Evaluation of Trace Elements in the Soil of Typical Peach Orchards in Zunyi City

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Abstract [**Objectives**] This study was conducted to clarify the enrichment and paucity of trace elements in the soil environment of peach orchards in Zunyi City, and to provide reference for supplementary application of microelement fertilizers and high-quality peach production in peach orchards. [**Methods**] Taking the soil of three typical peach orchards (Taoli Renjia peach orchard, Pengrui peach orchard and Taohuadao peach orchard) in Shenxi Town, Honghuagang District, Zunyi City as the research object, the contents of trace elements in soil were analyzed through field sampling and indoor determination of trace elements. [**Results**] The effective contents of trace elements in the soil of peach orchard bases in the study area were at a medium level, and the soil of the peach orchards was rich in available Fe and Se. The contents of available Cu, Mo and Mn were relatively rich. The contents of available B were not high overall. The contents of available Zn were at a moderate to low level overall. The soil of Taoli Renjia peach orchard was relatively rich in trace elements. [**Conclusions**] The research results can provide a scientific basis for the production of high-quality crispy peaches in peach orchards.

Key words Zunyi; Soil in peach orchard; Trace elements; Evaluation

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Soil is a loose porous material layer bearing the growth of green plants on the land surface, and it is a natural repository of trace elements and a database of basic materials on which plants depend for their livelihood. Trace elements refer to a group of chemical elements that are distributed widely in the natural environment system, mainly present in organic and inorganic forms with very small contents, but indispensable for the growth of organisms. Trace elements are necessary for the growth of animals, plants and microorganisms. They are closely related to animal molecular mitochondria, vitamins, protein, polysaccharides, nucleic acids, plant cell walls, chloroplasts, *etc.*[1-5]. They play an irreplaceable role in the plant growth system and have an important impact on the growth of peach trees and the quality of peach fruit.

In this study, soil available trace elements in three typical peach orchards (Taoli Renjia peach orchard, Pengrui peach orchard and Taohuadao peach orchard) in Shenxi Town, Honghuagang District, Zunyi City were evaluated, so as to clarify the nutrient status of trace elements in the soil environment of peach trees in Zunyi City and provide a scientific basis for the production of high-quality crispy peaches. This study makes up for the blank of soil trace elements research in production bases of high-quality crispy peaches in Zunyi City.

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Materials and Methods

Experimental materials

In this study, representative soils were collected in Taoli Renjia, Pengrui and Taohuadao peach orchards. The 0 – 30 cm of topsoil was taken by the 5-point sampling method, and a mixed soil sample of about 1 000 g was obtained by quartering. The soil samples were registered and coded, sealed and placed in the laboratory. After air-drying, grinding in a wooden grinding bowl and sieving, the samples were sealed for testing.

Testing and analysis methods

Available boron (B) in soil was determined by boiling water extraction-curcumin colorimetry. Available iron (Fe), manganese (Mn), zinc (Zn) and copper (Cu) in soil were determined by DTPA extraction-atomic absorption spectrophotometry. Available molybdenum (Mo) was extracted by an oxalic acid-ammonium oxalate solution, and determined by NH4SCN colorimetry[5]. Selenium (Se) was determined by hydride generation-atomic fluorescence spectrometry[6-7]. Abnormal data were processed by mathematical statistics. Through statistical analysis by Excel2021 and SPSS25 software, the effective value contents of soil trace elements (B, Zn, Cu, Mo, Fe, Mn, Se) have attracted more and more scholars. According to the regions, soil types and properties and climates, the evaluation criteria adopted by scholars are diverse. The grading criteria for the cultivated layer have been determined

through statistical analysis on the results of long-term field experiments by agricultural experts, so the national grading standards for trace elements were adopted, and trace elements were divided into five levels[3-4] (Table 1).

