Al-Azhar Journal of Agricultural Engineering 5 (2023) 32

Contents lists available at Egyptian knowledge Bank (EKB)

Al-Azhar Journal of Agricultural Engineering

journal homepage: https://azeng.journals.ekb.eg/

Full length article

Implications of different irrigation water qualities on crop production: A case study of Sharkia Governorate

Shaban Kh.M. [a, *], R. Abu El-Khair [b] , M. Osama [b], G. Abd El-Naser [a], H. Khaled [b] El-Gamal T.T. [a]

[a] Water Resources Research Institute (WMRI), National Water Research Center (NWRC), Giza, Egypt.

[b] Department of Soils and Water, Faculty of Agriculture, Al-Azhar University, Cairo, Egypt.

ARTICLE INFO

Handling Editor - Dr. Mostafa H. Fayed

Keywords:
Irrigation water quality
Soil salinity
Trace elements
Nutrients
Organic loads
Soil
Plant

Water and Irrigation Systems Engineering

ABSTRACT

This work aims to study the invasion of environmental pollutants from the irrigation water to the soil. To achieve this goal, three irrigated areas (at the same Zane) were selected. The first area is irrigated with fresh water; the second is irrigated with mixed water while the third is irrigated with drainage water. The three areas are exposed to the same climatic conditions. The crop pattern is similar for the three areas under study. The study was extended to two cultivated seasons, summer season (maize crop) and winter season (wheat crop). The farm management, which includes fertilizer application and their doses, pesticides broadcasting, is the same for the three of area study. The results of the study indicate that the fresh and mixed water were suitable for irrigating the different crops while the drainage water was suitable for irrigation of salt tolerant and semi tolerant crops only. They also indicate that all trace metals and nutrients were within the allowable limits except cadmium and copper. The average of total and fecal coli form in the different irrigation water qualities violated the recommended maximum limits and polluted these resources. The leaching process of salts took place for the different soils irrigated with the irrigation water of different qualities. The correlation values between the pollutants of irrigation water of different qualities with those of soil were significant for some parameters, while the correlation values were not significant for others. The correlations between the pollutants of irrigation water and those of plant differed from pollutant to another; there was no clear trend for the leaching of the studied pollutants with the irrigation water. The invasion of the different studied pollutants to the soil differed from one pollutant to another according to the solubility of pollutant in water, its concentrations, its importance to plant and the up taking rate and its movement to the drains with the drained water. The use of mixed or drainage water in irrigation causes a lack of productivity as well as increased crop water requirements. Elongation period between irrigations or adding small amount of irrigation water in each time would reduce crop productivity.

1. Introduction

Increased agricultural production has become an urgent requirement of the expanding world population. The government has adopted the horizontal expansion of cultivated land as a major policy to increase production to meet the needs of the increased population. Developing industry, expanding agriculture and the growing population in Egypt require continuously increasing amounts of water.

Tremonds efforts should be implemented to overcome shortage of water that facing Egypt at present. So, water and soil become critical factors in crop production. Different ways have been proposed to achieve effective irrigation management. Some of those are the use of marginal quality water and irrigation scheduling becomes necessity.

The use of saline water for irrigation has an environmental advantage. It reduces the non-saline water requirement for salt tolerant crops; it can utilize water

* Corresponding authors.
E-mail address: khaledsha3pan54@gmail.com (Shaban Kh.M.)

https://azeng.journals.ekb.eg/article_308716.html
Peer review under responsibility of Faculty of Agricultural Engineering, Al-Azhar University, Cairo, Egypt.
Received 31 January 2023; Received in revised form 1 March 2023; Accepted 2 March 2023
Available online 20 July 2023

of a wide range of quality. The suitability of irrigation water mainly depends on the amounts and type of salts present in water. The main soluble constituents are calcium, magnesium, sodium as cations and chloride, sulphate, bicarbonate as anions. The other ions that are present in minute quantities are boron, selenium, molybdenum, and fluorine which are harmful to animals fed on plants grown with excess concentration of these ions.

This study was focused on the role of the two factors of the use of marginal quality water and irrigation scheduling as well as their impact on the production of crops. Wheat and maize were chosen as winter and summer crops, respectively.

The aim of the present investigation is to study scheduling wheat and maize irrigation using marginal quality water from different resources and their effects on crop production, soil characteristics and environmental conditions.

Specific objectives of this study were:

1. Analysis the different irrigation water and its effect on soil physical, chemical, and biological properties.
2. Determining the soil water plant relations such as crop evapotranspiration and crop water productivity and water utilizations efficiency.
3. To find out the most suitable irrigation intervals under different water resources to maximize crop production with optimization of water and improving the environmental conditions.
4. To evaluate the most important resources i.e., different water qualities for increasing grain yield of wheat and maize, respectively.

2. Materials and methods

2.1. The site description

This work aims to evaluate the impact of irrigation water with different water qualities on the invasion of the environmental pollutants from the irrigation water to the soil and plant. In addition, the crop water relation was identified using different irrigation qualities.

The area of this site is about 21 feddans with rectangular shapes, since the type of soil is heavy clay with low permeability; there is a little need for pipelines or lined canals. The area of the site permitted the provision of six plots for each water treatment replicate.

The irrigation water is pumped from Bahr Mouse canal or Bahr Hadous drain to a field meska excavated through the field to supply the required irrigation water needed for each treatment. Twelve concrete junction boxes were installed along the field.

The site was leveled to zero slopes using laser leveler. The fields were plowed three times in opposite directions with a mechanical tractor connected to a hoe.

Irrigation canal to distribute irrigation water into each plot. Each junction box distributes water to two adjacent plots and the irrigation water quantity is measured by a sharp crested weir. the freshwater treatment is applied by pumping water from Bahr Mouse canal to the field meska. Each replicate is irrigated individually while all the other gates are closed. The second treatment, which is mixed water and the last treatment, which is the drainage water are irrigated directly from Bahr Hadous Drain.

Three irrigated areas were selected for implementing the study in three locations of Kafr Sakr district. At Sharkia governorate. Three treatments of water irrigation were arranged in a complete block design with eight replicates.

Fig. 1 presents the layout of the main irrigation and drainag system of Kafr Sakr district at Sharkia governorate. The three locations which consider as treatments arranged in a completed plot design with eight replicates as Follows:

- The first treatment is irrigated with fresh water from Bahr Mouse canal.
- The second treatment is irrigated with mixed water, the mixing ratio is 1:1 (Drainage: fresh water). The mixing process is done by using pipes and lifting pumps.
- The third treatment is irrigated with drainage water from Bahr Hadous Drain.

The soil texture of each area is clay and almost equal to the others as presented in Table 1.

Table 1
Soil Texture of the Studied Areas.

Irr. Water type	Clay%	Silt%	Sand%	Soil texture
Fresh	50.8	33.1	16.1	Clay
Mixed	51.2	32.0	16.8	Clay
Drainage	50.1	30.8	19.1	Clay

2.2. Experimental layout

The area under study belongs to the Drainage Research Institute; the research program which is conducted is followed during the study. The areas were cultivated with maize crop during summer season and wheat crop in winter season.

There were three treatments depending on the irrigation water qualities. The first treatment was the cultivated area irrigated with fresh water, the second was the cultivated area irrigated with mixed water while the third treatments was the cultivated area irrigated with drainage water.

Each study area was divided into eight replicates to help the conducting of suitable statistical analysis, as shown in Fig 2. The field investigation includes collecting samples of soils, irrigation water and drainage water, in addition to plant samples during the different stages of plant growth for the two crops of maize as summer crop and wheat as a winter crop.

All cultural practices were the same as recommended for the area except the irrigation parameter under study. These were the quantity of water applied and irrigation scheduling. Sowing and harvest date for maize 15/5 and 2/9, -2011, respectively. Whereas, for wheat 15/ 11 and 29/4, - 2012, respectively.

