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Available Contents and Spatial Distribution of Soil Microelements of Tobacco Fields in Liupanshui City

Shihai Wang[1], Chongde Zhang[1], Wengang Yang[1*], Jun Shang[1], Changquan Li[1], Zhongyu Wang[1], Wenjie Pan[2], Chaoying Jiang[2], Yuntao Zeng[2], Xiangzhen Kong[3,4], Decheng Li[3]

[1]Liupanshui Branch of Guizhou Tobacco Company, Liupanshui, China
[2]Guizhou Tobacco Company, Guiyang, China
[3]State Key Laboratory of Soil and Sustainable Agriculture, Institute of Soil Science, Chinese Academy of Sciences, Nanjing, China
[4]University of Chinese Academy of Sciences, Beijing, China
Email: *2510444363@qq.com

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Abstract

The contents of soil microelements can affect the growth, yield and quality of tobacco, but it is not clear of the status quo of soil microelements in tobacco fields in Liupanshui city. In this study, soil samples of the plough layers (0 - 20 cm) were collected from January to March in 2021 from 500 typical tobacco fields in Liupanshui City (100, 180 and 220 fields in Zhongshan, Shuicheng and Panzhou, respectively), the particle size composition, pH, the contents of organic matter (OM), available boron (B), copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo) and zinc (Zn) were measured and discussed. the results show that the mean contents of B, Cu, Fe, Mn, Mo and Zn are 0.92, 2.55, 66.47, 47.26, 0.39 and 3.96 mg/kg, respectively, and among which, B, Cu and Zn are at the high grades while Fe, Mn and Mo are at the very-high grades. There are significant differences in B, Fe and Zn among the three regions, while Cu is significantly different between Zhongshan and Shuicheng, Mn is significantly different between Panzhou with Zhongshan and Shuicheng, and Mo is significantly different between Zhongshan and Panzhou. The proportions of fields deficient in microelements are relatively low, no field is Fe-deficient, and the fields deficient in Mo, B, Cu, Zn and Mn are only account for 10.40%, 9.40%, 7.40%, 2.80% and 2.00% of the total fields respectively. B-deficient fields (green and light green colors, the same below) are mainly scattered in the northwest of Zhongshan and in the north and south of Panzhou, Cu-deficient fields mainly in the middle of Shuicheng and Panzhou, Mn-deficient fields mainly in northern Zhongshan, central Shuicheng and north of Panzhou. Mo-deficient fields are mainly in the middle of

Shuicheng and the middle and east of Panzhou, while Zn-deficient fields are mainly in the middle of Shuicheng and the middle and east of Panzhou. Altitude is negatively correlated with Mn ($P < 0.05$), pH is negatively correlated with B ($P < 0.05$), Fe and Mn ($P < 0.01$), and OM is positively correlated with Fe and Zn ($P < 0.01$). Sand is negatively correlated with B ($P < 0.05$), Mn and Mo ($P < 0.01$), but positively correlated with Zn ($P < 0.01$). Silt is positively correlated with Mo ($P < 0.05$); clay is positively correlated with B ($P < 0.05$) and Mn ($P < 0.01$), but negatively correlated with Zn ($P < 0.01$). In conclusion, most of the fields do not need to apply micro-fertilizers in Liupanshui, but the fields deficient in microelements should be considered to use the corresponding fertilizers.

Keywords

Tobacco Field, Microelements, Contents, Spatial Distribution, Quantitative Assessment

1. Introduction

The microelements are essential for normal growth and development of plants [1], their contents in soils can affect the growth, yield and quality of tobacco [2]-[7]. So far, more attention have been paid to the study on soil microelements in tobacco fields, and more than 90 relevant pieces of literatures in Chinese have been published (CNKI, https://www.cnki.net/) with the time span from 2002 [8] to 2022 [9]. For example, Ding (2002) investigated the contents of microelements in major tobacco soils in Guizhou Province in 2000 and found that iron (Fe), found that manganese (Mn) was generally very rich, manganese (Mo) rich, copper (Cu) and zinc (Zn) moderate, and boron (B) poor, and the contents of microelements differed obviously among different areas and soil types. Ding *et al.* (2022) [9] studied the available contents of trace elements in 191 typical topsoil samples (0 - 20 cm) of tobacco-planting fields in central Henan Province in 2020, found that Mn was generally sufficient, Mo extremely insufficient, and Cu and Zn insufficient in some soil samples, and there were quadratic function correlations between pH and organic matter with trace elements.

