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Full Length Research Paper

Inductively coupled plasma mass spectroscopy (ICP-MS) determination of the trace element of *Physalis alkekengi* L. and its influence on the succession cropping obstacle

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To determine the contents of trace element (Mg, K, Ca, V, Mn, Fe, Co, Ni, Cu, Zn, Se, Pb) in *Physalis alkekengi* L. rhizomes and the soil near the rhizomes, ICP-MS method was applied. The result indicated that the enrichment of Mg, K, Ca reduced, simultaneously, Se and Pb increased in the rhizomes along with the years increasing, suggesting the contents of Mg, K, Ca, Se and Pb are the important reason leading to the succession cropping obstacle of *P. alkekengi* L.

Key words: Physalis, succession cropping obstacle, trace element, inductively coupled plasma mass spectroscopy (ICP-MS).

INTRODUCTION

The general reasons of the succession cropping obstacle were ascribed to fungi of soil inducing the aggravation of the epiphyte, the nematode increasing, allelopathy, the unilateral absorption of the nutrient elements and the deteriorate of the physical and chemical character of the soil (Zhang et al., 2009). The absorption and assimilation of the trace element of the higher green plants are a necessarily processes of the growth and therefore the absorption and assimilation could lead to the changes of the trace elements of the soil. Some studies show that certain specific plants follow the rules of type and proportion of mineral elements absorption and need certain trace elements. The long-term succession cropping the same medicinal plants, can easily lead to deficiency or imbalance of some elements in soil. If these elements can not be supplemented timely, anti-adversity will be decreased, which may lead to a serious insect disease and directly affect the plantation in the next year. As a result, both the yield and quality will decline (Yu et al., 2004; Guan et al., 2005; Jian et al., 2009). However, Liang Yinli has found that decline in soil nutrients is not the main reason for the succession cropping obstacle and increasing fertilization show no avail towards this obstacle. Therefore, the study of trace element of the plant is very important for investigating the succession cropping obstacle (Liang et al., 2004). Hence, our experiment has made a synchronous research of the nutrient and harmful elements. *Physalis alkekengi* is a perennial plants of Solanaceae, whose growth is strongly afraid of the same soil leading to the succession cropping obstacle, that is, it could not grow continuously with two years or more in the same planting area and can be replanted (succession cropping) in same area after 7 to 8 years. Therefore, the study of the changes of trace elements can provide the evidences of the succession cropping obstacle of *P. alkekengi*.

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MATERIALS AND METHODS

The samples of the Physalis rhizomes and soil was collected from Shenyang, China, which was identified by Prof. Bing Wang, and voucher samples (No. 20100415) were kept at School Pharmacy, Liaoning University of Traditional Chinese Medicine.

Instrument and reagents

Electronic balance, A MDS-6 digester/extracter, 7500A ICP-MS (Agilent American), all the cuvette was soaked in the 25% HNO_3 for 48 h .The standard sample of Mg, K, Ca, V, Mn, Fe, Co, Ni, Cu, Zn, Se, Pb were purchased from Agilent (NJ, USA, No. 5183-4680).

Table 1. Digestion conditions of sample.

Step	Pressure (Mpa)	Time (min)	Intensity (W)
1	0.3	4	600
2	0.6	4	600
3	1.0	4	600
4	1.5	10	600

Table 2. Parameter of ICP-MS.

Settings	Parameters
Velocity of flow of the gas	1.14 L/min
Velocity of flow of plasma	15.0 L/min
Power of the RF	1300 W
Temperature of atomizing chamber	2
Depth of the collection	8.4 mm
Number of dots/mass	6
Analysis time	0.1 s

Ultrapure water was prepared with a Milli-Q deionization unit (Millipore, Bedford, MA, USA).

Nitric acid used for sample digestion was of high-purity grade and purchased from Kermel Chemical Reagent Co., Ltd (Tianjin, P.R. China, No. 20101010).

The condition of instruments

Sample preparation

The sample of 0.3 g of the Physalis rhizomes was crushed then digested in the digestion tank and nitro acid of 5 ml was added for digestion and then transferred into 100 ml measuring flask, metered volume with ultrapure water, which was stored in the low temperature before analysis

The preparation of the soil samples eliminated the impurities and impurity and then crushed to the size of 40 mesh. To 10 g of the samples after accurately weighed, 50 ml 0.1 mol/L hydrochloric acid was added in 100 ml conical flask, filtrated after soaking for 1 h. The filtrate of 10 ml was added in the test tube before analysis (Zhang et al., 2003) (Tables 1 and 2).