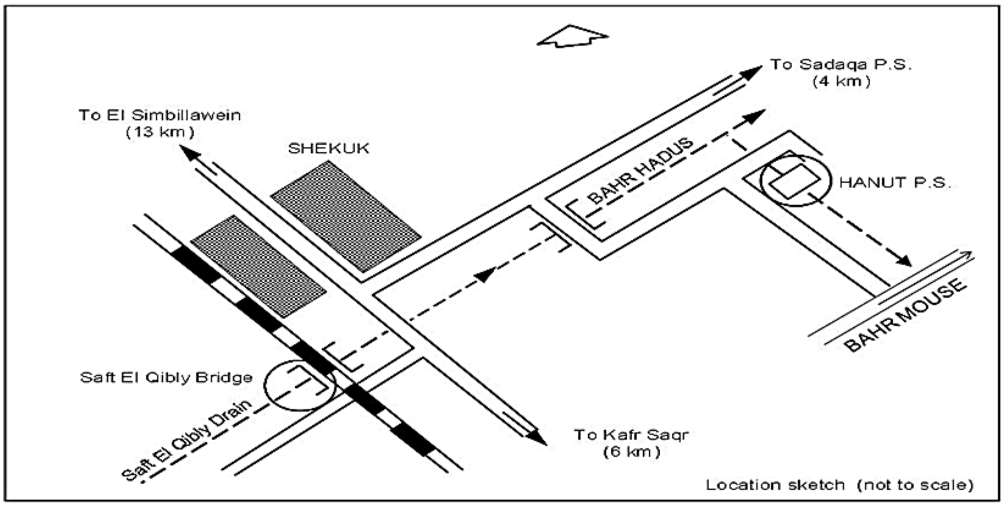

Fig. 1. layout of irrigation and drainage main system.

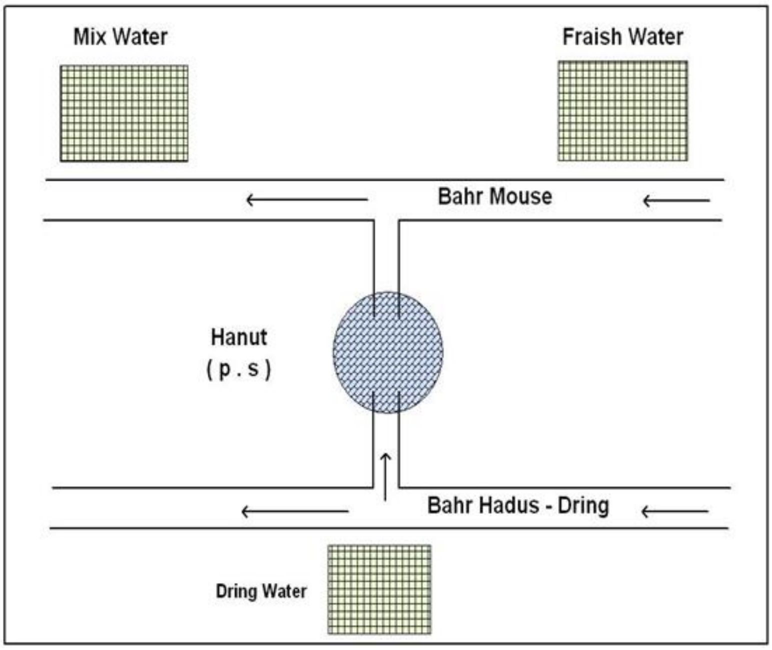

Fig 2. layout of field irrigation and drainage water and grid system.

2.3. Frequency of sampling

- Water samples were collected from the three types of irrigation water during each irrigation interval.
- Drainage water samples drained from the studied areas were also collected during each irrigation interval.

The entire water samples were collected by using a sampler and preserved cool during transportation from the field to the laboratory for conducting the different analysis.

- Added to that the analysis conducted to the different samples were judged and controlled by QA/QC system.

2.4. Laboratory Analysis

2.4.1. Soil Samples

- Soil samples were collected three times before and after cultivation in summer and at the end of the winter season according to the grid system (Fig.2). Crops (maize and wheat) sampling were conducted during different stages of establishment, midseason and before the harvesting time of maize and wheat.

2.4.2. Physical analysis

Particle size distribution using sodium hexametaphosphate as a dispersing agent according to methods described by Page (1982).

The determination was conducted by using the hydrometer method.

2.4.3. Chemical analysis

Chemical analysis that include pH, EC, Cations, and Anions, NO^{-}_{3}, NH^{+}_{4} and PO^{-3}_{4} and heavy metals (Cd, Cu, Fe, Pb and Zn) were determined, according to Page (1982).

The chemical Analysis of soil was conducted in soil saturation extract.

2.4.4. Soil Reaction (pH)

The pH values were measured in soil extract (1: 2.5).

2.4.5. Electrical Conductivity (EC)

The electrical conductivity was determined by using a conductivity meter.

2.4.6. Soluble Cations

Sodium and Potassium

Sodium and potassium were determined in the soil paste, by using the flame photometer.

Calcium plus Magnesium

Calcium (Ca^{+2}) and the Magnesium (Mg^{+2}) are measured by volumetric titration with a standardized solution of EDTA (0.01 N) (Ethylene Diamine Triacetate acetic Acid).

2.4.7. Soluble Anions

Carbonate

Carbonate (CO^{--3}) and bicarbonate (HCO^{-3}) are measured volumetrically by titration.

Chloride

Chloride (Cl^{-}) is measured by titration with a standard solution of silver nitrate (Ag NO_3) (0.01 N or 0.05 N), in presence of an indicator potassium dichromate ($K_2Cr_2O_7$) (1%).

Sulfate

Sulfate was determined by calculating the difference between the summation of soluble cations (Na, K, Mg and Ca) and soluble anions (Cl, HCO_3 and CO_3).

Nitrate and Ammonia

N-NO_3 and N-NH_4 were determined in soil extract by using Kijldahl apparatus according to method of soil analysis Page (1982).

Phosphate

Phosphate was determined in the soil extraction by using the stannous chloride method.

2.5. Trace elements

Trace elements in soil were determined according to method of soil analysis Page (1982), Cd, Cu, Fe, Pb and Zn were determined in the soil digested by percholeric acid and Nitric acid. The atomic absorption (Perkin elemer 273) was used for the determination.

2.6. Water samples

The three types of irrigation water in addition to the drained water from the soil samples were analysed according to the standard methods for the following:

Soluble cations i.e. Na, K, Ca, and Mg as well as soluble anions i.e. Cl, HCO_3, CO_3, and SO_4.

TDS as water salinity values were calculated from the summations of soluble cations and soluble anions calculated by milligrams per liter.

2.7. Plant Samples

Maize as a summer crop and wheat as winter crop, were sampled. The samples were taken during the different growing stages till the harvesting time of each of them (establishment, mid-season and harvesting).

The crop samples were analyzed for the following:

- Heavy Metals such as Cd, Cu, Fe, Pb and Zn.
- Nutrients such as N-NO_3, N-NH_4 and PO_4.

2.8. Water relations and yield of both crops

2.8.1. Potential evapotranspiration (ETp)

The potential evapotranspiration “ETp” was estimated using crop wat 4.3 model Smith (1991) by using the available meteorological data of the study area (Table2). The equation of the estimating (ETp) is:

$$\mathrm{ET_0} = \mathrm{ET_{rad}} + \mathrm{ET_{aero}}$$

where: $\mathrm{ET_0}$ is reference evapotranspiration in (mm/day), $\mathrm{ET_{rad}}$ is racliation term in (mm/day), and $\mathrm{ET_{aero}}$ is aerodynamic term in (mm/day).

Crop Coefficient (Kc) for each crop obtained from Doorenbos and kassam (1986) FAO paper No 33. Then ET crop values estimated from:

$$\mathrm{ET_{crop}} = \mathrm{ET_p} \times \mathrm{K_C}$$

where: ET_{crop} is estimated evapotranspiration in (mm/day), ET_p is reference evapotranspiration (mm/day), and K_C is crop coefficient.

