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Correlation between fungal populations and amino acid levels of salt desert plants

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The fungal populations of six halophytic plant species from the desert south of Iraq were investigated in relation with the levels of various amino acids determined in the shoots of each plant. The fungal populations of the succulent plant species were different from these associated with non-succulent plants. The differences in fungal populations were attributed to the levels of amino acids produced by the plants. The highest number of fungal isolates and species diversity was found on *Zygophyllum coccineum* which revealed high levels of tyrosine, methionine and leucine while *Suaeda monica* showed a low contents of amino acids correlated with low fungal populations.

Several studies have been carried out on the fungi associated with halophytes growing in saline environments (Pugh & Williams, 1968; Dickinson, 1976; Lindsey, 1976; Gessner, 1977; Pugh & Beeftink, 1980). Most of these works dealt mainly with the rhizosphere and phyllosphere fungi of dead or living plants. No attention, however, has yet been given to the relationship between the mycoflora and plant hosts growing under stress conditions and on the other hand little information is available on the effect of chemistry and physical nature of plants on the associated microbial populations (Tyagi, 1971; Johnson, 1975).

Muhsin (1985) has found that the ionic levels of different halophytes growing in salt marsh ecosystems influence their fungal community structures and recently (Muhsin, 1987) he postulated that the fungi associated with halophytes may be influenced by the osmotic strategies of these plants which involve a production and accumulation of osmotically active substances such as amino acids. This study, therefore, aims to elucidate the variation of fungal populations in relation with the amino acids composition of six xerohalophytic plant species growing in desert soils in the south of Iraq.

Materials and Methods

Salsola baryosma L., *Suaeda vermiculata* Forssk., *Suaeda monica* L., *Zygophyllum coccineum* L., *Cyperus conglomeratus* Rottb.

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and *Matthiola oxyceras* L. were collected from salt desert south of Iraq (30° 33' N, 48° 47' E) during the vegetative growth stage between March and April 1987. Five plant samples, ten plants per sample of each plant species, were immediately brought to the laboratory. Shoots of the plants were separated and prepared for analysis. Isolation of fungi from the shoots of each plant species was conducted by the previously described technique (MUHSIN & BOOTH, 1987). Air dried plant materials were weighed and ashed in a muffle furnace at 450° C for 24 h. The ashed plant materials were prepared for determination of amino acid concentrations using the acid hydrolysis procedure (BONNER & VARNER, 1965). Concentrations of the amino acids were determined by an amino acids analyzer (Biochrom Ltd., model 4400 LKB). Three replicates of each plant sample were analysed.

Fungal community parameters including total similarity index (IST), Jaccard's index (IS_J) and association coefficient (V), were analysed according to KREBS (1978).

Results

A total of 20 fungal taxa were recovered among 290 isolates derived from 450 plated shoot pieces of the six plants (Tab. 1). The percentage of fungal isolates was highest on *Zygophyllum coccineum,* followed by *Suaeda vermiculata, Salsola baryosma, Cyperus conglomeratus, Matthiola oxyceras,* and *Suaeda monica* (Tab. 1). *Alternaria alternata* and *Fusarium moniliforme* represent 38% of the total number of isolates from the six plants. The frequency of the other fungal isolates varied from one plant to another. 11 species were found on *Z. coccineum,* 10 species on *S. vermiculata,* 5 species each on *S. baryosma, C. conglomeratus* and *M. oxyceras,* and only two species were isolated from *S. monica. Alternaria alternata* was the most dominant fungus on all the investigated plants.

Fungi restricted only to one plant species include *Alternaria chlamydospora* on *S. baryosma, A. brassicicola* and *Ascochyta* sp. on *S. vermiculata* while *Alternaria citri, A. dennisii, Cladosporium herbarum, Dictyoarthrinum sacchari, Drechslera australiensis* and *Papulaspora halima* were found only on *Z. coccineum* (Tab. 1).

Tab. 3 shows the number of fungal taxa occuring in common between any pair of the six plant species. Five fungi *(Alternaria alternata, Fusarium moniliforme, Stemphylium botryosum, Ulocladium atrum* and *U. botrytis)* were found in common between *Suaeda vermiculata* and *Zygophyllum coccineum* and six species *(Alternaria alternata, A. dennisii, A. sonchi, Curvularia verruculosa, Stemphylium botryosum* and *Tetracoccosporium paxianum)* were common to *Cyperus* conglomeratus and *Matthiola oxyceras.* When

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Tab. 1. Total of fungal isolates on six desert plants growing in the South of Iraq.