Liupanshui City is one of the main tobacco-planting regions in Guizhou Province, with the current tobacco fields of 7000 hm^2, the annual yield of tobacco leaves of 12.5×10^4 t (the sweet-flavor style in China [10]). Soil properties of the tobacco fields in Liupanshui were studied by some previous studies [11] [12] [13] but little information is available on soil microelements. Soil available boron content was found insufficient in the tobacco fields in Liupanshui by previous studies on soil microelements in 2000 [14] and 2006 [15], but the status quo of soil microelements is not clear. Therefore, this study is to quantitatively assess the available contents and spatial distribution of soil microelements in tobacco fields in Liupanshui through the survey in 2021 in order to guide the rational application of micro-fertilizers.

2. Materials and Methods

2.1. Basic Information of Study Area

Liupanshui is located in the Yunnan-Guizhou Plateau of southwest China (25˚19'44"N - 26˚55'33"N and 104˚18'20"E - 105˚42'50"E) with a total area of 9914 km^2. The landform is mainly constituted of mountains and hills with the elevation of 586 - 2900 m, its mean annual temperature is 13˚C - 14˚C, precipitation is 1200 - 1500 mm, sunshine duration is 1100 - 1600 h, and frost-free period is 200 - 300 d. The main soil types of tobacco fields are yellow soil, lime soil and yellow-brown soil in Chinese Genetic Classification [16], roughly referred to Argosols or Cambosols in Chinese Soil Taxonomy [17], and Alfisols or Inceptisols in Soil Taxonomy of USA [18].

2.2. Sampling and Determination of Soil Samples

500 tobacco-planting units were divided in December of 2020 on the basis of the current spatial distribution of tobacco fields in Liupanshui city, then one typical tobacco field was determined in each tobacco-planting unit according to the information of terrain, parent material, tobacco perennial growth situation and crop rotation system, etc. (see **Figure 1**, among of the 500 fields, 100, 180 and 220 fields in Zhongshan, Shuicheng and Panzhou, respectively) according to the spatial distribution of tobacco fields. Soil samples of the plough layer (0 - 20 cm) in each typical field was collected from January to March in 2021 randomly at 8 sites with the stainless-steel soil drill and mixed fully (1.5 - 2 kg in total) before the application of base fertilizers and the transplantation of tobacco seedlings. After soil samples were natural air-dried and grinded, the particle size distribution of soil samples was tested by the pipette method with pretreatment for the removal of organic matter (OM) using H_2O_2 with Na hexametaphosphate as the dispersant agent. pH by potentiometry with the ratio of soil/water = 1:5, organic matter (OM) was tested by oxidation with $K_2Cr_2O_7$ and titration of excess dichromate with $(NH_4)_2FeSO_4$, available boron (B) by curcumin absorbance method, molybdenum (Mo) by oscillopolarography, and available iron (Fe), manganese (Mn), copper (Cu) and zinc (Zn) by atomic absorption spectrophotometry [19].

2.3. Classification of Soil Microelement Contents

According to the published literature [14] [15] on the tobacco fields in Guizhou, the classification of soil available microelement contents was determined for the tobacco fields in Liupanshui (**Table 1**).

2.4. Data Processing and Statistics

Microsoft Excel 2016 and IBM Statistics SPSS 22.0 software was used for data processing and statistics, significant differences and correlation and analysis (indicated by P < 0.05 or P < 0.01). The abnormal data were eliminated according to the mothed of mean ± 3 × S.D. The maps of the spatial distribution of microelements were formed by the kriging spatial interpolation method was used on ArcGIS 10.0 platform.

