ABSTRACT

The irrigation requirement is more significant in the world's dryland areas. The dryland without adequate rainfall has to face acute scarcity of water. One of the most valuable applications for water saving is in identifying opportunities for saving water and increasing its productive use. There are available methods to reduce the drainage water volumes which include: improving irrigation management; using drainage water for irrigation; integrating the management of irrigation and drainage system to induce crop water use from shallow ground water; and the sequential use of drainage water for irrigation prior to disposal.

Disposal of saline drainage water from subsurface drainage systems is a major problem limiting the sustainability of irrigated agriculture. The first step in solving this problem will be to reduce the drainage volume needing disposal. This can be accomplished by integrated management of the irrigation and drainage systems to reduce deep percolation losses from irrigation and to induce crop water use from shallow ground water. Five studies are mainly presented in this thesis:

1. To evaluate the impact of construction of subsurface drainage on rice cultivation in Nile Delta with taking into consideration that the grain yield should satisfy the needs of the local consumption and soil chemical improvement, the experiment was conducted during summer 2002 in two locations, one with subsurface drainage and the other without subsurface drainage. The results showed that water played a prominent role in rice production. The continuous presence of water on rice fields also generates water percolation and groundwater recharge, which are often beneficial for other water uses. This field experiment evaluated the suitability of irrigation water level for two new and short rice crop varieties under different subsurface drainage conditions. Results indicated that the water losses due to percolation might be quite high in irrigated rice cultivation in Egypt. The reduction of amounts of applied water was more pronounced in experimental fields without subsurface drainage status as compared with subsurface drainage status. The mean values of applied water increased with increasing irrigation water level under both drainage conditions. With regard to the water use efficiency (WUE), treatments without subsurface drainage status achieved the higher values. Regarding to irrigation water levels, controlled water level at zero cm achieved the highest values of WUE for both drainage conditions with and without subsurface drainage. The data

clearly showed that treatments without subsurface drainage status gave the higher grain yield. Rice grain yield increased in the two selected varieties with increasing controlled water depth. The subsurface drainage status improved soil salinity characteristics by reducing $SAR_{1:5}$, $EC_{1:5}$, and total anions and cations in all the analyzed soil layers. Rice cropping and water management with deeper ponding depth led to improved soil salinity characteristics.

2. To analyze the effects of drainage water (DW) reuse from branch drains by farmers on rice irrigation system, the field experiment was conducted in the lower Nile Delta, six treatments of irrigation with fresh water (FW) only (I), irrigation with FW mixed with DW at 1:1 ratio (I1D1), irrigation with FW mixed with DW at 1:2 ratio (I1D2), irrigation with FW mixed with DW at 2:1 ratio (I2D1), irrigation with FW mixed with DW at 1:3 ratio (I1D3) and irrigation with DW only (D) were set up. In all irrigation treatments three rice varieties were grown. Results indicated that; it can be save 5306 m^3 ha^{-1} and support grain yield of 8436 kg ha^{-1} due to applying I1D1 treatment with Sakha 101 rice variety through direct pumping of drainage water by farmers without deteriorating the soil chemical properties. Based on field water use efficiency and crop water use efficiency, I1D2 and I1D3 irrigation treatments can be applied with appropriate soil sodicity management.

3. To explore the effect of poor quality water on rice growth and yield under saline paddy soil of Egypt, two field experiments were conducted at agriculture research station of El-Sirw, Damietta province, Egypt during the years 2003 and 2004. The water quality treatments were; Mixed water (MW) with salinity level of 1.9~1.92 dS m^{-1} used from seedling to harvesting (T1), drainage water (DW) with 4.69~5.2 dS m^{-1} up to harvesting (T2), MW up to panicle initiation (PI) + DW up to harvesting (T3), and DW up to PI + MW up to harvesting (T4). The ponded water depth treatments were saturation (0 cm), 3 and 6 cm water depth and watering was done after every 4 days. Rice growth and yield was significantly affected by both water quality treatments and pond depths. The leaf area index (LAI), dry matter (DM) and number of tillers increased as flooding depths were increased and submergence level of 6 cm depth gave greater LAI, DM and number of tillers. While, crop growth under MW treatment was better regarding LAI, DM, number of tillers (m^{-2}) and days to flowering. Yield components were increased with increasing the ponding depth up to 6 cm except sterility percentage. MW treatment had favorable effect on yield components, while number of panicle reduced by 14.1, 5.8 and 6.3 % and percentage of filled grains reduced by

