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Research Paper

Effects of three kinds of improved substrates on soil nutrients and ginseng yield and quality in farmland

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ABSTRACT

Soil fertility is the main factor affecting the yield and quality of ginseng. The organic matter content of farmland soil in Yanbian area is low, the fertility is poor, which seriously restricts the development of ginseng industry. The three different modified substrates (green manure, organic manure and microelement fertilizer) were tested by L16 (4^5) orthogonal test to determine the fertilizer application proportion suitable for the growth and development of ginseng. In general, the application of three substrates reduces the pH of the soil, obviously increases the conductivity of the soil, and makes the root of ginseng more suitable for growth. The total nitrogen, total phosphorus and organic matter content were obviously improved by the three modified substrates. Among them, the content of total nitrogen and total phosphorus in green manure 4 kg/m^2, organic fertilizer 3 kg/m^2, and microelement fertilizer 100 g/m^2 was the highest. According to the results of agronomic characters and saponins content of ginseng, the three modified substrates had significant effects on plant height and total saponins content. Among which green manure 0 kg/m^2, organic fertilizer 2 kg/m^2, and microelement fertilizer 100 g/m^2 to the content of total saponins of ginseng root was the highest. The three improved matrix combinations showed a certain effect on the improvement of ginseng soil.

Key words: Farmland ginseng, soil improvement, orthogonal design, soil nutrient, ginsenoside.

INTRODUCTION

Ginseng is a perennial herb of Acanthopanax. It is cool and shady, and is not resistant to high temperature. The ginseng root has been used for over 2000 years, in the belief that it is a panacea and promotes longevity. As described in Chinese traditional medicine textbooks, its effectiveness reaches mythical proportions (Xie et al., 2005; Huang et al., 1999). The efficacy of ginseng was known in the West by the 18th century, and the study of ginseng has a long history (Huang et al., 1999). Active constituents found in most ginseng species include ginsenosides, polysaccharides, peptides, polyacetylenic alcohols and fatty acids, and Ginsenosides which are particularly important.

Ginsenosides are distributed in the whole part of ginseng, and the pharmacological activities of saponins are also different. Studies have shown that ginsenosides can enhance the body's immunity, have anti-fatigue effect (Attele et al., 1999; Kiyoko et al., 1996; Iishi et al., 1997; Kubo et al., 1992; Attele et al., 1999). The most important, ginsenosides, used in anti-cancer substances, can inhibit the proliferation of human prostate cancer cells (Liu et al., 2000). Scholars found antidiabetic effects of Panax ginseng berry extract (Attele et al., 2002). Ginseng has the functions of regulating nerve, improving cardiovascular and increasing gonadal function (Jin et al., 2013).

As the limit of the usage of available forest land, cultivated ginseng in the farmland would become the mainly Panax ginseng planting mode, meanwhile the non-polluted production technology would be the mainly development direction in the future. But the time of planting "farmland ginseng" is short, there is lack of

Table 1: Orthogonal test design of three different substrates.

Combination treatments	Green manure (kg/m^2)	Organic manure (kg/m^2)	Microelement fertilize (g/m^2)
L1	0	0	0
L2	0	1	50
L3	0	2	100
L4	0	3	150
L5	2	1	50
L6	2	1	0
L7	2	2	150
L8	2	3	100
L9	4	0	100
L10	4	1	150
L11	4	2	0
L12	4	3	100
L13	6	0	150
L14	6	1	100
L15	6	2	50
L16	6	3	0

experience in the cultivation of new varieties, and the technology is not yet complete. Blindly introduced farmland will not only cause the death of ginseng seedlings massively, but also lead to the waste of resources and land, and reduce the effect of the ginseng. Several researchers proposed that the soil remediation of cultivated ginseng should be carried out, the integrated pest and disease control platform should be established, new stress-resistant varieties suitable for farmland cultivation should be cultivated, and the strategy of non-pollution planting of ginseng should be established (Shen et al., 2017; Shen et al., 2015). Yang and Jiang (2016) found that they had a great relation between the effective components and soil enzyme activities, the activity of the same enzyme in humus soil was higher than that in farmland soil. Xu et al. (2017) found that comprehensive soil improvements including soil sterilization, green manure planting and organic fertilization application effectively improved the soil micro-ecology in farmlands. Other studies have shown that soil nutrients are closely related to ginseng growth (Liu et al., 2009; Sun et al., 2018).

