



Determination of Forty-Six Elements in Different Organs of *Orychophragmus violaceus* in Agricultural Farm

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Orychophragmus violaceus has been used for food, oil, health care, feed and ornamental horticulture, but its elements components were less studied. The elemental composition in different organs of *Orychophragmus violaceus* were determined to provide technical support for its agricultural application. The results showed that (1) the contents of most nutrition elements in leaf and flower were higher than those in root, which proved that *Orychophragmus violaceus* is a good plant for green manure and feed, (2) the metal elements aluminium and lead were the highest in flowers of *Orychophragmus violaceus*; Ti, Cr, Ni, As, Sn and Tl were the highest in leaf of *Orychophragmus violaceus*; cadmium was the highest in root of *Orychophragmus violaceus*, which proved that *Orychophragmus violaceus* can be used for phytoremediation of soils contaminated by heavy metals except cadmium, and (3) the content of rare earth elements were generally low in *Orychophragmus violaceus*.

Keywords: *Orychophragmus violaceus*, Heavy metals, Trace beneficial elements, Rare earth elements.

INTRODUCTION

Orychophragmus violaceus is a biennial herbaceous plants belonging to cruciferae, which is a good plant for food, oil, health care, feed and ornamental horticulture. *Orychophragmus violaceus* has high economic value, ornamental value and broad developing prospect¹.

Previous studies have shown that sowing *Orychophragmus violaceus* after the harvest of spring maize in North China, *Orychophragmus violaceus* can overwinter safely rapidly grow and cover ground after reviving and reached full bloom in April, when it is tender, juicy and high yield, can used as green manure to provide nutrients for the next crop after maize². Previous research on *Orychophragmus violaceus* is limited to the oil³, feed grass⁴, flowers⁵, its nutrient characteristics and effects of the green manure were little understood.

The elements components of *Orychophragmus violaceus* were less studied, which requires to study its various elements in detail. In this paper, the macroelements, secondary elements, heavy metals, trace beneficial elements and rare earth elements in different organs of *Orychophragmus violaceus* were determined, which will provide technical support for the agricultural application of *Orychophragmus violaceus*.

EXPERIMENTAL

Orychophragmus violaceus were collected from Langfang city of Hebei Province, China Academy of Agricultural Sciences experimental base. The whole plant and its flowers were showed as Figs. 1 and 2.



Fig. 1. *Orychophragmus violaceus* in corn field

Fig. 2. Flowers of *Orychophragmus violaceus*

The flower, leaf and root were separated, washed with deionized water. Grinding, digesting and detecting by ICP-MS. The parameters of ICP-MS were referred to Rui *et al.*⁶ method.

RESULTS AND DISCUSSION

Concentration of macroelements in different organs of *Orychophragmus violaceus*: *Orychophragmus violaceus* contained many kinds of macroelements, the descending order of macroelements is $K > Ca > P > Mg > Si > Na > B$. The results showed that Ca, Na, B and Mg had the highest concentration in leaf; K, P and Si were the highest in flower, all detected macroelements were the lowest in root (Table-1).

Elements	Flower	Root	Leaf
B	19.69	12.01	22.05
Na	210.53	199.25	240.61
Mg	1204.99	380.79	1271.30
Si	322.58	239.72	207.08
P	3864.03	1747.57	2613.93
K	12911.21	8075.82	10043.72
Ca	4750.79	3121.87	12834.32

Concentration of secondary elements in different organs of *Orychophragmus violaceus*: Secondary elements are important for plant growth and development. The descending order of secondary elements in leaf of *Orychophragmus violaceus* is $Fe > Sr > Mn > Zn > Br > Cu > I$; the descending order of secondary elements in root of *Orychophragmus violaceus* is $Fe > Sr > Zn > Mn > Cu > Br > I$; and the descending order of secondary elements in flower of *Orychophragmus violaceus* is $Fe > Zn > Mn > Sr > Cu > Br > I$. Most secondary elements in root were lower than leaf and flower, which is similar to macroelements (Table-2).

Elements	Flower ($\mu\text{g g}^{-1}$)	Root ($\mu\text{g g}^{-1}$)	Leaf ($\mu\text{g g}^{-1}$)
Mn	32.64	16.31	86.86
Fe	234.52	123.06	1776.91
Cu	8.56	3.34	4.98
Zn	44.10	16.65	28.75
Br	2.69	2.02	7.86
Sr	23.13	35.13	88.83
I	0.95	1.90	1.30

Concentration of heavy metals in different organs of *Orychophragmus violaceus*: Heavy metals reached to microgram level in *Orychophragmus violaceus* are Al, Ti, Cr, Ni and Pb. The heavy metal elements Al and Pb were the highest in flowers; Ti, Cr, Ni, As, Sn and Tl were the highest in leaf; Cd was the highest in root. Other heavy metals were all lower than $0.1 \mu\text{g g}^{-1}$ (Table-3). The above results show that *Orychophragmus violaceus* is a high quality plant for phytoremediation of soils contaminated by heavy metals.

Elements	Flower ($\mu\text{g g}^{-1}$)	Root ($\mu\text{g g}^{-1}$)	Leaf ($\mu\text{g g}^{-1}$)
Al	170.03	131.51	95.07
Ti	15.38	12.30	43.33
Cr	2.14	2.22	221.68
Ni	1.66	0.90	18.70

Elements	Flower (ng g^{-1})	Root (ng g^{-1})	Leaf (ng g^{-1})
As	186.91	134.73	235.72
Ag	6.28	38.92	8.64
Cd	108.49	378.24	236.92
Sn	69.47	26.40	71.05
Sb	34.83	10.24	20.16
Hg	0.00	0.00	0.00
Tl	27.98	12.97	45.37
Pb	1357.44	184.57	679.31

Concentration of trace beneficial elements in different organs of *Orychophragmus violaceus*: Molybdenum is the highest beneficial trace elements in *Orychophragmus violaceus*. Other beneficial trace elements were in turn Co, Li and Se. These four elements in the leaves was the highest, followed by the flowers and the lowest in the root (Table-4).

Elements	Flower	Root	Leaf
Li	301.48	198.00	414.79
Co	374.19	173.65	578.49
Se	5.52	Nil	50.89
Mo	884.66	575.79	1476.48

Concentration of rare earths elements in different organs of *Orychophragmus violaceus*: The content of rare earth elements were generally low in *Orychophragmus violaceus*, which is relative to the concentration in soil and little usage of rare earth fertilizer. Four highest rare earth elements are Ce, La, Sc and Nd (Table-5).

TABLE-5
 CONTENTS OF RARE EARTHS ELEMENTS IN
 DIFFERENT ORGANS OF *Orychophragmus violaceus* (ng g⁻¹)

Elements	Flower	Root	Leaf
La	247.81	135.18	113.78
Ce	716.60	419.89	343.49
Pr	51.77	28.45	24.24
Nd	185.00	102.41	87.13
Sm	28.55	12.97	23.04
Eu	9.71	7.51	7.92
Gd	33.12	17.07	21.60
Tb	4.57	2.05	2.16
Dy	22.27	10.92	11.52
Ho	3.43	2.73	2.16
Er	8.56	6.83	5.04
Tm	1.14	0.68	0.72
Yb	6.85	6.14	2.16
Lu	1.14	Null	Null
Y	88.88	46.88	42.25
Sc	232.78	158.17	179.07

Conclusions

• Most nutrition elements in leaf and flower were higher than root, which proved that *Orychophragmus violaceus* is a good plant for green manure and feed.

• *Orychophragmus violaceus* can be used for phyto-remediation of soils contaminated by heavy metals except cadmium.

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