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Full length article

Water accounting and water productivity of some major crops as affected by irrigation improvement activities at Nekla Canal (EL–Behira Governorate)

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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

The Irrigation Improvement project (IIP) is concerned with improving the existing irrigation system in Egypt. The overall objectives of the project were improving irrigation infrastructure, promoting more equable distribution of water, improving on-farm water management, minimizing different irrigation losses, and increasing water – use efficiency for different crops (Harby and Naya, 2014).

The development of agricultural of Egypt economy strongly depends on its ability to conserve and manage its water resources. So, under Egyptian condition, efforts should devote to maximizing water productivity. Improving water needs in agriculture (Oweis et al., 2000)

Water productivity cannot be discussed in isolation

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from water accounting. Better understanding of water accounting helps us understand balanced relationships among water efficiency, water productivity and saving water at both farm and basin level. Water accounting concepts are being used for enhancing water productivity in irrigated agriculture (EL–Bably et al., 2015).

The main objective of this work was to evaluate the impact of the improvement of field irrigation system on water accounting and water productivity of some crops at NeklaCanal.

2. Materials and methods

Methodology

Five farmers were selected (applied the same agricultural practices for such area) at each mesqa (Arafa Mousa at the head, Elafeer 2 at the middle and Elbanna at the tail end of Nekla Canal, El – Behira governorate) to assess the effect of the improvement of field irrigation system on water accounting and water productivity of Rice , wheat and Egyptian clover crops.

The following parameters were determined and recorded:

Water Accounting Measurements (records):

1. Reference Evapotranspiration (ET_O or ET_{rel}).ET_O (ET_{rel}) was estimated according to penman Monteith equation (FAO,1977).
2. Crop Evapotranspiration or Crop Consumptive use (ET_C) was calculated as following equation (FAO, 1977):

$$ET_C = ET_O \times K_C$$

3. Water Requirement (WR)was estimated as following equation (El-Marsafawy and Eid, 1999):

$$WR = ET_C \times \text{Water application efficiency}$$

4. Applied Irrigation water (AIW) was estimated and calculated at *mesqa* field level based on the discharge (q) from the irrigation pump and the operation hours (t) of this pump as following equation:

$$AIW = q \times t$$

5. On–farm Water Use Efficiency (OFWUE) was determined as follows:

$$OFWUE = \frac{\text{The calculated Levels of water requirements (WR)}}{\text{Total Water applied (AIW)}}$$

Crop Water Productivity (CWP) records:

- **Crop production**

The yield (kg/fed) of rice grain yield, wheat grain yield and Egyptian clover fresh yield were determined before and after improvement of irrigation system (Average of five farms at each mesqa).

- **Crop water productivity (CWP)**

The crop water productivity (CWP) was recorded and calculated for each as follows according to (El–Bably et al, 2015):

$$CWP\ (kg/m^3) = \frac{\text{Crop yield (kg/fad)}}{\text{Total water Applied } (m^3/fad)}$$

3. Results and discussions

3.1. Rice Crop

Data in Table 1 illustrates the averages of calculated water requirements (WR), applied irrigation water (AIW), on-farm water use efficiency (OFWUE), crop production and crop before and after field irrigation system improvements.

The calculated WR was found to be 3570.5 m^3/fed. for rice crop. Asubstantial increases in water saving due to the improvement of the irrigation system were noticed and was found to be 333.4 m^3/fed. (overall average values at Nekla Canal). The lowest value of OFWUE observed was (0.56) Before the improvement practices took place, while the highest values (0.61) were recorded after improvement practices. Therefore, any improvement of the OFWUE of rice crop will save a considerable amount of the scare water conditions of Egypt.

Concerning rice production (kg/fed) as affected by the irrigation system improvement, results in table (1) indicated remarkable increases in rice yield (358.5 kg/fed).

The lowest values of CWP (0.57 Kg/m^3) were recorded before the irrigation system improvement took place, whereas the highest values (0.69 Kg/m^3) were recorded after improvement practices.

The lowest values of (OFWUE) and (CWP) suggest that producers (farmers) over irrigate rice crop by an amount exceed its water requirements.

