Egyptian Journal of Aquatic Biology & Fisheries
Zoology Department, Faculty of Science,
Ain Shams University, Cairo, Egypt.
ISSN 1110 – 6131
Vol. 25(4): 981 – 1001 (2021)
www.ejabf.journals.ekb.eg

The integration of aquaculture with agriculture in a semi-arid region in Northwest of Algeria

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ARTICLE INFO

Article History:
Received: May 19, 2021
Accepted: July 17, 2021
Online: Aug. 30, 2021

Keywords:
Agriculture
Fish farming water
Irrigation
growth

ABSTRACT

The aim of this study is to contribute to the realization of the project which relies on integrating fish farming into agriculture. It consists of evaluating the effect of irrigation with fish farming water on plant growth and yield of cultivated species, in order to minimize the use of chemical fertilizers. All parameters of water were analyzed: the potential of hydrogen (pH), conductivity (CE), calcium (Ca^{2+}), sodium (Na^{+}), nitrate (NO_3^{+}), sulfate (SO_4^{2-}), magnesium (Mg^{2+}), potassium (K^{+}), and chloride (Cl^{-}). The analyses of potable and fish farming waters indicated that all studied parameters are balanced means that waters are appropriate for irrigation. In addition to analyzes of water, soil parameters were measured: the potential of hydrogen (pH), conductivity (CE), organic matter (OM), the mean weight diameter (MWD), chloride (Cl^{-}), sulfate (SO_4^{2-}), calcium (Ca^{2+}), magnesium (Mg^{2+}), limestone ($CaCO_3$). For the realization of our experience we choose the tomato (*Solanum Lycopersicum)* as a corps. We planted the seeds in special seedling pots, divided into 03 sections: Section irrigated with potable water, Section irrigated with fish farming water, and the last section irrigated with potable water with the addition of chemical fertilizers. The three tests summarize that the plant irrigated with potable water plus the fertilizer has similar results to the plant irrigated by fish farming water. Moreover, Plant development is highly adaptive to environmental conditions. On the contrary, plants irrigated with potable water have slow growth and a low yield.

INTRODUCTION

Among aquatic ecosystems, freshwater systems play an important role in maintaining life and support both social and economic sectors **(Mohammed and Al-Amin, 2018)**. However, the distribution of these precious ecosystems can lead to a negative impact on ecological systems and human security **(Millennium, 2005).**

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According to **UN-Water (2012),** climate change has a direct impact on freshwater water availability in the world. In addition, to climate change, population growth, economic development, and urbanization are accepted to have a cascade of negative consequences which affect all sectors **(Kundzewicz *et al.*, 2007).**

Algeria is extremely vulnerable to climate change, and this is directly linked to its arid and semi-arid climate **(Sahnoune *et al.*, 2013).** The effect of climate change in Algeria appears in demographic growth, the decline in the water run-offs, and rarity of water resources, damages, and deterioration of hydraulic infrastructure **(Mohammed and Al-Amin, 2018).**

Algeria has limited water resources, which are characterized by unequal rainfall distribution between all the regions **(Meddi, 1992; Laborde, 1993; Taibi *et al.*, 2015; Meddi *et al.*, 2016).** Studies show that the country will suffer from a reduction of 5-13% in precipitation and a significant increase of 0.6-1.1°C in temperature **(Mohammed and Al-Amin, 2018).**

These years Algeria suffers from a critical period of droughts, which lead to the degradation of water resources **(Mohammed and Al-Amin, 2018).**

Algeria's total natural water potential is 19 BCM yr^{-1}, more than half (11 BCM yr^{-1}) of this amount is in the form of surface water located in the North **(Bouchekima *et al.*, 2008).**

Algeria contains 84 reservoirs (19 under construction) with a storage capacity of 8.9 billion m^3 **(Hamiche *et al.*, 2015),** intended human consumption, industry, and agriculture.

According to the study of **Langenberg *et al.(*2021**), the consumption of drinking water had significantly increased (16-36%), and the consumption of irrigation water used for agriculture was decreased (80-60%).

In Algeria, most of the areas are irrigated from dams and boreholes in the north of the country. In the South, irrigation of the perimeters is ensured from deep boreholes in the large underground aquifers **(Benblidia, 2011).**

Their current total equipped area is of the order of 200,000 ha **(Benblidia, 2011).** The irrigable area represents approximately 150,000 ha. The effectively irrigated area is only around 40,000 ha **(Benblidia, 2011; Mohammed and Al-Amin, 2018).** Restoration and renovation programs for distribution systems are underway to increase this surface area.

