BIOLOGIA PLANTARUM 35 (4): 591-602, 1993

Mycological studies on the angiosperm root parasite *Cynomorium coccineum* L. and two of its halophytic hosts

S. A. OUF

Department of Botany, Faculty of Science, University of Cairo, Giza, Egypt

Abstract

The fungal colonization of the angiosperm root parasite *Cynomorium coccineum* and the halophytic hosts *Limonium delicatulum* and *Arthrocnemum glaucum* were investigated in a Mediterranean salt marsh in March 1992. The main fungal inhabitants on the leaves or shoot surface of the test plants were *Aspergillus niger*, *Penicillium chrysogenum* and *Cladosporium herbarum*. The qualitative analysis of the fungal species associating the parasite, the hosts and the non-infected plants showed similar pattern. However, the total population exhibited quantitative differences coupled with the amount and the chemical composition of the exudates on plant surface and the quantity of transpired water. The fungal catch from the aerial shoot (inflorescence) of the parasite was higher than that collected from either the leaves or aerial shoots of non-infected or host plants. The fungal density on the leaves of *L. delicatulum* was higher than those isolated from the aerial shoots of *A. glaucum*. Infection by *C. coccineum* caused a marked drop in the total fungal population on leaves or shoot surfaces of the hosts as compared to the corresponding non-infected individuals. The stimulative effect of washings on spore germination of some isolated fungal species was matched with the density of fungi on the target plants.

Introduction

In Egypt, the family *Cynomoriaceae* is represented by *Cynomorium coccineum* L. which is a perennial angiosperm holoparasite (obligate parasite) on roots of halophytes (Fig. 1A) in the Mediterranean coastal salt marshes (Taeckholm 1974, Fahmy 1986).

Received 23 November 1992, *accepted* 14 December 1992.
Acknowledgement: The author is grateful to Dr. G. M. Fahmy (Department of Botany, Faculty of Science, Cairo University) for help in collection of samples and fruitful discussions and suggestions.
Present address: Department of Plant Pathology, Coastal Plain Experiment Station, University of Georgia, Tifton, GA 317 93 - 0748, U.S.A.

Fahmy (1986) indicated that the salt-secreting halophytes have higher transpiration rates than the succulent ones. Experiments have shown that the accumulation of the transpired water vapour in the boundary layer favours the colonization and growth of microorganisms on the transpiring organs (Burrage 1971). Moreover, fungal colonization on the plant surfaces appeared to be favoured by the leaf secretions (Carroll and Petrini 1983). The mucilage secreted by the multicellular glands on the leaf axis of the halophyte *Limonium delicatulum* have been proved to provide a substratum for growth and reproduction of many fungal species (Fahmy and Ouf 1992). As in the cases of many host-parasite associations among angiosperms, the infection of the halophytic hosts by the root parasite *C. coccineum* caused alterations in their morphological, anatomical and physiological characteristics (Fahmy 1986). These changes were mainly due to the depletion of water and nutrients from the host plants (El-Ghamrawy 1968; Singh *et al.* 1972, Fahmy 1986). As a consequence of this, a possible variation in the amount and composition of leachable substances from the plant surface, is expected. Under such biotic stress, the phylloplane microbial systematics and their population dynamics may be altered.

This research aims to study the phylloplane mycoflora of non-infected and host individuals, as well as the parasite. The effect of leaf or shoot washings on spore germination of some isolated fungal species will be undertaken. The ecological study cited previously (Fahmy 1993) will be used to explain the changes in gross and establishment of mycoflora associating the leaves or shoot surfaces of the parasite and its hosts.

Materials and methods

The study site of *Cynomorium coccineum* and its associating species was a part of a Mediterranean coastal salt marsh located about 56 km west of Alexandria (for details see Fahmy 1993).

The fungal air-borne spores of the salt march were isolated using the exposed plate method. Ten sites were tested. For each site, 10 plates of 9 cm diameter containing sterile peptone-dextrose agar medium were used. The plates were exposed to the air at about 2 m height at local time 12.00 for 30 min. Following exposure, the plates were incubated at 25 - 27 °C for 3 - 5 d and the developing fungal colonies were counted, isolated and identified.

