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Development of Rhizosphere and Rhizoplane Microflora of Aristida coerulescens in the Libyan Desert

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Several workers (SABET 1935, 1939; REINBOLDT 1951; GAERTNER 1954 and MUSKAT 1955a, b) have made extensive studies on the soil fungi inhabiting natural soils or present in the rhizosphere of certain wild plants throughout the world.

The first author (SABET 1935, 1939) isolated—from Egyptian soil—many fungi inhabiting different types of soil, e.g. loamy fields, heavy clay, sandy natural soils, salt marshes, etc., and could prove variation in the abundance, as well as, genera and species of different isolates from the different localities under study. Similarly, REINBOLDT (1951) found that most of the *Phycomycetes* isolated by her from certain localities, in Germany, were irregularly distributed throughout the soil, and their frequency within the rhizosphere of certain higher plants was modified by the stimulatory and inhibitory influences of the latter. Among the plants that induced stimulatory effects were *Rumex acetosa* and chicory, while *Chelidonium majus* exerted a repressive effect. Mention should be also made to the work of GAERTNER (1954), who showed that natural soil of North Sweden or certain localities of Germany were very poor in soil fungi, especially with respect to *Mucoraceae* and *Pythiaceae*, in comparison with those present in African soils. Similar results were also concluded by MUSKAT (1955a, b) on comparing the mold-fungi of Bavarian and Tunesian soils.

However, the above mentioned authors, and others were not interested in studying the rhizosphere microflora (bacteria and fungi) of desert plants with respect to depth of the soil or the root zones themselves. Furthermore, comparisons between microflora of the rhizosphere, rhizoplane, and direct surface of the different root zones of specific wild plants has not been worked out.

Among many of the edaphic factors which affect the relative distribution of rhizospheric microflora of a specific higher plant are the depth of soil and the root zones themselves. The latter, i.e. root tip, zone of lateral roots and root base are expected to possess different microbiological activities governed by several factors, e.g. moisture and humus content, water-soluble salts, physico-chemical structure of the soil, root exudates, etc. However, it is hardly to say that the presented literature, in the last decades, on the rhizosphere microflora of different

plants, includes any complete study of the rhizosphere effect of the different root zones. Furthermore, very few investigations have so far been made of the fungal and bacterial floras of undisturbed natural soils, i.e. in the desert (Stenton 1953).

The root system of desert plants has proved to constitute a microhabitat within the soil which influences plant associations and their root development (Montasir et al. 1956). A study of the interrelationship between a xerophyte such as *Aristida coerulescens*, which forms one of the main associations with *Danthonia forskalii* in the Libyan desert (Hassib 1950), and the abundant microorganisms in its rhizosphere, in relation to the different root zones, may elucidate the significance of both microflora and root system as a biotic factor in development of the latter.

This work represents an investigation of the most abundant fungi and bacteria in the rhizosphere and rhizoplane of *Aristida coerulescens*, naturally occurring in the Libyan desert, in relation to its root zones. Attempt is also made to correlate between root zones and abundance as well as individuality of the isolates, especially of fungal flora.

