World Journal of Engineering and Technology, 2017, 5, 1-14
http://www.scirp.org/journal/wjet
ISSN Online: 2331-4249
ISSN Print: 2331-4222

Effects of Different Fertilization Treatments on Soil, Leaf Nutrient and Fruit Quality of *Citrus grandis* var. *longanyou**

Rongfei Li[1], Yaodong Chang[1], Tao Hu[2], Xueyou Jiang[2], Guolu Liang[1], Zhiming Lu[1], Youwen Yi[3], Qigao Guo[1#]

[1]College of Horticulture and Landscape Architecture, Southwest University, Beibei Chongqing 400716, China
[2]Guang'an District Agricultural Bureau, Guang'an Sichuan, 638500, China
[3]Guang'an Science and Technology Development and Training Center, Guang'an Sichuan, 638500, China
Email: #qgguo@126.com

How to cite this paper: Li, R.F., Chang, Y.D., Hu, T., Jiang, X.Y., Liang, G.L., Lu, Z.M., Yi, Y.W. and Guo, Q.G. (2017) Effects of Different Fertilization Treatments on Soil, Leaf Nutrient and Fruit Quality of *Citrus grandis* var. *longanyou*. *World Journal of Engineering and Technology*, **5**, 1-14.
https://doi.org/10.4236/wjet.2017.52B001

Received: March 7, 2017
Accepted: May 8, 2017
Published: May 11, 2017

Abstract

The five-year-old "Longanyou" trees were used as the experimental material to study the effects of different fertilization treatments. The nutrient contents in soil and leaves, fruit yield and quality were determined, and then the correlations were analyzed. The results showed that: 1) The soil nutrient contents of 0 - 20 cm depth were more than the 20 - 40 cm, and the trends of nutrient contents of the 0 - 20 cm soil layers were as follows: treatment 2 (T2) > treatment 3 (T3) > treatment 4 (T4) > treatment 1(T1) > control (CK). However, the 20 - 40 cm depth had not significant difference between different treatments, but T2, T4 and T3 were higher than T1 and CK. It indicated that the soil effective nutrient content increased in T2 and T3. 2) Compared with the control, the content of K and B elements was improved obviously in leaves with the increase of organic manure application. The contents of P (1.60 $g \cdot kg^{-1}$), B (26.00 $mg \cdot kg^{-1}$) and Mg (1.18 $g \cdot kg^{-1}$) were the highest, and other nutrients contents were also higher, indicating that T2 could effectively improve the leaves' nutrient contents. 3) The fruit yield per plant was the highest in T2 (95.40 kg $plant^{-1}$), and the single fruit weight, total sugar, sugar and acid ratio, vitamin C were also the highest, but titratable acid was lower. It indicated that T2 effectively improved fruit yield and quality. 4) There were positive correlations between multiple factors of soil nutrients and the quality index, such as fruit peel thickness, total sugar, solid acid ratio, sugar and acid ratio, Vc content and single yield etc. There was significant correlation between K, B, Zn, Fe contents and fruit yield and quality index, and the contents of B, Zn and Fe in leaves were significantly correlated with soil nutrient, indicating that the contents of K, B, Zn, Fe in soil and leaf were closely related to fruit yield and quality. In sum, the T2 was the best fertilization scheme for orchard management practice of "*Longanyou*".

*Funded projects: National science & technology support projects (2014BAD16B0102-I).

Keywords

Citrus grandis var. *longanyou*, Fertilization, Soil Nutrient, Leaf Nutrient, Fruit Quality

1. Introduction

Soil is a fundamental factor of fruit production, and fruit trees usually absorb water and nutrients by their roots, therefore fertilizers are traditionally applied into the soil. The soil nutrient elements will directly affect on growth, fruit set, retention, yield and quality improvement and the sustainable production of orchard [1]. So the efficient use of fertilizers to increase fruit yield is an important goal in all agricultural manipulation systems. However, soil fertilization also causes environmental contamination for nutrients leaching into ground water [2], thus improving soil physical and chemical properties by the rational fertilization tillage is the efficient way to reduce the environmental pollution and increase the capacity of soil fixation and tree absorption. Moreover, plant leaves extremely sensitive respond to the soil mineral nutrient, and to a certain extent, the content of mineral nutrient in leaves can reflect the nutrient status of the trees and soil [3]. Therefore, soil and leaf nutrient have a significant effect on fruit yield and quality, and especially, the index of the content of leaf nutrient can respond to the nutritional requirements more accurately for optimum fruit yield [4]. That is, soil nutrient provides the necessary mineral elements for plant growth, and different fertilization treatments influence on the level of leaf nutrients [5], and mineral nutrition is the material basis of fruit tree growth and development, yield formation and fruit quality improvement, so the leaf nutrient is closely related to fruit quality [6] [7]. The correlation between the soil and leaf nutrient content and fruit yield and quality, was mainly studied on apple [8], pear [9], navel orange [6] and so on, but there has not yet reached a uniform conclusion about the correlation. Therefore, continuing to investigate the correlation, especially focusing on improving soil physical and chemical properties, nutrition level of tree and fruit yield and quality in the different fertilization treatments, is the long-term and beneficial way to fruit production.

Citrus grandis var. *longanyou* is a special fruit tree in Guang'an City, Sichuan Province. It was approved as a national geographical indication protection product in 2008 [10] [11]. However, abandoned cultivation is widespread in farmers' orchard management practices; especially in hilly land zone of Guang'an, the soil fertility conditions are different and generally undesirable, which result in low nutrient flowing in tree and consequently cultivar reproductive potentials do not become evident, and eventually lead to low yield, poor quality and poor economic value. The main aim of this study was to investigate the effects of different fertilization treatments on nutrient and fruit quality of "Longanyou", and then analyze the correlation, which will directly provide the beneficial reference for "Longanyou" fertilization management.

2. Materials and Methods

2.1. Plant Growth Environment

The experiment was proceed in Long'an, a township of Guang'an City during 2015-2016. The average elevation is 320 m, the annual average temperature is 17.58˚C. The average temperature is 4˚C in January, it is the coldest in a year. The average temperature is 34˚C in July, it is the hottest in a year. Frost-free has 306 - 328 d, the average annual rainfall of 1240 mm, the average annual sunshine hours of 1213 h. The testing area which is a typical southwest hilly region of high temperature and rainy climate, and soil fertility is low.

2.2. Experimental Design

The experiments were conducted in a 5-year-old plantation, with a 5.0 m × 5.3 m planting spacing. In the experiment, 5 fertilizer schemes were set up. The treatments were as follows: treatment 1 (T1: nitrogen 315 kg, phosphorus 173.25 kg, potassium 306 kg and organic matter 1575 kg were used per hectare), treatment 2 (T2: nitrogen 450 kg, phosphorus 247.5 kg, potassium 438 kg and organic matter 2250 kg were used in per hectare), treatment 3 (T3: all applied organic fertilizer, 3000 kg in per hectare), treatment 4 (T4: total soluble fertilizer was reduced with fertilization times increasing, nitrogen 202.8 kg, phosphorus 252.3 kg and potassium 268.95 kg were used in per hectare), and control (CK: the trees that abandoned by farmers in the production). The applying fertilizer method: open hole (0.4 m × 0.4 m). The fertilization time is divided into: Basal fertilizer (November 10-15, 2015), Sprout fertilizer (February 25-30, 2016), and strong fruit fertilizer (May 25-30, 2016). One tree as a plot, each treatment has 15 trees.