Table 1 Evaluation and grading criteria for available trace elements in soil mg/kg

Nutritive element	Critical value	Extremely low (level 5)	Low (level 4)	Medium (level 3)	High (level 2)	Extremely high (level 1)
Available B	0.50	<0.25	0.25-0.50	0.50-1.00	1.00-2.00	>2.00
Available Zn	1.50	<1.00	1.00-1.50	1.50-3.00	3.00-5.00	>5.00
Available Cu	0.20	<0.10	0.10-0.20	0.20-1.00	1.00-1.80	>1.80
Available Mo	0.15	<0.10	0.10-0.15	0.15-0.20	0.20-0.30	>0.30
Available Fe	4.50	<2.50	2.50-4.50	4.50-10.00	10.00-20.00	>20.00
Available Mn	3.00	<3.00	3.00-5.00	5.00-10.00	10.00-15.00	>15.00
Available Se	0.17	<0.125	0.125-0.175	0.175-0.40	0.40-3.0	>3.00

Results and Analysis

Analysis on trace elements in the soil of main peach orchards

The enrichment and paucity and contents of trace elements (B, Zn, Cu, Mo, Fe, Mn, Se) in soil environment of the three typical peach orchard bases in Zunyi City are shown in Table 1 and Table 2.

The lowest value of available B was 0.36 mg/kg in the three peach orchards, and the highest value was 0.60 mg/kg. In specific, the contents of Pengrui and Taohuadao were between 0.25 and 0.50 mg/kg, which was a low level (level 4). The value in Taoli Renjia peach orchard was 0.60 mg/kg, which was 1.67 times that of Pengrui peach orchard, and it was at a medium level. The soils in peach orchards were deficient in available B as a whole. B supports the disease resistance of peach trees, so it is suggested to supplement B-containing trace fertilizers in peach orchard bases.

The contents of available Zn ranged from 0.56 to 1.48 mg/kg, and were a low level as a whole, below the critical value. The condition was particularly significant in Pengrui and Taoli Renjia, both of which were less than 1.00 mg/kg, which was at a very low level (level 5). Zn can enhance stress resistance, so it is suggested that Zn-containing micro-fertilizer should be applied appropriately to supply available Zn content and meet the demand of peach trees for Zn.

The available Cu contents were between 0.58 and 1.69 mg/kg, and the overall level was above average. Pengrui and Taohuadao were in the middle level (level 3), and Taoli Renjia showed a value of 1.69 mg/kg, which was 2.91 times that of Pengrui peach orchard and was in the high level (level 2). Cu is beneficial to crop growth and development and affects photosynthesis. These three peach orchards did not need to be supplemented with Cu.

The lowest value of available Mo content was 0.17 mg/kg, and the highest value was 0.30 mg/kg. The values were above the medium level. Both Taoli Renjia and Taohuadao were in the middle level (level 3), and Pengrui showed the highest value of 0.30 mg/kg, which was relatively high. Mo is beneficial to the fixation of nitrogen intermediate electron transporters and the formation of vitamins. None of these three peach orchards needed to be supplemented with Mo.

The content of available Fe was relatively rich, ranging from 40.20 to 109.40 mg/kg, which far exceeded the very high level (grade 1), especially for Taoli Renjia, the content of available Fe was the highest at 109.40 mg/kg, which might be related to the local soil type. The contents of Mn were between 6.40 and 16.20 mg/kg, and the contents of Pengrui and Taohuadao were in the middle level (grade 3), and the value of Taoli Renjia was in the high level (grade 2). Available Fe and Mn play an important role in peach tree photosynthesis, vitamin C formation, chlorophyll formation, nitrogen metabolism and disease resistance enhancement[8-10].

The contents of available Se ranged from 0.48 to 0.52 mg/kg. The contents of the three peach orchards were close, and all at a high level (level 2), so the soil was rich in Se. Se has antioxidation, immunity enhancement, antivirus, thyroid hormone regulation and anti-tumor functions. Keeping the pH value and organic matter content stable is beneficial to the improvement of Se nutrition level and the development of Se-rich peach industry.