Hosts / Fungal species	*Salsola baryosma*	*Suaeda monica*	*Suaeda vermiculata*	*Zygophyllum coccineum*	*Cyperus conglomeraturs*	*Mattiola oxyceras*
Alternaria alternata (FR.) KEISSLER	19	10	29	45	18	16
A. brassicicola (SCHW) WILTSHIRE	–	–	4	–	–	–
A. chlamydospora MOUCH.	16	–	–	–	–	–
A. citri ELLIS & PIERCE	–	–	–	2	–	–
A. dennisii ELLIS	–	–	–	5	–	–
A. sonchi DAVIS	–	–	–	–	3	2
Ascochyta chenopodii ROSTER	–	2	3	–	–	–
Ascochyta sp.	–	–	8	–	–	–
Chuppia sarcinifera DEIGHTON	3	–	2	–	–	–
Cladosporium herbarum (PERS.) LINK & GRAY	–	–	–	3	–	–
Curvularia verruculosa TANDON & BILGRAMI & ELLIS	–	–	–	–	4	2
Dictyoarthrinium sacchari (STEVEN.) DAMON	–	–	–	4	–	–
Drechslera australiensis (DRECH.) SUBRAM. & JAIN	–	–	–	4	–	–
Fusarium moniliforme SHELDON	4	–	15	21	–	–
Papulaspora halima AANSTAS.	–	–	–	5	–	–
Phoma glomerata (CORDA) WOLLEN & HOCHAP.	2	–	8	–	–	–
Stemphylium botryosum WALLR.	–	–	1	6	3	2
Tetracoccosporium paxianum SZABA	–	–	–	–	2	1
Ulocladium atrum PREUSS	–	–	2	6	–	–
U. botrytis PREUSS	–	–	2	6	–	–
Percentage of isolates	15.2	4,1	25.5	36.9	10.4	8.0

plants are compared the highest number of fungal species (nine species) was present on *Z. coccineum*.

Comparison of the fungal populations between the six plants, using total similarity index (IS_T), indicates that the similarity is greater for *Suaeda vermiculata* and *Zygophyllum coccineum* and for *Cyperus conglomeratus* and *Matthiola oxyceras* (25% of similarity) as shown in Tab. 4. The Jaccard's index (IS_J) was also the highest for these two plants. Coefficients of association (V) for all the plant combinations were negative with the exception of *S. vermiculata* with *Z. coccineum* and *C. conglomeratus* with *M. oxyceras*.

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Tab. 2. Concentrations of various amino acids in the shoots of six desert plant species.

Amino scids	*Salsola baryosma*	*Suaeda monica*	*Suaeda vermiculata*	*Zygophyllum coccineum*	*Cyperus conglomeraturs*	*Mattiola oxyceras*
Alanine	–	–	0.01	2.64	–	–
Arginine	3.37	T	3.95	–	2.64	1.3
Asparagine	3.40	–	–	–	–	–
Cystine	–	–	–	2.58	–	–
Glycine	–	0.01	–	–	–	–
Histidine	0.75	–	–	–	–	0.34
Isoleucine	0.56	0.12	T	–	–	–
Leucine	1.05	–	–	13.40	0.05	–
Lysine	0.75	–	1.34	2.45	–	1.03
Methionine	–	–	0.50	14.38	–	–
Proline	–	0.02	15.82	–	–	–
Phenylalanine	0.98	–	1.42	2.95	–	1.03
Threonine	–	–	–	–	T	0.98
Tyrosine	–	–	–	64.04	–	–
Valine	–	0.25	–	–	–	–

T = Traces

Tab. 3. Number of fungal taxa 6a), number of taxa present only on the horizontally listed plants (b), number of taxa present onyl on the vertically listed plants (c), and number of taxa not found on either plants (d) in each of the 15 paired plant combinations.

	Suaeda monica	*Suaeda vermiculata*	*Zygophyllum coccineum*	*Cyperus conglomeratus*	*Matthiola oxyceras*
Salsola baryosma	1 4 1 14	4 1 6 9	2 3 9 6	1 4 4 11	1 4 4 11
Suaeda monica		2 0 8 10	1 1 10 8	1 1 4 14	1 1 4 14
Suaeda vermiculata			5 5 6 4	2 8 3 7	2 8 3 7
Zygophyllum coccineum				2 9 3 6	2 9 3 6
Cyperus conglomeratus					5 0 0 15
Matthiola oxyceras					

Legend

a	b
c	d

a = taxa in common
b = taxa on plant 1
c = taxa on plant 2
d = taxa not found on plant 1 & 2

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Tab. 4. Similarity indices: total species in common (a), total similarity (IS_T), Jaccard's index (IS_J) and the coefficient of association (V) of the fungal populations on the six desert plant species.

