

## **Some Biological Activities of Halotolerant Microflora in Farasan Soil, Saudi Arabia**

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**ABSTRACT.** The biological activities in ten soil samples, from eight rhizosphere soils of halophytic plants and two of bare soils. At Protectorate Farasan Island, Saudi Arabia, were investigated. Respiration rates (CO<sub>2</sub> evolution), moisture content, organic matter, soluble salts and pH were estimated.

The results showed that respiration rates fluctuated greatly in soil samples of different plant species grown under identical conditions. The greater respiration rates were correlated with the greater organic matter content and the lower salinity levels. Both, the total and active microbial biomass, were calculated, the first was concomitant to the respiration rate activities, while the other was adversely proportional to the rate of respiration.

The microflora of the rhizosphere is affected by a number of factors, of which the surrounding soil of the root is the most important, and the total activities of the community, measured by CO<sub>2</sub> evolution, are enhanced by proximity to the root (Sparling 1981, Al-Fassi 1985 and 1992).

A close relationship between the rate of respiratory CO<sub>2</sub> evolution and the microbial biomass has been indicated under controlled conditions (Clark 1977, Anderson and Domsch 1978, Jenkinson and Ladd 1981).

Studies concerning the types of microorganisms and their number in saline soils from Saudi Arabia (Fawaz *et al.* 1975, Zaki *et al.* 1979, Abdel-Hafez 1981, and Abdel Hafez *et al.* 1989) can contribute to our understanding of soil biology, but they provide little information on the dynamics of soil processes. The present article aims to elucidate the total activities of organisms in the rhizosphere of halophytic plants grown in the protectorate salty area at Farasan Island, Saudi Arabia.

## Materials and Methods

### Sampling

Eight halophytic plants growing on the Red Sea shore at Farasan Island region (800 kms south of Jeddah) were selected for the present study. Identification of these plants was carried out according to preserved specimens in the herbarium of the Faculty of Science, King Abdulaziz University, Jeddah (Tackholm 1977, Migahid 1978). The plants were identified as follows:

At the vicinity of the sea (5-10 m offshore)	Inland (100 m offshore)
1. Bare soil (not plants)	6. Bare soil (not plants)
2. <i>Aeluropus massauensis</i>	7. <i>Avicennia marina</i>
3. <i>Halopiplus perfulate</i>	8. <i>Anabasis setifera</i>
4. <i>Indigofera sessiliffer</i>	9. <i>Solanum sarratense</i>
5. <i>Limonium cylindrifdia</i>	10. <i>Suaeda monoica</i>

Rhizosphere soil samples of these plants were separately collected according to the method of Louw and Webley (1959). In addition, two bare soil samples were collected. The soil samples were collected under aseptic conditions and stored in a refrigerator until analyses took place.

### Soil Analyses

Moisture conten, total soluble salts, organic matter and pH values were determined in replicate samples according to the techniques quoted by Jackson (1958).

### Measurement of Soil Respiration

The production of CO<sub>2</sub> from the soil samples [either unamended (basal) or amended with glucose] was estimated using the Infra Red Gas Analyzer (IRGA) and system as described by Anderson and Domsch (1975, 1978), Al-Fassi (1992).

The soil respiration rate was calculated as follows:

$$\begin{aligned} \text{Respiration rate} &= J \text{ c } 10^{-6} \text{ (ml CO}_2 \text{ /h/grams of oven dry soil)} \\ \text{where, J} &= \text{the flow rate of CO}_2 \text{ free air (400 ml} \\ &\quad \text{minute or 400 x 60 ml/hour)} \\ \text{C} &= \text{CO}_2 \text{ production in ppm.} \end{aligned}$$

#### ***Determination of Total Microbial Biomass***

It was determined according to the following empirically derived expression, by Anderson and Domsch (1978):

$$1 \text{ ml CO}_2 \text{ h}^{-1} = 40 \text{ mg microbial biomass carbon}$$

#### ***Determination of Active Microbial Biomass***

The active microbial biomass was calculated by dividing the respiration rate of the basal (unamended) soil by the equilibrium rate achieved after amending soil with glucose, using the formula given by Sparling (1981).