For isolation of phylloplane mycoflora, one hundred discs were cut by sterile cork borer from the mature leaves of *L. delicatulum* or aerial parts of *C. coccineum*. The area of each disc was nearly 1.03 cm^2. Ten samples were used as replicate for each treatment. Due to the difficulty in obtaining discs from *A. glaucum*, small segments (0.5 cm diameter and 1 cm length) were used. The leaf washing technique described by Dickinson (1965 and 1971) was used for isolation of phylloplane fungi. The developing fungal colonies were counted and identified according to Raper and Thom (1949), Gilman (1957), Raper and Fennell (1965), Barnett and Hunter (1972), Ellis (1976) and Christensen (1978).

The preparation of washings from the leaves of *L. delicatulum* or the aerial parts of *A. glaucum* and *C. coccineum* was carried out according to Edwards and Ayres (1982). The areas of 20 g of each sample were collected and enclosed in a clean plastic chamber and was exposed for 1 h to a continuous mist of distilled water. The washing was filtered and then evaporated to dryness at 30 °C in a preweighed flask using a rotary evaporator. The flask was reweighed before the washing was redissolved in water to give a 20 % (m/v) solution.

Sodium and potassium were determined in washing solutions by *Unicam sp. 1900* atomic absorption spectrophotometer. Chloride was determined according to Jackson (1958). The total soluble saccharides were determined after acid hydrolysis at 110 °C for 3 h using the modified Nelson solution (Naguib 1969). The total amino nitrogen was determined according to Russel (1944). Phenolics were estimated colorimetrically following the method described by Swain and Hilis (1959). All the results of chemical analyses were expressed in mg cm^{-2}(plant surface).

Effect of aqueous washings on spore germination was tested using series of vantigian slides (with a central cavity). Equal amounts (0.1 cm^3) of 20 % washing solution and the spore suspension of each fungus under test were introduced into the groove, mixed well and covered by sterile edge-grassed cover glass. The concentration was diluted to 10 %. The slides were incubated at 28 °C for suitable periods of time, previously determined for each test fungus, at the end of which the maximum spore germinatin was achieved in distilled water. At the end of incubation period, the germinated spores were counted and expressed as percentage of control. Three replicate slides were used and 10 microscopic fields/slide were examined for each fungus.

The perianth segments and the flower bracts of the inflorescence of *C. coccineum* were detached from fresh samples, then freeze-dried, gold coated and observed with a *Jeol 35C* scanning electron microscope (see Fahmy 1991 for details).

The data shown in the Tables 1, 2 and 3 are the arithmetic means ± standard deviations.

Results

Isolated fungi: The average count of air borne fungi per plate was 28.5. The genera *Aspergillus*, *Cladosporium* and *Penicillium* were in all exposures and accounted 9.19, 7.90 and 5.76 colonies respectively (Table 1). They were followed by *Alternaria* and *Ulocladium* which appeared in 5 and 3 exposures respectively. *Humicola* and *Monilia*, each was recorded twice in an average catch of 0.9 and 0.7 colonies.

Concerning the species count, *Cladosporium herbarum* was runner up of the isolated species and constituted the major count of its genus. *Penicillium chrysogenum*, *Aspergillus niger* ranked second on the basis of density and recovered in all exposures. *A. flavus*, *A. terreus*, *P. citrinum*, and *Alternaria alternata* were common in the air and were recovered in 4 - 6 exposures. The other fungal species were isolated in less than 4 exposures and their counts were <1.29 colonies.

Fig. 1A. The aboveground inflorescences (*single arrows*) of *Cynomorium coccineum* associating its halophytic host *Limonium delicatulum* (*h*).

