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Research article

Effect of clay amendment on the conservation of moisture in sandy soils of South East Tunisia

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Abstract
Sandy soils in arid regions of southern Tunisia is characterized by a low clay content which leads to strong leaching minerals and fertilizers, it therefore results in decrease in fertility and the retention capacity of the water, in such a situation, our attention is directed to the use of local products to correct the problem of infiltration of sandy soil and increased the useful reserve. The bentonite clay is used with the sandy soil in three sets at different depths in the soil with different percentages: 5 %, 10 %, 15 %, and 20 % to have their effect in the water conservation and in the moisture in the soil. Bentonite is used in two types of clay gravel and powder the experience includes 3 lots: lot with clay sand mixture in different percentage and two lots when the mixed layer is included between two layer of pure sand with different thickness, the result shows that incorporation of clay in the soil increases the retention of water in the soil for gravel clay as powdered clay and preserve humidity not in the clay layer s only but also in the sandy layers overcome.

Key words: Sandy soil, Bentonite, Water conservation, Soil moisture.

1. Introduction

The soils of arid regions of southern Tunisia are of coarse texture Sandy soils cover significant areas in Tunisia. Their location depends on the nature of the parent rock that given birth (Bousnina, 1993). In general, sandy soils are considered poor soils in humid for most crops. As for the southern ridge where conditions climatic aridity, are increasing, approaching the Sahara, sandy soils cover most valleys (Lesschen et al., 2007). Therefore, it is very draining soils with low capacity of water retention and moisture (Lesschen et al., 2007). In absence of any amendment, their agricultural production capacity is weak. To correct defects in the original properties of these soils, farmers resort to organic amendment (Powlson et al., 2001). This amendment certainly improves the chemical fertility of these soils when practiced in a sustained manner Soil fertility can be defined as the capacity of soil to provide physical, chemical and biological propriety conditions (Abbottand Murphy, 2007), however because the climatic change the degradation of organic matter in arid area is very fast (Lal, 2008), its effect is negligible in the correction of high permeability and low water retention of these sandy soils. In addition, the availability of this organic matter is increasingly rare today. For these reasons, our intention was directed towards to use of local materiel for the optimization of these soils. These products are clay materials of geological origin of which is quoted Bentonite. They have the advantage of not being biodegradable as organic matter. Their use in sandy soils of arid have a lasting action in improving the structure of the amended soil and resulting properties (Hlilat et al., 2006), including water retention and moisture in the soil by the decrease in 'infiltration of water during drainage.

2. Material and methods

Realized in the laboratory of soil science in Mednine South east of Tunisia, these experiments evaluate the effect of different sand fortification levels of clay on the retention of water in the conditions of natural drainage (figure 1).

In boxes cylinder of 11.5cm in height and 7 cm in diameter, with perforated bottom has been formed for the following three items where there are three repetitions for each % of clay brought:

→ **1st lot**: layer of soil of 10 cm consists of different mixtures Clay (powdered or gravel) either:

- 1st treatment: 1.5 kg of pure sand (control);
- 2nd treatment: 1.5 kg sand + clay 15.34 g (5 %);
- 3rd treatment: 1.5 kg sand + clay 30.68 g (10 %);
- 4th treatment: 1.5 kg sand + clay 46.02 g (15 %);
- 5th treatment: 1.5 kg sand + clay 61.36 g (20 %).

→ **2nd lot**: Succession of three layers as follows:

From top to down, we find a thin layer of pure sand (153.41 g) and then a mixture of 2 cm layer (306.83 g) or we made the corresponding amount of clay, and finally a thick layer of pure sand about 7 cm.

The second recovery: succession of three layers as follows:

Top to bottom, we find a thin layer of pure sand (153.41 g) and then a mixture of 2 cm layer (306.83 g) or we made the corresponding amount of clay, and finally a thick layer of pure sand about 7cm.

The third recovery: succession of three layers as follows. From bottom to top, we find the same arrangement as previously.