2.3. Methods

2.3.1. Soil Sampling and Nutrient Elements Determination

Soil sampling and determination were done following the protocols of as described by Tang *et al.* [12] and Zhang *et al.* [13]. In each treatment 15 - 20 sampling tree were chosen by "S" curve. A 200 g soil samples was collected under each tree crown at a 0 - 20 cm and 20 - 40 cm depth respectively, then mixed soil samples collected from 15 - 20 sampling sites and a 500 g soil was selected using a diagonal sampling method.

Soil chemical properties were analyzed by traditional analytical methods as described by Bao [14]. pH of soil was determined by potentiometrically in 1:1 soil/ distilled water suspensions after shaking. Organic matter content was determined by $K_2Cr_2O_7$ oxidation external heating method. Total nitrogen (N) was determined by Semi-microkine Kjeldahl method, and alkaline N was determined by alkali hydrolysis diffusion method. Total phosphorus (P) was determined by $HCIO_4$-H_2SO_4 decomposition and Molybdenum antimony anti-colorimetric method. Total potassium (K) content was determined by HF-$HClO_4$ decomposition and atomic absorption method. The available P content was extracted by

$NaHCO_3$ solution, Colorimetric method. The available K content determination uses ammonium acetate solution extraction, atomic absorption method [15]. The effective copper (Cu), iron (Fe), manganese (Mn), Zinc (Zn) and exchangeable calcium (Ca) and magnesium (Mg) were determined by atomic absorption spectrophotometer. The effective boron (B) was determined by boiling water extraction-ICP-AES method [12].

2.3.2. Leaf Sampling and Nutrient Elements Determination

Leaves samples were collected from four points of the half height canopy of the test trees, which located in north, south, east and west of the test trees. 15 healthy and mature leaves were respectively collected from the vegetative branches and bearing branches of each testing tree which have the same growth vigor, the samples were transported to the lab on ice in a cooler and stored in an icebox for elements determination. Their elements were determined following the protocols of as described by Zhuang *et al.* [16] and Diao [17]. The N content was analyzed by Kay type nitrogen method. The P content was determined by molybdenum antimony anti-color method. The contents of K, Mg, Fe and Zn were determined by atomic absorption spectrometry. The content of B was determined by dry ashing-imine colorimetric method.

2.3.3. Fruit Sampling and Yield, Quality Determination

Fruit yield of per plant and per hectare in different fertilization treatments were tested. And then respectively one fruit located in north, south, east, west and center of upper and lower canopy of each test tree were collected and transported to the lab. Their appearance quality was measured after washing and drying, fruit juice used as internal quality sample. Repeat 5 times.

The Total Soluble Solids (TSS), Titratable Acidity (TA), Vitamin C (Vc content), Total Sugar, Sucrose, Invert sugar and Reducing Sugar were measured according to national standard GB8210-87. And calculating

$$\text{The ratio of solid and acid} = \text{soluble solids/titratable acid}, \tag{1}$$

$$\text{Sugar and acid ratio} = \text{total sugar/titratable acid}. \tag{2}$$

Per fruit weight, fruit thickness, vertical diameter and transverse diameter of fruit were measured with a vermier caliper, and calculating

$$\text{The fruit shape index} = \text{vertical diameter/transverse diameter}. \tag{3}$$

2.4. Statistical Analysis

Data sorting with Excel, SPSS13.0 software was used for analysis of variance and correlation analysis.

3. Results

3.1. Soil Nutrient Contents

The effects of different fertilization treatments on the nutrient contents in different soil layers were inconsistent. Among them, the trend of nutrient content of 0 - 20 cm soil layers were as follows: T2 > T3 > T4 > T1 > CK. The treatments of 20

- 40 cm soil layers were not significant, but T2, T4 and T3 were higher than those of T1 and CK. The different soil layers in same treatment showed: 0 - 20 cm > 20 - 40 cm soil layer (**Table 1**). But the contents of total N, alkaline N, available Fe,Vailable Mn and Exchangeable Mg were the highest in 0-20cm soil layer of T3, the contents were: 1.49 $mg \cdot kg^{-1}$, 138.00 $mg \cdot kg^{-1}$, 56.74 $mg \cdot kg^{-1}$, 6.75 $mg \cdot kg^{-1}$, 0.62 $mg \cdot kg^{-1}$, respectively. And the organic matter content of T3 (17.2 $g \cdot kg^{-1}$) was significantly higher than that of T4, T1, CK and 20 - 40 cm soil layer of T2. Compared with the control, the organic matter, total P, alkaline N, available P, available K, available B, available Cu, available Zn and available Mn were significantly improved in 0 - 20 cm soil layer. Then T2 and T3 were beneficial to promote soil fertility levels.

3.2. Leaf Nutrient Contents

The different fertilization treatments had significant differences in the leaves' nutrient content of "Longanyou" (**Table 2**). Compared with the control, the

Table 1. The soil nutrient contents of different fertilization treatments in Longanyou orchard.