In the arid and semi-arid regions, the integration of aquaculture production with traditional agriculture is the best solution to face the problem of water consumption **(Mariscal-Lagarda *et al.*, 2012).**

Several studies around the world indicate that the integration of aquaculture production with traditional agriculture is a rational solution to conserve water and also achieve more efficient water use by maximizing farm production without increasing water consumption **(e.g., Zouakh *et al.*, 2016; Corner *et al.*, 2020; Mustapha and El Bakali, 2020).**

In algaria, a significant rate of farmers practicing fish farming in their basins: Biskra (65%), Adrar (59%), Ourgla (50%), Ghardaia (30%) **(Corner *et al.*, 2020).**

Due to the lack of water in the arid and semi-arid regions, the integration of aquaculture with agriculture is a successful method to face this problem. It has a socio-economic impact, on the one hand, to preserve water and contribute to food security in the region and on the other hand to protect the land from pollution and the use of fertilizers.

The present work aims to contribute to the realization of the project which relies on integrating fish farming into agriculture. It consists of evaluating the effect of irrigation with farm water on plant growth and yield of cultivated species, to minimize the use of chemical fertilizers in agriculture.

MATERIALS AND METHODS

1. Study area

Between the two largest cities Algiers and Oran, the Chlef region is located in the western tell 200 km (up to 300 km for the northwestern municipalities) west of Algiers and covers 4 975 km². It is bounded by the Mediterranean Sea in the north, Tissemsilit in the south, Ain defla, and Tipaza in the east, and Mostaganem and Relizan in the west **(Fig. 1).**

The population of the Chlef region is 1.237,277 inhabitants, with a rural population of 742,300 inhabitants. The total labor force is 519,400 of which the agricultural labor force represents 103,900 **(DSA, 2018).** The climate in Chlef is semi-arid climate, characterized by a very hot summer and a rainy and cold winter.

This study was performed in the year 2019, in the region of Chlef on the municipality of Ouled Abbes (the eastern part of the region) **(Fig. 1).**

2. Location of the irrigation basin

The irrigation basin is located in the municipality of Chettia of the Chlef region, on a typical farm of a farmer (Mr. Dridj. Aek) **(Fig. 2).** The fish farming system contains two types of fish the carp and the mule, which have a significant economic value.

Fig 1. The Study area was modified from **(Souad, 2018).**

Fig. 2. The irrigation basin.

3. The crops used

The crops on which we have worked are seasonal crops that should give results within the time limits necessary for the realization of our experience.

The tomato (*Solanum Lycopersicum L.esculentum*) is part of the nightshade family. This plant in almost all latitudes, on an area of approximately three million hectares, represents almost a third of the world's surfaces devoted to vegetables. The tomato has given rise to the development of an important processing industry, for the production of concentrate, sauces, juices, and preserves (**MTCTHG, 2009**).

Tomatoes require a relatively cool and dry climate to provide an abundant and quality harvest. The tomato is a hot-season plant. The optimum temperature for root growth is 15 to 18 ° C during the fruit growth phase, the optimum for ambient temperature is 25 ° C during the day and 15 ° C at night (**Elattir *et al,* 2003**).

The soil must be well ventilated and draining. Root asphyxiation, even temporary, is detrimental to the crop. The organic matter content of the soil must be high enough (2-3%) to obtain good yields, the tomato grows well on most mineral soils that have good water retention capacity and good aeration **(Elattir *et al.,* 2003).**

4. The irrigation method

We planted the seeds in special seedling pots, divided into 03 sections:

1 Section irrigated with normal (potable) water.

2 Section watered with fish farming water.

3 Section watered with normal water with the addition of chemical fertilizer.

We started the irrigation at the beginning of March. The cultures are irrigated once (in the evening) each day with 100 ml. To demonstrate the effect of irrigation by fish water, various parameters were studied. We initially added chemical fertilizer (Nutriplant) after the transplant process, as indicated in NPK (20,20,20), to provide nutrients for plant growth.

5. Water analyzes

The analysis of potable and fish farming water was carried out at the Algerian water Laboratory. The physicochemical parameters (pH, conductivity, chloride, sulfate, calcium, sodium, potassium) were analyzed according to methods mentioned in **Table 1**.

6. Soil preparation

6.1. Sowing.

Row sowing was done manually in pots, the seed rate was homogeneous for all the pots **(March 20, 2019) (Fig. 3).**

Before the start of the sowing process, we have already carried out several analyzes to ensure the success of the process, to realize the hypothesis of our tests.

This is the international reference method recommended by (USSL. Staff) USA **(Richards, 1954).** We use the standardized method to provide saturation to the sample near its liquidity limit **(Servant, 1975; Baize, 1988).**

Table 1. The analyzed parameters and the used methods.

