Survey on Fertility of Tea Garden Soil in Meizhou Region

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Abstract Survey on fertility of tea garden soil in Meizhou region indicates that tea garden soil has strong acidity; organic matter content remains at medium level; there is a severe lack of available content of nitrogen (N), phosphorus (P) and potassium (K); available calcium (Ca) and magnesium (Mg) content is also insufficient; available sulfur (S) is abundant. In the management of tea cultivation, it is recommended to supplement organic fertilizer, balance the application of NPK fertilizer, and adequately alleviate shortage of Ca and Mg element, to guarantee high and stable yield of tea.

Key words Tea garden, Soil fertility, Survey

Guangdong Province is one of the major tea production regions in China, and its tea planting area reaches 37 600 hm^2. Its tea planting is mainly concentrated in eastern region of Guangdong Province. Meizhou City plants 9 500 hm^2 (taking up 25.37% of the whole province), the yield is up to 11 200 tons (accounting for 21.79%) and both the planting area and yield rank first in Guangdong Province[1]. At present, the problem of excessive or insufficient fertilization coexist in tea garden management. Not only the phenomenon of "three values and three belittlements" (valuing chemical fertilizer and belittling organic fertilizer; valuing N fertilizer and belittling P and K fertilizer; valuing major element fertilizer and belittling trace element fertilizer) but also the traditional idea of regarding tea as a "heaven born and heaven raised" crop and in fear of chemical fertilizer application are existed in the fertilization management. Due to inadequate fertilization or shortage of nutrient in a long term, most tea gardens have the problem of uneven distribution or serious shortage of soil nutrient. In consequence, it leads to reduction of tea yield and degradation of tea quality, and exerts unfavorable influence on safe production and sustainable development of tea. Therefore, we surveyed the fertility of tea garden soil in Meizhou region, aiming at providing reference for scientific application of fertilizer.

1 Materials and methods

1.1 Collection of samples We selected 3 typical traditional tea production sites (Matu, Tangkeng and Qingliangshan) and collected 41 soil samples for 0 -20 cm soil layer. Each sample represents the area of 6.67 hm^2; subsamples are is randomly distributed; 10 subsamples are mixed to one sample. Samples were air dried and sieved in the room for test.

1.2 Items of sample test The content of organic matter and pH[2], as well as available content of N, P. K, Ca, Mg and SI[3] were analyzed. The critical values of available nutrients shortage were listed in Table 1. Survey data treatment was implemented with the aid of Excel software.

Table 1 Critical values of soil nutrient elements mg/kg

Items	N	P	K	Ca	Mg	S
Critical values of deficiency	50	12	78	400	121	12

2 Results and analyses

2.1 The pH value of tea garden soil in Meizhou region

Survey results (Table 2) indicate that the soil of these 3 sites turns acidic. The range of pH value of soil in Matu, Tangkeng and Qingliangshan tea gardens are 3.83 -5.20, 3.99 -5.53 and 3.64 -5.83 respectively, and coefficient of variation is separately 7.91%, 9.32% and 15.02% with the widest variation in site of Qingliangshan. Among these 3 sample sites, Qingliangshan has the highest soil acidity, its strong acid soil with pH value lower than 4.0 accounts for 43.8%, while Matu and Tangkeng take up 14.3% and 9.1% respectively; for pH value within 4.0 -5.0, Tangkeng soil takes up the largest portion (81.8%), the next is Matu (76.2%), and the last is Qingliangshan (43.8%); for pH value above 5.0, the proportion is 9.5%, 9.1% and 12.4% respectively; no sample has pH value greater than 6.0.

2.2 Organic matter of soil in tea gardens of Meizhou region

From Table 2, it can be seen that the organic matter of soil stays at medium level in Matu, Tangkeng and Qingliangshan tea gardens. Tea gardens in Qingliangshan have the lowest content of organic matter (8.2 -21.0 g/kg) with the coefficient of variation at 31.65%, and samples with organic matter lower than 10.0 g/kg account for 31.3%, and samples with organic matter higher than 15.0 g/kg take up 24.9%; tea gardens in Tangkeng have organic matter within 11.8 -19.1 g/kg with the coefficient of variation at 14.41%, about 54.5% soil has organic matter of 10.0 -15.0 g/kg, and 45.5% soil has organic matter higher than 15.0 g/kg; tea gardens in Matu have the content of organic matter within the

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range of 9.1 – 32.1 g/kg with the coefficient of variation at 44.43%, different soil samples have great difference in content of organic matter, 14.3% soil has organic matter lower than 10.0 g/kg, 47.6% soil has organic matter within 10.0 – 15.0 g/kg, and 38.1% soil has the organic matter above 15.0 g/kg.