Sample (cm)	CK		T1		T2		T3		T4	
	0 - 20	20 - 40	0 - 20	20 - 40	0 - 20	20 - 40	0 - 20	20 - 40	0 - 20	20 - 40
pH	5.2 ± 0.03b	5.7 ± 0.03a	4.7 ± 0.02d	4.8 ± 0.02c	5.2 ± 0.04b	4.1 ± 0.03e	5.7 ± 0.03a	4.8 ± 0.02c	5.7 ± 0.02a	5.2 ± 0.02b
Organic mater ($g \cdot kg^{-1}$)	9.81 ± 0.11g	9.30 ± 0.03h	16.90 ± 0.1c	12.50 ± 0.05f	19.50 ± 0.15a	12.60 ± 0.07f	17.20 ± 0.15b	17.20 ± 0.04b	16.00 ± 0.10e	16.60 ± 0.10d
N ($g \cdot kg^{-1}$)	1.22 ± 0.02e	0.82 ± 0.01f	1.45 ± 0.03b	1.25 ± 0.03e	1.52 ± 0.03a	1.38 ± 0.03c	1.49 ± 0.01	1.30 ± 0.03d	1.52 ± 0.04a	1.50 ± 0.01a
P ($g \cdot kg^{-1}1$)	0.64 ± 0.01g	0.58 ± 0.02h	0.92 ± 0.01d	0.91 ± 0.01d	1.59 ± 0.04a	0.79 ± 0.03f	1.47 ± 0.01b	1.07 ± 0.02c	0.85 ± 0.02e	0.83 ± 0.01e
K ($g \cdot kg^{-1}$)	23.40 ± 0.50c	23.40 ± 0.40c	25.30 ± 1.01ab	25.10 ± 0.80b	26.70 ± 0.70a	25.00 ± 0.50b	25.70 ± 0.50c	25.10 ± 0.40c	26.00 ± 0.7ab	25.60 ± 1.1ab
Alkaline N ($mg \cdot kg^{-1}$)	82.9 ± 2.3g	71.6 ± 1.6h	119.0 ± 2.0bc	117.0 ± 1.5cd	122.0 ± 2.5b	117.0 ± 3.0cd	138.0 ± 3.0a	113.0 ± 1.9de	109.1 ± 2.0ef	107.3 ± 2.8f
Available P ($mg \cdot kg^{-1}$)	17.9 ± 0.2h	12.6 ± 0.3i	70.3 ± 1.4d	41.4 ± 1.7g	143.4 ± 3.5a	64.8 ± 1.9e	92.4 ± 2.8b	80.7 ± 3.1c	51.7 ± 2.4f	38.6 ± 1.7g
Rapidly available K ($mg \cdot kg^{-1}$)	124.0 ± 4.0h	98.0 ± 2.4i	324.0 ± 3.8e	303.4 ± 3.0f	586.0 ± 3.5a	289.6 ± 2.2g	420.6 ± 2.8c	351.6 ± 3.5d	443.5 ± 22.3b	299.9 ± 3.1fg
Available B ($mg \cdot kg^{-1}$)	0.43 ± 0.02e	0.42 ± 0.01e	0.60 ± 0.01b	0.37 ± 0.02f	0.78 ± 0.01a	0.57 ± 0.02c	0.23 ± 0.01h	0.30 ± 0.01g	0.78 ± 0.01a	0.54 ± 0.01d
Available Cu ($mg \cdot kg^{-1}$)	1.86 ± 0.06e	0.90 ± 0.02f	4.78 ± 0.10c	3.69 ± 0.07d	15.72 ± 0.28a	3.67 ± 0.06d	7.86 ± 0.41b	4.57 ± 0.14c	4.75 ± 0.01c	3.53 ± 0.01d
Available Zn ($mg \cdot kg^{-1}$)	3.04 ± 0.15f	1.66 ± 0.08g	5.52 ± 0.17b	4.37 ± 0.17e	7.72 ± 0.21a	5.00 ± 0.14c	5.55 ± 0.14b	4.66 ± 0.18d	5.67 ± 0.16b	4.72 ± 0.10d
Available Fe ($mg \cdot kg^{-1}$)	38.13 ± 1.50d	37.30 ± 1.00e	43.78 ± 1.30ef	38.95 ± 1.10f	52.67 ± 1.40b	51.09 ± 0.90b	56.74 ± 1.30a	51.09 ± 1.20b	51.09 ± 1.10b	49.43 ± 1.70c
Available Mn ($mg \cdot kg^{-1}$)	2.97 ± 0.17c	2.12 ± 0.12f	2.91 ± 0.11c	2.61 ± 0.11de	4.53 ± 0.13b	2.70 ± 0.10d	6.75 ± 0.15a	4.69 ± 0.09b	2.61 ± 0.11de	2.42 ± 0.12e
Exchangeable Ca ($g \cdot kg^{-1}$)	8.16 ± 0.20c	7.46 ± 0.26de	7.66 ± 0.16d	7.45 ± 0.15de	7.03 ± 0.13e	6.13 ± 0.13f	7.24 ± 0.14de	6.21 ± 0.11f	10.70 ± 0.40a	10.10 ± 0.50b
Exchangeable Mg ($g \cdot kg^{-1}$)	0.35 ± 0.01g	0.34 ± 0.02g	0.45 ± 0.02d	0.40 ± 0.01e	0.47 ± 0.02d	0.39 ± 0.02ef	0.62 ± 0.02a	0.53 ± 0.01b	0.50 ± 0.02c	0.36 ± 0.01fg

Note: Values within a column followed by the different lowercase letter are significantly different at 0.05 level.

Table 2. The leaves' nutrient content of different fertilization treatments in Longanyou.

Treatment	Branch type	N ($g \cdot kg^{-1}$)	P ($g \cdot kg^{-1}$)	K ($g \cdot kg^{-1}$)	B ($mg \cdot kg^{-1}$)	Mg ($g \cdot kg^{-1}$)	Zn ($mg \cdot kg^{-1}$)	Fe ($mg \cdot kg^{-1}$)
CK	Bearing branch	24.00 ± 0.10d	1.13 ± 0.02de	8.33 ± 0.07f	11.47 ± 0.07e	0.85 ± 0.01ef	8.39 ± 0.07f	72.80 ± 0.10d
	Vegetative branch	24.20 ± 0.10d	1.16 ± 0.04d	10.80 ± 0.05d	11.77 ± 0.53e	0.96 ± 0.01c	9.20 ± 0.03e	69.70 ± 0.10ef
T1	Bearing branch	23.00 ± 0.44e	1.03 ± 0.03f	10.06 ± 0.12e	16.93 ± 0.75d	0.88 ± 0.03de	8.40 ± 0.24f	71.27 ± 1.06de
	Vegetative branch	27.00 ± 0.51a	1.32 ± 0.08c	10.63 ± 0.15de	17.20 ± 0.26d	1.10 ± 0.02b	10.20 ± 0.34bc	69.13 ± 1.14f
T2	Bearing branch	23.83 ± 0.80d	1.29 ± 0.06c	11.63 ± 0.30bc	25.40 ± 1.65a	0.80 ± 0.02f	9.75 ± 0.19cd	95.80 ± 2.00a
	Vegetative branch	27.97 ± 0.20b	1.60 ± 0.04a	12.23 ± 0.76ab	26.00 ± 0.36a	1.18 ± 0.05a	10.31 ± 0.42b	79.37 ± 1.02c
T3	Bearing branch	23.60 ± 0.30de	1.15 ± 0.01d	10.03 ± 0.08e	18.70 ± 0.20c	0.94 ± 0.03c	11.25 ± 0.05a	69.25 ± 0.95ef
	Vegetative branch	25.95 ± 0.15c	1.26 ± 0.02c	11.44 ± 0.24c	20.20 ± 0.20b	1.11 ± 0.03b	11.30 ± 0.40a	69.85 ± 0.75ef
T4	Bearing branch	26.60 ± 0.46bc	1.08 ± 0.03ef	12.13 ± 0.61ab	18.73 ± 0.31c	0.93 ± 0.04cd	9.41 ± 0.25de	81.27 ± 0.81b
	Vegetative branch	28.10 ± 0.53a	1.48 ± 0.02b	12.57 ± 0.38a	19.70 ± 0.44bc	1.11 ± 0.04b	10.27 ± 0.31b	69.87 ± 1.45ef

Note: Values within a column followed by the different lowercase letter are significantly different at 0.05 level. The same as followed.

content of K and B increased significantly with the increase of organic manure application, but had little effect on the content of P in leaf. The Zn content in the vegetative branches and bearing branches of T3 were higher. The content of P (1.60 $g \cdot kg^{-1}$), B (26.00 $mg \cdot kg^{-1}$) and Mg (1.18 $g \cdot kg^{-1}$) were the highest, and N, K, Zn and Fe content were relatively higher than others. While the nutrient contents of control leaves' were the lowest. The nutrient contents of different branches were different, the trend was vegetative branches higher than bearing branches, but the Fe content was the opposite. Compared comprehensively, the nutrient contents of leaves in T2 were higher than others.

