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Effect of clay amendment on the performance of barley crop in arid environments

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Abstract: The growth and establishment of barley crops is often restricted due to low quantity of water particularly in arid environments.
Clay may improve seeding growth by modifying the physical and chemical soil properties which enhance its ability to retain useful water necessary for plants hydric supplies.
Sandy clay mixture was prepared in pots, under greenhouse at different percentages: 0%, 5%, 10%, 15%, 20% of powder and gravel, tested with barley crops (Ardhaoui variety).
Our results show that the clay addition increases water reserve which leads to increase the agricultural yield production with a peak at a percentage of 15% for the gravel mixture.

Key Words: Sandy clay, yields production, graveled mixture.

Introduction

In a world where food security is difficult to maintain. The goal of all companies is to obtain a satisfying and sustainable agricultural production. A dream becoming more difficult to achieve particularly in arid and semi-arid areas where we witness almost a total breakdown in the fertility of cultivated lands together with a chronic water deficit. In such situation, the mean research work focused on improving the physical and chemical properties of sandy soils by indirect methods such as rainfed, the oasis systems, and direct methods such as the selection of irrigation method and the amendment.

The application of organic manure, alone or in combination with chemical fertilizer to increase production per unit area, had been considered as a solution [1] , many results of these experiments have been summarized in [2,3], with the conclusion that fertilizer application is an effective mean to increase yields in arable farming systems. However, in arid regions, the total mass of organic supplements is insufficient to cover the needs of these areas or for new extensions. In addition, the climatic conditions are favorable for rapid decomposition of the organic products which implies a continuous supply of these amendments to maintain a certain level of improvement to the physical and chemical soil quality.

With the various already mentioned constraints, our attention is directed to use mineral amendement to correct the defects of the original properties of these sandy soils, this amendement is bentonite clay of geological origin existing in south east of Tunisia. This clay is used due to its high cation exchange capacity to improve soil structure involving a good water retention, nutrient and ventilation for the plant. In this context, we aim to determine the effect of clay amendment of soil; be it in the powder form or the gravel one; on the behavior of a local variety of barley (*Hordeum vulgare*) irrigated with tap water.

Materials and Methods

The tests were put in pots in a greenhouse at the Institute of Arid Regions in Medenine area of El FJE at the latitude of 33° 21"16 'East and longitude of 10° 30"19 south east of Tunisia.
This area is characterized by hot dry temperatures that can exceed 40 °C in August with a very low average of annual rainfall not exceeding 150 mm/year.

The bentonite clay used in this test for amendment was obtained from a clay pit in El Hamma Jebel Hidoudi.

These clay materials have both very important capacities of cation exchange and water retention as shown in Table 1.

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Table 1. Main physicochemical characteristics of clay Jebel Hidoudi

Granulometry (%)			N total (%)	OM (%)	CEC (mEq/100g)	pH	EC (mS/cm)	Calcareous (%)		Bases exchangeable (mEq/100g)	
Clay	Silt	Sand						actif	Total	K^+	Na^+
70.57	20.67	0.96	0.22	0	48.2	7.9	8.3	10	0.16	12.22	179.11

N: Nitrogen, OM: organic matter, CEC: Cation exchange capacity and EC: electronic conductivity

The soil

The soil of El FJE has a sandy texture with a very small percentage of clay (1.7%) and silts (8.8%), soil pH is 7.5 and the electrical conductivity is moderately high (2.5 mS/cm) as shown in Table 2.

Table 2. Main Physical and chemical characteristics of the soil of El FJE (study area)

Granulometry (%)			Calcareous (%)		N total (%)	OM (%)	gypsum (%)	CEC (mEq/100g)	pH	EC (mS/cm)
Clay	Silt	Sand	Actif	Total						
1.7	8.8	89	5	18.05	0.1	0.51	2.9	0.16	7.5	2.5

N: Nitrogen, OM: organic matter, CEC: Cation exchange capacity: CE:electronic conductivity

Plant material

In our case we led our experiment on a barley crop variety Ardhaoui (*Hordeum vulgare L*).

Experimental Section

All experiments were performed on sand-clay mixtures where the percentage of clay is from 5% to 20%.

The clay was brought from Jebel Hidoudi under the form of large lumps and then was transformed in two forms:

- Clay pulverized by crushing and sieving to 100 µm;
- Aggregate Clay 2 to 4 mm;

This difference in the diameter of the aggregates level has the utility to understand the behavior of coarse particles (clay aggregate) and fine elements (clay powder) toward the soil used as input.

Were prepared two sets of mixtures sand + clay with the following clays percentages: 5%, 10%, 15%, and 20%.

- Sand + clay powder;
- Sand + gravel clay;

The parameters studied

- Rooting;
- The production;

Statistical analyses

We used the variance method to statistically analyze all parameters. The significance of different sources of variations was tested by error mean square of Fisher Snedecor's 'F' test at probability level (P = 0.05).