Parameters	Method
pH	NA 751
Conductivity (CE)	NA 749
Calcium (Ca^{2+})	NA 1657
Sodium (Na^{+})	NA 1653
Nitrate (NO_3^{+})	NA 1657
Sulfate (SO_4^{2-})	**Rodier (1996)**
Magnesium (Mg^{2+})	NA 752
Potassium (K^{+})	NA 1653
Chloride (Cl^{-})	ISO 6917

Fig. 3. The sowing used in the experiment**.**

6.2. The preparation dough

The dough is prepared according to the method of **Baize (1988).** After 24 hours most of the salts are dissolved **(Mathieu and Pieltain, 2003)** the solution was centrifuged at 3000 rpm for 10 min and placed in bottles after the filtration. The liquid solution is used to determine physicochemical parameters.

7. Soil physicochemical analyses

In the laboratory, the pH of the soil was measured by a pH meter (AMAST ETP-111) and the conductivity by a conductivity meter (HANNA 215 conductivety meter). Organic matter was realized according to **Anne (1954).** The methods of determining the level of organic matter by the determination of carbon are based on the fact that carbon represents 58% of the organic matter.

The most commonly used method consists of hot oxidizing the carbon of OM contained in a soil sample, under defined conditions, using a known quantity of an oxidant and then potassium dichromate in a sulfuric medium. It is assumed that the oxidant than the potassium dichromate in a sulfuric acid. We admit that the summed oxygen is proportional to the C we want to measure.

The excess dichromate is titrated by a reducing agent: Mohr's salt.

OM% = 100/58 x C%

The Mean Weight Diameter (MWD) is realized according to the **Le bissonnais (1996)** method. The method is largely inspired by the classic test of **Henin *et al.* (1958).**

The expression of the test results makes it possible to calculate the weighted average diameter called MWD (Mean Weight Diameter) for each phase, such as:

$$MWD = \frac{\sum_i^n Pidm}{Pt} \qquad dm = \frac{di + di + 1}{2}$$

With n: number of sieves.

Pi: dry weight of the fraction collected on the sieve with diameter di.

Pt: sum of dry weights.

dmi: average diameter of the particles found on the sieve.

d (i + 1): diameter of the mesh of the sieve greater than di.

The anions of our soil samples are analyzed in the Pedology Laboratory of the Faculty of Natural and Life Sciences at Chlef University. The Cl^- ions were determined by the classical titrimetric methods given by **Mathieu and Pieltain, (2003).** The determination of the SO_4^{2-} ion was carried out by ultraviolet spectrometry according to the method **(Rodier, 1996).**

The determination of alkalinity is carried out by acid titration. A strong acid is used, generally HCl or H_2SO_4. The determination of Ca^{+2} and Mg^{+2} was carried out by the titrimetric method with EDTA described by **ISO6058 (1984).**

The determination of the total limestone is for objective to determine the percentage of $CaCo_3$ which exists in our soil samples, the method followed in our experiments is the calcimeter, this method is frequently used, it consists in determining the percentage of $CaCO_3$ using a method called Bernard's Calcimeter **(Hulseman, 1966; Muller *and* Gatsner, 1971).**

8. Planting process

We prepared 06 plants after their preparation, about 30 days later, when their length was about 13 to 20 cm after the elimination of the harmful plants, we carried out the planting process on May 03, 2019, before planting; we choose the appropriate period (evening) when it is cold, then we planted two plants in each pot.

RESULTS

1. Climatic data analysis

The climatic data for the Chlef region were obtained from the station of the Regional Meteorological Center (DRMC). Only precipitation, temperature, wind, and relative humidity are treated.

During the year 2019, the temperature in the Chlef region varied between 9.3°C in January and 30.7°C in July with an average value of about 19.45°C **(Fig. 4).**