Experimental

Root samples were collected in a flat area, poor in vegetation, at the 52 nd kilometer along Alexandria desert road, where *Aristida* association was present a small distant far away from the right-hand side of the road. Soil in the collecting area was a sandy soil, with a uniform texture to a depth of 1 m or more, and a pH near 6.8. Moisture content at the time of sampling (January, 1962) ranged with depth from 8.4 to 12.8%. Mechanical analysis of soil from the locality (Montasir and Foda 1956) shows the following composition: coarse sand, 45.25%, fine sand, 42.20%, silt, 2.00%, and clay, 3.60%. Roots were collected at three different depths, i.e., at 20, 40, and 60 cm below soil surface. They were severed and placed, with adhering soil, in sterile glass—stopped one ltre. bottles. The roots were gently removed from adhering superfluous soil, and cut into portions, 4 cm each from the three different zones, i.e. root base, zone of lateral roots, and root tip. Care was taken to compare parallel portions of root from the same level in the different replicates. Rhizosphere soil was obtained by shaking the different root-portions in 100 ml of sterile distilled water for 5 minutes. Rhizoplane was obtained by further shaking the same previously washed root-portions for another equal time in 100 ml of sterile distilled water to which was added 1 g of sterile sand. Furthermore; the double washed root-portions were macerated in an electric blender for 5 minutes with another 100 ml of sterile distilled water. This method is mostly similar to that used by Goos and Timonin (1962). Dilution plates were prepared on the following agar media: Soil extract agar, Waksman's agar, and modified Knight and Proom inorganic basal medium. The first medium was used for growing bacteria, both simple and complex, while the last was only for those with simple nutritional requirements. Plates of both media included either ordinary unheated soil suspensions or pasteurized ones, for 15 minutes at 80° C, before plating. It is assumed that colonies developed from the latter arise from spores only, while in the former case, might arise from vegetative forms and spores, and are considered as total count (Naim et al. 1957).

All plates were incubated at 30° C and examined daily for a period of 24 days. Slants of pure isolates of most experimental fungi or bacteria were also made.

Results and Discussion

Counts of bacteria and fungi on the different experimental media in relation to the different root zones of *Aristida* are shown in Table 1. Results show a rhizosphere effect characteristic of each zone of the root-soil interface. Contrary to what is expected, the zone of the root base, i.e. surface layer of soil, contained the lowest numbers of fungal and bacterial

Table 1. *Counts of bacteria, and of fungi, in the rhizosphere soil, rhizoplane, and macerated root-portions, of Aristida, at different root zones, i.e. root base, zone of lateral roots, and root tip, per one gram dry weight of soil, or root tissue, on soil extract, modified Knight and Proom, and Waksman's agar media*

Root zone	Microflora of	Bacterial counts on:				Fungal counts on: Waksman's agar
		S. ext. agar		Knight and Proom agar		
		Total	Spores	Total	Spores	
Root base	Rhizosphere soil	18500	3800	1750	220	2000
	Rhizoplane	1640	200	180	25	1450
	Macerated roots	590	30	40	—	200
Z. lat. roots	Rhizosphere soil	20210	4000	2340	280	3500
	Rhizoplane	2110	244	290	40	1870
	Macerated roots	710	35	68	—	320
Root tip	Rhizosphere soil	26620	5300	3010	340	4610
	Rhizoplane	2540	292	340	60	1890
	Macerated roots	880	60	80	30	450

floras, and their amount gradually increased, within the limits of experiments, with depth of the root up to its apex, at the level of 60 cm below soil-surface. However, this observation was confirmed by MONTASIR et al. (1956b) on studying the distribution of soil microflora in relation to vegetation at yellow hills north to Cairo where the area supports open associations of vegetation and belongs to the Arabian desert. Similarly, the present results show difference in the relative abundance of fungi as compared with bacteria at the same root zone. The former are several times more than the latter on any of the root zones of *Aristida*, expecially those of the rhizosphere soil. The fact that total counts of complex nutritional bacteria (by subtracting total count on Knight and Proom medium from total count on soil extract agar) are higher than total

Table 2. *Fungi*[1] *isolated from the different root zones of Aristida and their distribution in the rhizosphere (R.S), rhizoplane (R.P), or resulting from its macerated root-portions (M.R)*