2.8.2. Crop Water Productivity (CWP)

CWP (kg/m³) for each crop under different irrigation quality determined by the following equation (Smith 2002):

$$\mathrm{CWP} = \frac{\text{Yield (kg/feddan)}}{\text{Seasonal ET } (\mathrm{m^3/feddan})}$$

2.8.3. Water utilization efficiency

Water utilization efficiency for maize or wheat were calculated according to the relation: Jensen, M.E., (1983).

$$\mathrm{W.U}_t.\mathrm{E} = \frac{\text{Maize or wheat yield (kg/feddan)}}{\text{applied water for maize or wheat } (\mathrm{m^3/feddan})}$$

Table 2

Normal climate and Eto (grass) Data for Sharkia.

Country: Egypt Station: Sharkia

Altitude: 13 meter (s) above M.S.L. Longitude: 31. 30 Deg. (East) Latitude: 30.33 Deg. (North)

Month	Max Temp (deg. C)	Mini Temp (deg. C)	Humidity (%)	Wind Spd. (km/d)	Sunshine (Hours)	Solar Rad. (Mj/m²/d)	ETo (mm/d)
January	21.0	10.5	63.0	138.2	7.1	12.5	2.27
February	21.6	10.5	62.0	146.9	7.8	15.5	2.86
March	24.7	12.9	60.0	172.8	8.4	19.0	3.98
April	30.1	15.6	57.0	164.2	9.4	22.8	5.31
May	34.0	19.3	55.0	164.2	10.4	25.4	6.39
June	36.2	22.8	58.0	164.2	11.9	27.9	7.08
July	34.9	24.6	61.0	164.2	11.6	27.2	6.76
August	34.9	24.9	65.0	146.9	11.1	25.5	6.17
September	33.9	23.0	61.0	129.6	10.3	22.4	5.25
October	31.8	20.3	61.0	121.0	9.2	18.0	4.00
November	27.2	16.6	62.0	112.3	8.0	13.9	2.72
December	22.7	12.7	63.0	112.3	6.8	11.5	2.05
Average	29.4	17.8	60.7	144.7	9.3	20.1	4.57

2.9. Statistical Analysis

Statistical correlation analyses were conducted to clear the significant impact of irrigation water with different qualities on soil, drained water and plant.

Linear Fitting curve in addition to the statistical correlation were conducted to find out the relations between the different pollutants in irrigation water and those in soil, plant and drained water to clear the invasion of different pollutants from the irrigation water with different qualities to the soil.

3. Results and discussions

4.1. Impact of using various water qualities on some main crops under Sharkia Governorate conditions

4.1.1. Maize crop

Results as recorded in Fig. 1 indicate the impact of various water qualities on productivity of maize grain yield and its water requirements. Grain yield was increased by using fresh water followed by mixed water. While, drained water gave the lowest one. The reduction of maize yield under the use of mixed or drainage water compared to fresh water reached about 9 and 18 %, respectively.

At the same time, water requirements were increased using mixed or drainage water for irrigation by 2.8 and 6.4 %, respectively compared to fresh water.

In this connection Doorenbose and Kassam (1986) (FAO No. 33) found that maize is moderately sensitive to salinity. Yield decrease under increasing soil 1.7 mmhos/ cm, 10 % at 2.5, 25 % at 3.8, 50 % at 5.9 and 100 % at ECe 10 mmhos/ cm.

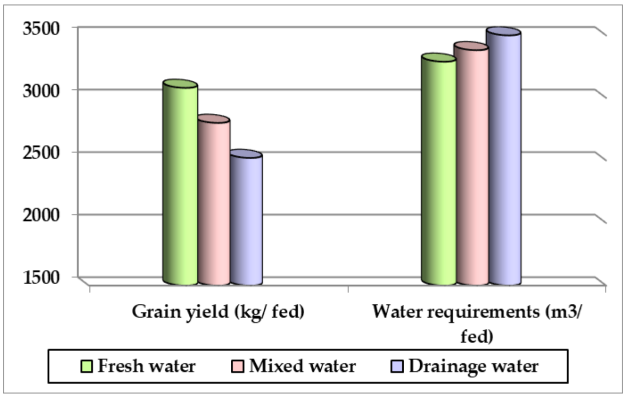

Fig. 1. Maize grain yield and water requirements under conditions of using various irrigation water qualities.

4.1.2. Wheat crop

The same trend was found for wheat grain yield and its water requirements (Fig. 2). Wheat yield decreased by 10 and 20 % for mixed and drainage water, respectively compared to fresh water. As to water requirement, it was increased by 2.8 and 6.4 % for the same respective two irrigation treatments compared to fresh irrigation water.

According to soil salinity, wheat is classified to be salt tolerant (Maas and Hoffman, 1977; Katerji et al., 2000). In the same context, Ben-Asher et al., 2006 a,b; Ahmed et al. (2007) indicated that saline water has been used successfully for agricultural irrigation.

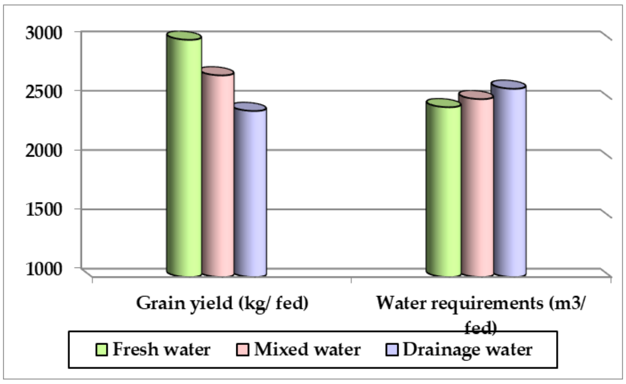

Fig. 2. wheat grain yield and water requirements under conditions of using various irrigation water qualities.

4.2. Management of field irrigation under conditions of using various irrigation water qualities.

To increase crop productivity and crop water productivity when different water qualities are used for irrigation, a number of strategies have been proposed to achieve these objectives. These strategies will determine the most appropriate **time** to irrigate and the appropriate amount of irrigation water in each time.

4.2.1. Maize crop

4.2.1.1. Fixed interval days between irrigations

Results as presented in Fig. 3 clearly show that shortening period between irrigations could be achieved more yield as compared with elongation periods between irrigations. The highest grain yield was obtained when applying irrigation every 10 days. Increasing maize productivity has reached 7 and 20 % in comparison with the application of irrigation every 15 days or 20 days respectively.

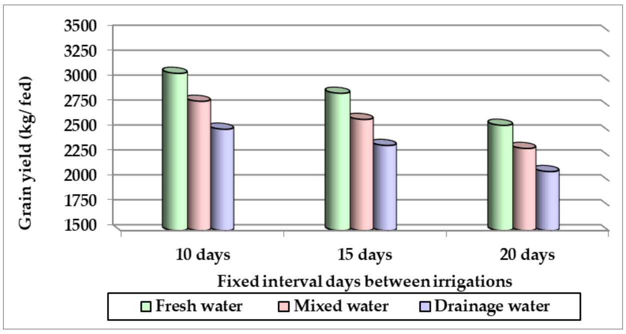

Fig. 3. Impact of fixed interval days between irrigations on maize grain yield under conditions of using various irrigation water qualities.

Shortening interval days between irrigations would lead to an increase in seasonal water requirements for maize plants. Results as recorded in Fig. 4 indicate that fixed intervals between irrigations every 10 days have led to increased water requirements for maize plants of about 6 % and 16 % as compared with fixed interval days every 15 and 20 days, respectively.