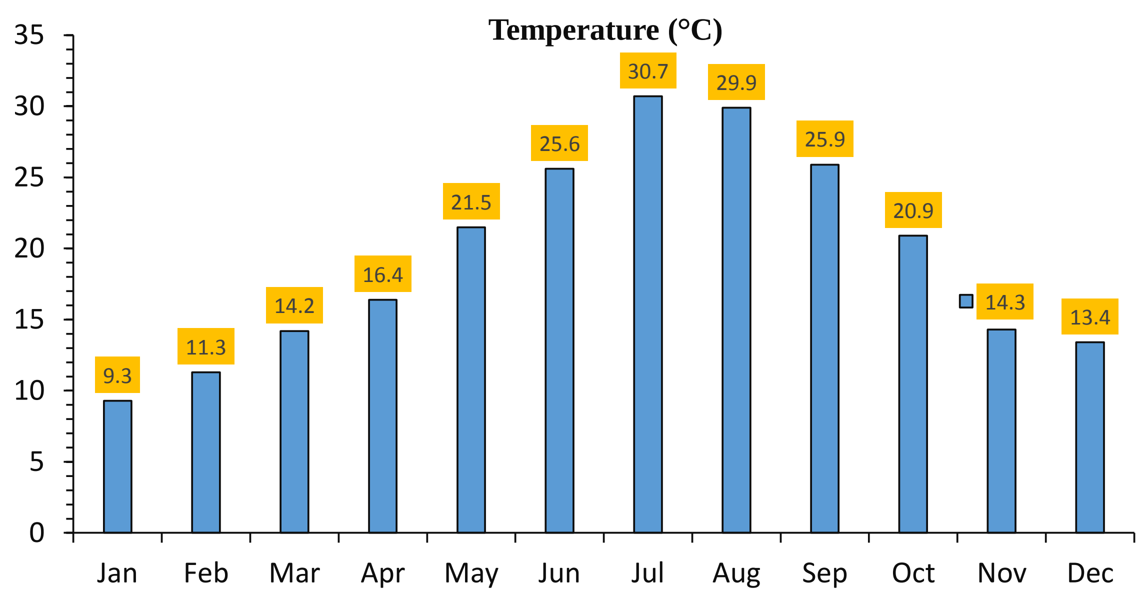

Fig. 4. Monthly temperature (T °C) of Chlef region during 2019.

The annual amount of precipitation in 2019 is about 267.18 mm. The low precipitation value was recorded in summer **(Fig. 5)** and the maximum in November 2019 **(Fig.5).**