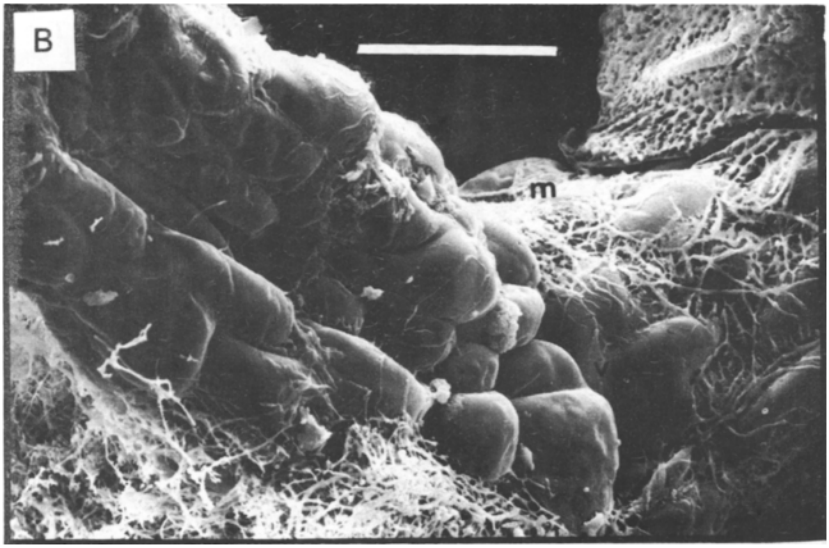

Fig. 1B. SEM micrograph of the adaxial side of the perianth segment of a flower on the aboveground inflorescence of the parasite. Note the dense colonizing fungal mycelium (*m*). Scale marker = 100 µm.

The total fungal catch, from aerial shoot (inflorescence) of the parasite; *Cynomorium coccineum* was more than that collected from the leaves of *Limonium delicatulum* or aerial shoot of *Arthrocnemum glaucum* (Table 1). Infection by *C. coccineum* decreased the total count of leaves or shoot surface fungi on the hosts. The leaves of *L. delicatulum* were loaded with fungi more than those isolated from the aerial shoot of *A. glaucum*. The high fungal catch on the inflorescence of *C. coccineum* is indicated in Fig. 1B where the perianth segment of the flower is colonized by actively growing and sporing mycelium.

The genus *Aspergillus* was the highest in occurrence since it was isolated in all samples of non-infected and host individuals as well as of the parasite. It constituted 41.29 and 16.19 on phylloplane of non-infected and host *L. delicatulum* respectively, 8.88 and 4.47 on the aerial shoot of non-infected and host plants of *A. glaucum*, respectively and 60.59 colonies cm^{-2} on the aerial shoot of *C. coccineum*.

A. niger was the most dominant aspergilli. In *L. delicatulum*, *A. niger* was codominated by *A. fumigatus*, *A. terreus* and *A. tamarii* and by *A. fumigatus* and *A. ochraceous* in the phylloplane of the non-infected and the host individuals, respectively. In *A. glaucum*, *A. niger* was codominated by *A. flavus* in shoot surface of the non- infected and the host individuals, while it was codominated by *A. fumigatus*, *A. ochraceous*, *A. versicolor* and *A. flavus* in shoot of *C. coccineum*.

On the basis of total count, *Aspergillus* was followed by *Penicillium* on the phylloplane of *L. delicatulum* and the aerial shoot of *A. glaucum*. The counts of the genus were more on the non-infected than the host plants. It was recovered in all isolations of *L. delicatulum* and in 7 and 5 isolations from the aerial shoot of non-infected and host individuals of *A. glaucum* respectively. *Penicillium* was retreated to become the third in order of density on the aerial shoot of *C. coccineum* although its count is relatively higher than on the other tested plants. Four *Penicillium* spp. were isolated of which *P. chrysogenum* and *P. citrinum* were the major. The former species was the most dominant being of high occurrence and density.

Cladosporium ranked third on phylloplane of non-infected, and host plants of *L. delicatulum* and on the aerial shoot of *A. glaucum*. It was recovered in all isolations of the first species and in 8 and 3 isolations on the aerial shoot of the non-infected and the host plants of *A. glaucum*. On the other hand, *Cladosporium* ranked second to *Aspergillus* on the aerial shoot of *C. coccineum* and recovered in all isolations; constituting 22.48 colonies cm^{-2}. In all samples two *Cladosporium* spp. were isolated, of which *C. herbarum* highly dominated *C. sphaerospermum*.