3.3. Fruit Yield and Quality

According to **Figure 1(a)**, the yield per plant of T2 was the highest, 95.40 kg $plant^{-1}$, followed by T4, and the lowest was control, only 14.13 kg $plant^{-1}$. The fruit number per tree of T3 was the highest, followed by T2, and the lowest was the control (**Figure 1(b)**).

According to the comparison of the appearance quality of the fruit (**Table 3**), There were significant difference in the average fruit weight among the treatments. The fruit weight of the upper layer was the largest (1736.70 g) in T2, and it was 2.01 and 2.58 times of the upper and lower in control, respectively. Then followed by T4 upper layer (1662.2 g). Moreover, the fruit peel of T2 and T4 were thicker than T1, T3 and CK, which indicating that T2 and T4 can improve the ability of anti-fungal invasion and enhance the storability, combining with the fruit weight, we suggested that T2 and T4 were benefit for increasing the production and commodity value of Longanyou.

It was observed in **Table 4** that the internal quality including the converting sugar, the total sugar, the ratio of sugar to acid, and the content of Vc were the highest in the upper layer fruits of the T2, followed by the upper layer fruits of T3. Titratable acid of the upper layer fruits were lower in T2 and T3, it was 0.66% and 067% respectively. Soluble solids (12.70%), solid acid ratio (19.01),

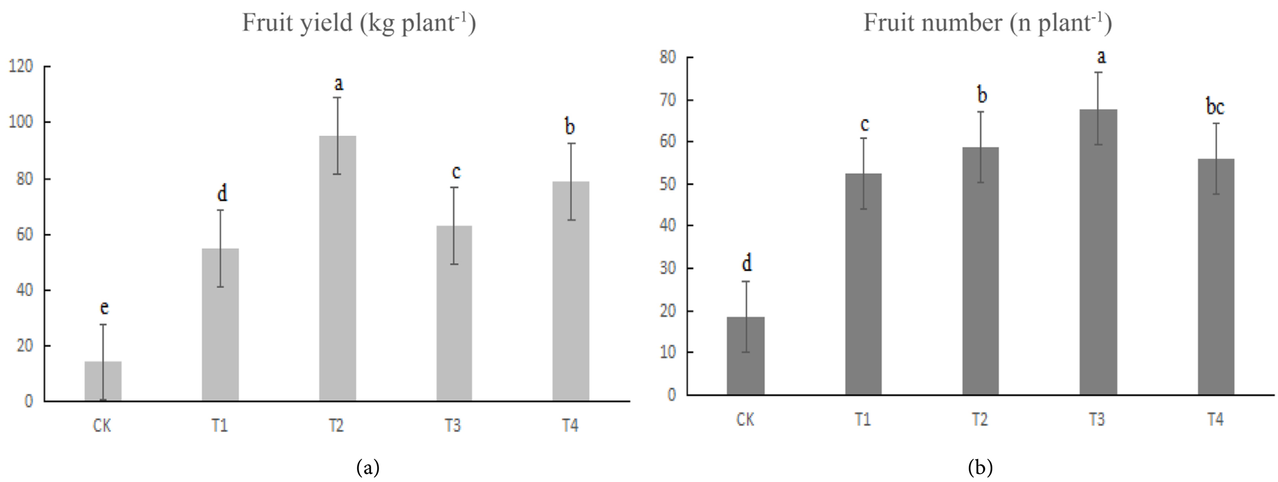

Figure 1. Fruit yield (a) and number (b) in different fertilization treatments.

Table 3. The fruits appearance quality of different fertilization treatments in Longanyou.

Treatment	Location	Fruit weight (g)	Vertical diameter (mm)	Transect diameter (mm)	Fruit shape index	Fruit peel thickness (mm)	Juice rate (%)	Edible rate (%)
CK	Upper	862.50 ± 2.50i	130.07 ± 1.15f	133.00 ± 2.00ef	0.98 ± 0.01h	14.00 ± 0.20e	46.31 ± 0.30a	49.85 ± 1.05a
	Lower	673.30 ± 3.30j	116.80 ± 2.20g	119.10 ± 2.10g	0.98 ± 0.00h	10.90 ± 0.20f	46.71 ± 0.51a	50.36 ± 1.16a
T1	Upper	1057.80 ± 7.50e	150.10 ± 2.10e	136.60 ± 2.20e	1.10 ± 0.00e	15.40 ± 1.10d	44.46 ± 0.26b	49.40 ± 1.40a
	Lower	1030.30 ± 7.00f	155.90 ± 2.30d	149.60 ± 2.60c	1.04 ± 0.00g	14.00 ± 0.40e	44.07 ± 0.19b	46.72 ± 0.72b
T2	Upper	1736.70 ± 6.70a	189.40 ± 2.40b	172.80 ± 2.80a	1.10 ± 0.00e	18.50 ± 1.00ab	35.83 ± 0.80g	43.52 ± 1.02d
	Lower	1508.07 ± 5.05c	180.90 ± 2.10c	143.30 ± 2.00d	1.26 ± 0.00a	17.40 ± 0.40bc	41.51 ± 1.00c	45.94 ± 0.94bc
T3	Upper	982.50 ± 2.50g	154.90 ± 1.90d	130.80 ± 2.20f	1.18 ± 0.01c	16.30 ± 0.30cd	38.11 ± 0.11f	46.71 ± 0.71b
	Lower	880.00 ± 5.00h	155.10 ± 2.10d	135.30 ± 2.30e	1.15 ± 0.00d	16.10 ± 0.20cd	39.57 ± 0.57e	46.68 ± 1.08b
T4	Upper	1662.20 ± 3.20b	205.80 ± 3.10a	168.10 ± 2.10b	1.22 ± 0.00b	19.50 ± 1.50a	40.71 ± 0.70cd	44.16 ± 1.10cd
	Lower	1161.00 ± 6.00d	155.50 ± 1.50d	142.70 ± 1.70d	1.09 ± 0.00f	17.00 ± 0.80c	39.79 ± 0.79de	45.28 ± 1.00bcd

Table 4. The fruit internal quality of different fertilization treatments in Longanyou.