→ **3rd lot**: Succession of three layers as follows, from top to down, we find the same arrangement as previously:

- 1st treatment: 1.5 kg of pure sand (control);
- 2nd treatment: 1.5 kg sand + clay 15.34 g (5 %);
- 3rd treatment: 1.5 kg sand + clay 30.68 g (10 %);
- 4th processing: 1.5 kg sand + clay 46.02 g (15 %);
- 5th treatment: 1.5 kg sand + clay 61.36 g (20 %).

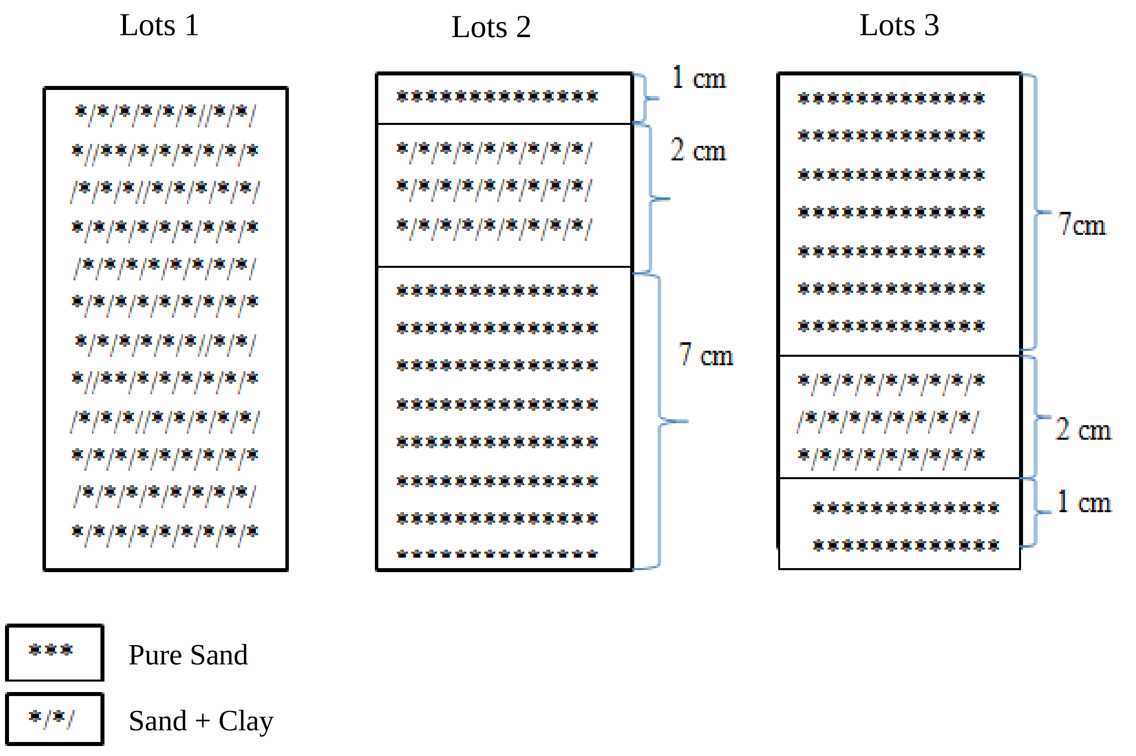

Fig. 1: Experimental setup for the natural drainage of the different types of soil amended

All cylinders were arranged on supports in which it is possible to collect drainage water of each treatment. The surface of each cylinder was covered with a fabric of highly permeable nylon, to prevent disruption of the surface layer during the supply of water. These treatments These treatments then received once each one in 500ml of water, more than sufficient quantity to cause a drain, to avoid the effect of evaporation.

Reading the results of this trial consisted of:

- To measure the amount of water drained in function of time;

- Deduct the total quantities retained by the soil columns;

- To determine the humidity Hs (%) of different layers;

3. Results and discussion

3.1. Effect of clay amendment on the retention of water in the conditions of natural drainage

The amount of water is drained measure ensures a function of time. The results are recorded in tables 1 and 2 show the effect of the percentage of clay on the natural drainage for each lot studied.