The other fungal genera appear to be restricted in their occurrence. *Alternaria alternata* and *Paecilomyces silvatica* were detected in phylloplane of non-infected *L. delicatulum* while *Mucor hiemalis* occurred on the infected one. *Humicola grisea* and *Mycelia sterilia* were isolated in counts ranging from 1.82 - 2.76 on phylloplane of both non-infected and host plants of *L. delicatulum*, respectively.

On the aerial shoot of *C. coccineum*, *H. grisea* ranked fourth and constituted 13.97 colonies cm^{-2} and recovered in all isolations. It is followed by *A. alternata*, *Ulocladium chlamydosporum* and *U. atrum*.

The other fungal genera were of relatively low densities and occurrence.

Table 1. Total count (TC) and number of cases of isolation (NCI, out of 10) of fungal genera and species isolated from the air [per plate, exposure 30 min] and the aerial part of *Cynomorium coccineum* (parasite) and *Arthrocnemum glaucum* or the leaves of *Limonium delicatulum* [cm^{-2}].

Fungal species	Air		*C. coccineum*		*L. delicatulum* non-infected		*L. delicatulum* host		*A. glaucum* non-infected		*A. glaucum* host	
	TC	NCI	TC	NCI	TC	NCI	TC	NCI	TC	NCI	TC	NCI
Aspergillus	9.19	10	60.55	10	41.29	10	16.19	10	8.88	10	4.47	7
A. niger	3.40	10	17.20	10	18.26	10	7.05	10	3.53	8	2.40	5
A. carbonarius	0	0	4.06	6	3.10	7	0	0	0	0	0	0
A. flavus	1.73	6	7.25	9	3.10	7	1.62	3	2.26	3	1.06	3
A. fumigatus	0	0	11.26	10	5.43	9	3.86	6	0	0	0	0
A. flaviceps	0	0	0.30	1	0	0	0	0	0	0	0	0
A. terreus	1.53	4	2.28	4	4.23	8	0	0	1.06	3	0	0
A. ochraceous	0	0	8.80	8	2.41	5	3.26	5	1.12	2	0.71	2
A. amstelodami	0	0	0	0	0.10	1	0	0	0	0	0	0
A. repens	0	0	0	0	0	0	0.20	1	0	0	0	0
A. tamarii	0	0	0	0	4.23	6	0	0	0.20	1	0	0
A. sulphureus	1.03	3	1.47	3	0.40	1	0	0	0	0	0	0
A. sydovi	1.20	3	0	0	0	0	0	0	0	0	0.30	1
A. versicolor	0.30	1	7.93	8	0.03	1	0.20	1	0.71	2	0	0
Penicillium	5.76	10	20.71	10	13.86	10	10.50	10	5.62	7	2.32	5
P. chrysogenum	3.86	10	8.93	8	8.80	10	6.63	10	3.25	5	1.06	3
P. citrinum	1.80	5	8.60	7	4.76	8	3.67	10	2.37	5	1.06	2
P. aurantiogriseum	0	0	2.78	4	0	0	0.20	1	0	0	0	0
P. commune	0.10	1	0.40	1	0.30	1	0	0	0	0	0.20	1
Cladosporium	7.90	10	22.48	10	13.73	10	7.97	10	5.26	8	2.06	3
C. herbarum	7.20	10	13.93	10	10.53	10	7.61	10	3.77	7	1.86	3
C. sphaerospermum	0.70	3	8.55	10	3.20	5	0.36	1	1.53	6	0.20	1