Treatment	Location	TSS (%)	TA (%)	TSS/acid	Reducing sugar (%)	Converting sugar (%)	Sucrose (%)	Total sugar (%)	Sugar/acid	Vc (mg·kg^{-1})
CK	Upper	10.30 ± 0.30e	0.79 ± 0.01b	13.07 ± 0.47d	3.23 ± 0.13b	7.26 ± 0.16f	3.62 ± 0.22d	7.07 ± 0.07f	8.97 ± 0.16e	53.89 ± 1.34b
	Lower	9.30 ± 0.10f	0.86 ± 0.00a	10.82 ± 0.14e	3.41 ± 0.11b	6.81 ± 0.11g	2.41 ± 0.10e	6.68 ± 0.10g	7.78 ± 0.10f	50.10 ± 1.05c
T1	Upper	10.60 ± 0.30de	0.69 ± 0.00de	15.28 ± 0.45bc	3.75 ± 0.15ab	8.07 ± 0.07d	4.56 ± 0.11bc	7.96 ± 0.16cd	11.47 ± 0.20c	54.42 ± 1.09b
	Lower	10.30 ± 0.30e	0.78 ± 0.04bc	13.31 ± 1.00d	3.71 ± 0.11ab	8.20 ± 0.10cd	4.40 ± 0.14c	7.83 ± 0.13d	10.11 ± 0.34d	52.43 ± 1.26bc
T2	Upper	12.00 ± 0.50b	0.66 ± 0.01f	18.29 ± 0.81a	4.51 ± 0.11ab	9.89 ± 0.19a	4.60 ± 0.10bc	9.62 ± 0.22a	14.66 ± 0.34a	59.57 ± 1.17a
	Lower	11.00 ± 0.40cd	0.76 ± 0.02c	14.54 ± 0.85c	3.89 ± 0.19ab	8.77 ± 0.17b	4.55 ± 0.15bc	8.53 ± 0.13b	11.27 ± 0.08c	57.45 ± 1.95a
T3	Upper	12.70 ± 0.20a	0.67 ± 0.02ef	19.01 ± 0.69a	4.94 ± 0.14a	8.77 ± 0.17b	5.11 ± 0.16a	8.54 ± 0.14b	12.78 ± 0.34b	54.56 ± 1.78b
	Lower	11.50 ± 0.50bc	0.76 ± 0.02c	15.20 ± 0.89bc	4.14 ± 0.14ab	7.64 ± 0.14e	4.64 ± 0.10bc	7.50 ± 0.20e	9.91 ± 0.49d	52.35 ± 1.92bc
T4	Upper	11.10 ± 0.10cd	0.68 ± 0.01def	16.40 ± 0.20b	4.27 ± 0.17ab	8.69 ± 0.19b	4.69 ± 0.19b	8.44 ± 0.14b	12.47 ± 0.21b	57.43 ± 0.97a
	Lower	10.90 ± 0.30cde	0.70 ± 0.01d	15.49 ± 0.57bc	3.45 ± 0.10b	8.40 ± 0.20c	4.46 ± 0.16bc	8.17 ± 0.17c	11.61 ± 0.35c	54.56 ± 1.78b

sucrose (5.11%) were the highest in the upper fruits of T3, followed by the upper layer fruits of T2. However, Titratable acid were the highest and the contents of the soluble solids, TSS/acid ratio, reducing sugar, sugar, sucrose, total sugar, sugar/acid ratio and Vc content were the lowest in control. Therefore, it was explained that T2 and T3 were beneficial to improve the internal quality of fruit.

3.4. The Correlation Analysis of Leaf and Soil Nutrient

From **Table 5**, the contents of B, Zn and Fe in leaves were significantly correlated with soil nutrient. However, the contents of N, P, K, Mg were no significant correlations with soil nutrient contents. There was a significant negative correlation between B content in leaf and pH value in soil, and positively correlated with available B, organic matter, total N, total P, available N, available P, available K, available Cu, available Zn, available Fe in soil. The Mg content in leaves was positively correlated with available N and available Fe, and negatively correlated with other indexes, especially with available Cu, available Zn and pH. While the Fe content of leaves was negatively correlated with pH value and exchangeable Ca. It was positively correlated with other indexes and had a significant positive correlation with total K, available K, available P, available B, available Cu and available Zn. It shows that leaf nutrient and soil nutrient were closely related.

3.5. The Correlation Analysis of Soil Nutrients and Fruit Yield and Quality

According to **Table 6**, the pH value was negatively correlated with the fruit yield

Table 5. Correlation between leaf and soil nutrient parameters.

R	N (g·kg^{-1})	P (g·kg^{-1})	K (g·kg^{-1})	B (mg·kg^{-1})	Mg (mg·kg^{-1})	Zn (mg·kg^{-1})	Fe (mg·kg^{-1})
pH	−0.370*	−0.571**	−0.153	−0.469**	−0.523**	−0.073	−0.025
Organic mater (g·kg^{-1})	−0.080	−0.025	0.398*	0.631**	−0.144	0.384*	0.396*
N (g·kg^{-1})	0.147	0.116	0.304	0.640**	−0.073	0.224	0.398*
P (g·kg^{-1})	−0.318	−0.039	0.096	0.560**	−0.302	0.477**	0.464**
K (g·kg^{-1})	0.062	−0.018	0.108	0.06	−0.331	−0.522**	0.531**
Available N (mg·kg^{-1})	0.053	0.154	0.236	0.677**	0.113	0.544**	0.198
Available P (mg·kg^{-1})	−0.251	0.060	0.242	0.745**	−0.252	0.368*	0.649**
Rapidly available K (mg·kg^{-1})	−0.024	0.018	0.416*	0.732**	−0.198	0.372*	0.648**
Available B (mg·kg^{-1})	0.103	0.021	0.444*	0.403*	−0.317	−0.457*	0.775**
Available Cu (mg·kg^{-1})	−0.303	0.005	0.191	0.630**	−0.438*	0.209	0.766**
Available Zn (mg·kg^{-1})	−0.028	0.089	0.357	0.776**	−0.210	0.236	0.672**
Available Fe (mg·kg^{-1})	0.138	0.227	0.493**	0.751**	0.093	0.625**	0.377*
Available Mn (mg·kg^{-1})	−0.407*	−0.166	−0.179	0.279	−0.215	0.581**	0.079
Exchangeable Ca (g·kg^{-1})	0.247	−0.210	0.189	−0.257	−0.164	−0.303	−0.019
Exchangeable Mg (g·kg^{-1})	−0.255	−0.313	0.033	0.325	−0.143	0.548**	0.079

Table 6. Correlation between soil nutrient and fruit yield and quality.