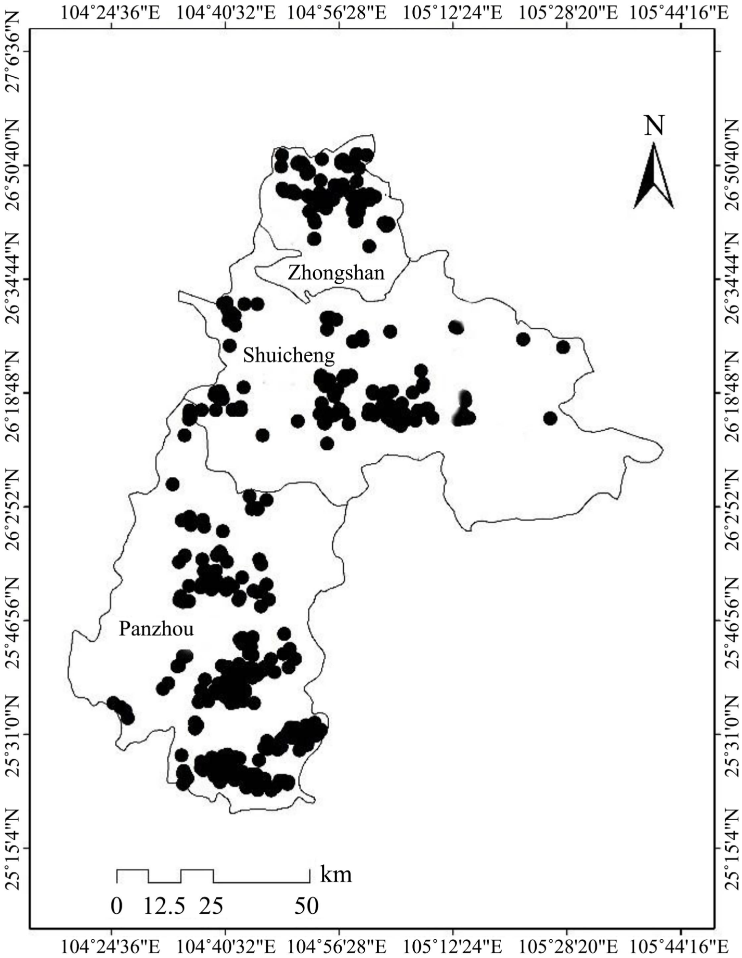

Figure 1. Sites of typical tobacco fields sampled in 2021 in Liupanshui.

Table 1. Classification of soil available microelement contents (mg·kg^{-1}).

Element	Grade				
	Very-Low	Low	Middle (Suitable)	High	Very-High
B	<0.15	0.15 - 0.3	0.3 - 0.6	0.6 - 1.0	≥1.0
Cu	<0.2	0.2 - 0.5	0.5 - 1.0	1.0 - 3.0	≥3.0
Fe	<2.5	2.5 - 4.5	4.5 - 10	10 - 60	≥60
Mn	<5	5 - 10	10 - 20	20 - 40	≥40
Mo	<0.1	0.1 - 0.15	0.15 - 0.2	0.2 - 0.3	≥0.3
Zn	<0.5	0.5 - 1.0	1.0 - 2.0	2.0 - 4.0	≥4.0

3. Results

3.1. General Statistics of Soil Microelements

Table 2 shows the statistical information of soil available microelement contents, the mean contents of B, Cu, Fe, Mn, Mo and Zn are 0.92, 2.55, 66.47, 47.26, 0.39 and 3.95 mg/kg, respectively, and compared with Table 1, B, Cu and Zn are at the high grades while Fe, Mn and Mo are at the very-high grades. All the elements are belonged to the moderate variation (C.V. (%) = 10% - 100%). Mn belongs to the negative skew distribution (Skewness < 0) and the gentle peak form (Kurtosis < 0), while other elements belong to the positive skew distribution (Skewness > 0) and the steep-peak form (Kurtosis ≥ 0) [20]. In terms of different

Table 2. General statistics of soil microelements.

