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SOME OBSERVATIONS ON THE ECOLOGY AND  
PHYTOCHEMISTRY OF NICKEL-ACCUMULATING  
ALYSSUM SPECIES FROM THE IBERIAN PENINSULA

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ABSTRACT

Experiments were carried out on the tolerance to, and uptake of nickel by Iberian subspecies of A. serpyllifolium. Two of these subspecies, the serpentinic-endemics s.sp. lusitanicum (from Bragança, Portugal) and s.sp. malacitanum (from Málaga, Spain) were hyperaccumulators (>1,000 µg/g in dried leaves) of nickel. Their precursor, s.sp. serpyllifolium (from Granada, Spain) was a non-accumulator of this element.

Seeds of the two serpentine-endemics germinated extensively in nickel concentrations up to 12,000 µg/g (1.2%) whereas s.sp. serpyllifolium only germinated in nickel concentrations of up to 60 µg/ml.

Tolerance tests involving measurement of new root lengths of excised seedlings placed in varying nickel concentrations again showed much greater tolerance of the two serpentine-phytes. In both series of experiments, the order of tolerance was: s.sp. lusitanicum > s.sp. malacitanum > s.sp. serpyllifolium.

In pot trials involving seedlings of s.sp. malacitanum grown in mixtures containing varying amounts of calcium, magnesium and nickel, the most important findings were that nickel uptake is somewhat stimulated by an excess of calcium in the substrate. This relationship was confirmed by inter-species and intra-species analyses of naturally-occurring plants. Enhanced calcium uptake concomitant with nickel uptake by hyperaccumulators results in a higher (more favourable) Ca/Mg ratio and thereby counteracts one of the unfavourable edaphic effects of serpentine soils.

The form of nickel in leaves of the three Iberian subspecies was investigated. Nickel existed mainly as a water-soluble polar complex in the vacuoles. Small concentrations of nickel did however exist in cell fractions, particularly in the mitochondria where enzyme systems are located. GLC studies on the purified nickel complexes showed that this element is associated principally with

malic and malonic acids which are present in high concentrations in the hyperaccumulators but not in s.sp. serpyllifolium.

It is suggested that production of malic acid is a mechanism whereby hyperaccumulators can tolerate unfavourable edaphic factors such as nickel-rich soils. Presence of nickel in the mitochondria blocks the citric acid cycle by deactivating malic dehydrogenase leading to build-up of malic acid in the vacuoles which then absorbs excess nickel by a complexing reaction and leads to its diffusion back into the vacuoles from the mitochondria, hence unblocking the citric acid cycle. Malonic acid also blocks the cycle and leads to a reduced level of malic acid and hence lesser tolerance to nickel. This is shown to be the case for s.sp. malacitanum which contains more malonic acid than s.sp. lusitanicum and is also less tolerant to nickel. It is postulated that the chemical evidence suggests that s.sp. lusitanicum and s.sp. malacitanum are sufficiently different chemically to lend weight to the argument that the latter should be promoted to full specific rank as has already been done for s.sp. lusitanicum.

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TABLE OF CONTENTS

	<u>Page</u>
ABSTRACT	i
ACKNOWLEDGEMENTS	iii
TABLE OF CONTENTS	iv
LIST OF FIGURES	vi
LIST OF TABLES	viii
LIST OF PLATES	x
1. INTRODUCTION	1
2. THE DISTRIBUTION AND ECOLOGY OF <u>ALYSSUM</u> <u>SERPYLLIFOLIUM</u> AND ITS IBERIAN SUBSPECIES	14
2.1 Introduction	
2.2 Geographical aspects of the Iberian ultrabasic occurrences	
2.3 Geological aspects	
2.4 Edaphic aspects	
2.5 Climate	
2.6 Vegetation	
3. ANALYTICAL METHODS	28
3.1 Atomic absorption spectrophotometer	
3.2 Flame photometry	
3.3 Colorimetry	
3.4 Preparation of plant and soil samples	
3.5 Statistical treatment of data	
3.6 Reliability of plant sample analysis	
4. IONIC RELATIONSHIPS AND CORRELATIONS IN HYPERACCUMULATORS	36
4.1 Inter-species relationships for section Odontarrhena of <u>Alyssum</u> (i) Table with means, standard deviations (ii) Table of species analysed (iii) Table of $\underline{r}$ values	
4.2 Intra-species relationships for s.sp. malacitanum	
4.3 Discussion of results	

4.4	Introduction to pot trials	
	Pot trial experiments	
4.5	Discussion of results	
5.	NICKEL UPTAKE AND TOLERANCE TESTS FOR <u>ALYSSUM SERPYLLIFOLIUM</u> AND ITS SUBSPECIES	58
5.1	Short introduction	
5.2	Methodology	
5.3	Germination tests	
5.4	Tolerance tests	
5.5	Nickel uptake tests	
6.	PHYTOCHEMICAL STUDIES	72
6.1	Introduction	
6.2	Plant species studies	
6.3	Preliminary studies on nickel in freeze-dried material	
	6.3.1 Solvent extraction	
	6.3.2 Differential centrifugation	
6.4	Mass spectral analysis	
7.	CONCLUSIONS AND RECOMMENDATION FOR FURTHER STUDIES	90
	REFERENCES CITED	92
	PUBLICATIONS ARISING FROM THIS THESIS	104