R	Fruit weight (g)	Fruit shape index	Fruit peel thickness (mm)	Juice rate (%)	Edible rate (%)	TSS (%)	TA (%)	TSS/ acid	Total sugar (%)	Sugar/ acid	Vc content (mg·kg^{-1})	Fruit number n plant^{-1}	Fruit yield (kg plant^{-1})
pH	−0.150	−0.265	−0.101	−0.063	0.015	0.065	−0.098	0.145	−0.107	0.040	−0.151	−0.294	−0.364*
Organic mater (g·kg^{-1})	0.507**	0.491**	0.708**	−0.847**	−0.630**	0.758**	−0.864**	0.849**	0.743**	0.831**	0.501**	0.788**	0.686**
N (g·kg^{-1})	0.681**	0.632**	0.856**	−0.716**	−0.679**	0.723**	−0.925**	0.836**	0.793**	0.859**	0.688**	0.746**	0.767**
P (g·kg^{-1})	0.387*	0.323	0.485**	−0.830**	−0.523**	0.838**	−0.709**	0.845**	0.746**	0.785**	0.447*	0.635**	0.505**
K (g·kg^{-1})	0.476**	−0.204	0.221	0.062	−0.163	−0.150	−0.202	0.031	0.245	0.259	0.342	−0.253	0.137
Available N (mg·kg^{-1})	0.447*	0.658**	0.618**	−0.707**	−0.534**	0.798**	−0.764**	0.811**	0.754**	0.766**	0.452*	0.899**	0.718**
Available P (mg·kg^{-1})	0.567**	0.451*	0.600**	−0.829**	−0.566**	0.781**	−0.713**	0.803**	0.824**	0.826**	0.590**	0.671**	0.656**
Rapidly available K (mg·kg^{-1})	0.742**	0.567**	0.793**	−0.872**	−0.775**	0.772**	−0.853**	0.862**	0.896**	0.925**	0.671**	0.760**	0.774**
Available B (mg·kg^{-1})	0.818**	0.237	0.570**	−0.219	−0.454*	−0.009	−0.429*	0.213	0.538**	0.527**	0.673**	0.045	0.219
Available Cu (mg·kg^{-1})	0.617**	0.245	0.554**	−0.793**	−0.596**	0.691**	−0.704**	0.764**	0.841**	0.850**	0.630**	0.473**	0.490**
Available Zn (mg·kg^{-1})	0.785**	0.572**	0.825**	−0.810**	−0.714**	0.745**	−0.894**	0.856**	0.938**	0.957**	0.746**	0.743**	0.811**
Available Fe (mg·kg^{-1})	0.559**	0.805**	0.781**	−0.893**	−0.664**	0.871**	−0.748**	0.857**	0.756**	0.780**	0.569**	0.824**	0.781**
Available Mn (mg·kg^{-1})	−0.009	0.306	0.260	−0.636**	−0.207	0.826**	−0.484**	0.720**	0.400*	0.469**	0.153	0.526**	0.621**
Exchangeable Ca (g·kg^{-1})	0.223	−0.029	0.286	0.046	−0.184	−0.126	−0.277	0.070	0.028	0.145	0.104	−0.120	0.201
Exchangeable Mg (g·kg^{-1})	0.174	0.560**	0.474**	−0.633**	−0.331	0.819**	−0.634**	0.781**	0.448*	0.555**	0.214	0.713**	0.019

Note: Correlation is significant at the 0.01 level. Correlation is significant at the 0.05 level, The same as followed.

and quality index, but only the correlation between pH value and yield per plant reached significant level. There was a significant positive correlation between total K and fruit weight, and the other indexes did not reach significant level. The contents of organic matter, total N, total P, available N, available P, available K, available B, available Cu, available Zn, available Fe, available Mn and exchangeable Mg were negative correlations with the juice yield, edible rate and titratable acid. There was a significant positive correlation with fruit weight, fruit thickness, total sugar, solid acid ratio, sugar and acid ratio, Vc content and fruit yield. There was a significant positive correlation between available B content, fruit weight, fruit thickness, total sugar, sugar and acid ratio and Vc content, and negatively correlated with juice yield, edible rate and titratable acid. The effective

Fe and Zn content was negatively correlated with the juice yield, edible rate and titratable acid, which was significantly correlated with other fruit yield and quality indexes. Therefore, soil nutrients have played a very important role in improving fruit quality.

3.6. The Correlation Analysis of Leaf Nutrients and Fruit Yield and Quality

According to **Table 7**, the correlation between K, B, Zn, Fe and fruit yield and quality index was significant, while the N, P, Mg were not significant correlations with the yield and quality of fruit. There was a significant positive correlation between the K content, fruit weight, fruit thickness, fruit number, fruit yield, total sugar, the ratio of sugar to acid, and the content of Vc, and negatively correlated with juice yield and edible rate. Negative correlations were shown between the B content and juice rate, edible rate and titratable acidity. The content of B was a significant positive correlation with the yield and quality of other indexes. There was a significant negative correlation between Fe content and juice yield and edible rate, and negatively correlated with titratable acid. There was a significant positive correlation with single fruit weight, single yield, fruit thickness, total sugar, and the solid acid ratio was significantly positive correlation. The content of Zn was significant negatively with the juice rate, and was negatively correlated with the edible rate, and was positively correlated with the soluble solids, fruit shape index, fruit number per plant and yield per plant. It was found that the leaf nutrient contents were negatively correlated with juice rate and edible rate.

4. Discussion

4.1. Effects of Fertilization on Nutrient Content and Correlations

Different fertilization treatments had a significant effect on soil nutrient content,

Table 7. Correlation between leaf nutrient and fruit yield and quality.

R	Fruit weight (g)	Fruit shape index	Fruit peel thickness (mm)	Juice rate (%)	Edible rate (%)	TSS (%)	TA (%)	TSS/acid	Total sugar (%)	Sugar/acid	Vc content (mg·kg^{-1})	Fruit number n plant^{-1}	Fruit yield (kg plant^{-1})
N (g·kg^{-1})	0.285	0.381*	0.310	−0.117	−0.432*	−0.104	0.085	−0.145	0.087	−0.035	0.085	0.309	0.472**
P (g·kg^{-1})	0.274	0.290	0.191	−0.269	−0.375*	0.057	0.089	−0.042	0.273	0.088	0.203	0.29	0.529**
K (g·kg^{-1})	0.568**	0.554**	0.511**	−0.525**	−0.679**	0.142	−0.254	0.196	0.451*	0.371*	0.380*	0.504**	0.727**
B (mg·kg^{-1})	0.760**	0.728**	0.727**	−0.782**	−0.758**	0.589**	−0.555**	0.586**	0.833**	0.725**	0.693**	0.761**	0.940**
Mg (mg·kg^{-1})	−0.094	0.343	0.001	−0.005	−0.136	−0.089	0.286	−0.238	−0.135	−0.264	−0.221	0.358	0.306
Zn (mg·kg^{-1})	0.024	0.486**	0.264	−0.621**	−0.449*	0.596**	−0.185	0.416*	0.272	0.227	−0.030	0.689**	0.453*
Fe (mg·kg^{-1})	0.842**	0.269	0.585**	−0.533**	−0.593**	0.325	−0.454*	0.426*	0.730**	0.668**	0.789**	0.171	0.555**

and different fertilization treatments had significant difference, but the evaluation results of fertilization treatments were different in the existing reports. Some researchers suggested that organic fertilizer alone significantly promote the absorption of calcium, and promote the transformation of nitrate nitrogen, adjust the soil nitrate content changes [18]. It was also suggested that organic manure could increase soil organic matter, total N, available P, available K, exchangeable Ca, exchangeable Mg, pH value and soil fertility [19]. As well as the researchers suggested that the orchard increased organic fertilizer can significantly improve the nutrient contents of leaf [20] [21]. More studies have found that the rational application of chemical fertilizers and organic fertilizers can significantly improve the soil fertility and fruit yield [22] [23].

