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Use of Sewage Sludge in Agriculture in Ain Defla Region, Algeria

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Abstract: This is an effort to study utilize sludge, from the treatment plant, as an organic amendment and investigate its impact on growth, development, and yield of potato tomato, and wheat crops. An assessment of physicochemical characteristics and sludge toxicity elements has been studied to determine the effect of the sludge on the morphological behavior of plants tested, e.g. the length growth, development, and yield. Our experiment is conducted with the application of sludge as a fertilizer on soil planted with three crops in three different agro-ecological regions (El Amra, Arib, and Miliana) of Ain Defla characterized with different soil texture. We initiated this study based on the physicochemical characteristics of soils that received sludge compared to the application of fertilizers and without sludge amendment (control). The short-term effects studied in this experiment indicate that the spreading of the sludge has a beneficial effect on the characteristics of the site, there was an improvement in the richness of the soil nutrient elements and therefore on the performance of Culture. So, the results of analysis of the soil of three cultures obtained give evidence of an increase of the pH and the rate of limestone which are related to the changes of the characteristics of the sites of plantations. These results are probably due to the biological characteristics of the sludge, whether it contains pathogenic elements, or it is very rich in fertilizing elements. Based on results it is concluded that residual sludge have limited feasibility to be used as source of nutrients.

Keywords: AinDefla; cultures, soil; biological characteristics, residual sludge.

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1. Introduction

Increasing scarcity of freshwater has lead to the expanding use of wastewater (treated or untreated) for irrigating crops (Galvis et al., 2018; Harrabi et al., 2018). In terms of wastewater treatment, Algeria currently has a dense network of purification plants; covering area, with 165 TPP (treatment plant and purification) managed by the ONA (National Office of Sewerage) (ONA, 2015). Sanitation sector development generates additional amounts of sludge and their fate posses serious environmental concerns, requiring effective and sustainable elimination (Bouslimani and Bezara, 2016).

Although sewage sludge is regarded as waste, however has agronomic interest due to rich in organic matter, nitrogen, phosphorus and a favorable carbon / nitrogen ratio (Becerra-Castro et al., 2015; Guerfi, 2012). However, to value this sludge, it is necessary to be environment friendly, cost effective and technically satisfactory (Jardé, 2005; Larson et al., 1972; Navas et al., 1998; Sastre et al., 1996). For several years researchers in Algeria are studying ways to utilize the residual sludge from sewage treatment plants to fertilize the fields (Belaid, 2015). It appears that the sludge is a source to increase yields and can potentially supplement nutrients to increase soil fertility (Belaid, 2015).

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Fig.1. Location of the wilaya of AinDefla (DSA, 2014).

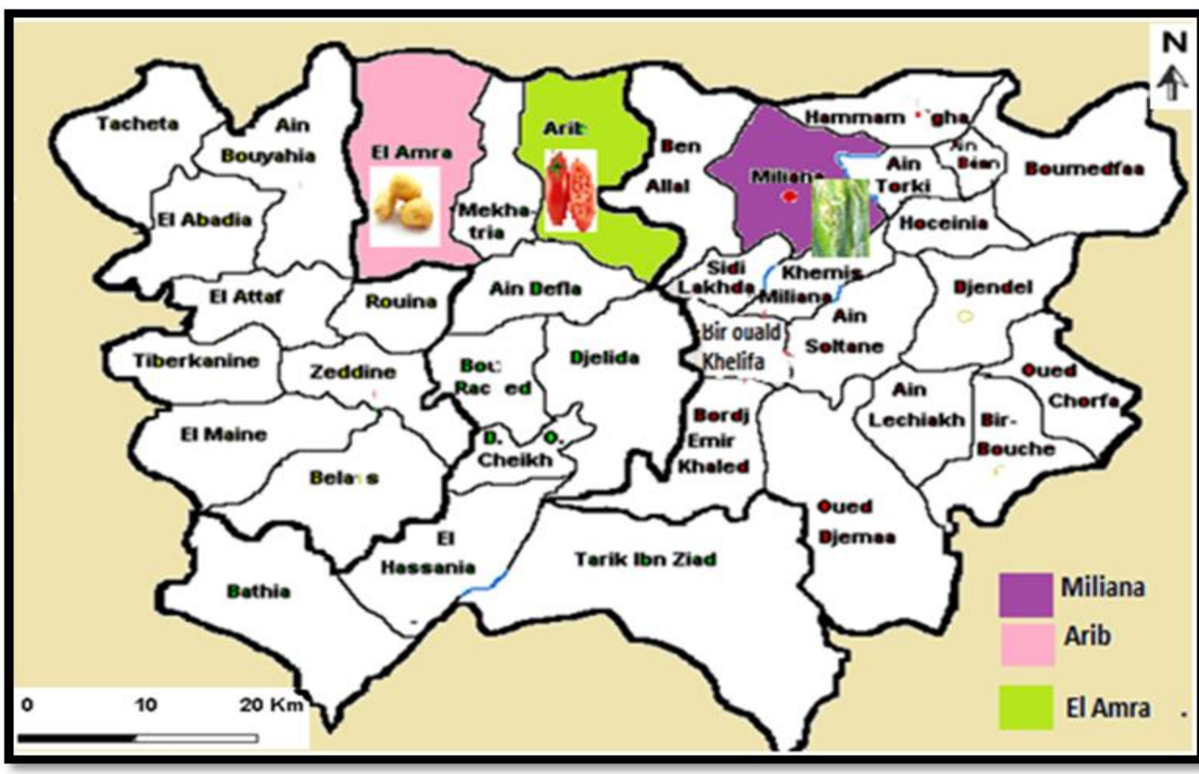

Fig. 2. Map of the implementation of crops (DSA, 2015).