At present, the mode of planting ginseng in our country is not mature, the soil improvement technology is not perfect, and the yield and quality of planting ginseng are not high. In this experiment, we analyzed the improvement of cultivated ginseng soil in Chaoyangchuan area by mensurating the soil nutrient, ginseng character and saponins content, and the suitable soil fertility index was evaluated through comprehensive comparison.

MATERIALS AND METHODS

Soil improvement matrix

Green manure (straw) is produced from the rice experiment field of Yanbian Academy of Agricultural Sciences; Organic manure comes from Longjing Piggery and is processed by decomposing treatment. The microelement fertilizer is a "full feeding" microelement water soluble fertilizer, purchased from Dunhua breeding farm, and produced by Shaanxi gage Road biological Co. Ltd.

Test site and tested soil

The test site is the three peak cave experimental base of Chaoyangchuan Academy of Agricultural Sciences in Yanji, Yanbian, Jilin province. The soil of the tested farmland is mainly white pulp soil, the content of organic matter is 20.97 g/kg, the total nitrogen, total phosphorus and total potassium content are 2.07, 0.19 and 10.10 g/kg, respectively with pH value 6.50 and EC value 96.9 μs/cm.

Experimental design

In this experiment, three different modified substrates (green manure, organic manure and microelement fertilizer) were designed by L_{16} (4^5) orthogonal test (Table 1) in a total of 16 treatments.

Soil treatment

The soil modification work began from May 2016. Green manure, organic manure and microelement fertilizer were applied to the stroma, and the fertilizer was mixed with the micro tillage machine. Repeated every two weeks until October.

Transplanting method

The test material was two years old ginseng Damaya, single plant weight 6-7 g, produced from Changbai County, bought in mid April 2017 and transplanted in April 19th. Before transplanting, ginseng was dipped into root disinfection with 800 times Carbendazim, then transplanted according to row spacing 25 × 8 cm, and the surface was covered with straw after transplanting. In April 27th, the ginseng shade shed was set up. In May 27th, shading shed was covered with blue film. In June 8th, the flower was topped to ensure the yield of ginseng root. In June 27th, shading blue film was sprayed with dimmer agent.

Determination method

Specific methods for the determination of soil pH value, EC, organic matter content, total nitrogen, ammonium nitrogen, nitrate nitrogen, total phosphorus, available phosphorus, total potassium and available potassium, were Bao SD's <Soil Agricultural Chemistry Analysis> (Bao, 1999). The extraction of ginsenosides is mainly based on the Chinese Pharmacopoeia 2010 Edition (Chinese Pharmacopoeia Commission, 2010). At the end of September 2017, 15 plants were collected randomly in each treatment. Plant height, leaf length, leaf width, root length and main root length were measured with a ruler. The stem diameter and root diameter were measured with vernier caliper, and fresh weight and dry weight of ginseng root were weighed with electronic balance.

Data processing

Office Excel 2010 was used to record the data. Significant difference of the data was analyzed using SPSS 22.0, and plotted with Excel.