	Suaeda monica	*Suaeda vermiculata*	*Zygophyllum coccineum*	*Cyperus conglomeratus*	*Matthiola oxyceras*
Salsola baryosma	1 5 20 0.02	4 20 57 0.0	2 10 17 −0.02	1 5 13 0.0	1 5 13 0.0
Suaeda monica		2 10 25 −0.01	1 5 9 −0.01	1 5 20 −0.01	1 5 20 −0.01
Suaeda vermiculata			5 25 46 0.03	2 10 18 −0.01	2 10 18 −0.01
Zygophyllum coccineum				2 10 17 −0.001	2 10 17 −0.003
Cyperus conglomeratus					5 25 100 1

Legend: a IS_T / IS_J V

Tab. 2 shows the amino acid concentrations, expressed as mg/g dry weight, in the shoots of each plant species. The type and amount of the detected aminoacids were variable; however, proline was present in a fairly high amount in the shoots of *Suaeda vermiculata* and was not detected in the other species: only a very low amount was found in *Suaeda monica*. Shoots of *Zygophyllum coccineum* showed high levels of tyrosine, methionine and leucine. Generally, the total amino acid content was high in *Z. coccineum* and low in *S. monica*.

Discussion

Halophytes growing in saline habitats usually accumulate high levels of salt ions, particularly sodium and chloride in their tissues (Waisel, 1972; Flowers, 1975). Subsequently it has been found that

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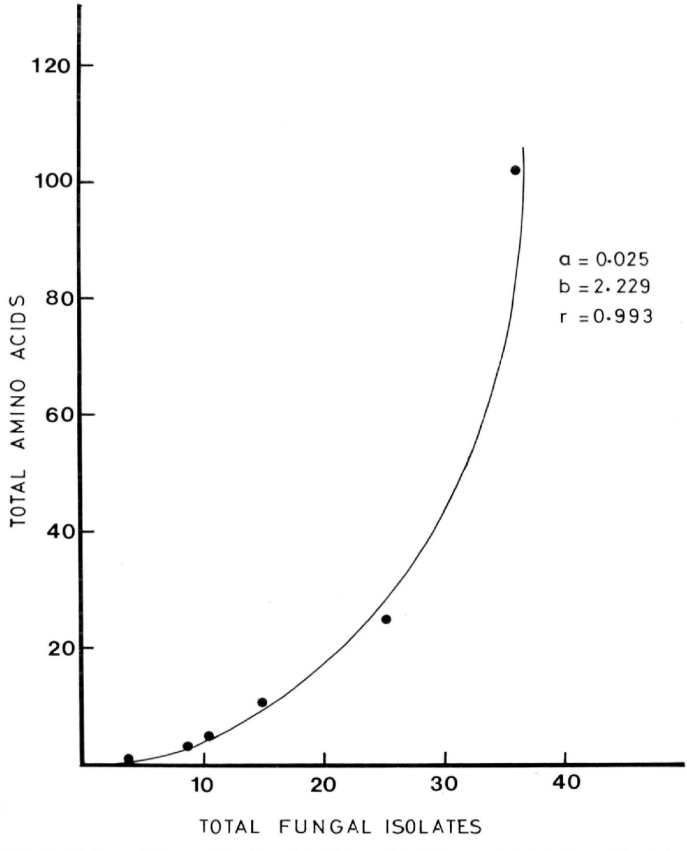

Fig. 1. – Polynomial regression line of total fungal isolates and total amino acids of six plant species.

these plants, in order to control their internal osmotic adjustment mechanism, produce high levels of osmotically active substances including various organic solutes (FLOWERS & HALL, 1978) and amino acids such as proline (STEWART & LEE, 1974) and betain (BRIENS & LARHER, 1982).

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Iraqi desert soils are characterized by the presence of high levels of sodium, chloride, calcium and sulfate ions (AL-ANI et al., 1971). Thus the succulent halophytic species like *Salsola baryosma, Suaeda vermiculata* and *S. monica* growing in these soils accumulate large amount of sodium and chloride in their shoots (THALLEN, 1979; MUHSIN & ZWAIN, unpublished) while the non-succulent species *(Cyperus conglomeratus, Matthiola oxyceras* and *Zygophyllum coccineum)* often absorb relatively high amounts of calcium, magnesium and sulfate (AL-ANI & al., 1971).