Table 2 Contents of available trace elements in the soil of high-quality peach orchards in Zunyi City mg/kg

Name of peach orchard	Sample No.	Available B	Available Zn	Available Cu	Available Mo	Available Fe	Available Mn	Available Se
Taoli Renjia	5	0.60	1.48	1.69	0.17	109.40	16.20	0.51
Pengrui	5	0.36	0.56	0.58	0.30	40.20	7.30	0.48
Taohuadao	5	0.39	0.88	0.70	0.18	66.20	6.40	0.52

Conclusions and Discussion

① Overall, the effective contents of trace elements in the soil of peach orchard bases in the study area were at a moderate level, and the soil of the peach orchards was rich in available Fe and Se, especially with significant Fe contents, all reaching a high level. The contents of available Cu, Mo and Mn were relatively rich, at a moderate to high level. The contents of available B were not high overall, distributed at a moderate to low level. The contents of available Zn were at a moderate to low level overall, all below the critical value and relatively lacking. The soil of Taoli Renjia peach

orchard was relatively rich in trace elements.

② Fertilization suggestions and measures: Appropriate amounts of grey shell and organic fertilizer can be applied to adjust soil pH value, accelerate soil mineral weathering, and promote the release and activation of trace elements such as B and Cu. Or the supplemented content of organic matter can be increased to increase the content of humus. It is also necessary to reasonably apply nitrogen, phosphorus and potassium compound fertilizers and maintain Se levels. Due to the lack of available B in the soil, B-containing microelement fertilizers should be applied in an appropriate amount, and it is recommended to mix B fertilizer with calcium phosphate or organic fertilizer for supplementary application. The soil in peach orchards is deficient in available Zn, and appropriate supplementation of Zn-containing microelement fertilizers is necessary. The mixed application of Zn, phosphorus fertilizer and urea has a more effective fertilizer efficiency. Efforts in soil and water conservation should be strengthened to prevent the loss of trace elements.

References

[1] YAN X, ZHANG YZ, ZHOU WJ, *et al.* Assessment for soil fertility quality of 6 tea bases of Baili Tea Zone in Changsha County[J]. Research of Agricultural Modernization, 2007(3): 354 – 357. (in Chinese).

[2] MA FL, SONG LM, WANG JM. Overview of research on trace elements in soil[J]. Qinghai Science and Technology, 2009, 16(3): 32 – 36. (in Chinese).

[3] ZHANG XQ, CHEN J, GAO XB, *et al.* Analysis on pH and major soil nutrients of tea gardens in key tea producing areas of Guizhou[J]. Southwest China Journal of Agricultural Sciences, 2015, 28(1): 286 – 291. (in Chinese).

[4] FENG XQ, YAN WX, FAN XP, *et al.* Evaluation of soil available trace elements and fertilization techniques in Mian County[J]. Primary Agricultural Technology Extension, 2017, 5(10): 101 – 102. (in Chinese).

[5] ZHANG JL, ZHANG G. Abundance evaluation of trace elements in tobacco planting soil of Nanbin in Shizhu County[J]. Journal of Anhui Agricultural Sciences, 2016, 44(23): 111 – 113. (in Chinese).

[6] ZHOU Y, WU WL, MENG FQ, *et al.* Review on the content, specification of selenium and its availability in soils[J]. Journal of Agricultural Resources and Environment, 2014, 31(6): 527 – 532. (in Chinese).

[7] ZHANG XL. Analysis of selenium content in tea leaves from the main tea producing areas in southern Anhui and its influencing factors[D]. Hefei: Anhui Agricultural University, 2014. (in Chinese).

[8] YANG MS, HUANG J, HE ZX, *et al.* The influence of geological background on trace elements of soil: A case study of Yubei Area[J]. Geophysical and Geochemical Exploration, 2018, 42(1): 199 – 205, 219. (in Chinese).