RESULTS AND DISCUSSION

Effects of improved soil on soil pH value, EC and organic matter content

Soil acidity and alkalinity (pH) is an important attribute of soil, which not only affects soil fertility, but also affects the availability of soil nutrients. Therefore, the effect of pH on plant growth and development cannot be ignored (Thomas et al., 1996). For example, 1a, the soil pH value, except L2 and L6, was slightly higher than L1. The pH values of the other soils were lower than L1, and the L10 and L14 were lower in the suitable range, except for L6 and L10, and there was no significant difference between the other treatments. The conductivity (EC) can reflect the soluble salt content in the soil, and the higher EC value was L11, L12 and L16, and the EC value of L1 was 42 us/cm lower than the other treatments (Figure 1b). The organic matter content of L12 was the highest, which was significantly different from other treatments. L7 and L15 were the second, and the other treatments had higher organic matter content than L1.

Effects of improved soil on soil nitrogen content

For example, 2a, L12, L15, L11, L13 and L10 had higher total nitrogen content, and there was no significant difference among treatments. The total nitrogen content in the other treatments was higher than L1. Ammonium nitrogen content was highest in L3, and significantly different from L1. L11 and L9 were the second and L15 ammonium nitrogen content was the lowest, but there was no significant difference between L1 and L1 (Figure 2b). As can be seen in Figure 2c, the nitrate nitrogen content of L11 and L15 is the highest, and there is a significant difference from L1, L16 and L12, and the other treatments have no significant difference as compared with L1. The soil organic matter, total nitrogen content, carbon and nitrogen ratio, and effective phosphorus content decreased with the increase of planting ginseng years (Lee, 2012; Sun et al., 2010; Zhang et al., 2010; Wang et al., 2015).

Effects of improved soil on content of phosphorus and potassium

As shown in Figure 3a, L12, L11 and L16 had higher total phosphorus content, the three had significant differences as compared with L1, while L2 and L9 total phosphorus content was slightly lower than L1, but there was no significant difference. For example, Figure 3b, L11 and L16 had higher content of available phosphorus, and there were significant differences as compared with L1, L10, L12, L15 and L8, and the other treatments had no significant difference as compared with L1. L2, L3 and L4 had no significant difference as compared with L1, and the total potassium content was lower than other treatments, among which L13 had the highest total potassium content (Figure 3c). The content of available potassium in L12 was the highest, followed by L4 and L11, and there was no significant difference between L1 and other treatments except L4 and L12 (Figure 3d). The application of phosphorus fertilizer increased the content of total phosphorus and available phosphorus in soil, improved the nutrition of P、N and K in root tissue, thus increased the level of sugar metabolism in root, promoted the synthesis and accumulation of storage polysaccharides such as starch, and increased the total saponin content (Suo et al., 1994).

Effects of improved soil on the grown of ginseng in the upper part of the earth

According to Table 2, the height of plant height and stem diameter can be compared. The height L11 of plant height