This study used sludge, from the treatment plant of Ain Defla region, as an organic amendment to investigate the growth, development, and yield of potato, tomato, and wheat. Moreover, analysis was done for the assessment of physical and chemical characteristics and toxicity elements of the sewage sludge (Bouslimani and Benzara, 2016).

2. Materials and Methods

2.1. Study Area Description

Current study was conducted in the southwestern province, Ain Defla, Algeria (Fig. 1), located at 145 km southwest of the capital Algiers (ANDI, 2014; Boulaine, 1957; DSA, 2015). Ain Defla province is crossed by the Cheliff valley on its entire length, where soils are light, fertile and movable, with a predominance of fines elements (80%) where clay presents more than 45% (DSA, 2013).

This area has an agricultural vocation par excellence. Cereal crops, vegetables (mainly potatoes), fruit growing, industrial crops occupy the land of the plain, while mountain areas are occupied by rainfed crops (cereals and forage) and the sheep and goat rearing. It is characterized by a climate of semi-arid Mediterranean. It records an average annual rainfall of over 500 mm (Bouslimani and Benzara, 2016). These rains are concentrated in the period from November to March where they account for 77.13% of annual precipitation.

2.2. Experimental Material

Field experiment was performed on agricultural field for the three crops (Tomato, Potato, and Wheat) in the three different regions (Fig. 2). A plot with an area of 12 m², in the municipality of El Amra located in the northwest of the wilaya of Ain Defla, was reserved for planting the potato. The second parcel of 4 m² selected area in the town of Miliana in the north of the province of Ain Defla, sown with durum wheat. Finally, in Arib town in the north - eastern province of Ain Defla we chose a parcel of 2 m² area reserved for growing tomatoes. Each experimental field was divided into three small sub-plots (SP) of equal sizes, where treatments control (SP-1, without nutrient supplementation), fertilizer (SP-2, fertilizer supplementation) sludge (SP-3, application of sludge).

2.3. Soil Preparation

Before plantation of selected crops, soil was prepared considering crop requirements. Shallow plough (15cm to 30cm) was applied for wheat, medium plough (35cm or even 40cm) for tomatoes and deep plough (35cm to 80cm) for potatoes. Mulch was application after thorough ploughing. Subsequently seeds of tomato (April 27th, 2015), potato (January 1st, 2016) and wheat (February 2nd, 2016) were sown in the well prepared soil.

2.4. Sludge and Fertilizer

The sludge used in our experiment was produced on 25th May, 2015 (Sludge No. 01) and 26th January, 2016 (Sludge No. 02) from the treatment plant of Ain Defla. Both types of sludge are dark black in color with an unpleasant odor. Collected samples of sludge were stable, dry and solid state, characterized with the average particle size of 6 mm. In addition to sludge, NPK ($N:P_2O_5:K_2O$, 15:15:15) as fertilizer and Super-46 were applied to tomato (NPK: 20 g, sludge 30 g, 19th June 2015), potato [(NPK: 1.8 kg m^{-2}, 27thJanuary, 2016), (Super 46, 1 kg m^{-2}, 10th March, 2016), (sludge, 1.8 kg m^{-2})] and wheat [(NPK: 40 g m^{-2}, 3rd February, 2016), (Super 46, 20g m^{-2}, 27th April, 2016), (sludge, 40 kg m^{-2})].

2.5. Irrigation equipment

We used three irrigation methods to supplement water for crop growth. In case of tomato drip irrigation (8 l h^{-1} , for 2 h after 48 h), aspersion for potato (4 mm for 3 h) and sprinkler irrigation (10 l after 48 h). Water from Ghrib dam was used to irrigation tomatoes and for wheat and potatoes irrigation water was obtained from Sidi M'Hamed Ben Taiba (SMBT) dam.

2.6. Crop Management

Insecticides, fungicides and herbicides were applied, as per location recommendations to protect crops from insects, diseases and weeds.

2.7. Soil Physico-Chemical Analysis

Soil analyses were performed for the studied plots which aim to provide information on the soil of El Amra, Arrib and Miliana. For this, we performed a soil sampling from three experienced treatments: control (soil), with fertilizer and sludge. The samples taken have been subjected to physical and chemical analyses in the laboratory of University of Khemis Miliana and the analytical laboratory of the National Institute of Soil and Irrigation and Drainage (INSID) in Relizane. This study was carried out in 3 steps including prospecting the ground; laboratory analysis and soil characterization.