Oweis et al. (2000); EL-Bably et al. (2015) came to the same trends of results.

Wheat Crop

Data in Table 2 Shows the average Calculated Water requirements (WR), applied irrigation Water (AIW), On-From Water Use efficiency (OFWUE), Crop production and crop water productivity (CWP) of wheat Crop before and after Field irrigation System improvements.

The Calculated Water requirements were estimated as 1868 m^3/fed. The applied irrigation water was decreased due to the improvement practices from 2410.2 to 2201.5 m^3/fed (over all averages of values am mg Nekla Canal) recorded 208.7 m^3/fed water saving. The

lowest value of OFWUE (0.72) was noticed before the improvement practices took place. On the other hand, the highest values of OFWUE were recorded after the improvement practices (0.88). So, any improvement on the OFWUE will save a Considerable amount of irrigation water.

The improvement of field irrigation system led to increase wheat production by 161.7 kg/Fed (Overall average Values among Nekla Canal).

The lowest values of wheat water productivity Was observed before improvement practices took place (1.01 kg/m^3), while the highest values of CWP (1.33 kg/m^3) recorded after the implementation of such improvements.

The lowest values of (OFWUE) and (CWP) show and indicates that farmers over irrigate wheat crop by an amount exceed its water requirements Oweis et al. (2000); El_Bably et al. (2015); El_Marsafawy and Eid (1999) reported the same trends.

Table 1

Calculated water requirements (WR), applied irrigation water (AIW), on–farm water use efficiency (OFWUE), crop production and crop water productivity of Rice Crop before and after field irrigation system improvements.

Mesqa Name	WR (m^3/fed) *	AIW (m^3/fed) *		OFWUE*		Rice production (Kg/fed) *		CWP (Kg/m^3)	
		before	after	before	after	before	after	before	after
ArafaMousa (Head of Nekla Canal)	3570.0	6371.8	6068.4	0.56	0.59	3654.0	4195.4	0.57	0.69
Elafeer 2 (Middle of Nekla Canal)	3570.0	6277.2	5928.0	0.57	0.60	3840.8	4110.2	0.61	0.69
Elbanna (Tail end of Nekla Canal)	3570.0	6240.0	5892.4	0.57	0.61	3679.4	3944.0	0.59	0.67
Average values for Nekla Canal		6296.3	5962.9	0.57	0.60	3724.7	4083.2	0.59	0.68

* Average value of five farms (farmers).

Table 2

Calculated water requirements (WR), applied irrigation water (AIW), on–farm water use efficiency (OFWUE), crop production and crop water productivity (CWP) of Wheat Crop before and after field irrigation system improvements.

Mesqa Name	WR (m^3/fed) *	AIW (m^3/fed) *		OFWUE*		Wheat production (kg/fed) *		CWP (kg/m^3)	
		before	after	before	after	before	after	before	after
ArafaMousa (Head)	1868.4	2604.04	2309.9	0.72	0.81	2632.0	2761.8	1.01	1.20
Elafeer 2 (Middle)	1868.4	2350.6	2131.6	0.79	0.88	2646.2	2838.6	1.13	1.33
Elbanna(tail end)	1868.4	2276.0	2163.0	0.82	0.86	2494.8	2657.8	1.10	1.23
Average values for Nekla Canal		2410.2	2201.5	0.78	0.85	2591.0	2752.7	1.08	1.25

* Average value of five farms (farmers).

3.2. Egyptian Clover

Results in Table 3 presents the calculated water requirements (WR), applied irrigation water (AIW), On- farm Water use efficiency (OFWUE), Crop production and crop water productivity (CWP) Of Egyptian Clover crop before and after Field irrigation system improvements.

Water requirements of Egyptian clover was calculated as (WR= 2045.3 m^3/fed.). Total irrigation water applied (AIW) decreased due to the improvement practices by 224.0 m^3/fed. (Over all averages values among Nekla canal).

The On-Farm water use efficiency (OFWUE) increased from 0.64 to 0.70 as the improvement practices took place.