Element	Region	n	Range mg·kg^{-1}	Mean ± S.D. mg·kg^{-1}	C. V. (%)	Skewness	Kurtosis
B	Total	500	0.03 - 5.39	0.92 ± 0.68	73.43	2.02	6.40
	Zhongshan	100	0.15 - 4.14	0.99 ± 0.74 B	74.58	1.45	3.03
	Shuicheng	180	0.07 - 5.39	1.11 ± 0.80 A	71.94	1.89	5.27
	Panzhou	220	0.03 - 3.09	0.74 ± 0.46 C	62.2	1.65	3.99
Cu	Total	500	0.03 - 21.15	2.55 ± 2.36	92.59	3.47	16.78
	Zhongshan	100	0.03 - 21.15	3.00 ± 2.59 A	86.54	4.03	24.64
	Shuicheng	180	0.05 - 17.16	2.41 ± 2.88 B	119.36	3.28	11.16
	Panzhou	220	0.05 - 10.59	2.46 ± 1.67 Ab	67.79	1.93	5.09
Fe	Total	500	8.84 - 220.10	66.47 ± 35.77	53.81	1.25	2.42
	Zhongshan	100	8.84 - 117.40	51.41 ± 23.72 C	46.13	0.59	0.03
	Shuicheng	180	13.76 - 214.75	74.78 ± 39.10 a	52.29	0.94	1.31
	Panzhou	220	13.08 - 220.10	66.52 ± 35.37 b	53.17	1.41	3.10
Mn	Total	500	3.75 - 70.80	47.26 ± 15.05	31.84	−0.84	−0.09
	Zhongshan	100	5.74 - 66.05	43.46 ± 15.71 b	36.15	−0.38	−0.80
	Shuicheng	180	3.75 - 67.50	42.86 ± 15.08 b	35.2	−0.55	−0.40
	Panzhou	220	5.01 - 70.80	52.59 ± 12.94 A	24.61	−1.56	2.25
Mo	Total	500	0.02 - 2.51	0.39 ± 0.26	66.11	2.25	10.51
	Zhongshan	100	0.13 - 1.45	0.44 ± 0.26 a	60.82	1.51	1.97
	Shuicheng	180	0.02 - 1.15	0.41 ± 0.23 ab	56.56	0.61	−0.07
	Panzhou	220	0.05 - 2.51	0.36 ± 0.28 b	76.56	3.45	19.28
Zn	Total	500	0.03 - 9.64	3.95 ± 1.62	40.9	0.32	0.43
	Zhongshan	100	0.03 - 9.64	5.05 ± 1.67 A	32.97	−0.2	0.91
	Shuicheng	180	0.06 - 9.34	3.87 ± 3.87 b	44.79	0.23	0.01
	Panzhou	220	0.07 - 7.68	3.51 ± 1.22 c	34.69	0.17	1.12

Different upper and lower case letters in the same column of Mean ± S.D. indicate significant difference at P < 0.01 and P < 0.05, respectively.

regions, there are significant differences in B, Fe and Zn among Zhongshan, Shuicheng and Panzhou, Cu is significantly different between Zhongshan and Shuicheng, Mn is significantly different between Panzhou with Zhongshan and Shuicheng, and Mo is significantly different between Zhongshan and Panzhou. All elements in Zhongshan and Panzhou are belonged to the moderate variation, while Cu in Shuicheng belongs to the intensive variation (C.V. (%) ≥ 100%) while the others belonged to the moderate variation. Mn in the three regions and Zn in Zhongshan belong to the negative skew distribution while others belonged to the positive skew distribution. Mn in Zhongshan and Shuicheng and Mo in Shuicheng are belonged to the gentle peak form, while others belonged to the steep-peak form [20].

3.2. Grade Statistical Information of Soil Microelements

Table 3 shows the grade statistical information of soil microelements, the proportion of fields deficient in microelements is low, no field is Fe-deficient, and the fields deficient in Mo, B, Cu, Zn and Mn (including Very low and Low grades, the same below) are only account for 9.40% of total fields in the whole city, accounted for 10.40%, 9.40%, 7.40%, 2.80% and 2.00% of the total fields in Zhongshan, Shuichen and Panzhou, respectively. In terms of the proportion of fields deficient in microelements in Zhongshan, Shuicheng and Panzhou, the fields deficient in B are accounted for 15.00%, 5.00% and 10.45%, respectively; the fields deficient in Cu accounted for 7.00%, 11.11% and 4.54%, respectively; the fields deficient in Mn accounted for 1.00%, 3.33% and 1.36%, respectively; the fields deficient in Mo accounted for 1.00%, 12.22% and 13.19%, respectively; and the fields deficient in Zn accounted for 2.00%, 2.23% and 3.64%, respectively.

