The Relative Contribution of Some Genera of Bacteria and Fungi to Aggregate Formation in Calcareous Soils

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The importance of microorganisms in improving the physical properties of soils through aggregate formation is well documented /GASPERI-MAHO and TROEH, 1979; LYNCH, 1981; LYNCH and BRAGG, 1985/. Some genera of bacteria excrete polysaccharides which bind soil particles into stable masses. Fungi may perform that through their masses of hypha, which act as the binding agents.

Several authors investigating soil microbes and aggregate stability have concluded that the decomposing action of microorganisms related to plant and animal residues influences soil structure, as microorganisms and their decomposition products constitute a major source of soil aggregating agents /ADU and OADES 1978a, 1978b; CHANEY and SWIFT, 1984/.

This paper presents results of studies carried out to compare the ability of aggregation of different microorganisms isolated from Iraqi soils in two types of calcareous soils in the presence and absence of different organic waste by-products.

Materials and methods

The microorganisms used in this study were two genera of fungi: Trichoderma sp. and Fusarium sp./ an actinomycete /Streptomyces sp./ and the native populations of each soil. Fungi were maintained in pure culture, using Martin's rose bengal medium /MARTIN, 1950/, while the actinomycete was maintained by utilizing starch casein medium /KUSTER and WILLIAMS, 1964/. All microorganisms were grown at 25 ^{o}C for 7 days. Spores were suspended in sterile deionized water to get a concentration of 10^6 spore per ml using a haemocytometer.

Wheat straw; alfalfa straw; tobacco factory by-product and sheep manure were collected from Hammam al-Alil farms, ground / <1 mm /. A portion was subsampled for total nitrogen and total carbon analyses /Table 1/. The remainder was kept dry. Glucose and cellulose were used for comparisons.

Soil samples representing different soil chemical and physical properties were collected from two sites in Northern Iraq /Table 1/. Soils were air-dried, sieved /< 2 mm/, and 100 g weighed into 250 ml Erlenmeyer flasks.

Table 1

Some physical and chemical properties of the studied soils and tested organic material

Soil and/or organic material	Total C	Total N	C:N ratio	Gypsum	$CaCO_3$	CEC	pH	EC$_{1:1}$
	%			%		meq/100g	/1:1/	dSm^{-1}
Soil I.	0.7	0.08	8.8	0.9	32.8	23.0	7.4	0.4
Soil II.	1.2	0.15	8.0	24.5	22.3	22.4	7.6	2.41
Sheep manure	40.0	1.17	34.6	-	-	-	-	-
Wheat straw	56.3	0.54	104.0	-	-	-	-	-
Tobacco by-product	56.4	1.50	37.6	-	-	-	-	-
Alfalfa straw	67.5	3.93	17.1	-	-	-	-	-
Cellulose	40.0	-	-	-	-	-	-	-
Glucose	40.0	-	-	-	-	-	-	-

In assaying the decomposing and aggregating ability of the cultures, triplicate flasks were used for each culture and for each organic material. The soil of each flask received 1.5% w/w of the specific organic material, thoroughly mixed and sterilized by autoclaving for 1 hour at 15 lb/in^2 on each of 3 consecutive days /ASPIRAS et al., 1971/. After cooling, the soil of each flask was inoculated with 10 ml of the specific microorganisms, then brought to 80% of field capacity. A test tube containing 20 ml of 1 M NaOH was fixed in each flask to trap CO_2 evolving from the decomposition of either the soil organic C or the treated ones. The flasks were covered tightly and incubated for two months at 25± 2 °C during which they were uncovered for aeration and maintaining soil moisture. Carbon dioxide was measured at weekly intervals by titrating the unreacting portion of the base with 1 M HCl after precipitation of the reacted portion with 1 M $BaCl_2$. The percentages of the organic carbon decomposed were calculated in a cumulative manner. At the end of the incubation period the degree of aggregation was determined by the wet sieving method /SKINNER, 1979/.

Results and discussion

Table 2 summarizes the cumulative percentages of CO_2-C evolved after incubating different organic materials in the two soils for two months. The data indicate that glucose decomposed faster than all other tested organic materials. With few exceptions the decomposition rates of the different organic materials were positively correlated with their C:N ratio. The narrower the ratio was the faster the decomposition /ALEXANDER, 1977/.

Trichoderma decomposed sheep manure quicker than Streptomyces in both soils, while Streptomyces decomposed alfalfa straw more rapidly than Trichoderma. Small differences were noted in the rate of decomposition of tobacco factory by-product and cellulose between the genera used. Generally, the decomposition was faster in the unsterile soils. This is due to the presence of many genera specialized in the decomposition of organic material as compared to the sterile ones, which are only inoculated with one genus.

Table 2 also presents the percentages of aggregates formed after incubating different organic materials in the two soils for two months. Inoculation

Table 2

Cumulative percentages of CO_2-C evolved as well as percentages of aggregates formed after two months of incubation of different organic materials in soil I and II

Type of organic material	Type of inoculum: Native population	Trichoderma sp.	Fusarium sp.	Streptomyces sp.
	Cumulative % of CO_2-C evolved*			
	Soil I			
Sheep manure	33	20	13	18
Wheat straw	33	20	21	17
Tobacco by-product	42	22	23	21
Alfalfa straw	56	25	25	27
Cellulose	31	17	19	16
Glucose	66	27	26	29
	Soil II			
Sheep manure	33	20	16	18
Wheat straw	34	20	22	19
Tobacco by-product	43	25	25	24
Alfalfa straw	58	26	25	27
Cellulose	31	19	18	17
Glucose	68	29	28	32
	Percentages of aggregates formed			
	Soil I			
Control	18	23	22	19
Sheep manure	28	34	31	29
Wheat straw	33	44	39	35
Tobacco by-product	34	55	38	36
Alfalfa straw	37	52	38	37
Cellulose	52	46	61	45
Glucose	48	67	51	40
	Soil II			
Control	17	17	17	17
Sheep manure	25	26	24	26
Wheat straw	30	34	32	26
Tobacco by-product	33	35	30	26
Alfalfa straw	35	33	32	28
Cellulose	49	54	36	49
Glucose	37	34	35	30

* Calculated by subtracting the amount of CO_2-C evolved in the control from that evolved from the treated soil

of the sterile soils with the fungus Trichoderma resulted in a better aggregation as compared to the soils inoculated with Fusarium or Streptomyces. This is due to the great masses of mycelia formed by this fungus, which was even visible to the naked eyes.

Generally, less aggregates were noted in the unsterile soils. This is probably due to the presence of different genera which differ in their effectivienss in aggregate formation: some are very effective and some are less effective and even some may have a negative effect by degrading agents, such as the polysaccharides excreted by the effective ones /ADU and OADES, 1978b/.

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