Alternaria	2.26	5	10.46	10	6.58	9	1.10	2	0	0	1.10	1
A. alternata	2.26	5	8.86	10	6.48	9	0	0	0	0	1.10	1
A. tenuissima	0	0	1.60	3	0.10	1	1.10	2	0	0	0	0
Ulocladium	1.39	3	7.54	8	0.60	2	0	0	0	0	0	0
U. atrum	1.29	3	3.66	5	0.60	2	0	0	0	0	0	0
U. chlamydosporum	0.10	1	3.88	5	0	0	0	0	0	0	0	0
Fusarium	0.33	2	0.90	1	2.63	5	0	0	0	0	0	0
F. oxysporum	0.30	1	0	0	1.53	4	0	0	0	0	0	0
F. moniliforme	0	0	0	0	1.10	2	0	0	0	0	0	0
F. neoceras	0.03	1	0.90	1	0	0	0	0	0	0	0	0
Humicola grisea	0.90	2	13.97	10	3.48	7	1.82	4	0.40	1	0.95	2
Mucor hiemalis	0	0	2.90	4	0	0	2.60	4	0	0	0	0
Acremonium implicatum	0	0	0.90	2	0	0	0	0	0	0	0	0
Scopulariopsis candida	0	0	0	0	0.70	2	0.10	1	0	0	0	0
Stachybotrys atra	0.10	1	1.28	2	0	0	0	0	0	0	0	0
Rhizopus stolonifer	0	0	0	0	0	0	0	0	0	0	0.10	1
Paecilomyces silvatica	0	0	3.20	5	2.76	4	0	0	1.73	3	0	0
Dichtomophthoropsis nymphaerum	0	0	0	0	0	0	0	0	0.10	1	0	0
Mycelia sterilia	0	0	0	0	2.76	4	2.23	3	0	0	0	0
Monilia sitophila	0.66	2	0	0	0.91	2	0	0	1.23	3	0.60	2
Total count	28.49		144.89		89.30		42.51		23.19		11.60	

Chemical composition of the aqueous washings from the aerial parts of the different species: The washings contained higher amounts of sodium and chloride ions followed by potassium in minor amounts (Table 2). The washings from both non-infected and infected individuals of *L. delicatulum* showed higher contents of sodium, chloride and potassium ions, particularly in the non-infected plants, than the washings from *A. glaucum* and *C. coccineum.*

Table 2. Chemical composition of the aqueous washings [μg cm^{-2}(surface area)] from the above ground inflorescence of the root parasite *Cynomorium coccineum* and those obtained from the leaves and the green stems of its hosts *Limonium delicatulum* and *Arthrocnemum glaucum*, respectively. P - parasite; NI - non-infected plant; H - host plant. Mean ± standard deviation.

	C. coccineum	*L. delicatulum*		*A. glaucum*	
	P	NI	H	NI	H
Sodium	3.21 ± 0.40	85.20 ± 13.2	48.50 ± 11.4	4.41 ± 1.5	3.81 ± 0.7
Potassium	0.02 ± 0.003	6.40 ± 1.3	2.50 ± 1.0	0.05 ± 0.02	0.03 ± 0.002
Chloride	7.97 ± 1.52	96.30 ± 12.6	32.00 ± 6.4	7.56 ± 0.72	5.31 ± 1.3
Soluble sugars	3.15 ± 0.72	1.02 ± 0.06	0.63 ± 0.08	0.85 ± 0.1	0.49 ± 0.1
Amino nitrogen	0.53 ± 0.07	0.25 ± 0.004	0.01 ± 0.003	0.12 ± 0.01	0.09 ± 0.01
Phenolics	18.36 ± 3.40	0	0	0	0

The washings from the aerial parts of the parasite contained higher amounts of soluble sugars (3.15 μg.cm^{-2}) than the hosts and the non-infected species. The washings from the non-infected plants of *L. delicatulum* and *A. glaucum* contained higher amounts of soluble sugars and amino nitrogen than those from the host plants (Table 2). Phenolics were the major organic constituents detected in the washings of *C. coccineum.* They were totally absent in the washings of the non-infected and host plants of *L. delicatulum.*

Effect of leaves or aerial shoot aqueous washings on spore germination: Table 3 shows the percentage stimulation or inhibition of some isolated phylloplane or shoot surface fungal spores in presence of aquous washings from the leaves of *L. delicatulum* and aerial shoots of *A. glaucum* and *C. coccineum.*