In this experiment, the results showed that the nutrient contents in soil increased with the increase of organic manure application. The nutrient contents in T2 and T3 were significantly increased, and the soil nutrient contents of 0 - 20 cm depth in T2 were the highest, which indicated that the increase of organic fertilizers was beneficial to improve soil available nutrient, and organic fertilizers with chemical fertilizers were better (T2). Furthermore, the nutrient contents of vegetative leaves in T2 were also the highest. It indicated that most of the nutrients in the tree came from the soil, and the leaf nutrient was closely related to the soil nutrient [24]. In addition, the results showed that the Mg content in the leaves was positively correlated with the available N and available Fe, and negatively correlated with other parameters, which indicated that the Mg deficiency in leaves was not only caused by the corresponding elements in the soil, and applying single fertilizer could not meet the tree's requirement for nutrient [25]. The results also showed that there was a positive correlation between Fe, B content in leaves and soil nutrient content, it indicated that soil nutrients directly affect the Fe and B nutrient content in leaves, and fertilization could significantly improve to the nutrient level in leaves. There were many factors that affect the relationship between soil and leaf nutrient, but there has not yet reached a uniform conclusion about the correlation in the existing reports. Thus the specific relationship and the reasons need to be further studied.

4.2. Effects of Fertilization on Fruit Yield and Quality and Correlations

The nutrient of leaf and soil had significant effect on fruit yield and quality, especially the index of leaves' nutrient content can respond to the nutritional requirements more accurately for optimum fruit yield [4]. Zang *et al.* suggested that the application of organic fertilizer can increase the soluble solids, Vc content and solid acid ratio, reduce the content of titratable acid [26]. Wang *et al.* suggested that the application of different ratio of compound fertilizer is enable to improve the yield and quality of citrus [27]. Marathe reported that the application of FYM (to supply 50% N) + 50% RDF (1000 g N + 400 g P_2O_5 + 400 g K_2O tree^{-1} year^{-1}) was optimum for sustaining higher fruit yield and quality of sweet orange [28]. In this study, the fruit and yield were the highest, the fruit peel was thicker, and the content of sugar, total sugar, Vc and rate of sugar and acid were the highest in T2, it indicated that T2 can improve the ability of anti-fungal invasion and enhance the storability [29].

The relationship between soil or leaf nutrient content and fruit yield and quality was complex. Zhang *et al.* found that available P in soil had the greatest effects on fruit quality, followed by K, N, and P in leaf could significantly increase the content of Vc and sugar, but reduce acidity, while Mg and B increase the acidity of fruit [30]. In addition, researchers have suggested that the content of soluble solids in fruit was negatively correlated with soil pH value, and there was a significant positive correlation with soil organic matter, available N, Fe, Mn and Zn. The content of Vc in fruit was positively correlated with soil pH and available K, and negatively correlated with soil organic matter and other nutrient contents [4]. It has also been suggested that most of the nutrients in citrus leaves were negatively correlated with the soluble solids of fruit quality, and positively correlated with Vc content [31]. In this study, we found that the content of available K, B, Fe and Zn in soil increased the content of mineral elements in leaves, which increased fruit peel thickness, fruit weight, total sugar and Vc content etc. The similar results have been reported by Aula *et al.* [32], Khayyat *et al.* [33], Patel *et al.* [34] and Asadi *et al.* [35]. Meanwhile, B, Fe, Zn content and titratable acid were significantly negatively correlated, it indicated that it could increase sugar and reduce acid content with increasing B, Fe, Zn content, Furthermore, the content of B and Zn was positively correlated with the soluble solid, and the content of available B and Zn was helpful to increase the soluble solids content of fruit. Therefore, foliage spraying K, B, Fe, Zn appropriately is the effective way for improving fruit yield and quality in the orchard fertilization practice.

References

[1] Huang, C.H., Qu, X.Y., Liu, K. P., Leng, J.H., Tu, G.Q., Li, B.M., *et al.* (2014) Analysis of Soil Physicochemical Properties, Leaf Nutrients and Fruit Qualities in the Orchards of "Jinkui" Kiwifruit (*Actinidiadeliciosa*). *Journal of Fruit Science*, **31**, 1091-1099.

[2] Yu, N.W., Li, J.C., Wang, J.Z., Cai, Z.M., Sha, S.F. and Li, H.J. (2013) Investigation and Analysis on Nutrient Status of Soil and Leaves in "Nan guoli" Pear Orchards in Liaoning Province. *Journal of Fruit Science*, **30**, 254-259.

[3] Dinnes, D.L., Karlen, D.L., Jaynes, D.B., Kaspar, T.K., Hatfield, J.L., Colvin, T.S., *et al.* (2002) Nitrogen Management Strategies to Reduce Nitrate Leaching in Tile-drained Midwestern Soils. *Agronomy Journal*, **94**, 153-171. https://doi.org/10.2134/agronj2002.0153

[4] Yang, S.Q. (2008) Effects of Soil and Leaf Nutrient Status on Yield and Quality of Citrus. Southwest University, Beibei.

[5] Qiu, X.K., Dong, Y.J., Wan, Y.S., Hu, G.Q. and Wang, Y.H. (2010) Effects of Different Fertilizing Treatments on Contents of Soil Nutrients and Soil Enzyme Activity. *Soils*, **42**, 249-255.

[6] Ling, L.L., Peng, L.Z., Chun, C.P., Jiang, C.L. and Cao, L. (2012) The Relationship between Leaf Nutrients and Fruit Quality of Navel Orange in Southern Jiangxi

Province of China. *Plant Nutrition and Fertilizer Science*, **18**, 947-954.

[7] Thamrin, M., Susanto, S., Susila, A.D. and Dan, A.S. (2014). Correlation between Nitrogen, Phosphorus and Potassium Leaf Nutrient with Fruit Production of Pummelo Citrus (*citrus maxima*). *Asian Journal of Applied Sciences*, **7**, 129-139. https://doi.org/10.3923/ajaps.2014.129.139

[8] Lu, C., Xue, X.M., Wang, C.L., An, G.N. and Wang, J.Z. (2011) Correlation Analysis Oil Fruit Quality and Leaves Nutrition and Soft Nutrient in Apple Orchard of Shandong Province. *Chinese Agricultural Science Bulletin*, **27**, 168-172.

[9] Song, X.H., Xie, K., Zhao, H.B., Li, Y.L., Dong, C.X., Xu, Y.C., *et al.* (2012) Effects of Different Organic Fertilizers on Tree Growth, Yield, Fruit Quality, and Soil Microorganisms in a Pear Orchard. *European Journal of Horticultural Science*, **77**, 204-210.

[10] Liu, Z.K. (2010) Early Knot and High-Yielding Cultivation Techniques of *Citrus Grandis* Var. longanyou. *Chinese Fruit Trees in Southern China*, **39**, 64-65.