According to tables 1, 2, time to natural drainage increases with the percentage of clay, as the result indicates that the control soil finishes his ground drainage after 2 hours, to 10 % clay, it requires at least 8 hours to complete their drainage for clay gravel and 12h for powder clay, for both 15 percent and 20 percent powder and gravel clay natural drainage is negligible confirming their high water retention.

For lot n°2 or was includes sand-clay mixture between two layer of different thickness of sand we note that natural drainage time increases with increasing percentage of clay, as shown in Table 3, 5 % clay finishes its drainage after 8 hours and 10 % clay finishes its drainage after 12 hours for gravel and powder clay after 24 hours.

For lot 3, we included the sand-clay mixture layer between two layer of sand of different thickness, one can distinguish the natural drainage decreases with increasing percentage of clay, as shown in table 4, 5% clay finishes its drainage after 8 hours by 10 % against the clay ends its drainage after 12 hours for gravel and after 24 hours for powder clay.

From these results we can conclude:

- The effect of the amendment on the clay water retention is confirmed;

- Drainage time increases with the percentage of clay;

- It follows that the aggregate clay has a second advantage: the first, is that to maximize the useful water retention, the second is to maintain a high permeability of the amended soil;

- The clay is able to decrease the percolation of water even if it is embedded between two layers of pure sand;

- The thinness of the layer to affect the natural drainage, it decreases as the result indicates when the upper layer (lot 3) is thicker.

3.2. Effect of clay on moisture on different lots

These results are asserted by statistical analyzes that indicate changes in the percentage of Hs based on the average percentages of clay in the soil.

Regarding the clay-like effect on this setting, it says what we have seen in the fig that the gravel clay is more significant than the powdered clay. What is shown in the tables 5 and 6.

Conservation of moisture in clay sand mixture level is confirmed. If this layer is introduced on depth between two layers of sands in different thicknesses, so we will distinguish their effect on the moisture layers of sand above them (figures 2 and 3).

From table 7, although the humidity is distinguished at the layer L2 is the most important compared to L1 and l3 layers. The humidity is in the range of 28.05 % for the 5% powder; on the other hand, for the gravel clay is in the range of 30.27 % for the 5 %. For 10 % gravel clay is in the order of 36.55 %, but does not exceed the 29 % for 10 % powdered clay. For layers of pure sand can be seen a greater increase in humidity L1 layer level (30.4 %) which surmounts clay gravel relative to the layer L1 (27.89 %) which surmounts powdered clay to the percentage of 5 % clay. For layers L3 can be seen a greater increase in the moisture layer L3 level (30.26 %) which surmounts clay gravel relative to the L3 layer (28.26 %) which surmounts the clay powder percentage of 10 % clay.

These results confirm what we have said previously that the gravel clay provides moisture retention than powder clay.

Table 1: Evolution drained volume over time (expressed in ml) for lot n°1 for gravel clay

C%	Time	0	5'	10'	15'	30'	1h	2h	6h	8h	12h	24h
0%		0	32.66	46	49.16	50.33	55.3	56.33	0	0	0	0
5%		0	30	40	44.33	45.33	46.33	48.53	0	0	0	0
10%		0	16.33	20	22	23	23.16	23.66	24.66	25.16	0	0
15%		0	0	0	0	0	0	0	0	0	0	0
20%		0	0	0	0	0	0	0	0	0	0	0

Table 2: Evolution drained volume over time (expressed in ml) for lot n° 1 for clay powder

C%	Time	0	5'	10'	15'	30'	1h	2h	6h	8h	12h	24h
0%		0	32.66	46	49.16	50.33	55.3	56.33	0	0	0	0
5%		0	12	18.66	21.5	22.5	22.83	23.83	24.83	0	0	0
10%		0	3.33	6	7.16	7.66	7.83	8.25	8.66	9.5	10	0
15%		0	0	0	0	0	0	0	0	0	0	0
20%		0	0	0	0	0	0	0	0	0	0	0