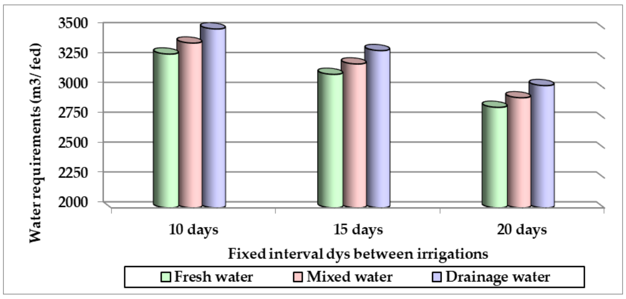

Fig. 4. Impact of fixed interval days between irrigations on maize water requirements under conditions of using various irrigation water qualities.

With respect to impact of fixed interval days between irrigations on crop water productivity (CWP) and water utilization efficiency (WU_tE), results as shown in Fig. 5 illustrate that use of fresh water for irrigation has led to increased CWP and WU_tE compared with other water qualities. On the other hand, the results showed that shortening the period between irrigations would increase CWP and WU_tE in comparison with the elongation periods. This may be due to a reduction in grain yield under elongation interval days between irrigations.

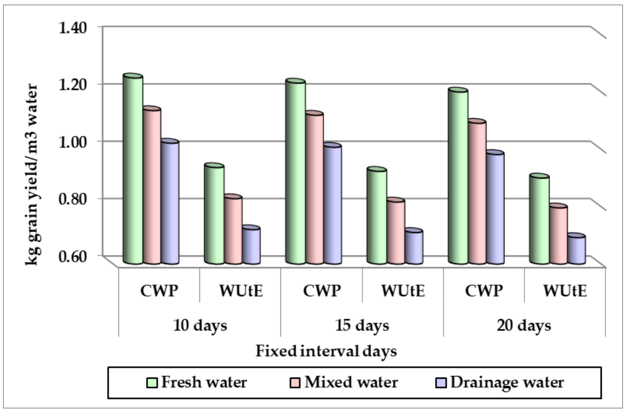

Fig. 5. Impact of fixed interval days between irrigations on maize water relations under conditions of using various irrigation water qualities.

4.2.1.2. Fixed interval days and fixed depths of irrigation water (75 mm each)

Results as shown in Fig. 6 indicate that shortening periods between irrigations with water amount 75 mm in each irrigation led to the increased productivity of maize crop compared to elongation periods with the same amount of water (75 mm). The results added that use of fresh water gave the highest yield followed by mixed water under all irrigation interval days treatments.

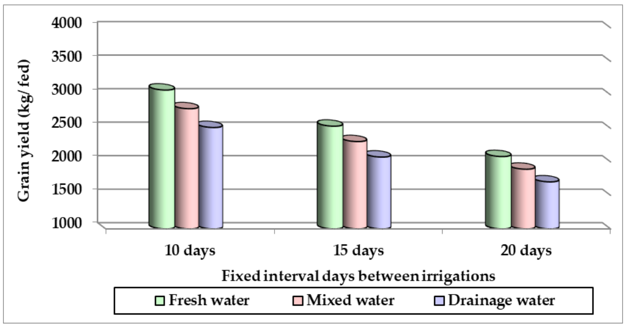

Fig. 6. Impact of fixed interval days and fixed depths of irrigation water (75 mm each) on maize grain yield under conditions of using various irrigation water qualities.

Regarding the impacts on crop water requirements, results as presented in Fig. 7 indicate that the highest crop water requirement was obtained when drainage water with irrigation application every 10 days was applied. However, the minimum one was registered for fresh water with irrigation application every 20 days.

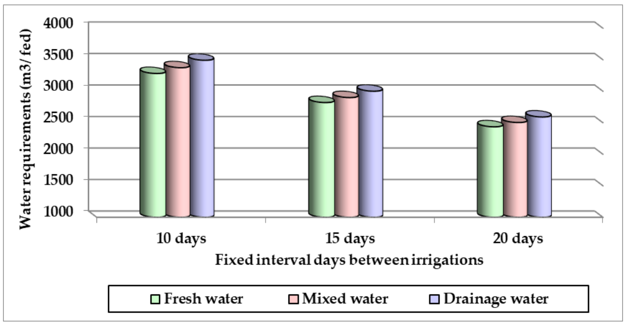

Fig. 7. Impact of fixed interval days and fixed depths of irrigation water (75 mm each) on crop water requirements under conditions of using various irrigation water qualities.

In the same direction, results as shown in Fig. 8 reveal that use of mixed or drainage water for irrigation resulted in reduce CWP and WUtE specially under the elongation periods between irrigations. The change percent in CWP reached -9.1 % and -11.3 % resulted from 75 mm mixed water or drainage water was applied, respectively compared with 75 mm fresh water. However, the change percent in WUtE reached -11.6 and -23.1 %, respectively.

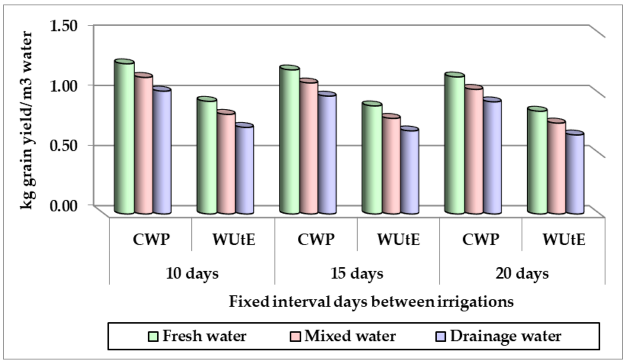

Fig. 8. Impact of fixed interval days and fixed depths of irrigation water (75 mm each) on crop water relations under conditions of using various irrigation water qualities.

4.2.1.3. Fixed interval days and fixed depths of irrigation water (50 mm each)

This strategy was suggested to study the effect of reducing the amount of irrigation water (50 mm each) on the productivity of maize crop under different irrigation periods (long and short periods). Results as recorded in Fig. 9 indicate that maize grain yield was affected by fixed interval days and fixed depths of irrigation water (50 mm each). The highest value was 2649 kg/ fed resulted from 50 mm fresh water with irrigation application every 10 days. While the lowest value was 1333 kg/ fed for 50 mm drainage water with irrigation application every 20 days.

From these results it can be concluded that under conditions of water shortage in Egypt we must use small amounts of irrigation water, as well as short interval between irrigations.

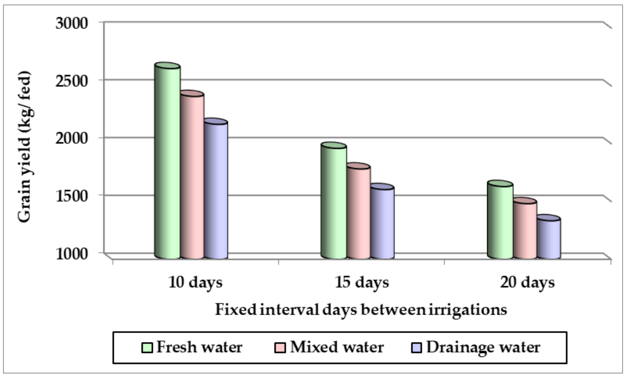

Fig. 9. Impact of fixed interval days and fixed depths of irrigation water (50 mm each) on maize grain yield under conditions of using various irrigation water qualities.

In this connection Doorenbose and Kassam (1986) (FAO No. 33) indicated that frequency and depth of irrigation and rain has a pronounced effect on grain yield. Maize appears relatively tolerant to water deficits during the vegetative and ripening periods. The greatest decrease in grain yields is caused by water deficits during the flowering period including tasseling and silking and pollination, due mainly to a reduction in grain number per cob. This effect is less pronounced when in the preceding vegetative period the plant has suffered water deficits. Sever water deficits during the flowering period particularly at the time of silking and pollination may result in little or no grain yield due to silk drying. Water deficits during the yield formation period may lead to reduced yield due to a reduction in grain size. Water deficit during the ripening period has little effect on grain yield. In addition, they added that the effect of limited water on maize grain yield is considerable and careful control of frequency and depth of irrigation is required to optimize yields under conditions of water shortage. Where water supply is limited, it may therefore be advantageous to meet, as far as possible, full water requirements (ET_m) to achieve near maximum yield from a limited acreage rather than to spread the limited water over a larger acreage.