In *Suaeda vermiculata* proline accounts for over 60% of the total amino acids. Tyrosine, as well as methionine and leucine, were detected in high amount in *Z. coccineum,* while arginine is the most abundant amino acid found in both *Cyperus conglomeratus* and *Matthiola oxyceras.* The role of these compounds in salt-tolerant plants has been suggested (FLOWERS & HALL, 1978). Accordingly the fungal taxa associated with these plants seem to be more affected by the presence of these amino acids in the shoots of each plant species. Regression analysis showed a positive correlation between the total amino acids and total fungal isolates (Fig. 1).

The present study demonstrates that the high number of fungal species and isolates recovered from *Z. coccineum* is positively correlated with the production of high levels of amino acids in the shoots of this halophyte (Fig. 2). On the contrary, *S. monica* hosts only two fungal species (12 isolates) and shows low content (0.31 mg/g dw) of amino acids. The variety of amino acids produced by *Z. coccineum* perhaps encourage the growth of diverse fungi on this plant. *Alternaria alternata* and *Fusarium moniliforme* are the most likely species to be enhanced by the available amino acids in the shoots of *Z. coccineum.* Although it is not certain which amino acid has a stimulatory action on the growth of these fungi, the high concentrations of tyrosine, methionine and leucine may influence the occurrence of fungi associated with *Z. coccineum.* Similarly, proline may also affect and stimulate the growth and occurrence of the mycoflora on *S. vermiculata.*

On the other hand, the high number of fungal isolates and species diversity found on both *Z. coccineum* and *S. vermiculata* is probably related to the activity of fungi on these plants in presence of high levels of amino acids. Other studies showed that phylloplane fungal spores germination is largely attributed to the presence of sugars, carbohydrates or amino acids (GODFREY & CLEMENTS, 1978; DICKINSON & BOTTOMLEY, 1980; TYAGI & CHAUHAN, 1982).

The present investigation also indicates that there is a considerable similarity, using the Jaccard's index and association coefficient, between the fungal populations of *Zygophyllum coccineum* and *Suaeda vermiculata* and of *Cyperus conglomeratus* and *Matthiola*

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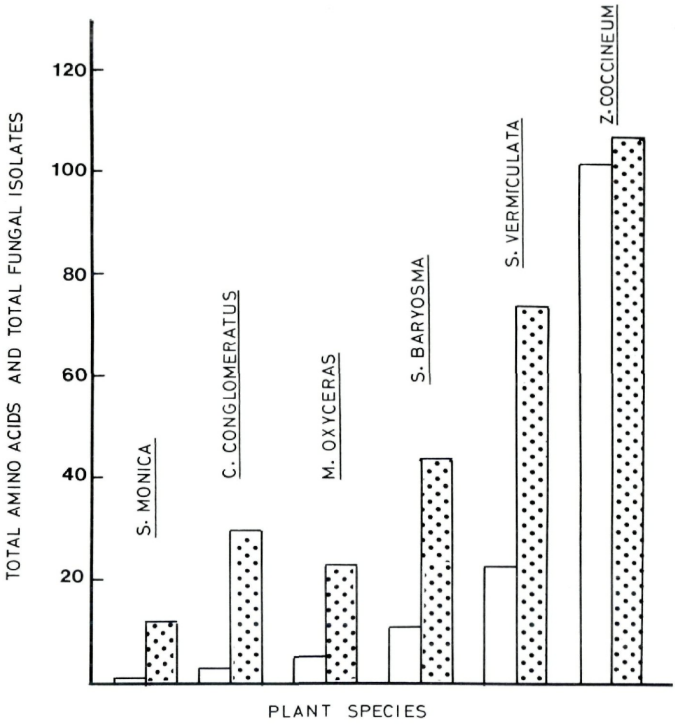

Fig. 2. – Total amino acids (white bars) and total fungal isolates (dotted bars) of six plant species.

oxyceras. Such differences in the fungal populations may be related to the osmotic strategy of each plant, since the strategies of the succulent desert plants differ from the non succulent species (McLEARY, 1974).

Further studies are needed to examine the influence of other organic compounds on the fungal populations associated with the desert plants and more attention should be drawn to investigate the effect of various amino acids on the growth of desert phylloplane fungi in vitro.

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