2.3 Available N level of soil in tea gardens of Meizhou region Survey results (Table 3) indicate that rapidly available N level of soil is 54.9, 53.1 and 57.2 mg/kg in Matu, Tangkeng and Qingliangshan respectively, and the coefficient of variation is 41.9%, 29.15% and 32.01% respectively. Matu has the largest portion (61.9%) of soil with content of available N level below the critical value, the next is Tangkeng, accounting for 45.5%, and the last is Qingliangshan, accounting for 37.5%. Generally, the available N level of soil in these 3 tea gardens remains at the shortage level, and Matu tea garden soil has the lowest content of rapidly available N level.

Table 2 The pH value of tea garden soil in Meizhou region

Place	Min.	Max.	Average	Coefficient of variation // %	<4.0 (%)	4.0 – 5.0 (%)	5.0 – 6.0 (%)	>6.0 (%)
Matu	3.83	5.20	4.30	7.91	14.3	76.2	9.5	0.0
Tangkeng	3.99	5.53	4.47	9.32	9.1	81.8	9.1	0.0
Qingliangshan	3.64	5.83	4.28	15.02	43.8	43.8	12.4	0.0

Table 3 Organic matter of soil in tea gardens of Meizhou region

Place	Min. // g/kg	Max. // g/kg	Average // g/kg	Coefficient of variation // %	<10.0 (%)	10.0 – 15.0 (%)	>15.0 (%)
Matu	9.1	32.1	16.1	44.43	14.3	47.6	38.1
Tangkeng	11.8	19.1	15.5	14.41	0.0	54.5	45.5
Qingliangshan	8.2	21.0	13.3	31.65	31.3	43.8	24.9

Table 4 Available N level of soil in tea gardens of Meizhou region

mg/kg

Place	Min.	Max.	Average	Coefficient of variation // %	Proportion lower than critical value // %
Matu	33.0	123.9	54.9	41.90	61.9
Tangkeng	33.1	92.0	53.1	29.15	45.5
Qingliangshan	32.4	95.0	57.2	32.01	37.5

2.4 Available P level of soil in tea gardens of Meizhou region Survey results (Table 4) show that the available P level of soil is not uniformly distributed in tea gardens of Meizhou region. The coefficient of variation for available P level is 81.89%, 118.71% and 80.63% in tea garden soil of Matu, Tangkeng and Qingliangshan separately. In Matu tea gardens, the available P level of soil remains in 3.6 – 133.9 mg/kg (49.7mg/kg on average), and 25.0% soil has available P level lower than the critical value; in Tangkeng tea gardens, the available P level of soil is in the range of 3.5 – 68.8 mg/kg (21.9 mg/kg on average), and 72.7% soil has available P level lower than the critical value; in Qingliangshan tea gardens, the available P level of soil stays in 2.8 – 25.6 mg/kg (7.1 mg/kg on average), and 90.5% soil has available P level lower than the critical value. In general, the available P level of soil in Qingliangshan tea gardens is the lowest, and the next is Tangkeng. Tea gardens in these two places are short of available P level. The situation in Matu tea gardens is better, but the available P level is still at medium or low level.

2.5 Available K level of soil in tea gardens of Meizhou region From Table 5, it can be seen that the available K level of soil is not uniformly distributed in Matu, Tangkeng and Qingliangshan tea gardens. The coefficient of variation is 47.53%, 51.77% and 37.16% with average value of 68.2 mg/kg, 44.1 mg/kg and 48.7 mg/kg respectively. This indicates that the available K level of soil remains at the shortage level: the shortage of available K level is most serious in Qingliangshan tea gardens, followed by Tangkeng and Matu tea gardens. The soil with available K level lower than the critical value accounts for 93.8%, 90.9% and 71.4% respectively.