Regarding the impact of fixed interval days and fixed depths of irrigation water (50 mm each) on maize water requirements, results as presented in Fig. 10 illustrate that shortening the interval days between irrigations with the use of a fixed amount of water in each irrigation led to increased water requirements for maize plants in comparison with elongation intervals. Results added that using drainage water led to increased water requirement compared with fresh water. The highest value was 3110 m^3/ fed registered for drainage water with irrigation application every 10 days. However, the lowest one was 2051 m^3/ fed for fresh water with irrigation application every 20 days.

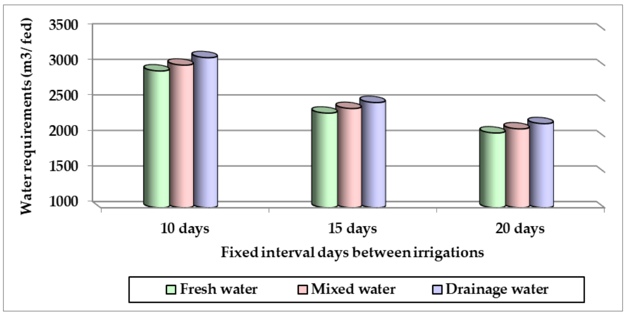

Fig. 10. Impact of fixed interval days and fixed depths of irrigation water (50 mm each) on crop water requirements under conditions of using various irrigation water qualities.

As to the impact of fixed interval days and fixed depths of irrigation water (50 mm each) on CWP and WUtE, results as shown in Fig. 11 reveal that CWP and WUtE affected by fixed interval days and fixed depths of irrigation water (50 mm each). The highest value was 1.21 kg / m^3 for 50 mm fresh water with irrigation application every 10 days. The lowest value was 0.61 kg / m^3 for 50 mm drainage water with irrigation application every 20 days. From these results it can be concluded that use fresh water for irrigation led to increased grain production and reduced water consumption and water requirement of maize plants and resulting in the increase of CWP and WUtE accordingly.

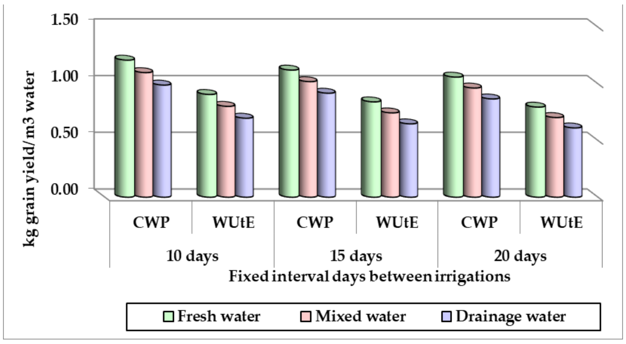

Fig. 11. Impact of fixed interval days and fixed depths of irrigation water (50 mm each) on crop water relations under conditions of using various irrigation water qualities.

4.2.1.4. Optimum irrigation management can be recommended for maize crop under the conditions of Sharkia governorate using various irrigation water qualities.

To get the optimum yield and optimum return from irrigation water unit, it should be added irrigation water in the best time and appropriate amount in each irrigation. To achieve this goal, two scenarios are used by CropWat model. These scenarios are:

- Application Timing: Irrigate when 100% of readily soil moisture depletion occurs.
- Applications Depths: Refill to 100% of readily available soil moisture.

Results as shown in Fig. 12 indicate that the optimum amount of irrigation water under using fresh water for irrigation could be arranged from first irrigation up to last irrigation as follows: 202.7, 293.4, 365.7, 401.0, 408.8, 408.8, 418.3, 529.2 and 261.5 m³/ fed.

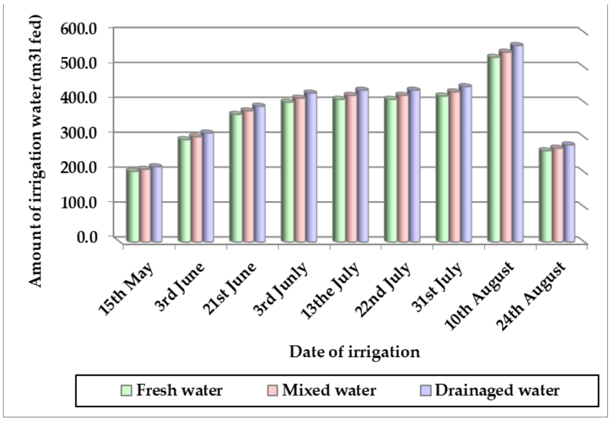

Fig. 12. Optimum amount of irrigation water in each one for maize crop under Sharkia governorate conditions using various irrigation water qualities.

With respect to mixed water, the same respective amounts could be arranged as follows: 208.4, 301.7, 375.9, 412.2, 420.2, 420.2, 430.0, 544.0 and 268.8 m³/ fed.

Regarding drainage water, amounts of irrigation water are: 215.7, 312.2, 389.1, 426.6, 435.0, 435.0, 445.1, 563.1 and 278.3 m³/ fed.

Seasonal water requirements for maize crop are 3289, 3382 and 3500 m³/ fed for fresh water, mixed water and drainage water, respectively.

In addition, results as presented in Fig. 13 indicate that the optimum interval days between irrigations could be arranged from sowing till harvest as follows: 18, 18, 12, 10, 9, 9, 10, 14 and 10.

4.2.2. Wheat Crop

4.2.2.1. Fixed interval days between irrigations

Results as shown in Fig. 14 reveal that different irrigation water quality has much impact on the productivity of wheat crop compared with the number of interval days between irrigations. The results showed that elongation periods between irrigations of 20 to 30 days did not cause a reduction in wheat productivity under the conditions of Sharkia governorate. The change percent of wheat yield for mixed water or drainage water compared to fresh water reached about -10 % and -20 %, respectively.

The crop is moderately tolerant to soil salinity but the ECe should not exceed 4 mmhos/ cm in the upper soil layer during germination. Yield decrease due to salinity is 0 % at ECe 6.0, 10 % at 7.4, 25 % at 9.5, 50 % at 13 and 100 % at ECe 20 mmhos/ cm (FAO 33, 1986).

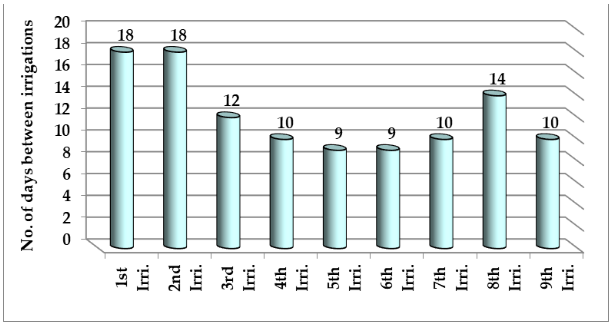

Fig. 13. Optimum interval days between irrigations for maize crop under Sharkia governorate conditions.

Water requirement of wheat plants increased with the use of mixed or drainage water for irrigation. Results as found in Fig. 15 indicate that values of water requirement for wheat crop were 2432, 2500, 2587 m³/ fed for fresh water, mixed water, and drainage water, respectively. There is no difference in water requirements for wheat crop with the interval days between irrigations treatments under study.

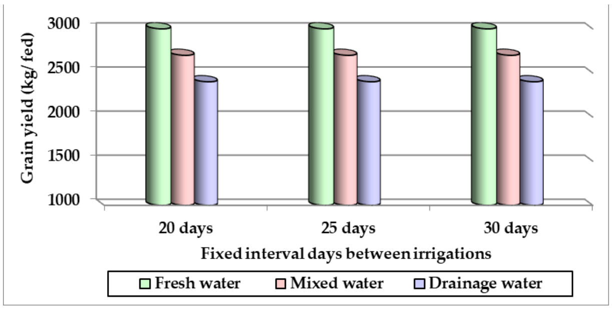

Fig. 14. Impact of fixed interval days between irrigations on wheat grain yield under conditions of using various irrigation water qualities.

