THE IMPACT OF IRRIGATION IMPROVEMENT ACTIVITIES ON WATER AND SALT BALANCE FOR THE IRRIGATED LAND IN NEKLA CANAL (EL-BEHIRA GOVERNORATE)

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ABSTRACT

Three representative mesqas, i.e. Arfa Mousa at the head, Elafeer2 at the middle and Elbanna at the tail of Nekla canal. El-Behara Gov., were selected to evaluate the impact of the implementation of activities and processes of field irrigation system development on crop yield, water saving, water productivity, water and salt balance.

Results indicated slight increases in yield of the tested crops either irrigated from head - Arfa Mouse, middle - Elafeer2 or Tail - Elbanna mesqas. The average increases were about 6.98, 5.99 and 7.19% respectively. The average increases in crop water productivity were about 19.9, 19.5 and 20.0 % for crops irrigated from the three mesqas respectively. The average increases in crop water productivity for wheat, rice, Egyptian clover, cantaloupe and watermelon pulp were 800, 3250, 1255, 848 and 454 kg/Fed respectively before and 702, 1939, 519, 388 kg/Fed after field irrigation system development. The average amount of salts removed from soil cultivated with wheat, rice, Egyptian clover, cantaloupe and watermelon pulp were 722, 2456, 1337, 802 and 454 kg/Fed after field irrigation system development.

Results revealed that the net water balance (NWB) values decreased to about 87.6, 76.7 and 85.5% as affected by field irrigation system development relative to values before development equal to 100 for wheat, rice and Egyptian clover respectively under irrigation from Arfa Mousa mesqa at the head of Nekla canal. Similar results were also observed for wheat, rice and Egyptian clover irrigated from Elafeer2 at middle, and Elbanna mesqa at tail of Nekla canal. The average amount of salts added into soil cultivated with wheat, rice, Egyptian clover, cantaloupe and watermelon pulp were 800, 2350, 1255, 848 and 454 kg/Fed respectively before and 702, 1939, 519, 388 kg/Fed after field irrigation system development.

INTRODUCTION

Egypt is unique among the nations of the world due to its main dependence upon a single water source, the River. Water demands in Egypt are growing rapidly due to the population explosion. The available fresh water per capita in Egypt dropped from 1893 cubic meters per person in 1959 to 800-900 cubic meters in 2000 and tends to decline further to the values of 670 cubic meter by 2017 and 600 by 2025 (Malashkia, 2003 and MWRI, 2005).
According to statistics, if the available fresh water per person drops below 1700 cubic meters, countries are considered as water stress regions. When per capita water use falls below 1000 cubic meters, countries undergo a chronic water scarcity, and less than 600 cubic meters of water per person would mean absolute water scarcity (Malash-kia, 2003).

Egypt by year 2025 will face absolute water scarcity. The consumed water for irrigated agriculture is about 85% of the budget of MWRI while 10% are dedicated to services for the water supply and sanitation sector, and 5% attributed to the industrial sector (MWRI, 2005).

In the final report of the integrated irrigation improvement and management project (IIIMP), Simons et al (2012) reported that one of the main measures that have been taken to solve problems related to the distribution of water in the irrigation network is the application of continuous flow, as a replacement of the typical system of rotational flow. Water delivery services to the farmers are improved and the flexibility of the water management system is increased. The flow in the branch canal is determined by regulation of the discharge at the head of the canal, while taking into account the area served by the canal and its cropping pattern (i.e. crop water demands). Lifting of the water from the branch canal into the mesqa network has been centralized through an electric pump set at a single control point, with the purpose of increasing the equity of water distribution and reducing operational cost. Water losses through seepage from the mesqas are reduced by piping of the tertiary canals, also allowing for pressurized water delivery. Similar improvements have been made to under IIIMP, either by lining of the canals with brick and mortar or piping by low-pressure pipes up to the on-farm gate.

Inadequate water supply in a canal command area is a major limiting factor for sustainable crop production, as well as for adoption of the suitable crops. Satyendra et al (2013) indicated that the interventions were able to save a substantial amount of irrigation water (3-46%) compared to surface methods, along with higher yields, a doubling of water productivity and more profits per mm of irrigation water. The study clearly showed that micro-irrigation in conjunction with an auxiliary reservoir should be recommended in canal-irrigated commands in order to improve water productivity and farmers’ income in arid regions.

A significant volume of water was lost from small-scale irrigation systems in Ethiopia mainly because farmers’ water application did not match crop needs (Derib et al 2011). They found that the high cost resulted by pumped irrigation positively affected water management by minimizing water losses and forced farmers to use deficit irrigation. Improving water productivity of small-scale irrigation requires integrated interferences including night storage mechanisms, optimal irrigation scheduling, empowerment of farmers to preserve canals and proper irrigation schedules. Noory et al (2011) pointed out that improving water management can decrease mean drainage water (22-48%) and salts (30-49%), compared with current water management without adverse effects on relative transpiration and root zone salinity.

In evaluation the effects of controlled irrigation and drainage on water productivity in paddy fields, Gao ShiKai et al (2018) found that the controlled irrigation and drainage reduced irrigation water without a significant impact on grain yields and increased the irrigation water productivity.

Water productivity can be expressed as agricultural production per unit volume of water. The United Nations, World water assessment programme calls for crop water productivity increases with the aim of reducing pressure to develop new supply sources or increasing water allocation to agriculture (UNESCO, 2009). FAO (2012) considers demand management as an important option to cope with water scarcity, with increasing agricultural water productivity as the single most important avenue for managing water demand in agriculture.

For wheat, rice and clover crops, the water productivity with respect to evapotranspiration is typically reported to be around 1.0-1.2 kg/m² for wheat (French and Schultz, 1984), 0.6 to 1.6 kg/m² for rice (Hsiao et al 1984) and 1.0–2.6 kg/m² for Egyptian clover (Grimes et al 1992).

The main objective of this work was to evaluate the impact of the implementation of the activities and processes of the development of field irrigation systems on crop yield, water productivity water saving, water balance and salt balance of some of the cultivated crops.

MATERIALS AND METHODS

The main objectives of this study were achieved by track the change in the characteristics of irrigation water and soil in different locations along Nekla canal representative by three mesqas,
The impact of irrigation improvement activities on water and salt balance for the irrigated land in Nekla canal (El-Behira Governorate)

(Arsa Mousa at the head, Elafeer2 at the middle and Elbanna at the tail) before and after field irrigation system development. In addition, crops yield, water saving, crop water productivity were determined for some of the cultivated crops in the areas irrigated from these mesqas before and after the implementation of activities and processes of the development of the field irrigation systems.