Table 3. Grade statistics of soil microelements.

Element	Grade	Total		Zhongshan		Shuicheng		Panzhou	
		Field No.	%	Field No.	%	Field No.	%	Field No.	%
B	Very low	8	1.60	0	0.00	3	1.67	5	2.27
	Low	39	7.80	15	15.00	6	3.33	18	8.18
	Middle	144	28.80	23	23.00	43	23.89	78	35.45
	High	145	29.00	17	17.00	51	28.33	77	35.00
	Very high	164	32.80	45	45.00	77	42.78	42	19.09
	Total	500	100.00	100	100.00	180	100.00	220	100.00
Cu	Very low	17	3.40	2	2.00	8	4.44	7	3.18
	Low	20	4.00	5	5.00	12	6.67	3	1.36
	Middle	35	7.00	6	6.00	17	9.44	12	5.45
	High	311	62.20	55	55.00	116	64.44	140	63.64
	Very high	117	23.40	32	32.00	27	15.00	58	26.36
	Total	500	100.00	100	100.00	180	100.00	220	100.00

Continued

Fe	Very low	0	0.00	0	0.00	0	0.00	0	0.00
	Low	0	0.00	0	0.00	0	0.00	0	0.00
	Middle	1	0.20	1	1.00	0	0.00	0	0.00
	High	242	48.40	66	66.00	68	37.78	108	49.09
	Very high	257	51.40	33	33.00	112	62.22	112	50.91
	Total	500	100.00	100	100.00	180	100.00	220	100.00
Mn	Very low	2	0.40	0	0.00	2	1.11	0	0.00
	Low	8	1.60	1	1.00	4	2.22	3	1.36
	Middle	21	4.20	9	9.00	7	3.89	5	2.27
	High	119	23.80	32	32.00	61	33.89	26	11.82
	Very high	350	70.00	58	58.00	106	58.89	186	84.55
	Total	500	100.00	100	100.00	180	100.00	220	100.00
Mo	Very low	15	3.00	0	0.00	7	3.89	8	3.64
	Low	37	7.40	1	1.00	15	8.33	21	9.55
	Middle	49	9.80	8	8.00	17	9.44	24	10.91
	High	108	21.60	27	27.00	27	15.00	54	24.55
	Very high	291	58.20	64	64.00	114	63.33	113	51.36
	Total	500	100.00	100	100.00	180	100.00	220	100.00
Zn	Very low	5	1.00	2	2.00	3	1.67	0	0.00
	Low	9	1.80	0	0.00	1	0.56	8	3.64
	Middle	32	6.40	7	7.00	12	6.67	13	5.91
	High	229	45.80	41	41.00	85	47.22	103	46.82
	Very high	225	45.00	50	50.00	79	43.89	96	43.64
	Total	500	100.00	100	100.00	180	100.00	220	100.00

3.3. Spatial Distribution Soil Microelements

Figure 2 shows the spatial distribution of soil microelements, B-deficient fields (green and light green colors, the same below) are mainly scattered in the northwest of Zhongshan and in the north and south of Panzhou, Cu-deficient fields mainly in the middle of Shuicheng and Panzhou, Mn-deficient fields mainly in northern Zhongshan, central Shuicheng and north of Panzhou. Mo-deficient fields are mainly in the middle of Shuicheng and the middle and east of Panzhou, while Zn-deficient fields are mainly in the middle of Shuicheng and the middle and east of Panzhou.