RESULTS AND DISCUSSION

ICP-MS determination of the trace element in Physalis rhizomes and soils

The samples were determined using the quantitative ICP-MS method and the results were shown in Tables 3 and 4.

Statistical analysis

The results of Table 3 indicated that the contents of the V and Pb in the rot rhizome were higher than that in the common rhizomes. However, the content of K, Fe and Cu were lower in the rot rhizomes than that of the common rhizomes. The results of t-test indicated that the differences of V were very significant (P<0.01) and the differences of the contents of K, Fe, Cu and Pb were significant (P<0.05). The results of main element test suggested that the elements of Pb, Zn and Cu were the important factors which effect the growth of the rhizomes. The results of the t-test indicated that K and Mg; Mn and Ca; Fe and V; Co and Mn, Fe; Ni and Mn, Fe; Cu and V; Se and Mn, Fe; Pb and V, Co, Ni, Se, had horizontal relevance (P<0.05), (Table 5), Ni and Co; Se and Co, Ni; Pb and Fe have obvious relevance (P<0.01), (Table 5), indicating that the elements above presented good synergetic action. The result of clustering analysis (Figure 1) showed that the contents of trace elements in Physalis rhizomes varied according to the growing stage. Table 4 showed that the contents of Mg, K and Ca in the soil for the biennials and triennials growths were higher than that of the soil for the annual growths and the ability of absorption of Mg, K, Ca in soil was gradually attenuated along with the growth years, but the phenomena were did happened on other elements.

The results of ANOVA test and principle continuant analysis (PCA) test showed that Pb, Ca, Cu, Ni, V and Fe in the rhizomes and soil were the main factors which play a key role in the growth of rhizomes (Table 6). The concentration of Ca for the annual rhizomes was 9 times of that of the biennials and triennials rhizomes and the concentrations of V, Fe, Se and Pb in rot rhizomes were higher than that of the common rhizome (Table 7).

Conclusion

In conclusion, the results above showed that the reasons for succession cropping could be the reduction of Mg, K, Ca, and the enrichment of V, Fe, Co, Se and Pb in the

Table 3. Results of the trace elements in the rhizomes (μg/g).

Element	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Mg	3962.94	6441.43	3343.26	4849.49	4008.59
K	9616.38	9761.06	5183.71	8613.96	6159.95
Ca	6540.96	8023.89	8540.22	6665.56	7822.21
V	4.62	8.09	16.43	6.39	16.8
Mn	106.63	142.43	211.98	7.45	159.19
Fe	2628.74	4071.68	8768.62	3229.9	7690.02
Co	1.52	2.28	3.88	1.53	3.09
Ni	18.61	12.44	17.54	9.03	15.37
Cu	5.41	6.39	3.71	7.82	2.71
Zn	35.24	68.52	50.98	43.37	46.6
Se	0.21	0.31	0.5	0.2	0.4
Pb	2.16	4.08	9.62	2.76	8.06

p.s: Sample 1 was the annual rhizomes ; Sample 2 was the biennial rhizomes; Sample 3 was the biennial rot rhizomes; Sample 4 was the triennial rhizomes; Sample 5 was the triennial rot rhizomes. The samples in Figure 1 and Table 7 were the same.

Table 5. Results of the Correlation analysis of the trace elements in the rhizomes.

		Mg	K	Ca	V	Mn	Fe	Co	Ni	Cu	Zn	Se	Pb
Mg	*R*	1											
	P	0											
K	*R*	0.972*	1										
	P	0.028	0										
Ca	*R*	-0.308	-0.499	1									
	P	0.692	0.501	0									
V	*R*	-0.802	-0.916	0.684	1								
	P	0.198	0.084	0.316	0								
Mn	*R*	-0.558	-0.717	0.961*	0.83	1							
	P	*0.442*	0.283	0.039	0.17	0							
Fe	*R*	-0.833	-0.939	0.746	0.982*	0.893	1						
	P	0.167	0.061	0.254	0.018	0.107	0						
Co	*R*	-0.722	-0.853	0.877	0.921	0.975*	0.970*	1					
	P	0.278	0.147	0.123	0.079	0.025	0.03	0					
Ni	*R*	-0.668	-0.818	0.899	0.928	0.978*	0.962*	0.994**	1				
	P	0.332	0.182	0.101	0.072	0.022	0.038	0.006	0				
Cu	*R*	0.683	0.825	-0.691	-0.981*	-0.803	-0.936	-0.877	-0.905	1			
	P	0.317	0.175	0.309	0.019	0.197	0.064	0.123	0.095	0			
Zn	*R*	0.685	0.525	0.476	-0.253	0.216	-0.218	-0.004	0.054	0.152	1		
	P	0.315	0.475	0.524	0.747	0.784	0.782	0.996	0.946	0.848	0		
Se	*R*	-0.685	-0.825	0.901	0.909	0.984*	0.958*	0.999**	0.996**	-0.871	0.048	1	
	P	0.315	0.175	0.099	0.091	0.016	0.042	0.001	0.004	0.129	0.952	0	
Pb	*R*	-0.813	-0.925	0.779	0.974*	0.915	0.999**	0.981*	0.974*	-0.928	-0.172	0.972*	1
	P	0.187	0.075	0.221	0.026	0.085	0.001	0.019	0.026	0.072	0.828	0.028	0