The activities and processes of the development of the field irrigation system included the conversion of the unlined canals to buried pipes operating under water pressure head or to lined canals and changing the multiple lift points to a single lifting point at the head of the mesqa and the replacement of the hand control gates to the mechanical control gates for each canal feeder. In addition to the replacement of sharing water lifting machines with diesel or electric pump (lifting machines). The development of field irrigation system extended to establish of water users’ associations at the branch canal level and the water council at the main canal level.

Water samples were collected several times from irrigation canals and mesqas under study to represent their properties at head, middle and tail before and after the development of field irrigation systems then subjected to chemical analyses (Table 1). Soil samples were taken using soil auger from investigated sites at the beginning and at the end of each crop growth season from the soil layers at 0-15, 15-30, 30-45 and 45-60 cm depth. The collected soil samples were air dried and ground to pass through a 2 mm sieve, and then the different determinations of soil physical properties were conducted according to Klute (1986) and represented in Tables (2 and 3).

Table 1. Chemical analysis of water samples taken from Arsa Mousa (AM) at the head, Elafeer2 (EF2) at the middle and Elbanna (EB) at the tail mesqas, before and after field irrigation system development

| Site  | pH  | EC dS/m | Ca²⁺  | Mg²⁺  | Na⁺  | K⁺  | Cl⁻  | SO₄²⁻ |
|-------|-----|---------|-------|-------|------|-----|------|-------|
| AM    |     |         |       |       |      |      |      |       |
| Head  |     |         |       |       |      |      |      |       |
| Before | 8.22 | 0.57 | 2.80 | 2.00 | 1.00 | 0.22 | 0.50 | 4.50  |
| After  | 8.15 | 0.53 | 1.90 | 1.40 | 1.45 | 0.77 | 0.50 | 4.00  |
| Mean  | 8.19 | 0.55 | 2.35 | 1.70 | 1.23 | 0.50 | 0.50 | 4.25  |
| EF2   |     |         |       |       |      |      |      |       |
| Middle|     |         |       |       |      |      |      |       |
| Before | 8.13 | 0.57 | 2.33 | 2.00 | 1.00 | 0.47 | 0.50 | 4.00  |
| After  | 7.80 | 0.54 | 2.25 | 1.50 | 1.00 | 0.77 | 0.50 | 4.10  |
| Mean  | 7.97 | 0.56 | 2.29 | 1.75 | 1.00 | 0.62 | 0.50 | 4.05  |
| EB    |     |         |       |       |      |      |      |       |
| Tail  |     |         |       |       |      |      |      |       |
| Before | 8.20 | 0.57 | 2.45 | 2.00 | 1.00 | 0.22 | 0.50 | 4.00  |
| After  | 8.03 | 0.55 | 1.90 | 1.72 | 1.00 | 0.97 | 0.50 | 3.85  |
| Mean  | 8.12 | 0.56 | 2.18 | 1.86 | 1.00 | 0.60 | 0.50 | 3.93  |
| Mean  |     |         |       |       |      |      |      |       |
| Before | 8.18 | 0.57 | 2.53 | 2.00 | 1.00 | 0.30 | 0.50 | 4.17  |
| After  | 7.99 | 0.54 | 2.02 | 1.54 | 1.15 | 0.84 | 0.50 | 3.98  |

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Table 2. Soil bulk density and some soil moisture parameters of the served area by Arafa Mousa (AM), Elaffeer2 (EF2) and Elbanna (EB) mesqas, before field irrigation system development

| Site                  | Soil depth cm | bulk density g/cm³ | Soil moisture parameters % |
|-----------------------|---------------|--------------------|----------------------------|
|                       |               |                    | FC | PWP | TAW |
| Arafa Mousa at head   | 00-15         | 1.1                | 46.1 | 24.8 | 21.4 |
|                       | 15-30         | 1.2                | 41.2 | 21.3 | 19.9 |
|                       | 30-45         | 1.2                | 36.8 | 20.4 | 16.5 |
|                       | 45-60         | 1.3                | 34.9 | 19.1 | 15.8 |
| Mean                  | 00-60         | 1.2                | 39.8 | 21.4 | 18.4 |
| Elaffeer2 at middle   | 00-15         | 1.1                | 46.7 | 25.4 | 21.2 |
|                       | 15-30         | 1.1                | 40.2 | 21.8 | 18.3 |
|                       | 30-45         | 1.3                | 38.3 | 20.8 | 17.5 |
|                       | 45-60         | 1.3                | 34.3 | 18.6 | 15.6 |
| Mean                  | 00-60         | 1.2                | 39.8 | 21.6 | 18.2 |
| Elbanna at tail       | 00-15         | 1.2                | 40.4 | 21.9 | 18.4 |
|                       | 15-30         | 1.2                | 37.2 | 20.2 | 17.0 |
|                       | 30-45         | 1.2                | 34.2 | 18.6 | 15.6 |
|                       | 45-60         | 1.3                | 34.2 | 18.6 | 15.6 |
| Mean                  | 00-60         | 1.2                | 39.6 | 21.5 | 18.1 |

Table 3. Particales size distribution of the served area by Arafa Mousa (AM), Elaffeir2 (EF2) and Elbanna (EB) mesqas, before field irrigation system development

| Site                  | Soil depth cm | Particales size distribution - % | Texture |
|-----------------------|---------------|----------------------------------|---------|
|                       |               | Sand | Silt | Clay |       |
| Arafa Mousa at head   | 00-15         | 13.4 | 31.3 | 55.3 | Clay  |
|                       | 15-30         | 21.3 | 29.1 | 49.6 | Clay  |
|                       | 30-45         | 22.1 | 31.2 | 46.7 | Clay  |
|                       | 45-60         | 23.1 | 34.2 | 42.7 | Clay  |
| Mean                  | 00-60         | 20.0 | 31.5 | 48.6 | Clay  |
| Elaffeer2 at middle   | 00-15         | 12.3 | 33.3 | 54.4 | Clay  |
|                       | 15-30         | 20.2 | 34.2 | 48.6 | Clay  |
|                       | 30-45         | 20.4 | 34.5 | 45.1 | Clay  |
|                       | 45-60         | 21.1 | 35.7 | 43.2 | Clay  |
| Mean                  | 00-60         | 18.5 | 34.4 | 47.8 | Clay  |
| Elbanna at tail       | 00-15         | 13.8 | 31   | 55.2 | Clay  |
|                       | 15-30         | 20.9 | 34.3 | 44.8 | Clay  |
|                       | 30-45         | 21.7 | 38.7 | 39.6 | Clay  |
|                       | 45-60         | 22.1 | 39.7 | 38.2 | Clay  |
| Mean                  | 00-60         | 19.6 | 35.9 | 44.5 | Clay  |
Electrical conductivity values (EC) in dS/m were measured in the collected water samples or in the extract of saturated soil paste using electrical conductivity meter according to the method described by (Jackson, 1958).