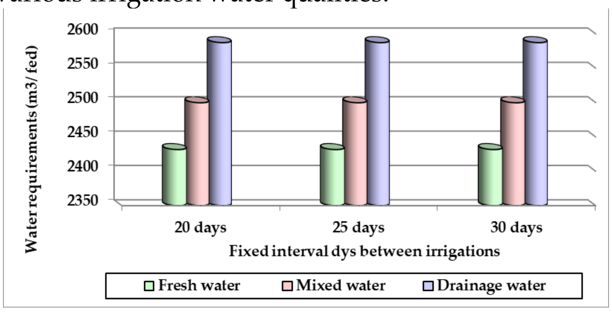

Fig. 15. Impact of fixed interval days between irrigations on wheat water reuirements under conditions of using various irrigation water qualities.

Regarding the impact of fixed interval days between irrigations on CWP and WUtE, results as shown in Fig. 16 illustrate that CWP increased by about 11 % and 21 % for fresh water compared with CWP under mixed or drainage water conditions, respectively. At the same time, WUtE increased by about 14 % and 33 % for fresh water compared to the same respective irrigation treatments. These results are full agreement with those obtained by Mao et al. (2003); Panda et al. (2003); Farré and Faci (2006). They indicated that an appropriate deficit irrigation system with fresh water can increase irrigation efficiency without significantly decreasing yield.

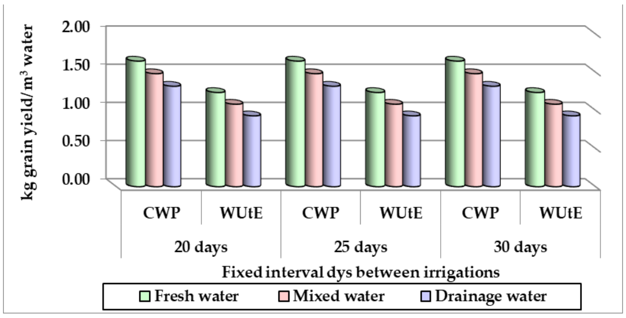

Fig. 16. Impact of fixed interval days between irrigations on wheat water relations under conditions of using various irrigation water qualities.

4.2.2.2. Fixed interval days and fixed depths of irrigation water (75 mm each)

Results as shown in Fig. 17 reveal that elongation of the period between irrigations with the application of 75 mm water amount every time resulted in few reductions in wheat yield compared with the short time between irrigations. The reduction of wheat yield reached 1.2 % with irrigation treatment every 30 days compared with irrigation every 25 days or 20 days. The highest value (3000 kg/ fed) is recorded with freshwater treatment and application of irrigation every 20 or 25 days. While the lowest value (2371 kg/ fed) was found with drainage water treatment and application of irrigation every 30 days.

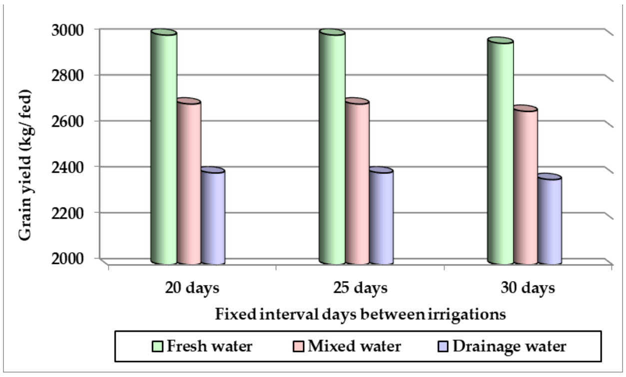

Fig. 17. Impact of fixed interval days and fixed depths of irrigation water (75 mm each) on wheat grain yield under conditions of using various irrigation water qualities.

Concerning water requirements for wheat crop under fixed interval days and fixed depths of irrigation water (75 mm each) results as shown in Fig. 18 indicate that elongation interval days between irrigations save irrigation water about 2% compared with short intervals. The highest water requirements were 2587 m³/ fed found with drainage water treatment and application of irrigation every 20 days while the lowest water requirements were 2383 m³/ fed registered with fresh water and irrigation application every 30 days.

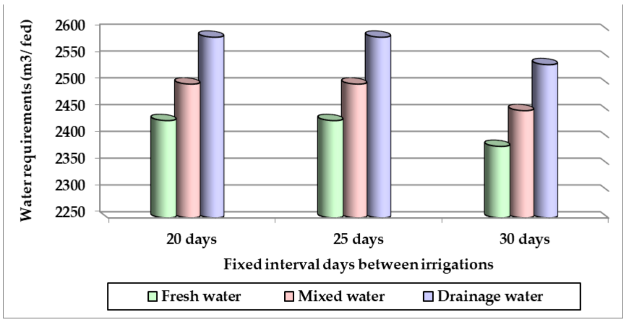

Fig. 18. Impact of fixed interval days and fixed depths of irrigation water (75 mm each) on crop water requirements under conditions of using various irrigation water qualities.

Results as presented in Fig. 19 indicate the impact of fixed interval days and fixed depths of irrigation water (75 mm each) on crop water relations under conditions of using various irrigation water qualities. There is a slight increase in CWP and WUtE with treatment of irrigation application every 30 days in comparison with treatment of irrigation application every 25 days or 20 days. This increase can be attributed to saving 2% of irrigation water with a slight decrease in wheat productivity.

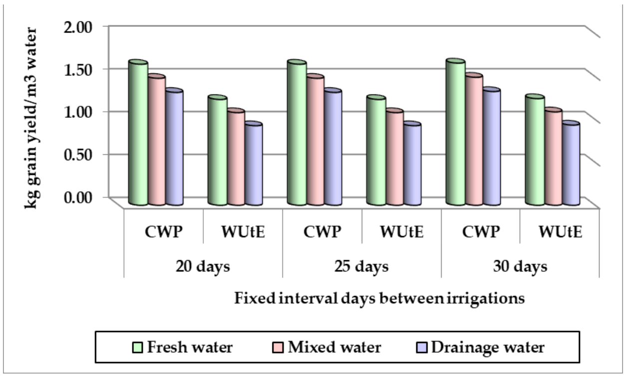

Fig. 19. Impact of fixed interval days and fixed depths of irrigation water (75 mm each) on crop water relations under conditions of using various irrigation water qualities.

4.2.2.3. Fixed interval days and fixed depths of irrigation water (50 mm each)

There is a clear effect of the depth of irrigation water on the productivity of wheat crop, especially under conditions of elongation interval between irrigations. Results as recorded in Fig. 20 indicate that the highest productivity of wheat under these conditions registered with fresh water and irrigation application every 20 days, while the lowest one found with drainage water and irrigation application every 30 days. The change percent between the lowest values compared to the highest one reached about -24 %.

There is saving irrigation water under conditions of long intervals between irrigations compared with short intervals. Results as recorded in Fig. 21 show that water requirements for wheat crop decreased 4% and 8% when applying irrigation every 25 days and every 30 days compared to apply irrigation every 20 days. In the same direction, more saving of irrigation water was found with the interaction between applying irrigation every 30 days and using fresh water for irrigation.

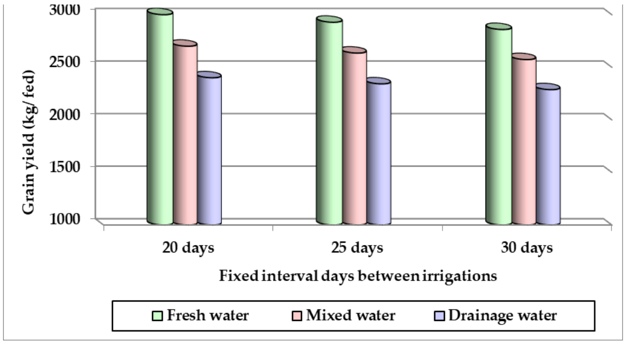

Fig. 20. Impact of fixed interval days and fixed depths of irrigation water (50 mm each) on wheat grain yield under conditions of using various irrigation water qualities.