Table 3. Evolution drained over time (expressed in ml) for lot n° 2 clay powder and gravel

C%	Time	0	5'	10'	15'	30'	1h	2h	6h	8h	12h	24h
C-Gravel												
5%		0	48.33	54.33	57	59	60	61.33	62.33	63.33	0	0
10%		0	34	39,33	41,33	43,33	44,33	49	50	52	45	0
15%		0	0	0	0	0	0	0	0	0	0	0
20%		0	0	0	0	0	0	0	0	0	0	0
C-Powder												
5%		0	43.3	48.3	57.3	59	60	61	61.5	62	0	0
10%		0	18	21	23.5	24.5	25	27	27.5	30	30.5	46
15%		0	0	0	0	0	0	0	0	0	0	0
« 20%		0	0	0	0	0	0	0	0	0	0	0

Table 4. Evolution of drained water as a function of time (expressed in ml) of lots n° 3 clay powder and gravel

C%	Time	0	5'	10'	15'	30'	1h	2h	6h	8h	12h	24h
C-Gravel												
5%		0	40	46.66	50	51	53	54	55	56	0	0
10%		0	30	35	37	39	41	42	43	44	45	0
15%		0	0	0	0	0	0	0	0	0	0	0
20%		0	0	0	0	0	0	0	0	0	0	0
C-Powder												
5%		0	37	40.6	43	44	44.5	45	45.5	46	0	0
10%		0	15.3	17.3	18.3	18.83	19.08	21.3	22.3	24.3	24.83	26.4
15%		0	0	0	0	0	0	0	0	0	0	0
« 20%		0	0	0	0	0	0	0	0	0	0	0

Table 5. Different combinations used

Average	modalities	Combinations
20%	34.8	A*
15%	33.3	A*
10%	32.3	AB*
5%	30.7	BC*
0%	29.2	C*

** Means with the same letter are not statistically different*

Table 6. Comparison's averages of effect on Hs in the types of clay

Average	modalities	Combinations
Gravel	32.2	B*
Powder	31.9	A*

** Means with the same letter are not statistically different*

Table 7. Effect of the incorporation of a layer of clay on Hs% (clay powder and gravel)

C% Layer	Hs % L1 : Pure sand	Hs% L2 : Clay + Sand	Hs% L3 : Pure clay
5 % Powder	27.89	28.05	28.17
10 % Powder	27.77	29.18	28.26
5 % Gravel	30.44	30.27	28.47
0 % Gravel	32.76	36.55	30.26

Table 8. Effect of the incorporation of a layer of sand on Hs% (clay powder and gravel)

C% Layer	Hs % L1 : Pure sand	Hs% L2 : Sand + Clay	Hs% L3 : Pure sand
5 % Powder	27.73	28.33	24.00
10 % Powder	27.49	28.37	24.88
5 % Gravel	30.68	30.41	33.13
0 % Gravel	31.50	49.23	30.50