Water application at mesqa field level is calculated based on the discharge from the pumps and the operation hours of this pump. The calibrate the pumps depends on the type of this pump either improved (fixed) or unimproved (movable) pumps. In the unimproved pumps, where water pumping freely to farm canal (Marwa), flumes are used to measure discharge from pumps. In this method, the discharge is defined based on the water depths at the upstream (Ha) and the downstream (Hb) of the cut throat flume. The discharge can be obtained from the corresponding tables based on the coefficient C that is calculated using the following equation described by Water measurement manual, USA (2001):

\[ C = (Ha - Hb) / Ha \]

In improved mesqas, the ultrasonic flow meter is used to measure the discharge, with reflective type (V). In type (V), both transducers mounted on one side of the pipe, and the distance between them is defined based on the characteristics of the pipelines and the measured liquid. The flow is recorded in (lit/sec). The flow from the pump depends on the pressure (head), and the pressure consists of suction head and delivery head. Suction head is related to the water level in the suction side. Delivery head depends mainly on the friction losses, and therefore, it depends on the opened valve(s). The head is measured around the pumps (suction and delivery heads) for different scenarios of opening valves to define the range of the flow from the pumps.

With the flow from the pump, the operation hours should be collected/recorded to define total water supply from the mesqa. The simple way to get the operation hours is to collect them manually. The operator of the mesqa record the daily starting and stopping hours of the pumps. Other time, advanced techniques are used to define such starting and stopping hours. A data logger that is connected to the electric circle is used for this purpose. The device is recording the situation (on/off) each time interval. The recorded data is analyzed to define the starting and stopping time for each pump such recorded data.

Level and salinity values of water table are recorded automatically using automatic recorders. A recorder (Solinst) was installed inside a pipeline (piezometer). The time interval for recording the data is defined during the setup, and normally it is half an hour. The recorder is defining the water depth above its datum, and using the level of this datum, such depths could be converted into levels. The salinity is measured directly.

Weather data for the experimental site were obtained from Nekla agro-meteorological station. Monthly values of solar radiation, minimum, maximum and mean air temperature, relative humidity, wind speed, and pan evaporation (RH, U and Es respectively) are presented in Table (4). Where: Rs is Solar radiation in (MJ/m²/day), Tmax is Maximum air temperature C°, Tmin is Minimum air temperature C°, Tmean is Average air temperature C°, Tdew is Dew point temperature in C°, P is Precipitation in mm/day, U is Wind speed in km/h and RH is Relative humidity in %.

Water Consumption for crops (WU) after or before field irrigation development was determined by tracking the change in the soil moisture content before each irrigation. Soil moisture content (θg) was gravimetrically determined in soil sample taken before each irrigation from the active root zone (D_s) at 0-60 cm depth (Hansen et al. 1979). Field capacity (θfc), permanent wilting point (θwp) and soil bulk density (ρw) were determined according to Klute (1986). Seasonal crop water consumptive use for each of the studied crops (WU) in mm or m³/feddan were calculated using the following equation:

\[ WU = \sum ((\theta g - \theta wp) / 100) \times (\rho w / \rho s) \times D_s \times 4200 \] m³/Fed

Where: WU is crop water consumptive use of the tested values through growth season of each crop in mm or m³/Fed, θg is soil moisture percentage before irrigation in % (w/w), θfc is Soil field capacity in % (w/w), D_s is soil layer depth or active root zone in m, ρw is soil bulk density in g/cm² and ρs is water density in g/cm².

Change in soil moisture storage (CSMS) was gravimetrically determined in soil sample taken from active root zone before and after the development. Water productivity (WP) is a simple ratio between crop yield in kg/m² and water consumptive use (WU) in m³/m² as shown in the following equation (El-Bably et al. 2015).

\[ WP = \text{Crop yield} / WU \]
Table 4. Monthly agro-meteorological data recorded for El-Behaira - Nekla during 2017

| Months | $R_s$ | $T_{\text{max}}$ | $T_{\text{min}}$ | $T_{\text{mean}}$ | $T_{\text{dew}}$ | RH | U | P |
|--------|------|-----------------|-----------------|-----------------|-----------------|----|---|---|
| Jan    | 12.4 | 17.6            | 5.97            | 10.9            | 3.54            | 61.2| 3.80| 0.00|
| Feb    | 15.2 | 20.0            | 6.71            | 12.4            | 4.94            | 60.6| 3.90| 0.00|
| Mar    | 19.8 | 24.1            | 10.1            | 16.3            | 5.95            | 51.5| 5.90| 0.00|
| Apr    | 23.7 | 28.5            | 12.2            | 19.9            | 6.58            | 43.5| 5.10| 68.1|
| May    | 27.2 | 33.4            | 16.8            | 24.7            | 9.40            | 39.1| 1.70| 0.00|
| June   | 29.6 | 36.6            | 19.8            | 28.0            | 12.6            | 39.4| 1.30| 0.00|
| July   | 29.1 | 38.6            | 22.1            | 29.92           | 15.5            | 42.3| 1.20| 0.00|
| Aug    | 26.9 | 37.1            | 22.2            | 29.0            | 16.7            | 47.4| 1.40| 0.00|
| Sept   | 23.6 | 30.5            | 15.5            | 22.2            | 11.3            | 45.3| 3.00| 0.00|
| Oct    | 18.9 | 29.5            | 16.3            | 22.2            | 11.4            | 51.2| 3.10| 0.00|
| Nov    | 14.0 | 24.3            | 12.2            | 17.4            | 8.98            | 58.4| 3.20| 0.00|
| Dec    | 10.4 | 21.3            | 10.3            | 14.9            | 7.92            | 63.5| 4.00| 0.00|
| Mean   | 20.9 | 28.5            | 14.2            | 20.6            | 9.57            | 50.3| 3.13| 68.1|

In this work the actual crop water productivity was calculated as the ratio between crop yield in kg/Fed and applied irrigation water (AIW) in m$^3$/Fed.

$$CWP = \frac{\text{Crop yield}}{\text{AIW}}$$

Water balance considers water inflows and outflows from field. Water outflow components at field are crop water consumptive use, deep percolation, runoff, soil moisture storage change. The inflow components are applied irrigation water, effective rainfall, subsurface contributions and surface seepage flows. Subsurface contributions and surface seepage flows were considered zero. Storage change component is soil moisture change in active root zone. Process depletion components are actual evapotranspiration, outflow components are deep percolation, and surface runoff. Deep percolation was calculated from the difference between the total amount of water applied (irrigation application and rainfall) and actual consumptive use. Surface runoff was zero. Drainage outflows are often not measured (Molden, 1997), as more emphasis has been placed on knowledge of inflows to irrigation systems. Gross inflow is the total amount of water flowing into the field from rainfall and surface and subsurface sources. Net inflow is the gross inflow plus any changes in storage. If water is removed from storage over the time period of interest, net inflow is greater than gross inflow; if water is added to storage; net inflow is less than gross inflow. Net inflow water is either depleted, or flows out of the field of interest.