Results and Discussion

Effect of clay amendment on the roots

Root development is related to the intense presence of water, nutrients and good ventilation in the soil, **Fig. 1** shows the change in weight of the fresh roots in function of the percentage of clay in the soil which increases by less than 1 g in the control soil, by more than 2.5g in the soil with 15% of clay then undergoes a drop at 20% clay and reaches 1.72g.

The weight of dry roots as shown in Fig. 1 increases with the percentage of clay and appears more indicative in the gravel clay respect to the powder. This is due to the beneficial effects of macro-porosity of the gravel clay offering a better retention of water and minerals and a good aeration for the plant.

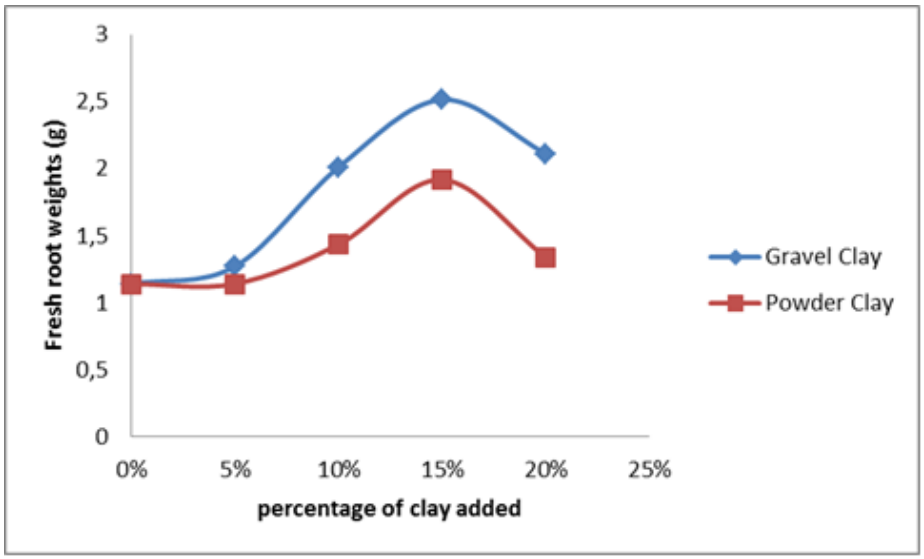

Figure 1. Changes in weight of fresh roots based on the percentage and type of clay

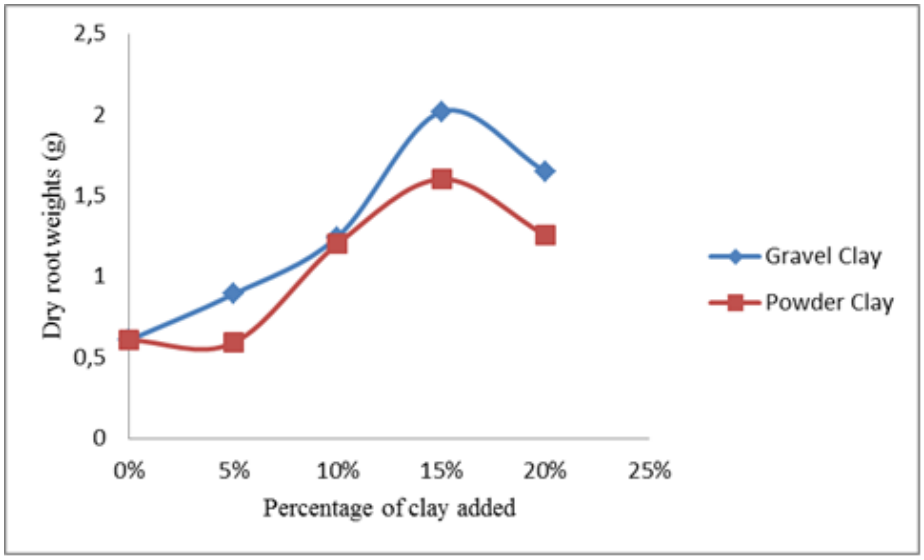

Figure 2. Evolution of the weight of dry roots depending on the type and percentage of clay