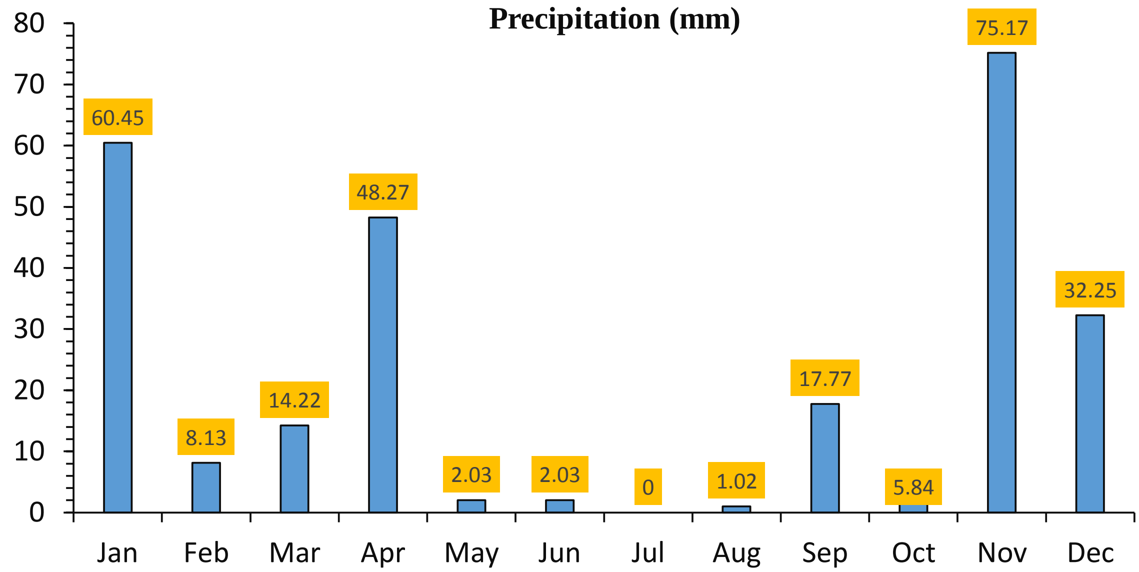

Fig. 5. Monthly average precipitation of Chlef region during 2019**.**

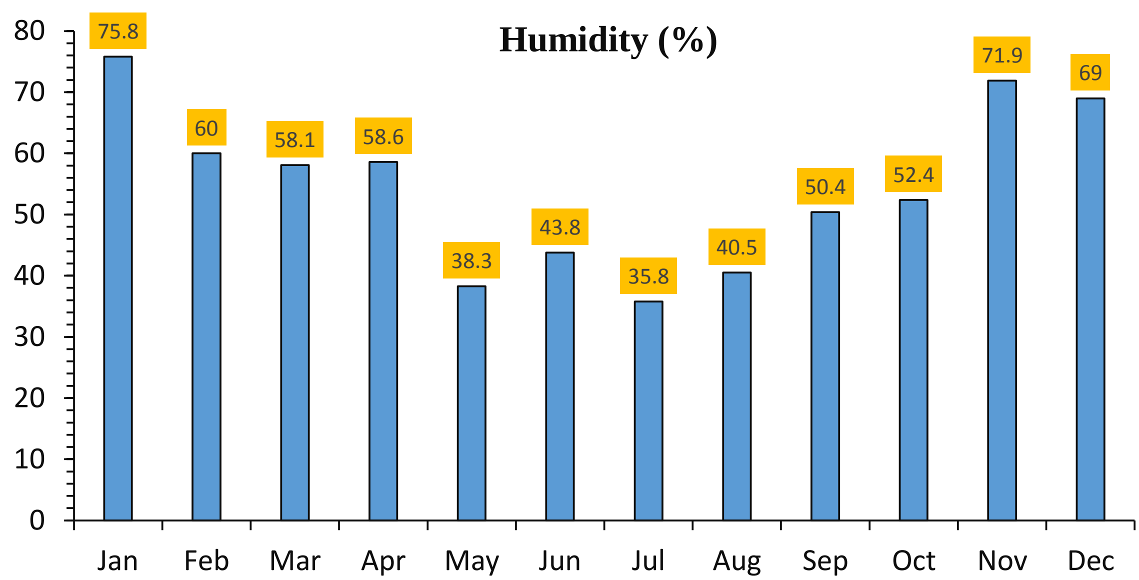

Fig. 6. Monthly average relative humidity of the Chlef region during 2019.

Levels of humidity indicate that the high value (75.8%) is recorded in January and the low value is registered in July it is 2 times lower than the high value **(Fig. 6).**

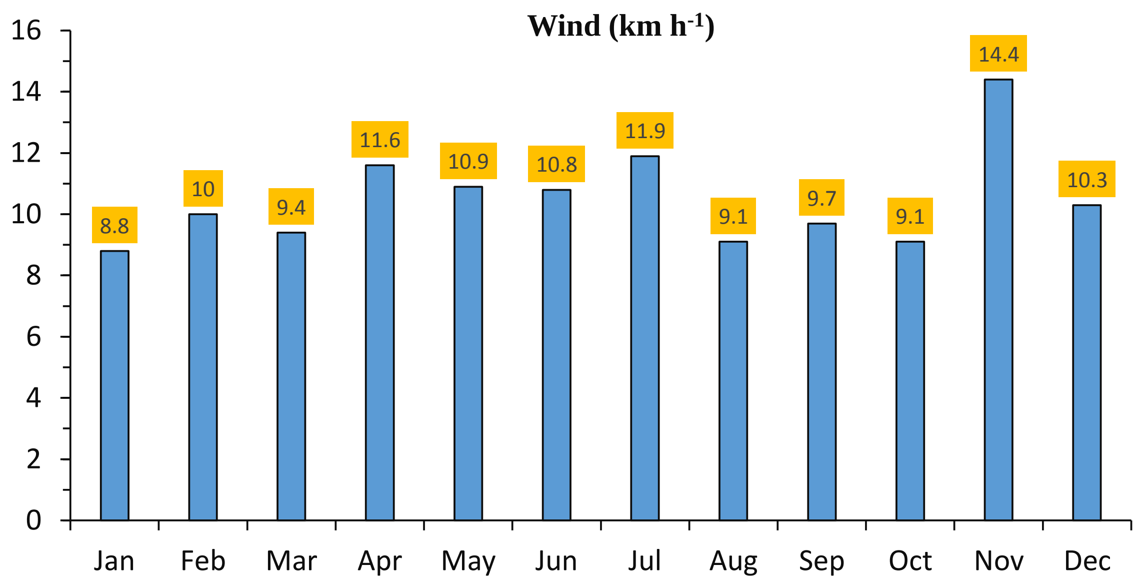

Fig. 7. Average monthly wind speed in Chlef region Km h^{-1} during 2019.

Winds in the Chlef region are very frequent and vary in speed between 8.8 km h^{-1} to 14.4 km h^{-1} during the study period **(Fig. 7).**

2. Water analysis

The water analysis indicates that the pH mean value of the water used for irrigation is close to 8.5, which means that these waters have an alkaline pH **(Table 2).** The conductivity is almost similar (1 mS cm^{-1}) in the two water **(Table 1)**. The chloride (Cl^-) concentrations are low (0.25-2.56), and they do not cause problems.

Table 2. The average results of irrigation water analyzes.

Water parameter	Unit	Potable water	Fish farming water	Usual range in irrigation water
Acid/Basicity (pH)	1–14	8.48	8.50	6.0 – 8.5
Electrical Conductivity (EC)	mS cm^{-1}	0.99	1.20	0 – 3
Calcium (Ca^{2+})	meq L^{-1}	1.56	0.51	0 – 20
Magnesium (Mg^{2+})	meq L^{-1}	0.97	1.50	0 – 5
Sodium (Na^{2+})	meq L^{-1}	2.65	0.70	0 – 40
Bicarbonate (HCO_3^-)	meq L^{-1}	2.80	2.84	0 – 10
Chloride (Cl^-)	meq L^{-1}	2.56	0.25	0 – 30
Sulfate (SO_4^{2-})	meq L^{-1}	0	2.69	0 – 20
Nitrate (NO_3^-)	meq L^{-1}	0	5.73	0-7

The concentration in potable water is 10 fold higher than that of fish farming water **(Table 2).** The bicarbonate (HCO_3) values are also high (around 2.8 meq L^{-1}) **(Table 2),** which can cause soil alkalinity problems over time.