Salt balance was determined as a difference between average salinity of water, both rainfall and irrigation water were taken under consideration into the field and average salinity of drainage water before and after growing season. The following are the salt balance equations as described by Taylor (1996):

$$\text{Incoming salt} = \text{outgoing salt} + \text{storage of salt}$$

$$\text{Incoming salt} = \text{inflow} \times \text{salt concentration of the inflow}$$

$$\text{Outgoing salt} = \text{outflow} \times \text{salt concentration of the outflow}$$

RESULTS AND DISCUSSIONS

The evaluation of the impact of the development of the field irrigation system in this study is based mainly on equitable distribution of irrigation water between the beneficiaries farmers by recognizing the change in crop yield, water saving, crop water productivity, water balance and salt balance for some crops before and after the development.
Effects of irrigation system development on applied irrigation water

Results in Table (5) indicate the applied irrigation water (AIW) in m$^3$ per irrigation and water saving of crops irrigated from Arafa Mouse at head, Elafeer at middle, and Elbanna mesqas at tail of Nekla canal before and after field irrigation system development. The applied irrigation water for wheat, rice, Egyptian clover, cantaloupe and watermelon pulp were ranged between 2169-2029, 6417-5592, 3408-2960, 2329-2072 and 1295-1161 for crops irrigated from Arfa Mousa at the head, 2224-2058, 6406-5589, 3407-2961, 2355-2089 and 1218-1077 for crops irrigated from Elafeer2 at the middle and 2184-2006, 6500-5652, 3504-2989, 2291-2291 and 1222-1128 m$^3$/Fed for crops irrigated from Elbanna mesqa at the tail of Nekla canal before - after field irrigation system development respectively.

It could be observed the differences in the irrigation water applied by the farmer for all crops before and after field irrigation system development. The applied irrigation water clearly decreased for all crops after field irrigation system development.

The highest difference between AIW before and after field irrigation system development was observed for rice while the lowest difference was observed for wheat crop. These results may be due to prevailing water control through irrigation development.

Similar trend were also observed by Tariq (2010) who found that the relative water supply index varies from 1.66 to 2.02 during summer, whereas in winter it varies from 2.22 to 2.55. Irrigation supplies were reliable over the whole growing season.

Effects of irrigation system development on crop water use and applied irrigation water

Water consumptive uses for some crops irrigated from Nekla canal were determined during growth season of each crop either irrigated from Arafa Mousa, Elafeer2 or Elbanna mesqas, Nekla canal, Elbeihara Gov. before and after irrigation system development and presented in Table (6).

The results showed that there is no specific trend to change the water consumption values of different crops due to the development of the field irrigation system. This may be due to the nature of these estimated WU values which based on crop growth and weather conditions during the different stages of growth and the homogeneous soil moisture in the root-zone and water control along irrigation canal.

As expected, all the estimated values of water consumption use (WU) of different crops are less than that of the values of applied irrigation water (AIW) by the farmer himself during the growing season. That is mean low on-farm irrigation efficiency. In fact, irrigation efficiency is usually reach to the highest whenever the difference between the estimated values of water consumption (WU) and applied irrigation water (AIW) during different stages of growth is in minimal. This is what should looking for.

Seasonal crop water use (WU) for wheat, rice, Egyptian clover, cantaloupe and watermelon pulp irrigated from the head (Arfa Mousa mesqa) were 1422-1465, 2976-2925, 2075-2036 1356-1376 and 822-795. While the WU by the same crops irrigated from the middle (Elafeer2 mesqa) were 1404-1438, 2944-2936, 2069-1977, 1373-1396 and 840-837 and 1438-1425, 2964-2943, 2041-2074, 1343-1325 and 789-845 m$^3$/Fed for crops irrigated from the tail (Elnbanna mesqa) of Nekla canal before - after field irrigation system development respectively (Table 6).

The observed irregular differences between the estimated water consumption (WU) values of the tested crops (Table 6) and the regular differences between the applied irrigation water (AIW) values for the same crops before and after field irrigation system development (Table 2) may ascribed to the positive effects of the development. One of the most important positive effects of irrigation system development is farmers' conviction at the head, middle and tail of irrigation canals of equitable water distribution.

Effects of field irrigation system development on water saving

Results obtained for the effects of field irrigation system development on water saving at different irrigations of crops were presented in Table (5). Water saving is calculated as the difference between applied irrigation water for crops before and after field irrigation system development. Data indicated that the increments in water saving were associated with the increases in the quantity of applied irrigation water for each irrigation during growth season. The highest values of water saving were observed at the sowing irrigations for each crops.
Table 5. Average values of applied irrigation water (AIW) and water saving of crops irrigated from Nekla canal before and after field irrigation system development

| Crops          | Applied irrigation water in m³/Fed | Field irrigation system development |
|----------------|-----------------------------------|-------------------------------------|
|                | Araf Mousa | Elfeer2 | Elbanna | Before | After | Before | After | Before | After | Before | After | Before | After | Before | After | WS% | Before | After | Before | After | WS% |
| Wheat          | 2169       | 2029    | 6.45    | 2224    | 2058   | 7.46    | 2184   | 2006   | 8.15 |
| Rice           | 6417       | 5592    | 12.9    | 6406    | 5589   | 12.8    | 6500   | 5652   | 13.0 |
| Eg. clover     | 3408       | 2960    | 13.1    | 3407    | 2961   | 13.1    | 3504   | 2987   | 14.8 |
| Cantaloupe     | 2329       | 2072    | 11.0    | 2355    | 2089   | 11.3    | 2291   | 2076   | 9.4  |
| Watermelon pulp| 1295       | 1161    | 10.3    | 1218    | 1077   | 11.5    | 1222   | 1128   | 7.69 |

A substantial increase in water saving for all the tested crops irrigated from Araf Mousa at the head, Elfeer2 at the middle and Elbanna meqa’a at the tail of Nekla canal as affected by field irrigation system development. The average increases in water saving were about 10.8, 11.2 and 10.6% for crops irrigated from the three tested meqas respectively. These results are in agreement with that obtained by Radwan (2017) who concluded that the expected minimum, maximum, and average annual water saving from improved on-farm irrigation projects in Egypt are about 2.6, 6.72, and 4.67, respectively.