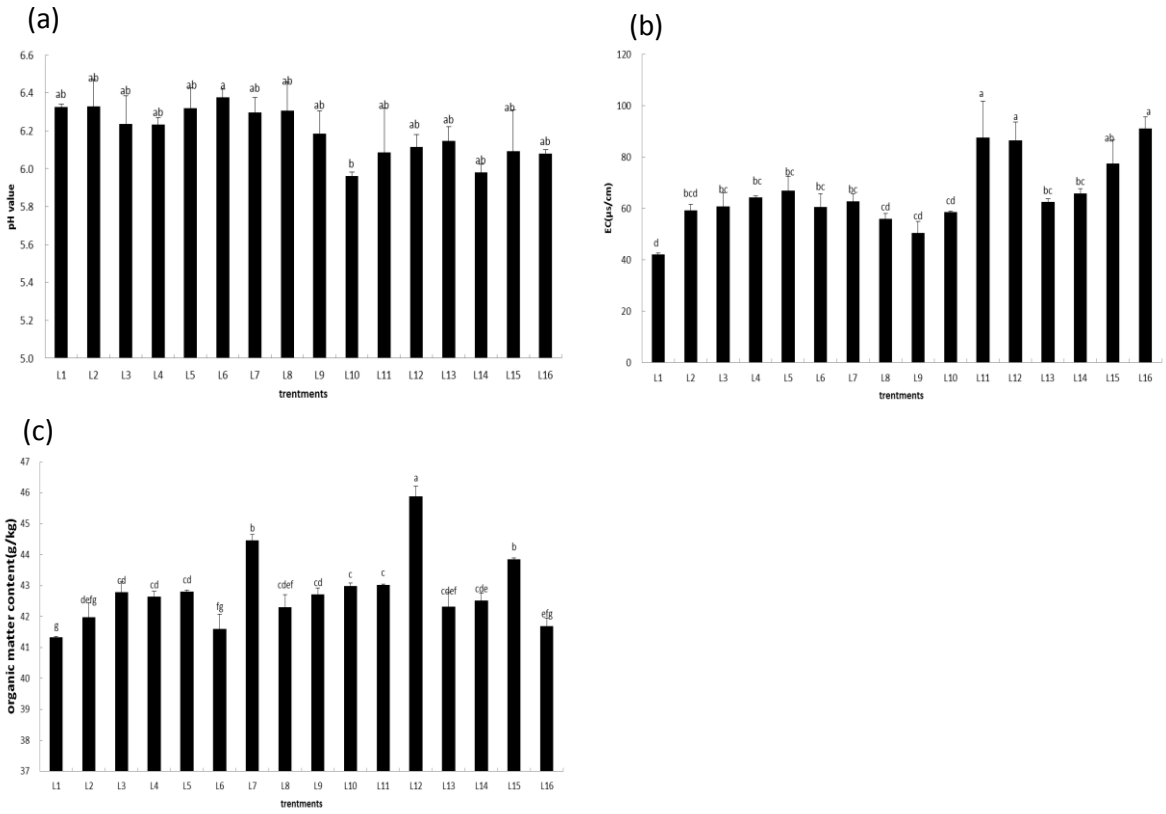

Figure 1: Effects of different treatments on pH value, EC and organic matter content.