p.s.: ** Correlation is significant at the 0.01 level. * Correlation is significant at the 0.05 level.

rhizomes. And the enrichment of V, Fe, Co, Se and Pb might lead to the rhizome rot. The modern studies indicated that the low concentration of Se was beneficial to the growth of the plant, however, it presented toxicity and lead to stunted growth and etiolation at the high concentration and Pb presented rank poison to the plant. Succession cropping of the *P. alkekengi* L.could change the physical and chemical properties of the soil. This

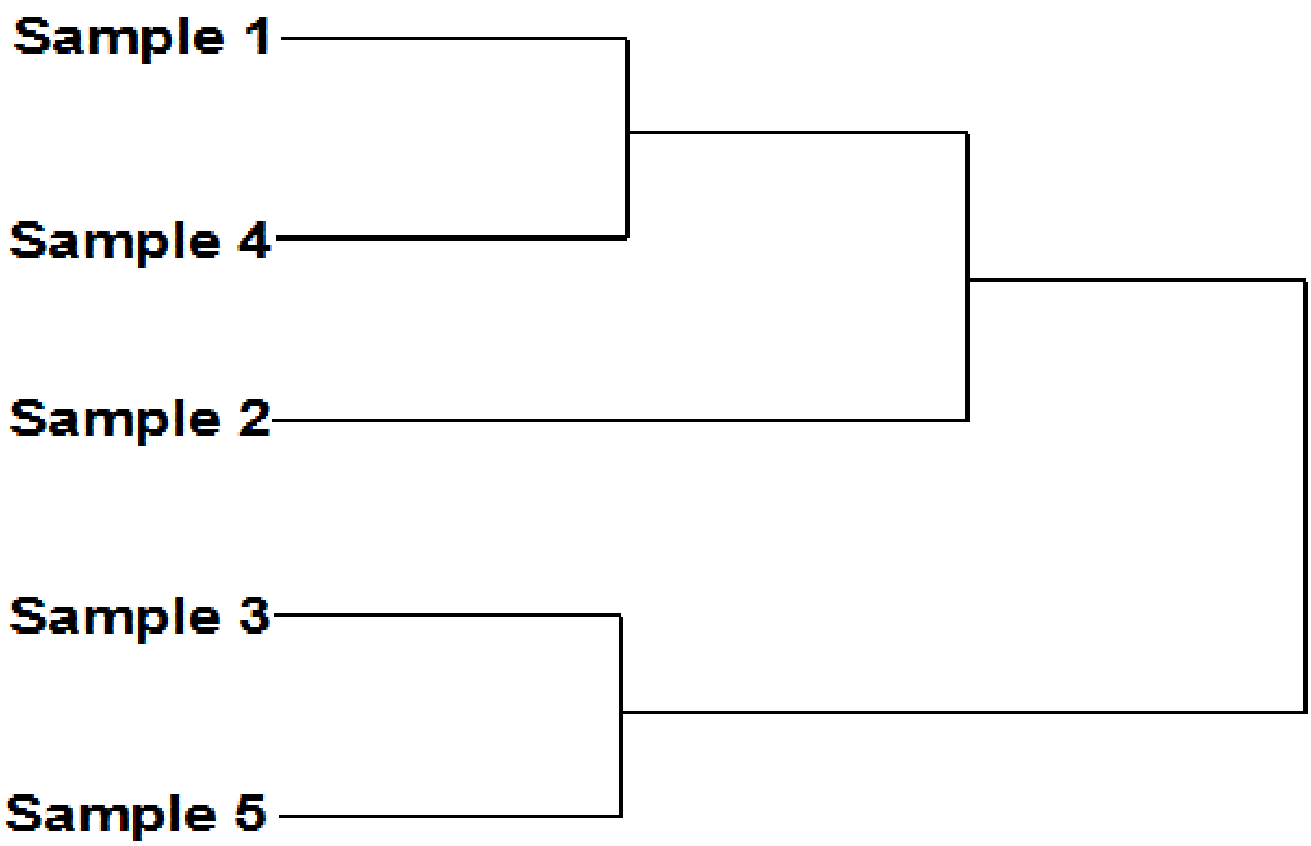

Figure 1. Results of the clustering test of the elements in the rhizomes.