The average increases in water saving for wheat, rice, Egyptian clover, cantaloupe and watermelon pulp as affected by field irrigation system development were about 7.36, 12.9, 13.7, 10.6 and 9.88% respectively (Table 5). The average increases in water saving for wheat, rice, Egyptian clover, cantaloupe and watermelon pulp as affected by field irrigation system development were about 7.36, 12.9, 13.7, 10.6 and 9.88% respectively.

Effects of field irrigation system development on crop yield and water productivity

The yields of the tested crops were determined from the field data collected through the farmers’ interviews. Results obtained for the effects of field irrigation system development on crop yield and crop water productivity (CWP). Concerning crop yield as affected by field irrigation system development. Results in Table (7) indicated a slight increase in yield of the tested crops either irrigated from head - Araf Mouse, middle – Elfeer2 or Tail -
Elbanna mesqas. The average increases were about 6.98, 5.99 and 7.19% respectively. The average relative increases in crop yield of wheat, rice, Egyptian clover, cantaloupe and watermelon pulp as affected by field irrigation system development were about 6.84, 5.83, 6.11, 6.01 and 6.68% respectively. These increase in crop yield may be attributed to the development of field irrigation system and enhanced water allowance. This result is in agreement with that obtained by Tariq (2010) who found a significant increase in crop yield as a response to irrigation systems modernization. Date showed that the expected improvement in water distribution equity after field irrigation system development was more effective in increasing crop yield irrigated from the tail of Nekla canal (Elbanna mesqa). This increase in crop yield was more pronounced for wheat, Egyptian clover and watermelon pulp. Crop water productivity, as defined by Molden, et al (2010) is the ratio of crop yield or crop value, to a selected measure of water consumed, applied, or evaporated in the process of growing a crop. In this work crop water productivity in kg/m³ is calculated by deviding the crop yield in kg/Fed on applied irrigation water in m³/Fed.

Data in Table (7) revealed a substantial increases in crop water productivity for all the tested crops irrigated from Arafa Mousa at the head, Elafeer2 at the middle and Elbanna mesqa’s at the tail of Nekla canal as affected by field irrigation system development. The average increases in crop water productivity were about 19.9, 19.5 and 20.0 % for crops irrigated from the three meqas respectively. The average increases in crop water productivity for wheat, rice, Egyptian clover, cantaloupe and watermelon pulp as affected by field irrigation system development were about 15.3, 21.5, 22.9, 18.5 and 20.6% respectively. The results of crop water productivity (CWP) found in this work are in agreement with that obtained by French and Schultz, (1984) for wheat, Hsiao et al (1984) for rice and Grimes et al., (1992) for clover.

The increases in crop yield and crop water productivity may be due to the positive effects of field irrigation system development on regular availability of water in the irrigation canals and the ease of the application by the farmers with more accuracy and with less effort, which ultimately lead to improve rationalize the use of water resources. It is worthy to mentioned that, Ashour et al (2010) found that the positive effects of field irrigation development may be ascribed to the improvement process preventing seepage and weed growth increases. It also made water available all the time in the mesqa, better scheduling of irrigation and higher flow rate at the field level has also contributed to reduce the irrigation time. The irrigation time does not only include the time when the pump is actually operating, but also the time to transport the water to the land. The losses are only due to evaporation from free water surface, which was also reduced by reducing mesqas’ cross section.

Effects of irrigation system development on water balance

Results presented in Table (8 and 9) showed the water balance components and net water balance for crops irrigated from Arafa Mousa at the head, Elafeer2 at the middle and Elbanna mesqas at the tail of Nekla canal, Elbeihara Gov. before and after field irrigation system development. Results revealed that the net water balance (NWB) values decreased by about 87.6, 76.7 and 85.5% as affected by field irrigation system development relative to values before development equal to 100 for wheat, rice and Egyptian clover respectively under irrigation from Arafa Mousa mesqa at the head of Nekla canal. Similar results were also observed for wheat, rice and Egyptian clover irrigated from Elafeer2 at middle, and Elbanna mesqa at tail of Nekla canal.

The average total inflow values for crops irrigated from Nekla canal before field irrigation system development were 2691, 6591, 3901, 2465 and 1365 m³/Fed for wheat, rice, Egyptian clover, cantaloupe and watermelon pulp respectively. While the average total inflow values for crops irrigated from Nekla canal after development were 2405, 5741, 3363, 2219 and 1242 m³/Fed for wheat, rice, Egyptian clover, cantaloupe and watermelon pulp respectively.

The average total water outflow values for crops irrigated from Nekla canal before field irrigation system development were 2192,6441, 3440, 2325 and 1245 m³/Fed for wheat, rice, Egyptian clover, cantaloupe and watermelon pulp respectively. While the average total inflow values for crops irrigated from Nekla canal after development were 2031, 5611, 2969, 2079 and 1122 m³/Fed for wheat, rice, Egyptian clover, cantaloupe and watermelon pulp respectively as shown in Table (9).
Table 7. Applied irrigation water (AIW), crop yield and crop water productivity (CWP) of some crops irrigated from Arafa Mousa at the head, Elafeer2 at the middle and Elbanna mesqas at the tail of Nekla canal, El-Behaira Gov before and after field irrigation system development

| Area in Fed | Crop       | AIW | Yield | CWP | %     |
|------------|------------|-----|-------|-----|-------|
|            |            | m³/Fed | kg/Fed | kg/m³ |     |
|            | Before     | After | Before | After | Before | After |
| Arafa Mousa mesqa at the head of Nekla canal | Wheat | 2169 | 2029 | 2700 | 2892 | 1.25 | 1.43 | 14.5 |
|            | Rice       | 6417 | 5592 | 4160 | 4320 | 4.59 | 5.5  | 19.2 |
|            | Eg clover  | 3408 | 2960 | 29433 | 31000 | 1.22 | 1.46 | 21.3 |
|            | Cantaloupe | 2329 | 2072 | 4180 | 4530 | 1.79 | 2.19 | 21.8 |
|            | Watermelon | 1295 | 1161 | 390  | 430  | 0.30 | 0.37 | 23.0 |

Elafeer2 mesqa at the middle of Nekla canal 19.9

| Area in Fed | Crop       | AIW | Yield | CWP | %     |
|------------|------------|-----|-------|-----|-------|
|            |            | m³/Fed | kg/Fed | kg/m³ |     |
|            | Before     | After | Before | After | Before | After |
| 49         | Wheat      | 2224 | 2058 | 2710 | 2870 | 1.22 | 1.39 | 14.4 |
| 15         | Rice       | 6406 | 5589 | 4124 | 4350 | 4.65 | 5.72 | 20.9 |
| 19         | Eg clover  | 3407 | 2961 | 29757 | 32000 | 1.21 | 1.47 | 23.7 |
| 25         | Cantaloupe | 2355 | 2089 | 4200 | 4510 | 1.78 | 2.16 | 21.1 |
| 10         | Watermelon | 1218 | 1077 | 386  | 400  | 0.14 | 0.16 | 17.2 |

