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Effect of Clay Amendment on Water Retention in Sandy Soil of Arid Southeastern Tunisia areas

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Abstract

This work aims to study the clay amendment effect on the water conservation in sandy soils in arid areas. It was led on crop pots containing sandy soil enriched with different rates of clay powder or gravel (0%, 5%, 10%, 15% and 20%). The used sandy soil is from the region of El Fje in Medenine (in the Southeastern part of Tunisia). The used Clay amendment consists of bentonite. Its provenance is from El Jebel Hidoudi in El Hamma of Gabes (in the Southeastern part of Tunisia). The obtained results show that the addition of clay increases the water reserve available to plants; this effect is clearly tangible only for clay percentage that exceeds 5%. Starting from this rate, the gain in useful water reserve relative to the non-amended soil is even more important when the rate of amendment is higher. The gain provided by amendment with gravel clay is slightly better than amendment with clay powder.

Keywords: Bentonite, gravel clay, powder clay, water reserve.

Introduction

Soils in arid regions of southern Tunisia are coarse textured; therefore they are very draining soils with low water and nutritional elements retention capacity. In absence of any amendment, their agricultural production capacity is very low. To correct defects in the original properties of these soils, farmers resort to organic amendment. Certainly, this amendment improves the chemical fertility of these soils when practiced in a sustained manner. However, its effect is negligible in the correction of high permeability and low water retention of those sandy soils. In addition, the availability of this organic matter is nowadays increasingly rare. For these reasons, our intention has been oriented towards the use of local resources (which are available on site). These products are clay materials of geological origin such as Bentonite. They have the advantage of not being biodegradable unlike organic matter. Their use in sandy soil amendment of dry lands would have a lasting effect in improving the structure of the amended soil and its resulting properties, including water retention.

Material and Methods

Our study involved mixtures of a sandy soil with a clay in powder or in gravel form. For every amendment modality (clay powder or in gravel), 5 clay rates (0%, 5%, 10%, 15% and 20%) were incorporated into the sandy soil. Each mixture was prepared in triplicate[1-2]. It consists of adding in dry to a quantity of clay material similar ensuring homogenization of the whole.

The sandy soil used is the soil of El FJE in Medenine province in the south-east of Tunisia, which is characterized by a sandy texture 89% * with a small percentage of silt in the surface layer.

Table-1
Grain size distribution of the El- FJE soil

Granulometry (%)		
Clay (C)	**Silt(s)**	**Sand* (S)**
1.7	8.8	89

The used Bentonite comes from a clay pit at Djbel Hidoudi located 20 km north of the town of El Hamma of Gabes in the south-eastern region of Tunisia. Table-2 had given physical and chemical characteristics of Jebel Hidoudi. Its mineralogical composition is shown in table-3.

Table-2
Physical and chemical characteristics of Jebel Hidoudi's clay

Granulometry (%)			Limestone (%)		N total (%)	OM (%)	CEC (méq/100g)	pH	EC (mS/cm)	Exchangeable Bases Méq/100g	
Clay	Silt	Sandy	Actif	Total						K^+	Na^+
70.5	20.6	9.6	10	0.16	0.22	0	48.2	7.9	8.3	12.22	179.11

Table-3
The mineral species of Jebel Hidoudi's clay

Type of Clay	Distances regarding the various treatments			% Presence
	raw (Å)	Firing (Å)	Glycerolage (Å)	
Kaolinite	7.2	Destroyed	7.2	3 à 10
Illite	10	10	10	1 à 3
Sodium montmorillonite	13	10	18	90 à 95

To characterize the water retention of sandy soil - clay mixtures, we proceeded at the determination of weighable water levels at field capacity and at the point of permanent wilting.

To obtain the weighable water level at field capacity (or water level at pF2.5), we took for each mixture, three sub-samples that were saturated during 24 hours and later subjected to pressure of 1/3 atmosphere for 48 hours. After those 48 hours, we determined for each elementary sample its wet weight Ph (cc) and its dry weight Ps (cc) after drying in an oven at 105^0C for 24 hours.