2.7.1. Soil pH

After soil sampling, samples were first air dried at room temperature and subsequently in an oven at 105 °C for 24 hours. Oven dried samples were sieved through a 2 mm sieve.

Table 1: Comparison of physicochemical characteristics of sludge with AFNOR standards

Characteristic	Sludge-1	Sludge-2	French Standardization Association (AFNOR)
pH	9.64	7.77	/
EC (ms cm-1)	7.51	7.28	/
OM (%)	64.95	67.34	40 - 65 %
Phosphorus (awilable, ppm)	*	*	/

*: No test result; /: No standard.

Electrical pH meter was used to measure soil pH and categorized as strongly acidic (pH ≤5.5), moderately acidic (5.5<pH≤6.0), slightly acidic (6.0<pH≤6.5), neutral (6.5<pH≤7.0), slightly alkaline/basic (7.0<pH≤7.5), strongly alkaline/basic (pH>7.5) (Hallouz et al., 2017). Dried to 30%. The sludge / quicklime mixture was homogenized to allow chemical reaction and nutrient availability (Hallouz et al., 2017).

2.7.2. Soil Moisture

Field moisture corresponds to the moisture content of a soil sample at a given time; in particular at the time the sample was expressed as a percentage, moisture is obtained by weight difference in the sample after desiccation at 105 ° C for 48 hours. (Hallouz et al., 2017). Indeed, at the output of waste water treatment, the water content of the sludge is around 99% of the crude material. Reducing the masses to be handled by avoiding dust and improving quality are the issues involved in the recycling and recovery of sewage sludge. Water content of sludge was reduced by drying (Hallouz et al., 2017).

2.7.3. Soil Electrical Conductivity

For determination of electrical conductivity (EC) diluted extract (extract 1/5) was used (Samai, 2002). Equipment was calibrated using KCl (0.02N) inside the oven (25 ° C) (Hallouz et al., 2017) (Table 1). Soil EC was described as unsalted (EC<2.5), slightly saline (EC 2.5-5), moderately saline (EC 5 to 10), saline (EC 10 to 15), highly saline (EC 15 to 20), very strongly saline (EC 20 to 27.5), and hyper saline (EC >40) (Chhabra, 2014).

2.7.4. Soil Organic Matter

Soil organic matter is determined by means of organic carbon, taking as a fact that organic carbon accounts for 58% of the organic matter, using the method described by Anne (1945). Soil organic matter was calculated using equations [1 & 2].

$$\%C = (V_{control} - V_{sample}) \times 0.61\text{:} \quad [1]$$

Where **P:** soil weight (g).

$$OM = \%C \times 1 \quad [2]$$

2.7.5. Soil $CaCO_3$

The evolution of limestone ($CaCO_3$) in the sludge must be monitored from the measurement of CO_2 evolution in Bernard Calcimetre, and therefore by gasometry, this dosage is based on the characteristic reaction of calcium carbonate and hydrochloric acid using equation [3] (Aubert 1978):

$$CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + (\quad [3]$$

In addition, the presence of limestone plays an important role in ionic equilibrium, particularly in pH values, and the limestone content is related to the nature of the substrate or to the different artificial inputs to correct the pH of the soil and to increase the buffer capacity of these studied soils (Guerfi, 2012).

2.7.6. Soil Granulometry

Granulometric analysis was done to determine the soil texture by classifying the mineral particles based on their soil diameter. Soil particles were separated into sand (2 to 0.05 mm), silt (0.05 to 0.02 mm) and clay (<0.02 mm) (Damay et al., 2009). Soil texture influences root penetration, water retention capacity and compaction (Calvet, 2003; Oleghe et al., 2017). This method uses the Robinson pipette, the texture is determined by a textural triangle. The removal of clays and fine silt was carried out using the Robinson pipette; the fine and coarse sands were recovered by sieving, the coarse silts were deducted by the difference (Fig. 3) (Jones et al., 2003).

3. Results

3.1. Physico-chemical characteristics of sludge

According to the results, the sludge used in our experiment are made of: 21% clay, 6% silt, and 76% sand for sludge No. 1, and 23% of clay, 8% silt and 69 % sand for sludge No. 2.

Table 2. Physical and chemical characteristics of the studied soil before the crop establishment

Analyzes	Parameters		Units	Tomato	Potato	Wheat
Physical	Granulometry	Clay	%	52	33	32
		Silt	%	40	29	60
		Sand	%	8	30	5
	Electrical conductivity (EC)		ms/cm	0.453	0.104	0.222
	pH			7.37	7.47	6.81
Chemical	OM		%	1.22	0.53	2.65
	$CaCO_3$ Total		%	4.24	03.39	12.31
	$CaCO_3$ Actie		%	0.25	01.12	01.25
	P_2O_5		ppm	ND	73.57	180.46
	Na^+		Meq/100g	1.86	0.44	0.19
	K^+		Meq/100g	0.94	0.49	0.56
	CEC		Meq/100g	19.5	6.75	11.25

ND, not detecable

According to US textural triangle (USA), sludge was categorized as silty-sandy loam texture and according to Henin (1969), the texture obtained for both sludge is in middle class. The results (Table 1 were compared with the AFNOR standards cited by Laced (1985). Average pH of the sludge ranged between 9.64 and 7.77, slightly alkaline considered for the sludge No. 2 and alkaline for sludge No. 1. Therefore, they are considered as suitable for almost all crop plants. The electrical conductivity (EC) is in order of 7.51 mS / cm (sludge No. 1) and 7.28 mS / cm (sludge No. 2), classified as medium saline. According to the French Standardization Association (AFNOR), the results of the two sludge show that are very rich in organic matter where their rates exceed 64% (Table 1).