% active microbial biomass =

$$\frac{\text{Basal respiration rate (ml CO}_2\text{/h/100g oven dry soil)}}{\text{Amended respiration rate (ml CO}_2\text{/h/100g oven dry soil)}} \times 100$$

## **Results and Discussion**

### ***Some Parameters of the Soil Samples***

The results (Table 1) revealed that the moisture content determination of the bare soil, at the vicinity of the sea, has the highest value (10.2% of oven dry soil), while that of the inland has the lowest one (3.2%), where it is subjected to the direct sunlight and hence a high rate of evaporation. However, the first usually subjected to water logging. In general, the moisture content of the samples near to the sea have higher values (mean 8.32%) than that of the inland samples (mean 4.12%). As for the total soluble salts, soil samples of the inland site have values higher by about 114% of that at the vicinity of the sea. This is mainly due to the continuous receiving of droplets of sea water which accumulated by evaporation.

The organic matter content of the bare soil near to the sea showed the lowest value. This may be due to the continuous washing exerted by the sea water and for the absence of plant cover. However, the mean of the organic matter content of the inland samples was higher by about 31% than that of the vicinity samples, due to the higher plant cover as compared to that near to the sea.

**Table 1.** Moisture content, total soluble salts and organic matter percentages (wt/wt) as well as the pH values of the tested soil samples

Site / soil sample	Moistur content (%)	Table soluble Salts (%)	Organic Matter (%)	pH Value
At the vicinity of the sea				
1. Bare soil	10.2	4.0	0.95	8.7
2. <i>Aeluropus massauensis</i>	8.3	3.3	3.89	8.6
3. <i>Halopiplus perfulate</i>	8.7	5.2	1.59	7.9
4. <i>Indigofera sessiliffer</i>	7.9	5.4	1.31	8.5
5. <i>Limonium cylindrifdia</i>	7.5	4.2	2.05	8.2
Mean	8.3	4.4	1.96	8.3
Inland (100m offshore)				
6. Bare soil	3.2	8.5	2.01	8.5
7. <i>Avicennia marina</i>	4.5	8.3	2.59	8.3
8. <i>Anabasis setifera</i>	3.9	11.7	2.19	8.6
9. <i>Solanum sarratense</i>	4.8	9.3	3.21	8.3
10. <i>Suaeda monoica</i>	4.2	9.5	2.80	8.4
Mean	4.1	9.5	2.56	8.4

As the soil reaction is concerned, alkalinity is one of the distinctive feature of the soils under investigation. This may be due to the calcareous nature of the soil and as it was described by Daubenmire (1959) that in warm dry climate, soils are usually circum-neutral to strongly basic because there is insufficient rainfall to leach away the bases as soon as they are released in weathering, and few acidic materials are produced there by natural process of decay.

### Soil Respiration

The mean respiration rates of both basal and glucose amended soil samples as well as the estimation of total microbial biomass carbon and active biomass are given in Table 2.

The data revealed that glucose is necessary for accelerating the respiration rate when amended to the soil samples, where the CO<sub>2</sub> outputs showed from 1.4 to 3.4 fold increase as compared to the unamended (basal) soils. Some workers reported on the importance of amendment of soil with glucose for acceleration of soil respiration (Anderson and Domsch 1975, 1978, Al-Fassi 1985, 1992).

**Table 2.** Mean respiration rate, total microbial biomass and active microbial biomass of the different soil samples collected from Farasan soil, Saudi Arabia

Site / soil sample	Mean respiration rate ml CO <sub>2</sub> /h/100g oven dry soil		Total Microbial biomass carbon mg/100g oven dry soil	Active biomass (%)
	Basal	Glucose amended		
At the vicinity of the sea				
1. Bare soil	0.9	1.6	64	56.25
2. <i>Aeluropus massauensis</i>	6.1	16.8	672	36.31
3. <i>Halopiplus perfulate</i>	3.7	12.5	500	29.60
4. <i>Indigofera sessiliffer</i>	4.3	11.0	440	39.10
5. <i>Limonium cylindrifidia</i>	1.7	3.9	156	43.59
Mean	3.34	9.16	366.4	40.97
Inland (100m offshore)				
6. Bare soil	1.2	1.7	68	70.57
7. <i>Avicennia marina</i>	1.7	3.5	140	48.57
8. <i>Anabasis setifera</i>	1.4	3.1	124	45.16
9. <i>Solanum sarratense</i>	3.3	8.7	348	37.93
10. <i>Suaeda monoica</i>	1.3	2.9	116	44.82
Mean	1.78	3.98	159.2	49.41