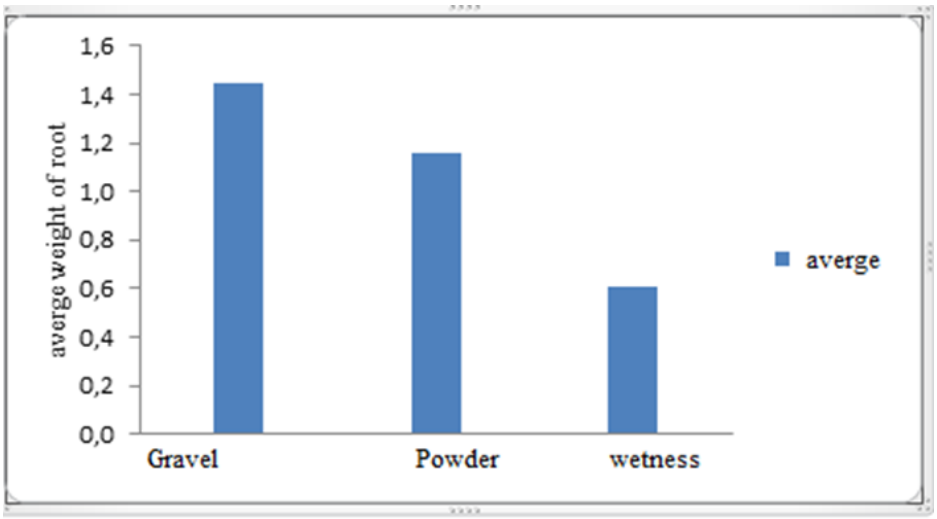

Figure 3. Effect of clay on root growth (g)

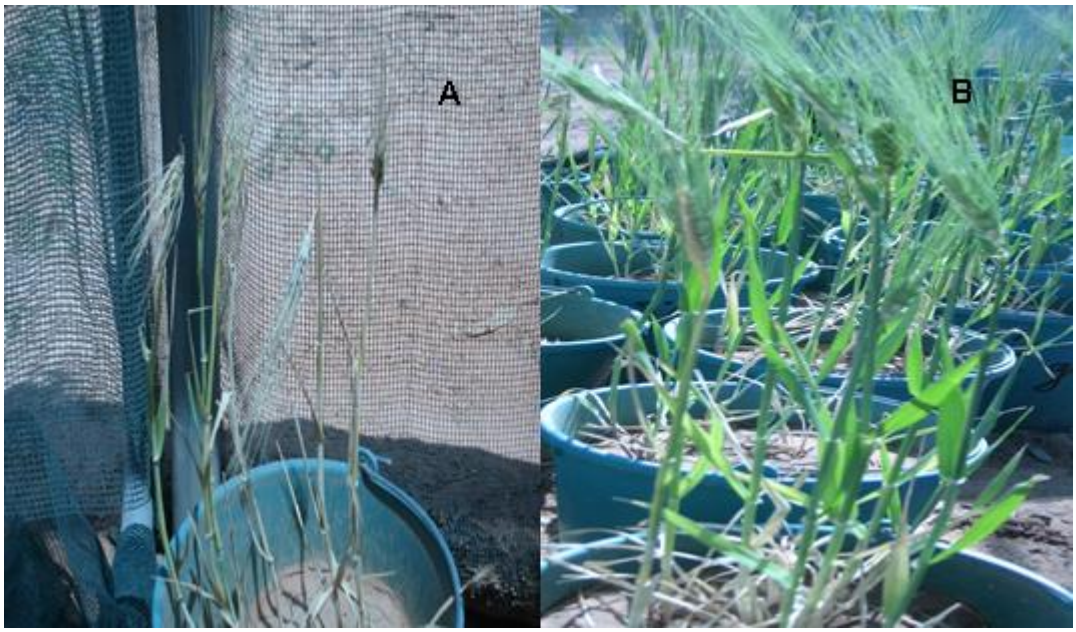

Figure 4. The state of the plant in A: 20% B: 15% of gravel clay

Effect of clay amendment on production

After maturation, the harvest is made in order to know which is the percentage and type of clay that gives the best performance. We were interested in weighing 1000 seeds for each percentage and type of clay. Fig.5 shows the improvement of production according to the increase of clay percentage in the soil.

The percentage of 15% clay presents the maximum of production with 348.8g for gravel clay; this is associated with better productivity and better root growth (Table 3).