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29.7, 7.7 and 24.1 % in T2, T3 and T4, respectively. It was observed that Ca^{2+} and K^{+} contents in rice leaves increased with ponding depth but Na^{+} contents reduced. While Na^{+} uptake was lower in MW treatment (T1) than Ca^{2+} and K^{+} uptake as compared to other treatments. The interactive effects of water quality and ponding on different parameters have been discussed. Current study suggests the application of MW irrigation at early growth stage and its substitution by DW at late growth stage for rice growth under saline soil condition. Analogously, flooding depth with 6 cm is recommended to apply when poor quality water has to be used in the irrigation under saline soil.

4. To determine the optimum irrigation frequency and tillage to maximize water use efficiency (WUE) and yield of rice, the experiment was conducted at Sakha Research Station. Two rice cultivars (Giza 177 and Sakha 101) were tested for the experiment. Four main tillage treatments were applied to both the rice cultivars: 1) chisel plough (2-passes) and wet leveling (T-1), 2) chisel plough (1-pass) and dry leveling (T-2), 3) moldboard plough, disc harrow and then dry leveling (T-3), 4) zero tillage (T-4). Rice crop was irrigated at four different intervals as sub-treatments: at every 3 days (i.e., continuous flooding) (I-1), 6 days (I-2), 9 days (I-3) and 12 days (I-4). As indicators for the performance of rice production; root volume, root/shoot ratio, grain yield and WUE were determined. Soil penetration resistance (SPR) and dry bulk density (BD) of post-harvest soils were also measured. Irrigation schedules and tillage types had profound effects on the crop and soil parameters. The main results are as follows: (1) irrigation interval of 6 days is recommendable for paddy rice in Egypt, (2) amounts of water can be saved through irrigation every 6 days with 8.6% for Sakha 101 and 13.7% for Giza 177 rice varieties compared with irrigation every 3 days, (3) based on grain yield, WUE and the ability to reduce soil compaction, the tillage practice T-3, recommended by Rice Research and Training Center (RRTC) in Egypt, is suggested to be reviewed in favor of T-1 which is commonly used by the rice farmers, (4) to increase rice productivity and water use efficiency, Giza 177 rice variety should be reviewed in favor of Sakha 101 variety.

5. To investigate the performance and limitations of surge irrigation technique, field experiments were conducted in the Nile Delta of Egypt. The experiments consisted of different surge irrigation treatments compared with continuous discharge; all evaluated using two irrigation discharges- 2.4 (Q1) and 3.2 (Q2) L s^{-1} per furrow. The irrigation treatments

were: continuous discharge (I1), surge flow with a cycle ratio (CR) of 0.33 (I2), surge flow with a CR of 0.50 (I3), surge flow with a CR of 0.67 (I4) and surge flow with a CR of 0.75 (I5). The suitability of surge irrigation was assessed based on consumptive use of water, water advance rate, grain yield and several efficiencies. Results obtained on the average basis of two discharge treatments indicated that I5 could save 11% (75 mm) and 12.1% (84.4mm) of the water applied in 2002 and 2003, respectively. For consumptive use of water, I4 treatment could save 2.7% (14.6 mm) and 2.9% (15.8 mm) under Q1 and Q2 irrigation discharge respectively, for the two studied seasons. Applying the surge irrigation technique increased maize grain yield by 9.8% (746.7 kg ha^{-1}) and 4.4% (344.4 kg ha^{-1}) under respective discharge treatments for the two studied seasons. Increased irrigation discharge led to increased water application efficiency and improved water distribution uniformity. The highest mean values of water utilization efficiency were 1.284 (2002) and 1.30 kg m^{-3} (2003) from the interaction between Q2 irrigation discharge and surge I3. The results show that through the application of surge flow irrigation, water can be saved and the saved water can be used elsewhere, whilst production can be maintained and even increased on existing areas. There is large potential in disseminating surge flow irrigation for saving water resources in the Nile Delta.