Table 4. Results of the trace elements in the soil samples (μg/g).

Element	Soil sample 1	Soil sample 2	Soil sample 3
Mg	400.85	390.95	511
K	74.25	95.6	100.55
Ca	190.5	1949.5	2213
V	2.83	2.81	3.73
Mn	84.9	87.65	94.05
Fe	594	596.5	638.5
Co	0.4	0.45	0.5
Ni	0.57	0.55	0.57
Cu	3.49	3.18	4.36
Zn	3.16	3.54	3.99
Se	0.01	0.01	0.01
Pb	6.27	5.76	6.63

p.s.: The soil samples 1 to 3 were taken from the rhizomes planted 1, 2 and 3 years ago, respectively.

leads to serious nutrition imbalance which could affect the solubility changes of other elements in the soil and ultimately change the physical and chemical properties as well. Thus, it can be concluded that the additional supply of lost trace elements after planting Physalis and elimination of enriched toxic elements would be the

Table 6. Results of the correlation analysis of the trace elements between the rhizomes and soil.

		Mg	K	Ca	V	Mn	Fe	Co	Ni	Cu	Zn	Se	Pb
Mg	R	1											
	P	0											
K	R	0.961**	1										
	P	0	0										
Ca	R	0.892**	0.850**	1									
	P	0.003	0.008	0									
V	R	0.478	0.357	0.759*	1								
	P	0.231	0.385	0.029	0								
Mn	R	0.387	0.284	0.694	0.890**	1							
	P	0.343	0.496	0.056	0.003	0							
Fe	R	0.574	0.477	0.838**	0.983**	0.904**	1						
	P	0.137	0.232	0.009	0	0.002	0						
Co	R	0.645	0.554	0.886**	0.951**	0.922**	0.988**	1					
	P	0.084	0.154	0.003	0	0.001	0	0					
Ni	R	0.769*	0.819*	0.908**	0.694	0.683	0.789*	.834*	1				
	P	0.026	0.013	0.002	0.056	0.062	0.02	0.01	0				
Cu	R	0.626	0.657	0.342	-0.247	-0.306	-0.13	-0.045	0.182	1			
	P	0.097	0.076	0.407	0.555	0.461	0.76	0.916	0.666	0			
Zn	R	0.957**	0.875**	0.947**	0.664	0.628	0.747*	0.815*	0.816*	0.445	1		
	P	0	0.004	0	0.073	0.096	0.033	0.014	0.014	0.269	0		
Se	R	0.717*	0.64	0.923**	0.923**	0.888**	0.974**	0.994**	0.877**	0.036	0.863**	1	
	P	0.045	0.088	0.001	0.001	0.003	0	0	0.004	0.932	0.006	0	
Pb	R	-0.353	-0.502	-0.003	0.609	0.648	0.506	0.434	-0.03	-0.761*	-0.087	0.336	1
	P	0.391	0.205	0.995	0.109	0.082	0.201	0.283	0.944	0.028	0.838	0.415	0

** Correlation is significant at the 0.01 level. * Correlation is significant at the 0.05 level.

Table 7. The enrichment factor of the samples of the rhizomes.

Element	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Mg	9.886	15.709	8.552	9.49	7.845
K	129.514	102.103	54.233	85.668	61.263
Ca	34.336	4.116	4.381	3.012	3.535
V	1.636	2.878	5.843	1.715	4.508
Mn	1.256	1.625	2.419	0.802	1.693
Fe	3.877	6.855	14.762	5.059	12.044
Co	3.782	5.096	8.677	3.066	6.17
Ni	32.538	22.518	31.748	15.891	27.063
Cu	1.55	2.006	1.164	1.794	0.623
Zn	11.163	19.342	14.39	10.866	11.675
Se	20.415	27.581	44.333	19.029	37.463
Pb	0.345	0.708	1.669	0.416	1.216

hopeful relief for the succession cropping obstacle.

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