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Study on the Effect of Sheep Manure and Chemical Fertilizer on Growth and Fruit Quality of Grape

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Abstract: *In this paper,5 years old "Kyoho" grape were taken as research object to study the effect of sheep manure and chemical fertilizer on growth and fruit quality of grape using different sheep manure, urea and diammonium phosphate orthogonal design. The results show that different sheep manure and chemical fertilizer combination had significant effects on grape branches length and diameter, internode length, fruit length, fruit diameter and other growth indexes and grape seed weight, soluble solids, soluble sugar content and titratable acid content and sugar acid fruit quality index were also significant different. A comprehensive analysis and evaluation of the indexes of grape growth and grape quality demonstrated that the optima sheep manure and chemical fertilizer combination for grape cultivation were in the order: the combination with Sheep (60t/ hm2) + urea (0.4t/ hm2) + diammonium phosphate (0.5t/ hm2), sheep (40t/ hm2) + urea (0.4t/ hm2) + diammonium phosphate (0.5t/ hm2) and sheep (60t/ hm2) + urea (0.4t/ hm2) + diammonium phosphate (0.4t/ hm2)*

Keywords: *Sheep manure; chemical fertilizer; grape; growth; fruit quality*

1. INTRODUCTION

Vitis vinifera grape is a woody vine of the Vitis of the Vitaceae, and it originated in Western Asia. Grape is a combination of edible, medicinal and processing. Now it is widely cultivated in China. With the improvement of people's living standards, improving the conditions of grape cultivation to improve the yield and quality of grape is an important part of grape cultivation [1]. Among them, soil fertilization mode is one of the most important methods, and the improvement of soil fertilization is the most important part of grape cultivation. Chemical fertilizers provide essential trace elements for plant growth, such as nitrogen, phosphorus and potassium, but they release rapidly, can not meet the needs of grapes throughout the growth period, and excessive use is easy to cause sudden solidification and soil microbial flora destruction; while plant materials and organic fertilizer fermented from animal feces have slow release rate and complete fertilizer efficiency. It can improve soil nutrient utilization, and enhance tree vigor, photosynthetic efficiency of high plants and improve plant growth [2].

Domestic scholars mostly focused on the effects of organic manure on grape growth and fruit quality. For example, Gao Yingjie [3] studied the effects of pig manure, cow manure and biogas residue on grape yield and quality; Wang Xiaodi[4] studied the effects of green-source organic fertilizer, chicken manure, sheep manure and cattle manure on the growth of potted grapes. Zhou Xing [5] studied the effects of bio-organic fertilizer, humic acid organic fertilizer and total nutrient organic fertilizer on the growth and fruit quality of wine grape, but there were few reports on the effects of combined application of organic fertilizer and chemical fertilizer on grape. Xu Fengting[6] studied the effects of combined application of organic fertilizer (sesame cake fertilizer, fermented chicken manure) and chemical fertilizer (potassium sulfate, urea and diammonium phosphate) on the growth and fruit quality of "Giant Rose" grape. Tian Yihua[7] studied the effects of different amounts of cow manure organic fertilizer on growth and fruit quality of grape. Tang Xiaoning[8] studied the effects of organic ecological fertilizer and potash fertilizer on grape quality. In grape cultivation, because of the different ratio of organic fertilizer and chemical fertilizer, the fertilizer efficiency and release rate of various elements of organic fertilizer and chemical fertilizer will be different, thus affecting the growth of grapes and fruit quality. In this paper, the effects of different ratios of sheep manure, urea and

diammonium phosphate on the growth and fruit quality of grape were studied, to provide technical reference for the rational utilization of sheep manure in grape cultivation.

2. MATERIALS AND METHODS

2.1. Survey of Research Area

The study area is located in Taizhou City, Jiangsu Province（32°21′N，119°58′E）, with an altitude of 918.7m. It's located in the alluvial plain of the Yangtze River Delta and belongs to the subtropical marine climate zone. The annual average temperature is 17.4℃, the annual rainfall is 1281 mm, the annual frost-free period is 220 days, the average sunshine is 225.8 hours, the annual average relative humidity is 79%, and easterly winds prevail throughout the year, and the Soil types are mainly sandy soil with low fertility but good tillage. The organic matter in the soil is above 10.0 g/kg, the available nitrogen is 142.70 mg/kg, the total nitrogen is 1.785 g/kg, the alkali-hydrolyzed nitrogen is 148.5 mg/kg, the available phosphorus is 4.5 mg/kg, and the available potassium is 57 mg/kg.