[9] ZHAO CC, WANG Y, GAO RM. Soil trace element abundance in different forest types at the Loess hilly region of Qinghai Province[J]. Journal of Arid Land Resources and Environment, 2017, 31(3): 130 – 135. (in Chinese).

[10] LI Y, LIU YH, ZHAO N, *et al.* Determination of Se in soils of Ziyang high selenium region by microwave digested-hydride generation atomic fluorescence spectrometry[J]. Journal of Anhui Agricultural Sciences, 2013, 41(18): 7800 – 7801, 7805. (in Chinese).

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Environmental stress induces oxidative damage and changes the balance of ROS production and clearance. The damage of drought and heat stress to turfgrass in cold season is related to the decrease of antioxidant enzyme activity and lipid peroxidation induced by oxidative stress[9]. In *C. dactylon* under drought stress and *S. guianensis* in warm season under cold stress, the antioxidant enzyme activity decreased[10]. During the whole stress period, the SOD activity of *D. sanguinalis* decreased easily due to the influence of low temperature. After 5 and 10 d of cold storage, the activity of CAT and POD increased temporarily, while plants were not or rarely damaged by cold storage stress. After 10 d of cold storage, the activity of CAT and POD decreased with the increase of cold storage days, and was related to the increase of osmotic potential, indicating that the decrease of antioxidant enzyme activity was related to 10 d of cold storage.

ABA has a positive effect on the cold resistance of maize[10]. *D. sanguinalis* treated with ABA had higher CAT and POD activity than untreated plants, especially after 10 d of low temperature stress. Our results are consistent with previous investigations on other plants. ABA increased the activity of CAT and POD, and ABA triggered the increase of ROS production, which further led to the induction of the antioxidant system. The results showed that ABA improved the cold resistance of *D. sanguinalis*, which was related to the induction of the antioxidant system.

References

[1] DMITRY B, JUHASZOVA M, Sollott SJ. Mitochondrial reactive oxygen species (ROS) and ROS-induced release[J]. Physiol. Rev., 2014 (94): 909 – 950.

[2] SWANSON S., GILROY S. ROS in plant development[J]. Physiol. Plantarum, 2010(138): 384 – 392.

[3] HODGSON RAJ, RAISON JK. Superoxide production by thylakoids during chilling and its implication in the susceptibility of plants to chilling-induced photoinhibition[J]. Planta, 1991(183): 222 – 228.

[4] PASTORI G, FOYER CH, MULLINEAUX P, *et al.* Low temperature-induced changes in the distribution of water and antioxidants between the bundle sheath and mesophyll cells of maize leaves[J]. J. Exp. Bot., 2000(342): 107 – 113.

[5] QUEIROZ CGS, ALONSO A, MARES-GUIA M, *et al.* Chilling-induced changes in membrane fluidity and antioxidant enzyme activities in *Coffea Arabica* L. roots[J]. Biol. Plant., 1998(41): 403 – 413.

[6] BRAVO LA, ZŮÑIGA GE, ALBERDI M, *et al.* The role of ABA in freezing tolerance and cold acclimation[J]. Physiol. Plant., 1998 (103): 12 – 23.

[7] GIANNOPLITIS CN, RIES SK. Superoxide dismutase: I. Occurrence in higher plants[J]. Plant Physiol., 1977(59): 309 – 314.

[8] CHANGE B, MAEHLY AC. Assay of catalases and peroxidase[J]. Methods in Enzym., 1955(2): 764 – 775.

[9] LIU X, HUANG B. Heat stress injury in relation to membrane lipid peroxidation in creeping bentgrass[J]. Crop Sci., 2000(40): 503 – 510.

[10] LU S, GUO Z, PENG X. Effects of ABA and S-3307 on drought resistance and antioxidative enzyme activity of turfgrass[J]. J. Hort. Sci. Biotech., 2003(78): 663 – 666.

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