To obtain the weighable water level at the point of permanent wilting (or water level at pF 4.2), the process is the same except that the applied pressure is 15 atmospheres. The levels of weighable water at field capacity Ws (cc) and at the permanent wilting point Ws (pfp) Were calculated respectively using the following formulas:

Ws (cc) = [Ph (cc)-Ps (cc)/Ps (cc)]*100

and

Ws (pfp) = [Ph (pfp)-Ps (pfp)/Ps (pfp)]*100

The percentage of usable water RU was calculated according to the formula

RU (%) = Ws (cc) – Ws (pfp)

Results and Discussion

Effect of clay rate and its input form (powder or gravel) on the water retention at field capacity of the amended soil: The field capacity or soil moisture, after soak, after receiving a volume of water, the soil is saturated then this water progressively migrates by gravity into the drainage pores, it remains in the part of the Shipping dry soil only the capillary water on which the forces of gravity are no longer acting[3].

The indicator sand is characterized by a very low ability to retain water; this is explained by the presence of macroporosity, which corresponds, according to the law of Jurin-Laplace, to pores of 50 to 15 µm. This phenomenon is similar with the blends with 5% of bentonite but it already appears lower than in the sand[4-5].

Figure-1 show that Water retention increase by a peak at 10% of clay and reaches its top at 20% of clay in gravel form with a retention rate equal at 35%. For powder clay, the retention capacity appears less important than with clay in gravel form.

Effect of clay percentage and input form (powder or gravel) on water retention at permanent wilting point of the amended soil: this corresponds to the moisture in which all plants show signs of wilting.

According to figure-2, the evolution of pF is proportional to the evolution in the percentage and change in the type of clay in the soil; it evolves from 0.5% for the indicator soil to 4.5 for 20% of clay in gravel form.

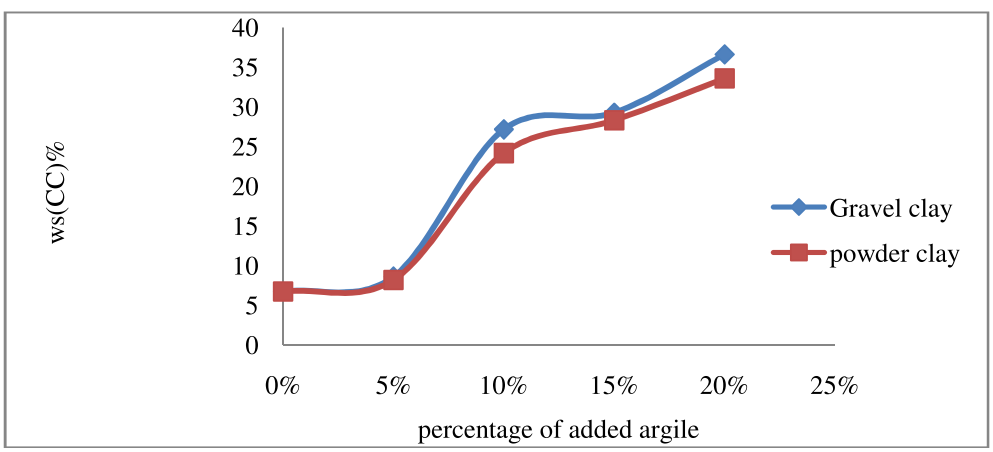

Figure-1
Evolution of the field capacity according to the percentage and type of added clay in the soil