Elbanna mesqa at the tail of Nekla canal 19.5

| Area in Fed | Crop       | AIW | Yield | CWP | %     |
|------------|------------|-----|-------|-----|-------|
|            |            | m³/Fed | kg/Fed | kg/m³ |     |
|            | Before     | After | Before | After | Before | After |
| 21         | Wheat      | 2184 | 2006 | 2678 | 2879 | 1.23 | 1.44 | 17.0 |
| 15         | Rice       | 6500 | 5652 | 4000 | 4330 | 4.52 | 5.5  | 24.5 |
| 21         | Eg clover  | 3504 | 2987 | 29398 | 31000 | 1.14 | 1.45 | 23.7 |
| 3          | Cantaloupe | 2291 | 2076 | 4364 | 4470 | 1.90 | 2.15 | 13.0 |
| 9          | Watermelon | 1222 | 1128 | 385  | 410  | 0.30 | 0.36 | 21.7 |

Average values for Nekla canal 20.0

| Area in Fed | Crop       | AIW | Yield | CWP | %     |
|------------|------------|-----|-------|-----|-------|
|            |            | m³/Fed | kg/Fed | kg/m³ |     |
|            | Before     | After | Before | After | Before | After |
| 87         | Wheat      | 2192 | 2031 | 2696 | 2880 | 1.23 | 1.42 | 15.3 |
| 67         | Rice       | 6441 | 2969 | 29529 | 31333 | 4.58 | 5.58 | 21.5 |
| 50         | Eg clover  | 3440 | 5611 | 4095 | 4333 | 1.19 | 1.46 | 22.9 |
| 33         | Cantaloupe | 2325 | 2079 | 4248 | 4503 | 1.83 | 2.17 | 18.5 |
| 28         | Watermelon | 1245 | 1122 | 380  | 413  | 0.25 | 0.30 | 20.6 |

CWP: Crop water productivity
The impact of irrigation improvement activities on water and salt balance for the irrigated land in Nekla canal (El-Behira Governorate)

Table 8. Water balance components for crops irrigated from Arafa Mousa at the head, Elafeer2 at the middle and Elbanna mesqas at the tail of Nekla canal, El-Behaira Gov. before and after field irrigation system development

| Crop               | Inflow in m³/Fed | Outflow in m³/Fed | NWB in m³/Fed |
|--------------------|------------------|-------------------|---------------|
|                    | AIW              | R                 | SS            | Total          | WU             | Dp | Total          |
| Arafa Mousa mesqa at the head of Nekla canal |                   |                   |               |                |                |    |                |
| Wheat              | Before           | 2169              | 277           | 150            | 2596           | 1445| 724            | 2169 | 427          |
|                    | After            | 2029              | 244           | 130            | 2403           | 1445| 584            | 2029 | 374          |
| Rice               | Before           | 6417              | 0             | 150            | 6567           | 2940| 3477           | 6417 | 150          |
|                    | After            | 5592              | 0             | 130            | 5722           | 2940| 2652           | 5592 | 130          |
| Eg clover          | Before           | 3408              | 291           | 170            | 3869           | 5058| 1650           | 3408 | 461          |
|                    | After            | 2960              | 244           | 150            | 3354           | 5058| 2098           | 2960 | 394          |
| Cantaloupe         | Before           | 2329              | 0             | 140            | 2469           | 1348| 981            | 2329 | 140          |
|                    | After            | 2072              | 0             | 140            | 2212           | 1348| 724            | 2072 | 140          |
| Watermelon pulp    | Before           | 1295              | 0             | 120            | 1415           | 811 | 484            | 1295 | 120          |
|                    | After            | 1161              | 0             | 120            | 1281           | 811 | 350            | 1161 | 120          |
| Elafeer2 mesqa at the middle of Nekla canal |                   |                   |               |                |                |    |                |
| Wheat              | Before           | 2224              | 276           | 150            | 2650           | 1428| 796            | 2224 | 426          |
|                    | After            | 2058              | 244           | 130            | 2432           | 1428| 630            | 2058 | 374          |
| Rice               | Before           | 6406              | 0             | 150            | 6556           | 2936| 3470           | 6406 | 150          |
|                    | After            | 5589              | 0             | 130            | 5719           | 2936| 2653           | 5589 | 130          |
| Eg clover          | Before           | 3407              | 291           | 170            | 3868           | 2024| 1383           | 3407 | 461          |
|                    | After            | 2961              | 244           | 150            | 3355           | 2024| 937            | 2961 | 394          |
| Cantaloupe         | Before           | 2355              | 0             | 140            | 2495           | 1386| 969            | 2355 | 140          |
|                    | After            | 2089              | 0             | 140            | 2229           | 1386| 703            | 2089 | 140          |
| Watermelon pulp    | Before           | 1218              | 0             | 120            | 1338           | 840 | 378            | 1218 | 120          |
|                    | After            | 1077              | 0             | 120            | 1197           | 840 | 237            | 1077 | 120          |
| Elbanna mesqa at the tail of Nekla canal |                   |                   |               |                |                |    |                |
| Wheat              | Before           | 2184              | 277           | 150            | 2611           | 1445| 739            | 2184 | 427          |
|                    | After            | 2006              | 244           | 130            | 2380           | 1445| 561            | 2006 | 374          |
| Rice               | Before           | 6500              | 0             | 150            | 6650           | 2953| 3547           | 6500 | 150          |
|                    | After            | 5652              | 0             | 130            | 5782           | 2953| 2699           | 5652 | 130          |
| Eg clover          | Before           | 3504              | 293           | 170            | 3967           | 2058| 1446           | 3504 | 463          |
|                    | After            | 2987              | 244           | 150            | 3381           | 2058| 929            | 2987 | 394          |
| Cantaloupe         | Before           | 2291              | 0             | 140            | 2431           | 1340| 951            | 2291 | 140          |
|                    | After            | 2076              | 0             | 140            | 2216           | 1340| 736            | 2076 | 140          |
| Watermelon pulp    | Before           | 1222              | 0             | 120            | 1342           | 819 | 403            | 1222 | 120          |
|                    | After            | 1128              | 0             | 120            | 1248           | 819 | 309            | 1128 | 120          |
Table 9. Average net water balance for crops grown on areas irrigated from Nekla canal, El-Behira Gov. before and after field irrigation system development