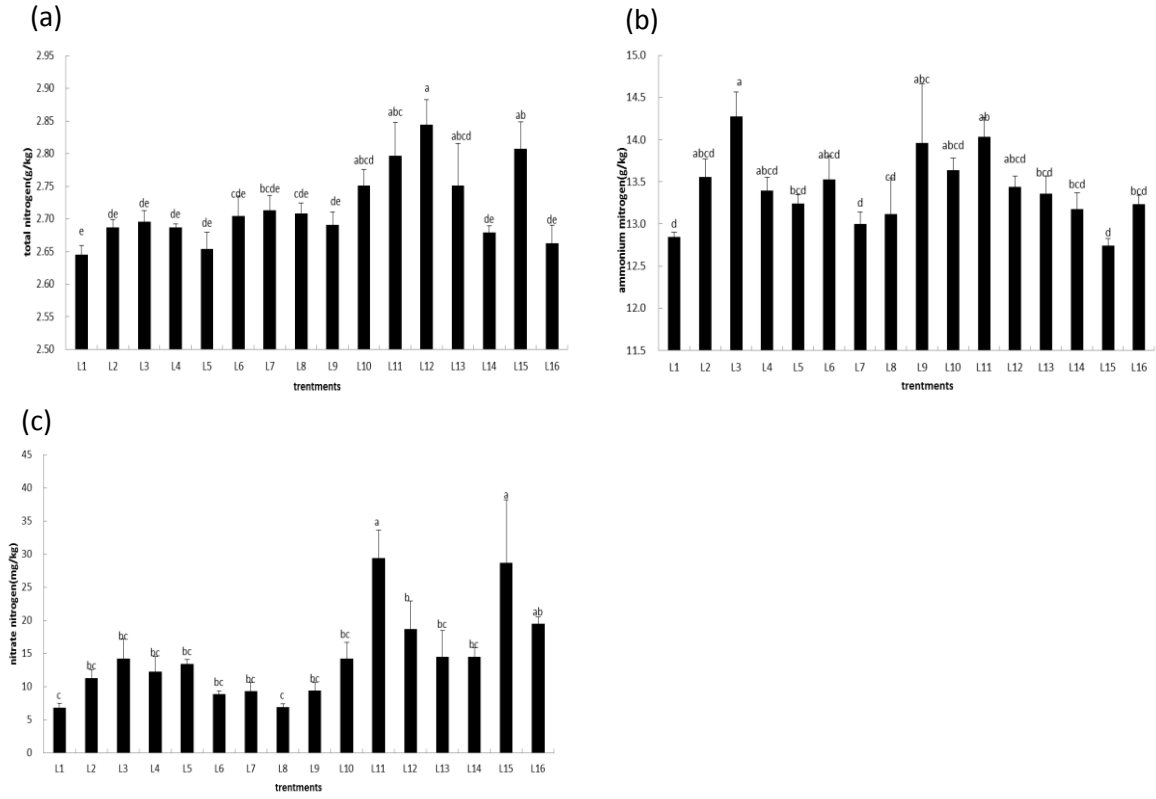

Figure 2: Effects of different treatments on contents of total nitrogen, ammonium nitrogen and nitrate nitrogen.