3.2. Heavy Metals

The sludge has always been considered toxic substrates because they often contain high amounts of heavy metals. However, analyses (Fig. 3), allowed us to conclude that the sludge from the Ain Defla station meets the standards. According to the results of analyses of the two sewage sludge, the heavy metal contents remained below the upper threshold (not recommend their use for agricultural use), considered as safe for crop production use.

3.3. Physico-chemical characterization of the soil

In order to monitor the variability of the analyzed parameters, soil plots reserved for crop implantation has been the object of a physicochemical characterization before and after different crops (Tomato, Potato, and wheat), the main results are shown in the Table 2. The texture influences permeability, water retention, aeration and cation exchange capacity (Fig. 3) (Oleghe et al., 2017).

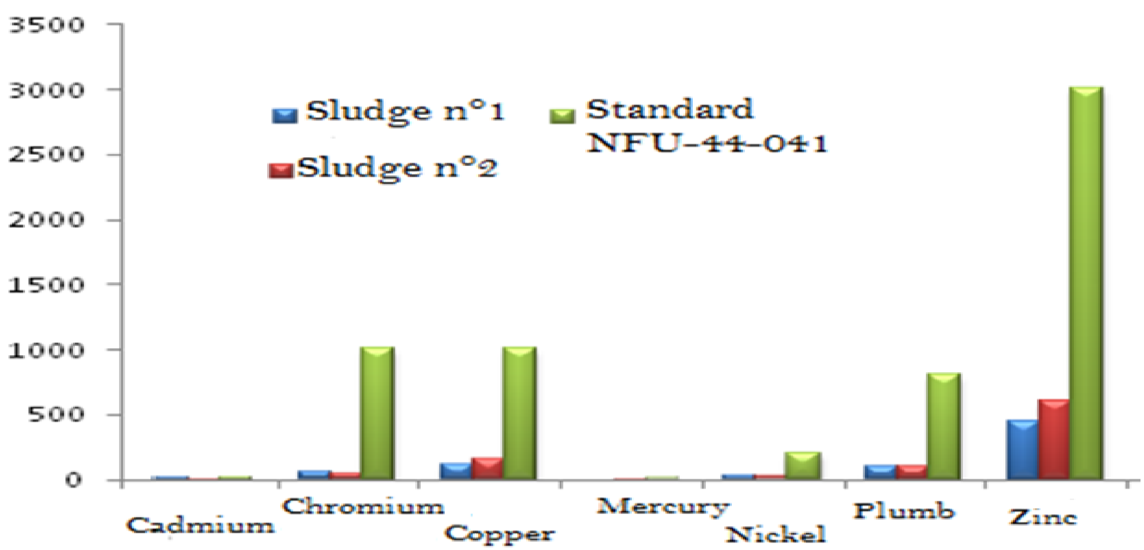

Fig. 3. Concentration of heavy metals in sludge compared to the standards (mg / kg).