| Crop        | Inflow in m$^3$/Fed | Outflow in m$^3$/Fed | NWB m$^3$/Fed |
|-------------|---------------------|----------------------|---------------|
|             | AWI | R | CSMS | Total | WU | Dp | Total |
| Wheat       |     |   |      |       |    |    |       |
| Before      | 2192 | 277 | 150  | 2619  | 1439 | 753 | 2192  | 427    |
| After       | 2031 | 244 | 130  | 2405  | 1439 | 592 | 2031  | 374    |
| Rice        |     |   |      |       |    |    |       |
| Before      | 6441 | 0  | 150  | 6591  | 2943 | 3498 | 6441  | 150    |
| After       | 5611 | 0  | 130  | 5741  | 2943 | 2668 | 5611  | 130    |
| Eg. clover  |     |   |      |       |    |    |       |
| Before      | 3440 | 292 | 170  | 3901  | 3047 | 393  | 3440  | 462    |
| After       | 2969 | 244 | 150  | 3363  | 3047 | 77   | 2969  | 394    |
| Cantaloupe  |     |   |      |       |    |    |       |
| Before      | 2325 | 0  | 140  | 2465  | 1358 | 967  | 2325  | 140    |
| After       | 2079 | 0  | 140  | 2219  | 1358 | 721  | 2079  | 140    |
| Watermelon pulp | 1245 | 0  | 120  | 1365  | 823  | 422  | 1245  | 120    |

Assuming runoff = 0
AIW: Applied irrigation water
R: Rainfall
CSMS: Change in soil moisture storage
Dp: Deep percolation = AIW - WU
Total water inflow = AIW + Rainfall + Soil Storage
Total water outflow = WU + Runoff + Deep percolation
NWB: Net water balance = Inflow - Outflow

Effects of irrigation system development on salt balance

Results in Table (10 and 11) show the salt balance components and net salt balance for the different crops grown on areas irrigated from Arafa Mousa at the head, Elafeer2 at the middle and Elbanna mesqas at the tail of Nekla canal, Elbehira before and after field irrigation system development. Results revealed that salt balance in plant growth medium depends mainly on the quantity of salts added through applied irrigation water and partially through the quantity of rainfall and salt removed mainly by leaching through drainage water.

As expected, the results showed that the amount of salts added (SA) to rice-cultivated soil irrigated from Arafa Mousa at the head, Elafeer2 at the middle or Elbanna mesqas at the tail of Nekla canal were higher before than after field irrigation system development. While the amount of salts removed from rice-cultivated soil irrigated from Arafa Mousa at the head, Elafeer2 at the middle or Elbanna mesqas at the tail of Nekla canal tail was lower before than after field irrigation system development.

The amount of salts removed (SR) from the cultivated land with wheat, Egyptian clover, cantaloupe and watermelon crops was higher before than after field irrigation system development. This may be attributed to the reduction in irrigation water associated with field irrigation system development which led to reduce the amount of salts added and reduce the amounts of salts removed from the soil.

Concerning This may be attributed to the large quantities of irrigation water that farmers added to soil cultivated with rice crop either before or after field irrigation system development where. The large quantity of irrigation water may increase the amount of salt added and salt remove by leaching.

It could be observed from Table (10) that the average amount of salts added into soil cultivated with wheat, rice, Egyptian clover, cantaloupe and watermelon pulp were 800, 2350, 1255, 848 and 454 kg/Fed respectively under irrigation from Nekla canal before development and 702, 1939, 1026, 719 and 388 kg/Fed after field irrigation system development.
The impact of irrigation improvement activities on water and salt balance for the irrigated land in Nekla canal (El-Behira Governorate)

Table 10. Salt balance components for crops grown on soils irrigated from Arafa Mousa at the head, Elafeer2 at the middle and Elbanna mesqas at the tail of Nekla canal, El-Behira before and after field irrigation system development

| Crop         | Salt - IN | Salt - OUT |
|--------------|-----------|------------|
|              | AIW = IN  | TSS$_{dw}$ | SA = OUT  | Q$_{dw}$ | TSS$_{dw}$ | SR | NSB | RSR |
|              | m$^3$/Fed | mg/l       | kg/Fed    | m$^3$/Fed | mg/l       |    | kg/Fed |    |
|              |           |            |           |           |            |    |       |    |
|              | Araf Mousa mesqa at the head of Nekla canal | | | | | | | |
| Wheat        | Before    | 2169       | 365       | 791       | 728        | 960 | 699  | 92  |
|              | After     | 2029       | 346       | 701       | 588        | 960 | 564  | 137 |
| Rice         | Before    | 6417       | 365       | 2341      | 3979       | 640 | 2547 | -206|
|              | After     | 5592       | 346       | 1933      | 3154       | 960 | 3028 | -1095|
| Eg clover    | Before    | 3408       | 365       | 1243      | 1350       | 960 | 1296 | -53 |
|              | After     | 2960       | 346       | 1023      | 902        | 640 | 577  | 446 |
| Cantaloupe   | Before    | 2329       | 365       | 850       | 981        | 832 | 816  | 33  |
|              | After     | 2072       | 346       | 716       | 724        | 832 | 602  | 114 |
| Watermelon   | Before    | 1295       | 365       | 472       | 484        | 1024| 496  | -23 |
| pulp         | After     | 1161       | 346       | 401       | 350        | 1024| 358  | 43  |
|              |           |            |           |           |            |    |       |    |
|              | Elafeer2 mesqa at the middle of Nekla canal | | | | | | | |
| Wheat        | Before    | 2224       | 365       | 811       | 796        | 960 | 764  | 47  |
|              | After     | 2058       | 346       | 711       | 630        | 960 | 605  | 106 |
| Rice         | Before    | 6406       | 365       | 2337      | 3470       | 640 | 2221 | 116 |
|              | After     | 5589       | 346       | 1932      | 2653       | 960 | 2547 | -615|
| Eg clover    | Before    | 3407       | 365       | 1243      | 1383       | 960 | 1328 | -85 |
|              | After     | 2961       | 346       | 1023      | 937        | 640 | 600  | 424 |
| Cantaloupe   | Before    | 2355       | 365       | 859       | 969        | 832 | 806  | 53  |
|              | After     | 2089       | 346       | 722       | 703        | 832 | 585  | 137 |
| Watermelon   | Before    | 1218       | 365       | 444       | 378        | 1024| 387  | 57  |
| pulp         | After     | 1077       | 346       | 372       | 237        | 1024| 243  | 130 |
|              |           |            |           |           |            |    |       |    |
|              | Elbanna mesqa at the tail of Nekla canal | | | | | | | |
| Wheat        | Before    | 2184       | 365       | 797       | 731        | 960 | 702  | 95  |
|              | After     | 2006       | 346       | 693       | 553        | 960 | 531  | 162 |
| Rice         | Before    | 6500       | 365       | 2371      | 4062       | 640 | 2600 | -228|
|              | After     | 5652       | 346       | 1953      | 3214       | 960 | 3085 | -1132|
| Eg clover    | Before    | 3504       | 365       | 1278      | 1446       | 960 | 1388 | -110|
|              | After     | 2987       | 346       | 1032      | 929        | 640 | 595  | 438 |
| Cantaloupe   | Before    | 2291       | 365       | 836       | 943        | 832 | 785  | 51  |
|              | After     | 2076       | 346       | 717       | 728        | 832 | 606  | 112 |
| Watermelon   | Before    | 1222       | 365       | 446       | 411        | 1024| 421  | 25  |
| pulp         | After     | 1128       | 346       | 390       | 317        | 1024| 325  | 65  |