2.2. Experimental Design

The experimental materials were 5-year-old "Jufeng" grape (row spacing is 1.5 m×3.0 m), the fruit yield per plant was 100-150, and The area of vineyard with combined application of fertilizer and sheep manure is 6670 ㎡, and 2250 plants/ha were planted. We adopt random arrangement design, and the top dressing and pest control adopted are routine methods.

Mix the fermented thoroughly-decomposed sheep manure (organic matter 24% - 27%, nitrogen 0.7% - 0.8%, phosphorus 0.45% - 0.6%, potassium 0.4% - 0.5%) with urea (nitrogen 15% - 24%) and diammonium phosphate (phosphorus 15% - 42%) to be as basal fertilizer (see table 1). Those without basal fertilizer were set as CK. Each treatment was repeated three times. The area of the small zone is 6㎡, and there are 28 zones.. The management method adopted for vineyard is routine management method.

Table1. *Proportioning and application amount of sheep manure and chemical fertilizer*

No	matrix composition and proportion(v/v)
CK	
M1	Sheep manure（20t/ ha）+ urea（0.2t/ ha）+ diammonium phosphate（0.4t/ ha）
M2	Sheep manure（40t/ ha）+ urea（0.2t/ ha）+ diammonium phosphate（0.4t/ ha）
M3	Sheep manure（60t/ ha）+ urea（0.2t/ ha）+ diammonium phosphate（0.4t/ ha）
M4	Sheep manure（20t/ ha）+ urea（0.2t/ ha）+ diammonium phosphate（0.4t/ ha）
M5	Sheep manure（20t/ ha）+ urea（0.2t/ ha）+ diammonium phosphate（0.5t/ ha）
M6	Sheep manure（40t/ ha）+ urea（0.4t/ ha）+ diammonium phosphate（0.4t/ ha）
M7	Sheep manure（40t/ ha）+ urea（0.4t/ ha）+ diammonium phosphate（0.5t/ ha）
M8	Sheep manure（60t/ ha）+ urea（0.4t/ ha）+ diammonium phosphate（0.4t/ ha）
M9	Sheep manure（60t/ ha）+ urea（0.4t/ ha）+ diammonium phosphate（0.5t/ ha）

2.3. Determination Method

Determination of growth characteristics: In July 2017, randomly measure 10 grapes growth characteristics, including: branch growth (measuring the length of branches between 6-8 nodes with a tape gauge); branch thickness (measuring the thickness of the fourth node with a Vernier caliper); fruit quality determination: On September 1st, harvest 50 grains from the fruit with the same maturation period. The fruit weight (1/1000 balance), fruit vertical and horizontal diameter (Vernier caliper), soluble solids (hand-held refractometer), titratable acid (NaOH neutralization titration method) and other indicators were measured, each treatment repeated three times, taking the average.

Fruit shape index = longitudinal diameter / transverse diameter (1)

Solid acid ratio = soluble solid / titratable acid (2)

2.4. Data Statistics Method

DPSv7.05 software was used for statistical analysis of the experimental data. For each processing, we use the LSD method to analyze the difference significance between data 5% and 1%.

3. Results and Analysis

3.1. Effects of Combined Application of Sheep Manure and Chemical Fertilizer on Grape Growth

The effects of different fertilization rates on grape growth were shown as Table 2. The effects of different fertilization rates on grape growth were different. The length and thickness of branches were the largest in T7 treatment, which are 106.61 cm and 1.15 mm respectively, followed by T9 treatment, which are 99.7017 cm and 1.10 mm respectively, and the differences between T7 treatment and other treatments were very significant ($p < 0.01$). The shortest branch length was T1, the value was 76.95 cm, only 1% higher than the control, and the difference with the contrast was not significant ($P > 0.05$), the thinnest branch diameter was T4, the value was 0.83 mm, only 4% higher than the contrast, and the difference with the contrast was not significant ($P < 0.05$).