LIST OF FIGURES

	<u>Page</u>	
1.1	Average nickel content of various sedimentary and igneous rocks.	2
1.2	Geographical distribution of <u>Alyssum</u> species with nickel contents exceeding 1,000 $\mu\text{g/g}$ (0.1%) on a dry mass basis.	8
1.3	The world wide geographical distribution of species of <u>Alyssum</u> section Odontarrhena.	10
1.4	Histograms of nickel concentrations in individual specimens of <u>Alyssum</u> .	12
2.1	Map of Bragança.	16
2.2	Map of Málaga.	17
3.1	Schematic diagram showing essential requirements for atomic absorption spectrophotometry.	28
3.6.2	Graphical representation showing reliability of two sets of data.	35
4.5.1	Graphical representation of the uptake of nickel, calcium, magnesium by s.sp. malacitanum.	53
4.5.2	A graphical representation showing nickel, calcium, magnesium contents of a random selection of plant specimens from Alyssum.	55
5.3.2	Graphical representation of seed germination tests for <u>Alyssum</u> species expressed as a % of the number of seeds germinated (total of 20) at different nickel concentrations ( $\mu\text{g/g}$ ).	63



- 5.4.1 Tolerance tests involving new root lengths of excised seedlings of Alyssum species grown in solutions of varying nickel concentrations ( $\mu\text{g/ml}$ ). 67
- 5.5.1 Nickel concentrations ( $\mu\text{g/g}$ ) in dried leaves of Alyssum species as a function of nickel concentrations ( $\mu\text{g/g}$ ) measured in the soil. 68
- 6.4.2.1 Elution curves from Sephadex G-10 column showing nickel complexes in aqueous extracts of Alyssum subspecies. 83
- 6.5.1 Gas-liquid chromatograph of methyl derivatives of plant extracts of Alyssum subspecies. 85

LIST OF TABLES

	<u>Page</u>
2.4.1 Analytical data for lherzolite-type ultrabasic rocks from the Vinhais area, N.E. Portugal.	20
2.4.2 Analytical work for a typical serpentinic soil profile from Macedo de Cavaleiros, N.E. Portugal.	21
2.4.3 Analytical data for major elements in ultrabasic soils from Serrania de Ronda, Málaga, Spain.	23
3.1.2 Instrumental conditions for the Varian Techtron Model AA5 spectrometer.	32
3.6.1 Determinations of nickel only in Section Odontarrhena of <u>Alyssum</u> .	33
4.1.1 Elemental concentrations and ratios in <u>Alyssum</u> species of Section Odontarrhena.	37
4.1.2 Statistical significance of relationships of nickel with other elements in Section Odontarrhena of <u>Alyssum</u> .	40
4.1.3 Geometric means and standard deviation ranges for the various elements in <u>Alyssum</u> Section Odontarrhena.	41
4.2.1 Nickel and major element concentrations in dried leaves of <u>A. serpyllifolium</u> s.sp. <u>malacitanum</u> .	42
4.2.2 Statistical data for elemental concentrations in <u>A. serpyllifolium</u> s.sp. <u>malacitanum</u> .	44

4.4.1	Seedlings of <u>A. serpyllifolium</u> s.sp. <u>malacitanum</u> grown in different concentrations of nickel, calcium and magnesium.	45
4.4.2	Conditions of plants after a period of 4 weeks.	47
4.4.3	State of healthy plants after a period of 4 weeks.	49
4.4.4	Elemental concentrations ( $\mu\text{g/g}$ ) in plants of <u>A. serpyllifolium</u> s.sp. <u>malacitanum</u> still alive after 4 weeks.	51
4.5.1	Nickel, calcium and magnesium concentrations in <u>Alyssum</u> specimens.	52
5.3.1	Seed germination tests for <u>Alyssum serpyllifolium</u> subspecies, expressed as a percentage of number of seeds germinated (total of 20) at different nickel concentrations.	62
5.5.2	Range of nickel concentrations used in the nickel uptake studies.	70
6.3.1	Distribution of nickel in various solvent extracts (%) of leaf material.	76
6.3.2	Nickel in cell fractions (dry mass) of <u>A. serpyllifolium</u> s.sp. <u>malacitanum</u> .	78
6.3.3	Nickel in cell fractions (dry mass) of <u>A. serpyllifolium</u> s.sp. <u>serpyllifolium</u> .	79
6.5.2	Retention times of the methyl derivatives of plant extracts of <u>Alyssum</u> subspecies compared with those of the standards.	86

LIST OF PLATES

	<u>Page</u>
2.6 <u>Alyssum serpyllifolium</u> Desf. s.sp. <u>lusitanicum</u> Dudley and P. Silva, growing at Carrazedo near Bragança.	27



A typical *Alyssum* hyperaccumulator of nickel ( *A. robertiannum* Bern. ex. gren.) from section Ordontarrhena.