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Table 11. Net Salt balance for the different crops grown on areas irrigated from Nekla canal, El-Behira before and after field irrigation system development

| Crop          | Salt - IN | Salt - OUT |
|---------------|-----------|------------|
|               | AIW m³/Fed | TSSᵣᵣ mg/l | SA kg/Fed | Qᵣᵣ m³/Fed | TSSᵣᵣ mg/l | SR kg/Fed | NSB kg/Fed | RSR % |
| Wheat         | Before     | 2192       | 365       | 800       | 752       | 960       | 722       | 78     | 90   |
|               | After      | 2031       | 346       | 702       | 590       | 960       | 567       | 135    | 81   |
| Rice          | Before     | 6441       | 365       | 2350      | 3837      | 640       | 2456      | -106   | 104  |
|               | After      | 5611       | 346       | 1939      | 3007      | 960       | 2887      | -948   | 149  |
| Egyptian clover | Before   | 3440       | 365       | 1255      | 1393      | 960       | 1337      | -82    | 107  |
|               | After      | 2969       | 346       | 1026      | 923       | 640       | 591       | 436    | 58   |
| Cantaloupe    | Before     | 2325       | 365       | 848       | 964       | 832       | 802       | 46     | 95   |
|               | After      | 2079       | 346       | 719       | 718       | 832       | 598       | 121    | 83   |
| Watermelon pulp | Before  | 1245       | 365       | 454       | 424       | 1024      | 435       | 20     | 95   |
|               | After      | 1122       | 346       | 388       | 301       | 1024      | 309       | 79     | 79   |

AIW: Applied irrigation water.
TSSᵣᵣ: Total saluble salts of irrigation water.
Qᵣᵣ: Quantity of drainage water
TSSᵣᵣ: Total saluble salts of drainage water.
SA: Salt added
SR: Salt removed
NSB: Net salt Balance
RSR: Relative salt remove

As shown in Table (10) the average amount of salts removed from soil cultivated with wheat, rice, Egyptian clover, cantaloupe and watermelon pulp were 722, 2456, 1337, 802 and 454 kg/Fed respectively under irrigation from Nekla canal before development and 567, 2887, 591, 598 and 309 kg/Fed after field irrigation system development.

The relative net salts outflow or removed from the growth medium of the tested crops were in the descending order: Rice > Egyptian clover > Wheat > Cantaloupe > Watermelon pulp as affected by field irrigation system development Table (11).

It could be concluded that the investment in irrigation modernization and improvement to make the water delivery system and its management flexible enough to take full advantage of new technologies and effective crop patterns so, it is very important and viable to continue and expand the irrigation improvement activities in the old land of Egypt.

It can recommend that under conditions of water scarcity that we are facing, the development of field irrigation is a must because it improves water management at the field level, increase agricultural productivity; overcomes problems of water distribution among farmers, saves of the irrigation water used and increases the value of water productivity. Besides, maximizing the benefits of return from the unit of land and water associated with economic, environmental and social aspects.

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تأثير تطوير الري على الاتزان المائي والملحى للأراضى المرودية من ترعة نكلا

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أجريت عدة قياسات حقلية في مواقع مختلفة على طول قناة نكلا بمحافظة البحيرة. وقد تم اختيار ثلاثة مساقى مرودة منها بدءًا من فم الترعة ووسطها وعند ذيلها لتقديم تأثير تغيير الأنشطة والعمليات المختلفة في نظام الري الحقيقي على إنتاجية عدد المحاصيل المزروعة بالمنطقة وتروى من ترعة نكلا من أي من مساقاتها تحت الدراسة وهي القمح والأرز والبرسيم المصري والكانتالوب ولب البطيخ. كما تم التقييم إلى مدى توفر مياه الري وإنتاجية وحدة المياه بالإضافة إلى التوزيع المائي والتوزيع الملحى والذي يتبع على إمكانية تقييم تدفق استخدام موارد المياه. أدى تطوير نظام الري الحقيقي إلى زيادة كبيرة في توفير مياه الري لجميع المحاصيل سواء كانت مساقى الري عند رأس أو وسط أو ذيل الترعة بعد التطوير. أظهر النتائج أن تحسن الماء المضافة (SA) إلى تربة القرشية بحيرة الأرز المروية من المساقى عند رأس أو وسط أو ذيل قناة نكلا كانت أعلى بعد التطور. يمكن أن نخلص إلى أن تطوير نظام الري الحقيقي له تأثير إيجابي على توفير المياه وإنتاجية المحاصيل والملحى، وتكمل ترقيم الماء في وسط بيئة نمو المحاصيل حيث أن تطوير نظام الري الحقيقي يمنع زيادة التجفيف. أن تدفق مياه الري ونوع الحشائش في المساقى المطرية ويدفع المياه متاحة لجميع المزارعين. الكمات الدالة: تطوير الري على الاتزان المائي والملحي، ترعة نكلا.

المصادر الموجبة

أظهر النتائج أنكشفت أن كمية الأملاح المضافة (SA) إلى تربة القرشية بحيرة الأرز المروية من المساقى عند رأس أو وسط أو ذيل قناة نكلا كانت أعلى قبل التطوير. يمكن أن نخلص إلى أن تطوير نظام الري الحقيقي له تأثير إيجابي على توفير المياه وإنتاجية المحاصيل والملحى، وتكمل ترقيم الماء في وسط بيئة نمو المحاصيل حيث أن تطوير نظام الري الحقيقي يمنع زيادة التجفيف. أن تدفق مياه الري ونوع الحشائش في المساقى المطرية ويدفع المياه متاحة لجميع المزارعين. الكمات الدالة: تطوير الري على الاتزان المائي والملحي، ترعة نكلا.

الكلمات الدالة: تطوير الري على الاتزان المائي والملحي، ترعة نكلا.