From the point of view of internode length of grape under different fertilization rates, the order of effect of 9 different fertilization rates on internode length of grape was T9 > T8 > T7 > T6 > T3 > T4 > T5 > T2 > T1. Compared with CK, the length of main root increased by 45.56%, 44.82%, 38.71%, 26.15%, 23.40%, 13.77%, 10.45%, 7.86% and 4.34% respectively. Multiple comparisons showed that there was no significant difference between T9 and T8 ($P>0.05$), and the difference between the other treatments was very significant ($P < 0.01$).

Different ratios of sheep manure and chemical fertilizer have effects on the vertical and horizontal diameters of grape fruits (table 2). The largest vertical and horizontal diameters are T9, which are 3.84 cm and 3.47 cm respectively, followed by T8, whose values are 3.76 cm and 3.38 cm. The analysis of variance shows that the difference between the horizontal and vertical diameters is not significant ($P > 0.05$), and the longitudinal diameter difference is significant（$p < 0.05$）. The fruit shape indexes of treatment combinations of 9 kinds of sheep manure and chemical fertilizer ratio were between 1.109 and 1.147. The analysis of variance showed, except that the difference between T9 and CK is very significant ($P < 0.01$), the difference between other treatments and contrast and other treatments are not significant($P>0.05$), which indicated that different proportions of sheep manure and chemical fertilizer increased fruit grain but had little effect on fruit shape index.

Combining with the determination of grape growth index, the grape growth states of the of T9, T8, T7 and T4 combinations were good, and the grape growth states of the T5, T4, T2 and T1 combinations were relatively the worst.

Table2. *Effect of different amount of fertilizer on grape growth*

Treatment	Branch length/cm	Branch thickness/cm	Internode length/cm	Longitudinal diameter of fruit	Transverse diameter of fruit	Fruit shape index
CK	76.52±0.05hH	0.80±0.002gG	10.43±0.10iI	3.12±0.01gD	2.72±0.01fD	1.147±0.01aA
T_1	76.95±0.03hH	0.86±0.005fF	10.88±0.03hH	3.25±0.06fC	2.84±0.03eC	1.143±0.01aAB
T_2	77.13±0.02hH	0.90±0.003eE	11.25±0.06gG	3.33±0.05eC	2.93±0.01cdC	1.135±0.02abAB
T_3	79.37±0.12gG	0.97±0.010dD	12.87±0.05dD	3.55±0.04cB	3.15±0.02bB	1.126±0.02abAB
T_4	84.31±0.04fF	0.83±0.002fFG	11.86±0.04eE	3.23±0.05fC	2.85±0.02deC	1.132±0.02abAB
T_5	92.59±0.04dD	0.86±0.038fEF	11.52±0.08fF	3.32±0.02eC	2.94±0.04cC	1.128±0.02abAB
T_6	88.17±0.04eE	0.96±0.010dD	13.15±0.05cC	3.46±0.01dB	3.09±0.06bB	1.122±0.02abAB
T_7	106.61±1.42aA	1.15±0.025aA	14.46±0.01bB	3.52±0.08cdB	3.14±0.13bB	1.121±0.02abAB
T_8	97.63±1.53cC	1.02±0.015cC	15.10±0.02aA	3.76±0.04bA	3.38±0.05aA	1.112±0.02bAB
T_9	99.70±1.34bB	1.10±0.021bB	15.18±0.03aA	3.84±0.03aA	3.47±0.03aA	1.109±0.01bB

3.2. Effects of Combined Application of Sheep Manure and Chemical Fertilizer on Grape Fruit Quality

Different ratios of sheep manure and chemical fertilizer have different effects on grape fruit quality (table 3). The grape grain weight under T9 treatment increased the most, which is 13.49g, followed by T8, which is 13.39g, and the following order is T3 > T7 > T6 > T5 > T4 > T2 > T1 > CK, and the analysis of variance showed that the differences between the treatment and the contrast were extremely significant. ($P < 0.01$).

In the proportion test of sheep manure and chemical fertilizer, the maximum content of soluble solids in grape appeared in T9 treatment, which was 15.37 $mg*g^{-1}$, followed by T8, which was 15.23, which was 9.21% and 8.24% higher than that of the contrast, and the following order is T7 > T3 > T6 > T2 > T5 > T3 > T1. Compared with CK, the soluble solids increased by 7.31%, 6.86% and 8.24%, 6.18%, 4.71%, 2.70%, 1.63%, 1.01% respectively. Multiple comparisons showed that there was a significant difference among all the substrates ($P < 0.01$).