Fungi	Root base			Z. lat. roots			Root tip		
	R. S.	R. P.	M. R.	R. S.	R. P.	M. R.	R. S.	R. P.	M. R.
Alternaria tenuis Nees	+	+	+	+	+	−	+	−	−
Aspergillus awamori Nakazawa	+	+	−	−	−	−	−	−	−
Aspergillus flavus Link	+	−	−	+	+	+	+	+	+
Aspergillus niger van Tieghem	+	+	−	−	−	−	+	−	−
Aspergillus terreus Thom	+	+	−	+	+	−	−	−	−
Coniella sp.	+	+	−	−	−	−	−	−	−
Corticium solani (Prill. and Delacr.) Bourd. and Galz.	+	+	−	+	−	−	−	−	−
Cunninghamella echinulata Thaxter	−	−	−	+	+	−	−	−	−
Cunninghamella elegans Lendner	−	−	−	+	+	+	−	−	−
Fusarium equiseti (Corda) Sacc. sensu Gordon	+	+	+	+	+	+	+	+	+
Fusarium oxysporum Schlecht. ex. Fr. sensu Snyder and Hansen	+	−	−	+	−	−	+	+	+
Fusarium solani (Prill. and Delacr.) Bourd. and Galz.	−	−	−	+	−	−	+	+	+
Gibberella fujikuroi (Sawada) Wollenw.	−	−	−	+	−	−	+	+	+
Helminthosporium sativum Pammel, King and Bakke	−	−	−	−	−	−	+	+	+
Hormodendrum hordei Bruhne	−	−	−	−	−	−	+	+	−
Humicola fusco-atra Traaen	−	−	−	−	−	−	+	+	−
Macrophomina phaseoli (Maubl.) Ashby	+	+	−	+	+	−	+	+	+
Monilia humicola Oudemans	−	−	−	−	−	−	+	+	−
Mucor mucedo (Linne) Brefeld	+	+	+	+	+	+	+	+	+
Penicillium notatum Westling	+	+	−	−	−	−	−	−	−
Penicillium funiculosum Thom	+	+	−	+	+	−	−	−	−
Rhizopus nigricans Ehrenberg	+	+	+	+	+	+	+	+	+
Sordaria sp.[2]	−	−	−	+	−	−	+	+	+
Stemphylium sp.	−	−	−	+	−	−	+	+	−

[1] Other fungi or isolates were not included owing to difficulty in isolation or identification. Thanks are due to Dr. W. L. GORDON, Dr. E. ELLIS, and Dr. BROWN, as well as other members of the Commonwealth Mycological Institute for their kind help in identifications and descriptions of newly recorded *Sordaria* sp.

[2] *Sordaria* sp. newly recorded. + present; − absent.

counts of simple nutritional bacteria, has been confirmed by studies of WEST and LOCHHEAD (1940), though they were on cultivated plants.

Concerning individual fungal isolates from the different root zones, distributed in the rhizosphere, rhizoplane, or resulting from macerated

root-portions, the list (Table 2) shows that a greater number of fungi was isolated from the root tip, than from either the zone of lateral roots, or root base. Similarly rhizosphere soil contained a greater number of species than from rhizoplane or macerated root-portions. However, some of the fungal species which were found in a specific root-zone or root-surface were not present in the other, e.g. *A. awamori* was present in the root base rhizosphere or rhizoplane, but absent from all root-surfaces of the portion of lateral roots or root tip. Similarly, *Helminthosporium*, *Hormodendrum*, *Humicola*, and *Monilia* spp. were absent from the root base, but present in the rhizosphere or rhizoplane of the root tip, in almost all cases.

Most of the isolated rhizospheric fungi are naturally occurring in cultivated (SABET 1935) and undistributed natural soils (MONTASIR et al. 1956b), but their distribution is clearly correlated with root zones and root-surface of *Aristida* naturally occurring in the Libyan desert.

Summary

Microflora of rhizosphere soil, rhizoplane and macerated root-portions of *Aristida coerulescens*, naturally occurring in the Libyan desert, were different in count and isolates, in the different root zones. A rhizosphere effect characteristic of each zone is shown. The root base contained the lowest numbers of microflora (bacteria and fungi) whilst the root tip included the highest counts. Distribution of most of the individual fungal species in the different root zones and root-surfaces is given in text.

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