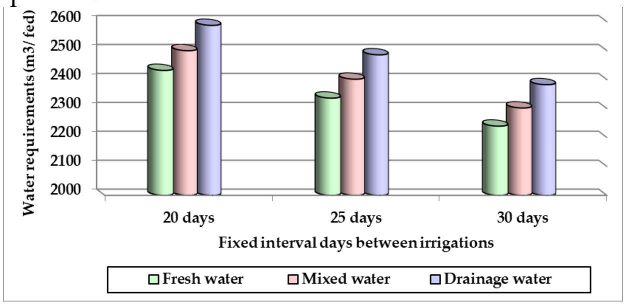

Fig. 21. Impact of fixed interval days and fixed depths of irrigation water (50 mm each) on crop water requirements under conditions of using various irrigation water qualities.

Regarding the impact of fixed interval days and fixed depths of irrigation water (50 mm each) on CWP and WUtE, results as shown in Fig. 22 indicated that CWP and WUtE affected by fixed interval days and fixed depths of irrigation water (50 mm each). The highest CWP was 1.70 kg grains / m^3 consumed water for 50 mm fresh water with irrigation application every 30 days. The lowest CWP was 1.32 kg grains / m^3 consumed water for 50 mm drainage water with irrigation application every 20 days. The change percent between the highest and lowest values reached about 29 %. The same trend was found for WUtE, the highest and lowest values were 1.28 and 0.93 kg grains/ m^3 applied water, respectively, and the change percent between them reached about 38 %.

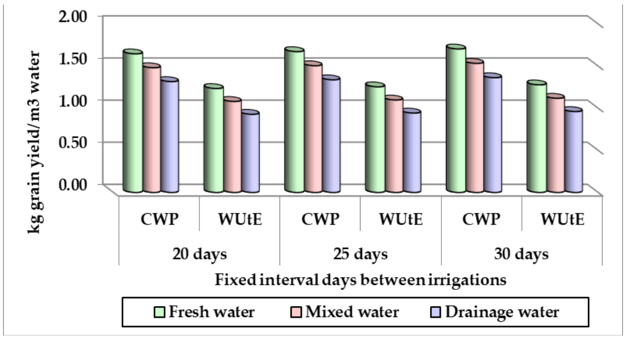

Fig. 22. Impact of fixed interval days and fixed depths of irrigation water (50 mm each) on crop water relations under conditions of using various irrigation water qualities.

4.2.2.4. Optimum irrigation management can be recommended for wheat crop under the conditions of Sharkia governorate using various irrigation water qualities.

Results as recorded in Fig. 23 illustrated that the optimum amount of irrigation water under using fresh water for irrigation could be arranged from first irrigation up to last irrigation as follows: 100.2, 152.9, 345.0, 628.9, 784.0 and 420.0 m^3/ fed.

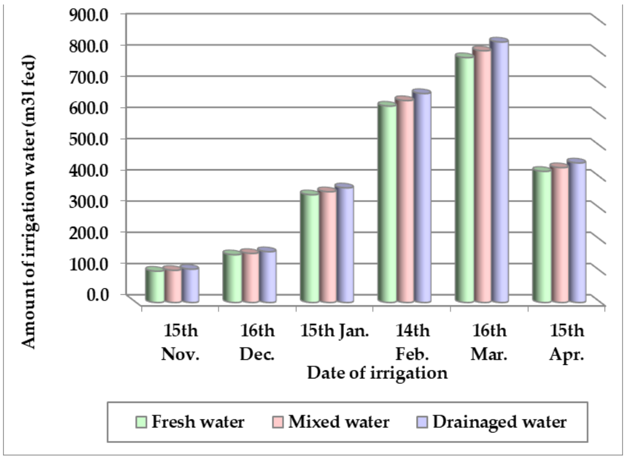

Fig. 23. Optimum amount of irrigation water in each one for wheat crop under Sharkia governorate conditions using various irrigation water qualities.

With respect to mixed water, the same respective amounts could be arranged as follows: 103.0, 157.2, 354.6, 646.5, 806.0 and 431.8 m^3/ fed.

Regarding drainage water, amounts of irrigation water are: 106.7, 162.7, 367.0, 669.1, 834.2 and 446.9 m^3/ fed.

Seasonal water requirements for wheat crop are

2431, 2499 and 2587 m^3/ fed for fresh water, mixed water and drainage water, respectively.

In addition, results as presented in Fig. 24 indicate that the best interval days between irrigations for wheat from sowing till harvest is 30 days as this would save irrigation water about 8% without a decrease in the productivity of the crop.

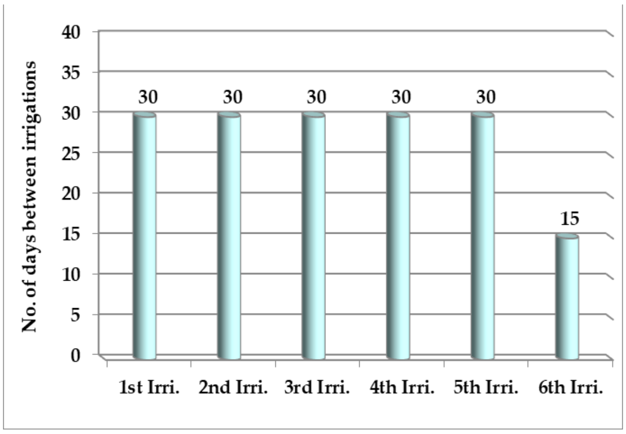

Fig. 24. Optimum irrigation interval days between irrigations for wheat crop under Sharkia governorate conditions.

In this connection, Jing JIANG et al (2013) conducted two field experiments in 2008 and 2009 to study the effects of deficit irrigation with saline water on spring wheat growth and yield in an arid region of Northwest China. Nine treatments included three salinity levels s1, s2 and s3 (0.65, 3.2, and 6.1 dS/m) in combination with three water levels w1, w2 and w3 (375, 300, and 225 mm). In 2008, for most treatments, deficit irrigation showed adverse effects on wheat growth; meanwhile, the effect of saline irrigation was not apparent. In 2009, growth parameters of w1 treatments were not always optimal under saline irrigation. At 3.2 and 6.1 dS/m in 2008, the highest yield was obtained by w1 treatments, however, in 2009, the weight of 1,000 grains and wheat yield both followed the order w2 > w1 > w3. In this study, spring wheat was sensitive to water deficit, especially at the booting to grain-filling stages, but was not significantly affected by saline irrigation and the combination of the two factors. The results demonstrated that 300-mm irrigation water with a salinity of less than 3.2 dS/m is suitable for wheat fields in the study area.

4. Conclusions

To encourage and increase investment in agricultural areas should be better package recommendations for each climatic zone to reach a higher return from the land and water unit and the maximum economic return.

To achieve this objective, this study was conducted in Sharkia governorate under the conditions of using various water qualities. The results indicated that:

Using mixed or drainage water in irrigation causes a lack of productivity as well as increased crop water requirements. The reduction of maize yield under the use of mixed or drainage water compared to fresh water reached about 9 and 18 %, respectively. At the same time, water requirements were increased by 2.8 and 6.4 %, respectively.

Regarding wheat crop, the productivity decreased by 10 and 20 % and water requirements increased by 2.8 and 6.4 % for the same respective irrigation treatments compared to fresh water.

An elongation period between irrigations or adding small amount of irrigation water in each time would reduce crop productivity. To get the optimum yield and optimum return from irrigation water unit, it should be added irrigation water in the best time and appropriate amount in each irrigation. This will preserve the physical and chemical properties of soil and its sustainability and achieve the highest economic return.