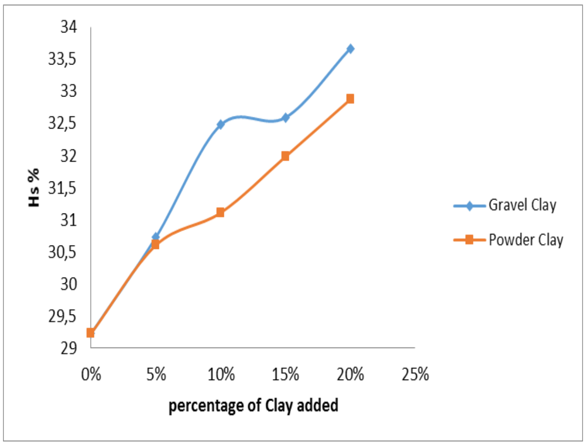

Fig. 2. Evolution of moisture in lot n° 1 for two types of clay

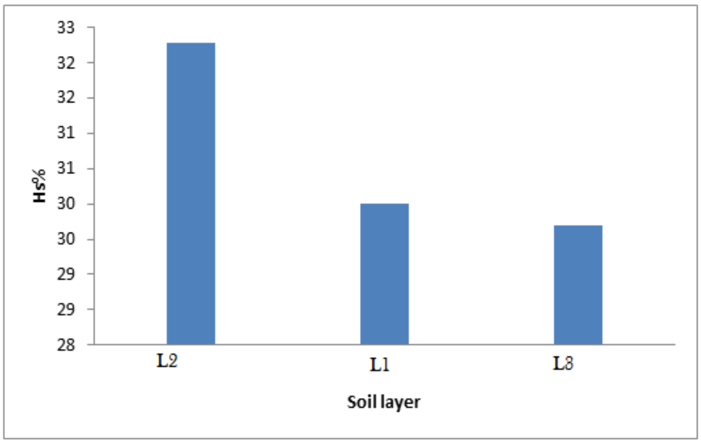

Fig. 3. Comparing the average Hs moisture in different layers

For lot 3, the layer L2 is characterized by a significant Hs for gravel that the powder, the L1 and L3 layers are distinct by moisture content, which increase the clay gravel that powder clay, it is in the order of 30.68% at L1 to 5% gravel and 27.73% in L1 of 5% powder.

For L3, it is in the range of 33.13% in 5% gravel and 24.008% in 5% powder.

These results were confirmed by statistical analysis Hs variation in the different layers of the two lots.

According to fig.3, Hs% humidity is important to the L2 layer is sand-clay mixture layer with a value of 32.5% underwent .moisture increase the level of pure sand layers L1 and L2. We can say that the incorporation of a deep clay layer is capable of providing not only increase the humidity in amended layers but also in the share of sand layers either side of that, this increase is due mainly to a slower percolation, this result is confirmed by Bousnina (1994), which showed that the incorporation of clay in depth ensures the increase of moisture from layers else it overcomes. Bousnina (1993) compared the experience by clogging test walls in soil oasis of Tozeur and found that the walls sealing method is more effective for moisture conservation with the test of incorporation of a long mixing layer. The humidity Hs is greater when the sand layer is thicker (lot3), as shown in Tables 9 which highlighted the importance of Hs in the lots3 relative to lots 2.These results are further confirmed by the results of the comparison statistical analysis averages the effect of the thickness of the layer in the different batches on humidity Hs. (Hassink , 1997)

The moisture is important for lot 3 that the lot 2, lot 2 is characterized by a sand layer which surmounts the layer of clay, sand mixture against the layer that surmounts the clay sand mixture for lot 3 is thick. So we Table 10 Comparison of average clay type of statistical analysis says the experimental results and indicates that the humidity Hs is also influenced by the type of clay, it is more effective for gravel clay that clay powder that is confirmed by Bold, (1972) and Bossuyt et al., (2002) which showed that the coarse element when saturated can transmit water to sand it helps to moisten, and he placed conclude that a porous body in the sand passes through two phase, wetting phase (when filled with water) and a water transmission phase the sand dries. It can be concluded that the incorporation of clay in the sandy soil ensures decreasing natural drainage and increased humidity even if the mixed layer is incorporated in depth.

These results seem of great importance (Denef et al., 2001; Six et al., 2000b), because they find other perspective of amendment clay in sandy soils. Just as in this case, the roots of plants in an amended soil, not forced to expend energy to get water deep under the effect of the potential difference that develops between the two materials (sand and clay) water may be provided in the surface layers to be used by the roots can conclude is that the thickness of the layer which surmounts the clay sand mixture to a significant role on the pure sand moisture.

4. Conclusion

- The clay made in powder form is less effective than that provided in the form of aggregates of diameter from 2 to 4 mm;
- While improving the water retention, and decreasing natural drainage, clay made as aggregates maintains good permeability in mixture clay sand;

- Incorporation of a mixture layer between two sand layers capable of reducing the percolation of water and increased moisture from both sides of the layers which overcome.

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