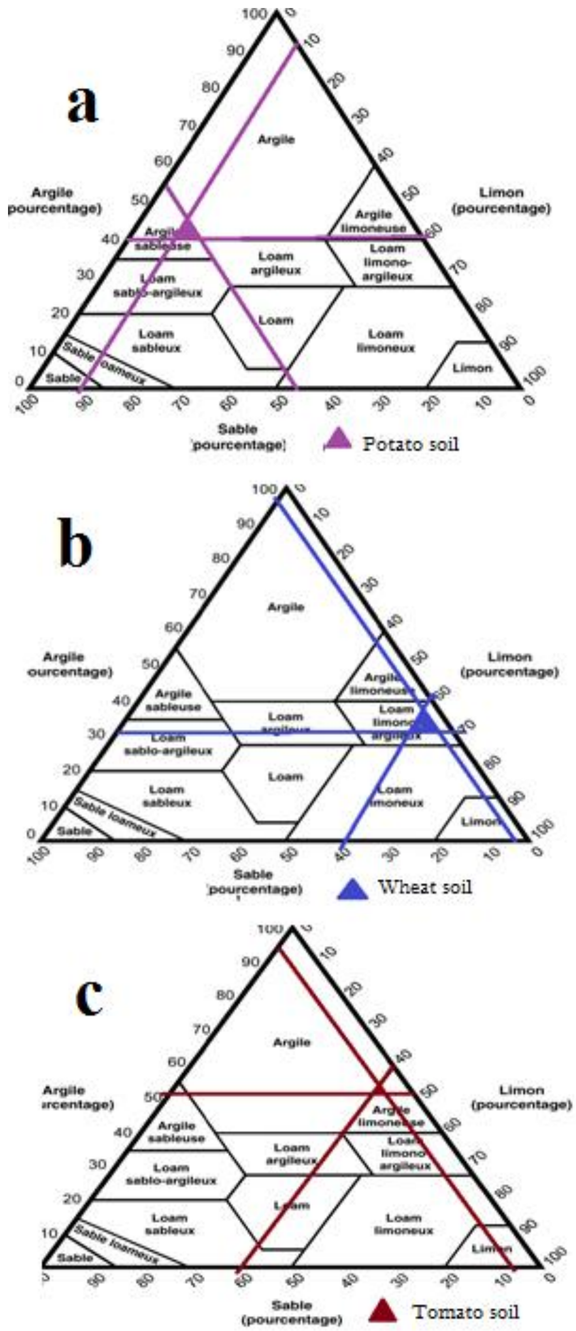

Fig. 4. Texture of different planting site a. potato, b. wheat, c. tomato crop.

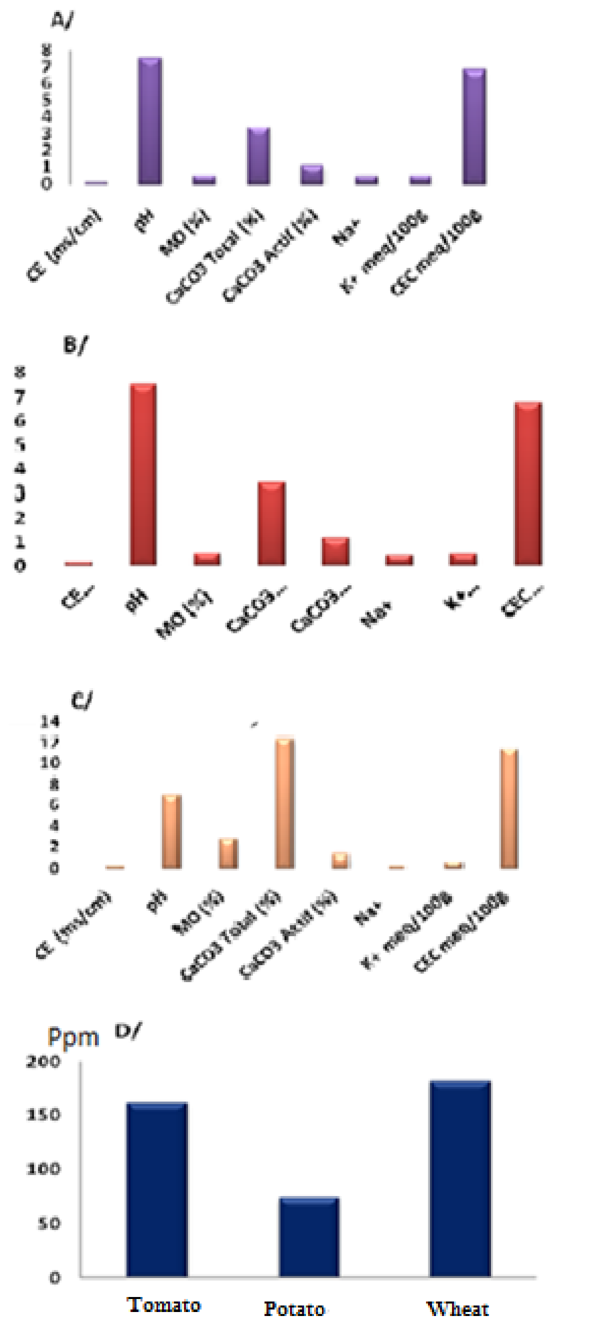

Fig. 5. Soil analysis before crop (A : Potato, B : Tomato, C : Durum wheat, D: phosphorus analysis result of each culture).

The analyzed soil was dominated by sand, with silt and clay. The percentage of each fraction (Table 2) using the textural triangle, concluded that soil of El Amra (potato field) is categorized as sandy clay class, and is more sensitive to the risk of compaction as result of movement of agricultural machinery. However, soil of Miliana is categorized as silty clay, requiring more efforts for mechanical operation and limited water movement. Soil physicochemical parameters are shown in the Fig. 5.

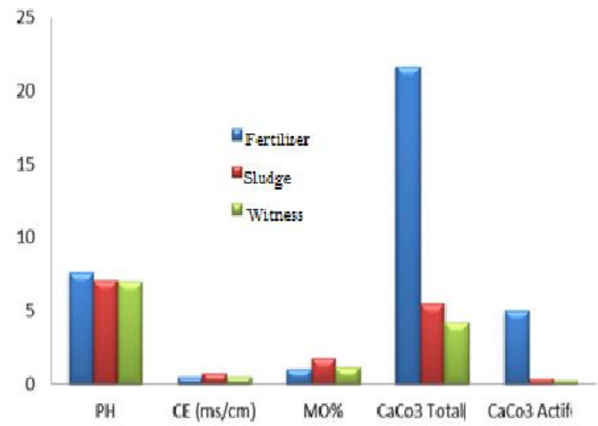

Fig. 6. Variation of soil physicochemical parameters under different soil treatments in tomato crop (Fertilizer, sludge and witness).