[11] Xiong, A.M. (2012) High-quality Fruit Production Technology of *Citrus grandis* var. longanyou. *Chinese fruit trees in Southern China*, **41**, 83.

[12] Tang, Y.Q., Peng, L.Z., Chun, C.P., Ling, L.L., Fang, Y.W. and Yan, X. (2013) Correlation Analysis on Nutrient Element Contents in Orchard Soils and Sweet Orange Leaves in Southern Jiangxi Province of China. *ActaHorticulturaeSinica*, **40**,623-632.

[13] Zhang, C.M. (2013) The Effects of Different Fertilizer Treatments on the Soil and Leaf Nutrient and the Metbolism of Citric Acid of Navel in Zigui. Wuhan: Huazhong Agricultural University.

[14] Bao, S.D. (2000) Soil Agrochemical Analysis.3rd Edition, China Agricultural Publishing Press, Beijing.

[15] Mu, H.T.R.Z., Wu, Z.B., Gu, L. M.R.K. and Shi, Y.J. (2015) Effects of Different Proportions of Organic-inorganic Fertilizers on Soil Nutrition, Photosynthetic Parameters and Leaf-Fruit Ratio of Junzao. *Chinese Journal of Soil Science*, **46**, 405-411.

[16] Zhuang, Y.M., Wang, R.J., Chen, L.X., Xie, Z.N., Xu, W.B., Huang, Y.Z., *et al.* (1991) Optimum Range of Mineral Element Contents in the Leaves of Guanxi Honey Pomelo (*Citrus grandis*). *Journal of Fujian Academy of Agriculture Sciences*, **6**, 52-58.

[17] Diao, L.H. (2013) Seasonal Changes of Nutrient Element Contents in Leaves of Four Citrus Cultivars. Beibei: Southwest University.

[18] Hu, L.P., Xie, T.Z., Zou, Y.L., Wang, T.P., Chen, Q. and Ye, X.Y. (2011) Effects of Different Fertilizations on the Calcium Content in the Apple Fruits and Soil Nutrient. *Northern horticulture*, **14**, 16-19.

[19] Zang, X.P., Zhou, Z.X., Lin, X.E., Dai, M.J., Ge, Y., Liu, Y.X., *et al.* (2016) Effects of different Organic Manure Application Rate on Mango Fruit Quality and Soil Fertility. *Chinese Soil and Fertilizer*, **1**, 98-101.

[20] Chu, C.B., Wu, S.H., Zhang, X.Y., Zhou, D.P., Fan, J.Q. and Jiang, Z.F. (2012) Effects of Organic Fertilizer Application on Soil Fertility and Leaf Nutrients and Fruit Quality of Citrus. *Acta Agriculturae Shanghai*, **28**, 65-68.

[21] Wang, Y.X. (2015) Effects of Organic Fertilizerson Soil Nutrient, Tree Nutrition and Fruit Quality of Feicheng Peach. Shandong Agricultural University, Tai'an.

[22] Luo, H., Li, M., Hu, D.G., Song, H.R., Hao, Y.J. and Zhang, L.Z. (2012) Effects of Organic Fertilization on Fruit Yield and Quality of Feicheng peach (*Prunuspersica* cv. Feicheng). *Plant Nutrition and Fertilizer Science*, **18**, 955-964.

[23] Zhao, Z.P., Tong, Y. A., Liu, F. and Wang, X.Y. (2013) Effects of Different Long-Term Fertilization Patterns on Fuji Apple Yield, Quality, and Soil Fertility on

Weibei Dryland. *Chinese Journal of Applied Ecology*, **24**, 3091-3098.

[24] Zhao, Z.G., Tang, F.L., Li, S.H., Huang, Z.Q., Shi, Y.P., Fu, C.M., *et al.* (2013) Corrlation Analysis on Nutrition Status of Soil and Leaf Nutrients for *Pyruspyrifolia* cv. Hosui Citrus demonstration Orchard. *Guihaia*, **33**, 171-176.

[25] Wei, X.M., Liao, M.A., Zhou, Y.G. and Dai, S.Y. (2008) Study on the Correlation between Leaf Nutrition and Soil Nutrient of *Pyruspyrifolia*Nak. cv. Jinhua. *Xiandai Horticulture*, **9**, 4-6.

[26] Zang, X.P., Lin, X.E., Zhou, Z.X., Tan, L., Ge, Y., Dai, M.J., *et al.* (2015) Effects of Different Fertilization Treatments on Quality of Mango Fruit and Soil Fertility. *Subtropical Plant Science*, **44**, 146-149.

[27] Wang, R., Wei, Y.Z., Yang, X.E., Tang, C.H., Jia, Y.B., Hong, C.L., *et al.* (2004) Effects of Different Proportioning Compound Fertilizers on Yield and Quality of Citrus. *Journal of Zhejiang Agricultural Sciences*, **1**, 243-245.

[28] Marathe, R.A. (2005) Effect Of Integrated Nutrient Management On Soil Properties, Yield and Quality Of Sweet Orange (*Citrus Sinensis* Osbeck) Grown on Vertisol.

[29] He, T.F. (1999) Chinese Pomelo Cultivation. China Agricultural Publishing Press, Beijing, 129-137.

[30] Zhang, L., Shi, X.G., Fan, G.E. and Lin, M. (2010) Relationship between Soil and Leaf Nutrient Quality and Fruit Quality of Satsuma Mandarine. *Journal of Zhejiang Agricultural Sciences*, **1**, 961-963.

[31] Xu, H.Y., Xiong, W., Yang, C.F., Huang, Y. and Zeng, M. (2012) Correlation Analysis of Mineral Nutrients in Citrus Leaf and Fruit Quality in Kaixian County. *Journal of Southwest University* (*Natural Science Edition*), **34**, 27-32.

[32] Aular, J., Rengel, M., Montaño, M. and Aular-Rodriguéz, J. (2010) Relationship between Soil and Leaf Potassium Content and "Valencia" Orange Fruit Quality. *Acta Horticulturae*, **868**, 401-404. https://doi.org/10.17660/ActaHortic.2010.868.54

[33] Khayyat, M., Tafazoli, E., Eshghi, S. and Rajaee, S. (2007) Effect of Nitrogen, Boron, Potassium and Zinc Sprays on Yield and Fruit Quality of Date Palm. *American-Eurasian Journal of Agricultural & Environmental Sciences*, **2**, 289-296.

[34] Patel, P.C., Kalyansundram, N.K. and Patel, M.S. (1998) Effect of Iron Nutrition on the Yield, Chlorosis, Fruit Quality and Leaf Composition of Acidlime Trees Grown on Loamy Sand Soils. *Gujarat Agricutural University Research Journal*.

[35] Asadi, K.S.A., Negin, A.A. and Bizhan, M. (2007) Effect of Rates and Methods of Zinc Application on Yield and Fruit Quality of Satsuma Mandarin. *Iranian Journal of Soil and Waters Sciences*, **21**, 1-14.