The improvement of field irrigation system increased the Egyptian clover production (Fresh yield, kg/fed.) from 28408.6 to 32200.0 kg/fed. (3791.4 kg/fed. increase in fresh yield).

The Crop Water productivity (CWP) of Egyptian Clover increased from 8.83 kg/m^3 to 10.91 kg/m^3 (23.6 percent increase) because of the improvement of field irrigation system. The lowest Values of both OFWUE And CWP indicates that Farmers (Producers) over irrigate this crop be a large amount compared to its requirements.

Oweis et al. (2000); EL-Marsafawy and Eid (1999); El-Bably et al. (2015) showed the same trend of results.

4. Conclusions and Recommendation

- Data observed and showed in this research paper clarified the importance of water accounting as an important tool to assess the impact of irrigation improvement project on crop water productivity and rationalizing (saving) the applied irrigation water at farmers' fields.
- Better understanding of water accounting helps the decision makers to understand balanced relationships among water efficiency, water productivity and saving water at both farm and basin level.

Table 3
Calculated water requirements (WR), applied irrigation water (AIW), on – farm water use efficiency (OFWUE), crop production and crop water productivity (CWP) of Egyptian clover Crop before and after field irrigation system improvements.

Mesqa Name	WR (m^3/fed) *	AIW (m^3/fed) *		OFWUE *		Egyptian clover production (kg/fed) *		CWP (kg/m^3)	
		before	after	before	after	before	after	before	after
ArafaMousa (Head)	2045.3	3217.4	2997.8	0.64	0.68	30084.6	32190.0	9.35	10.74
Elafeer 2 (Middle)	2045.3	3090.4	2951.0	0.66	0.69	29265.4	32200.0	9.47	10.91
Elbanna (tail end)	2045.3	3216.0	2903.4	0.64	0.70	28408.6	31066.0	8.83	10.70
Average values for Nekla Canal		3174.6	2950.6	0.65	0.69	29252.9	31818.7	9.22	10.78

* Average value of five farms (farmers).

5. Conclusions and recommendations

- Data observed and showed in this research paper clarified the importance of water accounting as an important tool to assess the impact of irrigation improvement project on crop water productivity and rationalizing (saving) the applied irrigation water at farmers' fields .
- Better understanding of water accounting helps the decision makers to understand balanced relationships among water efficiency, water productivity and saving water at both farm and basin level.

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تأثير أنشطة تطوير الري على الإنتاجية المائية والمحاسبة المائية لبعض المحاصيل الرئيسية على ترعه نكلا بمحافظة البحيرة

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الملخص العربي

تم اختيار خمسة مزارعين على مسقى عرفه موسي (بداية الترعة) ومسقى الغفير (وسط الترعة) ومسقى البنا (نهاية الترعة) لتقييم تأثير أنشطة تطوير وتحسين الري على الإنتاجية المائية والمحاسبة المائية لمحاصيل الأرز والقمح والبرسيم المصري.

قدرت الاحتياجات المائية لمحاصيل الأرز والقمح والبرسيم المصري حيث بلغت ٣٥٧٠,٠٠ ، ١٨٦٨,٠٠ ، ٢٠٤٥,٣ م^3/فدان على الترتيب.

تناقصت كميات المياه المضافة للمحاصيل الثلاثة بعد عمليات التطوير والتحسين لنظام الري الحقلي وحيث بلغت كميات المياه والتي تم توفيرها على نحو ٣٣٣,٤ و ٢٠٨,٧ و ٢٢٤,٠٠ م^3/فدان لمحاصيل الأرز، القمح والبرسيم المصري على الترتيب.

تزايدت إنتاجية المحاصيل الثلاثة نتيجة لعمليات تطوير وتحسين نظام الري وبكميات بلغت ٣٥٨,٥ و ١٦١,٧ و ٣٧٩١,٣ كجم/فدان لمحاصيل الأرز، القمح والبرسيم المصري على الترتيب.

تزايدت قيم كفاءة استعمال المياه على مستوى الحقل والانتاجية المائية للمحاصيل الثلاثة (الأرز والقمح والبرسيم المصري) حيث سجلت أعلى القيم بعد انجاز عمليات التطوير والتحديث.