3.4. Correlation between Soil Microelements and Other Factors

In this study, no information of soil parent material and soil types was obtained, so only the relationship between soil microelements with altitude, soil pH, organic matter (OM) and particle size composition are considered. Table 4 shows the statistical information of soil pH, OM and particle size composition (sand, silt and clay contents), and Table 5 shows their correlation with microelements. Altitude is negatively correlated with Mn ($P < 0.05$), pH is negatively correlated with B ($P < 0.05$) and with Fe and Mn ($P < 0.01$), OM is positively correlated with Fe and Zn ($P < 0.01$). Sand is negatively correlated with B ($P < 0.05$), Mn and Mo ($P < 0.01$), but positively correlated with Zn ($P < 0.01$). Silt is positively correlated with Mo ($P < 0.05$), clay is significantly correlated with B ($P < 0.05$) and Mn ($P < 0.01$), but negatively correlated with Zn ($P < 0.01$).

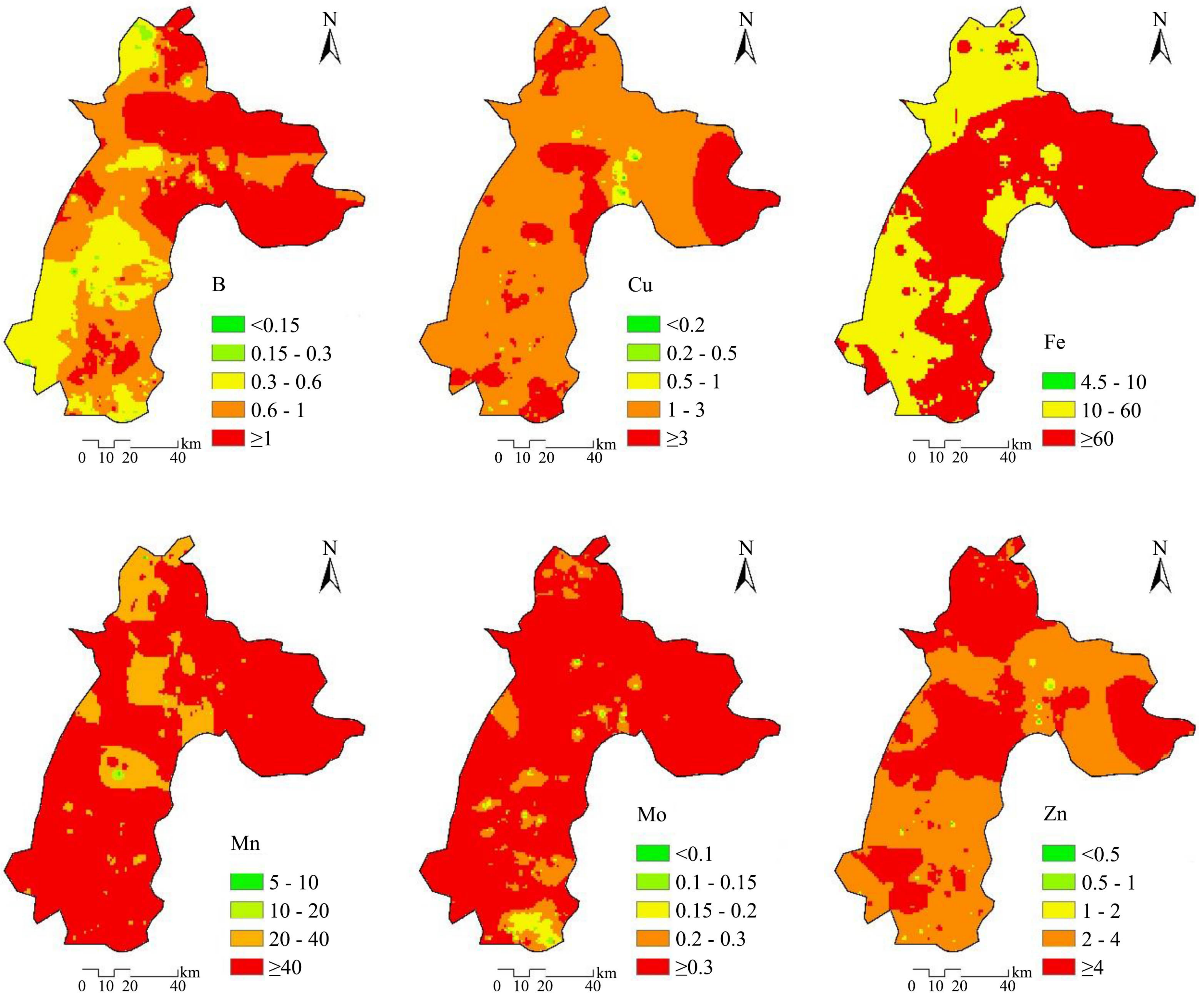

Figure 2. Grade distribution of soil microelements of tobacco fields.