Table 5 Available P level of soil in tea gardens of Meizhou region

mg/kg

Place	Min.	Max.	Average	Coefficient of variation // %	Proportion lower than critical value // %
Matu	2.8	25.6	7.1	80.63	85.7
Tangkeng	3.5	68.8	21.9	118.71	72.7
Qingliangshan	3.6	133.9	49.7	81.89	18.8

Table 6 Available K level of soil in tea gardens of Meizhou region

mg/kg

Place	Min.	Max.	Average	Coefficient of variation // %	Proportion lower than critical value // %
Matu	21.6	164.9	68.2	47.53	71.4
Tangkeng	21.5	100.5	44.1	51.77	90.9
Qingliangshan	27.6	104.0	48.7	37.16	93.8

2.6 Available Ca level of soil in tea gardens of Meizhou region Survey results (Table 6) show that the available Ca level of soil is not uniformly distributed in tea gardens of Matu, Tangkeng and Qingliangshan. The coefficient of variation is 97.47%, 93.19% and 102.53% with average of 203.8 mg/kg, 275.5 mg/kg and 316.9 mg/kg respectively; the soil with available K level lower than the critical value accounts for 85.7%, 81.8% and 75.0% respectively. In general, tea gardens in Matu, Tangkeng and Qingliangshan are extremely short of available Ca level in soil.

2.7 Available Mg level of soil in tea gardens of Meizhou region Survey results (Table 7) indicate that the available Mg level of soil is not uniformly distributed in tea gardens of Matu, Tangkeng and Qingliangshan. The coefficient of variation is 91.75%, 77.42% and 48.25% with average of 23.1 mg/kg, 20.2 mg/kg and 27.7 mg/kg respectively. In all samples, the available Mg level of soil is lower than the critical value, showing extreme shortage of magnesium.

Table 7 Available Ca level of soil in tea gardens of Meizhou region

mg/kg

Place	Min.	Max.	Average	Coefficient of variation//%	Proportion lower than critical value//%
Matu	55.3	822.5	203.8	97.47	85.7
Tangkeng	69.1	918.7	275.5	93.19	81.8
Qingliangshan	68.6	1210.7	316.9	102.53	75.0

Table 8 Available Mg level of soil in tea gardens of Meizhou region mg/kg

Place	Min.	Max.	Average	Coefficient of variation//%	Proportion lower than critical value//%
Matu	7.5	85.5	23.1	91.75	100.0
Tangkeng	9.4	65.0	20.2	77.42	100.0
Qingliangshan	11.3	57.6	27.7	48.25	100.0

2.8 Available S level of soil in tea gardens of Meizhou region Survey results (Table 8) show that the available S level of soil is rich in tea gardens of Matu, Tangkeng and Qingliangshan. In Matu tea gardens, the available S level of soil is in the range of 30.5 – 56.8 mg/kg (45.3 mg/kg on average), with coefficient of variation 16.19%; in Tangkeng tea gardens, the available S level of soil is in the range of 28.4 – 82.0 mg/kg (53.2 mg/kg on average), with coefficient of variation 26.65%; in Qingliangshan tea gardens, the available S level of soil is in the range of 22.4 – 105.4 mg/kg (37.5 mg/kg on average), with coefficient of variation 52.79%, higher than that in Matu and Tangkeng tea gardens. This indicates that the available S level is abundant in soil of three sample tea gardens.