The calcium (Ca) and sodium (Na) means values are higher in potable water (1.56-2.65 meq L^{-1}) than in fish farming water **(Table 2).**

The sulfate (SO_4) and nitrate (NO_3) values are zero for potable water, on the other hand, they are about 2.70 and 5.70 (meq L^{-1}) respectively for fish farming water **(Table 2).** Magnesium (Mg) average value in fish farming water is about 1.5 higher than in the mean value of potable water (**Table 2).**

3. Soil analyses

The physicochemical analyzes of the soil are limited only to parameters, that are necessary for the growth and development of the tomato crop.

In our study, we focused on comparing the four types of soils: the soil before planting, the soil of the pot irrigated by potable water, the soil of the pot irrigated by fish farming water, and the soil of the pot irrigated by potable water with the use of fertilizers **(Table 3).**

The pH values in the four soil samples show that our soil has a moderately alkaline pH, which poses a risk of soil alkalization in the long term. As we have recorded a decrease in the pH values of the three types of soil after irrigation compared to the initial state of the soil **(Table 3).**

The measurement of electrical conductivity (EC) is to determine the degree of salinity of the studied soils, the values obtained after the measurements are shown in the table **(Table 2).**

According to the riverside USA classification, the values of the electrical conductivities measured in the four types of soil show that the soil sample before planting is unsalted with an EC value equal to 0.80 mS m^{-1}, on the other hand, irrigated soils by potable water and fish farming water are slightly salty soils with almost identical EC values. In addition, the soil irrigated by potable water with the use of fertilizers is saline soil with CE value of 5 mS m^{-1}.

Comparing the CE values, the soil irrigated by potable water with the use of fertilizers has a high CE, which is directly linked to the use of fertilizers.

Measurements of the mean weight diameter (MWD) of the four soil types showed a moderately stable soil structure with an MWD equal to 0.87 mm for the control sample, 0.95 mm, 1.01 mm, and 0.80 mm for the pots irrigated with potable water, pot irrigated by fish farming water, and pot irrigated by potable water using fertilizers respectively **(Table 3).**

Table 3. The average results of soil analyzes (before and after planting).

Soil before planting		Soil after planting		
		Irrigated by potable water	Irrigated by fish farming water	Irrigated by potable water + fertilizers
pH	8.19	7.83	7.98	7.70
CE (mS cm^{-1})	0.80	3.5	3.6	5
Mean weight diameter (mm)	0.87	0.95	1.01	0.80
Organic matter (%)	8.9	2.34	2.72	2.55
Total limestone (%)	8	9	9	8
Cl (meq.100 g L^{-1})	3	4.2	4.8	4.6
Ca (meq L^{-1})	0.002	0.014	0.019	0.016
Mg (meq L^{-1})	0.50	0.57	1.33	0.62
SO_4 (meq L^{-1})	13.46	109.8	97.6	100.1
Alkalinity (meq L^{-1})	0.25	0.13	0.16	0.11

The evaluation of organic matter rate indicates that soil before plaiting contains 8.93% of organic matter, which means that this sample is rich in organic matter. The other three types of soil comprise an average percentage of organic matter fluctuated between 2.34-2.72% **(Table 3).**

According to **Table 3**, analysis of total limestone in our soil samples indicates that our soil types are weakly calcareous soils with nearly equal (9%) percentages in all four soil types **(Table 3).**

Chloride can be produced by the degradation of organic matter from plants, (leaves, branches, roots). In the first phase the Cl^- concentration is equal to 3 (meq.100 g L^{-1}), after the irrigation the Cl concentration increased and varied between 4.2-4.8 (meq.100 g L^{-1}) **(Table 3).**

During the study period Ca concentration was very low. In the first stage, the calcium value is almost zero, (0.0002 meq L^{-1}), the other three samples contain concentrations fluctuated between 0.014 (meq L^{-1}) for the pot irrigated by potable water and 0.019 (meq L^{-1}) for the pot irrigated by fish farming water **(Table 3).**

The analyzes of Mg in our soil samples show that the magnesium value of our soil at the initial state and that of the soil irrigated by potable water are almost identical (0.5 meq L^{-1}). However, the high value (1.33 meq L^{-1}) of the magnesium concentration is recorded in the soil irrigated with the fish farming water.

The soil sulfate concentration in the initial state contains is 13.45 (meq L^{-1}). This value jumped to almost 100 (meq L^{-1}) in the three other irrigated pots **(Table 3).**
The results of the soil alkalinity show that all obtained concentrations are lower in the four pots, these values vary between 0.11- 0.25 (meq L^{-1}).