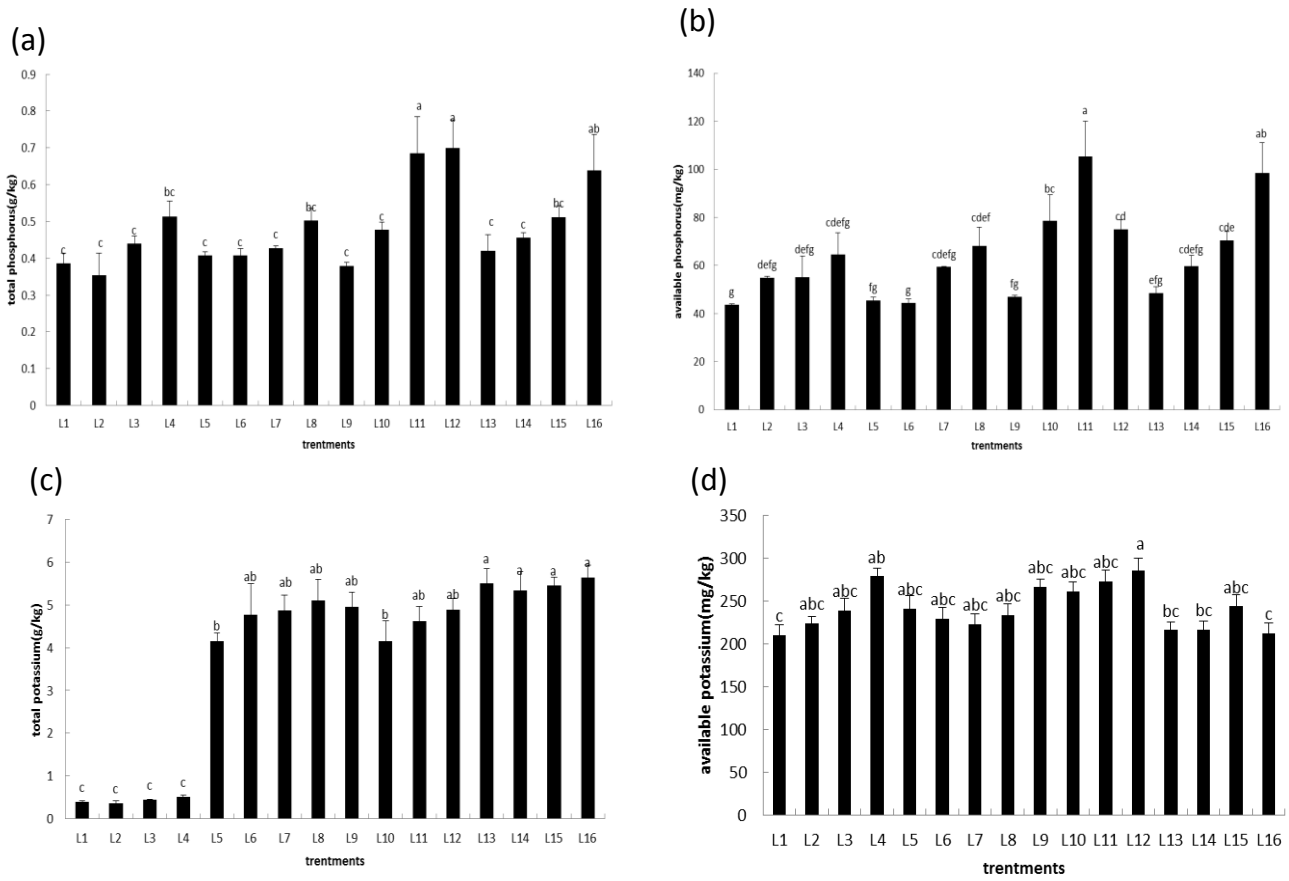

Figure 3: Effects of different treatments on contents of total phosphorus, available phosphorus, total potassium and available potassium.

Table 2: Effects of three improved substrates on the growth of ginseng aerial parts.

Treatments	Height (cm)	Stem diameter (cm)	Leaf length (cm)	Leaf width (cm)
L1	14.62±0.74 c	0.28±0.012 c	8.58±0.33 e	3.46±0.07 e
L2	15.83±0.55 bc	0.32±0.019 abc	10.68±0.12 abc	4.46±0.07 a
L3	16.27±0.56 bc	0.31±0.019 bc	10.48±0.13 abc	4.36±0.09 ab
L4	16.94±0.75 abc	0.33±0.014 abc	10.40±0.12 abcd	4.00±0.13 cd
L5	16.33±0.77 bc	0.33±0.024 abc	10.28±0.14 abcd	4.14±0.04 bc
L6	16.91±0.58 abc	0.33±0.014 abc	10.40±0.34 abcd	4.18±0.13 bc
L7	15.93±0.64 bc	0.32±0.015 abc	9.70±0.29 d	3.82±0.15 c
L8	16.91±0.69 abc	0.30±0.012 bc	10.08±0.47 bcd	4.22±0.06 abc
L9	15.27±0.61 bc	0.34±0.018 ab	10.38±0.18 abcd	4.06±0.11 cd
L10	16.47±0.76 abc	0.34±0.012 ab	10.46±0.25 abc	4.10±0.10 bcd
L11	18.64±0.78 a	0.37±0.018 a	10.38±0.11 abcd	4.02±0.11 bc
L12	16.90±0.68 abc	0.32±0.007 abc	10.36±0.09 abcd	3.96±0.07 bc
L13	16.43±0.69 abc	0.32±0.012 abc	10.50±0.28 abc	3.92±0.06 bc
L14	16.48±0.83 abc	0.31±0.012 bc	9.92±0.09 cd	4.04±0.07 bc
L15	14.94±0.68 bc	0.30±0.009 bc	10.38±0.08 abcd	4.06±0.06 bc
L16	17.05±0.38 ab	0.32±0.006 abc	10.90±0.14 a	4.00±0.03 bc

was the highest, followed by L16, and there was a significant difference from L1. The stem diameter L11 was the largest, followed by L9, L10, and there was a significant difference from L1. It can be preliminarily concluded that

Table 3: Effect of three improved substrates on the growth of ginseng underground.