The aerial shoot washing of *C. coccineum* was promotive for the spore germination of all tested fungi. The maximum promotion was shown by *Cladosporium herbarum, Penicillium chrysogenum* and *Aspergillus niger.*

In spite of their inhibition to spore germination of *Humicola grisea* and *Rhizopus stolonifer,* the washings from aerial parts of *A. glaucum* and leaves of *L. delicatulum* were stimulative for spore germination of the most remaining fungi. The stimulation was more apparent in the case of washings from *L. delicatulum* than *A. glaucum* and with non-infected individuals than the corresponding host ones. The spore germination of *A. niger, P. chrysogenum, Fusarium oxysporum* and *C. herbarum* was highly stimulated in presence of *L. delicatulum* washing. The stimulation of spore germination was less remarkable or completely nullified on using *A. glaucum* washing especially with *C. herbarum, P. citrinum* and *F. oxysporum.*

Table 3. Spore germination, expressed as increase or decrease (values denoted by asterisk) of germination in percentage of control, of some phylloplane fungal species in presence of 10 % aqueous washings from leaves of *L. delicatulum* and the aerial parts of *A. glaucum* and *C. coccineum*. P - parasite - NI - non-infected; H - host. Mean ± standard deviation.

Fungal species	*C. coccineum*	*L. delicatulum*		*A. glaucum*	
	P	NI	H	NI	H
Aspergillus niger	63.21 ± 1.02	46.61 ± 0.95	28.21 ± 0.40	15.93 ± 0.63	7.38 ± 0.37
Aspergillus fumigatus	18.93 ± 0.72	18.93 ± 0.30	16.00 ± 0.51	3.17 ± 0.06	1.13 ± 0.09
Aspergillus versicolor	31.82 ± 1.09	12.22 ± 0.48	9.17 ± 0.08	3.00 ± 0.03	3.00 ± 0.16
Penicillium chrysogenum	76.81 ± 1.80	39.11 ± 0.72	15.11 ± 0.37	7.71 ± 0.52	4.89 ± 0.31
Penicillium citrinum	12.87 ± 0.53	9.76 ± 0.31	2.96 ± 0.03	0.72 ± 0.02	0.72 ± 0.02
Cladosporium herbarum	76.33 ± 1.36	27.00 ± 0.96	16.36 ± 0.46	2.35 ± 0.03	0.43 ± 0.01
Ulocladium chlamydosporum	20.15 ± 0.75	20.56 ± 0.62	15.17 ± 0.56	11.90 ± 0.39	0.55 ± 0.02
Fusarium oxysporum	11.60 ± 0.83	35.16 ± 1.09	19.88 ± 0.70	0	0
Humicola grisea	18.62 ± 0.96	12.14 ± 0.79*	20.51 ± 0.79*	4.53 ± 0.02*	2.63 ± 0.02*
Rhizopus stolonifer	12.77 ± 0.46	9.94 ± 0.31*	2.15 ± 0.03*	2.52 ± 0.02*	2.01 ± 0.02

Discussion

The present investigation reveals that the air is mainly loaded by four fungal species of relatively higher densities which can be arranged in the order of densities as follows: *Cladosprium herbarum, Penicillium chrysogenum, Aspergillus niger* and *Alternaria alternata*. The prevalence of *C. herbarum* spores in the atmosphere is well established (Hyde and Williams 1953, Kramer *et al.* 1959).

Although the qualitative analysis of the fungal species on the test plants has similar pattern, the quantitative differences between populations of the phylloplane of *L. delicatulum* and the aerial shoot fungi of *A. glaucum* were relatively high and coupled with the difference in the amount of compounds on the plant surface (Table 2).

