studies. Furthermore, comparable results were obtained in both neutral and slightly alkaline soils. The nutrients slowly released from this fertilizer could effectively regulate the diffusion rate of nutrients such as different nitrogen forms (Hu *et al.*, 2008). As the release of nutrients is closely associated with eggplant growth, the use of SRF or CCF significantly improved eggplant yield quality as described by Suge *et al.* (2011).

Ghiasi *et al.* (2012) found that the rutin plays a role in safeguarding against oxidative degradation of hemogolobin and has, therefore, been commonly used in human medicine. Compared with CF and CCF, SRF significantly improved the rutin content of eggplant in this study. Solanine, another secondary eggplant metabolite, occurs at high levels in eggplant fruit. A moderate amount of solanine had positive effects on human health, but too much solanine can negatively affect the taste and flavor of eggplant and can even be poisonous (Lu *et al.*, 2010; Ji and Gao, 2012). SRF increased the solanine content in Zhuqie eggplants with low solanine levels and decreased the solanine content in Heisheng eggplant with high solanine levels. The coordinated effects of SRF with multiple N forms could improve the dietary benefits and increase the taste and flavor of eggplant. The balancing effect of the SRF on eggplant solanine levels may be associated with the presence of different nitrogen forms because solanine is a kind of alkaloids that secondary metabolic products containing nitrogen (Xi, 2005). Anthocyanins is an important natural pigment in eggplant that acts a free radical scavenger and antioxidant and functions in anti-aging, improving immunity, preventing cardiovascular disease, and liver protection, these health benefits have led to a greater interest in anthocyanins for human consumption levels (Ravanfar *et al.*, 2015; Linac *et al.*, 2016; Zhou *et al.*, 2018), because of the coordination and balancing effect of SRF with multiple nitrogen forms.

A previous study has indicated that application of SRF, especially in combination with organic manure, had more pronounced effects when compared with a pure CF application model (Guan *et al.*, 2010). Based on soil microbiota, the microbial community composition and variability were affected by the nutrient status of the fertilizer, soil pH, and organic matter. Moreover, the soil microbiota in this research also reacted differently to Heisheng and Zhuqie eggplant varieties. In this study, bacteria, actinomycetes, and fungi polulations with SRF treatment were the highest in neutral soil growing Heisheng eggplants, with SRF treatment resulting in significantly higher polulations of bacteria and fungi than CF treatment. SRF treatment resulted in significantly higher fungi polulations in neutral soil growing Zhuqie eggplants than CF and CCF treatment. In slightly alkaline soil planted with Heisheng eggplants, soil bacteria and fungi polulations were significantly higher with SRF than with CCF treatment. SRF treatment resulted in significantly higher soil fungi levels than CF and CCF treatment in slight alkaline soil planted Zhuqie eggplant. Taken together, this indicates that the cultivation of different crops affects soil microorganisms, consistent with the results observed by Sui *et al.* (2013).

Conclusion

SRF could slowly release different nitrogen forms and was rich in organic matter, thus effectively promoted eggplant growth and improving eggplant quality, especially the levels of rutin, solanine, and anthocyanins. Eggplant rutin levels were higher with SRF. Owing to the even nature of the nitrogen supply, SRF increased the solanine content of Zhuqie eggplant, which typically contained low levels of solanines, and decreased the solanine content of Heisheng eggplant Furthermore, according to the correlation analyses, yield in Heisheng eggplant was positively correlated with solanine levels, while yield in Zhuqie eggplant was positively correlated with soluble sugar and chlorophyll levels.

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