Treatments	Root diameter (cm)	Root length (cm)	Main root length (cm)	Root weight	
				Fresh weight (g)	Dry weight (g)
L1	1.39±0.04 c	20.16±0.33 c	8.12±0.42 e	13.02±0.14 g	3.94±0.15 g
L2	1.54±0.08 a	21.43±0.76 bc	9.46±0.45 abcd	19.68±0.58 bc	6.11±0.26 bc
L3	1.52±0.04 abc	21.47±0.85 bc	9.06±0.32 abcde	20.68±1.19 b	5.49±0.10 d
L4	1.53±0.05 ab	20.70±0.28 c	8.84±0.18 abcde	20.12±0.29 ab	6.64±0.02 b
L5	1.46±0.04 abc	21.56±0.84 bc	9.10±0.33 abcde	17.56±0.47 de	5.11±0.04 def
L6	1.53±0.02 ab	20.03±0.30 c	8.82±0.39 bcde	18.22±1.82 cde	6.28±0.26 b
L7	1.40±0.04 bc	20.02±0.47 c	9.20±0.30 abcde	14.98±0.79 fg	4.70±0.19 f
L8	1.44±0.03 abc	20.16±0.30 c	8.93±0.32 abcde	17.64±0.65 de	5.58±0.27 cd
L9	1.45±0.00 abc	20.11±0.26 c	8.38±0.50 de	17.66±0.29 de	6.19±0.13 b
L10	1.47±0.02 abc	20.40±0.19 c	8.74±0.26 cde	19.30±0.90 bcd	6.34±0.20 b
L11	1.50±0.04 abc	21.60±0.34 bc	9.98±0.24 a	22.87±0.44 a	7.25±0.19 a
L12	1.41±0.06 abc	22.93±0.63 ab	9.08±0.33 abcde	17.42±0.60 de	5.63±0.13 cd
L13	1.48±0.05 abc	23.46±0.22 a	9.76±0.39 abc	17.70±0.57 cde	5.31±0.16 de
L14	1.46±0.02 abc	21.39±0.72 bc	9.68±0.29 abc	16.24±0.37 ef	4.83±0.09 ef
L15	1.46±0.03 abc	22.46±0.70 ab	9.54±0.05 abc	17.88±0.29 cde	5.45±0.10 d
L16	1.47±0.03 abc	23.68±0.50 a	9.96±0.40 ab	16.46±0.67 ef	5.40±0.21 d

Table 4: Effect of different treatments on the content of ginsenosides in *Panax ginseng*.

Treatments	Rb1 (mg/g)	Rb2 (mg/g)	Rg1 (mg/g)	Rc (mg/g)	Rd (mg/g)	Re (mg/g)	Rf (mg/g)
L1	5.58	2.74	2.58	3.09	1.79	1.89	0.86
L2	6.75	3.89	2.39	4.70	2.75	2.32	0.95
L3	7.55	3.84	2.93	4.93	2.47	2.62	0.89
L4	6.08	3.07	2.24	3.87	2.15	2.22	1.30
L5	6.46	2.71	2.15	3.14	1.66	2.08	1.53
L6	6.10	2.44	1.98	3.41	1.87	2.48	1.09
L7	7.02	3.20	3.61	3.66	2.28	2.09	1.28
L8	7.09	2.97	2.29	4.00	2.23	2.84	0.96
L9	6.75	3.78	3.07	4.69	2.62	2.92	1.26
L10	5.62	2.82	2.72	3.99	2.11	1.93	0.88
L11	7.28	3.98	2.95	4.12	2.28	3.16	1.28
L12	6.06	2.91	2.27	3.69	1.84	2.67	0.93
L13	6.68	3.38	2.72	3.74	2.09	2.68	0.93
L14	7.48	3.34	2.30	3.92	2.38	3.08	1.24
L15	7.97	3.61	2.86	3.71	2.51	2.78	1.38
L16	7.60	3.65	2.28	4.01	2.49	3.41	1.55

L11 treatment is most suitable for the growth of ginseng aerial parts. The leaf width of Ye Changhe could reflect the leaf size of ginseng and indirectly reflected the dry matter accumulation rate of plant leaf photosynthesis.

By contrast, the leaf length and leaf width of each treatment were significantly greater than L1, indicating that the improved matrix combination had a significant effect on the growth of ginseng leaves. The leaf length of each group was different from that of leaf width, and the leaf length of L16 treatment was the longest, while the width of L2 treated leaf was the largest.