On the contrary to the stem succulent halophyte *A. glaucum*, specialized salt-secreting glands occur in the leaf epidermis of *L. delicatulum* (Batanouny *et al.* 1992) which secrete NaCl and $CaCO_3$ (Fahmy 1991). Very often also certain amounts of organic substances such as amino acids, amines, proteins and sugars have been reported in the secreted fluid of the salt glands in other genera (Thomson 1975, Lüttge 1975). The secreted salt crust on the leaf surface of *L. delicatulum* possibly

acts as a trap-medium for the fungal spores especially when the crust is hydrated in the early morning or late afternoon. The presence of organic substances in the secreted salt crust may support leaf colonization by fungi which metabolize the leaf secretion. Godfrey (1976) stated that leachates may have a direct effect on microorganisms, either stimulating or inhibiting growth. When the spore germination and growth is stimulated, this effect is usually regarded as nutritional and attributed to the presence of carbohydrates and amino acids. The temperature of *L. delicatulum* leaf loaded with its salt crust was higher than that of a crust-free leaves as well as the surrounding air (Fahmy, unpublished data). Such conditions together with the high relative humidity of both the air and the boundary layer surrounding the leaf are considered among the factors which favour fungal growth and sporulation on the leaf surface.

Although the occurrence of the main fungal inhabitants such as *A. niger*, *P. chrysogenum* and *C. herbarum* was nearly similar on the hosts and the non-infected plants, their densities exhibited marked drop which was coupled with low transpiration rates of the hosts (Fahmy 1993) in addition to the low contents of mineral ions and organic constituents in the leaf or stem washings of the hosts. A positive correlation have been reported between the total amount of salt excreted by the salt glands of *Avicennia marina* and the total amount of water transpired (Drennan and Pammenter 1982).

The aqueous washing of the parasite has been proved to be highly promotive for spore germination of some isolated fungi as: *A. niger*, *P. chrysogenum* and *C. herbarum*. This might explain the high density of these fungi on the parasite. The inflorescence of the parasite with its dense flowers, perianth leaves, bracts and scale leaves provides a substratum for gowth and reproduction of a variety of fungi. This has been proven from the scanning electron migrograph of the perianth segment (Fig. 1B) which appeared colonized by actively growing and sporing mycelium. During night when the relative atmospheric humidity was high, it has been observed a faint red sap accumulating in the cavity created by the perianth segments of the male flowers of the parasite. This liquid has been assumed to be a guttation fluid or nectar secreted by nectaries in the male flowers (detailed investigation of this case is going on). This secreted fluid may be favourable for fungal colonization since the chemical analysis of the inflorescence washings indicated that its contents of soluble sugars and amino nitrogen were higher than those in the washings of the hosts. The stimulation of spore germination of the tested fungi by the aqueous washings of the non-infected *L. delicatulum* leaves appears to be mainly due to the presence of high contents of organic substances compared to those in the washings of the host plants or the host and the non-infected plants of *A. glaucum*.

References

Barnett, H.L., Hunter, B.B.: Illustrated Genera of Imperfect Fungi. - Burgess Publishing Company, Minneapolis 1972.

Batanouny, K.H., Hassan, A.H., Fahmy, G.M.: Eco-physiological studies on halophytes in arid and semi-arid zones. II. Eco-physiology of *Limonium delicatulum* (Gir.) Ktze. - Flora **186**: 105-116, 1992.

Burrage, S.W.: The micro-climate at the leaf surface. - In: Preece, T.F., Dickinson, C.H. (ed.): Ecology of Leaf Surface Microorganisms. Pp. 91-101. Academic Press, London 1971.

Carroll, G., Petrini, O.: Patterns of substrate utilization by some fungal endophytes from coniferous foliage. - Mycologia **75**: 53-63, 1983.

Christensen, M.: Synoptic key to *Aspergillus nidulans* group species and related *Emericella* species. - Trans. brit. mycol. Soc. **71**: 177-191, 1978.

Dickinson, C.H.: The mycoflora associated with *Halimione portulacoides*. III. Fungi on green and moribund leaves. - Trans. brit. mycol. Soc. **48**: 603-610, 1965.

Dickinson, C.H.: Cultural studies of leaf saprophytes. - In: Preece, T.F., Dickinson, C.H. (ed.): Ecology of Leaf Surface Microorganisms. Pp. 129-137. Academic Press, London 1971.