4. Culture growth

In this part we compared the dimensions of the tomato crop in the different pots: tomato from the pot irrigated by potable water, tomato from the pot irrigated by fish farming water and the tomato from the pot irrigated by potable water and fertilizers, the results are summarized in the table below **(Table 4).**
The results show that in the pot irrigated with potable water the size of the longest stems is 43 cm and the leaf maximum size varies between 5.4 and 6.5 cm **(Table 4).**
For the pot irrigated by fish farming water; the size of the largest stems is 51 cm and the leaf maximum size varies between 6.9 and 7.5 cm **(Table 4).**
In the pot irrigated with potable water with the use of fertilizers; the size of the largest stems is 59 cm and the leaf size varies between 7 and 8 cm **(Table 4).**
Comparing the sizes of the tomato crop of the different pots, we find that the best results were recorded in the last two pots and that the results of the tomato from the pot irrigated by the fish farming water are similar to the results of the tomato from the pot irrigated by potable water using fertilizers.

Table 4. Variation of stem and leaf lengths (cm).

Irrigated by potable water		Irrigated by fish farming water		Irrigated by potable water + fertilizers	
Stem length	Leaf length	Stem length	Leaf length	Stem length	Leaf length
15	0.5	18	1	20	1
17	0.9	23	1.5	25	1.9
20	1.7	28	3	29	2.5
24	2.5	33	4.1	36	4
29	3.5	37	5	41	5.2
35	4.6	40	6	48	6.5
39	5.4	45	6.9	52	7.1
43	6.5	51	7.5	59	8

DISCUSSION

Comparison of the temporal variability of temperature and rainfall and climate parameters shows that Algeria suffers from a long period of drought linked to the scarcity and unequal distribution of rainfall **(Bemani *et al.*, 2021).**

According to **Solomon et *al. (*2007),** a warming trend varied between 0.2 and 0.4 W C per decade in Northern Algeria has also been observed from 1975 to 2004. The Same findings were reported by **Giorgi (2000)** and **New *et al.* (2001)** for various periods over the 20th century.

Comparing to the other region the west of Algeria including the Chlef region suffers from low rainfall **(Meddi, 2013; Meddi *et al.*, 2016; Bemani *et al.*, 2021).).**

Significant programs to protect water resources in Algeria has taken place, their fundamental objective is to face the chronic shortages that affect the source of water **(Garadi, 2006; Kettab, 2008).**

Integrated fish farming has been recommended for better use of resources, better income, waste recycling, pollution reduction, and environmental conservation **(Acharya and Biswas, 1996; Lu and Li, 2006; Miller, 2010; Hu *et al.*, 2016; Zouakh *et al.*, 2016; FAO, 2020).**

The use of this strategy requires extensive monitoring of physicochemical analyses of water. These parameters were carried in the reservoirs during the year 2019 and are mentioned in **Table 1**. The results indicate a favorable environment for the reproduction and growth of *Cyprinus carpio* and *Mugil Céphalus*.

According to the guideline of **FAO (2003),** irrigation and reservoir water is highly saline they exceed 0.7 mS cm^{-1}. This finding is mentioned in several studies in Algeria **(Koull *et al.*, 2013; Bouaroudj *et al.*, 2019)** also in Southern India **(Brindha and Kavitha, 2015; Etteieb *et al.*, 2017).** In addition, this study shows that the pH in both types of waters is slightly alkaline. Those values are not much different from, for example, those of the study of **Rana *et al.* (2010)** and **Bassuony *et al.* (2014)** for water samples collected from northeast Delta-Egypt, and **Bouaroudj *et al.* (2019)** for the Northeast of Algeria and also that of **Shammi *et al.* (2016)** realized in Khulna District, Bangladesh. Results of pH fall in the safe limit of pH standard (6–8.5) for irrigation purposes **(Ayers and Westcot 1985).**

Bicarbonate levels are ranged between 0-10 meq L^{-1}, which did not cause any growing problem **(Ayers and Westcot, 1985).** Nitrates were low in potable water, and are generally a product of fertilizer application. The NO_3 concentrations in potable water are lower than **FAO** guidelines **(2003),** even lower than nitrate concentrations recorded from the Medjerda River in Tunisia **(Etteieb *et al.*, 2017).**

In farming water the NO_3 concertation is about 5 meq L^{-1}, this value is 5 times higher than that of potable water. But this value did not exceed the suitable range **(Table 2).**

The water had an excellent quality of Calcium (Ca), Magnesium (Mg) and Sodium (Na), Sulfate (SO_4), Potassium (K) concentrations in both types of waters. All studied parameters are balanced means that waters are appropriate for irrigation based on values of **Table 2.**