Table3. *Effect of different amount of fertilizer on fruit quality*

Treatment code	Firmness kg/cm^{-2}	soluble solid /%	Soluble sugar /%	titration acid /%	sugar-acid ratio	Vc
CK	12.05±0.011jJ	14.07±0.05jI	12.28±0.06iH	0.723±0.007aA	16.99±0.08hH	8.17±0.020iI
T_1	12.10±0.012iI	14.22±0.04iH	12.76±0.03hG	0.709±0.005bB	18.00±0.08gG	8.28±0.045hH
T_2	12.15±0.004hH	14.74±0.02fE	15.73±0.05bcB	0.654±0.004eE	24.07±0.13dD	8.33±0.015gG
T_3	13.13±0.004cC	15.04±0.03dC	14.88±0.01eD	0.608±0.004jH	24.49±0.13cC	8.69±0.015cC
T_4	12.24±0.028gG	14.30±0.02hG	13.28±0.05gF	0.694±0.002cC	19.12±0.11fF	8.46±0.015fF
T_5	12.29±0.009fF	14.45±0.03gF	14.50±0.06fE	0.672±0.004dD	21.58±0.15eE	8.27±0.006hH
T_6	12.36±0.027eE	14.94±0.03eD	15.48±0.03dC	0.637±0.005gF	24.31±0.15cdCD	8.54±0.021eE
T_7	12.44±0.025dD	15.10±0.04cC	15.70±0.02cB	0.645±0.002fEF	24.36±0.09cCD	8.62±0.025dD
T_8	13.39±0.023bB	15.23±0.04bB	16.87±0.08aA	0.626±0.005hG	26.97±0.33aA	8.78±0.015bB
T_9	13.49±0.024aA	15.37±0.02aA	15.78±0.02bB	0.617±0.001iGH	25.60±0.06bB	8.93±0.020aA

Note: *use LSD test. Lowercase letters represent 0.05 difference level. Capitals represent 0.01 difference level.*

The results of determination of glucose soluble sugar and titratable acid content under different ratios of sheep manure and chemical fertilizer showed that the combined application of sheep manure and chemical fertilizer could increase the content of glucose soluble sugar. The maximum value of each treatment appeared in T8 treatment, which1 was 16.87 mg/g, followed by T9, which was 15.78, and they both increased by 37.40% and 28.52% compared with the contrast. The following order was T2 > T7 > T6 > T3 > T5 > T4 > T1. Compared with CK, the soluble sugar increased by 28.12%, 27.85%, 26.03%, 21.17%, 18.05%, 8.11% and 3.93% respectively. Multiple comparisons showed that the differences between the substrates were very significant ($p < 0.01$). Compared with CK, the titratable acid content of grape decreased by 15.95%, 17.26%, 13.46%, 11.94%, 10.84%, 9.59%, 7.10%, 3.97% and 1.94% respectively. Multiple comparisons showed that the differences between T3 and T9, T2 and T7 treatments were significant ($p < 0.05$), and the difference between other treatments and the contrast was extremely significant ($p < 0.01$); the treatment of 9 kinds of sheep manure and chemical fertilizer ratios could increase the sugar-acid ratio of the grape fruit, and the biggest increase of the sugar-acid ratio was T9, the value was 8.93, 9.30% higher than the contrast, the smallest increase was T5, the value was 8.27, only 1.26% higher than the contrast. Variance analysis showed that the difference was very significant with other treatments ($P < 0.01$).

4. DISCUSSION

Soil is the place of energy and material conversion in agricultural ecosystem. Water and nutrients needed for plant growth are absorbed from soil through plant roots. Therefore, the amount of nutrients in soil directly affects the growth of plants and fruit quality. Soil fertilization is an important way of nutrient supply in the soil, but long-term use of chemical fertilizers will cause a series of problems, such as soil hardening, soil microbial imbalance and soil trace element deficiency. Adding organic fertilizers to the soil can release organic acids to promote the dissolution of insoluble salts, thereby fertilizing the soil, forming humus and improving the soil, improving soil structure and increasing soil water retention, fertilizer retention and soil buffer capacity, and it also increases microbial activity and release effective components, thereby promoting the growth and development of grapes [13].