3 Conclusions and discussion

Suitable pH value of soil for tea growth should be below 6.5. Excessive acidity will influence tea quality, and in the range of 5.0 – 6.5, it can obtain better tea quality[4]. In Meizhou region, most tea gardens have pH value of soil in 4.0 – 5.0, which is acid or strong acid soil, so it is required to apply farm manure or neutral organic fertilizer to adjust soil acidity. The organic matter in soil is an important indicator for assessing ripeness of soil and fertility of tea garden soil, and plays a significant role in growth of tea trees and quality and yield of tea. Applying organic fertilizer can improve color, fragrance and water extract of tea infusion[5-6], and Chinese famous tea producing areas have organic matter content of soil higher than 20.0 g/kg[7]. In this survey, we found that most tea gardens in Meizhou region have medium level of organic matter, so it is required to properly increase application of farm manure or organic fertilizer, to improve organic matter in soil and increase soil fertility. Nitrogen, phosphorus and potassium can significantly increase tea yield, and play important role in improving tea quality. Nitrogen is important composition of protein, amino acid and caffeine of tea[8]; phosphorus promotes synthesis of flavonoid, polyphenols and L – Theanine[9]; potassium can significantly increase polyphenols and free amino acid in tea[10]. However, the soil in Meizhou tea gardens is available potassium, available phosphorus and rapidly available nitrogen. The shortage degree is available K level > available P level > available N level. This may be resulted from no or insufficient application of fertilizer for a long time. Therefore, it is required to reinforce application of major element fertilizer. Sulfur is important composition of amino acid. It participates in synthesis of protein and is closed related to synthesis of vitamin and chlorophyll[9]. In addition, calcium and magnesium content in soil should not be too high. Too high calcium and magnesium will influence tea quality[11]. On the contrary, it will impair growth of tea tree. Researches have shown that increasing application of magnesium fertilizer in red – yellow tea gardens with low content of magnesium can improve tea quality[12]. Available calcium and magnesium remain at shortage level in soil of Meizhou tea gardens. The proportion of magnesium shortage reaches 100.0%. Thus, it should properly supplement calcium fertilizer, especially application of magnesium fertilizer. Available S level is abundant in soil of Meizhou tea gardens. In view of the above survey results, it is recommended to supplement application of organic fertilizer in tea cultivation and management, balance application of nitrogen, phosphorus and potassium fertilizer, and properly supplement trace element such as calcium and magnesium, so as to ensure high and stable yield of tea, and to realize sustainable development of tea industry.

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(To page 105)

culture, rich natural landscape and strong ethnic and folk customs, local cultural deposit, which provide solid foundation for construction of forest culture. In this new historical period and trend, it is especially necessary to further enhance forest cultural construction, and promote development of forest culture through making plans, improving policies, innovating mechanisms and strengthening support, *etc*.

3.9 Taking the responsibilities of environmental protection and national development becomes the core of forestry related international convention and the common requirements of international society From the 1920s, international society started formulation of environmental protection laws. Especially after the United Nations Conference on the Human Environment held in Stockholm in 1972 and the United Nations Conference on Environment and Development held in 1992, a lot of international conventions related to forest environment were concluded, including *Ramsar Convention on Wetlands*, *Convention on International Trade in Endangered Species of Wild Fauna and Flora*, *International Tropical Timber Agreement*, *Agenda* 21, *Declaration of Principles on Forest*, *Convention on Biological Diversity*, *United Nations Framework Convention on Climate Change*, *Kyoto Protocol*, and *United Nations Convention to Combat Desertification*, *etc*. Taking responsibilities of environmental protection and national development becomes the core of forestry related international convention. Environmental protection oriented towards protection of biological diversity, wetland protection, prevention and control of desertification, is receiving more and more attention of international society and countries. In recent 30 years, forest problem has attracted unprecedented attention and takes on international trend. The 1992 United Nations Conference on Environment and Development put the forest problem to a new height, and finally formed the *Agenda* 21 and *Declaration of Principles on Forest*. Focus of international society about forest issue is mainly on international convention on forest. For this, international society has reached extensive common understanding that international society must make joint effort, pay highly attention to and promote protection and sustainable forest management. Through efforts of all sides, UN Economic and Social Council passed *Non-legally Binding Instrument on All Types of Forests* in 2007. Any action taken by the international society in forest issue will exert certain influence on forest protection and sustainable management in China. As a large developing country, China also has responsibility and duty to protect global environment and forest resources, and should participate in major related discussion, cooperation and exchange in active attitude. Since 1946, China has concluded or participated in 40 major international environmental contentions, including the above mentioned conventions related to forest issue.

3.10 Acceleration of forestry globalization development fosters new international forestry Nowadays, economic globalization is developing further, trade liberalization trend is irreversible, revolution of new high technology is speeding up, and global and regional cooperation is in the ascendant. In particular, with increasingly prominent of global environmental problem, the connection of forestry with economic development, climate change and international environmental protection activities is closer and closer. This promotes people to review forest from the global perspective and rethink development path of world forestry. In the new situation, with acceleration of globalization, forestry development of any country is inseparable from the world. It needs sharing development opportunity and jointly dealing with various challenges. It can be said that globalized new forestry has become inevitable trend of global forestry development. This not only provides China with unprecedented opportunity for forestry development, but also brings huge challenges. China's forestry management should fully understand international rules, follow new concept of global forestry development, and constantly adjust and optimize forestry policies, to constantly improve its contribution to regional and global forestry development.

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(From page 99)

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