The lowest respiration rates were coincident with the bare soils at the two sites. More likely related to the low organic matter content and the non-rhizospheric nature in both the samples as compared to the other rhizospheric samples in each site. It was reported by many workers that the organic matter have a definite influence on microbial population of soil (Pochen et al. 1957, Abdel Malek *et al.* 1961). It is also known that the rhizosphere of many plants supports intense development of microflora which are physiologically more active than the non-rhizospheric one (Mahmoud and Ibrahim 1970, Zaki *et al.* 1979).

The highest respiration rates was recorded in the rhizospheric sample of *Aeluropus massauensis* (at the vicinity of the sea) and for the inland sample *Solanum sarratense* was the first, both samples have the highest organic matter content. However, *Limonium cylindrifidia* (at the vicinity of the sea), and *Suaeda monoica* (inland) showed the lowest respiration rates, inspite of their high organic matter

content, as compared to the rest of rhizospheric samples. This may be due to their toxic root exudates to the microflora and/or non-assessability of their letter for microbial utilization. It was established that the chemical composition of root exudates vary in different plant species and influence the balance of the rhizosphere microflora (Mahmoud and Ibrahim 1970, Vancura and Hanzlikova 1972).

The results indicated that the overall mean of respiration for the samples collected at the vicinity of the sea was higher by about 130% as compared to that of the inland mean, inspite of the mean of organic matter for the latter was higher by about 31% than the first. This may be attributed to the high salinity content of the inland samples which resemble 114% increase in comparison to the samples collected at the vicinity of the sea. It was reported that high levels of salinity have a bad effect on soil microflora (Zaki *et al.* 1980, Khodair *et al.* 1991).

As for the calculated total microbial biomass carbon, which reflects the close relationship between the rate of respiratory CO<sub>2</sub> evolution and the weight of biomass carbon in the microbial population (Clark 1977, Jenkinson and Ladd 1981), it was concomitant to the respiration rate activities, *i.e.* the highest respiration rate was accompanied by the maximum total microbial biomass carbon and vice versa. However the ratio between the rate of respiration of the basal and glucose amended soils, and which reflect the percentage of active microbial biomass, was adversely proportional to the rate of respiration.

The results represented in Fig. (1) indicated that, as the organic matter of the soil sample increased the total soluble salts decreased and vice versa. Also revealed that the high organic matter content leads to high respiration rate, and this may be limited by root exudates. In other words, the organic matter is responsible for soil respiration and this may be stimulated or inhibited according to the type of the root exudates.

The results (Fig. 1) showed that not only the high organic matter is responsible for high respiration rate but also the low content of total soluble salts, *i.e.* high salt content has adverse effect to the organic matter on soil respiration.