Soil pH observed towards neutral with an electrical conductivity less than 2.5 mS / cm, so these soils are categorized as non-saline. For the chemical parameters, soil is poor in organic matter for the regions of El Amra and Arrib unlike the soil of Miliana which is moderately low in organic matter. The total limestone content is low in our results, it is less than 20% with a proportion of 0.25% to 1.25% active limestone, and the cation exchange capacity (CEC) is very important for retention of cations for plant uptake. Among the nutrient elements, phosphorus, indispensable for plant growth and development (Amin et al., 2017; Bi et al., 2013; Maathuis, 2009). However, its concentration on soil used for potato cultivation was much lower as compared to the soils used for wheat and tomato crops..

3.3.1. Soil characteristics after crop cultivation

3.3.1.1. Tomato

The following parameters were monitored namely pH, electrical conductivity, organic matter, phosphorus, the total and active limestone (Fig. 6). Given these results, we observed that the pH of each test varies from 7.03 to 7.62; indicating that experimental soils are neutral to slightly basic. The EC was greater than 2 ms/cm, so the test with fertilizer and control soil are slightly saline, sludge is moderately salty, and potentially can cause salinity. Moreover, O.M of the sludges remained significantly low (ranged between 1.06% and 1.78% for all cultivated soils), as compared to standards which make our soils moderately poor in organic matter and CEC of tomato soil (Fig. 7).

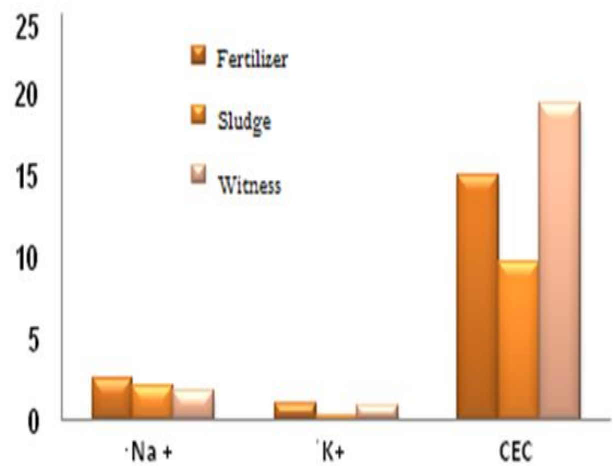

Fig. 7. Soil cations and cation exchange capacity (CEC) used for tomato crop.

The CEC value is essential for proper interpretation of the contents of exchangeable cations elements (K^+, Ca^{++}, Mg^{++}, and Na^+). The distribution of different cations on the CEC sites and the saturation rate provides valuable information about how the ground; and in the CEC classification table, we noticed that for the control ground the value of CEC remains very high compared to other tests or in the soil supplemented with the fertilizers or treated by the sludge.

Results clearly showed spatial variations in soil phosphorus content, very high in the control soil relative to that of the sludge treated soil, however less than in the fertilizer treated soil. This can be attributed to different type of root system of different crops leading to varying nutrient absorption capacity, and different nutrient needs of each crop plant. The morphological results showed that combination of sludge with fertilizer is most suitable in term of nutrient supply for plant growth. (Table 3).

In our experiment, the results relating to the fruit character are satisfying for treatment with sludge that gave weighing of 7.8 kg which was the better in terms of all studied parameters, for treatment with fertilizer (6.5 kg) and control (4.5 kg) which are the lowest. Changes in tomato fruit weight in response to application of fertilizer and sludge are given in Table 4. Although tomato yield was higher when treated with sludge, however its product quality was poor with short shelf life.

Table 3. Growth of the vegetative parts of tomato and potato under different sources of nutrients

Crop	Tomato			Potato		
Treatment	Root (cm)	Stem (cm)	Leaf	Root (cm)	Stem (cm)	Leaf
Fertilizer	25	60	10	20	26	10
Sludge	20	75	14	14	10	8
Control	25	65	12	16	20	9

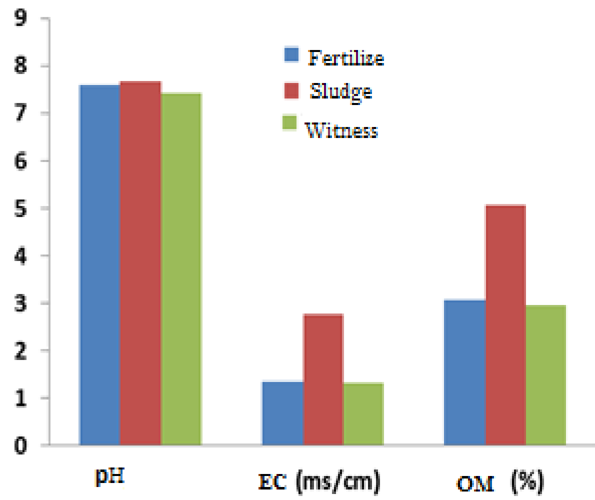

Fig. 7. Soil parameters under different treatment of potato crop.