Measurements of pH before and after plating indicate that our soil is characterized by alkaline pH. Among the reason for the soil alkalinity is the nature of irrigated water, which has an alkaline pH. Moreover, and according to **Mashhady and Rowell (1978),** the principal factors responsible for alkaline pH are partial CO_2 pressure and concentration of CO_3^{2-} and HCO_3^- ions. Soils generally have a pH between 4 and 10 **(Szabolcs, 1989),** which is a result of some compounds such as the soil clay minerals, organic matter, associated ion exchange, and hydrolysis reactions **(Sumner *et al.*, 1991).** In arid and semiarid region soils pH is often alkaline **(Suarez *et al.*, 1984; Quirk & Schofield, 1955; Bronick and Lal, 2005).**

Organic matter is the main important constituent for sustainable agricultural **(Tiessen *et al.*, 1994; Zech, 1997)** because it contributes considerably to nutrient supply, cation exchange capacity (CEC), and to a favorable soil structure **(Glaser *et al.*, 2002; Huber *et al.*, 2011).**

Wet aggregate stability determined is usually used as a measure of the stability of soil aggregates **(Blair, 2010).** In our study, the Mean weight diameter (MWD) is comparable in the 4 samples.

The composition of the soil in limestone is about (9%), it steals stable in the four samples.

Calcium and Magnesium are generally in sufficient quantity to face the needs of the plants **(Rehm, 2008).** The value of Ca and Mg in the first sample are low. However, in the three other samples, the concentration of Mg and Ca increase considerably plant development will be positively affected. Due to the use to the stricter controls on atmospheric emissions of S and the use of S-free high analyzes fertilizers, the concentration of Sulfur ions in soil decreases considerably **(Scherer, 2001).** The amount of Sulfur in the three samples guarantees a good development for plants and did not cause a deficiency in crop production **(Table 3).**

Integrated fish farming is more recommended in rural areas, especially at the level of medium and small farms for its significant protein intake **(MPRH, 2009).** Serval studies around the world encourage this method due to its double benefits for aquaculture and agriculture (**Dela, 1992; Cofad et *al.*, 1999; Bamba and Kienta, 2000)** In Algeria; the Ouargla region is the best example of the success of this project.

According to **Zouakh *et al.* (2016) and Corner *et al.* (2020),** this new activity has several advantages and the most important one is the preservation of water consumption especially for deserts and regions which are characterized by an arid climate.

The results obtained in this study are similar to those reported by **Zouakh *et al.* (2016),** which use reservoir water to irrigate different types of crops **(Table 5).**

The results obtained show that water from fish farming has an impact on plant growth on the one hand and increased profitability of production on the other **(Table 5).**

Our work has shown that the integration of fish farming in agriculture by irrigating with water from the breeding pond has a positive effect on tomato yields since significant differences were recorded for the different yield parameters studied.

Table 5. Comparison of the variation of stem and leaf lengths (cm) in several crops irrigated by fish farming water.

Melon *Cucumis melo*		Pastèque *Citrullus lanatus*		Courgette *Cucurbita pepo*		Tomato *Solanum Lycopersicum*			
Irrigated by fish farming water		Irrigated by fish farming water		Irrigated by fish farming water		Irrigated by fish farming water		Irrigated by potable water + fertilizers	
Stem length	Leaf length	Stem length	Leaf length	Stem length	Leaf length	Stem length	Leaf length	Stem length	Leaf length
94.5	13	75	11.3	162	10	18	1	20	1
122	12.5	69	13.5	123.5	12.5	23	1.5	25	1.9
108	13.5	73	14	124.5	11	28	3	29	2.5
93	12	14	11.5	200	12.5	33	4.1	36	4
83.5	12	06	11.5	115	11	37	5	41	5.2
91	11	7	14.5	117.5	11.5	40	6	48	6.5
139	13	5	9.5	113.5	13.5	45	6.9	52	7.1
97	14,5	28	11	156	10	51	7.5	59	8
146	12.5	18	12	100	8,5				
131	12.5	36	14.5	127	11,5				
119	14	34	13.5	174	12				
140	15	41	16.5						
101	13.5	92	14.5						

CONCLUSION

Based on our study, we can conclude that irrigation with fish farming water has a significant positive effect on agricultural plants, including tomatoes, compared to water normally approved for irrigation.

The difference between the three tests summarizes that the plant irrigated with potable water plus the fertilizer has similar results to the plant irrigated by fish farming water. Moreover, Plant development is highly adaptive to environmental conditions. On the contrary, plants irrigated with potable water have slow growth and a low yield. Our work has shown that the integration of fish farming in agriculture by irrigating with water from the fish farming water has a positive effect on tomato yields since significant differences were recorded for the different yield parameters studied.

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