Table 4. Statistics of altitude, soil pH, organic matter content and particle size composition.

Parameter	Range	Mean ± S.D.	C. V. (%)	Skewness	Kurtosis
Altitude (m)	1097 - 2110	1762 ± 128	7.29	−0.34	1.74
pH	3.88 - 8.73	5.91 ± 0.99	16.80	0.51	−0.22
OM ($g \cdot kg^{-1}$)	13.67 - 93.39	37.00 ± 11.23	30.35	1.16	2.84
Sand ($g \cdot kg^{-1}$)	6.76 - 62.95	26.72 ± 9.94	37.22	0.98	1.11
Silt ($g \cdot kg^{-1}$)	18.81 - 64.59	42.33 ± 7.54	17.82	−0.07	0.17
Clay ($g \cdot kg^{-1}$)	9.29 - 63.42	30.95 ± 9.15	29.56	0.19	0.05

Table 5. Correlation coefficients between other factors and soil microelements.

Factor	Correlation	B	Cu	Fe	Mn	Mo	Zn
Altitude	R	0.020	−0.043	0.051	−0.092*	0.057	0.032
	P (2-tails)	0.658	0.336	0.250	0.039	0.202	0.477
pH	R	−0.095*	−0.070	−0.681**	−0.273**	0.017	0.001
	P (2-tails)	0.034	0.120	0.000	0.000	0.701	0.990
OM	R	−0.081	0.038	0.207**	0.002	0.001	0.282**
	P (2-tails)	0.072	0.398	0.000	0.970	0.986	0.000
Sand	R	−0.089*	0.085	−0.005	−0.279**	−0.123**	0.138**
	P (2-tails)	0.047	0.057	0.909	0.000	0.006	0.002
Silt	R	−0.021	−0.050	0.066	−0.009	0.113*	−0.041
	P (2-tails)	0.640	0.265	0.140	0.844	0.012	0.362
Clay	R	0.114*	−0.051	−0.049	0.311**	0.041	−0.116**
	P (2-tails)	0.011	0.253	0.274	0.000	0.358	0.009

** or *, indicates significant difference at $P < 0.01$ or $P < 0.05$, respectively.

4. Discussions

This study shows that the contents of soil microelements are high in the tobacco fields in Liupanshui, which are similar to the previous studies [14] [15], and indicate most of the tobacco fields are sufficient in soil microelements. The high contents of soil microelements in Liupanshui could be attributed to that it is a well-known region rich in mineral resources (such as iron, zinc, copper, etc.) in southwest China.

This study also finds that there are significant differences in soil microelements in the tobacco fields between Zhongshan, Shuicheng and Panzhou. For example, Cu, Mo and Zn are the highest in Zhongshan, B and Fe are the highest in Shuicheng, and Mn is the highest in Panzhou. Usually, the types and amounts of fertilizers applied in the three regions are the same or very similar under the uniform technical standard for tobacco cultivation, and the years of tobacco planting is 37 years in Zhongshan, 51 years in Shuicheng and 72 years in Panzhou, therefore, it is difficult to explain the differences in soil microelements in the three regions from the perspective of fertilization and tobacco-planting years, which may suggest that it could be a combination of different factors.