3.3.1.2. Potato

Most soils are suitable for growing potatoes provided that they are well drained and not too rocky (Razdan and Mattoo, 2005). Preferred soils are those that are deep, fertile and furniture. The physicochemical parameters of potato soil in our experiments are shown in the Fig. 7.

The physicochemical analysis of our samples shows that the pH> 7.5 is a basic pH. For the values obtained from the EC that are inferior to 2.5ms/cm, we find that the soil with fertilizers and witnesses have a low conductivity, thus unsalted soil from the ground in the presence of sludge, including the EC varies from 2.5 ms/cm to 5 ms/cm, which makes low salt. The OM content is an important factor for the physical, chemical and biological activity of potato ground. In general, the production capacity of a soil is proportional to its content of OM, and in our testing, it ranges from 2.5% to 6%, so it is rich soils with OM. After the comparison of the vegetative development of each treatment, we notice that potato is well developed with fertilizer test (Table 3).

Potato weight was significantly influenced by different sources of nutrients. Application of sludge produced smaller potatoes, potentially due to low concentration of nutrients (Gwenzi et al., 2016; Zahoor et al., 2016).

3.3.1.3. Wheat

Wheat adapts to different soil types. The intake of nutrients is essential for proper development of wheat. Any deficiency in inputs at critical growth stages can results in compromised yield (Bennani, 2014; Ding et al., 2011). The results of chemical analysis of cultivated soils; showed relatively neutral pH soil ranging from 7.6 to 6.81 (Fig. 8). For the EC, we consider that the soil is slightly salty for fertilizer test with 3.90ms/cm and moderately salty for soil treated by sludge 7.15ms/cm, and the witness soil we found an EC less than 2.5ms / cm so it is a non-salty soil. Cultivated soils are considered as rich in OM for sludge and fertilizer treatments while for the control ground his OM content makes it moderately rich.

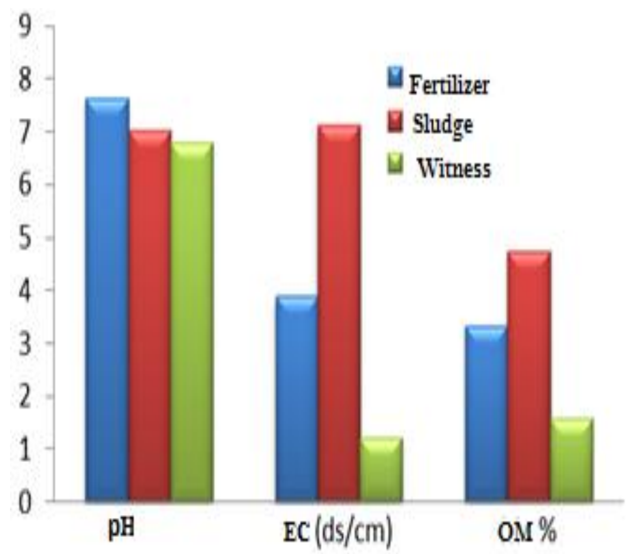

Fig. 8. Soil parameters under different treatment on wheat.

Table 4. Response of tomato, potato and wheat yield under different sources of nutrients

	Tomato ($t\ ha^{-1}$)	Potato ($t\ ha^{-1}$)	Wheat ($t\ ha^{-1}$)
Fertilizer	16.2	50.0	3.45
Sludge	19.5	7.5	1.17
Control	11.2	28.0	0.65

Results regarding wheat yield are presented in the Table 4, was more than 300% higher yield in the experimental plots treated with fertilizer, as compared to sludge and control. This potentially can contribute to limited availability of nutrients for wheat crop, which leads to very less reduced translocation of photosynthates to grains in term of yield.

In wheat roots are of adventitious type and root development is very important for wheat growth, so the wheat is more sensitive for availability of nutrients (Hamner et al., 2017; Steffens and Rasmussen, 2016). Therefore ample supply of nutrients is required to meet nutritional needs of wheat, which were restricted in other treatments. The stems and leaves are well developed in the presence of sludge than in the presence of fertilizer this is probably due to that the sludge contains nutrients other than those present in fertilizers which promote better a vegetative growth. The results relating to this parameter are very important, where the treatment with fertilizer was the most developed in terms of all parameters studied previously, by cons, we recorded a low yield for other treatments (Table 4).

4. Discussion

The sludge contains certain elements and useful substances for plant growth; it is the total nitrogen, phosphorus, etc, and has great importance in agriculture, which encourages their use either by direct application or by composting with household waste (Gamrasni, 1979; Khanmohammadi et al., 2017; Srinivasan et al., 2017).

Application of sludge significantly modified soil physicochemical properties including texture, granulometry analysis. Soil texture is important for aeration, which is crucial for optimum root functions (Patrick and Henderson. 2017) including water and nutrient uptake, regulating plant growth and development (Ben-Noah and Friedman, 2018; Dickopp et al., 2018; Miller et al., 2011; Tan et al., 2018). Sludge contains sand and coarse elements (Mateo-Sagasta et al., 2015), despite the waste water treatment process to remove different components. However after purification operations such waste will be mixed with the sludge extracted from the basin.