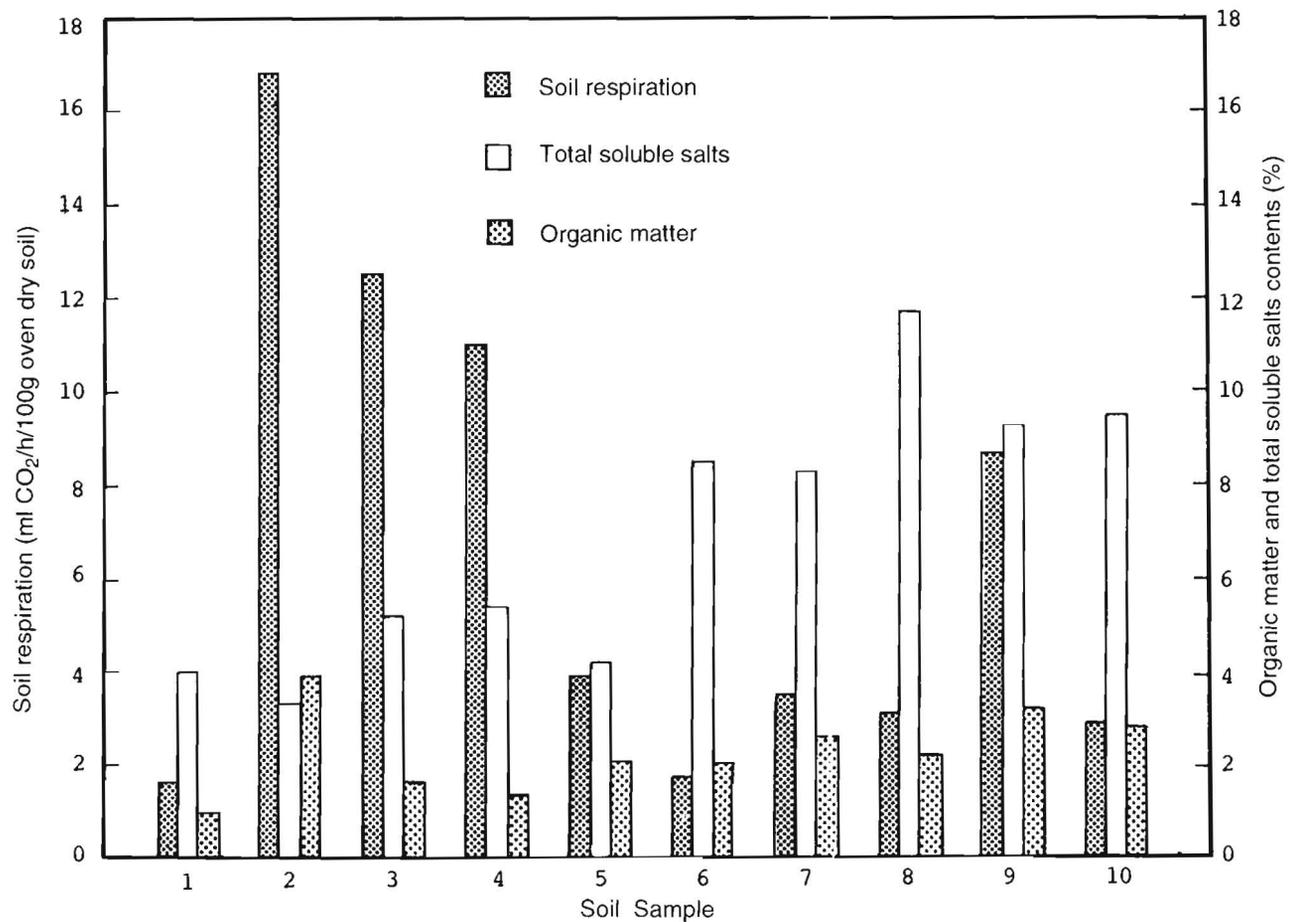


Fig. 1. Soil respiration, total soluble salts and organic matter contents of soil samples collected from the protectorate Farasan Island

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## بعض النشاط البيولوجي للفونة الميكروبية المقاومة للملوحة بأرض فراسان بالمملكة العربية السعودية

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شملت الدراسة الحالية النشاط البيولوجي للفونة الميكروبية لعشر عينات من التربة المحيطة بجذور ثمان نباتات محبة للملوحة بالاضافة لعينات تربة خالية من النباتات في منطقة فراسان بالمملكة العربية السعودية . وقد تم تحديد معدل التنفس ، ومحتوى الرطوبة . وقد أوضحت النتائج أن النشاط التنفسي يتباين بدرجة كبيرة لعينات التربة المحيطة بجذور النباتات النامية تحت نفس الظروف .

وكان أعلى معدل للتنفس مرتبط بالمحتوى العالي للمادة العضوية والمحتوى المنخفض من الملوحة . ولقد تم أيضاً حساب الوزن الحيوي الميكروبي النشط لعينات التربة المختلفة .