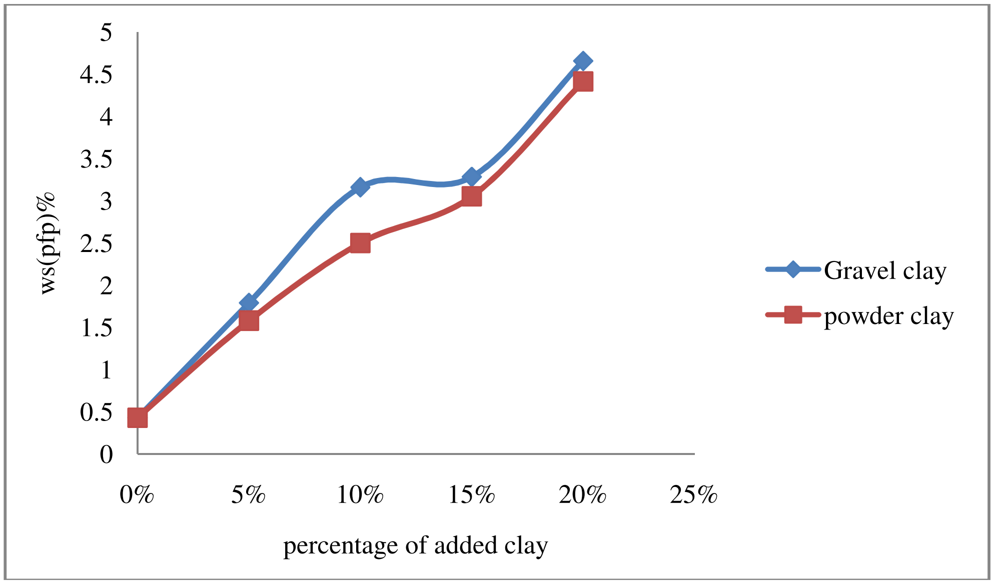

Figure-2
Evolution of wilting point according to the percentage and type of added clay in the soil

Effect of clay rate and input form (powder or gravel) on the useful water reserve in amended soil: Table-4 indicate that the water reserve in the soil has become more significant when the proportion of clay in the soil exceeds 5%.

Table-5 are confirmed statistically this result by the variance analysis of the RU according to the average percentage of clay type, who demonstrated an increase in RU depending on the percentage of added clay in indicator soil.

Table-4
Change water reserve in the soil as clay content added (powder or gravel)

Soil Types	**Witness Sandy Soil**	**Witness Soil+Gravel Clay**			
	0%	5%	10%	15%	20%
Useful Reserve (UR%)	6.33	6.83	24.02	26.01	31.96

Soil Type	**Witness Sandy Soil**	**Witness Soil+ Powder Clay**			
	0%	5%	10%	15%	20%
Useful Reserve (UR%)	6.33	6.63	21.69	25.28	29.19

These results mean that the more the clay content increases the more the useful water reserve increases, increasing the content of clay in the soil ensures the increase of the useful water reserve[6].

The type of clay has a significant effect following the statistical analysis on the evolution of UR in the sandy soil, as shown in the comparative statistic table of averages. Also, it confirms that the clay gravel is more effective than clay powder.

Table-5
Change in average useful reserve in soil according to the percentage of added clay

Terms	**Average**	**Combinations**
20%	30.6	A*
15%	25.6	B*
10%	22.9	C*
5%	6.8	D*
0%	6.4	D*

The integration of a porous rough element into a sand in process of wetting can behave in different ways during the process of wetting of the system sand-rough elements, before being saturated with water, the rough element can absorb water because of the sucking it performs, and thus retards the wetting process of sand[7].

Table-6 findings that the assemblage mode of the clay with the sandy soil used in different experiments and the difference in diameter of the used clay aggregates[2].

Table-6
Change in average useful reserve in soil according to the percentage of added clay

Terms	**Average**	**Combinations**
Gravel	22.2	A*
Powder	20.7	B*
Indicator	6.3	C*

Conclusion

It can be concluded from these results that the addition of clay improves the water retention capability of the sandy soil: The retained water content increases with the increase of the percentage of added clay; The clay in gravel form is able to hold more water than clay in powder form because the coarse element can absorb water due to the sucking effect it performs, and thus retards the wetting process of the sand; Therefore, bentonite clay is an effective solution to enhance hydric features of filter sandy soil.

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