Variability in different sludges can be due to variations in climatic conditions in the sampling an/or cropping season (Sun et al., 2018; Zoghlami et al., 2018). Therefore experimental plots were exposed varying levels of rainfall which enables the dilution of the soil solution and chemical properties. Soil pH regulates nutrient availability (Ramade, 1993; Akinnusotu et al., 2018; Tahir et al., 2018). Mobility of the most of trace elements increased with reducing pH (Alloway, 1995; Sherameti and Varma, 2010). Moderately saline electrical conductivity of sludge used in this study can be attributed to presence of large amounts of minerals ions. Therefore application of such sludge, if not chemically treated, may cause accumulation of salts in the agricultural soils (Ors et al., 2015).

The sludge used in this study are considered rich in OM with a value that exceeds 25%, this property makes the sludge as good organic fertilizer especially for soils of the El Amra area (poor in OM), as compared to the soils of Miliana and Arrib which are moderately low OM. According to AFNOR standards this result is close to the range for the sludge No. 01, while the OM for the sludge No. 02 is greater than 65%, this is may be due to the season where the drying bed is in overload in the winter season due to the rainfall which prevents drying of the sludge, and there will be no disposal of sludge that will be accumulated in the ventilation basins, which will influence on the degradation of OM (Guerfi, 2012).

Presence of heavy metals is the main factor which limits the application of sewage sludge in agriculture. Accumulation of heavy metals in soil is almost irreversible and has long-term negative consequences to the physical and chemical conditions. The content of the sludge in these elements is the likely of the water's source, the values of heavy metals in sludge used in our experiment are well below thresholds (NFU44-041) except for cadmium (sludge 1, at par with the upper threshold), which corroborates its safe use in agriculture.

In our experiment, our soil has a pH> 7.5 is a basic soil; this value is subject to seasonal variations. It varies with soil moisture, temperature and prevailing cropping system (Jiao et al., 2016; Turmel et al., 2015). The EC describes the concentration of electrolytes and degree of salinization. The results of our study show that soil is not salty compared to the sewage sludge. The total limestone content is important in our results with a lower rate of 20%. Higher Phosphorus contents in the soil used for production of tomato and wheat field can be due to previous crop or inherent soil phosphorus (Munda et al., 2018; Torma et al., 2018).

The physicochemical analysis of soil samples from experimental plots showed that the application of urban sewage sludge had significantly altered soil chemistry. Moreover, soil of different textures and with different crops tested in this study to determine the effect of such amendment on the yield of crops. Similarly, other studies also highlighted that application of sludge produced beneficial effect on soil nutrient status and subsequently improved the crops yield (Abdelhak et al., 2012; Mateo-Sagasta et al., 2015).

The results of soil analysis of the three cultures obtained attest to a slight increase in the pH and lime rates that are related to changes in plantation sites features. So, we believe that in the short term, the spreading of sludge has no considerable effect on soil pH. Comparing the effect of different treatments on the soil electrical conductivity shows an increase of the latter as a function of time (before the introduction of the sludge and to harvest) and the following results, we noticed that the rate of the EC in the sludge treatment is very important in relation to other results. It is accepted that the spreading of sewage sludge can induce an effect of salinity in agricultural soils in the medium term (Bouslimani and Benzara, 2016).

Organic compounds present in sewage sludge will help to buildup soil organic matter and organic carbon. They will improve soil properties such as porosity, structure and water holding capacity (Abdelhak et al., 2012). According to the measurements made on the ground, we also recorded an increase in the OM content but with a considerable amount of the cultivation of tomato compared to other plants. The other parameters of the soils studied showed no differences to report. This may be due to the short period of the test which is not sufficient to have a clear idea about the impact of sludge on agricultural soils.

5. Conclusion

The results of physicochemical analyses of the sludge showed their nutrient rich composition and organic matter easily mineralizable. In addition, this sludge contains only a small proportion of heavy metals that are well below the standards (NFU44-041), so they pose no risk of toxicity. The soil plots reserved for the implementation of selected crops have been a subject of physicochemical characterization before and after the establishment of crops (tomato, potato and durum wheat). The ground test consists of several fractions dominated much more by sand, silt, and clay, indicating that the wilaya of Ain Defla has a different texture from one site to another. In addition, we found that our soil is poor in organic matter for the regions of El Amra and Arrib unlike ground Miliana is moderately low in OM. Organic compounds of sewage sludge will help increase the organic matter sources in the soil and thus enrich with the organic carbon, which will improve soil properties such as porosity, structure and soil moisture. Indeed, the introduction of sludge in our cultures yielded the following results: Tomato crop better performed with the application of sludge, however characterized with poor shelf life. Performance of potato and wheat remained non-satisfactory under sludge treatment. The appearance of diseases on leaves and rots were observed on wheat and potatoes. Finally, we concluded that the sludge cannot be used as natural fertilizer on field crops such as cereals, the vegetable crops such as tomato and potato. For satisfactory results, it is important to make thorough analyses of the sludge for nutrient supplementation and to study their impact on medium-term trials (over 4 years).

List of abbreviations: pH: Hydrogen potential - OM: Organic matter- EC: Electric conductivity.

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