The optimum interval days between irrigations for maize crop could be arranged from sowing till harvest as follows: 18, 18, 12, 10, 9, 9, 10, 14 and 10. The optimum amount of irrigation water could be arranged from first irrigation up to last irrigation as follows: 202.7, 293.4, 365.7, 401.0, 408.8, 408.8, 418.3, 529.2 and 261.5 m3/ fed when use fresh water for irrigation, 208.4, 301.7, 375.9, 412.2, 420.2, 420.2, 430.0, 544.0 and 268.8 m^3/ fedfor using mixed water, and 215.7, 312.2, 389.1, 426.6, 435.0, 435.0, 445.1, 563.1 and 278.3 m3/ fed for using drainage water.

Regarding wheat crop, the best interval days between irrigations for wheat from sowing till harvest is around 30 days as this would save irrigation water about 8% without a marked decrease in the productivity of the crop.

The optimum amount of irrigation water could be arranged from first irrigation up to last irrigation as follows: 100.2, 152.9, 345.0, 628.9, 784.0 and 420.0 m3/ fed- when use fresh water for irrigation, 103.0, 157.2, 354.6, 646.5, 806.0 and 431.8 m3/ fed for using mixed water, and 106.7, 162.7, 367.0, 669.1, 834.2 and 446.9 m3/ fed for using drainage water.

References

Ben-Asher, J., Tsuyuki, I., Bravdo, B.A., Sagih, M., 2006a. Irrigation of grapevines with saline water: I. Leaf area index, stomatal conductance, transpiration and photosynthesis. Agricultural water management, 83(1-2), 13-21. https://doi.org/10.1016/j.agwat.2006.01.002.

Ben-Asher, J., Van Dam, J., Feddes, R.A., Jhorar, R.K., 2006b. Irrigation of grapevines with saline water: II. Mathematical

simulation of vine growth and yield. Agricultural water management, 83(1-2), 22-29. https://doi.org/10.1016/j.agwat.2005.11.006.
Doorenbos, J., A.H., Kassam, 1986. Yield response to water. Irrigation and Drainage Paper, FAO No. 33, Rome, Italy.
Farré, I., Faci, J.M., 2006. Comparative response of maize (Zea mays L.) and sorghum (Sorghum bicolor L. Moench) to deficit irrigation in a Mediterranean environment. Agricultural water management, 83(1-2), 135-143. https://doi.org/10.1016/j.agwat.2005.11.001.
Jiang, J., Huo, Z., Feng, S., Kang, S., Wang, F., Zhang, C., 2013. Effects of deficit irrigation with saline water on spring wheat growth and yield in arid Northwest China. Journal of arid land, 5, 143-154. https://doi.org/10.1007/s40333-013-0152-4.
Katerji, N., Van Hoorn, J.W., Hamdy, A., Mastrorilli, M., 2000. Salt tolerance classification of crops according to soil salinity and to water stress day index. Agricultural water management, 43(1), 99-109. https://doi.org/10.1016/S0378-3774(99)00048-7.
Maas, E.V., Hoffman, G.J., 1977. Crop salt tolerance—current assessment. Journal of the irrigation and drainage division, 103(2), 115-134. https://doi.org/10.1061/JRCEA4.0001137.
Mao, X., Liu, M., Wang, X., Liu, C., Hou, Z., Shi, J., 2003. Effects of deficit irrigation on yield and water use of greenhouse grown cucumber in the North China Plain. Agricultural water management, 61(3), 219-228. https://doi.org/10.1016/S0378-3774(03)00022-2.
Ahmed, B.O., Yamamoto, T., Rasiah, V., Inoue, M., Anyoji, H., 2007. The impact of saline water irrigation management options in a dune sand on available soil water and its salinity. Agricultural Water Management, 88(1-3), 63-72. https://doi.org/10.1016/j.agwat.2006.10.001.
Panda, R.K., Behera, S.K., Kashyap, P.S., 2003. Effective management of irrigation water for wheat under stressed conditions. Agricultural water management, 63(1), 37-56. https://doi.org/10.1016/S0378-3774(03)00099-4.

آثار استخدام مياه ري مختلفة النوعية على إنتاجية المحصول: حاله دراسية لمحافظة الشرقية

خالد محمد شعبان [١]، رمضان عبد المقصود أبو الخير [٢]، محمود أسامه المعتصم بالله [٢]،

جمال عبد الناصر كامل [١]، حسين خالد أحمد خالد [٢]، طلعت طاهر الجمل [١]

[١] معهد بحوث إدارة المياه، المركز القومي لبحوث المياه، الجيزة، مصر.
[٢] قسم الأراضي والمياه، كلية الزراعة، جامعة الأزهر، القاهرة، مصر.

الملخص العربي

يهدف هذا البحث إلى دراسة تدفق الملوثات البيئية من مياه الري إلى التربة. ولتحقيق هذا الهدف تم اختيار ثلاثة مناطق تقع تحت ظروف مناخية واحدة والتركيب المحصولي واحد تروى الأولى منها بمياه عذبة والثانية تروى بمياه خلط والثالثة تروى بمياه صرف. وقد امتدت الزراعة إلى موسمين زراعيين صيفي وشتوي وكان الذرة هو المحصول الصيفي المنزرع، وكان القمح هو المحصول الشتوي المنزرع. وتشابهت الخدمة الزراعية والتي تشمل الأسمدة المضافة وكمياتها وكذلك المبيدات في المناطق الثلاثة.

وقد اشتملت الدراسة على الآتي:

- تقويم صلاحية المياه المستخدمة في الري.
- تأثير مياه الري على التربة (ملوحة – عناصر ثقيلة – مغذيات – مادة عضوية)
- تأثير مياه الري على تركيب النبات المنزرع (عناصر ثقيلة – مغذيات)
- تقدير أهم العلاقات المائية لمحصولي الذرة الشامية والقمح.

وأوضحت نتائج الدراسة ما يلي:

- مياه الري العذبة والمخلوطة تصلح لزراعة جميع أنواع المحاصيل بينما كانت مياه الصرف تصلح لري المحاصيل المتحملة ومتوسطة التحمل للملوحة.
- العناصر النادرة والمغذيات كانت في الحدود المسموح بها عدا عنصر الكادميوم والنحاس.
- كل قيم وتركيزات BOD و COD في مياه الري المستخدمة زادت وارتفعت عن تلك المسموح بها طبقاً للمواصفات وكانت مصدراً كبيراً للتلوث.
- متوسط الحمل الميكروبي (أعداد الميكروبات المعدية) زادت بدرجة كبيرة عن تلك المسموح بها طبقاً للمواصفات وتعتبر مصدراً كبيراً لتلوث تلك المياه بالميكروبات المعدية.
- عملية غسيل الأملاح حدثت من التربة تحت معاملات الري مختلفة النوعية. وأوضحت نتائج الارتباط بين الملوثات في مياه الري مختلفة النوعية وتلك الملوثات في التربة كانت معنوية لبعض العناصر بينما كانت قيم الارتباط غير معنوية مع عناصر أخرى. هذا وقد اختلف الارتباط بين الملوثات في مياه الري والملوثات في النبات من ملوث إلى أخر ولم يكن هناك اتجاه واضح لغسيل الملوثات التي تم دراستها مع مياه الري.
- تدفق الملوثات التي تمت دراستها من مياه الري إلى التربة اختلفت من ملوث إلى آخر طبقاً لذوبان الملوث في المياه وتركيزاته وأهميته بالنسبة للنبات وامتصاصه بواسطة النبات وحركته مع المياه المنصرفة من التربة.
- استخدام المياه المخلوطة أو مياه الصرف في الري أدى إلى انخفاض إنتاجية المحصول وزيادة الاحتياجات المائية للمحاصيل تحت الدراسة. هذا وقد أوضحت النتائج أن إطالة الفترة بين الريات أو استعمال كمية قليلة من مياه الري لها كل مرة من شأنه أن يقلل إنتاجية المحصول.