4.1. Effects of Combined Application of Sheep Manure and Chemical Fertilizer on Grape Growth

Organic fertilizer contains abundant organic nitrogen. When it is applied to soil, it can improve the nitrogen supply level of soil and increase the chlorophyll synthesis level of plant. At the same time, sheep manure can increase the carbon dioxide supply level between plant cells, thereby improving the photosynthesis ability of plant, thus promoting the growth of plant [14]. The study results of Zhou Xing showed that the fresh treetop length and fruit weight of grape with bio-organic fertilizer were significantly greater than those with conventional fertilization, and the chlorophyll content was significantly increased [15]. The study result of Li Jianjun[16] showed that applying organic manure and biogas slurry fertilizer at growth stage could obviously promote the growth of branch, leaf and fruit of Red Globe grape.

The results showed that the effects of combined application of sheep manure and chemical fertilizer on the grape branch length, branch thickness, internode length, fruit longitudinal diameter and fruit transverse diameter were significant. T7 treatment had the most obvious promoting effect on the length and thickness of branches; T9 treatment had the fastest increasing effect on internode length, fruit longitudinal diameter and fruit transverse diameter; the growth performance of branch length, branch thickness, internode length, fruit longitudinal diameter and fruit transverse diameter in T1 and T4 combination was poor, which might be due to the higher urea and diammonium phosphate and fewer sheep manure, which result in soil compaction and porosity decreased, and the activities of beneficial microorganisms in the soil weakened, thus affecting the absorption of nutrients, resulting in the poor growth of grape.

4.2. Effects of Combined Application of Sheep Manure and Chemical Fertilizer on Grape Fruit Quality

The content of soluble solids, the type and quantity of sugar and the ratio of sugar to acid in grape berries reflect the quality of grape fruits. The synthesis of these substances in grape fruits is a complex physiological and biochemical process, which is affected by many environmental factors [17]. Studies have shown that organic fertilizer can fertilize the vineyard soil, improve the site conditions for grape growth, promote the activities of soil beneficial microorganisms, improve soil nutrient supply, increase the growth of trees, improve the intrinsic quality of grapes[18]; GULIBIYA·KEYIMU[19] studied organic fertilizers and special grape fertilizers, indicating that organic fertilizer treatment increased grape grain weight, ear weight and grape yield. MIREJIHAN·ABUDUREMU[20] studied the effects of organic and inorganic compound fertilizers on the yield and quality of seedless grapes. The results showed that the 100-grain weight, aspect ratio, Vc, soluble sugar and sugar-acid ratio of grape were significantly increased. Tian Yihua's study showed that increasing organic fertilizer could improve photosynthetic efficiency, plant growth and fruit quality of Summer Black Grape.

5. CONCLUSION

In this study, the effects of combined application of sheep manure and chemical fertilizer on grape grain weight, soluble solids, soluble sugar content, titratable acid relative content and sugar-acid ratio were studied. The results showed that the content of soluble sugar was the highest in T8 treatment, and the fruit sugar acid ratio was the largest. The content of soluble solids was the highest in T9 treatment, and the titratable acid decreased the most. The grape grain weight, soluble solids, soluble sugar content, relative content of titratable acid and sugar-acid ratio were lower in both T1 and T2 treatments, which might be due to the higher urea and diammonium phosphate and fewer sheep

manure, which result in soil compaction and porosity decreased, and the activities of beneficial microorganisms in the soil weakened, thus affecting the absorption of nutrients, resulting in the decline of grape fruit quality.

After comprehensive analysis according to the determination results of the higher morphological indexes such as the length and thickness of grape branches and the physiological indexes such as soluble solids, the suitable combined application of sheep manure and chemical fertilizer for grape growth was selected. They were T9 treatment: sheep manure (60t/ha) + urea (0.4t/ha) + diammonium phosphate (0.5t/ha). Then T7 treatment: sheep manure (40t/ha) + urea (0.4t/ha) + diammonium phosphate (0.5t/ha). T8 treatment: sheep manure (60t/ha) + urea (0.4t/ha) + diammonium phosphate (0.4t/ha).

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