Effects of improved soil on the growth of ginseng underground

It is known from Table 3 that L2 had the thickest root thickness and significant difference from L1, followed by significant difference between L4 and L6 and L1. There was a significant difference between L2 and L7, and no significant difference between the other treatments. The root length of L16 was the longest, which was significantly different from that of L1, followed by L13, L12, L15 and L1. The longest root length was L11, followed by L16, but there

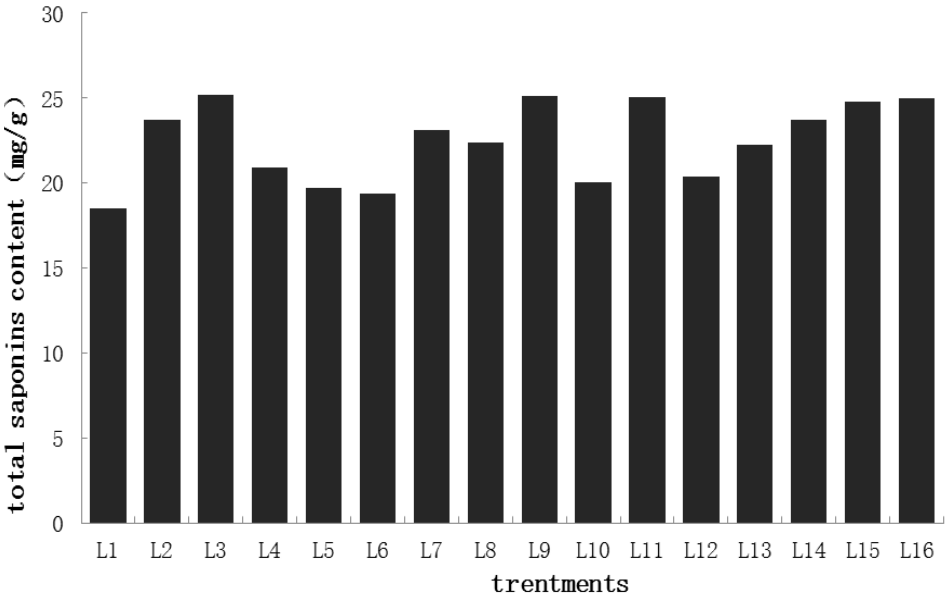

Figure 4: Effect of different treatments on total saponins content of ginseng.

was no significant difference between L2, L11, L13, L14, L15, L16 and L1. There was significant difference between the treatment and L1, the root fresh weight was L11 (22.87 g), the root dry weight was L11 (7.25 g), and there was significant difference between the dry weight treatment and the L1 between the root fresh weight and the L1.

Effects of improved soil on total saponins content of ginseng

By comparing the single saponins (Table 4), the highest content of Rb1 in L15 treatment was 7.97 mg/g, and the highest Rb2 content in the treatment of L11 was 3.98 mg/g. The Rg1 content in L7 treatment was the highest, the Rc content of L3 treatment was 4.93 mg/g, and the highest content was 2.75. The other treatments were 3.41 and 1.55 mg/g, respectively.

As shown in Figure 4, the total saponins content of L3 was the highest, and there was no significant difference among L9, L11, L15 and L16. L2, L7 and L14 were the lowest, and the total total saponins content of L1 was the lowest. Thus there were significant differences with other treatments. It can be seen that the improved soil has some effect on the improvement of ginseng saponin content, and helps to improve ginseng quality. Liu (2012) found that corn straw has great influence on Ginsenoside Rb3, ginsenoside Rd and ginsenoside Rb2. The effect of pig manure on Ginsenoside Rb1 is greater. This experiment found that three modified substrates have significant effect on the total ginsenoside content of Panax ginseng. The results show the straw and pig manure in the three modified substrates. The content of saponins has an obvious influence.

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