As for the changes of soil microelements, it can be seen from **Table 6** that all the six microelements (B, Cu, Fe, Mn, Mo and Zn) show the decreasing trend from 2000 [14] to 2006 [15], decreased by 4.88%, 23.87%, 16.24%, 5.08%, 23.08% and 6.53%, respectively, which is possibly attributed to the seldom application of micro-fertilizers during this period. But from 2006 to 2021, only Cu shows a continuous decrease (decreased by 24.56%), all other microelements show the increasing trend, B, Fe, Mn, Mo and Zn are increased by 135.90%, 93.51%, 17.53%, 95.00% and 112.37%, respectively, which is possibly related to the application of micro-fertilizers (particularly of B, Mo and Zn fertilizers) during this period, anyhow, it is hard to explain accurately the increase of Fe since no Fe-fertilizer are used for the farmlands.

Table 7 lists the factors which could affect soil microelements as reported in the related literature [21]-[30]. In this study, altitude is significantly negatively correlated with Mn, which is consistent with the literature [21] [22] [23], but contrary to the literature [24]. pH is significantly negatively correlated with B, which is consistent with the literature [22] [23]; pH is significantly negatively correlated with Fe, which is consistent with the literature [22] [23] [24] [26] [28] [30], but contrary to the literature [27], and pH is significantly negatively correlated with Mn, which is consistent with the literature [23] [24] [30], but contrary to the literature [21]. OM is significantly positively correlated with Fe, which is consistent with the literature [22] [23] [25] [28] [30], but contrary to the literature [27], and OM is significantly positively correlated with Zn, which is consistent with the literature [23] [26] [27] [28], but contrary to the literature [22]. Sand is significantly negatively correlated with Mn, which is contrary to the literature [29], and sand is significantly positively correlated with Zn, which is consistent with the literature [29]. Clay is significantly positively correlated with Mn, which is consistent with the literature [29], but clay is significantly negatively correlated with Zn, which is contrary to the literature [29].

Table 6. Mean contents of soil microelements (mg·kg^{-1}) in different years.

Year	B	Cu	Fe	Mn	Mo	Zn
2000 [12]	0.41	4.44	41.01	42.36	0.26	1.99
2006 [13]	0.39	3.38	34.35	40.21	0.20	1.86
2021 (See **Table 2**)	0.92	2.55	66.47	47.26	0.39	3.95

Table 7. Correlation between other factors with microelements.

Factor	Correlation	B	Cu	Fe	Mn	Mo	Zn
Altitude	+		[22]		[22]	[22]	
	−		[21]	[21]	[19] [21]		[21]
pH	+			[25]	[19]	[19]	[20] [25]
	−	[20] [21]	[20] [22] [24] [26]	[20] [21] [22] [24] [26] [28]	[21] [22] [28]	[21]	[21] [26] [28]
OM	+	[20] [21]	[22] [24] [26] [28]	[20] [21] [23] [26] [28]	[21] [24] [25] [26]	[19] [21] [22]	[21] [22] [24] [25]
	−	[19]	[20]		[20]		
Sand	+		[27]	[27]	[27]		[27]
	−		[26]	[26]			
Clay	+		[26] [27]	[26] [27]	[27]		[27]

+ or −, indicates significant positive or negative correlation, respectively.

This study shows that the proportion of tobacco fields deficient in microelements is relatively low in Liupanshui, which indicates that most tobacco fields do not need to apply micro-fertilizers. However, it should also be noted that there are still 10.40%, 9.40%, 7.40%, 2.80% and 2.00% of tobacco fields insufficient in Mo, B, Cu, Zn and Mn, respectively, thus, corresponding micro-fertilizers should be applied in these fields, such as ammonium molybdate [31], holding boron [32], copper sulfate [33], macro-particle zinc [34], and manganese sulfate [35].

It should be pointed out that the assessment on the abundance or deficiency of microelements contents were based on the current grading standards in our study, although the results can generally guide the scientific application of micro-fertilizers, whether they are consistent with the actual demands for microelements of tobacco growth in Liupanshui city still remains to be verified by the practical effect of micro-fertilizer application in field experiments.

5. Conclusion

The study finds that the available contents of soil microelements (B, Cu, Fe, Mn, Mo, Zn) are generally high in the tobacco fields in Liupanshui city, and most fields do not need applying micro-fertilizers. The fields deficient in microelements are scattered in space and the corresponding micro-fertilizers should be applied. Altitude, pH, OM and particle size composition are significantly correlated with some soil microelements.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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