Drennan, P., Pammenter, N.W.: Physiology of salt excretion in the mangrove *Avicinnia marina* (Forsk.) Vierh. - New Phytol. **91**: 597-606, 1982.

Edwards, M.C., Ayres, P.G.: Effect of materials from oak leaf surfaces on germination of *Microsphaera alphitoides* conidia. - Trans. brit. mycol. Soc. **78**: 123-128, 1982.

El-Ghamrawy, N.: The Effect of *Orobanche* Parasitism on Soluble Sugars and Some Minerals of *Vicia faba*. - M.Sc. Thesis. Fac. Agr., Cairo Univ., Cairo 1968.

Ellis, M.B.: More Dematiaceous Hyphomycetes. - Commonwealth Mycological Institute, Kew 1976.

Fahmy, G.M.: Eco-physiological Studies on Some Halophytes in the Mediterranean Zone, Egypt. - Ph.D. Thesis., Fac. Sci., Cairo Univ., Cairo 1986.

Fahmy, G.M.: The nature of salts secreted by the epidermal glands of some-halophytes: An energy dispersive X-ray analysis. - Egypt. J. appl. Sci. **6**: 410-422, 1991.

Fahmy, G.M.: Transpiration and dry matter allocation in the angiosperm root parasite *Cynomorium coccineum* L. and two of its halophytic hosts. - Biol. Plant.**35**: 603-608, 1993.

Fahmy, G.M., Ouf, S.A.: The mucilage glands of *Limonium delicatulum* (*Plumbaginaceae*): Secretion and fungal colonization. - Zagazig J. agr. Res. **19**: 789-804, 1992.

Gilman, J.C.: A Manual of Soil Fungi. - Iowa State Univ. Press, Ames 1957.

Godfrey, B.E.S.: Leachates from aerial parts of plants and their relation to plant surface microbial population. - In: Dickinson, C.H., Preece, T.F. (ed.): Microbiology of Aerial Plant Surfaces. Pp. 433-440. Academic Press, London - New York 1976.

Hyde, H.A., Williams, D.A.: The incidence of *Cladosporium herbarum* in the outdoor air at Cardiff, 1949-50. - Trans. brit. mycol. Soc. **36:** 260-266, 1953.

Jackson, M.L.: Soil Chemical Analysis. - Constable & Co., London 1958.

Kramer, C.L., Pady, S.M., Rogerson, C.T.: Kansas aeromycology. III : *Cladosporium*. - Trans. Kansas Acad. Sci. **62**: 200-207, 1959.

Lüttge, U.: Salt glands. - In: Baker, D.A., Hall, J.L. (ed.): Ion Transport in Plant Cells and Tissues. Pp. 335-376. North-Holland, Amsterdam - London 1975.

Naguib, M.I.: On the colorimetry of nitrogen components of plant tissue. - Bull. Fac. Sci. Cairo Univ. **43**: 1-5, 1969.

Raper, K.B., Fennel, D.I.: The Genus *Aspergillus*. - Williams and Wilkins Company, Baltimore 1965.

Raper, K.B., Thom, C.: A Manual of Penicillia. - Williams and Wilkins Company, Baltimore 1949.

Russel, J.A.: Colourimetric detection of amino nitrogen. - J. biol. Chem. **56**: 467, 1944.

Singh, J.N.; Rai, T.B., Singh, J.N.: Studies on the physiology of host-parasite relationship in *Orobanche*. III. Carbohydrate and nitrogen metabolism of host and parasite. - Physiol. Plant. **27**: 347-353, 1972.

Swain, T., Hillis, W.E.: The quantitative analysis of phenolic constituents. - J. Sci. Food Agr. **10**: 63, 1959.

Taeckholm, V.: Student's Flora of Egypt. 2nd ed. - Cairo University, Cairo 1974.

Thomson, W.W.: The structure and function of salt glands. - In: Poljakoff-Mayber, A., Gale, J. (ed.): Plants in Saline Environments. Pp. 188-246. Springer-Verlag, Berlin - Heidelberg - New York 1975.

Communicated by J. ŠPAK