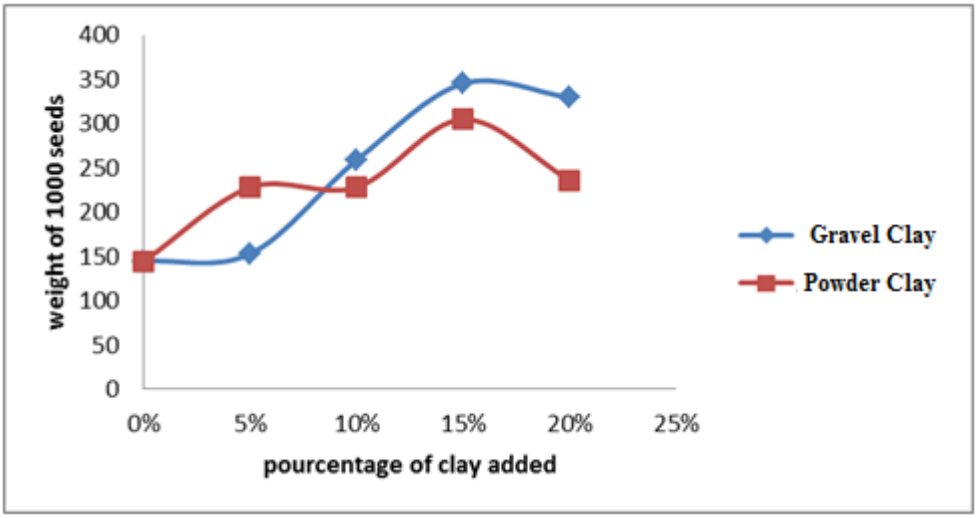

Figure 5. Effect of amendments on the weight of 1000 seeds

Table 3. Change in average weight of 1000 seeds depending on the soil percentage of clay in

modalities	Average
15%	261,8
20%	252,6
10%	238,6
5%	204,3
0%	198,1

Alongside with Fig.4, Table3 shows that 15% of gravel clay is the most effective and favorable condition that promotes the best performance.

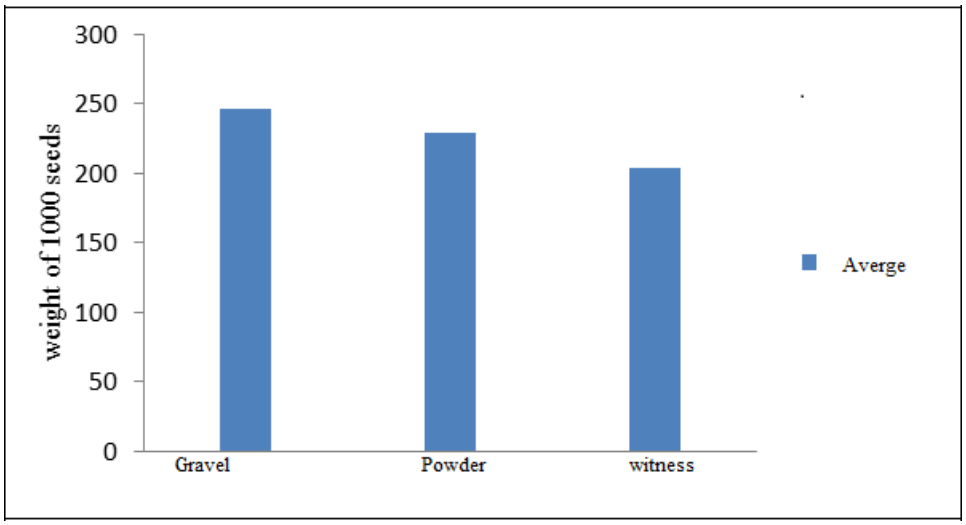

Figure 6. Effect of the type of clay on the weight of 1000 seeds (g)

According to Fig.6, the gravel clay is more efficient to ensure a better efficiency, as shown previously it is able to give the best performance in sandy soil of El FJE Mednine south east of Tunisia

This result can be compared by:

- Czechoslovakian finding in 1985 that the best performance is given by a percentage of 9% clay;
- In Egypt. In 1982 [5] where a dose of 7.2% clay is sufficient to give a better performance;
- Belgacem in Tunisia in 1986, found that a dose of 2% gravel clay is sufficient to provide a better return for the sandy soil of El Hamma;

These differences are due to the particle size of the materials used and should not be generalized.

In conclusion our result can be represented in Ton / hectare (T/h) as shown in Table 4.

Table 4. Amount of clay added to the soil for a better production (T/h)

Author	% Clay	Clay quantity T / h
Cherif (1982)	7.5	127.5
Jenik (1985)	9	153
Belgacem (1986)	2	34
Expérience 2013	15	256

Discussion

To achieve food self-sufficiency for a growing population in south Tunisia, the solution is to increase the production per unit area. Agricultural research has shown convincingly that to achieve that goal, important measures have to be addressed to the improvement of soil and water and nutrient availability which play key roles in plant growth [6].

Nutrient supply for the crop can be improved by applying clay amendment, resulting in the increase of plant production; moreover, the rate of nutrient supply from mineral manures is slower, as the bentonite Clay material must be decomposed to release the nutrient elements which also makes taming of nutrient availability uncertain. On other hand, bentonite Clay contain various nutrient elements (P, K and N)

Agricultural research faces the challenge to answer the question which combination of fertilizer is most efficient for production increase.

Conclusion

This work were conducted in pots containing various percentages of clay mixed with sand from El FJE, this clay is used in two forms powder and gravel.

Experimental series were conducted in the laboratory to check the effect of clay amendment on the production of a variety of local barley crop.

The clay amendment has a very marked effect on barley crops, root system growth path which improved in accordance to the increase in percentage of clay up to an optimal dose of 15% especially with gravel clay giving a total production of 256T / H;

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